INSTRUCTIONS TO CANDIDATES
Write your Candidate number in the spaces at the top of this page and on any separate answer paper used.

Section A
Answer all questions.
Write your answer in the spaces provided on the question paper.

Section B
Answer all three questions from this section.
The last question is in the form EITHER / OR and only one alternative should be attempted.
Write your answers on the answer paper provided.
At the end of the examination, hand up the paper in one bundle.

INFORMATION FOR CANDIDATES
The number of marks is given in brackets ( ) at the end of each question or part question.
A copy of the Periodic Table is printed on page 16.
You may use a calculator.

FOR EXAMINER'S USE

<table>
<thead>
<tr>
<th>Section</th>
<th>B8</th>
<th>B9</th>
<th>B10</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section A

Answer all questions in the spaces provided.

The total mark for this section is 50.

A1 Carbon dioxide can be formed by a number of different types of reaction. Suggest the identities for each of the following:

a. a liquid that burns in excess oxygen to give carbon dioxide and water only.

b. a solid that burns to give carbon dioxide only.

c. a gas that burns to give carbon dioxide only.

d. a solid that when heated gives carbon dioxide as one of the two products.

e. a solution of a solid that produces carbon dioxide and ethanol with yeast.

f. a soluble compound that reacts with an acid to produce carbon dioxide.

[Total: 6]
A2 The chart below shows the reaction scheme of an element R.

Element R

\[ \text{Warm with Acid S} \]

\[ \text{Green solution} \xrightarrow{\text{HNO}_3 \text{ (aq)) followed by Ba(NO}_3)_2 \text{ (aq)}} \]

\[ \text{White precipitate T} \]

\[ \text{a few drops of NaOH (aq) followed by excess} \]

\[ \text{Dirty green precipitate U} \xrightarrow{\text{On standing}} \]

\[ \text{Green precipitate turns into a red-brown precipitate V} \]

a. Give the formulae of the following substances. [2]

\[ \text{T:} \]

\[ \text{V:} \]

b. Write the ionic equation, with state symbols, for the formation of the precipitate U. [2]

c. i. Acid S is a strong acid. What is a strong acid and name the ion needed for acidic properties? [2]

ii. Write the equation for the reaction of element R and acid S. [1]

iii. Describe how a pure dry sample of green crystals can be prepared from the reaction between element R and acid S. [3]

[Total: 10]
A3 A metal cup is electroplated with silver using aqueous silver nitrate as the electrolyte. The anode is a piece of 20.0 g silver and the other electrode is the metal cup.

a Explain why a plastic cup is not suitable for electroplating. [1]

b Explain why the concentration of the electrolyte remains constant throughout the process. [2]

c The cup is plated with 2.7 g of silver and the final mass of the silver anode is 18.6 g. Calculate the percentage purity of the silver anode to 3 significant figures. [2]

[Total: 5]

A4 In the Haber process, ammonia is manufactured by the reaction between nitrogen and hydrogen. The equation is given below.

$$\text{N}_2 (g) + 3 \text{H}_2 (g) \rightleftharpoons 2 \text{NH}_3 (g)$$

a Explain in terms of changes in the oxidation states, why this is a redox reaction. [2]

b Name a source of hydrogen for the above reaction. [1]

c Ammonia is mostly made into ammonium sulfate to be sold as fertilizers. Farmers add these fertilizers to the soil to produce a good yield of crops. However, farmers should not add calcium hydroxide to the soil at the same time. Explain why calcium hydroxide is not used together with these fertilizers. [2]

[Total: 5]
A5 The hulls of ships are built from steel. The hull is painted and also have zinc blocks welded to the hull as shown in the diagram.

a Steel is stronger than pure iron which makes it more suitable for building the hull of the ship. Explain why steel is stronger than iron. [3]

b Explain how the coat of paint on the hull of the ship reduces rusting. [2]

c i State and explain the role of the zinc blocks welded to the steel hull. [3]

ii State the products when calcium is reacted with cold water. [1]

iii Explain why magnesium can be an alternative for zinc but calcium is unsuitable. [1]

[Total: 10]
A6 The structural formulae of three alcohol molecules are given below.

\[
\begin{align*}
\text{Pentenol:} & \quad H - C - C - C - C - C - OH \\
\text{Pentanol:} & \quad H - C - C - C - C - C - OH \\
\text{Cyclopentanol:} & \quad \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\end{array}
\end{align*}
\]

a Which of these molecules are isomers? Explain your answer. [2]

b One mole of cyclopentanol undergoes substitution reaction with one mole of chlorine. Use the structural formulae to construct the equation for the reaction. You should also indicate the conditions needed for the reaction. [2]

c When warmed with a strong oxidizing agent, pentanol can be oxidized. Name a suitable oxidizing agent and give the structural formula of the organic product. [2]
d. Pentenol undergoes addition polymerization. By showing three repeat units, draw part of the molecule of poly(pentenol). [2]

A7

In an experiment, small amounts of three metals were added to three aqueous metal nitrate solutions.

The results are shown in the table.

<table>
<thead>
<tr>
<th></th>
<th>Aqueous zinc nitrate</th>
<th>Aqueous iron(III) nitrate</th>
<th>Aqueous chromium(III) nitrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>No reaction</td>
<td>Orange solution turns colourless and zinc is coated with a shiny grey solid</td>
<td>Green solution turns colourless and zinc is coated with a shiny grey solid</td>
</tr>
<tr>
<td>Iron</td>
<td>No reaction</td>
<td>No reaction</td>
<td>No reaction</td>
</tr>
<tr>
<td>Chromium</td>
<td>No reaction</td>
<td>Orange solution turns pale yellow and chromium is coated with a shiny grey solid</td>
<td>No reaction</td>
</tr>
</tbody>
</table>

a. Arrange the three metals in increasing order of reactivity. [2]

b. Write the ionic equation, with state symbols, for the reaction between zinc and aqueous chromium(III) nitrate. [2]

c. Aluminium metal was added to aqueous iron(III) nitrate in another experiment. Suggest why there is no visible reaction. [2]
Section B

Answer all three questions from this section.

The last question is in the form EITHER / OR and only one alternative should be attempted.

Tie any extra sheets used loosely to this booklet.

B8 Five pupils (A to E) burnt different masses of magnesium in air using the apparatus in the diagram.

A graph of the mass of oxygen against the mass of magnesium is plotted as shown.

![Graph of mass of oxygen vs mass of magnesium]

a Which pupil is most likely to have unburnt magnesium in the crucible at the end of the experiment? Explain your answer. [2]
b. Using data from student E, show that the formula of magnesium oxide is MgO. [2]

c. Describe in terms of the bonding and structure, why magnesium oxide has a high melting point of 2800 °C. [2]

Air contains about four times as much nitrogen as oxygen by volume.

i. Suggest why, despite this, you would not expect much magnesium nitride to be formed in this experiment. [2]

ii. Draw the dot and cross diagram to show the bonding in magnesium nitride. You only have to show the outer electrons. [2]

[Total: 10]
Some margarine is made by hydrogenating carbon-carbon double bonds in vegetable oils. You can recognize the presence of this in food because the ingredients list will include words showing that it contains "hydrogenated oils" or "hydrogenated fats".

Fats and oil are similar molecules and they are polyesters with three ester linkages. They differ in their melting points which are largely determined by the presence of carbon-carbon double bonds in the molecules. The higher the number of carbon-carbon double bonds, the lower the melting point.

Sunflower oil is an example of a polyunsaturated vegetable oil. In a laboratory test, 0.2 mole of the oil is found to react with 160 g of bromine in an addition reaction.

a  What is unsaturation? [1]

b  Calculate the number of carbon-carbon double bonds in the sunflower oil. [2]

Sunflower oil is treated with hydrogen to form a **hydrogenated fat** molecule as shown below:

![Diagram of hydrogenated fat molecule]

The hydrogenated fat molecule

c  Circle the 3 ester linkages in the hydrogenated fat molecule above. [1]
When the hydrogenated fat undergoes a certain treatment with water, it can be broken down into four monomers (This treatment is the reverse process of polymerization). The monomers are:

- glycerol,
- linoleic acid,
- stearic acid and
- oleic acid.

The formulae of glycerol and linoleic acid are shown below.

This tri-alcohol is glycerol

Deduce the formulae of stearic acid and oleic acid. [2]

Stearic acid is a saturated monomer in d(i) above. From comparing the formulae of the acids, it can be deduced that oleic acid contains only one carbon-carbon double bond.

Deduce the number of carbon-carbon double bonds in linoleic acid. Explain your reasoning. [2]

Three fat molecules are given below.

Fat molecule X  Fat molecule Y  Fat molecule Z

Arrange them in order of their melting points in descending order. [2]

[Total: 10]
EITHER

B10 Hydrogen peroxide decomposes according to the equation:

\[ 2 \text{H}_2\text{O}_2 \text{(aq)} \xrightarrow{\text{catalyst}} 2 \text{H}_2\text{O} \text{(l)} + \text{O}_2 \text{(g)} \]

The apparatus below was set up to compare the effects of two catalysts on the rate at which oxygen is evolved from the decomposition of hydrogen peroxide.

Two experiments were carried out with identical conditions except for the catalyst used. 0.5 g of manganese(IV) oxide was the catalyst used in Experiment 1 and 0.5 g of copper(II) oxide in Experiment 2. The graphs obtained is shown below.

![Graph 1: Result from Experiment 1](image)

Graph 1: Result from Experiment 1

![Graph 2: Result from Experiment 2](image)

Graph 2: Result from Experiment 2

Time / s

Volume of O₂ / cm³

120

a What is a catalyst? [1]

b Explain whether manganese(IV) oxide or copper(II) oxide is a better catalyst for this reaction? [1]
c In each experiment, the volume of the hydrogen peroxide used was 50 cm³ and the volume of oxygen gas was collected at room temperature and pressure. Calculate the concentration of the hydrogen peroxide solution.

[2]

d Pyrogallol absorbs oxygen. When the gas in the syringe was shaken with sufficient pyrogallol to absorb all the oxygen present, about 40 cm³ of gas remained in the syringe.
Name this gas and state how it managed to get into the syringe.

[2]

e Experiment 1 was repeated two more times; Experiment 3 and 4, both with only one condition changed. On the same axes on page 12, sketch and label the graphs of these experiments.

[2]

<table>
<thead>
<tr>
<th>The condition changed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 3</td>
</tr>
<tr>
<td>Experiment 4</td>
</tr>
</tbody>
</table>

f The structural formula of hydrogen peroxide is H-O-O-H. Explain in terms of bond breaking and forming, why this is an exothermic reaction.

[2]

[Total: 10]
B10 The diagram below shows an electrolysis cell that produces hydrogen and oxygen from water.

(adapted from https://energy.gov/eere/fueltech/hydrogen-production-electrolysis (U.S. Department of Energy)

Electrolysis is a promising option for hydrogen production from renewable resources. Hydrogen produced via electrolysis can result in zero greenhouse gas emissions, depending on the source of the electricity used. Most of the electricity generated today uses technologies that are energy intensive, because of the amount of fuel required due to the low efficiency of the electricity generation process. In many countries, today’s power grid is not ideal for providing electricity required for electrolysis.

In the electrolysis cell above, the anode and cathode is separated by an electrolyte, known as a polymer electrolyte membrane (PEM) electrolyzer. This electrolyte is a solid specially plastic material.

At the anode, water undergoes a reaction to form oxygen gas and positively charged hydrogen ions, at the same time producing electrons. The electrons flow through an external circuit and the hydrogen ions selectively move across the membrane to the cathode. At the cathode, hydrogen ions combine with the electrons from the external circuit to form hydrogen gas.

a Write down the chemical equations, with state symbols, for the reaction at the anode and the cathode. [4]

Anode: 

Cathode: 

b Suggest why today’s power grid is not ideal? [1]
c. Give an example of renewable energy options that will result in virtually zero greenhouse gas emissions. [1]

d. Name the major greenhouse gas that is produced when fossil fuels are burnt for energy. [1]

e. The electrolysis is endothermic and the overall equation for the reaction is:
   \[ 2 \text{H}_2\text{O} (l) \rightarrow 2 \text{H}_2 (g) + \text{O}_2 (g) \text{; endothermic} \]

   Draw the energy profile diagram for the reaction and label the activation energy and the enthalpy change. [3]

[Total: 10]
The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Group 6</th>
<th>Group 7</th>
<th>Group 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>He</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td></td>
<td>K</td>
<td>Ca</td>
<td>Sc</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cr</td>
<td>Mn</td>
<td>Fe</td>
<td>Co</td>
<td>Ni</td>
<td>Cu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cu</td>
<td>Zn</td>
<td>Ga</td>
<td>Ge</td>
<td>As</td>
<td>Se</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rb</td>
<td>Sr</td>
<td>Yb</td>
<td>Lu</td>
<td>Hf</td>
<td>Ta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cs</td>
<td>Ba</td>
<td>Lu</td>
<td>Act</td>
<td>Pb</td>
<td>Bi</td>
</tr>
</tbody>
</table>

*58-71 Lanthanoid series
†190-103 Actinoid series

Key:
- a = relative atomic mass
- X = atomic symbol
- b = proton (atomic) number

The volume of one mole of any gas is 24 cm³ at room temperature and pressure (r.t.p.)
P1

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| C | A | C | D | B | D | A | A | D | B | B | C | D | A | B | D | C | D | A | B |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| B | A | C | B | B | A | C | D | D | A | B | C | D | D | C | B | A | C | B | A |

P2

A1
a. Pentane/ pentene onwards, alcohols or any suitable organic compound
b. Carbon/ graphite or suitable allotrope of carbon
c. Carbon monoxide
d. Any metal carbonate but not those of group 1 metals
e. Sugars/ glucose
f. Sodium carbonate, potassium carbonate, ammonium carbonate

A2
a. $T: \text{BaSO}_4$
   $V: \text{Fe(OH)}_3$
   
   b. $\text{Fe}^{2+} \ (\text{aq}) + 2 \ \text{OH}^- \ (\text{aq}) \rightarrow \text{Fe(OH)}_2 \ (\text{s})$
   
   c. i. A strong acid dissociates/ionises completely in water to produce hydrogen ions.
   
   ii. $\text{Fe} \ (s) + \text{H}_2\text{SO}_4 \ (\text{aq}) \rightarrow \text{FeSO}_4 \ (\text{aq}) + \text{H}_2 \ (g)$
   
   iii. Acid excess iron to warmed dilute sulfuric acid. Filter away excess iron. Heat to evaporate the solvent of filtrate to get a hot saturated/concentrated solution. Cool for crystals to form. Filter out crystals and dry with pieces of filter paper.

A3
a. Plastic is not a conductor and the cup is acting as the cathode which must be an electrical conductor.

b. Silver ions from the electrolyte discharged to form silver metal at the cathode. At the same rate, the silver anode dissolves/oxygenises to form silver ions that enter the electrolyte. Hence, concentration is constant.

Mass loss at silver anode $= 20 - 16.9 = 3.1g$
$\%$ purity of silver anode $= \frac{2.7}{3.1} \times 100 = 87.1\%$

A4
a. Oxidation state of nitrogen decreases from 0 (in $\text{N}_2$) to -3 (in $\text{NH}_3$), this is reduction.
Oxidation state of hydrogen increases from 0 (in $\text{H}_2$) to +1 (in $\text{NH}_3$), this is oxidation.

b. Cracking of hydrocarbons/steam reforming

c. Calcium hydroxide reacts with ammonium salts to produce ammonia gas. As a gas, it escape from the soil and the fertilizers would lose its nitrogen content.
A6 a Pure iron consists of iron atoms orderly arranged in layers which slide past each other easily.

Steel is made up of different sized atoms of carbon and iron. The orderly arrangement is disrupted and the atoms do not slide easily.

b Paint forms a barrier between iron and air/oxygen and water, the conditions for rusting

c i Zinc provides sacrificial protection. Zinc is more reactive than iron in the steel. It loses electrons more easily and corrodes in place of iron.

ii Calcium hydroxide and hydrogen gas or Ca(OH)$_2$ and H$_2$

iii Magnesium and calcium are more reactive than iron. But calcium reacts readily with water instead of acting as a sacrificial metal for iron.

A6 a Pentanol and cyclopentanol. They have the same molecular/chemical formula but different structural formulas.

b

![Chemical structures]

c Acidified potassium manganate(VII) or potassium dichromate(VI)

d

A7 a iron, chromium, zinc

b $3 \text{Zn (s)} + 2 \text{Cr}^{3+} (\text{aq}) \rightarrow 3 \text{Zn}^{2+} (\text{aq}) + 2 \text{Cr (s)}$

c Aluminium has an impervious/non-porous/protective layer of aluminium oxide.
Pupil C.
Mass of oxygen is proportional to magnesium in the graph. For pupil C, the mass of oxygen is less than expected.

Using data from pupil B:

<table>
<thead>
<tr>
<th></th>
<th>Mg</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass</td>
<td>0.6g</td>
<td>0.4g</td>
</tr>
<tr>
<td>mol</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>ratio</td>
<td>0.6/24 = 0.025</td>
<td>0.4/16 = 0.025</td>
</tr>
</tbody>
</table>

Hence the formula is MgO

Magnesium oxide has an ionic structure. The positive magnesium ions and negative oxide ions are held together by strong electrostatic forces of attraction in a giant lattice structure. A lot of energy is needed to overcome these strong forces. Hence, the high melting point.

Nitrogen is unreactive as the nitrogen-nitrogen triple bond is very strong.

Unsaturation is the presence of a carbon-carbon double bond which allows for addition reaction/ addition of atoms into the molecule.

No of moles of Br₂ = mass / Molar mass of Br₂ = 160/160 = 1 mol
Ratio of sunflower oil: Br₂ is 1:5
Since 1 C=C uses up 1 Br₂, there are 5 carbon-carbon double bonds

2 carbon-carbon double bonds.
Linoleic acid has 4 hydrogen atoms less than stearic acid.

X, Y, Z
EITHER

B10 a. A catalyst is a substance that speeds up a chemical reaction but remains chemically unchanged.

b. Manganese(IV) oxide is a better catalyst because graph 1 has a steeper gradient and a faster speed of reaction.

c. From the graph, volume of O₂ gas = 120 cm³
No. of mol of O₂ = 120/24000 = 0.005 mol
Hence, from the equation, no. of mol of H₂O₂ = 0.005 x 2 = 0.01 mol
Concentration = 0.01/50 x 1000 = 0.200 mol/dm³

d. The conical flask and the delivery tube has air at the start of the experiment. Air has 78% nitrogen. The 40 cm³ gas must be the unreactive nitrogen gas.

e. 

f. The energy taken in to break 4 moles of O-H bonds and 2 moles of O-O bonds is less than the energy given out to make 4 moles of O-H bonds and 1 mole of O=O bonds.

OR

B10 a. Anode: 2 H₂O(l) → O₂(g) + 4 H⁺(aq) + 4 e⁻
Cathode: 2 H⁺(aq) + 2 e⁻ → H₂(g)

b. Greenhouse gas emissions due to the burning of fossil fuels/large amounts of fuel required/due to the low efficiency of the electricity generation process.

c. Wind energy/ hydroelectric power/ nuclear energy.

d. Carbon dioxide gas.

e. 

ACS(Independent) 2017 Prelim exam Y4 express
READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name and register number on the Question Paper and Answer Sheet in the spaces provided.

There are forty questions on this paper. Answer all questions.
For each question there are four possible answers A, B, C, and D.
Choose the one you consider correct and record your choice in soft pencil on the separate Answer Sheet.

Read the Instructions on the answer sheet very carefully.
Each correct answer will score one mark.
A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.
A copy of the Periodic Table is printed on page 17.
The use of an approved scientific calculator is expected, where appropriate.
1. The diagram below shows the set-up used to obtain pure water from seawater.

At which part of the set-up, A, B, C or D, do the water molecules lose the most energy?

2. Titan is the largest moon of Saturn. There is no water on Titan. The average surface temperature on Titan is -179°C.

Which of the substances in the table below would form oceans on Titan?

<table>
<thead>
<tr>
<th>substance</th>
<th>melting point / °C</th>
<th>boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A argon</td>
<td>-189</td>
<td>-186</td>
</tr>
<tr>
<td>B carbon monoxide</td>
<td>-205</td>
<td>-192</td>
</tr>
<tr>
<td>C methane</td>
<td>-183</td>
<td>-164</td>
</tr>
<tr>
<td>D nitrogen</td>
<td>-210</td>
<td>-196</td>
</tr>
</tbody>
</table>

3. The table below shows some information about four substances labelled P to S.

<table>
<thead>
<tr>
<th>substance</th>
<th>appearance</th>
<th>change on heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Colourless liquid</td>
<td>boils away, leaving a white residue.</td>
</tr>
<tr>
<td>Q</td>
<td>Colourless gas</td>
<td>burns in oxygen to form water and carbon dioxide only.</td>
</tr>
<tr>
<td>R</td>
<td>Yellow solid</td>
<td>splits up by electricity to form a metal and a gas.</td>
</tr>
<tr>
<td>S</td>
<td>White solid</td>
<td>burns in air to form an oxide as the only product.</td>
</tr>
</tbody>
</table>

Which of these substances P, Q, R and S are compounds?

A. P and Q only
B. Q and R only
C. R and S only
D. Q, R and S only
4 A student was tasked to separate a mixture containing an organic liquid T and aqueous sodium bromide.

Properties of organic liquid T were given as follows.
- It is miscible with water.
- It has a lower density than water.
- It is yellowish in colour.
- It boils at 120°C.

Which of the following experimental techniques should the student use to obtain samples of the organic liquid T and sodium bromide from the mixture?
A evaporation to dryness followed by chromatography
B fractional distillation followed by evaporation to dryness
C separating funnel followed by evaporation to dryness
D simple distillation followed by filtration

5 The Rf values for the coloured dyes D, E, F and G, in four different solvents are shown in the table below.

<table>
<thead>
<tr>
<th>coloured dyes</th>
<th>water</th>
<th>ethanol</th>
<th>propanone</th>
<th>tetrachloromethane</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.3</td>
<td>0.9</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>E</td>
<td>0.0</td>
<td>0.8</td>
<td>0.6</td>
<td>0.2</td>
</tr>
<tr>
<td>F</td>
<td>0.5</td>
<td>0.7</td>
<td>0.6</td>
<td>0.1</td>
</tr>
<tr>
<td>G</td>
<td>0.2</td>
<td>0.6</td>
<td>0.4</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Which solvent could be used to separate all four coloured dyes, D, E, F and G from a mixture?
A ethanol
B propanone
C tetrachloromethane
D water
6. An element Z consists of four isotopes, three of which have isotopic masses of 50, 52 and 54.

The diagram below gives the mass spectrum of the element Z which shows the relative percentage abundance of three of its isotopes.

What is the isotopic mass of the fourth isotope if the relative atomic mass of element Z is 52.06?

A 52  B 53  C 55  D 56

7. An ion of an element, X, has 22 electrons and a nucleon (mass) number of 55. What is the charge on the ion if the number of neutrons is 30?

A 2-  B 2+  C 3-  D 3+

8. The proton numbers and nucleon (mass) numbers of elements U and V are given in the table below.

<table>
<thead>
<tr>
<th>element</th>
<th>proton number</th>
<th>nucleon number</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>V</td>
<td>16</td>
<td>32</td>
</tr>
</tbody>
</table>

The relative molecular mass of the compound formed between U and V is

A 44  B 56  C 76  D 88
9. The structures of three substances J, K and L at room temperature and pressure, are represented as follows.

![Structures of J, K, and L]

Which statement about the three substances is incorrect?

A. All three substances are solids at room temperature and pressure.
B. All three substances have high melting points.
C. Substances K and L are elements while substance J is a compound.
D. Substances J and L can conduct electricity in the molten state.

10. A mixture of magnesium and sand was added to dilute hydrochloric acid in a beaker as shown in the diagram below.

![Diagram of a beaker with dilute hydrochloric acid and bubbles of gas Y]

Which of the following options indicates correctly the type of particles present in the substances?

<table>
<thead>
<tr>
<th></th>
<th>magnesium</th>
<th>sand</th>
<th>dilute hydrochloric acid</th>
<th>gas Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>atoms</td>
<td>molecules</td>
<td>ions</td>
<td>atoms</td>
</tr>
<tr>
<td>B</td>
<td>ions and electrons</td>
<td>atoms</td>
<td>ions and molecules</td>
<td>molecules</td>
</tr>
<tr>
<td>C</td>
<td>ions and electrons</td>
<td>atoms</td>
<td>ions</td>
<td>molecules</td>
</tr>
<tr>
<td>D</td>
<td>ions and electrons</td>
<td>molecules</td>
<td>ions and molecules</td>
<td>molecules</td>
</tr>
</tbody>
</table>

Preliminary Examination 4E/5N Chemistry 2017 5073/1
11 Which of the following is/are suitable method(s) used to test the acid strength of two acids, hydrochloric acid and ethanoic acid, which are of the same concentration?

I using a pH meter  
II measuring their electrical conductivity  
III titration using sodium hydroxide solution

A I and II only  
B I and III only  
C II and III only  
D I, II and III

12 Which of the following properties show that a certain substance, M, is alkaline?

A Addition of dilute hydrochloric acid to aqueous M produces no precipitate.  
B Aqueous M can react with zinc oxide  
C Aqueous M forms ammonia gas when warmed with ammonium chloride.  
D Aqueous M forms a white precipitate with aqueous iron(III) sulfate.

13 Alvin attempted to prepare some salts by the methods shown in the table below.

<table>
<thead>
<tr>
<th>experiment</th>
<th>salt prepared</th>
<th>method used</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>zinc chloride</td>
<td>Mixing aqueous zinc nitrate and hydrochloric acid</td>
</tr>
<tr>
<td>II</td>
<td>sodium nitrate</td>
<td>Titrating aqueous sodium carbonate with nitric acid</td>
</tr>
<tr>
<td>III</td>
<td>calcium sulfate</td>
<td>Mixing aqueous calcium nitrate and sulfuric acid</td>
</tr>
</tbody>
</table>

Which of the experiment(s) give(s) a good yield?

A I only  
B I and III only  
C II and III only  
D I, II and III
A titration was conducted by adding NaOH from a burette to HCl in a conical flask. The pH of the solution in the flask was recorded during the titration and graph 1 was produced.

A second titration was conducted by adding NaOH to a different acid, Acid Z. The pH of the solution in the flask was recorded during the titration and graph 2 was produced.

The table below shows some indicators that could be used to identify the endpoint of titrations. For the NaOH – HCl titration, the appropriate indicator is bromothymol blue.

<table>
<thead>
<tr>
<th>indicator</th>
<th>acidic colour</th>
<th>range of colour change</th>
<th>alkaline colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>methyl orange</td>
<td>red</td>
<td>3.1 – 4.4</td>
<td>yellow</td>
</tr>
<tr>
<td>methyl red</td>
<td>red</td>
<td>4.4 – 6.2</td>
<td>yellow</td>
</tr>
<tr>
<td>bromothymol blue</td>
<td>yellow</td>
<td>6.0 – 7.6</td>
<td>blue</td>
</tr>
<tr>
<td>cresolphthalein</td>
<td>colourless</td>
<td>8.1 – 9.7</td>
<td>red</td>
</tr>
<tr>
<td>alizarin yellow</td>
<td>yellow</td>
<td>10.1 – 12.0</td>
<td>red</td>
</tr>
</tbody>
</table>

Which indicator in the table is appropriate for the NaOH – Acid Z titration?

A  alizarin yellow
B  cresolphthalein
C  methyl orange
D  methyl red
15 A mixture containing aqueous lead(II) nitrate and nitric acid, is tested with Universal indicator and potassium iodide solution separately.

Which set of results would the mixture produce in the tests?

<table>
<thead>
<tr>
<th>Universal indicator</th>
<th>potassium iodide solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A green</td>
<td>yellow precipitate</td>
</tr>
<tr>
<td>B orange</td>
<td>yellow precipitate</td>
</tr>
<tr>
<td>C red</td>
<td>colourless solution</td>
</tr>
<tr>
<td>D red</td>
<td>yellow precipitate</td>
</tr>
</tbody>
</table>

16 Sulfuric acid and potassium hydroxide can react together to form potassium hydrogensulfate, $KHSO_4$, and water only.

Which of the following amounts of the reactants are required to form potassium hydrogensulfate?

A equal number of moles of sulfuric acid and potassium hydroxide
B equal volumes of sulfuric acid and potassium hydroxide
C one mole of sulfuric acid and two moles of potassium hydroxide
D two moles of sulfuric acid and one mole of potassium hydroxide

17 Elements, $X$, $Y$ and $Z$, are all in the same period of the Periodic Table. Oxides of $X$ reacts with both acid and alkali. Solid $Y$ does not conduct electricity. $Z$ forms an ionic oxide, $ZO$.

Which of the following gives the correct order of the elements across the period?

A $X \rightarrow Y \rightarrow Z$
B $Y \rightarrow X \rightarrow Z$
C $Z \rightarrow X \rightarrow Y$
D $Z \rightarrow Y \rightarrow X$
18 The diagram below shows a set-up used to investigate the relative reactivity of halogens.

Which of the following would be the correct colours observed for gas T, gas U and in the water during the experiment?

<table>
<thead>
<tr>
<th></th>
<th>gas T</th>
<th>gas U</th>
<th>water</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>brown</td>
<td>reddish-brown</td>
<td>colourless</td>
</tr>
<tr>
<td>B</td>
<td>colourless</td>
<td>violet</td>
<td>black</td>
</tr>
<tr>
<td>C</td>
<td>reddish-brown</td>
<td>brown</td>
<td>violet</td>
</tr>
<tr>
<td>D</td>
<td>reddish-brown</td>
<td>violet</td>
<td>brown</td>
</tr>
</tbody>
</table>

19 In some countries, anhydrous calcium chloride is used as a drying agent to reduce dampness in houses.

When the anhydrous salt absorbs enough water to form the dihydrate, CaCl₂·2H₂O, what is the percentage increase in mass for the anhydrous salt?

A 14%
B 24%
C 32%
D 36%

20 If 200 cm³ of 0.1 mol/dm³ hydrochloric acid were added to 1.24 g of copper(II) carbonate, which of would be obtained after the reaction?

A black solid and a blue solution
B green solid and a blue solution
C pink solid and blue solution
D blue solution only
21 Three electrolytic cells are set up using inert electrodes. The electrolytes used are listed below.

   Cell 1: concentrated aqueous rubidium chloride
   Cell 2: dilute sulfuric acid
   Cell 3: molten zinc bromide

In which of these cell(s) is/are gases formed at both electrodes?

A 2 only
B 3 only
C 1 and 2 only
D 1 and 3 only

22 During the electrolysis of an aqueous solution of a cerium salt, 70 g of cerium (A of Ce = 140) is deposited at the cathode by 2 moles of electrons.

What is the formula of the cerium ion?

A Ce⁺
B Ce²⁺
C Ce³⁺
D Ce⁴⁺

23 Which simple cell set-up would produce the greatest reading on the voltmeter?

A

B

C

D
24 A diagram of the hydrogen-oxygen fuel cell is shown below.

Which of the following is/are correct statement(s) about the fuel cell?

I. Electrons flow from the anode to the cathode in the electrolyte.
II. Electricity is used to generate hydrogen and oxygen.
III. Hydrogen and oxygen undergo redox reactions to generate electricity.
IV. The anode and cathode are the negative and positive electrodes respectively.

A. I and II only
B. I and III only
C. II and III only
D. III and IV only

25 A student borrowed a friend’s chemistry notes and copied out the notes wrongly in the box below.

"The temperature of molecules increases during an exothermic reaction and the products have less energy than their reactants."

Which of the following should be the correct version of the notes?

A. The temperature of molecules increases during an exothermic reaction, and the products have more energy than their reactants.
B. The temperature of molecules decreases during an exothermic reaction, and the products have less energy than their reactants.
C. The temperature of the surrounding increases during an exothermic reaction, and the products have less energy than their reactants.
D. The temperature of the surrounding decreases during an exothermic reaction, and the products have more energy than their reactants.
26  The energy profile diagram of the following reversible reaction is shown below.

\[ E \rightleftharpoons F + G \]

In the forward reaction, \( E \) decomposes to form \( F \) and \( G \) while in the backward reaction, \( F \) and \( G \) recombine to form \( E \).

Which of the following could be inferred from the energy profile diagram?

<table>
<thead>
<tr>
<th></th>
<th>reaction</th>
<th>enthalpy change / kJ</th>
<th>activation energy / kJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>backward</td>
<td>+100</td>
<td>60</td>
</tr>
<tr>
<td>B</td>
<td>backward</td>
<td>+40</td>
<td>100</td>
</tr>
<tr>
<td>C</td>
<td>forward</td>
<td>+40</td>
<td>60</td>
</tr>
<tr>
<td>D</td>
<td>forward</td>
<td>-40</td>
<td>100</td>
</tr>
</tbody>
</table>

27  Which of the following correctly explains how a catalyst increases the rate of a reaction?

<table>
<thead>
<tr>
<th></th>
<th>effect of catalyst</th>
<th>activation energy of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>increases the kinetic energy of particles</td>
<td>decreases</td>
</tr>
<tr>
<td>B</td>
<td>increases the kinetic energy of particles</td>
<td>increases</td>
</tr>
<tr>
<td>C</td>
<td>provides an alternative reaction pathway</td>
<td>decreases</td>
</tr>
<tr>
<td>D</td>
<td>provides an alternative reaction pathway</td>
<td>increases</td>
</tr>
</tbody>
</table>
28  The formulae for four chloride compounds are given below.

$$\begin{align*}
&\text{PCl}_3 \\
&\text{Cl}_2\text{O} \\
&\text{ClO}_3^- \\
&\text{ClO}_4^-
\end{align*}$$

Which one of the following shows correctly the oxidation numbers of chlorine in the above chloride compounds respectively?

\[ \text{Diagram with graphs A, B, C, D} \]

29  Disproportionation reaction occurs when an element is simultaneously oxidized and reduced. Which one of the following named elements does not undergo disproportionation?

<table>
<thead>
<tr>
<th>element</th>
<th>equation of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A carbon</td>
<td>$\text{H}_2\text{C}_2\text{O}_4 \rightarrow \text{H}_2\text{O} + \text{CO} + \text{CO}_2$</td>
</tr>
<tr>
<td>B nitrogen</td>
<td>$\text{H}_2\text{O} + 2\text{NO}_2 \rightarrow \text{HNO}_3 + \text{HNO}_2$</td>
</tr>
<tr>
<td>C sulfur</td>
<td>$2\text{FeSO}_4 \rightarrow \text{Fe}_2\text{O}_3 + \text{SO}_2 + \text{SO}_3$</td>
</tr>
<tr>
<td>D tin</td>
<td>$2\text{Sn}^{2+} \rightarrow \text{Sn}^{4+} + \text{Sn}$</td>
</tr>
</tbody>
</table>

30  The data gives the concentration (ppb), in parts of pollutant per billion parts of air, of polluting gases in four different industrial cities. In which city are limestone buildings under the greatest threat from pollution?

<table>
<thead>
<tr>
<th></th>
<th>ozone</th>
<th>sulfur dioxide</th>
<th>nitrogen dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11</td>
<td>38</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>21</td>
<td>45</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>23</td>
<td>17</td>
<td>46</td>
</tr>
<tr>
<td>D</td>
<td>30</td>
<td>32</td>
<td>33</td>
</tr>
</tbody>
</table>
31 To reduce atmospheric pollution, the following waste gases from a power station are passed through wet powdered calcium carbonate.

- carbon monoxide
- nitrogen monoxide
- sulfur dioxide
- carbon dioxide
- nitrogen dioxide
- phosphorus(V) oxide

How many waste gases will not be removed by the wet powdered calcium carbonate?

A  1   B  2   C  3   D  4

32 In the past, CFC (chlorofluorocarbons) such as CF₂CH₂Cl were used as aerosol propellants.

Which element in CFC can cause a depletion of ozone?

A  carbon  B  chlorine  C  fluorine  D  hydrogen

33 In the Haber process,

I  the hydrogen needed can be obtained from the cracking of petroleum.
II the reaction chamber is pressurized to speed up the reaction.
III the ammonia formed is removed by condensation.

Which of the above options are correct?

A  I and II only  B  I and III only  C  II and III only  D  I, II and III

34 Nickel is placed between iron and lead in the reactivity series.

Which of the following is true about the reactivity of nickel?

A  Nickel can be obtained by moderate heating of nickel carbonate.
B  Nickel can displace hydrogen rapidly from steam.
C  Nickel can be displaced from an aqueous nickel salt by adding iron.
D  Nickel cannot displace hydrogen from an acid.
35 Element W is a metal that is more reactive than aluminium.
Which of the following extraction methods would be the most suitable to produce element W?

A  Electrolyzing concentrated chloride of W.
B  Electrolyzing molten oxide of W.
C  Heating oxide of W with carbon monoxide.
D  Heating chloride of W with coke.

36 Approximately 40% of all iron and steel is produced by recycling.
Which of the following are correct reasons for recycling iron?
1. Iron, when obtained by a recycling process, produces less carbon dioxide than the blast furnace process.
2. Scrap steel contains a higher percentage of iron than iron ore.
3. Scrap metal, if not recycled, would cause environmental problems due to disposal by landfill.

A  1 and 2 only
B  1 and 3 only
C  2 and 3 only
D  1, 2 and 3

37 Which reaction is not a step in the production of iron from haematite in the blast furnace?

A  Carbon is burnt in air to produce carbon dioxide.
B  Carbon is reacted with carbon dioxide to produce carbon monoxide.
C  Iron (III) oxide is reduced by carbon monoxide to form iron
D  Iron is reacted with limestone to produce slag

38 Which statement about the fractional distillation of petroleum is correct?

A  Only one compound is collected from each level of the fractionating column.
B  The higher up the fractionating column, the greater is the temperature.
C  The fractions collected at the bottom of the fractionating column are the most flammable.
D  The fractions reaching the top of the fractionating column have the smallest relative molecular mass.
39 Which formula of alkenes does not change as the number of carbon atoms in the molecule increases?

A Chemical formula
B Empirical formula
C Molecular formula
D Structural formula

40 Yoghurt contains lactic acid which has the structural formula shown below.

What statement(s) about lactic acid is/are true?

I It can decolourise aqueous bromine in darkness.
II It can decolourise acidified potassium permanganate(VII).
III It can undergo polymerization by itself under suitable conditions.
IV One mole of lactic acid requires two moles of sodium hydroxide for complete neutralization.

A I and II only
B II and III only
C I, II and III only
D I, II, III and IV

END OF PAPER
### 2017 Prelim Chemistry Exam (5073/1)

**Paper 1**

**Answers**

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>11</td>
<td>A</td>
<td>21</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>12</td>
<td>C</td>
<td>22</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>13</td>
<td>C</td>
<td>23</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>14</td>
<td>B</td>
<td>24</td>
<td>D</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>15</td>
<td>D</td>
<td>25</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>16</td>
<td>A</td>
<td>26</td>
<td>B</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>17</td>
<td>C</td>
<td>27</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>18</td>
<td>D</td>
<td>28</td>
<td>A</td>
</tr>
<tr>
<td>9</td>
<td>B</td>
<td>19</td>
<td>C</td>
<td>29</td>
<td>C</td>
</tr>
<tr>
<td>10</td>
<td>B</td>
<td>20</td>
<td>D</td>
<td>30</td>
<td>A</td>
</tr>
</tbody>
</table>
ANDERSON SECONDARY SCHOOL
Preliminary Examination 2017
Secondary Four Express and
Five (Normal) Academic

CANDIDATE NAME: 

CLASS: 

INDEX NUMBER: 

CHEMISTRY

Paper 2

5073/02

23 August 2017

1 hour 45 minutes

0800 – 0945h

No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A
Answer all questions in the spaces provided.

Section B
Answer all three questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 23.

The use of an approved scientific calculator is expected, where appropriate.

<table>
<thead>
<tr>
<th>Section A</th>
<th>Section B</th>
<th>Total</th>
</tr>
</thead>
</table>

This document consists of 23 printed pages and 1 blank page.
Section A

Answer all questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The position of six elements, represented by letters, A, B, C, D, E and F are shown in the Periodic Table below.

```

A

 B

 C

 D

 E

 F
```

Select from the given letters, A to F, the element that best fits the following characteristics.

The elements, A to F, may be used once, more than once or not at all.

(a) An element which contains the smallest number of protons in each atom. ................................................................. [1]

(b) An element which combines with element D to form a very volatile compound. ....................................................... [1]

(c) Two elements which reacts the most vigorously. ........................................................................................................... [1]

[Total: 3]
A2 The Solvay process is used for the industrial preparation of sodium carbonate, also known as soda ash. The schematic diagram below shows the four reactions (labelled as I, II, III and IV) and the different chemicals involved.

![Diagram of the Solvay process]

The process produces many products, some of which are used for further reactions. Such products are termed as intermediate products. For example, the intermediate products formed in reaction I are NaHCO₃ and NH₄Cl. Products which are not involved in further reactions are collected as products.

(a) Complete the table below by giving the chemical formula(e) of the intermediate product(s), by-product(s) or main product(s).

<table>
<thead>
<tr>
<th>reaction</th>
<th>Intermediate product</th>
<th>product</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>NaHCO₃ and NH₄Cl</td>
<td>----</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>----</td>
</tr>
<tr>
<td>III</td>
<td>two intermediate products</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Two intermediate products, a pungent gas and a colourless liquid were formed in reaction III. Name the two products.

pungent gas: ................................ colourless liquid: ................................ [1]

(c) Write an overall chemical equation for the Solvay process.

.................................................................................................................. [1]
(d) Sodium bicarbonate (NaHCO₃), produced in reaction 1, is an amphoteric compound. When dissolved in water, sodium bicarbonate ionizes to form carbonic acid and hydroxide ion.

\[ \text{NaHCO}_3 + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{H}_2\text{CO}_3 + \text{OH}^- \]

(i) What is the nature of an aqueous solution of sodium bicarbonate? Circle your choice below.

- strongly acidic
- mildly acidic
- mildly alkaline
- strongly alkaline

(ii) Explain your choice.

__________________________________________________________

__________________________________________________________

[Total: 7]

A3

Nitrogen atoms easily react with most elements to form nitrides such as boron nitride and aluminium nitride.

(a) Boron nitride exists in two possible forms, hexagonal boron nitride (h-BN) and cubic boron nitride (c-BN) as shown below.

![Hexagonal and Cubic Boron Nitride Structures](image)

Based on the structures shown, explain the difference in hardness between h-BN and c-BN.

__________________________________________________________

__________________________________________________________

[3]
(b) The melting points of aluminium nitride and another compound, \( \text{JO}_3 \), are given below. \( J \) is not the actual chemical symbol of the element.

<table>
<thead>
<tr>
<th>compound</th>
<th>melting point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>aluminium nitride (A/N)</td>
<td>2200</td>
</tr>
<tr>
<td>( \text{JO}_3 )</td>
<td>17</td>
</tr>
</tbody>
</table>

(i) Draw a ‘dot-and-cross’ diagram to show the bonding in aluminium nitride. Shows outer electrons only.

(ii) The diagram below shows the bonding found in a molecule of \( \text{JO}_3 \).

![Diagram of \( \text{JO}_3 \) bonding](image)

**key**

\( \times \) = electron of \( J \)
\( \circ \) = electron of oxygen

Explain in terms of the structures, why the melting points of aluminium nitride and \( \text{JO}_3 \) are different.

[Total: 8]
A4 In the chemical industry, Haber and Contact processes are used to manufacture ammonia and sulfuric acid respectively.

(a) In the Haber process, nitrogen reacts with hydrogen to form ammonia in a reversible reaction.

(i) State the optimum conditions of the Haber process.

The graphs below show the percentage yield of the Haber process under different conditions.

(ii) Use the graph to predict the percentage yield of ammonia formed at the optimum conditions given in (a)(i).

......................................................... [1]
(b) Contact process comprises many stages.

In Stage 2, sulfur dioxide reacts with oxygen to form sulfur trioxide in a reversible reaction.

In the converter, sulfur dioxide and oxygen are passed over several beds of loosely packed porous vanadium oxide catalyst.

The reaction between sulfur dioxide and oxygen is exothermic and is carried out at an optimum pressure of 1 atm.

A graph showing the percentage conversion of sulfur dioxide into sulfur trioxide under different temperatures is given below.

\[ \text{percentage of } SO_2 \text{ converted to } SO_3 \]

![Graph showing percentage conversion vs temperature]

(i) Write a balanced chemical equation for the conversion of sulfur dioxide into sulfur trioxide in Stage 2 of the Contact Process.

(ii) The optimum temperature for Stage 2 of the Contact process is the same as that for the Haber process. Use the graph to predict the percentage conversion of sulfur trioxide obtained at the optimum temperature.
(iii) Using the given information about Stage 2 of Contact process, suggest explanations for the following conditions.

The optimum temperature is used although it does not obtain the highest percentage conversion of sulfur trioxide.

..........................................................[1]

Vanadium oxide used is ‘loosely packed’.

..........................................................[1]

The converter is not heated to its optimum temperature at the start of the reaction.

..........................................................

[Total: 7]
In metal-plating, a layer of coherent metal coating is used as a protective layer to prevent the underlying metal from corrosion or rusting. Metal-plating can be achieved via electrolysis.

The table shows the information about three different electrolytic set-ups that were used to electroplate either silver or iron with copper.

<table>
<thead>
<tr>
<th>Electrolytic Set-up</th>
<th>Final Product at the Cathode</th>
<th>Ionic Equation at the Anode</th>
<th>Ionic Equation at the Cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set-up 1</td>
<td>Silver metal plated with copper</td>
<td>( \text{Copper} \rightarrow \text{Silver} )</td>
<td>( \text{Copper} \rightarrow \text{Silver} )</td>
</tr>
<tr>
<td>Set-up 2</td>
<td>Iron metal plated with copper</td>
<td>( \text{Copper} \rightarrow \text{Iron} )</td>
<td>( \text{Copper} \rightarrow \text{Iron} )</td>
</tr>
<tr>
<td>Set-up 3</td>
<td>Iron metal plated with copper</td>
<td>( \text{Copper} \rightarrow \text{Iron} )</td>
<td>( \text{Copper} \rightarrow \text{Iron} )</td>
</tr>
</tbody>
</table>

(a) (i) Complete the table by filling in the missing ionic equation at each anode. [3]

(ii) Complete the table by filling in the missing ionic equation at the cathode. This equation is the same for all three set-ups. [1]
(b) Explain why the protective layer of copper obtained in set-up 3 is inferior to that obtained in set-up 2.

(c) Explain why the 'copper coated' silver obtained in set-up 1 is more resistant to corrosion than the 'copper coated' iron obtained in set-up 2, when scratched or dented.

[Total: 8]
A6. The use of catalytic converters, as shown below, can decrease the emission of pollutant gases from cars.

(a) Name a suitable catalyst used in the converter. 

................................................................. [1]

(b) Carbon monoxide and nitrogen monoxide are pollutant gases produced from the car engines. These pollutant gases can react with one another in a redox reaction at the catalytic converter to form less polluting exhaust gases.

Explain, in terms of oxygen transfer, why the reaction between carbon monoxide and nitrogen monoxide at the catalytic converter is a redox reaction.

................................................................. [2]

(c) Explain why catalytic converters do not remove all the environmental problems caused by the exhaust gases.

................................................................. [2]
(d) Petrol contains mainly alkanes. One of them is alkane X.

(i) Given the information that alkane X is made up of 84.2% carbon and 15.8% hydrogen, find the empirical formula of alkane X.

Empirical formula is .............................................................. [3]

(ii) Using the molecular formula of alkane X, write a balanced chemical equation for the complete combustion of alkane X.

.................................................................................................. [1]

(iii) Calculate the volume of oxygen gas needed to burn 3 moles of alkane X completely.

.................................................................................................. [2]

[Total: 11]
A7 A student carried out a series of experiments on five metals P, Q, R, S and T. The results are shown in the table below. The letters P to T do not represent the actual symbols of the metals.

<table>
<thead>
<tr>
<th>Metal</th>
<th>reaction with steam when heated</th>
<th>reaction with dilute HCl</th>
<th>reaction with water</th>
<th>metal oxide reduced by carbon when heated</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Q</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>R</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>S</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>T</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

Note: 'yes' indicates a reaction took place; 'no' indicates no reaction took place.

(a) (i) Arrange the five metals in the descending order of reactivity. [2]

most reactive .......................................................... least reactive

(ii) In the reactivity order of the five metals as arranged in (a)(i), state the position which you would place the element carbon.

.................................................................................. [1]

(iii) Suggest a possible identity for metal R. [1]

(b) In another experiment, the student placed a piece of brass into dilute sulfuric acid.

![Diagram of dilute sulfuric acid with brass and fine pinkish-brown solid]

The following observations were recorded by the student.

- Effervescence
- Fine pinkish-brown solid formed at the bottom of the beaker.

Explain the following observations:

Formation of effervescence: .............................................................................. [1]

Formation of pinkish-brown solid: .................................................................... [1]

[Total: 6]
**Section B**

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

**B8** The transition metals are a block of elements in the centre of the Periodic Table. Transition metals usually have the following properties:

Some information about the transition metals in Period 4 are shown in the tables below.

**Table 1**

<table>
<thead>
<tr>
<th>Element</th>
<th>Sc</th>
<th>Ti</th>
<th>V</th>
<th>Cr</th>
<th>Mn</th>
<th>Fe</th>
<th>Co</th>
<th>Ni</th>
<th>Cu</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>density</td>
<td>2.99</td>
<td>4.50</td>
<td>5.96</td>
<td>7.20</td>
<td>7.20</td>
<td>7.86</td>
<td>8.90</td>
<td>8.90</td>
<td>8.92</td>
<td>7.14</td>
</tr>
<tr>
<td>(g/cm³)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>melting</td>
<td>1541</td>
<td>1600</td>
<td>1890</td>
<td>1857</td>
<td>1244</td>
<td>1535</td>
<td>1495</td>
<td>1455</td>
<td>1083</td>
<td>420</td>
</tr>
<tr>
<td>point (°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>element</th>
<th>Sc</th>
<th>Ti</th>
<th>V</th>
<th>Cr</th>
<th>Mn</th>
<th>Fe</th>
<th>Co</th>
<th>Ni</th>
<th>Cu</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>common oxidation states that occur in compounds</td>
<td>+3</td>
<td>+4</td>
<td>+5</td>
<td>+7</td>
<td>+6</td>
<td>+6</td>
<td>+5</td>
<td>+5</td>
<td>+5</td>
<td>+7</td>
</tr>
<tr>
<td></td>
<td>+4</td>
<td>+4</td>
<td>+5</td>
<td>+5</td>
<td>+6</td>
<td>+6</td>
<td>+4</td>
<td>+4</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td>+3</td>
<td>+3</td>
<td>+3</td>
<td>+3</td>
<td>+4</td>
<td>+4</td>
<td>+3</td>
<td>+3</td>
<td>+3</td>
<td>+4</td>
</tr>
<tr>
<td></td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
<td>+2</td>
</tr>
</tbody>
</table>

(a) Across Period 4 of the Periodic Table, describe the trend in the number of oxidation states formed by the transition metals in their compounds.

.................................................................................................................................................. [1]
(b) Some scientists do not consider two of the metals found in Period 4 as ‘transition metals’.

(i) Name the two metals.

................................................................................... and .................................................. [2]

(ii) Using your knowledge about transition elements and the information provided from Tables 1 and 2, explain your answers in (b)(i).

........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................ [3]

(c) Two equations showing the displacement reactions between transition metals in Period 4 are as follows.

equation 1: \( \text{Zn} + \text{Co(NO}_3\text{)}_2 \rightarrow \text{Zn(NO}_3\text{)}_2 + \text{Co} \)

equation 2: \( \text{Co} + \text{Ni(NO}_3\text{)}_2 \rightarrow \text{Co(NO}_3\text{)}_2 + \text{Ni} \)

A student wrote in his notes, ‘the greater the number of oxidation states exhibited by a metal in its compounds, the higher will be the reactivity of that metal’.

Do you agree with the student? Explain your reasoning.

........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
.......................................................................................................................................................................... [2]
(d) Table 3 shows the colours of different compounds formed by vanadium using different oxidation states.

<table>
<thead>
<tr>
<th>substance</th>
<th>colour</th>
<th>oxidation state of vanadium</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(H₂O)₆³⁺</td>
<td>green</td>
<td>+3</td>
</tr>
<tr>
<td>VO₂⁺</td>
<td>yellow</td>
<td>+5</td>
</tr>
<tr>
<td>V(H₂O)₆²⁺</td>
<td>violet</td>
<td></td>
</tr>
<tr>
<td>VO²⁺</td>
<td>blue</td>
<td></td>
</tr>
</tbody>
</table>

(i) Study the examples of oxidation states given.
Complete Table 3 by filling in the missing oxidation states. [1]

(ii) Substance X is a compound containing vanadium. When dissolved in water, substance X forms a yellow solution.
When substance Y (a colourless liquid), is added to an aqueous solution of substance X, a green solution is obtained.

Two students, John and Sally, attempted to explain the observation.
John: 'I think substance Y acts as an oxidising agent in the reaction'.
Sally: 'I think substance Y acts as a reducing agent in the reaction'.

Which student is correct? Explain your reasoning.

.................................................................................................................................
.................................................................................................................................
.................................................................................................................................
.................................................................................................................................

[Total: 11]
This is a question about the rate of reaction in producing HBr.

**Reaction of amine with bromine**

Reaction: \( \text{C}_6\text{H}_5\text{NH}_2 + 3\text{Br}_2 \rightarrow \text{C}_6\text{H}_5\text{NH}_2\text{Br}_3 + 3\text{HBr} \)

The initial rate of this reaction was determined using different concentrations of the reactants as shown in the following experiments.

<table>
<thead>
<tr>
<th>experiment</th>
<th>concentration of ( \text{C}_6\text{H}_5\text{NH}_2 ) (mol/dm(^3))</th>
<th>concentration of ( \text{Br}_2 ) (mol/dm(^3))</th>
<th>initial rate of reaction (mol/dm(^3) s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.001</td>
<td>0.001</td>
<td>0.007</td>
</tr>
<tr>
<td>2</td>
<td>0.001</td>
<td>0.002</td>
<td>0.014</td>
</tr>
<tr>
<td>3</td>
<td>0.001</td>
<td>0.003</td>
<td>0.021</td>
</tr>
<tr>
<td>4</td>
<td>0.002</td>
<td>0.003</td>
<td>0.084</td>
</tr>
<tr>
<td>5</td>
<td>0.003</td>
<td>0.003</td>
<td>0.189</td>
</tr>
</tbody>
</table>

From the data in Table 1, changes in the concentration of each reactant affect the rate of reaction differently. Knowing how the rate is affected by the concentration of each reactant will allow us to predict the rate of reaction.

Depending on how the rate is affected by concentrations of each reactant, we can classify reactions into the following two types as shown in Table 2.

<table>
<thead>
<tr>
<th>type of reaction</th>
<th>characteristic</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>First order reaction with respect to reactant A</td>
<td>The rate of reaction is proportional to the concentration of A</td>
<td>If you double the concentration of A, the rate doubles as well. If you increase the concentration of A by a factor of 4, the rate goes up 4 times as well.</td>
</tr>
<tr>
<td>Second order reaction with respect to reactant A</td>
<td>The rate of reaction is proportional to the square of the concentration of A</td>
<td>If you doubled the concentration of A, the rate would go up 4 times ( (2^2) ). If you tripled the concentration of A, the rate would increase 9 times ( (3^2) ).</td>
</tr>
</tbody>
</table>
(a) Using information from Table 1, show why the order of reaction with respect to Br₂ is First order.

............................................................................................................................................ [3]

(b) (i) Using information from Table 1, describe how the rate of reaction changes as the concentration of C₆H₅NH₂ changes.

............................................................................................................................................ [2]

(ii) Hence, determine the order of reaction with respect to C₆H₅NH₂.

............................................................................................................................................ [1]

(c) Determine the rate of reaction when concentration of C₆H₅NH₂ is 0.002 mol/dm³ and concentration of Br₂ is 0.001 mol/dm³.

............................................................................................................................................ [1]

(d) Use ideas about collisions between particles to explain the effect of concentration on the speed of reaction.

............................................................................................................................................ [2]

[Total: 9]
B10 (a) The table below shows some information about the homologous series of a class of organic compounds called aldehydes.

<table>
<thead>
<tr>
<th>name</th>
<th>chemical formula</th>
<th>structural formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethanal</td>
<td>CH₃CHO</td>
<td><img src="image" alt="Structural formula for ethanal" /></td>
</tr>
<tr>
<td>propanal</td>
<td>C₂H₅CHO</td>
<td><img src="image" alt="Structural formula for propanal" /></td>
</tr>
</tbody>
</table>

(i) Write the chemical formula of the next member of this homologous series.

.......................................................... [1]

(ii) Explain why ethanal and propanal belong to the homologous series, aldehydes.

............................................................................................................................................................................ [2]

(iii) Propanal is an isomer of another organic compound, Q.

Draw the structure of this organic compound, Q.

.......................................................... [1]
(b) Polyethylene terephthalate, a type of plastic, is used extensively in the manufacture of plastic bottles. The structure of polyethylene terephthalate is shown below.

Another plastic, polymer X, has the following structure.

Both polyethylene terephthalate and polymer X are polymers. However, they belong to different types of polymers.

(i) Explain why they are polymers.

................................................................................................................................. [1]

(ii) Show the structural formulae of the monomers used to form polyethylene terephthalate in the space below.

................................................................................................................................. [2]

(iii) Explain, with reference to the monomers and the polymerization involved, why polyethylene terephthalate and polymer X are different types of polymers.

................................................................................................................................. [3]

[Total: 10]
OR

B10 (a) Beta-carotene, a pigment found in yellow and orange fruits and vegetables, protects the body from free radicals and help to boost the body's immunity system. The diagram below shows the structure of beta-carotene.

```
CH₃ CH₃ CH₃
CH₃

Legend: [ ] represents a hydrocarbon group
```

(i) Beta-carotene is polyunsaturated. Explain the term 'polyunsaturated'.

............................................................................................................................................................................................ [1]

(ii) Describe a test to confirm the presence of unsaturation in beta-carotene.

............................................................................................................................................................................................ [1]

(iii) Beta-carotene is broken down in the human body to give vitamin A and a by-product, M. The diagram below shows the structure of vitamin A.

```
CH₃ CH₃ CH₃
CH₃

OH
```

Explain how the body breaks beta-carotene down to vitamin A.

............................................................................................................................................................................................ [2]
(b) Methanoic acid can be produced by the oxidation of methanol with oxygen in the presence of bacteria.

(i) Showing the full structural formulae of the reactants and the products, construct a balanced equation for the reaction.

(ii) Methanoic acid reacts with sodium hydroxide to form sodium methanoate and water.

Draw a 'dot-and-cross' diagram to show the bonding in sodium methanoate. Show the outer shell electrons only.

(c) Methanoic acid and vitamin A can combine to form a larger molecule and this molecule is an example of a polyester.

Do you agree with this statement? Explain your answer.
2017 Prelim Chemistry Exam

Paper 2

A1 (a) D
(b) E
(c) A and E

A2 (a)

<table>
<thead>
<tr>
<th>reaction</th>
<th>Intermediate product</th>
<th>main or by-product (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>NaHCO₃ and NH₄Cl</td>
<td>--</td>
</tr>
<tr>
<td>II</td>
<td>CaO and CO₂</td>
<td>CaCl₂</td>
</tr>
<tr>
<td>III</td>
<td>two immediate products</td>
<td>CaCl₂</td>
</tr>
<tr>
<td>IV</td>
<td>CO₂</td>
<td>Na₂CO₃</td>
</tr>
</tbody>
</table>

(b) ammonia and water

(c) \(2\text{NaCl} + \text{CaCO}_{3} \rightarrow \text{Na}_{2}\text{CO}_{3} + \text{CaCl}_2\)

(dii) circle 'mildly alkaline'
(diii) Carbonic acid, (a weak acid), partially ionises to form H⁺ ions.
The concentration of OH⁻ ions is lower than the concentration of H⁺ ions. Thus, the solution is mildly alkaline. (Accept "more OH⁻ than H⁺ in the solution"

A3 (a) Hexagonal boron nitride (HBN) is soft while cubic boron nitride (CBN) is very hard

1. The layers of atoms in HBN is held by weak van der Waals forces while the atoms in CBN are held by strong covalent bonds in tetrahedral arrangement.
2. When a force is applied, the layers of atoms in HBN can slide over another while atoms in CBN cannot slide as the structure is rigid.

(b)(i)

\[
\begin{array}{c}
\text{Al}^{3+} \\
\text{N}^{3-}
\end{array}
\]

(ii) JO₃ has simple molecular structure while AIN has giant ionic (lattice) structure.

(b) (i) Much less heat or energy is required to overcome the weak intermolecular / Van der Waals forces between the JO₃ molecules than the strong electrostatic forces of attraction between ions in AIN.

Thus, JO₃ has a low melting point while AIN has a very (high) melting point.

A4 (a) 450°C, 250 atm and iron as catalyst

(aii) 27 %

(b) \[2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3\]

(bii) 85 %

(biii) At the optimum temperature, the reaction will be faster/not be too slow and hence enable the conversion to be more economical/time or cost effective/productive.

'Loosely' packed vanadium provides a larger (total) surface area of contact with or exposed (to the reacting gases/particles) for the catalyst to increase the rate of reaction further/more effectively.

The (forward) reaction is \textit{exothermic}. (Must be stated first)
If heated, the temperature in the converter may exceed the optimum temperature (OR may become too high to favour the decomposition of sulfur trioxide) (and thus, causes the percentage conversion of sulfur trioxide to decrease).

OR Hence, the heat liberated by the reaction is sufficient to raise the temperature to the optimum temperature so heating is not required.

OR Heat liberated by the reaction to surroundings raises the temperature and not heating saves energy.

A5 (a) anode equation at set-up 1: \(2Cl^- (aq) \rightarrow Cl_2 (g) + 2e^-\)

anode equation at set-up 2: \(Cu (s) \rightarrow Cu^{2+} (aq) + 2e^-\)

anode equation at set-up 3: \(4OH^- (aq) \rightarrow O_2 (g) + 2H_2O (l) + 4e^-\)

(a) cathode equation: \(Cu^{2+} (aq) + 2e^- \rightarrow Cu (s)\)

(b) 1) The protective layer of copper in set-up 3 is thinner than in set-up 2.
   2) The \(Cu^{2+}\) ions that were reduced at the cathode in set-up 3 are not replenished by copper anode, unlike that in set-up 2.
   (Do not accept one-sided answer, Do not accept "the concentration of \(Cu^{2+}\) in the solution of set-up 3 is more concentrated")

(c) When the protective layer is scratched, water and oxygen in the air will enter.
   Copper being more reactive than silver, will lose electrons more readily and will corrode in place of silver. Thus, silver metal is still protected.
   Iron is more reactive than copper. Thus, iron will rust (even faster) when the copper layer is scratched.

A6 (a) platinum / rhodium

(b) Nitrogen monoxide loses oxygen to carbon monoxide and is reduced to nitrogen.
   Carbon monoxide gains oxygen and is oxidized to carbon dioxide.

(c) Carbon dioxide gas is a greenhouse gas, and when emitted excessively, will cause global warming.
   State any one detailed effect of global warming.

(dii)
Thus, the empirical formula is \( C_4H_9 \).

\[
\text{(dii)} \quad 2\text{C}_9\text{H}_{18} + 25 \text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O}
\]

\[
\text{(diii)} \quad \text{Number of mole of oxygen gas needed} = \frac{3}{2} \times 25 = 37.5
\]

\( \text{ECF from (dii) only if the formula of } X \text{ is that of an alkane} \)

\[
\text{Volume of oxygen gas needed} = 37.5 \times 24 \text{ dm}^3 = 900 \text{ dm}^3 \text{ or } 900,000 \text{ cm}^3
\]

A7 (a) \( Q, S, R, P, T \)

(a) between metals \( S \) and \( R \) (accept below \( S \) and above \( R \))

(b) \( S \) and \( R \) form \( 1 \) \( \text{mol} \) hydrogen gas.

Pinkish-brown solid: The \( \text{copper} \) (in brass) is unreactive to the \( \text{dilute sulfuric acid} \) and is left behind in the reaction.

B8 (a) Across period \( 4 \), the number of oxidation states increases (from Sc) to Mn, before decreasing (to Zn).

(b) Scandium and zinc

(b) 1) Both Sc and Zn have only one or a fixed oxidation state instead of the variable oxidation states shown by transition metals.

2) Sc has a lower density compared to the rest of the transition-metals of period \( 4 \) which has densities of at least \( 4.50 \text{ g/cm}^3 \).

3) The melting point of Zn, \( 420 \degree \text{C} \) is lower than the high melting points of transition metals which are above \( 1000/ \text{ at least } 1083 \degree \text{C} \). (Note: need to compare with transition metals to score)

(c) No. / Disagree.
For equation 1, Zn is more reactive than Co as Zn displaces Co from its salt solution.
Zn exhibits only one oxidation state while Co can have four/many oxidation states.

(dii) 
| V(H₂O)₅⁺⁺ | +2 |
| VO²⁺ | +4 |

(dii) Sally is correct.
Substance Y acts as a reducing agent as it decreases the oxidation state of vanadium.
The oxidation states of vanadium decreases from +5 to +3 in the reaction.

B9 (a) The rate of the reaction doubles when the concentration of Br₂ doubles. From experiment 1 and 2, the rate of reaction increases from 0.007 mol/dm³ s to 0.014 mol/dm³ s when the concentration increases from 0.001 mol/dm³ to 0.002 mol/dm³. (OR expt 1 and 3, rate triples when conc triples with evidence)

(b) The rate of the reaction increases by 4 times when the concentration of C₆H₅NH₂ doubles.
From experiment 3 and 4, the rate of reaction increases from 0.021 mol/dm³ s to 0.084 mol/dm³ s when the concentration increases from 0.001 mol/dm³ to 0.002 mol/dm³. (OR expt 3 and 5, when concentration triples, rate is 9X faster)

(bii) Second order reaction

(c) 0.028 mol/dm³ s

(d) 1. Increased concentration increases the number of particles per unit volume OR the distances between reacting particles decreases.
   This increases the frequency of collisions between particles.
2. As a result, the number of effective collisions per unit time increases and the speed of reaction as well.

Either
B10 (ai) \( \text{C}_2\text{H}_7\text{CHO} \)

(ii) **same** general formula as aldehydes, \( \text{C}_n\text{H}_{2n-1}\text{CHO} \)

**same** functional group as aldehydes, \( \cdot\text{CHO} \)

(iii) Draw structure as shown below (any one)

\[
\begin{align*}
\text{H} & \quad \text{O} \\
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{H}
\end{align*}
\]

(bi) **long-chain molecules** made up of many repeating units (or many small / monomer molecules joined together).

(ii) Draw structure as shown below

\[
\begin{align*}
\text{H} & \quad \text{O} \\
\text{H} & \quad \text{C} \quad \text{O} \\
\text{H} & \quad \text{O} \\
\text{H} & \quad \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{H}
\end{align*}
\]

(biii) Polymer X is an **addition polymer** while polyethylene terephthalene is a **condensation polymer**.

Monomers of Polymer X contain \( \text{C} = \text{C} \) bonds/unsaturated while monomers of polyethylene terephthalene have different functional groups.

Monomers of Polymer X add onto one another (at the \( \text{C} = \text{C} \) bonds) without any loss of material/atoms (reject: molecules) while simple molecules of water are removed/formed as by-products when monomers react with one another (at the functional groups).
B10 (ai) **multiple/many carbon-carbon double/C=C bonds**

(aii) Add **aqueous** bromine to beta-carotene. The **reddish-brown** aqueous bromine will turn **colourless/decolourised** immediately/rapidly if beta-carotene is unsaturated.

(aiii) Breakdown involves the **reaction with water**.
which results in the **addition of hydrogen atom and hydroxyl group** at the **carbon-carbon double / C=C bond** and the **breakage** of (carbon-carbon single) bond with the hydrocarbon group.

(bii) **Draw structure as shown below.**

![Structure](image)

(bii) **Draw structure as shown below.**

![Structure](image)

(c) Correct that a larger molecule is formed as they have the **carboxyl** and **hydroxyl group** to form an **ester/ester linkage** (with the removal of water molecules).

Incorrect that a polyester is formed as the product contains only **one ester linkage/group per molecule** (reject: does not contain many ester groups or linkages).
PRELIMINARY EXAMINATION 2017
SECONDARY 4

CHEMISTRY
Paper 1 Multiple Choice

5073/01
14 September 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name, class and register number clearly in the spaces provided at the top of this page.

There are forty questions on this paper. Answer all questions. For each question there are four possible answers A, B, C and D. Choose the one you consider correct and record your choice in soft pencil on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 18. The use of an approved scientific calculator is expected, where appropriate.

This document consists of 19 printed pages.

[Turn over
1 The diagram shows the apparatus used to separate hexane (boiling point, 70 °C) and heptane (boiling point, 98 °C).

Which graph would be obtained if the temperature at point T was plotted against the total volume of distillate collected?

A

<table>
<thead>
<tr>
<th>temperature/°C</th>
<th>total volume of distillate</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>100</td>
<td>70</td>
</tr>
</tbody>
</table>

B

<table>
<thead>
<tr>
<th>temperature/°C</th>
<th>total volume of distillate</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>100</td>
<td>70</td>
</tr>
</tbody>
</table>

C

<table>
<thead>
<tr>
<th>temperature/°C</th>
<th>total volume of distillate</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>100</td>
<td>70</td>
</tr>
</tbody>
</table>

D

<table>
<thead>
<tr>
<th>temperature/°C</th>
<th>total volume of distillate</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>100</td>
<td>70</td>
</tr>
</tbody>
</table>
2 Chromatography is used to separate different dyes present in mixture X. The chromatogram of mixture X and individual dyes labelled 1 to 5 is shown below.

Which dyes are found in X and which dye in X has the smallest $R_f$ value?

<table>
<thead>
<tr>
<th>dyes present in X</th>
<th>dye with the smallest $R_f$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1, 2, 5</td>
<td>4</td>
</tr>
<tr>
<td>B 1, 2, 3</td>
<td>2</td>
</tr>
<tr>
<td>C 1, 2, 5</td>
<td>2</td>
</tr>
<tr>
<td>D 1, 3, 5</td>
<td>1</td>
</tr>
</tbody>
</table>

3 An experiment was set up as shown in the diagram below.

It was observed that after leaving to stand for several days, the liquid in the jar had the same colour throughout. This is due to the movement of

A the water molecules only.
B the copper and sulfate ions only.
C the copper(II) sulfate molecules only.
D the copper ions, sulfate ions and water molecules.
4 The figure below shows the melting points of mixtures containing different percentages of metals X and Y.

Which statement is true about the melting point of any mixture of metals X and Y?

A. It must be above the melting point of pure X.
B. It must be below the melting point of pure Y.
C. It must be below the melting point of pure X.
D. It must be between the melting points of pure X and pure Y.

5 In which of the following molecules are all the outer electrons of the atoms involved in bonding?

A. CH₄
B. NH₃
C. CO₂
D. HCl

6 The formula of the sulfate of element X is XSO₄. Which of the following is the correct formula for a compound formed between X and an oxalate ion, C₂O₄²⁻?

A. X(C₂O₄)₂
B. X₃C₂O₄
C. X₂(C₂O₄)₃
D. X(C₂O₄)₄
7. The electronic configuration of element M is 2.8.6. M is known to react with element J which has a shiny appearance and floats on water. Which of the following best fits the compound formed between M and J?

<table>
<thead>
<tr>
<th>type of bonding</th>
<th>formula of compound formed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A covalent</td>
<td>JM₂</td>
</tr>
<tr>
<td>B covalent</td>
<td>JM₃</td>
</tr>
<tr>
<td>C ionic</td>
<td>JM₂</td>
</tr>
<tr>
<td>D ionic</td>
<td>J₃M</td>
</tr>
</tbody>
</table>

8. The empirical formula of a compound is C₂H₄O. Which of the following are possible molecular formulae for this compound?

I. CH₃CH₂OH
II. CH₃CH₂COOCH₃
III. HOCH₂CHCH₂CH₂OH

A. I only
B. I and III
C. II and III
D. I, II and III

9. Which statement is true?

A. Ar has more electrons than Cr
B. Cr has more electrons than K⁺
C. Fe²⁺ has more electrons than Fe²⁺
D. K has more electrons than K⁺

10. When a 200 g sample of tripure potassium hydrogen carbonate, KHCO₃ (M = 100), was heated under a strong flame, 6.00 dm³ of carbon dioxide gas (measured at room temperature and pressure), was collected. Determine the percentage purity of the potassium hydrogen carbonate sample.

\[2\text{KHCO}_3 \rightarrow \text{K}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2\]

A. 25%
B. 50%
C. 75%
D. 100%
11 The table below shows the results of different experiments conducted on two acids, A1 and A2, of equal concentration.

<table>
<thead>
<tr>
<th>acids</th>
<th>conductivity of acid solution / arbitrary units</th>
<th>temperature change when excess acid was reacted with 100 cm³ of 1.0 mol/dm³ sodium hydroxide / °C</th>
<th>observation during reaction of acid with 3.0 cm magnesium strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>1000</td>
<td>+6.9</td>
<td>rapid effervescence of a colourless gas</td>
</tr>
<tr>
<td>A2</td>
<td>7.0</td>
<td>+6.7</td>
<td>slow bubbling of a colourless gas</td>
</tr>
</tbody>
</table>

Which of the following deductions can be made about acids A1 and A2?

A  A1 is a weak acid while A2 is a strong acid.
B  A1 is a strong acid while A2 is a weak acid.
C  Both A1 and A2 are weak acids, except that A1 is a dibasic acid.
D  Both A1 and A2 are strong acids, except that A2 is a dibasic acid.

12 In an experiment, 5 cm³ of 2.0 mol/dm³ aqueous potassium hydroxide was added to 10 cm³ of 0.5 mol/dm³ hydrochloric acid as shown in the diagram below. The acid solution was pre-treated with some Universal Indicator.

Which change, if any, would be observed in the colour of the Universal indicator?

A  Remains red.
B  Changes from red to blue.
C  Changes from green to red.
D  Changes from blue to red.

13 Which of the following burns in air to form an oxide which, when dissolved in water, gives a solution with a pH greater than 7?

A  carbon
B  copper
C  hydrogen
D  sodium
The effect of certain conditions on the speed of reaction between excess solid zinc carbonate and hydrochloric acid was investigated in experiments 1 and 2.

\[ \text{ZnCO}_3(s) + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2(aq) + \text{H}_2\text{O(l)} + \text{CO}_2(g) \]

The table below shows the conditions used for the two experiments.

<table>
<thead>
<tr>
<th>experiment</th>
<th>temperature / °C</th>
<th>concentration of acid used / mol/dm(^3)</th>
<th>volume of acid used / cm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>4.00</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>2.50</td>
<td>400</td>
</tr>
</tbody>
</table>

The volume of gas given off was plotted against time. Which graph correctly shows the results in experiments 1 and 2?
15 The scheme shows some reactions of a compound Y.

![Chemical diagram]

What could the compound Y be?

A aluminium sulfate
B calcium carbonate
C copper(II) carbonate
D zinc carbonate

16 A student attempts to prepare magnesium chloride using magnesium carbonate and hydrochloric acid. Which apparatus is/are necessary for this salt preparation method to help the student finally obtain a pure, dry sample of magnesium chloride crystals?

![Apparatus images]

A 1 and 3
B 1 and 2
C 2 and 3
D 2 only
17 If an element with atomic symbol Q has an oxidation number of -1 in all its compounds, which of the following cannot be a compound of Q?

   I  MgO₂  
   II  KQ  
   III  K₂QO₃  

A  I and II only  
B  I and III only  
C  III only  
D  I, II and III  

18 Propanoic acid reacts with magnesium hydroxide to form magnesium propanoate salt and water as products. The incomplete chemical equation is given below:

   2CH₃CH₂COOH + Mg(OH)₂ → ................. + 2H₂O  

Which of the following gives the correct chemical formula of magnesium propanoate?

A  MgCOOH  
B  CH₃CH₂COOMg  
C  CH₃CH₂Mg₂  
D  (CH₃CH₂COO)₂Mg  

19 An experiment is set up as shown in the diagram:

![Diagram showing a setup with carbon electrode X and Y, concentrated aqueous nickel(II) chloride, and a reaction between chloride ions and chlorine gas.]

What occurs at the carbon electrode X?

A  Chloride ions are oxidized and chlorine gas is formed.  
B  Chloride ions are reduced and chlorine gas is formed.  
C  Hydroxide ions are reduced and oxygen gas is formed.  
D  Hydrogen ions are oxidized and hydrogen gas is formed.
20 The diagram shows the structure of a compound of silicon and carbon, (SiC)_n.

![Diagram of SiC_n structure]

Which statement would be true for (SiC)_n?

A. It acts as a lubricant.
B. It conducts electricity.
C. It is insoluble in water.
D. It has a low melting point.

21 A new Chemistry student attempted to make a solution for his experiment by dissolving some potassium carbonate into a beaker of tap water. However, he noticed that the beaker of water began to turn cloudy with a suspension of white solids instead.

Which of the following could be a possible reason for this observation?

A. The tap water contained sulfate ions.
B. The tap water was acidic.
C. The tap water contained nitrate ions.
D. The tap water contained magnesium ions.
The diagram below shows a simple chemical cell.

![Diagram of a simple chemical cell]

The voltages produced by different combinations of metal electrodes are shown in the table below.

<table>
<thead>
<tr>
<th>Positive Electrode</th>
<th>Negative Electrode</th>
<th>Voltage / V</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper</td>
<td>zinc</td>
<td>1.10</td>
</tr>
<tr>
<td>copper</td>
<td>X</td>
<td>2.70</td>
</tr>
<tr>
<td>copper</td>
<td>Y</td>
<td>0.78</td>
</tr>
<tr>
<td>Z</td>
<td>copper</td>
<td>0.46</td>
</tr>
</tbody>
</table>

What is the order of the reactivity of the metals?

<table>
<thead>
<tr>
<th></th>
<th>Most Reactive</th>
<th>Least Reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>zinc</td>
<td>copper</td>
</tr>
<tr>
<td>B</td>
<td>X</td>
<td>zinc</td>
</tr>
<tr>
<td>C</td>
<td>X</td>
<td>Y</td>
</tr>
<tr>
<td>D</td>
<td>Y</td>
<td>copper</td>
</tr>
</tbody>
</table>

Need a home tutor? Visit smiletutor.sg
23. What is the volume of hydrogen produced at room temperature and pressure when 4.6 g of sodium is reacted with 9.0 g of water? (1 mol of gas occupies 24 dm$^3$ at room temperature and pressure)

$$2\text{Na(s)} + 2\text{H}_2\text{O(l)} \rightarrow 2\text{NaOH(aq)} + \text{H}_2(g)$$

A. 1.2 dm$^3$
B. 2.4 dm$^3$
C. 4.8 dm$^3$
D. 12 dm$^3$

24. The following shows an outline of the Periodic Table.

Which of the elements U, V, W, X, and Y would react with one another in the ratio of 1:1?

A. U and X
B. U and Y
C. V and Y
D. W and X

25. One way in which the corrosion of underground steel tanks can be prevented by sacrificial protection is shown in the diagram.

Which element is most suitable for use as the sacrificial substance?

A. carbon
B. copper
C. iron
D. magnesium
26. The energy diagram below represents the energy changes in a chemical reaction.

What is the enthalpy change of this reaction?

A. +50 kJ
B. -50 kJ
C. +100 kJ
D. -100 kJ

27. In the extraction of iron in the blast furnace, which of the following results in the formation of a reducing agent?

A. \( C + O_2 \rightarrow CO_2 \)
B. \( C + CO_2 \rightarrow 2CO \)
C. \( CaCO_3 \rightarrow CaO + CO_2 \)
D. \( Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2 \)
28. Four iron paper-clips are exposed to four different conditions in an experiment to study rusting.

![Diagram showing four test tubes: 1. dry air 15°C, 2. tap water 15°C, 3. boiled tap water 15°C, 4. tap water 25°C.]

Which two paper clips will rust after 1 week?

A 1 and 3  
B 1 and 4  
C 2 and 3  
D 2 and 4

29. The diagram shows an experiment to produce and collect hydrogen gas.

![Diagram showing a setup involving water, inert absorbent, heat, and a collecting vessel for hydrogen gas.]

What is R?

A lead  
B iron  
C lead(II) oxide  
D copper(II) oxide
A fixed mass of the carbonates of four metals, J, L, M and R, were placed in a boiling tube and subjected to high temperatures from a strong Bunsen flame as shown in the diagram below.

The time taken for a white precipitate to be observed in the limewater was recorded in the table shown below.

<table>
<thead>
<tr>
<th>carbonate of metal</th>
<th>time taken to observe white precipitate / s</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>20</td>
</tr>
<tr>
<td>L</td>
<td>252</td>
</tr>
<tr>
<td>M</td>
<td>not observed</td>
</tr>
<tr>
<td>R</td>
<td>110</td>
</tr>
</tbody>
</table>

Which of the following statements is true?

A Metal J is above metal R in the reactivity series.
B Metal L can displace ions of metal M from its salt solution.
C Metal M is an unreactive metal.
D Metal M is more reactive than metals J, L and R.

Which statement about the properties of ammonia is correct?

A It has strong forces of attraction between nitride and hydrogen ions.
B It reacts with alkalis to form salts.
C It is a product of the reaction between ammonium chloride and sodium hydroxide.
D It turns damp blue litmus paper red, and then bleaches the litmus paper.
32 The table below shows the composition of exhaust gases from a car engine.

<table>
<thead>
<tr>
<th>gas</th>
<th>% of gas in the exhaust fumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon dioxide</td>
<td>14</td>
</tr>
<tr>
<td>water vapour</td>
<td>13</td>
</tr>
<tr>
<td>carbon monoxide</td>
<td>1</td>
</tr>
<tr>
<td>hydrocarbons (uncombusted)</td>
<td>0.3</td>
</tr>
<tr>
<td>oxides of nitrogen</td>
<td>0.2</td>
</tr>
<tr>
<td>sulfur dioxide</td>
<td>&lt; 0.003</td>
</tr>
</tbody>
</table>

What is gas Y?
A ammonia
B argon
C chlorine
D nitrogen

33 Excess chlorine gas can be tested with damp blue litmus paper and by bubbling the gas through potassium iodide solution.

What colour would the damp blue litmus paper and potassium iodide solution be at the end of the test with excess chlorine?

<table>
<thead>
<tr>
<th>litmus paper</th>
<th>potassium iodide solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A bleached / white</td>
<td>brown</td>
</tr>
<tr>
<td>B bleached / white</td>
<td>colourless</td>
</tr>
<tr>
<td>C red</td>
<td>brown</td>
</tr>
<tr>
<td>D red</td>
<td>colourless</td>
</tr>
</tbody>
</table>

34 Consider the two organic compounds shown in the diagram below.

Which of the following statements concerning these two compounds are correct?
A They have the same structural formula.
B They turn damp blue litmus paper red.
C They are both ionic compounds.
D They have different boiling points.
35. When 1 mole of hydrocarbon Q reacts with exactly 5 moles of oxygen gas, it forms carbon dioxide and water as the only products. What is hydrocarbon Q?

A. methane, CH₄  
B. ethane, C₂H₆  
C. propane, C₃H₈  
D. butane, C₄H₁₀

36. Which row about the oxides SO₂, SiO₂, CO₂ and NO₂ is correct?

<table>
<thead>
<tr>
<th></th>
<th>CO₂</th>
<th>NO₂</th>
<th>SO₂</th>
<th>SiO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>B</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>C</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>D</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

37. When cracked, one mole of compound X produces one mole of propene and one mole of hydrogen gas as shown in the chemical equation below:

\[ X \rightarrow C_3H_6 + H_2 \]

What type of compound is X?

A. an alcohol  
B. an alkane  
C. an alkene  
D. a carboxylic acid

38. Wine is an alcoholic drink. If wine is left exposed to air for too long, reactions can occur, and the wine turns acidic.

This is because the ethanol in wine is ... 1 ... to the acid ... 2 ...

Which word and formula correctly fills blanks 1 and 2?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>oxidised</td>
<td>CH₂COOH</td>
</tr>
<tr>
<td>B</td>
<td>oxidised</td>
<td>CH₃CH₂COOH</td>
</tr>
<tr>
<td>C</td>
<td>reduced</td>
<td>CH₃COOH</td>
</tr>
<tr>
<td>D</td>
<td>reduced</td>
<td>CH₃CH₂COOH</td>
</tr>
</tbody>
</table>
39. Which of the following has been prepared by reaction between a carboxylic acid and an alcohol with the elimination of a water molecule?

A
\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{C} \\
\text{O} \\
\text{C} \\
\text{H} \\
\text{H}
\end{array}
\]

B
\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{O} \\
\text{H} \\
\text{H}
\end{array}
\]

C
\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{H} \\
\text{H}
\end{array}
\]

D
\[
\begin{array}{c}
\text{CH}_3 \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{H}
\end{array}
\]

40. Polymer W is shown in the diagram below.

The following four terms can be used to describe polymers:

I. addition polymer
II. condensation polymer
III. polyamide
IV. polyester

Which two of the above terms are applicable to Polymer W?

A. I and III
B. I and IV
C. II and III
D. II and IV
### Marking Scheme

#### Paper 1

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>2</td>
<td>C</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>7</td>
<td>D</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>B</td>
<td>12</td>
<td>B</td>
<td>13</td>
</tr>
<tr>
<td>16</td>
<td>C</td>
<td>17</td>
<td>C</td>
<td>18</td>
</tr>
<tr>
<td>21</td>
<td>D</td>
<td>22</td>
<td>C</td>
<td>23</td>
</tr>
<tr>
<td>25</td>
<td>B</td>
<td>27</td>
<td>B</td>
<td>29</td>
</tr>
<tr>
<td>31</td>
<td>C</td>
<td>32</td>
<td>D</td>
<td>33</td>
</tr>
<tr>
<td>36</td>
<td>B</td>
<td>37</td>
<td>B</td>
<td>38</td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>B</td>
<td>9</td>
<td>D</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>B</td>
<td>15</td>
<td>B</td>
<td>19</td>
</tr>
<tr>
<td>20</td>
<td>C</td>
<td>24</td>
<td>B</td>
<td>25</td>
</tr>
<tr>
<td>29</td>
<td>B</td>
<td>30</td>
<td>D</td>
<td>34</td>
</tr>
<tr>
<td>35</td>
<td>C</td>
<td>38</td>
<td>A</td>
<td>40</td>
</tr>
</tbody>
</table>
PRELIMINARY EXAMINATION 2017
SECONDARY 4

CHEMISTRY
Paper 2

11 September 2017
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name, class and register number clearly in the spaces provided at the top of this page. Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer all questions in the spaces provided.

Section B
Answer all three questions, the last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic table is printed on page 21.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner’s Use

<table>
<thead>
<tr>
<th>Paper 1</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper 2: Section A</td>
<td>50</td>
</tr>
<tr>
<td>Paper 2: Section B</td>
<td>30</td>
</tr>
<tr>
<td>Option E / O</td>
<td></td>
</tr>
<tr>
<td>Paper 2 (A+B)</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

This document consists of 20 printed pages and 2 blank pages.

[Turn over

Need a home tutor? Visit smiletutor.sg
Section A

Answer all the questions in this section in the spaces provided.

The total mark for this section is 50.

A1  Use the following clues to complete the crossword puzzle.

(e) 1 across A separation process which depends on the size of solid particles to work.
(b) 2 down The most reactive halogen in the Periodic Table.
(c) 3 down The catalyst used in the industrial production of ammonia.
(d) 4 down An ion that would undergo reduction in electrolysis.
(e) 5 down The total number of protons and neutrons in the nucleus of an atom is known as the number.

[Total: 5]
A2 The table below lists some substances and their melting and boiling points.

<table>
<thead>
<tr>
<th>substance</th>
<th>melting point / °C</th>
<th>boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>iodine</td>
<td>114</td>
<td>164</td>
</tr>
<tr>
<td>lead(II) bromide</td>
<td>370</td>
<td>514</td>
</tr>
<tr>
<td>methane</td>
<td>-182</td>
<td>-161</td>
</tr>
<tr>
<td>bromine</td>
<td>-7</td>
<td>59</td>
</tr>
<tr>
<td>silicon dioxide</td>
<td>1610</td>
<td>2230</td>
</tr>
<tr>
<td>lithium</td>
<td>180</td>
<td>1360</td>
</tr>
</tbody>
</table>

Use the names of the substances in the table to answer the following questions.

(a) (i) Which substance sublimes readily when heated?

(ii) Which substance is a hydrocarbon?

(iii) Which substance(s) will conduct electricity when molten?

(iv) Which substance(s) react(s) violently with cold water?

(v) Which(s) substance(s) exist(s) as diatomic molecules?

(b) In terms of structure and bonding, explain the difference in the boiling points between bromine and silicon dioxide.

(c) (i) Lead(II) bromide is insoluble in water. State two reagents that can be used to prepare lead(II) bromide.

reagent A: ........................................... [1]

reagent B: ........................................... [1]
(ii) Using reagents A and B, describe how a pure, dry sample of lead(II) bromide may be obtained.

..............................................................................................................................................[2]

[Total: 12]

A3 When magnesium is burned in air on earth, a mixture of ionic solids are formed. Two main products can be obtained by the reaction between magnesium and the two abundant gases present in air.

One of the products formed is magnesium nitride. The chemical reaction for the formation of magnesium nitride is shown below:

\[ 3\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2 \]

(a) (i) Write a chemical equation for the formation of the second main product formed when magnesium is burned in air.

..............................................................................................................................................[1]

(ii) Draw a dot-and-cross diagram of the magnesium ion. Show only the outer electrons.

..............................................................................................................................................[1]

(b) Magnesium nitride, when added to water, reacts to form white insoluble magnesium hydroxide and a pungent, alkaline colourless gas. Describe a physical test that can be used to confirm the identity of this gas.

..............................................................................................................................................[2]

[Total: 4]
A4

Nickel is an important metal in the material science industry. The extraction and purification of nickel is known as the Mond Process, which involves converting its ore, nickel oxide, into pure nickel. The Mond Process consists of 3 steps as shown in the table below:

<table>
<thead>
<tr>
<th>step</th>
<th>process</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>extraction</td>
<td>Reaction of nickel(II) oxide with hydrogen gas at 200 °C to give raw nickel solid and steam.</td>
</tr>
<tr>
<td>2</td>
<td>purification</td>
<td>Reaction of the raw nickel with carbon monoxide at 600 °C to form an intermediate product, nickel tetracarbonyl, Ni(CO)_4. Ni (s) + 4CO (g) → Ni(CO)_4 (g). Impurities are then separated from the nickel tetracarbonyl.</td>
</tr>
<tr>
<td>3</td>
<td>Decomposition</td>
<td>Remaining nickel tetracarbonyl is heated to 250 °C, which decomposes the nickel tetracarbonyl to obtain pure nickel solid.</td>
</tr>
</tbody>
</table>

(a) (i) Suggest the role of hydrogen gas in step 1 of the process.

(ii) Construct a chemical equation, with state symbols, for the reaction in step 1.

(b) In a particular batch of nickel extract, 120 000 dm³ of carbon monoxide was added in step 2 to an excess of raw nickel. The quality officer realized that the volume of nickel tetracarbonyl vapour obtained was 22 500 dm³.

Calculate the percentage yield of nickel tetracarbonyl in this process. (You may make the assumption that at 60 °C and 1 atm pressure, 1 mole of gas occupies a volume of 24 dm³.)

(c) Nickel is a transition metal. State one possible property of nickel compounds.

[Total: 6]
A5 Disproportionation is a reaction by which a substance undergoes oxidation and reduction simultaneously to give different products. The chemical equation below shows the disproportionation of hydrogen peroxide into water and oxygen gas. This is a highly exothermic reaction.

\[ 2\text{H}_2\text{O}_2 (aq) \rightarrow 2\text{H}_2\text{O} (l) + \text{O}_2 (g) \]

\[ \Delta H = -196 \text{ kJ/mol} \]

The rate of this disproportionation reaction can be increased by the addition of a manganese(IV) oxide as a catalyst. **Graph 5.1** below shows two graphs (1 and 2) for the disproportionation of hydrogen peroxide. One had a catalyst added to the set-up, while the other one did not have any catalyst added. The volume of hydrogen peroxide used was the same for both experiments.

![Graph 5.1](image)

(a) (i) Identify the graph that used a catalyst in the experiment.

..................................................................................................................[1]

(ii) **Using Graph 5.1, explain your answer in (a)(i).**

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................[2]

(iii) Using ideas about collision of particles, explain how the catalyst works in this reaction.

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................

..................................................................................................................[3]
(b) (i) Complete the following table with the oxidation states of the elements found within the reactant and products of this reaction.

<table>
<thead>
<tr>
<th></th>
<th>oxidation state of H</th>
<th>oxidation state of O</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen peroxide</td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>oxygen gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Hence, explain why the above reaction is a disproportionation reaction.

(c) Suggest why the disproportionation of hydrogen peroxide is too dangerous to be used as an industrial method to produce oxygen gas.

(d) Sketch an energy profile diagram in the axes below for the disproportionation of hydrogen peroxide, labelling clearly the reaction enthalpy change ($\Delta H$) and the activation energy ($E_a$).
A6 Acrylamide is an important chemical used in the making of paper, dyes and plastics. The chemical structure of acrylamide is seen in Fig. 6.1 below.

![Chemical structure of acrylamide](image)

**Fig. 6.1**

(a) When acrylamide reacts with water under the right conditions, it undergoes a reaction called hydrolysis. One of the two products of hydrolysis is acrylic acid. The chemical structure of acrylic acid is shown below in Fig. 6.2.

![Chemical structure of acrylic acid](image)

**Fig. 6.2**

(i) Suggest the identity of the other product in the hydrolysis of acrylamide.

...................................................................................................................[1]

(ii) Describe a physical test to distinguish between acrylamide and acrylic acid.

..................................................................................................................

..................................................................................................................

...................................................................................................................[2]

(iii) State the observations when acrylic acid reacts with aqueous bromine.

...................................................................................................................

...................................................................................................................[1]

(iv) Draw the structural formula of the product formed for the reaction in a(iii).
A synthetic pathway is a flowchart diagram used by organic chemists to plan their laboratory synthesis (formation) of a desired organic compound from a given starting material. A simple synthetic pathway involving 2 reaction steps can be represented as shown in Fig. 6.3 below.

**Fig. 6.3**

Malonic acid is an important organic acid used as a preservative additive for foods.

Acrylic acid can be used as a starting material in the synthesis of malonic acid. The reactant required for step 1 has been provided. Complete the 2-step synthetic pathway below for the synthesis of malonic acid as the target product C.

```
```

Starting material A: Acrylic acid

Steam / water Condition(s):

Intermediate B

Reagent(s) Condition(s):

Target product C: Malonic Acid

[3]

[Total: 8]
Section B

Answer all three questions in this section.

The last question is in the form of an either / or and only one of the alternatives should be attempted.

B7 Reversibility of reactions

Reactions can be classified as reversible or irreversible. The reversibility of a reaction can generally be represented by the use of a concentration-time graph, whereby the concentrations of the reactants and products in a reaction are tracked over time.

In an irreversible reaction, the reactants react to form products as such:

\[
\text{Reactant A + Reactant B} \rightarrow \text{Product C + Product D}
\]

Graph 1: Concentration-time graph of an irreversible reaction

In a reversible reaction, the reactants react to form products as such:

\[
\text{Reactant A + Reactant B} \rightleftharpoons \text{Product C + Product D}
\]

Graph 2: Concentration-time graph of a reversible reaction

Examples of irreversible reactions include that of reactions between reactive metals and mineral acids, neutralisation reaction between strong acids and strong alkalis or decomposition of metal carbonates into metal oxides and carbon dioxide.

Equally frequent are reversible reactions, such as that between nitrogen and hydrogen to form ammonia as well as esterification between alcohols and carboxylic acids.
Reversible reactions and the Le Chatelier's Principle

Reversible reactions that take place in a closed system (i.e. one that happens in an enclosed vessel and there is no exchange of matter between the reaction mixture and the surrounding environment) can eventually reach a state of dynamic equilibrium. This means that the rate of the forward reaction (reactants → products) is the same as the rate of the backward reaction (products → reactants).

The Le Chatelier's Principle is a well-known scientific principle that applies to reversible reactions occurring in closed systems, such as the Haber Process. It states that when the system in dynamic equilibrium is subjected to a change in conditions (such as temperature, pressure and concentration), the system will respond to counteract the effect of the change so as to re-establish the state of equilibrium.

For example, in this reversible reaction: Reactant A + Reactant B ⇌ Product C + Product D

Le Chatelier's Principle will apply at dynamic equilibrium. If there is an increase in the concentration of reactant A:
- position of the equilibrium shifts to the right
- the rate of the forward reaction increases (so as to remove the additional reactant A in the system)
- equilibrium concentration of the products C and D increases
- concentration of reactants A and B decreases

The Haber Process

Nitrogen and hydrogen are used in the manufacturing of industrial ammonia, where nitrogen and hydrogen react in a reversible reaction to form ammonia. The changes in the concentrations of nitrogen, hydrogen and ammonia with time in a closed system can be represented by a graph as shown. The forward reaction (formation of ammonia) has an enthalpy change as shown.

\[ N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g) \quad \Delta H = -92 \text{ kJ/mol} \]

The Haber Process is a classic example of how the Le Chatelier's Principle is put to good application. The conditions selected for the production of ammonia in the Haber Process were carefully studied with reference to the Le Chatelier's Principle.
(a) Using Graphs 1 and 2, state and explain one difference between reversible and non-reversible reactions.

.................................................................................................................. [2]

(b) Use information given about the Haber Process and Le Chatelier's Principle to answer the following questions.

(i) State and explain if the reaction to form ammonia absorbs or releases heat.

.................................................................................................................. [1]

(ii) State and explain the effect on the position of the equilibrium of the reaction between nitrogen and hydrogen if the reaction was carried out at a lower temperature.

.................................................................................................................. [2]

(iii) Hence, state the effect on the equilibrium concentration of ammonia if the reaction was carried out at a lower temperature.

.................................................................................................................. [1]

(iv) Using your answers from b(i) to b(iii), sketch, on the diagram given, another line showing only the concentration of ammonia to illustrate what happens when the reaction is carried out at a lower temperature. Label your graph P.
(c) According to the Le Chatelier's Principle, using a high pressure in the Haber Process will favour the forward reaction and result in a higher equilibrium ammonia concentration.

(i) Explain why, despite knowing this, manufacturers of ammonia still do not choose to use very high pressures.

(ii) When the pressure gets too high, gaseous ammonia begins to behave like a liquid. Describe the changes in the arrangement and movement of the ammonia molecules when this happens.

[Total: 10]
Many biological molecules in the natural world (cells of living things) are polymers. Proteins, which are important compounds in our body for growth, repair and many other functions for example, are polymers made of many amino acids bonded together.

Amino acids are molecules with two key functional groups. Each of them consists of an amine group on one side, and a carboxyl group on the other, which allows them to polymerise into long chains known as "polypeptides" held essentially by amide linkages. There are currently twenty known naturally occurring amino acids, three of which are shown below.

![Amino acid structures](image)

Cysteine (Cys)

Alanine ( Ala)

Threonine (Thr)

(a) A section of a protein has the sequence –Cys–Ala–Thr–. Draw this section of the protein using the structures of the three amino acids provided.
(ii) State the type polymerisation reaction that the amino acids undergo to form the protein.

.................................................................................................................[1]

(iii) Explain your answer in a(ii)

.................................................................................................................[2]

(iv) Suggest the name of a synthetic polymer that also has amide linkages.

.................................................................................................................[1]

(b) Alanine (condensed structural formula: $\text{H}_2\text{NCHCH}_2\text{COOH}$) reacts like a usual carboxylic acid because of its $-\text{COOH}$ (carboxyl) group. For example, it readily undergoes neutralization with sodium hydroxide to form a soluble organic salt by the name of “sodium aminopropanoate” according to the following equation:

$$\text{H}_2\text{NCHCH}_2\text{COOH} + \text{NaOH} \rightarrow \text{H}_2\text{NCHCH}_2\text{COONa} + \text{H}_2\text{O}$$

Alanine also reacts with an alcohol to form an ester whose structural formula is shown.

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\begin{array}{c}
\text{O} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\end{array}
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\begin{array}{c}
\text{O} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\begin{array}{c}
\text{O} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{C} \\
\end{array}
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\end{array}
\]

(i) Write an ionic equation for the reaction of alanine with aqueous sodium hydroxide.

.................................................................................................................[2]

(ii) Using the information provided, name the ester formed above.

.................................................................................................................[1]

(iii) An isomer of this ester was added to a test tube of aqueous sodium carbonate. Effervescence of the colourless gas evolved gave a while precipitate when bubbled into limewater. Draw a possible structure of this isomer.

.................................................................................................................[1]

[Total: 10]
Either

Instead of carrying many tanks of oxygen and adding to the mass of the submarine which makes it inefficient to move, naval forces sometimes make use of chemistry to constantly generate sufficient oxygen for the soldiers in the submarine to breathe.

One such method is the electrolysis of aqueous sodium hydroxide. The diagram below shows the schematic diagram of a set-up used for this purpose.

![Diagram of electrolysis](image)

(a) State how the composition of the electrolyte changes after the electrolysis has been running for some time.

(b) After some time, the power pack can be replaced by a voltmeter. This set-up, shown below, then acts like a fuel cell to provide additional electricity to power the submarine.

The left hand electrode in the diagram becomes the negative rod of the cell and the right hand electrode becomes the positive rod.
(i) State the direction of the electron flow in the external circuit.

(ii) Construct an equation to represent the reaction that occurs at the negative rod in this fuel cell.

(c) Other than submarines, cars can also be fitted with an engine powered by a hydrogen fuel cell or a conventional petrol engine.

One of the advantages of hydrogen fuel cells over the use of petrol in cars is that the only by-product is water, making it a clean fuel. A hydrogen fuel cell in operation, however, can sometimes achieve temperatures that are comparable to the conventional petrol engine.

(i) Give one environmental disadvantage of using petrol to power car engines.

(ii) Suggest why hydrogen as a fuel (in the fuel cell) may not be that economically viable.

(iii) Explain why it is possible for nitrogen oxides to be produced in both types of car engines.

(iv) Suggest why a catalytic converter, if installed in a car that is powered by a hydrogen fuel cell, will fail to reduce nitrogen oxide levels as compared to that in a car powered by petrol.

[Total: 10]
B9

Aqueous copper(II) sulfate is electrolysed as shown in the set-up below.

(a) Write a half equation for the reaction that occurs at the cathode.

......................................................................................................................[1]

(b) Describe and explain any changes that occur in the electrolyte as the reaction continues for a period of time.

..............................................................................................................................
..............................................................................................................................
..............................................................................................................................[3]

(c) Suggest another type of electrodes that can be used to replace these graphite electrodes without changing the results of the experiment.

......................................................................................................................[1]

(d) Two students, A and B made statements about the electrolytic set-up.

Student A: “If we change the electrolyte to a highly concentrated solution of copper(II) sulfate, the results of this experiment will be entirely different.”

Student B: “The concentration of the copper(II) sulfate electrolyte here does not affect the results of the experiment.”

Which student made the correct statement? Give a reason for your answer.

..............................................................................................................................
..............................................................................................................................
..............................................................................................................................[2]
(c) A student investigated the relationship between the mass of copper formed and the total charge passed through the solution. The graph of the results are seen below.

![Graph showing mass of copper formed vs. charge passed through the solution.]

(i) Deduce the mass of copper formed when a charge of 600 coulombs is passed through the solution.

(ii) Use information given in the graph to predict the charge needed to form 1 g of copper, and hence deduce the charge needed to deposit 1 mole of copper.

[Total: 10]
A1
(a) 1 across – FILTRATION
(b) 2 down – FLUORINE
(c) 3 down – IRON
(d) 4 down – CATION
(e) 5 down – NUCLEON

A2
(a) (i) Iodine
(ii) Methane
(iii) Lead(II) bromide, lithium
(iv) Lithium
(v) Iodine, bromine
(b) • Silicon dioxide has a higher boiling point than bromine [1]
• Silicon dioxide has giant covalent structure, bromine has simple molecular structure [1]
• Less energy required to overcome weak intermolecular forces of attraction in bromine than to break strong Si-O covalent bonds in silicon dioxide. [1]

A3
(a) (i) $2Mg + O_2 \rightarrow 2MgO$
(ii) 

No penalty for missing key / did not write atomic symbol in the diagram.

(b) • Place a piece of damp red litmus paper into the gas. [1]
• If the damp red litmus paper turns blue, the gas is ammonia gas. [1]

Must identify ammonia gas.
A4 (a) (i) Reducing agent

(ii) \( \text{NiO (s)} + \text{H}_2 (g) \rightarrow \text{Ni (s)} + \text{H}_2\text{O (l)} \)

[1] correct and balanced equation
[1] correct state symbols (only awarded if equation is correct)

(b) \( \text{Ni + 4CO} \rightarrow \text{Ni(CO)}_4 \)

No. of moles of \( \text{CO} = \frac{120}{24} = 5000 \text{ mol} \)
No. of moles of \( \text{CO} = \frac{4}{1} \)
No. of moles of \( \text{Ni(CO)}_4 \) expected = \( \frac{5000}{4} = 1250 \text{ mol} \)
Mass of \( \text{Ni(CO)}_4 \) expected = \( 1250 \times [58 + 4(12+16)] = 213750 \text{ g} \) [1]

No. of moles of \( \text{Ni(CO)}_4 \) obtained = \( \frac{22500}{24} = 937.5 \text{ mol} \)
Mass of \( \text{Ni(CO)}_4 \) obtained = \( 937.5 \times [58 + 4(12+16)] = 160312.5 \text{ g} \) [1]

Percentage yield = \( \frac{213750}{160312.5} \times 100\% = 75.0\% \) (3 s.f.) [1]

OR

Mole ratio of gas = volume ratio of gas \rightarrow \frac{\text{No. of moles of CO}}{\text{No. of moles of Ni(CO)}_4} = \frac{\text{Volume of CO}}{\text{Volume of Ni(CO)}_4} = \frac{4}{1}
Volume of \( \text{Ni(CO)}_4 \) expected = \( \frac{120000}{4} = 30000 \text{ dm}^3 \) [1]
Hence, \% yield = \( \frac{22500}{30000} \times 100\% = 75.0\% \) (3 s.f.) [1]

(c) Nickel compounds are likely to be coloured / Nickel exists in variable oxidation states in its compounds

A5 (a) (i) Graph 2

(ii) Catalysts speed up chemical reactions. [1]
Graph 2 had a steeper initial gradient, which indicated a higher initial rate compared to graph 1. [1]

(iii) Catalysts provide an alternative pathway with a lower activation energy for the reaction to occur. [1]
More reacting particles possess energy that is greater than or equal to the activation energy. [1]
Frequency of effective collisions between reacting particles increase, rate of reaction increases. [1]

(b) (i)

<table>
<thead>
<tr>
<th>oxidation state of H</th>
<th>oxidation state of O</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen peroxide</td>
<td>+1</td>
</tr>
<tr>
<td>oxygen gas</td>
<td>0</td>
</tr>
<tr>
<td>water</td>
<td>+1</td>
</tr>
</tbody>
</table>

[1] correct oxidation states of H
[1] correct oxidation states of O
(ii) Hydrogen peroxide is reduced: oxidation state of oxygen increases from -1 in hydrogen peroxide to 0 in oxygen gas. [1]
    Hydrogen peroxide is also oxidised: oxidation state of oxygen decreases from -1 in hydrogen peroxide to -2 in water. [1]

(c) The reaction is highly exothermic / releases a lot of heat energy. [1]
    Oxygen is one of the products – high risk of explosion [1]

[1] – Correct shape of diagram
[1] – Correct $E_a$
[1] – Correct $\Delta H$
-1 mark if no indication of reactants + products

A6 (a) (i) Ammonia / Ammonium hydroxide
(ii) Place a piece of blue litmus paper into a sample of both solutions. [1]
    The solution that turns the blue litmus paper red is acrylic acid. [1]
(iii) Reddish-brown aqueous bromine decolourises rapidly.
    © if student does not state initial colour / no mention of 'rapidly'

(iv) ![Chemical structure](image)

(b) ![Chemical reaction](image)
[1] – correct condition for addition of steam to alkene
[1] – correct structure of intermediate alcohol
[1] – correct reagent and condition of oxidation
@ any variation in structure as long as it is sound

B7 (a) In an irreversible reaction, the concentration of the reactant can reach 0, but this is not the case in a reversible reaction. [1]

(b) (i) If releases heat, because the reaction is exothermic. [1]
(ii) The reaction is exothermic. [1]
    When the temperature is lowered, the position of the equilibrium shifts to the right. [1]
    This is to release more heat, to counteract the effect of lowering the temperature. [1]
The equilibrium concentration of ammonia becomes higher.

Mark for:
- Gentler gradient than original
- Higher concentration of products than original (regardless of how high)

(c)(i) High pressures require large amounts of energy to maintain, which can increase the cost [1]

(c)(ii) Ammonia molecules change from being very far apart from each other to closely packed together. [1]
- They change from moving randomly in all directions at high speeds to sliding past each other throughout the liquid. [1]

B8

(a)(i)

\[
\begin{align*}
&\text{H} - \text{C} - \text{N} - \text{C} - \text{N} - \text{C} - \text{N} - \text{C} - \\
&\text{H} \quad \text{H} \quad \text{H} \quad \text{H}
\end{align*}
\]

[1] – correct amide linkage between Cys – Ala (including structure of amino acids)

B9

(E)(a) Concentration of Na\(^+\) and OH\(^-\) increases; becomes more alkaline / pH increases

B9

(E)(b)(i) From the negative rod to the positive rod

\[2\text{H}_2(\text{g}) + 4\text{OH}^-{\text{(aq)}} \rightarrow 4\text{H}_2\text{O(}l\text{)} + 4\text{e}^-\]

State symbols not required
| (c) (i) | Formation of carbon dioxide [1]  
A greenhouse gas that can cause global warming, resulting in rising sea levels + melting  
ice caps [1] OR  
Formation of carbon monoxide due to incomplete combustion [1]  
Toxic gas that can cause difficulty in breathing and even death [1] OR  
Unburnt hydrocarbons may be released due to incomplete combustion [1]  
Formation of photochemical smog when present with other polluting gases [1] |
| (ii) | To obtain hydrogen, we require cracking of longer-chain hydrocarbons [1] OR  
To obtain hydrogen, electrolysis of water must be carried out [1]  
Which requires large amount of heat and electricity that can be very costly [1] |
| (iii) | At high temperatures, nitrogen reacts with oxygen in air to form nitrogen oxides [1]  
Both types of engines will function at high temperatures [1] |
| (iv) | In a hydrogen fuel cell powered engine, there is absence of carbon monoxide to function  
as a reducing agent in the catalytic converter. OR  
For a catalytic converter to remove NO, the following must happen:  
\[ 2CO + 2NO \rightarrow 2CO_2 + N_2 \]  
However, there is no carbon monoxide present in the engine powered by the fuel cell. OR  
NO is soluble in water present in the fuel cell, and will not reach the catalytic converter  
for reaction to occur. |

| B9 O | (a) | Cu^{2+} (aq) + 2e^- \rightarrow Cu (s) |
| (b) | Must have state symbols.  
The blue colour becomes less intense; pH of the solution decreases. [1]  
Cu^{2+} is discharged at the cathode and OH^- is discharged at the anode. [1]  
H^+ and SO_4^{2-} are the ions left in the solution forming sulfuric acid. [1] |
| (c) | Platinum |
| (d) | Even if concentrated copper(II) sulfate is used as the electrolyte, only Cu^{2+} and OH^- will be  
preferentially discharged. [1]  
Student B is correct. [1] |
| (e) (i) | 0.2 g |
| (ii) | To discharge 0.1 g of copper \( \rightarrow \) 300 coulombs (read from graph)  
Charge needed to form 1 g of copper \( = 300 \times 10 \)  
= 3000 coulombs [1]  
Molar mass of copper = 64 g/mol  
Hence, charge needed to form 1 mol copper \( = 3000 \times 0.04 \)  
= 120 000 coulombs [1] |
CRESIDENT GIRLS' SCHOOL
SECONDARY FOUR
PRELIMINARY EXAMINATION 2017

CHEMISTRY

Paper 1 Multiple Choice

5073/01
28 AUGUST 2017
1 hour

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluids.

Write your name, index number and class on the answer sheet in the spaces provided.

There are forty questions on this paper. Answer all questions. For each question, there are four possible answers, A, B, C and D.

Choose the one you consider correct and record your choice in soft pencil on the answer sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet

A copy of the Periodic Table is printed on page 2.

This paper consists of 14 printed pages, including the cover page.

Need a home tutor? Visit smiletutor.sg

<p>| Page 111 |</p>
<table>
<thead>
<tr>
<th>Group</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>He</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
<td>Ne</td>
<td>Na</td>
<td>Mg</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Ar</td>
<td>K</td>
<td>Ca</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cl</td>
<td>As</td>
<td>Se</td>
<td>Br</td>
<td>Rb</td>
<td>Sr</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ar</td>
<td>Se</td>
<td>Kr</td>
<td>Xe</td>
<td>Cs</td>
<td>Ba</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>86</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>88</td>
</tr>
</tbody>
</table>

**Key:**
- **a** = relative atomic mass
- **X** = atomic symbol
- **b** = proton (atomic) number

The Periodic Table of the Elements
1. The following apparatus can be used in the measurement of volumes of liquids:

   I: 25 ml pipette  
   II: 25 ml beaker  
   III: 50 ml burette  
   IV: 25 ml graduated measuring cylinder

Which of the following shows the correct order of increasing accuracy of these apparatus?

A  I, II, IV, III  
B  I, IV, II, III  
C  II, IV, I, III  
D  II, III, IV, I

2. A new substance was discovered and a series of experiments were conducted on it.

Which observation suggests that the substance cannot be an element?

A  It has a sharp melting point.  
B  When heated in air, it could form two oxides.  
C  It dissolved in water to form a colourless solution.  
D  Electrolysis of the molten substance produced two products.

3. The table below shows some information about the physical properties of mercury and ethanol.

<table>
<thead>
<tr>
<th></th>
<th>Melting point/ °C</th>
<th>Boiling point/ °C</th>
<th>Solubility in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>-38</td>
<td>357</td>
<td>No</td>
</tr>
<tr>
<td>Ethanol</td>
<td>-114</td>
<td>78</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Which of the following can be used to separate a mercury-ethanol mixture dissolved in water at room temperature and pressure?

A  distillation  
B  filtration  
C  paper chromatography  
D  separating funnel
4. Toluene and cyclohexane are two common organic solvents and they form a homogenous mixture when mixed together.

The following graph shows the boiling points of mixtures containing different percentages of toluene and cyclohexane.

Using information from the graph, which statement is true?

A  The boiling point of pure toluene is 81 °C.
B  The boiling point of pure cyclohexane is 110 °C.
C  The boiling point of any cyclohexane and toluene mixture is below that of the boiling points of pure cyclohexane and pure toluene.
D  The boiling point of any cyclohexane and toluene mixture is between the boiling points of pure cyclohexane and pure toluene.

5. Which gas(es) has/ have a pungent smell and causes a change in colour when tested with moist red litmus paper?

I: Ammonia
II: Carbon dioxide
III: Chlorine
IV: Hydrogen

A  I only  
B  I and III
C  II and III
D  II and IV

6. A colourless solution T, was tested with aqueous sodium hydroxide. A precipitate was observed and it was insoluble in excess sodium hydroxide.

Which of the following could be solution T?

A  CaCl₂  
B  CuSO₄
C  Fe(NO₃)₂
D  Pb(NO₃)₂
7. X, Y and Z are three covalent substances which are found in different states at the same temperature and pressure. X is a solid, Y is a gas and Z is a liquid.

Which of the following shows the order of increasing strength of their intermolecular forces?

A: X < Y < Z  B: X < Z < Y  C: Y < Z < X  D: Z < X < Y

8. Deuterium is an isotope of hydrogen and has the symbol D.

Which formula is incorrect for a compound of deuterium?

A: PhOD  B: ND₃  C: D₂O  D: CD₄

9. Which allotrope of carbon is a non-conductor of electricity?

A  

![Graphite structure]

B  

![Diamond structure]

C  

![Amorphous carbon structure]

D  

![Fullerene structure]

10. When heated, two moles of X give one mole of oxygen and two moles of chlorine.

What is the molecular formula of X?

A: ClO₂  B: Cl₂O  C: Cl₂O₂  D: Cl₄O₂
11. Which nitrogen compound contains the highest percentage by mass of nitrogen?

A  \( \text{NH}_3 \)  
B  \( \text{NH}_4\text{NO}_3 \)  
C  \( (\text{NH}_2)_2\text{SO}_4 \)  
D  \( \text{CH}_3\text{NH}_2 \)  

12. Sulfur trioxide decomposes according to the following equation:

\[ 2\text{SO}_3 \rightarrow 2\text{SO}_2 + \text{O}_2 \]

What is the total volume of gas produced from the decomposition of 100 cm\(^3\) of sulfur trioxide (all volumes of gases being measured at r.t.p.)?

A  50 cm\(^3\)  
B  150 cm\(^3\)  
C  200 cm\(^3\)  
D  300 cm\(^3\)  

13. Which particles can be found in a solution of ethanoic acid, \( \text{CH}_3\text{COOH} \)?

I:  \( \text{H}^+ \)  
II:  \( \text{C}_2\text{O}_2^- \)  
III:  \( \text{CH}_3\text{COO}^- \)  
IV:  \( \text{CH}_3\text{COOH} \)

A  I and III  
B  I, II and III  
C  I, III and IV  
D  All of the above  

14. Electrolysis of different substances were carried out.

For which combination of electrolyte and electrodes can the reaction for the formation of \( \text{X}_2 \) be represented by the equation shown below?

\[ 2\text{X}^- + 2\text{e}^- \rightarrow \text{X}_2 \]

A  concentrated sodium chloride solution with inert electrodes  
B  dilute copper(II) nitrate solution with inert electrodes  
C  dilute silver nitrate solution with silver electrodes  
D  molten iron(III) bromide with inert electrodes  

Need a home tutor? Visit smiletutor.sg | Page 116
15. A metal spoon is to be electroplated with copper in the following set up:

![Diagram of electroplating setup]

What are the conditions required to electroplate the spoon successfully?

<table>
<thead>
<tr>
<th>Electrode Q</th>
<th>Spoon connected as</th>
<th>Electrolyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Iron</td>
<td>Anode</td>
</tr>
<tr>
<td>B</td>
<td>Iron</td>
<td>Cathode</td>
</tr>
<tr>
<td>C</td>
<td>Copper</td>
<td>Anode</td>
</tr>
<tr>
<td>D</td>
<td>Copper</td>
<td>Cathode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper(II) chloride</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper(II) hydroxide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper(II) hydroxide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper(II) chloride</td>
</tr>
</tbody>
</table>

16. An electrochemical cell was set up as shown below.

![Diagram of electrochemical cell]

Which pair of metals would generate the flow of electrons as shown in the diagram above?

<table>
<thead>
<tr>
<th>Metal X</th>
<th>Metal Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>zinc</td>
</tr>
<tr>
<td>B</td>
<td>aluminium</td>
</tr>
<tr>
<td>C</td>
<td>magnesium</td>
</tr>
<tr>
<td>D</td>
<td>lead</td>
</tr>
</tbody>
</table>
17. Hydrogen-powered cars use hydrogen fuel to produce electricity to run the car.

   How is the electricity generated directly in the car?
   
   A   hydrogen is burnt to form steam
   
   B   hydrogen ions react with hydroxide ions to form water
   
   C   hydrogen and oxygen react at the electrodes to form water
   
   D   water is decomposed into hydrogen and oxygen at the electrodes

18. The positions of four elements, A, B, C and D, are shown in the outline of part of the Periodic Table. Element X has a high melting point and is a good conductor of electricity. It also forms two types of oxides, XO and XO₂, which exist as black solids at room temperature and pressure.

   Which element is X?

   

19. The table below shows the information about the chlorides of some elements in Period 3 of the Periodic Table.

<table>
<thead>
<tr>
<th>Element</th>
<th>Formula of main chloride</th>
<th>Bonding present in chloride</th>
<th>pH of resulting solution when dissolved in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>NaCl</td>
<td>Metallic</td>
<td>7</td>
</tr>
<tr>
<td>Magnesium</td>
<td>MgCl₂</td>
<td>Metallic</td>
<td>7</td>
</tr>
<tr>
<td>Aluminium</td>
<td>AlCl₃</td>
<td>Covalent</td>
<td>3</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>PCl₃</td>
<td>Covalent</td>
<td>2</td>
</tr>
<tr>
<td>Sulfur</td>
<td>S₂Cl₂</td>
<td>Covalent</td>
<td>2</td>
</tr>
</tbody>
</table>

   What will be the bonding present in the chloride of silicon and the pH value of the resulting solution when the chloride is dissolved in water?

<table>
<thead>
<tr>
<th>Bonding present in chloride</th>
<th>pH of resulting solution when dissolved in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>7</td>
</tr>
</tbody>
</table>
20. V, W, X, Y and Z are five consecutive elements in the Periodic Table. The following graph shows the oxidation states of the five elements plotted against their atomic numbers.

What is the atomic number of element Z?

A  7
B  10
C  17
D  19

21. Which reaction is an example of a redox reaction?

A  \( \text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl} \)
B  \( 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3 \)
C  \( \text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O} \)
D  \( \text{CuO} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O} \)

22. Three test tubes were arranged as in the diagram below. The tests were conducted to determine the reactivity of three metals (zinc, copper and an unknown metal Q).

Each test tube contained a piece of one metal, half-immersed in an aqueous solution containing the ions of one of the other two metals. A deposit was formed in all three test tubes.

What could be the identity of metal Q?

A  Calcium  B  Iron  C  Magnesium  D  Silver
23. Metal X reacts rapidly with dilute hydrochloric acid and can be used for the sacrificial protection of underwater pipes.

Metal Y does not corrode easily and can be used to manufacture jewellery.

Metal Z reacts rapidly with water to form hydrogen.

Which method of extraction of the metals from their ores is most likely to be used?

<table>
<thead>
<tr>
<th>Electrolysis of molten ore</th>
<th>Heating with carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>X and Y</td>
</tr>
<tr>
<td>B</td>
<td>X and Z</td>
</tr>
<tr>
<td>C</td>
<td>Y</td>
</tr>
<tr>
<td>D</td>
<td>Z</td>
</tr>
</tbody>
</table>

24. During the manufacture of iron, which substance is the main reducing gas in the middle of the furnace?

A  carbon monoxide  
B  carbon dioxide  
C  nitrogen  
D  oxygen

25. Which process is exothermic?

A  melting of ice  
B  evaporation of ethanol  
C  condensation of water vapour  
D  formation of iodine vapour from iodine crystals
26. The energy profile diagram shows how adding substance X to a reaction mixture changes the reaction pathway.

![Energy profile diagram]

Which change is likely to be observed when X is added to the reaction mixture?

A. an increase in yield of products obtained
B. a shorter time taken to complete the reaction
C. a greater drop in temperatures of surroundings
D. a greater increase in temperature of surroundings

27. Two reagents were mixed in a beaker and a chemical reaction took place.

The mass of the beaker and its contents were recorded as the reaction progressed and a graph of the results is obtained.

![Graph of mass and time]

Which reaction could not have produced the graph?

A. $\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4\text{Cl}$
B. $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
C. $\text{NaNO}_3 + \text{NH}_4\text{Cl} \rightarrow \text{NaCl} + 2\text{H}_2\text{O} + \text{N}_2$
D. $\text{ZnCO}_3 + 2\text{HNO}_3 \rightarrow \text{Zn(NO}_3)_2 + \text{CO}_2 + \text{H}_2\text{O}$
28. 50 g of calcium carbonate granules is reacted with aqueous methanoic acid to produce carbon dioxide.

Which change is least likely to lead to an increase in the rate of formation of carbon dioxide from the reaction?
A  grinding the calcium carbonate into fine powder
B  using nitric acid instead of methanoic acid
C  adding more calcium carbonate
D  warming up the acid

29. The depletion of the ozone layer in the upper atmosphere reduces the Earth’s natural protection from harmful ultraviolet radiation.

Which compound would cause the most severe depletion of the ozone layer?
A  CCIBF
B  CIF4
C  CHCIF2
D  CH2F2

30. What is the minimum volume of air required for the complete combustion of 46 g of ethanol?
A  100 dm³
B  250 dm³
C  400 dm³
D  450 dm³

31. Photochemical smog is an effect of pollution seen occurring in many industrialised cities.

Which of the following is not responsible for its formation?
A  nitrogen dioxide
B  ozone
C  pentane
D  sulfur dioxide
32. When crude oil is fractionally distilled, which compounds will leave from the top of the fractional column?
   A  compounds that are the least flammable
   B  compounds that are the most viscous
   C  compounds with the highest relative molecular mass
   D  compounds with the lowest boiling point

33. Paraffin (kerosene), one of the fractions obtained from the fractional distillation of crude oil, is used as an energy source for various purposes.

   In how many of the following can paraffin (kerosene) be used as an energy source?

<table>
<thead>
<tr>
<th>aircraft</th>
<th>cooking</th>
<th>air conditioning units</th>
<th>heavy lorries</th>
<th>cars</th>
<th>power stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1</td>
<td>B 2</td>
<td>C 3</td>
<td>D 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

34. Which statements concerning the process of cracking are correct?

   I: It is an endothermic process.
   II: It produces alkanes with lower relative molecular mass.
   III: Gaseous products from cracking can decolourise aqueous bromine rapidly.

   A  I and II  
   B  I and III 
   C  II and III 
   D  I, II and III

35. On complete combustion, one mole of a hydrocarbon X produces two moles of carbon dioxide and two moles of water.

   Given that hydrocarbon X decolourises brown aqueous bromine rapidly, which is the molecular formula of hydrocarbon X?

   A  $C_2H_4$  
   B  $C_2H_6$  
   C  $C_2H_8$  
   D  $C_3H_8$

36. Which bond in a molecule of ethanol acid is broken when it reacts with magnesium?

   A  C – H bond
   B  C – C bond
   C  O – H bond
   D  C = O bond
37. Which acid would react with ethanol to give the ester C₃H₇CO₂C₂H₅?
   A butanoic acid       B ethanoic acid
   C methanoic acid      D propanoic acid

38. The structure of an organic compound is shown below:

   HO—C—C—C
   H     H       O

   Which statement about the organic compound is incorrect?
   A It produces ammonia gas when heated with aqueous sodium hydroxide.
   B It produces carbon dioxide when reacted with sodium carbonate.
   C It decolourises purple acidified potassium manganate(VII).
   D It undergoes condensation polymerisation by itself.

39. In the polymerisation of ethene to form poly(ethene), which does not change?
   A boiling point       B empirical formula
   C density             D molecular mass

40. Which pair of organic compounds can be reacted to form a condensation polymer?
   A HOOC—CH₂—CH₂—COOH and CH₃—CH₂—CH₂—NH₂
   B HOOC—CH₂—CH₂—COOH and H₂N—CH₂—CH₂—NH₂
   C CH₃—CH₂—CH₂—OH and CH₃—CH₂—CH₂—NH₂
   D HO—CH₂—CH₂—OH and H₂N—CH₂—CH₂—NH₂
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>11</td>
<td>A</td>
<td>21</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>12</td>
<td>B</td>
<td>22</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>13</td>
<td>C</td>
<td>23</td>
<td>B</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>14</td>
<td>A</td>
<td>24</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>15</td>
<td>D</td>
<td>25</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>A</td>
<td>16</td>
<td>B</td>
<td>26</td>
<td>B</td>
</tr>
<tr>
<td>7</td>
<td>C</td>
<td>17</td>
<td>C</td>
<td>27</td>
<td>A</td>
</tr>
<tr>
<td>8</td>
<td>A</td>
<td>18</td>
<td>C</td>
<td>28</td>
<td>C</td>
</tr>
<tr>
<td>9</td>
<td>B</td>
<td>19</td>
<td>A</td>
<td>29</td>
<td>A</td>
</tr>
<tr>
<td>10</td>
<td>B</td>
<td>20</td>
<td>C</td>
<td>30</td>
<td>C</td>
</tr>
</tbody>
</table>

This paper consists of 20 printed pages including cover page.

Need a home tutor? Visit smiletutor.sg

Page 125
READ THESE INSTRUCTIONS FIRST

Write your name, index number and class in the spaces provided at the top of this page.
Write in blue or black pen in the spaces provided on the Question Paper.
You may use a pencil for any diagrams, graphs, or rough working.
You may use a calculator.
All final answers for calculations are to be rounded off to 3 significant figures.
Do not use staples, paper clips, highlighters, and glue or correction fluid.

Section A (50 Marks)
Answer all questions in the spaces provided.

Section B (30 Marks)
Answer all THREE questions from this section.
The last question is in the form of EITHER/OR and only ONE of the alternatives should be attempted.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.

For Examiner's Use

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
<td></td>
</tr>
<tr>
<td>Section B</td>
<td></td>
</tr>
<tr>
<td>Deductions</td>
<td>Significant Figures</td>
</tr>
<tr>
<td></td>
<td>Units</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
</tr>
</tbody>
</table>

This paper consists of 20 printed pages including cover page.
Section A

Answer all questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The two states of matter, gas and liquid, have both commonalities and differences in terms of their characteristics.

(a) Complete the table below by choosing the characteristics that are only true for liquids; only true for gases; or true for both.

Put a tick (✓) in one box in each row.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>only true for gas</th>
<th>only true for liquid</th>
<th>true for both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particles are arranged disorderly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particles have high kinetic energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attractive forces between particles are strong</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diffusion can take place in this state</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

(b) Chlorine exists as gaseous state while bromine exists as liquid state at room temperature and pressure.

Explain, in terms of bonding and structure, why there is a difference in the physical state although both are Group VII elements.
A1  (c) Potassium is vital in for normal organs function in human body and potassium chloride tablet is commonly used to treat low levels of potassium for patients.

(i) Draw a 'dot-and-cross' diagram to show the bonding in potassium chloride.

Show outer shell electrons only.

(ii) The medicine usually comes in a tablet form.

Describe an experiment that can be used to show that the tablet contains chloride ions.

State the expected observation from the experiment.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

[Total: 10]

A2  Limescale is the hard, off-white deposit found in kettles, hot-water boilers and other electrical appliances. It is unsightly and may impair the operation or damage various components in these electrical appliances. Limescale is made up of mainly calcium carbonate.

Limescale can be removed by using descaling agents which contain ethanoic acid or hydrochloric acid.

(a) Write an equation to show the descaling process using ethanoic acid.

________________________________________________________________________
A2 (b) Ethanoic acid is a weak acid.

(i) Explain the term weak acid.

(ii) Explain, in terms of collisions between particles, which descaling agent, ethanoic acid or hydrochloric acid, would remove the limescale faster.

(iii) Descaling agents used should not contain sulfuric acid.

Explain why.

[Total: 7]

A3 The diagram shows a dissection of an electrical wire.

(a) Copper is the most common material used to make electrical wire.

Give two reasons why copper is being used.

[2]

Page 4 of 20
A3 (b) Copper is extracted from its ore, chalcocpyrite, \( \text{CuFeS}_2 \), in a 2-step reaction.

Copper(I) sulfide formed in Step 1 is further reacted to form copper in Step 2.

- **[Step 1]** \( 2\text{CuFeS}_2 + 2\text{SiO}_2 + 4\text{O}_2 \rightarrow \text{Cu}_2\text{S} + 2\text{FeSiO}_3 + 3\text{SO}_2 \)

- **[Step 2]** \( \text{Cu}_2\text{S} + \text{O}_2 \rightarrow 2\text{Cu} + \text{SO}_2 \)

(i) State and explain, in terms of electron transfer, which substance is reduced in Step 2.

Support your answer using half ionic equation(s).

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

[3]

(ii) The gaseous by-product is recycled to manufacture sulfuric acid.

Describe a simple test to show that the gaseous by-product is acidic.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

[1]

(iii) Explain, other than cost, why the by-product should be recycled and not released directly into the environment.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

[2]
A3  (b)  (iv)  Some copper is used to make brass, which is a mixture of copper and zinc. Yellow brass is the industry standard brass commonly used in making musical instruments. It comprises of 30% zinc and 70% copper.

Draw a diagram to show the arrangement of atoms in brass. Explain why it is more useful in making musical instruments than pure copper. Label your diagram.

[3]

[Total: 11]

A4  The diagram below shows the apparatus used for the fractional distillation of petroleum.

(a)  State the name and one use of the fraction X.
(b) Some motor vehicles use diesel fuel while some use petrol.

Explain why the combustion of diesel produce more soot than petrol.

(c) Both petrol and diesel cars produces carbon monoxide.

Describe a harmful effect of carbon monoxide.

(d) Besides carbon monoxide, nitrogen dioxide is also produced in motor vehicles.

A device is installed in motor vehicles' exhaust to remove both gases.

State the name of the device and explain, using a single equation, how carbon monoxide and nitrogen dioxide is removed in motor vehicles using the device.

(e) Despite having the device mentioned above, explain why it does not solve all the pollution problems caused by motor vehicles.

[Total: 8]
Alkynes are a homologous series of organic compounds.

<table>
<thead>
<tr>
<th>Alkyne</th>
<th>Chemical Formula</th>
<th>Structural formula</th>
<th>Boiling point °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethyne</td>
<td>C₂H₂</td>
<td>H≡C≡H</td>
<td>−84</td>
</tr>
<tr>
<td>propyne</td>
<td>C₃H₄</td>
<td>H–C≡C≡H</td>
<td>−23</td>
</tr>
<tr>
<td>butyne</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Pentyne</td>
<td>C₅H₈</td>
<td>H–C=C≡C≡C–H</td>
<td>39</td>
</tr>
</tbody>
</table>

(a) Use the information in the table to give two pieces of evidence that suggest that the alkyynes are a homologous series.

(b) Give the chemical formula and full structural formula of butyne.

Chemical formula:

Full structural formula:
A5  (c) The first member of the homologous series is ethyne. Explain why there is no alkyne with a single carbon.

(d) Ethyne undergoes a similar polymerisation reaction like ethene. The diagram below shows the structure of polyethyne.

\[
\begin{align*}
\text{C} & \equiv \text{C} & \text{C} & \equiv \text{C} & \text{C} & \equiv \text{C} \\
\text{H} & & \text{H} & & \text{H} & \\
\end{align*}
\]

Give one similarity and one difference between polyethylene and polyethene.

[Total: 7]

A6  Fats and protein are two natural polymers that are essential part of our diets and has a number of important roles in our body.

The diagrams below show examples of fats and protein molecules:

**Fats**

\[
\begin{align*}
\text{H} & \quad \text{O} \\
\text{H} & \quad \text{C} - \text{O} - \text{C} \\
\text{H} & \quad \text{C} - \text{O} - \text{C} \\
\text{H} & \quad \text{C} - \text{O} - \text{C} \\
\text{H} & \\
\end{align*}
\]

**Protein**

\[
\begin{align*}
\text{H} & \quad \text{O} \\
\text{H} & \quad \text{C} - \text{N} - \text{C} - \text{N} - \text{C} - \text{N} - \text{C} - \text{N} - \text{C} - \text{N} - \text{C} - \text{O} \\
\text{H} & \quad \text{O} \\
\end{align*}
\]
A6  
(a)  
(i) Circle the amide linkage in the diagrams in Page 9. Label it "amide".  
(ii) Circle the ester linkage in the diagrams in Page 9. Label it "ester".  

(b) Draw the structures of the monomers that are used to form fats and protein.  

Fats:  

Protein:  

(c)  
(i) Name a synthetic polymer that has a similar linkage to fats.  

(ii) State one use for the polymer stated above.  

[Total: 7]
Section B (30 Marks)
Answer all three questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Read the information about the industrial production of oxygen.

There are many methods used in the industry to produce oxygen. Production cost, purity and volume desired are some of the key factors determining the selection criteria. The production of oxygen using Pressure Swing Adsorbers (PSA) and electrolysis are simplified in the diagrams below.

Pressure Swing Adsorbers (PSA)

Air is pressurised in the compressor before passing into adsorber towers. In the adsorber towers, nitrogen and oxygen in the air are separated. The substance used in the adsorber towers needs to be replaced or regenerated after a certain volume of air has been separated as it will become saturated with nitrogen.

Electrolysis

Dilute aqueous NaCl is electrolysed to produce oxygen and hydrogen using graphite electrodes. In theory, the ratio of hydrogen gas to oxygen gas collected should be 2:1. As oxygen is more soluble than hydrogen in water thus the ratio of gases collected will change.
The table below shows more information about the two methods.

<table>
<thead>
<tr>
<th></th>
<th>Pressure Swing Adsorbers (PSA)</th>
<th>Electrolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall energy consumption (kWh per m³ of O₂) 1 m³ = 1000 dm³</td>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>Purity of O₂ produced</td>
<td>&lt;95% (≥99.9% can only be achieved with extremely high-end device)</td>
<td>&gt;99.9%</td>
</tr>
<tr>
<td>By-product</td>
<td>Impure nitrogen is produced.</td>
<td>Produced hydrogen which can be used as fuel</td>
</tr>
</tbody>
</table>

(a) Give two disadvantages, other than lower purity, of producing oxygen using PSA.

[2]

(b) Explain why the theoretical volume ratio hydrogen to oxygen produced in electrolysis is 2:1.

[2]

(c) State and explain how would the final volume of the gases collected in electrolysis change due to the difference in solubility of the gases in water.

[2]
(d) Calculate the energy consumption using electrolysis per mole of oxygen gas produced.

(e) What happens to the concentration of NaCl during the electrolysis?

Explain your reasoning.

__________________________________________________________

__________________________________________________________

(f) The electrolyte used in the electrolysis set up above needs to be replaced regularly.

Explain why the electrolyte needs to be replaced regularly.

Support your answer with equations explaining the reaction at each electrode.

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

[Total: 12]
Ostwald process is a chemical process for making nitric acid. The raw materials of Ostwald process are ammonia, water and oxygen gas. Platinum is used as catalyst for the process. There are multiple steps in the process. In the first step of the process, ammonia reacts with oxygen in a reversible reaction to form nitrogen monoxide. It gives 65% yield at the optimum temperature of 800°C and pressure of 1 atm. The equation below shows the reaction between ammonia and oxygen.

\[
4\text{NH}_3(g) + 5\text{O}_2(g) = 4\text{NO}(g) + 6\text{H}_2\text{O}(g) \quad \Delta H = -104 \text{ kJ/mol}
\]

The graph below shows the yield of nitrogen monoxide with varying temperature and pressure.

(a) State the conditions for the process to obtain ammonia in the industry.

__________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________

(b) (i) Describe the relationship between percentage yield of nitrogen monoxide with temperature and pressure.

__________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________________
(b)  
(ii) Use the graph to explain why the optimum temperature and pressure is chosen for the first step of Ostwald process.  

\[ \text{[2]} \]

\[ \text{[3]} \]

(c) Draw an energy profile diagram to show the effect of the catalyst on the first step of Ostwald process.

Your diagram should show and label:
- reactants and products,
- the activation energy for the uncataylsed and catalysed reactions respectively,
- the enthalpy change of reaction.

(d) A reaction is carried out at 800 °C and 2 atm using 1 tonne of ammonia with excess oxygen.

With reference to the graph, calculate the volume of nitrogen monoxide produced.  
(1 tonne = 1 \times 10^6 g)
EITHER

B9 Water soluble laundry bags are made of PVA (polyvinyl alcohol). It is often used in hospital to reduce the hazards associated with storage and cleaning of contaminated washable items.

The structure of PVA is given below:

\[
\text{CH}_2 - \text{CH} - \text{CH}_2 - \text{CH} - \text{CH}_2 - \text{CH} - \text{CH} - \text{CH}_2 - \text{CH} - \text{CH}_2 \\
\text{O} \quad \text{O} \quad \text{H} \quad \text{H}
\]

(a) (i) State the type of polymerisation occurred to form PVA.

(ii) Draw the structure of the monomer of PVA.

(b) The monomer reacts with hydrogen to form ethanol.

Ethanol can be oxidised to form two other products under different conditions.

(i) Suggest a suitable reagent that can be used to oxidise ethanol to form product 2.
EITHER

B9 (b) (ii) Are product 1 and 2 isomers of ethanol?
Explain your reasoning.

___________________________________________________________________________

___________________________________________________________________________

[2]

(iii) Ethanol reacts with product 2 to produce a sweet smelling substance.
Give the name and structure of the product formed.

Name of the product: ___________________________________

Structure: _____________________________________________

[2]

(iv) State a commercial use of the substance formed in (iii).

___________________________________________________________________________

[1]

[Total: 8]
The diagram below shows the two methods used to make polyethylene.

\[ \text{Glucose} \rightarrow \text{Ethanol} \rightarrow \text{Compound Y} \rightarrow \text{Polyethylene} \]

\[ \text{Naphtha} \]

(a) Name for the process used to make ethanol from glucose and state the optimum conditions for the reaction. 
__________________________

(b) State the possible source for the raw material to produce ethanol from glucose and give the balance chemical reaction for the reaction. 
__________________________

(c) A student carried out an experiment to produce compound \( Y \) from ethanol.

Suggest a method for the student to check if compound \( Y \) has formed and state the expected observation. 
__________________________

(d) Compound \( Y \) can also be obtained from naphtha.

Suggest one way in which it can be obtained from naphtha. 
__________________________
OR
B9 (e) State an advantage, other than cost and percentage yield, of obtaining compound Y from glucose rather than naphtha.

[1]

[Total: 8]

End of paper
The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8-18</td>
</tr>
<tr>
<td>1</td>
<td>H</td>
<td>He</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Li</td>
<td>Be</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>Ne</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key:
- a: relative atomic mass
- x: atomic symbol
- b: proton number for the element

This diagram represents the periodic elements, highlighting their properties and groupings within the periodic table.
Section A

Answer all questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The two states of matter, gas and liquid, have both commonalities and differences in terms of their characteristics.

(a) Complete the table below by choosing the characteristics that are only true for liquids; only true for gases; or true for both.

Put a tick (✓) in one box in each row.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>only true for gas</th>
<th>only true for liquid</th>
<th>true for both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particles are arranged disorderly</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Particles have high kinetic energy</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attractive forces between particles are strong</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Diffusion can take place in this state</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

[4 ✓ - 2m; 2 - 3 ✓ - 1m; 1 ✓ - 0]

(b) Chlorine exists as gaseous state while bromine exists as liquid state at room temperature and pressure.

Explain why, in terms of bonding and structure, there is a difference in the physical state although both substances are from the same group.

Both chlorine and bromine has simple molecular structure ✓ and weak intermolecular forces of attraction ✓. The intermolecular forces of attraction in bromine is stronger ✓ than chlorine as bromine has higher molar mass ✓.

Higher energy ✓ is required to overcome the stronger forces of attraction.

Thus, bromine has a higher boiling point ✓ and exist as liquid in RTP.

[6 ✓ - 3m; 4 - 5 ✓ - 2m; 2 - 3 ✓ - 1m]
A1 (c) Potassium is vital in for normal organs function in human body and potassium chloride tablet is commonly used to treat low levels of potassium for patients.

(i) Draw a 'dot-and-cross' diagram to show the bonding in potassium chloride. 

Show outer shell electrons only. 

[1m for K⁺; 1m for Cl⁻] 

(ii) The medicine usually comes in a tablet form. 

Describe an experiment that can be used to show that the tablet contains chloride ions. 

State the expected observation from the experiment. 

Dissolve KCl tablet in water. [1] 

Add HNO₃ and follow by AgNO₃ / PbNO₃ / acidified AgNO₃ / PbNO₃ [1] 

White ppt observed showing the presence of Cl⁻ [1] 

[Total: 10] 

A2 Limescale is the hard, off-white deposit found in kettles, hot-water boilers and other electrical appliances. It is unsightly and may impair the operation or damage various components in these electrical appliances. Limescale is made up of mainly calcium carbonate.

Limescale can be removed by using descaling agents which contain ethanoic acid or hydrochloric acid.

(a) Write an equation to show the descaling process using ethanoic acid.

$$2\text{CH}_3\text{COOH} + \text{CaCO}_3 \rightarrow \text{Ca(CH}_3\text{COO)}_2 + \text{CO}_2 + \text{H}_2\text{O}$$ [1]
(b) Ethanoic acid is a weak acid.

(i) Explain the term weak acid.

Dissociate partially in water to give a lower concentration of H⁺. [1]

(ii) Explain, in terms of collisions between particles, which descaling agent, ethanoic acid or hydrochloric acid, would remove the limescale faster.

Hydrochloric acid should remove the limescale faster as it is a strong acid. [1]

It dissociates completely in water to give a higher concentration of H⁺. [1]

Higher no. of mol. of H⁺ for the same volume, higher frequency of effective collision thus faster speed of reaction. [1] [3]

(iii) Descaling agents used should not contain sulfuric acid.

Explain why.

H₂SO₄ reacts with CaCO₃ to form calcium sulfate, insoluble in water. [1]

Thus, it will not be removed and remain as ppt in appliances. [1] [2]

---

A3 The diagram shows a dissection of an electrical wire.

(a) Copper is the most common material used to make electrical wire.

Give two reasons why copper is being used.

Copper is ductile and can be drawn into a thin wire. [1]

Copper is a good conductor of electricity due to the presence of mobile electrons. [1] [2]
A3 (b) Copper is extracted from its ore, chalcopyrite, CuFeS₂ in a 2-step reaction.

Copper(I) sulfide formed in Step 1 is further reacted to form copper in Step 2.

[Step 1] \[2\text{CuFeS}_2 + 2\text{SiO}_2 + 4\text{O}_2 \rightarrow \text{Cu}_3\text{S} + 2\text{FeSiO}_3 + 3\text{SO}_2\]

[Step 2] \[\text{Cu}_3\text{S} + \text{O}_2 \rightarrow 2\text{Cu} + \text{SO}_2\]

(i) State and explain, in terms of electron transfer, which substance is reduced in Step 2.

Support your answer using half ionic equation(s).

Cu₂S is reduced. [1]

\[\text{Cu}^+ (l) + e^- \rightarrow \text{Cu} (s)\] [1]

Cu⁺ gains electrons to form Cu. Thus, it is reduced. [1]

(ii) The gaseous by-product is recycled to manufacture sulfuric acid.

Describe a simple test to show that the gaseous by-product is acidic.

Place a moist blue litmus paper at the mouth of a test tube.

The moist blue litmus paper will turn red. [1]

(iii) Explain, other than cost, why the by-product should be recycled and not released directly into the environment.

Sulfur dioxide is acidic.

It will dissolve in rain water to form acid rain[1]. Acid rain destroy building / kill aquatic life. [1]

[2]
A3  (b)  (iv) Some copper is used to make brass, which is a mixture of copper and zinc. Yellow brass is the industry standard brass commonly used in making musical instruments. It comprises of 30% zinc and 70% copper.

Draw a diagram to show the arrangement of atoms in brass. Explain why it is more useful in making musical instruments than pure copper. Label your diagram.

Brass is harder than pure copper. Zinc atoms has different size from copper and disrupted the regular arrangement in pure copper. The atoms of different sizes cannot slide over each other easily.

[1m for labelling and correct ratio of Cu and Zn]

[4] [2m; 2 - 3] [1m; 1 - 0]

[Total: 11]

A4  The diagram below shows the apparatus used for the fractional distillation of petroleum.

(a) State the name and one use of the fraction X.

Petroleum gas [1]

For cooking [1] [2]

Page 6 of 20
A4  (b) Some cars use diesel as fuel while some use petrol.

Explain why the combustion of diesel produce more soot than petrol.

Diesel has a longer carbon chain / number of carbon than petrol. [1]

Thus, the chances of incomplete combustion of diesel is higher producing more soot. [2]

(c) Both petrol and diesel cars produces carbon monoxide.

Describe a harmful effect of carbon monoxide.

Breathing in CO will cause respiratory problem / combines with haemoglobin to form carboxyhaemoglobin and lead to death. [1]

(d) Besides carbon monoxide, nitrogen dioxide is also produced in motor vehicles.

A device is installed in motor vehicles’ exhaust to remove both gases.

State the name of the device and explain, using a single equation, how carbon monoxide and nitrogen dioxide is removed in motor vehicles using the device.

Catalytic converter. [1]

\[ 4CO + 2NO_2 \rightarrow 4CO_2 + N_2 \] CO and NO\textsubscript{2} reacts to form a less harmful products CO\textsubscript{2} and N\textsubscript{2}. [2]

(e) Despite having the device mentioned above, explain why it does not solve all the pollution problems caused by motor vehicles.

CO\textsubscript{2} is not removed.

CO\textsubscript{2} is a greenhouse gas that cause global warming, melting ice caps and flood in low rise land. [1]

[Total: 8]
Alkynes are a homologous series of organic compounds.

<table>
<thead>
<tr>
<th>Alkyne</th>
<th>Chemical Formula</th>
<th>Structural formula</th>
<th>Boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethyne</td>
<td>C₂H₂</td>
<td>H–C≡C–H</td>
<td>-84</td>
</tr>
<tr>
<td>propyne</td>
<td>C₃H₄</td>
<td>H–H–C≡C–H</td>
<td>-23</td>
</tr>
<tr>
<td>butyne</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Pentyne</td>
<td>C₄H₆</td>
<td></td>
<td>39</td>
</tr>
</tbody>
</table>

(a) Use the information in the table to give two pieces of evidence that suggest that the alkynes are a homologous series.

Alkynes have the same general formula of CₙH₂ₙ−2 [1]

Alkynes have the same functional group C≡C [1] [2]

(b) Give the chemical formula and full structural formula of butyne.

Chemical formula: C₄H₆ [1]

Full structural formula:

![ structural formula of butyne ]

[1] [2]
A5  (c) The first member of the homologous series is ethyne. Explain why there is no alkyne with a single carbon.

The functional group is C≡C. Thus the **minimum number** of carbon in a molecule of alkyne should be 2. [1]

(d) Ethyne undergoes a similar polymerisation reaction like ethene. The diagram below shows the structure of polyethylene.

![Polyethylene structure](image)

Give one similarity and one difference between polyethylene and polyethene.

Polyethene is **saturated** while polyethylene is **unsaturated** hydrocarbon. [1]

Both polyethylene and polyethene are **hydrocarbons**. [1]

[Total: 7]

A6  
Fats and protein are two natural polymers that are essential part of our diets and has a number of important roles in our body.

The diagrams below show examples of fats and protein molecules:

![Fats and Protein structures](image)
(a) (i) Circle the amide linkage in the diagrams in Page 9. Label it “amide”. [1]
(ii) Circle the ester linkage in the diagrams in Page 9. Label it “ester”. [1]
[any of the ester and amide linkage in the molecule with label; 1 m each]

(b) Draw the structures of the monomers that are used to form fats and protein. [3]

Fats:

\[
\begin{align*}
\text{glycerol} & : & \text{fatty acids} \\
\end{align*}
\]

Protein:

\[
\begin{align*}
\end{align*}
\]

(c) (i) Name a synthetic polymer that has a similar linkage to fat. [1]

Terylene

(ii) State one use for the polymer stated above. [1]

Clothing / sleeping bag / parachutes

[Total: 7]
Section B (30 Marks)

Answer all three questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Read the information about the industrial production of oxygen.

There are many methods used in the industry to produce oxygen. Production cost, purity and volume desired are some of the key factors determining the selection criteria. The production of oxygen using Pressure Swing Adsorbers (PSA) and electrolysis are simplified in the diagrams below.

<table>
<thead>
<tr>
<th>Pressure Swing Adsorbers (PSA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air in</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Air is pressurised in the compressor before passing into adsorber towers. In the adsorber towers, nitrogen and oxygen in the air are separated. The substance used in the adsorber towers needs to be replaced or regenerated after a certain volume of air has been separated as it will become saturated with nitrogen.

<table>
<thead>
<tr>
<th>Electrolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilute aqueous NaCl is electrolysed to produce oxygen and hydrogen using graphite electrodes. In theory, the ratio of hydrogen gas to oxygen gas collected should be 2:1. As oxygen is more soluble than hydrogen in water thus the ratio of gases collected will change.</td>
</tr>
</tbody>
</table>
The table below shows more information about the two methods.

<table>
<thead>
<tr>
<th></th>
<th>Pressure Swing Adsorbers (PSA)</th>
<th>Electrolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall energy consumption (kWh per m³ of O₂) 1 m³ = 1000 dm³</td>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>Purity of O₂ produced</td>
<td>&lt;95 %  (&gt;99.9 % can only be achieved with extremely high-end device)</td>
<td>&gt;99.9 %</td>
</tr>
<tr>
<td>By-product</td>
<td>Impure nitrogen is produced</td>
<td>Produced hydrogen which can be used as fuel</td>
</tr>
</tbody>
</table>

(a) Give two disadvantages, other than lower purity, of producing oxygen using PSA.

Nitrogen produced is not usable as it is impure / contaminated. [1]

The adsorbents need to be replaced regularly and this may increase the cost of production. [1]

[2]

(b) Explain why the theoretical volume ratio hydrogen to oxygen produced in electrolysis is 2:1.

2H₂O → 2H₂ + O₂ [1]

Water is electrolysed to form hydrogen and oxygen. The mole ratio of H₂O to H₂ is 1:1 while to O₂ is 2:1. [1]

[2]

(c) State and explain how would the final volume of the gases collected in electrolysis change due to the difference in solubility of the gases in water.

The volume of oxygen collected will be lower than expected as it is soluble in water. [1] The volume of hydrogen collected should be the same as it is not soluble in water. [1]

[2]
(b) Calculate the energy consumption using electrolysis per mole of oxygen gas produced.

10 kWh of electricity produces 1000 dm$^3$ of oxygen

No of mol of O$_2$ produced = 1000 / 24

= 41.6666 mol [1]

Energy consumption per mol of O$_2$ produced = 10 / 41.6666

= 0.240 kWh [1] (3sf with unit) [2]

(e) What happens to the concentration of NaCl during the electrolysis?

Explain your reasoning.

The concentration of NaCl would increase. Water is being electrolysed to form gases and thus the solution become more concentrated. [1]

(e) The electrolyte used in the set up above needs to be replaced regularly.

Explain why the electrolyte needs to be replaced regularly.

Support your answer with equations explaining the reaction at each electrode.

Oxygen will not be produced in concentrated NaCl. Cl$^-$ will be selectively discharged / oxidised at the anode for concentrated NaCl. [1]

Anode: $2Cl^-$ (aq) $\rightarrow$ Cl$_2$ (g) + 2e$^-$ [1] Cathode: 2H$^+$ (g) + 2e$^-$ $\rightarrow$ H$_2$ (g) [1]

[Total: 12]
Oswald process is a chemical process for making nitric acid. The raw materials of Oswald process are ammonia, water and oxygen gas. Platinum is used as catalyst for the process. There are multiple steps in the process. In the first step of the process, ammonia reacts with oxygen in a reversible reaction to form nitrogen monoxide. It gives 85% yield at the optimum temperature of 800°C and pressure of 1 atm. The equation below shows the reactions between ammonia and oxygen.

\[ 4\text{NH}_3 (g) + 5\text{O}_2 (g) = 4\text{NO} (g) + 6\text{H}_2\text{O} (g) \quad \Delta H = -104 \text{ kJ/mol} \]

The graph below shows the yield of nitrogen monoxide with varying temperature and pressure.

(a) State the conditions for the process to obtain ammonia in the industry.

\[ 200 - 250 \text{ atm}, \quad 400 - 450^\circ\text{C} \text{ and finely divided iron as catalyst [1]} \]

(b) (i) Describe the relationship between percentage yield of nitrogen monoxide with temperature and pressure.

The lower the temperature and pressure, the higher the yield. [1]

(b) (ii) Use the graph to explain why the optimum temperature and pressure is chosen for the first step of Oswald process.

Low temperature and pressure high yield but slow speed of reaction [1]

High temperature and pressure low yield and requires high end equipment [1]
(c) Draw an energy profile diagram to show the effect of the catalyst on the first step of the Ostwald process.

Your diagram should show and label:
- reactants and products,
- the activation energy for the uncatalysed and catalysed reactions,
- the enthalpy change of reaction.

![Energy Profile Diagram]

\[ \Delta H = -104 \text{ kJ/mol} \]

(d) A reaction is carried out at 800 °C and 2 atm using 1 tonne of ammonia with excess oxygen.

With reference to the graph, calculate the volume of nitrogen monoxide produced.

(1 tonne = 1 x 10^6 g)

The percentage yield at 800 °C and 2 atm is 50%.

No mol of ammonia = \( \frac{1000000}{17} \) mol = 58823.53 mol [1]

\( \text{NH}_3 : \text{NO} \equiv 1 : 1 \)

No of mol of NO produced = 58823.53 mol

Volume of NO produced = \( 58823.53 \times 24 \times 50\% \) [1]

\[ = 705882.4 \text{ dm}^3 \]

\[ = 7.06 \times 10^5 \text{ dm}^3 \text{ (3 s.f.)} \] [1]

[Total: 10]
EITHER

B9 Water soluble laundry bags are made of PVA (polyvinyl alcohol).

It is often used in hospitals to reduce the hazards associated with storage and cleaning of contaminated washable items.

The structure of PVA is given below:

\[ \text{CH}_2-\text{CH}-\text{CH}_2-\text{CH}-\text{CH}_2- \]

\[ \text{O} \quad \text{O} \quad \text{H} \quad \text{H} \]

(a) (i) State the type of polymerisation occurred to form PVA.

Type of polymerisation: Addition polymerisation

(ii) Draw the structure of the monomer of PVA.

(b) The monomer reacts with hydrogen to form ethanol.

Ethanol can be oxidised to form two other products under different conditions.

(i) Suggest a suitable reagent that can be used to oxidise ethanol to form the product 2.

Acidified KMnO\text{4}
EITHER

B9 (b) (i) Are product 1 and 2 isomers of ethanol?
Explain your reasoning.

They are **not isomers** of ethanol. [1]

Both product 1 and 2 **don't have the same molecular formula** as ethanol.

Product 1 is $C_2H_5O$ and product 2 is $C_3H_6O_2$ while ethanol is $C_2H_5O$. [1]

(ii) Ethanol reacts with product 2 to produce a sweet smelling substance.

Give the name and structure of the product form.

Name of the product: Ethyl ethanoate [1]

Structure:

![Structure of Ethyl Ethanoate]

(iv) State a commercial use of the substance above.

**Food flavouring / solvent / making perfume**

[Total: 8]
OR

B9 The diagram below shows the two methods used to make polythene.

```
Glucose ➔ Ethanol ➔ Compound Y ➔ Polythene

Naphtha
```

(a) Name for the process used to make ethanol from glucose and state the optimum conditions for the reaction.

Fermentation [1]

Anaerobic condition with 37°C [1] [2]

(b) State the possible source for the raw material to produce ethanol from glucose and give the balanced chemical reaction for the reaction.

Sugarcane / fruits / rice [1]

\[ \text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2 \] [1]

[2]

(c) A student carried out an experiment to produce compound Y from ethanol.

Suggest a method for the student to check if compound Y has formed and state the expected observation.

Add aqueous bromine to the compound Y. [1]

Brown bromine solution turns colourless. [1]

[2]

(d) Compound Y can also be obtained from naphtha.

Suggest one way in which it can be obtained from naphtha.

Catalytic (thermal) cracking [1]
(e) State an advantage, other than cost and percentage yield, of obtaining compound Y from glucose rather than naphtha.

Glucose is a **renewable** source thus it is sustainable **OR**

It helps to **conserve** the **finite** natural resource of petroleum. [1]

[Total: 8]

End of Paper
READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, class and register number on the Answer Sheet in the spaces provided unless this has been done for you.

There are forty questions on this paper. Answer all questions.
For each question there are four possible answers A, B, C and D.
Choose the one you consider correct and record your choice in soft pencil on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark.
A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic table is printed on page 17.
1. The diagram shows the apparatus used to separate Methylcyclopentane (boiling point 70°C) and heptane (boiling point 98°C).

Which graph would be obtained if volume of distillate collected was plotted against temperature?

A

B

C

D

2. Which one of the following pairs of gases diffuses at the same speed?

A  nitrogen and oxygen
B  nitrogen and carbon monoxide
C  nitrogen and ammonia
D  nitrogen and nitrogen dioxide
3. Sulfur dioxide gas is over twice as dense as nitrogen gas. A gas jar of sulfur dioxide was placed on top of a gas jar of nitrogen gas with the open ends together.

After half an hour, which of these statements would be true?

A. The top gas jar contained nitrogen gas only.
B. Some of each gas would have moved into the other gas jar.
C. The gases would not have mixed.
D. The bottom gas jar would contain nearly all the sulfur dioxide.

4. A stable molecule containing atoms of the elements X, Y and Z has the following structure:

\[
\begin{array}{c}
Y \\
Z \\
Z \\
X \\
Y \\
X \\
Y \\
Z
\end{array}
\]

Which of the following is a possible combination of elements?

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Si</td>
<td>P</td>
<td>Na</td>
</tr>
<tr>
<td>B</td>
<td>P</td>
<td>Si</td>
<td>F</td>
</tr>
<tr>
<td>C</td>
<td>F</td>
<td>Si</td>
<td>P</td>
</tr>
<tr>
<td>D</td>
<td>Si</td>
<td>P</td>
<td>F</td>
</tr>
</tbody>
</table>

5. Which particle has the least number of electrons in its valence shell?

A. I
B. N⁺
C. Ne
D. O²⁻
6 The diagram represents an atom of an isotope X of an element.

If the element consists of only two isotopes, which one of the following is likely to represent the particles of the other isotope of the element?

<table>
<thead>
<tr>
<th></th>
<th>Proton</th>
<th>Neutron</th>
<th>Electron</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>D</td>
<td>11</td>
<td>12</td>
<td>11</td>
</tr>
</tbody>
</table>

7 Which of the following substances contain delocalised electrons?

- I. copper
- II. graphite
- III. solid copper (II) chloride
- IV. molten copper (II) chloride

A I and II  
B I and IV  
C II and III  
D III and IV
8. Elements P and R react to form compound S which is a liquid at room conditions. The formula of S is $P_2R$.

   If R is a group VI element, P is

   A. sodium
   B. phosphorous
   C. hydrogen
   D. silicon

9. 12.0 g of anhydrous magnesium sulfate combines with 12.6 g of water to form hydrated magnesium sulfate.

   What is the formula of hydrated magnesium sulfate?

   A. $\text{MgSO}_4\cdot3\text{H}_2\text{O}$
   B. $\text{MgSO}_4\cdot5\text{H}_2\text{O}$
   C. $\text{MgSO}_4\cdot7\text{H}_2\text{O}$
   D. $\text{MgSO}_4\cdot9\text{H}_2\text{O}$

10. A hydrocarbon contains 86% carbon and 14% hydrogen by mass.

    What is the probable molecular formula?

    A. $\text{CH}_4$
    B. $\text{C}_4\text{H}_8$
    C. $\text{C}_6\text{H}_6$
    D. $\text{C}_8\text{H}_8$

11. Compound X is a white solid. When X is warmed with sodium hydroxide solution, a gas with pungent smell is liberated. The gas turns moist red litmus paper blue. When a solution of X is treated with dilute hydrochloric acid, bubbles are seen in the solution.

    What is X most likely to be?

    A. ammonium sulfate
    B. ammonium carbonate
    C. potassium nitrate
    D. potassium hydrogen carbonate
12 The following tests were carried out on a green solid.

I. It produced water when it was gently heated alone.
II. It gave a green precipitate when dissolved in water and added to aqueous ammonia.
III. It gave a white precipitate when dissolved in water and added to silver nitrate solution.

From these tests, identify the green solid.

A. anhydrous copper (II) chloride
B. hydrated iron (II) chloride
C. hydrated iron (II) sulfate
D. hydrated copper (II) sulfate

13 Which one of the following reagents gives a precipitate with a solution of Cu²⁺ (aq), which dissolves in excess reagent?

A. NaOH (aq)
B. NH₃ (aq)
C. AgNO₃ (aq)
D. Na₂CO₃ (aq)

14 The table below gives information about three indicators.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Colour in strongly acidic solution</th>
<th>pH at which colour changes</th>
<th>Colour in strongly alkaline solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>methyl orange</td>
<td>red</td>
<td>4.5</td>
<td>Yellow</td>
</tr>
<tr>
<td>bromothymol blue</td>
<td>yellow</td>
<td>6.5</td>
<td>Blue</td>
</tr>
<tr>
<td>phenolphthalein</td>
<td>colourless</td>
<td>9.0</td>
<td>Pink</td>
</tr>
</tbody>
</table>

If equal amounts of indicators were added to separate samples of pure water, what would be the colours of the resulting solutions?

A. methyl orange: yellow, bromothymol blue: blue, phenolphthalein: pink

B. methyl orange: red, bromothymol blue: yellow, phenolphthalein: colourless

C. methyl orange: yellow, bromothymol blue: yellow, phenolphthalein: colourless

D. methyl orange: yellow, bromothymol blue: blue, phenolphthalein: colourless
15 Which of the following mixtures produces ammonia when heated?

A  CH₃COONH₄ + Ba(OH)₂
B  NH₄NO₃ + NaCl
C  NH₄NO₃ + HCl
D  NH₄NO₃ + Al

16 Which of the equation does not represent a redox reaction?

A  3Cl₂(g) + 2Fe (s) → 2FeCl₃ (s)
B  Ba²⁺ (aq) + SO₄²⁻ (aq) → BaSO₄ (s)
C  Fe²⁺ (aq) + Mg (s) → Fe (s) + Mg²⁺ (aq)
D  Zn (s) + 2HCl (aq) → ZnCl₂ (aq) + H₂ (g)

17 In which reaction does chromium undergo a change in oxidation number?

A  Cr₂O₃ + 3H₂SO₄ → Cr₂(SO₄)₃ + 3H₂O
B  Cr₂(SO₄)₃ + 6NaOH → 2Cr(OH)₃ + 3Na₂SO₄
C  K₂Cr₂O₇ + 4H₂SO₄ + 6HCl → Cr₂(SO₄)₃ + K₂SO₄ + 7H₂O + 3Cl₂
D  2K₂CrO₄ + H₂SO₄ → K₂Cr₂O₇ + K₂SO₄ + H₂O

18 Small portions of aqueous potassium iodide (KI) and acidified potassium manganate (VII) (KMNO₄) were separately added to four solutions.

The colour changes are shown in the table below:

<table>
<thead>
<tr>
<th>solution number</th>
<th>potassium iodide</th>
<th>potassium manganate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>colourless to brown</td>
<td>purple to colourless</td>
</tr>
<tr>
<td>2</td>
<td>colourless to brown</td>
<td>no change</td>
</tr>
<tr>
<td>3</td>
<td>no change</td>
<td>purple to colourless</td>
</tr>
<tr>
<td>4</td>
<td>no change</td>
<td>no change</td>
</tr>
</tbody>
</table>

Which solution(s) contained an oxidising agent?

A  1 only
B  1 and 2
C  1 and 3
D  2 and 4
19 Which of the following diagrams shows the structure of bronze?

A

B

C

D

20 Three metallic oxide powders containing metals, R, S and T are heated strongly in a hard glass tube as shown below. At the same time, carbon monoxide gas is directed through the tube.

![Diagram]

Oxide of R glows slightly, oxide of T glows strongly while oxide of S does not undergo any changes.

Based on these observations, which list shows the descending order of reactivity (most reactive first) of metal R, S and T?

A  R, S, T
B  T, R, S
C  S, R, T
D  T, S, R
21 Several properties of metals can be explained by the fact that layers of atoms can slide over each other.

Which one of the following properties of metals is not explained by this fact?

A  Metals are malleable.
B  Metals conduct electricity.
C  Pure metals are softer than alloys.
D  Metals are ductile.

22 The diagram shows the results of an electrolysis using inert electrodes.

Which of the following could be liquid R?

A  aqueous silver nitrate
B  aqueous sodium carbonate
C  concentrated hydrochloric acid
D  molten magnesium iodide
23 The diagram below shows a simple electrochemical cell.

An electric current flows from P to Q. Suggest the identity of P and Q.

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>copper</td>
<td>magnesium</td>
</tr>
<tr>
<td>B</td>
<td>zinc</td>
<td>magnesium</td>
</tr>
<tr>
<td>C</td>
<td>zinc</td>
<td>iron</td>
</tr>
<tr>
<td>D</td>
<td>copper</td>
<td>iron</td>
</tr>
</tbody>
</table>

24 When an aqueous solution containing Fe$^{2+}$ and V$^{n+}$ ions is electrolysed, the same amount of charge produces 16.8 g of iron and 10.2 g of vanadium.

What is the value of $n$ in V$^{n+}$ ion?

A 1  
B 2  
C 3  
D 4

25 The element astatine (At) is beneath iodine in Group VII of the Periodic Table.

Which one of the following is a likely property of astatine?

A It can be liberated from a solution of its salt by chlorine gas.  
B It conducts electricity in molten state.  
C It forms a basic oxide.  
D It displaces iodine from aqueous potassium iodide.
26. The table below represents 8 elements P, Q, R, S, T, U, V and W across Period 2 of the Periodic Table.

| 3P | 4Q | 5R | 6S | 7T | 8U | 9V | 10W |

Which of the following properties is **incorrect**?

A. The chlorides of T have high melting points whereas chlorides of P have low melting points.
B. The oxides of T are acidic whereas the oxides of P are alkaline.
C. P and Q are metals whereas V and W are non-metals.
D. V atoms are smaller than P atoms.

27. Which statement about groups in the Periodic Table is **correct**?

A. All elements form either positively charged ions or negatively charged ions.
B. In Group I, all the elements form covalent compounds with hydrogen.
C. In Group VII, all the elements form ionic bonds with most metals.
D. All groups contain acidic and basic oxides.

28. The process of dissolving potassium iodide in water is **endothermic**.

Which of the following graphs shows the temperature changes that occur when potassium iodide is stirred with water until no further change in temperature is observed?

A. [Graph A]
B. [Graph B]
C. [Graph C]
D. [Graph D]
29. Which one of the following is an endothermic process?

A. \( \text{C (s)} + \text{O}_2 (g) \rightarrow \text{CO}_2 (g) \)
B. \( \text{HCl (aq)} + \text{NaOH (aq)} \rightarrow \text{NaCl (aq)} + \text{H}_2\text{O (l)} \)
C. \( 6\text{CO}_2 (g) + 6\text{H}_2\text{O (g)} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(aq) + 6\text{O}_2(g) \)
D. \( \text{H}_2\text{O (g)} \rightarrow \text{H}_2\text{O (l)} \)

30. The combustion of methane is an exothermic process.

\[ \text{CH}_4 (g) + 2\text{O}_2 (g) \rightarrow \text{CO}_2 (g) + 2\text{H}_2\text{O (g)} \quad \Delta H = -890 \text{ kJ} \]

How much methane should be used to produce 2670 kJ of heat?

A. 48 g
B. 64 g
C. 96 g
D. 120 g

31. Sodium thiosulfate reacts with hydrochloric acid to form sulfur.

Which sodium thiosulfate solution gives the highest initial rate of reaction?

A. 4 g of sodium thiosulfate dissolved in 50 cm³ of water.
B. 10 g of sodium thiosulfate dissolved in 100 cm³ of water.
C. 20 g of sodium thiosulfate dissolved in 500 cm³ of water.
D. 40 g of sodium thiosulfate dissolved in 2000 cm³ of water.
32 A student performs two reactions.

Reaction 1
10 g of magnesium ribbon with excess 2.0 mol/dm³ dilute hydrochloric acid

Reaction 2
5 g of magnesium powder with excess 2.0 mol/dm³ dilute hydrochloric acid

In both experiments, the volume of hydrogen produced, V, is measured against time, t, and the result plotted graphically.

Which set of graphs is correct?

33 Ammonia is produced industrially by Haber process.

Which of the following statement is not true about the Haber process?

A Nitrogen is obtained from air.
B High temperature is applied to overcome the activation energy.
C A catalyst is added to decrease the enthalpy change of the forward reaction.
D High pressure is applied to increase the yield of ammonia.
34 Which one of the following pairs of gases are common pollutants of the atmosphere?

A nitrogen and sulfur dioxide
B chlorine and hydrogen
C carbon dioxide and ammonia
D sulfur dioxide and nitrogen dioxide

35 Which one of the following explains why carbon monoxide is poisonous?

A It is oxidised to carbon dioxide in the lungs.
B It is reduced to carbon in the lungs.
C It combines with haemoglobin.
D It is inflammable.

36 Which one of these pollutant gases in the air is mainly responsible for the greenhouse effect?

A sulfur dioxide
B carbon dioxide
C carbon monoxide
D nitrogen dioxide

37 The reaction between the hydrocarbon C₆H₆ and hydrogen can be represented by the equation:

\[ \text{C}_6\text{H}_6 (g) + \text{H}_2 (g) \rightarrow \text{C}_6\text{H}_8 (g) \]

Which of the following statements about the above reaction is true?

A It is a substitution reaction.
B UV light is required for the reaction to take place.
C The molecular formula of the hydrocarbon is C₂H₆.
D The molecular formula of the hydrocarbon is C₆H₆.
38 The diagram shows the fractional distillation of petroleum.

Which statements about fractions X and Y are correct?

<table>
<thead>
<tr>
<th></th>
<th>X is more flammable than Y</th>
<th>X burns with a less sooty flame than Y</th>
<th>X is more viscous than Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>B</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>C</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

39 The diagram shows the structure of a hydrocarbon X.

Which of the following structures are isomers of hydrocarbon X?

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A i, ii
B i, iii
C i, ii, iv
D i, ii, iii, iv
The structure of the plastic Perspex is shown below.

What is the molecular structure of the monomer from which this plastic is formed?

A

B

C

D

End of Paper
Marking Scheme

Geylang Methodist School (Secondary)
Prelim Exam 2017
Chemistry 5073

Paper 1

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>11</td>
<td>B</td>
<td>21</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>12</td>
<td>B</td>
<td>22</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>13</td>
<td>B</td>
<td>23</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>14</td>
<td>D</td>
<td>24</td>
<td>C</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>15</td>
<td>A</td>
<td>25</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>16</td>
<td>B</td>
<td>26</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>A</td>
<td>17</td>
<td>C</td>
<td>27</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>18</td>
<td>B</td>
<td>28</td>
<td>D</td>
</tr>
<tr>
<td>9</td>
<td>C</td>
<td>19</td>
<td>B</td>
<td>29</td>
<td>C</td>
</tr>
<tr>
<td>10</td>
<td>B</td>
<td>20</td>
<td>C</td>
<td>30</td>
<td>A</td>
</tr>
</tbody>
</table>

Need a home tutor? Visit smiletutor.sg
READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer all questions in the spaces provided.

Section B
Answer all three questions, the last question is in the form either/or.
Write your answers in the spaces provided.

At the end of the examination, detach Section A from Section B and hand them in separately.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page 22.
Section A
Answer all the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The diagram shows the nuclei of five different atoms.

key

○ neutron
● proton

atom A  atom B  atom C  atom D  atom E

(a) Which atom is most likely to be in Group 0? ..................................................[1]

(b) Which atom has an atomic number of 3? .............................................................[1]

(c) Which atom has a nucleon number of 6? .........................................................[1]

(d) Which two atoms are isotopes of the same element? ........................................[1]

   and..........................................................

(e) Suggest the name of the element in (d). .............................................................[1]

(f) Which two atoms lose an electron when they form ions? ..................................[2]

[Total: 7]
A2 The table below shows the concentration of different ions found in a sample of aqueous industrial waste:

<table>
<thead>
<tr>
<th>ion</th>
<th>concentration (mol/dm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca²⁺</td>
<td>0.125</td>
</tr>
<tr>
<td>H⁺</td>
<td>2.300</td>
</tr>
<tr>
<td>K⁺</td>
<td>0.234</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>3.680</td>
</tr>
<tr>
<td>Cu²⁺</td>
<td>0.450</td>
</tr>
</tbody>
</table>

Use the information in the table to answer the following questions.

(a) Write the chemical formula of a coloured salt that could be obtained from the sample.

(b) A student wants to obtain the salt in (a) using the following method.

metal + dilute nitric acid \[\rightarrow\] salt in (a) + hydrogen

Why is this method not feasible?

(c) Suggest a modification to the method in (b) to obtain a pure and dry sample of the salt in (a).
(d) Is the sample of aqueous industrial waste acidic, neutral or alkaline? Explain your answer.

[1]

(e) What would be observed when aqueous sodium hydroxide is added to a sample of the aqueous industrial waste until no further change is seen?

[2]

[Total: 8]

A3 The structures of phosphorus trioxide and diamond are shown below. Phosphorus trioxide is a covalent compound with a simple molecular structure. Diamond has a giant molecular structure of carbon atoms.

(a) Write down the molecular formula of phosphorus trioxide.

[1]

(b) Describe how a simple molecular structure differs from a giant molecular structure.

[2]
(c) Explain why the melting point of phosphorus trioxide is lower than that of diamond.

(d) An oxide was found to have the following composition by mass.

<table>
<thead>
<tr>
<th>element</th>
<th>percentage by mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>phosphorus</td>
<td>43.7</td>
</tr>
<tr>
<td>oxygen</td>
<td>56.3</td>
</tr>
</tbody>
</table>

Deduce whether this oxide could be phosphorus trioxide by determining its empirical formula.

[Total: 9]
Ammonia is manufactured by the Haber Process.

\[ N_2 + 3H_2 \rightleftharpoons 2NH_3 \quad \Delta H = -92.4 \text{ kJ/mol} \]

The table below shows how the percentage yield of ammonia at equilibrium varies with both temperature and pressure.

<table>
<thead>
<tr>
<th>pressure / atm</th>
<th>percentage yield of ammonia at equilibrium</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200 °C</td>
</tr>
<tr>
<td>40</td>
<td>72</td>
</tr>
<tr>
<td>100</td>
<td>81</td>
</tr>
<tr>
<td>200</td>
<td>86</td>
</tr>
<tr>
<td>300</td>
<td>88</td>
</tr>
</tbody>
</table>

(i) Describe how the percentage yield of ammonia at equilibrium changes with temperature.

.........................................................................................................................[1]

(ii) Describe how the percentage yield of ammonia at equilibrium changes with pressure.

.........................................................................................................................[1]

(iii) Explain how using a catalyst in the Haber Process has an economic advantage.

.........................................................................................................................[2]
(b) Ammonia is used to manufacture nitric acid by a two-stage process.

**Stage 1** Ammonia is converted to nitrogen monoxide.

\[ 4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{g}) \]

**Stage 2** Nitrogen monoxide is converted to nitric acid.

\[ 4\text{NO}(\text{g}) + 2\text{H}_2\text{O}(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 4\text{HNO}_3(\text{aq}) \]

(i) It is possible to find out whether the reaction in **Stage 1** has completed by following the pH changes during the reaction. Samples of gas are taken from the reaction vessel at regular time intervals and bubbled through water to form a solution. The pH of each solution is measured. Explain why the measured pH changes during the reaction.

(ii) Use the equations in the two stages to construct an overall equation for the conversion of ammonia to nitric acid.

[Total: 6]
The manufacture of sulfuric acid is described below.

step 1: Sulfur is burnt in excess air to form sulfur dioxide.

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

step 2: Sulfur dioxide reacts with more oxygen to form sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -196 \text{ kJ/mol}$$

step 3: Sulfur trioxide is dissolved in concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

$$H_2SO_4(l) + SO_3(g) \rightarrow H_2S_2O_7(l)$$

step 4: Oleum can then react safely with water to produce concentrated sulfuric acid.

$$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$$

(a) Is step 3 a redox reaction? Use ideas about oxidation states to explain your answer.

(b) Explain, in terms of collisions between reacting particles, how a higher pressure affects the rate of reaction in step 1.
(c) (i) Complete the energy profile diagram below for the reaction of sulfur dioxide and oxygen to produce sulfur trioxide. The activation energy for this reaction is 2200 kJ/mol.

Label clearly the reaction enthalpy change and the activation energy.

\[ \text{energy / kJ/mol} \]

\[ 2\text{SO}_2 + \text{O}_2 \]

progress of reaction

[3]

(ii) State the values of the enthalpy change, \( \Delta H \), and the activation energy, \( E_a \), of the reverse reaction.

\[ \Delta H = \ldots \text{kJ/mol} \]

\[ E_a = \ldots \text{kJ/mol} \]

[2]

[Total: 9]
The atmosphere contains a large number of gases including oxygen, nitrogen, carbon dioxide, sulfur dioxide, oxides of nitrogen, methane and chlorofluorocarbons (CFCs).

(a) Carbon dioxide, methane and CFCs are greenhouse gases.

(i) State one effect of an increase in the atmospheric concentration of carbon dioxide and methane.

(ii) State one source of methane gas.

(iii) State one other environmental effect of the presence of CFCs in the atmosphere.

(b) The formula of one chlorofluorocarbon is CFC\(_3\).

Draw a dot-and-cross diagram to show the bonding in a molecule of CFC\(_3\).

You only need to show outer shell electrons.

[2]
(c) Oxides of nitrogen are produced during the combustion of petrol (gasoline) in a car engine.

(i) Describe the chemical reaction that takes place within a car engine to form nitric oxide, NO.

(ii) Most of the nitric oxide and other pollutants present in the exhaust gases of a car are removed in a catalytic converter. Describe the redox reactions that happen within a catalytic converter.

(d) Nitrogen dioxide is one of the causes of acid rain. Two moles of nitrogen dioxide react with one mole of water to make an aqueous solution of two acids only. One of these acids is nitric acid. Deduce the formula of the other acid.

[Total: 9]

End of Section A
Section B

Answer all three questions from this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.
The total mark for this section is 30.

B7 Alkenes are unsaturated hydrocarbons. They contain one or more carbon-carbon double bonds. Alkenes can exist as branched or unbranched hydrocarbons. Short-chain alkenes such as ethene and propene are used as starting materials for making ethanol and plastics.

Table 1 shows the boiling points of some straight chain alkenes.

<table>
<thead>
<tr>
<th>name</th>
<th>formula</th>
<th>boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethene</td>
<td>C₂H₄</td>
<td>-104</td>
</tr>
<tr>
<td>propene</td>
<td>C₃H₆</td>
<td>-47</td>
</tr>
<tr>
<td>butene</td>
<td>C₄H₈</td>
<td>-6</td>
</tr>
<tr>
<td>pentene</td>
<td>C₅H₁₀</td>
<td>30</td>
</tr>
<tr>
<td>hexene</td>
<td>C₆H₁₂</td>
<td>63</td>
</tr>
</tbody>
</table>

Table 2 shows properties of branched isomers of some of the alkenes.

<table>
<thead>
<tr>
<th>branched alkene 1</th>
<th>number of carbon atoms in molecule</th>
<th>formula</th>
<th>boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>branched alkene 2</td>
<td>5</td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>
(a) How is the boiling point of a straight chain alkene affected by branching in isomerism? Use evidence from Table 1 and Table 2 to explain your reasoning.

.................................................................................................................................................. [3]

(b) X is a gaseous hydrocarbon which can decolourise a solution of bromine and has a density of 1.75 g/dm³ at room temperature and pressure.

(i) Calculate the relative molecular mass of X.

.................................................................................................................................................. [1]

(ii) Hence, identify X. Explain your reasoning.

.................................................................................................................................................. [2]

(c) Both ethene and ethane can react with chlorine to form dichloroethane. Give two differences between the two reactions.

.................................................................................................................................................. [2]
(d) Alkynes are hydrocarbons containing carbon-carbon triple bond (C≡C). Table 3 shows some properties of the first four members of the alkyne homologous series.

<table>
<thead>
<tr>
<th>alkyne</th>
<th>molecular formula</th>
<th>boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethyne</td>
<td>C₂H₂</td>
<td>-84</td>
</tr>
<tr>
<td>propyne</td>
<td>C₃H₄</td>
<td>-23</td>
</tr>
<tr>
<td>butyne</td>
<td>C₄H₆</td>
<td>8</td>
</tr>
<tr>
<td>pentyne</td>
<td>C₅H₈</td>
<td>40</td>
</tr>
</tbody>
</table>

(i) Draw the full structural formula of the alkyne with 6 carbon atoms.

(ii) Do alkenes or alkynes burn with a smokier flame? Explain your answer.

(e) A Chemistry book has the following line.

"...in general, the higher the relative molecular mass of the molecule, the higher the melting and boiling points of the compound due to the higher intermolecular forces of attraction."

Use the data in Table 1 and Table 3 to justify whether the statement is valid.
B8. Zinc reacts with aqueous iodine to form zinc iodide. The following apparatus was used to measure the rate of the reaction between zinc and aqueous iodine at 25°C.

The mass of the zinc plate was measured every minute until the reaction was complete. Graph 1 shows the results obtained.

Graph 1

(a) Identify the reagent that was used in excess.

(b) (i) The experiment was repeated with 100 cm³ of 0.05 mol/dm³ aqueous iodine and keeping all other conditions the same. On the same axes as Graph 1 above, sketch the curve that would be obtained and label it 'Y'.
(ii) Explain the shape of the graph obtained in (b)(i).

..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................

[2]

(c) Explain, in terms of collisions between reacting particles, the effect on the speed of reaction if the experiment was repeated at 15°C with all other conditions kept constant.

..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................

[2]

(d) Describe and explain what would be observed if aqueous chlorine was bubbled into the resulting zinc iodide solution.

..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................

[2]

[Total: 8]
B9 Galvanisation is the process of coating the entire surface of a piece of iron with zinc to prevent it from rusting. Two common ways of galvanising iron are hot-dip galvanisation and electro-galvanisation.

(a) Hot-dip galvanisation

The piece of iron to be galvanised is dipped into a molten bath of zinc at a temperature of around 460°C. The piece of iron is then cooled and exposed to the air. The outermost layer of zinc then reacts with oxygen and carbon dioxide in the air as follows:

reaction 1: zinc reacts with oxygen to form zinc oxide
reaction 2: zinc oxide reacts with carbon dioxide to form zinc carbonate

The resulting iron piece is as shown.

![Diagram showing the outermost layer of zinc carbonate, zinc, and piece of iron]

(i) Write balanced chemical equations for reaction 1 and reaction 2.

reaction 1

reaction 2

(ii) Use reaction 2 to explain how zinc oxide acts as a basic oxide.

(b) A student says 'galvanising a piece of iron is more effective in preventing it from rusting than painting it.'

Do you agree with the student? Explain your reasoning.

..........................................................[2]
(c) Electro-galvanisation (electroplating an object with zinc)

The piece of iron to be galvanised and a piece of zinc are used as electrodes and dipped into an electrolyte containing a mixture of aqueous zinc cyanide, Zn(CN)₂⁻, and aqueous sodium hydroxide at room temperature and pressure. An external electrical power supply is used. Zinc ions are discharged to form zinc atoms, which are coated onto the piece of iron.

(i) Draw a labelled diagram of the experimental setup for electro-galvanisation.

(ii) What is the formula for the cyanide ion?

(iii) Some processes of electro-galvanisation employ the use of dilute acids in the electrolyte instead of aqueous sodium hydroxide.

Explain what problem this could pose.

(d) Suggest an advantage that electro-galvanisation has over hot-dip galvanisation.

[Total: 10]
B9 The diagram below shows the electrolysis of an aqueous solution of potassium sulfate using inert electrodes.

(a) Write equations for the reactions that happen at each electrode during the electrolysis of aqueous potassium sulfate. Include state symbols.

At the cathode:

At the anode:

(b) When graphite anode and a very high current are used in this electrolysis, the gas liberated is a mixture of oxygen, carbon monoxide and carbon dioxide. In the experiment illustrated above, 30 cm³ of gas formed above the cathode and 17 cm³ of gas formed above the anode.

(i) Explain, with the help of two equations, why the oxides of carbon are produced at the anode.

(ii) Using the equations in b(i), explain why the volume of gas collected at the anode is larger than expected.
(iii) The gas at the anode was collected and its volume was reduced to 9 cm³ when shaken with aqueous sodium hydroxide. Deduce the volume of carbon dioxide in the gas mixture at the anode and explain the reaction that results in the reduction of volume.

[2]

(c) An experiment is set up to electroplate a fresh flower with silver. Suggest why the fresh flower must be coated with carbon particles first.

[1]

[Total: 10]

End of Paper
<table>
<thead>
<tr>
<th>Qns</th>
<th>Answers</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1a</td>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>c</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>D and E</td>
<td>1</td>
</tr>
<tr>
<td>e</td>
<td>carbon</td>
<td>1</td>
</tr>
<tr>
<td>f</td>
<td>A and C</td>
<td>2</td>
</tr>
<tr>
<td>A2a</td>
<td>Cu(NO₃)₂</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Copper does not react with dilute acids.</td>
<td>1</td>
</tr>
<tr>
<td>c</td>
<td>Add excess copper(II) oxide / copper(II) carbonate with dilute nitric acid and stir. Filter to remove the excess copper(II) oxide and collect copper(II) nitrate as the filtrate. Heat copper(II) nitrate solution until it is saturated. Cool the saturated solution. Wash the crystals with a little cold water and dry between sheets of filter paper.</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>Acidic. There are H⁺ ions present.</td>
<td>1</td>
</tr>
<tr>
<td>Qns</td>
<td>Answers</td>
<td>Marks</td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>-------</td>
</tr>
</tbody>
</table>
| e   | A white precipitate is formed.  
The precipitate is insoluble in excess sodium hydroxide.  
OR  
A blue precipitate is formed.  
The precipitate is insoluble in excess sodium hydroxide. | 1 |
| A3a | P₄O₆     | 1 |
| b   | A simple molecular structure has small discrete molecules with weak intermolecular forces while  
a giant molecular structure is a lattice of many atoms covalently bonded together. | 1 |
| c   | A small amount of energy is needed to overcome the weak intermolecular forces between the molecules in phosphorus trioxide.  
A very large amount of energy is needed to overcome the strong covalent bonds between the carbon atoms in the structure of diamond. | 1 |
| d   | ![Table](image) | 1 |
|     | Since the empirical formula of phosphorus trioxide is P₂O₃, not P₂O₆, this oxide cannot be phosphorus trioxide. | 1 |
| A4a(i) | The percentage yield of ammonia decreases with increasing temperature. | 1 |
| (ii) | Percentage yield of ammonia increases with increasing pressure. | 1 |
| (iii) | Catalyst speeds up the reaction / lowers activation energy.  
Catalyst shortens the production time / lowers energy costs as less energy is used. | 1 |
<table>
<thead>
<tr>
<th>Qns</th>
<th>Answers</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>b(i)</td>
<td>Ammonia is an alkaline gas, while oxygen, nitrogen monoxide and water vapour are neutral gases. Ammonia gas is gradually used up, the pH decreases as the products are neutral. When pH value remains constant at 7, it indicates that ammonia gas is used up completely for reaction and left with the neutral gases.</td>
<td>1</td>
</tr>
<tr>
<td>(ii)</td>
<td>$\text{NH}_3 + 2\text{O}_2 \rightarrow \text{HNO}_3 + \text{H}_2\text{O}$</td>
<td>1</td>
</tr>
<tr>
<td>A5a</td>
<td>No. The oxidation states of $\text{S}$, $\text{O}$ and $\text{H}$ remains the same at +6, -2 and +1 respectively in both reactants and products.</td>
<td>Minus 1 mark for each mistake in oxidation states.</td>
</tr>
<tr>
<td>b</td>
<td>The rate of reaction is faster at higher pressure. The gas molecules are closer together. There are more molecules per unit volume of the gas and they collide more frequently.</td>
<td>1</td>
</tr>
<tr>
<td>c(i)</td>
<td><img src="image" alt="Energy Diagram" /></td>
<td>correct $\Delta H$ – 1m correct $\text{E}_a$ – 1m correct exothermic graph – 1m</td>
</tr>
</tbody>
</table>
| (ii) | $\Delta H = +196 \text{ kJ}/\text{mol}$  
$\text{E}_a = 2398 \text{ kJ}/\text{mol}$                                                                 | 1     |
<p>| A6   | a(i) Global warming/ ice caps melting/ sea level rising                                                                                                                                                  | 1     |
| (ii) | One source of methane is rotting vegetation.                                                                                                                                                             | 1     |
| (iii) | CFCs cause ozone depletion.                                                                                                                        | 1     |</p>
<table>
<thead>
<tr>
<th>Qns</th>
<th>Answers</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>b</strong></td>
<td><img src="image" alt="Diagram" /></td>
<td>Minus 1 mark for each mistake</td>
</tr>
<tr>
<td>c(i)</td>
<td>Reaction of nitrogen with oxygen at high temperature produces nitric oxide.</td>
<td>1</td>
</tr>
<tr>
<td>(ii)</td>
<td>Nitric oxide is reduced to form nitrogen gas. Carbon monoxide is oxidised to form carbon dioxide.</td>
<td>1</td>
</tr>
<tr>
<td><strong>d</strong></td>
<td>HNO₂</td>
<td>1</td>
</tr>
<tr>
<td><strong>B7a</strong></td>
<td>Branching in isomerism decreases the boiling point of straight chain alkenes. From the data, the boiling point of straight chain butene (-6 °C) is higher than the branched butene (-7 °C). The boiling point of straight chain pentene (30 °C) is also higher than the branched pentene (20 °C).</td>
<td>1</td>
</tr>
</tbody>
</table>
| **b(i)** | \( M_r = \text{density} \times 24 \, \text{dm}^3 \) \[= 1.75 \times 24 \]
\[= 42 \] | 1 |
| (ii) | \( X \) is propene / \( C_3H_6 \) with \( M_r \) of propene = \((12 \times 3) + (1 \times 6) = 42. \)
As \( X \) decolourises aqueous bromine, it is unsaturated / an alkene with general formula \( C_3H_2X. \) | 1 |
| **c** | Differences: any two
- substitution in ethane requires UV light whereas addition in ethene does not.
- substitution in ethane involves breaking of C-H bond whereas addition in ethene involves breaking of C=C bond.
- substitution in ethane produces many products whereas addition in ethene produces only one product (dichloroethane).
- substitution in ethane produces a by-product (HCl) whereas addition in ethene does not. | 1m – each difference |
<table>
<thead>
<tr>
<th>Qns</th>
<th>Answers</th>
<th>Marks</th>
</tr>
</thead>
</table>
| **d(i)** | \[
\begin{align*}
    &H \quad H \quad H \quad H \\
    &H-C-C-C-C-C=\text{C}-H \\
    &H \quad H \quad H \quad H
\end{align*}
\] | 1 |
<p>| <strong>(ii)</strong> | Alkynes burn with a smokier flame because they have a higher percentage of carbon compared to alkenes. | 1 |
| <strong>e</strong> | Although ethyne (Mr = 26) has a relative molecular mass smaller than ethene (Mr = 28), the boiling point of ethyne is -84 °C whereas the boiling point of ethene is lower at -104 °C. The statement is invalid as alkynes have higher boiling points even though they have smaller relative molecular mass. | 1 |
| <strong>B8a b(i)</strong> | zinc | 1 |
| <strong>(ii)</strong> | Gradient is less steep as the concentration of iodine is halved, resulting in a slower speed of reaction. Half the mass of zinc reacted since only half the number of mole of the limiting reagent, iodine is present. | 1 |
| <strong>c</strong> | At 15 °C, the zinc atoms and iodine molecules have lower kinetic energy. Hence, less particles have energy greater or equal to the activation energy. The frequency of effective collisions between the zinc atoms and iodine molecules decreases. Hence, speed of reaction decreases. | 1 |
| <strong>d</strong> | The colourless zinc iodide solution will turn brown. Chlorine displaces the iodine from zinc iodide solution as chlorine is more reactive than iodine. | 1 |</p>
<table>
<thead>
<tr>
<th>Qns</th>
<th>Answers</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>EITHER</td>
<td>reaction 1: (2Zn + O_2 \rightarrow 2ZnO)</td>
<td>1</td>
</tr>
<tr>
<td>B9a(i)</td>
<td>reaction 2: (ZnO + CO_2 \rightarrow ZnCO_3)</td>
<td>1</td>
</tr>
<tr>
<td>(ii)</td>
<td>It reacts with an <strong>acidic oxide</strong> (carbon dioxide) to form a salt (zinc carbonate).</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Yes, galvanising protects the piece of iron from coming into contact with oxygen and water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the protective layer is scratched, the exposed iron beneath will not rust as zinc is more reactive than iron and will corrode in place of iron.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the paint layer is scratched, the exposed iron beneath will start to rust when it reacts with oxygen and water.</td>
<td></td>
</tr>
<tr>
<td>c(i)</td>
<td><img src="image" alt="Diagram" /></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iron electrode connected to negative electrode of cell.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>correct electrodes -1m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>correct electrolyte -1m</td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>(CN^-)</td>
<td>1</td>
</tr>
<tr>
<td>(iii)</td>
<td>The acids in the electrolyte will react with the zinc and iron pieces.</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>Electro-galvanisation is carried out at room temperature and no heating is needed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot-dip galvanisation is carried out at 460°C.</td>
<td>1</td>
</tr>
<tr>
<td>Qns</td>
<td>Answers</td>
<td>Marks</td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>-------</td>
</tr>
</tbody>
</table>
| OR B9(a) | At the cathode: $2H^+ (aq) + 2e^- \rightarrow H_2 (g)$  
At the anode: $4OH^- (aq) \rightarrow 2H_2O (l) + O_2 (g) + 4e^-$ | correct equations - 1m each  
correct state symbols - 1m |
| b(i) | Oxygen produced reacts with the carbon electrode to form carbon dioxide, which continues to react with the carbon electrode to form carbon monoxide.  
$C + O_2 \rightarrow CO_2$  
$C + CO_2 \rightarrow 2CO$ or  
$2C + O_2 \rightarrow 2CO$ | 1 |
| (ii) | 1 mol of oxygen produces 2 mols carbon monoxide. | 1 |
| (iii) | 8 cm$^3$  
Carbon dioxide, an acidic oxide reacts with the alkali, sodium hydroxide. | 1 |
| c | Carbon is a conductor of electricity. | 1 |
READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and register number on the OTAS in the spaces provided.

There are forty questions on this paper. Answer all questions. For each question, there are four possible answers, A, B, C and D.
Choose the one you consider correct and record your choice in soft pencil on the OTAS.

Read the instructions on the OTAS very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer
Any rough working should be done on this paper.
A copy of the Periodic Table is printed on page 17
The use of an approved scientific calculator is expected, where appropriate.

This document consists of 17 printed pages including the cover page.
1. A gaseous mixture of propene, oxygen and sulfur trioxide is passed through the apparatus as shown below.

What is the property of the gas collected?

A. It turns damp blue litmus red.
B. It relights with a glowing splint.
C. It extinguishes lighted splint with a 'pop' sound.
D. It turns purple acidified potassium manganate(VII) solution colourless.

2. Carbonic acid is obtained by passing carbon dioxide gas into water. Which of the following best describes the movement and arrangement of the respective particles at room temperature?

<table>
<thead>
<tr>
<th></th>
<th>Carbon dioxide molecules in air</th>
<th>Hydrogen ions, carbonate ions in the solution</th>
<th>Water molecules in the solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Quite closely packed, moving rapidly and randomly in all directions</td>
<td>Quite closely packed, rotate and vibrate about in fixed position</td>
<td>Quite closely packed, moving in constant random motion</td>
</tr>
<tr>
<td>B</td>
<td>Far apart, moving in constant random motion</td>
<td>Far apart, moving in constant random motion</td>
<td>Quite closely packed, slides past each other and move freely throughout the liquid</td>
</tr>
<tr>
<td>C</td>
<td>Quite closely packed, moving in constant random motion</td>
<td>Far apart, moving in constant random motion</td>
<td>Quite closely packed, slides past each other and move freely throughout the liquid</td>
</tr>
<tr>
<td>D</td>
<td>Far apart, moving in constant random motion</td>
<td>Quite closely packed, rotate and vibrate about in fixed position</td>
<td>Quite closely packed, moving in constant random motion</td>
</tr>
</tbody>
</table>
3 The word ‘molecule’ can be used to describe the structures of the following except for that of

A diamond  
B limestone  
C sugar  
D nylon

4 A sample of isotonic drink containing two water-soluble vitamins was analysed during chromatography with water as a solvent. The following chromatogram (not drawn to scale) was obtained.

Given that the $R_f$ value of vitamin $B_2$ is 0.35, determine the $R_f$ value of vitamin $B_5$.

A 0.23  
B 0.23cm  
C 0.27  
D 0.27cm

5 The following describes three separations of various mixtures:

1. Obtain pure ethanol from the fermentation of glucose.
2. Obtain solid sugar from sugar solution.
3. Obtain silicon dioxide from a mixture of silicon dioxide and aqueous silver nitrate.

Which of the following correctly describes the method used in each separation?

A distillation  
B distillation  
C separating funnel  
D separating funnel

1 evaporation  
2 crystallisation  
3 sublimation

Need a home tutor? Visit smiletutor.sg
6. Krypton has a melting point of -157 °C and a boiling point of -153 °C, and is much lighter than air. The following diagram represents krypton particles in a sealed container at 0 °C.

Which of the following shows krypton particles after the temperature is lowered to -100 °C?

A

B

C

D

7. The diagrams show the structures of two atoms of the elements J and W respectively.

What is the mass of 1 mole of the compound formed by J and W?

A  11 g
B  12 g
C  23 g
D  30 g
8. Silicon carbide has a structure that is similar to diamond as shown below.

\[
\text{Carbon face}
\]

\[
\text{Silicon face}
\]

Which of the following sets of properties describes silicon carbide?

<table>
<thead>
<tr>
<th></th>
<th>Physical Properties</th>
<th>When strongly heated in oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>good conductor of electricity</td>
<td>rigid and extremely hard</td>
</tr>
<tr>
<td>B</td>
<td>good conductor of electricity</td>
<td>soft and slippery</td>
</tr>
<tr>
<td>C</td>
<td>does not conduct electricity</td>
<td>soft and slippery</td>
</tr>
<tr>
<td>D</td>
<td>does not conduct electricity</td>
<td>rigid and extremely hard</td>
</tr>
</tbody>
</table>

9. The formulae of some oxides are shown below.

\[ \text{Al}_2\text{O}_3, \text{CO}, \text{Na}_2\text{O}, \text{MgO}, \text{SO}_2, \text{ZnO} \]

Which of the following gives the correct number of each type of oxide?

<table>
<thead>
<tr>
<th></th>
<th>Acidic</th>
<th>Amphoteric</th>
<th>Neutral</th>
<th>Basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

10. Which of the following involves the largest number of electrons for complete discharge during electrolysis?

A. 5 mol of Al\(^{3+}\) ions
B. 6 mol of OH\(^-\) ions
C. 7 mol of O\(^2-\) ions
D. 12 mol of K\(^+\) ions
11 Ammonia is manufactured by the Haber process, \( \text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3 \). Which of the following is true about the Haber process?

I Iron catalyst is used to increase the speed of reaction and yield of ammonia.
II Nitrogen is reduced to form ammonia.
III Ammonia formed is condensed and collected as a liquid.
IV The reaction stops after a period of time.

A I and II only
B I and III only
C II and III only
D I, II, III and IV

12 One of Mars exploration rovers discovered vanadium jarosite mineral in the sedimentary rocks on Mars. It has the chemical formula \( \text{NaV}_x(\text{OH})_6(\text{SO}_4)_2 \). What is the oxidation state of vanadium in the mineral?

A +2
B +3
C -3
D -2

13 A commercial production of iodine involves the reduction of a solution of iodate(V) ions, \( \text{IO}_3^- \), with hydrogen sulfite ions, \( \text{HSO}_3^- \).

The equation for the reaction may be written as:

\[ x\text{IO}_3^- + y\text{HSO}_3^- \rightarrow z\text{SO}_4^{2-} + l_2 + 3\text{H}^+ + \text{H}_2\text{O} \]

Which of the following shows the correct values of \( x, y \) and \( z \) respectively?

A \[ \frac{x}{2} \quad \frac{y}{5} \quad \frac{z}{5} \]
B \[ \frac{x}{2} \quad \frac{y}{5} \quad 2 \]
C \[ 5 \quad 2 \quad 2 \]
D \[ 5 \quad 5 \quad 2 \]
14 During beta decay of an unstable nucleus in an atom, a neutron is decomposed into a proton with the emission of an electron.

Which of the changes below describes an unstable nucleus undergoing beta decay?

A \(^{12}\text{C} \rightarrow ^{12}\text{N}\)
B \(^{22}\text{Na} \rightarrow ^{22}\text{Ne}\)
C \(^{35}\text{I} \rightarrow ^{35}\text{Xe}\)
D \(^{81}\text{Kr} \rightarrow ^{83}\text{Br}\)

15 A 0.4764g sample of an oxide of iron was reduced by a stream of carbon monoxide. The mass of iron that remained was 0.3450g. What is the empirical formula of the oxide of iron?

A \(\text{Fe}_2\text{O}\)
B \(\text{FeO}\)
C \(\text{Fe}_2\text{O}_3\)
D \(\text{Fe}_3\text{O}_4\)

16 What is the mass of one molecule of water?

Hint: Given that \(M_r(\text{H}_2\text{O})=18\).

A \(3.33 \times 10^{-25}\text{ g}\)
B \(3.33 \times 10^{-24}\text{ g}\)
C \(3.00 \times 10^{-20}\text{ g}\)
D \(3.00 \times 10^{-23}\text{ g}\)

17 Iron(II)sulfate is a common nutritional supplement used in treating iron-deficiency anaemia. A 5.00g tablet containing iron(II)sulfate is dissolved in water and excess barium chloride solution is added. After mixing, 2.89g of barium sulfate is precipitated out as white solid. What is the percentage of iron(II)sulfate in the tablet?

A 18.9%
B 37.7%
C 42.2%
D 57.8%
18 A cell was set up by dipping 2 strips of metal, R and S, into a liquid Q. This cell is used to light a bulb up in an electrical circuit. Which of the following combination makes the bulb shine the brightest?

<table>
<thead>
<tr>
<th>Metal R</th>
<th>Metal S</th>
<th>Liquid Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A iron</td>
<td>zinc</td>
<td>dilute sulfuric acid</td>
</tr>
<tr>
<td>B magnesium</td>
<td>iron</td>
<td>distilled water</td>
</tr>
<tr>
<td>C aluminium</td>
<td>lead</td>
<td>dilute sulfuric acid</td>
</tr>
<tr>
<td>D copper</td>
<td>magnesium</td>
<td>distilled water</td>
</tr>
</tbody>
</table>

19 Mohr's salt, is a compound with the formula \((\text{NH}_4)_2\text{Fe(III)}\left(\text{SO}_4\right)_2\cdot6\text{H}_2\text{O}\). Aqueous sodium hydroxide was added to a hot solution of the salt, stirred and left to stand over a period of time. Which of the observation would be incorrect?

A A green precipitate is formed.
B The precipitate dissolves in excess aqueous sodium hydroxide.
C A pungent gas which turns moist red litmus paper blue is produced.
D On standing, the precipitate turns red-brown.

20 Which of the following electrolytes will produce gases at both electrodes during electrolysis with inert electrodes?

A concentrated aqueous silver chloride
B molten sodium fluoride
C dilute aqueous potassium iodide
D aqueous copper (II) nitrate

21 Which of the following methods would not produce ammonia?

A Heating ammonium chloride with aqueous calcium hydroxide.
B Heating ammonium chloride with aqueous strontium hydroxide.
C Heating ammonium chloride with dilute nitric acid.
D Heating solid ammonium chloride crystals.
22. The graph shows the optimal yield of ammonia at 200 °C and 250 atm.

Which of the following graphs shows a correct comparison of the yield of ammonia produced at temperature of 400 °C and 250 atm?
23 In the graph, curve X represents the results of the reaction between 2.0 g of magnesium ribbon with excess 1.0 mol/dm³ of nitric acid at room temperature.

![Graph showing total volume of gas produced/cm³ vs. time/s](image)

Which of the following changes will produce curve Y?

A. Using 1.0 g of magnesium ribbon and 2.0 mol/dm³ of nitric acid
B. Using 2.0 g of magnesium ribbon and 0.5 mol/dm³ of nitric acid
C. Using 1.0 g of magnesium ribbon at 10°C.
D. Using 4.0 g of powdered magnesium at room temperature.

24 Bismuth(III) oxychloride is dissolved in concentrated hydrochloric acid to give a clear solution of bismuth(III) chloride. Addition of water re-forms the bismuth(III) oxychloride as a white precipitate

$$\text{BiOCl} {\text{(s)}} + 2\text{HCl} {\text{(aq)}} \rightarrow \text{BiCl}_3 {\text{(aq)}} + \text{H}_2\text{O} {\text{(l)}}; \Delta H = -132 \text{ kJ/mol}$$

The activation energy for the forward reaction is 45 kJ/mol. The activation energy for the reverse reaction is

A. -45 kJ/mol
B. 87 kJ/mol
C. -87 kJ/mol
D. 177 kJ/mol

25 Iodine reacts with chlorine to form iodine chloride:

$$\text{I}_2 + \text{Cl}_2 \rightarrow 2\text{ICl} \quad \Delta H = -11 \text{ kJ}$$

The bond energies for $\text{I}--\text{I}$ and $\text{Cl}--\text{Cl}$ are 151 kJ/mol and 242 kJ/mol, respectively. What is the bond energy in kJ/mol for the $\text{I}--\text{Cl}$ bond?

A. 191 kJ/mol
B. 202 kJ/mol
C. 382 kJ/mol
D. 404 kJ/mol
26 The nickel-cadmium rechargeable battery is based on the following overall reaction.

\[ \text{Cd} + 2\text{Ni(OH)}_2 + 4\text{H}_2\text{O} \rightarrow \text{Cd(OH)}_2 + 2\text{Ni(OH)}_2\cdot\text{H}_2\text{O} \]

What is the oxidation number of nickel at the beginning and at the end of the reaction?

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>A -1.5</td>
<td>0</td>
</tr>
<tr>
<td>B +1.5</td>
<td>+2</td>
</tr>
<tr>
<td>C +2</td>
<td>+3</td>
</tr>
<tr>
<td>D +3</td>
<td>+2</td>
</tr>
</tbody>
</table>

27 The diagrams show pairs of metal strips of equal size placed in beakers Q, R, S and T with dilute nitric acid.

After 3 minutes, which of the following is true about concentration of lead(II) ions present in the solutions in the beakers?

<table>
<thead>
<tr>
<th>Highest concentration of Pb(^{2+}) ions</th>
<th>Lowest concentration of Pb(^{2+}) ions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A R</td>
<td>Q</td>
</tr>
<tr>
<td>B R</td>
<td>S</td>
</tr>
<tr>
<td>C S</td>
<td>Q</td>
</tr>
<tr>
<td>D S</td>
<td>R</td>
</tr>
</tbody>
</table>

28 Information on three metals, X, Y and Z are given in the table below:

<table>
<thead>
<tr>
<th>Metal</th>
<th>Action of dilute acid on the metal</th>
<th>Action of carbon on the metal oxide</th>
<th>Action of placing the metal in aqueous iron(II) nitrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Hydrogen evolved</td>
<td>Reduced</td>
<td>No reaction</td>
</tr>
<tr>
<td>Y</td>
<td>No reaction</td>
<td>Reduced</td>
<td>No reaction</td>
</tr>
<tr>
<td>Z</td>
<td>Hydrogen evolved</td>
<td>No reaction</td>
<td>Iron metal formed</td>
</tr>
</tbody>
</table>

Which of the following places the metals in order of decreasing reactivity?

A Y, Z, X
B Z, X, Y
C Y, X, Z
D X, Y, Z
29 Which of the following is/are true about the air and atmosphere?

I All air pollutants are acidic in nature.
II Acid rain can be caused by excessive burning of fossil fuels.
III Nitrous oxide and water vapour contributes to global warming.
IV At ground level, ozone is emitted directly from industries and the burning of fossil fuel.

A III only
B I and II
C II and III
D I, II, III and IV

30 Which of the following is least commonly found in air yet is the most abundant element in the universe?

A Krypton
B Nitrogen
C Hydrogen
D Water vapour

31 Transition metals are often used as catalysts in industries. Which of the following is not an example of a transition metal acting as a catalyst?

A rhodium in catalytic converters
B iron in Haber process
C copper in the electroplating of cutlery
D nickel in the manufacture of margarine

32 The diagram below shows a reaction scheme involving solution P.

Solution P → Add HNO₃ (aq) → Colourless solution (No effervescence)

Add a little NaOH (aq)

White precipitate

What is the identity of solution P?

A aluminium sulfate
B potassium sulfate
C iron(II) nitrate
D zinc carbonate

Need a home tutor? Visit smiletutor.sg

| Page 220 |
The diagram below shows the setup for an experiment.

What are the main colours observed for propanone, water, gases Q and P during the experiment?

<table>
<thead>
<tr>
<th></th>
<th>Propanone</th>
<th>Water</th>
<th>Gas Q</th>
<th>Gas P</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>red-brown</td>
<td>purple</td>
<td>brown</td>
<td>yellow-green</td>
</tr>
<tr>
<td>B</td>
<td>red-brown</td>
<td>red-brown</td>
<td>purple</td>
<td>red-brown</td>
</tr>
<tr>
<td>C</td>
<td>purple</td>
<td>brown</td>
<td>purple</td>
<td>brown</td>
</tr>
<tr>
<td>D</td>
<td>purple</td>
<td>purple</td>
<td>red-brown</td>
<td>brown</td>
</tr>
</tbody>
</table>

Wine is produced by fermentation of the natural sugars present in grapes. Which of the following equations describes fermentation correctly?

A \[ C_6H_{12}O_6(l) + 6O_2(g) \rightarrow 6CO_2(g) + 6 H_2O(g) \]
B \[ C_6H_{12}O_6(l) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g) \]
C \[ C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g) \]
D \[ C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6 H_2O(g) \]

Which statement about fractional distillation of petroleum is correct?

A At each fraction in the fractionating column, only one compound is collected with a fixed boiling point.
B As the vapour rises up the column, the temperature increases.
C The hydrocarbons collected at the bottom of the fractionating column are the most flammable.
D The hydrocarbons collected at the top of the fractionating column have the smallest relative molecular mass.
36. Aspirin is a commonly used drug to reduce pain. The structural formula of aspirin is shown below:

![Aspirin structure]

Which statement about aspirin is incorrect?

A. It is an unsaturated hydrocarbon.
B. It contains 3 different functional groups.
C. It reacts with magnesium metal.
D. Its aqueous solution reacts with potassium carbonate.

37. When a mixture of butanol and propanoic acid is allowed to react, what are the substances found in the final mixture?

A. Propyl butanoate and water
B. Butyl propanoate and water
C. Propyl butanoate, water, butanol and propanoic acid
D. Butyl propanoate, water, butanol and propanoic acid

38. The diagram shows the structure of the amino acid, lysine. Lysine supplements have also been used to prevent eruptions of shingles, a viral infection that causes a painful rash.

![Lysine structure]

Which statement about lysine is true?

A. It forms a polymer with the same linkage as nylon.
B. It reacts with calcium to form salt and water only.
C. It readily decolourises acidified potassium manganate (VII) solution.
D. It burns in air to produce carbon dioxide and water only.
PMMA, is the most important commercial polymer of the acrylic class, often used in glazing applications. Which of the following correctly describes the polymer shown?

A. Condensation

B. Addition

C. Condensation

D. Addition
40. Which of the following compounds are isomers of each other?

A. II, III and V only
B. I, II and III only
C. I, II, III and V only
D. All of the above
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

Answers to 2017 Prelim 2 Chemistry Papers 1 & 2
INSTRUCTIONS TO CANDIDATES
Write your name, register number and class in the spaces provided on the question paper.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A: Structured Questions [50 marks]
Answer all questions. Write your answers in the spaces provided on the question paper. All workings must be shown clearly.

Section B: Data-based and Free-response Questions [30 marks]
Answer all three questions in this section. The last question is in the form of an either/or and only one of the alternatives should be attempted. Write your answers in the spaces provided on the question paper. All workings must be shown clearly.

The number of marks is given in brackets [ ] at the end of each question or part question.
The total marks for this paper is 80.

A copy of the Periodic Table is printed on page 19.
The use of an approved scientific calculator is expected, where appropriate.
Section A – Structured Questions (30m)

Answer all questions in the spaces provided.

A1. The position of six elements from Period 1 to 4 of the Periodic Table is represented by letters A, B, C, D, E and F as shown below.

<table>
<thead>
<tr>
<th>A</th>
<th></th>
<th>B</th>
<th></th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Select from the given letters, A to F, the element that best fits the following characteristics. They can be used once, more than once, or not at all. [5]

a) An element which combines with element E to form a very volatile compound.

b) An element which contains the smallest number of protons in each atom.

c) An element which is monatomic.

d) An element which is used as a catalyst in chemical reactions.

e) An element which is the strongest reducing agent.

A2. A sample of black ink contains a mixture of red, blue and yellow dyes. The solvent used to separate the dyes in the black ink is a mixture of ethanol and water. The $R_f$ values of the coloured dyes with different percentages of ethanol is as shown:

![Graph showing $R_f$ values of dyes](image)

---

Blue

Red

Yellow
a) State the $R_f$ value of blue dye on the chromatogram when the solvent is a mixture of 42 cm$^3$ of ethanol and 150 cm$^3$ of water. [1]

b) Using data from the graph, explain why a pure solvent of either water or ethanol is not suitable for the separation of the black ink using paper chromatography. [2]

c) Damien conducted a chromatography on the black ink using a certain mixture of ethanol and water as solvent. He concluded that his black ink is pure. Using data from the graph, explain why Damien could be wrong. [2]

A3. Since its discovery in 2003, graphene has been a hot topic in chemistry and materials science research. Graphene is a single layer of graphite and its properties include:

- high electrical conductivity,
- 200 times stronger than steel,
- thin and lightweight,
- transparent, and
- high thermal conductivity.

In terms of bonding and structure, explain why graphene is strong. [2]

b) graphene is a good conductor of electricity. [2]
c) State and explain why a sheet of graphite which has a large number of carbon layers would not be suitable for a touchscreen display on a handphone. [2]

A4. Some fruit drinks claim to be high in antioxidants such as vitamin C, C₆H₈O₆. The vitamin C content in a fruit drink can be determined by titrating it with iodine.

The redox reaction which takes place is shown:

\[
C₆H₈O₆(aq) + I₂(aq) \rightarrow C₆H₈O₆(aq) + 2H⁺(aq) + 2I⁻(aq)
\]

a) Suggest if I₂ is an oxidising or reducing agent. State the colour change observed during the titration. [2]

b) Some students carried out an investigation of fruit drinks to determine their vitamin C content. An average of 25.4 cm³ of 0.00125 mol/dm³ of iodine solution was required for the complete titration of the vitamin C in a 20.0 cm³ sample of fruit drink. Calculate the mass, in grams, of vitamin C in the 1 dm³ carton of fruit drink. [2]

c) The recommended daily consumption for Vitamin C is 0.0500g per day. Calculate the mass of Vitamin C provided by 200 cm³ of the drink in (b). Hence state whether this drink meets the recommended daily allowance for Vitamin C. [2]
A5. The diagram shows the set-up of an electrolysis experiment.

W and X are copper electrodes, while Y and Z are silver electrodes.

a) Give the formulae of all the ions present in (i) silver nitrate and (ii) copper(II) sulfate solution. [2]

b) Which two electrodes would increase in mass? [1]

c) Write the half equations for each electrode in your answer (bi). [2]

iii) Which electrode would increase its mass at a faster rate? Give a reason for your answer. [2]
A6. An aqueous solution of ammonium nitrite, \( \text{NH}_2\text{NO}_2 \), decomposes when heated gently.

\[
\text{NH}_2\text{NO}_2(\text{aq}) \rightarrow \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})
\]

a) Describe how you could show that aqueous ammonium nitrite contains ammonium ions. [2]

b) A sample of 25.0 cm\(^3\) of 0.500 mol/dm\(^3\) aqueous ammonium nitrite is heated. Calculate the volume of nitrogen formed, measured at room temperature and pressure. [2]

c) A cold pack, used to treat sporting injuries, contains a bag of water inside a larger bag of finely powdered ammonium nitrate, \( \text{NH}_4\text{NO}_3 \). Squeezing the pack causes the bag of water to break and the \( \text{NH}_4\text{NO}_3 \) to dissolve, as shown below.

\[
\text{NH}_4\text{NO}_3(s) \rightarrow \text{NH}_4\text{NO}_3(\text{aq}) \quad \Delta H = +25 \text{ kJ/mol}
\]

i) From the equation, state and explain if the dissolving process is exothermic or endothermic. [1]
ii) \[ \text{NH}_4\text{NO}_3 (s) \rightarrow \text{NH}_4\text{NO}_3 (aq) \quad \Delta H = +25 \text{ kJ/mol} \]

The activation energy for the above reaction is 35 kJ/mol.

On the graph below, complete the energy profile diagram showing the changes that occur in chemical energy as the \( \text{NH}_4\text{NO}_3 \) powder dissolves.

Label the activation energy, \( E_a \), and the enthalpy change, \( \Delta H \). [3]

![Energy profile diagram](image-url)
A7. The iodine clock reaction was discovered by Hans Heinrich Landolt and is mainly used to demonstrate speed of reaction.
In the experiment, the solutions used are hydrogen peroxide, \( \text{H}_2\text{O}_2 \), potassium iodide, KI, thiosulfate solution, \( \text{S}_2\text{O}_3^{2-} \) and starch to test the presence of iodine, \( \text{I}_2 \).

The reaction occurs in two stages:

**Stage 1:** The hydrogen peroxide, \( \text{H}_2\text{O}_2 \), reacts with the iodide ions in potassium iodide in acidic conditions.

\[
\text{H}_2\text{O}_2 + 2\text{I}^- + 2\text{H}^+ \rightarrow 2\text{H}_2\text{O} + \text{I}_2
\]

**Stage 2:** The iodine produced is then absorbed by reaction with a fixed amount of thiosulfate ions.

\[
2\text{S}_2\text{O}_3^{2-} + \text{I}_2 \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^- 
\]

As soon as all the thiosulfate is used up, free iodine remains in solution and reacts with the starch to give a dark blue solution.

The time for the blue colour to appear can be recorded.

4 experiments were carried out with differing concentrations of \( \text{H}_2\text{O}_2 \) and thiosulfate solution. How quickly the blue colour appears is a good measurement of how fast the reaction takes place.

<table>
<thead>
<tr>
<th>Expt</th>
<th>Concentration of ( \text{H}_2\text{O}_2 ) (mol/dm(^3))</th>
<th>Concentration of ( \text{S}_2\text{O}_3^{2-} ) (mol/dm(^3))</th>
<th>Time taken for blue colour to appear (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.020</td>
<td>0.030</td>
<td>2.00</td>
</tr>
<tr>
<td>2</td>
<td>0.040</td>
<td>0.030</td>
<td>0.50</td>
</tr>
<tr>
<td>3</td>
<td>0.030</td>
<td>0.040</td>
<td>0.75</td>
</tr>
<tr>
<td>4</td>
<td>0.040</td>
<td>0.080</td>
<td>0.25</td>
</tr>
</tbody>
</table>

a) What is the relationship between the concentrations of the reactants and the rate of reaction? Justify your answer using the results in the table, stating clearly the experimental data you are using. [3]
b) Explain the effect of concentration on the rate of reaction in terms of collisions between particles. 

__________________________

__________________________

__________________________

c) Predict the time taken for blue colour to appear if the experiment was conducted using 0.040 mol/dm$^3$ of H$_2$O$_2$ and 0.120 mol/dm$^3$ of S$_2$O$_3^{2-}$. 

__________________________

d) Using oxidation states, state and explain which element is oxidised in Stage 2. 

__________________________

__________________________
A3. Succinic acid, \( \text{C}_4\text{H}_6(\text{COOH})_2 \), is a natural antibiotic and is a **weak** acid. The structure of succinic acid is as shown.

\[
\begin{align*}
&\text{O} \\
&\text{H} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{O} \\
&\text{H} \quad \text{H} \quad \text{H} \quad \text{H}
\end{align*}
\]

a) Explain what it means by the term 'weak acid'.

b) Succinic acid is also a **dibasic** acid. Write an equation to show how a weak dibasic acid will behave.

c) Succinic acid can form a polymer with ethane-1,2-diol. The structure is as shown.

\[
\begin{align*}
&\text{H} \quad \text{O} \\
&\text{C} \quad \text{C} \quad \text{O} \\
&\text{H} \quad \text{H} \quad \text{H}
\end{align*}
\]

i) Name the type of polymerisation which would take place between succinic acid and ethane-1,2-diol.

ii) Draw the structural formula of the polymer formed between succinic acid and ethane-1,2-diol.
Section B: Data-based and Free-response Questions [30 marks]
Answer all three questions in this section. The last question is in the form of an either/or and only one of the alternatives should be attempted. All working must be shown clearly.

B1a) The graph below shows the electronegativity of the Group VII elements.

Electronegativity is a measure of the tendency of an atom to attract electrons. It is usually measured on the Pauling scale, on which the most electronegative element (fluorine) is given an electronegativity of 4.0.

Group VII elements gain electrons to form ions of negative charge.

Electronegativity of the Group VII elements

[Bar graph showing electronegativity of fluorine, chlorine, bromine, and iodine]

i) From the information given above, describe and explain the trend of reactivity of the halogens on going down the group. [2]

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

ii) Describe what is seen when chlorine gas is passed through potassium bromide solution. [1]

________________________________________________________________________

________________________________________________________________________

iii) Write an ionic equation with state symbols for the reaction in (ii). [2]

________________________________________________________________________
The following experiments were conducted to determine the order of reactivity of four metals, copper, P, Q and R. In the first experiment, the oxides of the four metals were heated in the absence of oxygen. The results are shown in the table below.

<table>
<thead>
<tr>
<th>Metal oxide</th>
<th>CuO</th>
<th>P₂O₅</th>
<th>Q₂O₅</th>
<th>RO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>No reaction</td>
<td>Silvery-grey solid deposits observed</td>
<td>No reaction</td>
<td>No reaction</td>
</tr>
</tbody>
</table>

In the second experiment, copper, P, Q and R are added separately to copper(II) sulfate solution. The observations are shown in the diagram below.

i) For the reaction between Q and copper(II) sulfate solution, give another observation that should be seen. Explain the observation. [2]

ii) Explain the formation of bubbles in the reaction between R and copper(II) sulfate solution. [2]

iii) Arrange the four metals in increasing order of reactivity. [1]
B2  Ethanol is the most common alcohol and is an important drug and solvent in the chemical industry.

In some countries, ethanol is used as a substitute for petrol. This ethanol is produced by fermentation of glucose, obtained from sugarcane, using yeast enzymes. During the fermentation process, glucose is first converted into pyruvate. The pyruvate is then converted to ethanol in a two-step process.

\[ \text{CH}_3\text{COOCOOH} \quad \text{Step 1} \quad \text{CH}_3\text{CHO} \quad \text{Step 2} \quad \text{CH}_3\text{CH}_2\text{OH} \]

pyruvate \quad \text{ethanal} \quad \text{ethanol}

\[ \text{CO}_2 \]

**Step 1** is catalysed by an enzyme. Enzymes are proteins that can act as catalysts because they have specific shapes.

**a)** Why does the rate of reaction decrease when the temperature is raised above a certain value?  

**b)** Why is Step 2 described as a reduction reaction?  

**c)** Describe one advantage of the formation of ethanol from glucose.  

**d)** Ethanol undergoes complete combustion. Write the balanced chemical equation for this reaction.

---

Need a home tutor? Visit smiletutor.sg
The table below shows the bond energies of some bonds:

<table>
<thead>
<tr>
<th>Type of bond</th>
<th>Bond energy (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C – C</td>
<td>346</td>
</tr>
<tr>
<td>C = C</td>
<td>602</td>
</tr>
<tr>
<td>C – O</td>
<td>358</td>
</tr>
<tr>
<td>C = O</td>
<td>799</td>
</tr>
<tr>
<td>C – H</td>
<td>411</td>
</tr>
<tr>
<td>O – H</td>
<td>459</td>
</tr>
<tr>
<td>O – O</td>
<td>142</td>
</tr>
<tr>
<td>O = O</td>
<td>494</td>
</tr>
<tr>
<td>H – H</td>
<td>432</td>
</tr>
</tbody>
</table>

e) Use the table of bond energies above to calculate the amount of heat produced (in kJ) when ethanol undergoes complete combustion reaction represented by equation in d).

[3]

f) The 3 tables show the boiling points of isomers of 3 different alcohols.

Table 1: Isomers of C₄H₁₀OH

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₃CH₂CH₂CH₂OH</td>
<td>118</td>
</tr>
<tr>
<td>CH₃</td>
<td>CH₂CH₂OH</td>
</tr>
<tr>
<td>OH</td>
<td>CH₃CH₂CH₂CH₃</td>
</tr>
</tbody>
</table>
Table 2: Isomers of \( \text{C}_2\text{H}_5\text{OH} \)

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} )</td>
<td>137</td>
</tr>
<tr>
<td>( \text{CH}_2\text{CH}_2\text{CH}_2\text{OH} )</td>
<td>128</td>
</tr>
<tr>
<td>( \text{OH} )</td>
<td>119</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 )</td>
<td>101</td>
</tr>
<tr>
<td>( \text{OH} )</td>
<td></td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 )</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Isomers of \( \text{C}_6\text{H}_{13}\text{OH} \)

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} )</td>
<td>159</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} )</td>
<td>149</td>
</tr>
<tr>
<td>( \text{OH} )</td>
<td>121</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 )</td>
<td></td>
</tr>
</tbody>
</table>

i) Using information from the tables, describe one way in which differences in the structures affect boiling point of isomeric alcohols. [2]

ii) Predict a boiling point for hexan-2-ol. [1]

---

Need a home tutor? Visit smiletutor.sg

| Page 240 |
B3 Either

Galvanisation is the process of coating the entire surface of a piece of iron with zinc to prevent it from rusting. The information below shows two common ways of galvanising iron – hot-dip galvanisation and electro-galvanisation.

**Hot dip galvanisation**

The piece of iron is dipped into molten zinc at 460°C. The piece of coated iron is then cooled and exposed to air. The outermost layer of zinc then reacts with oxygen and carbon dioxide in air in the following reactions:

- **Reaction 1:** Zinc reacts with oxygen to form zinc oxide.
  \[ 2Zn + O_2 \rightarrow 2ZnO \]
- **Reaction 2:** Zinc oxide then reacts with carbon dioxide to form zinc carbonate.
  \[ ZnO + CO_2 \rightarrow ZnCO_3 \]

The resulting iron piece will appear as follows:

![Diagram of iron with zinc oxide outer layer]

**Electro-galvanisation**

The piece of iron to be galvanized and a piece of zinc are used as electrodes and dipped into an electrolyte containing a mixture of aqueous zinc cyanide, Zn(CN)_2 and aqueous sodium hydroxide. Zinc cyanide is highly toxic and must be handled with care.

An external electrical supply is used. Zinc ions are discharged to form zinc atoms, which are coated onto the piece of iron.

**Other facts about both types of galvanisation**

<table>
<thead>
<tr>
<th>Hot dip galvanised Iron</th>
<th>Electro-galvanised Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer of zinc is coarse and thick</td>
<td>Layer of zinc is smooth and thin</td>
</tr>
<tr>
<td>Used to make alloy sheets for roofs</td>
<td>Used to make bolts and nuts</td>
</tr>
<tr>
<td>Done at high temperature of 460°C</td>
<td>Done at room temperature</td>
</tr>
</tbody>
</table>

a) In hot dip galvanisation, explain how zinc oxide displays basic properties in reaction 2.  

_________________________________________________________________________
b) If 12.5g of zinc carbonate were found on a piece of hot dip galvanised iron, calculate the mass of zinc which reacted to form this mass of zinc carbonate. [3]

c) Draw a clearly-labelled diagram of the experimental set-up used in electro-galvanisation. Your diagram should include the battery and zinc and iron electrodes. [2]

d) From the information above, compare one advantage and disadvantage of electro-galvanisation over hot-dip galvanisation. [2]

____________________________________________________________________________________________________

____________________________________________________________________________________________________

____________________________________________________________________________________________________

e) Some older processes of electro-galvanisation use dilute acid in the electrolyte instead of aqueous sodium hydroxide.

i) Explain why dilute acid is used as the electrolyte. [1]

____________________________________________________________________________________________________

____________________________________________________________________________________________________

ii) Suggest what problem this could cause. [1]
B3 OR

The structure of retinol, a common form of vitamin A, is shown below.

![Retinol](image)

**Retinol**  
(Vitamin A)

a) Write the empirical formulae of retinol.

Empirical formula ______________

b) Retinol undergoes oxidation reaction to produce an organic compound which can react with sodium carbonate. Suggest the name of the organic product formed and state the reactant required for this reaction.

________________________________________

________________________________________

[2]

c) Name 2 functional groups that can be found in retinol.

________________________________________

[2]

d) Describe what will be observed when retinol reacts with aqueous bromine. Explain your answer.

________________________________________

[2]

e) Retinol can react with hydrogen gas in the presence of nickel catalyst to give a saturated compound. Calculate the minimum volume of hydrogen gas, measured at room temperature and pressure, required to convert 2.86g of retinol into the saturated compound.

[3]
Answers to 2017 Prelim 2 Chemistry Papers 1 & 2

Paper 1

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>11</td>
<td>C</td>
<td>19</td>
<td>B</td>
<td>27</td>
<td>A</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>12</td>
<td>B</td>
<td>20</td>
<td>C</td>
<td>28</td>
<td>B</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>13</td>
<td>A</td>
<td>21</td>
<td>C</td>
<td>29</td>
<td>C</td>
<td>37</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>14</td>
<td>C</td>
<td>22</td>
<td>B</td>
<td>30</td>
<td>C</td>
<td>38</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>15</td>
<td>D</td>
<td>23</td>
<td>A</td>
<td>31</td>
<td>C</td>
<td>39</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>16</td>
<td>D</td>
<td>24</td>
<td>D</td>
<td>32</td>
<td>A</td>
<td>40</td>
</tr>
</tbody>
</table>

Paper 2

Section A – Structured Questions (50 marks)

<table>
<thead>
<tr>
<th>No.</th>
<th>Answer</th>
<th>Marks Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A2. R_f for blue dye is 0.6

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>When pure water is used as solvent, the R_f value of yellow dye is 0. When pure ethanol is used as solvent, the R_f value of red dye is 0.</td>
<td>1</td>
</tr>
</tbody>
</table>

Need a home tutor? Visit smiletutor.sg
Page 244
This indicates that the dye is insoluble in pure water and pure ethanol.

c) Damian used a mixture with 80% ethanol and 20% water
At 80% ethanol, all 3 dyes had the same Rf value / Rf value of 0.36.

A3.

a) Graphene has giant molecular / covalent structure
where carbon atoms are bonded by strong covalent bonds.

b) Each carbon atom of graphene uses 3 out of 4 valence electrons for bonding.
Hence there are free moving electrons to conductor electricity.

c) There are weak intermolecular forces of attraction between layers, hence, the screen will be soft and/or slippery / may be bent / easily broken / not hard enough

OR

Too many layers will cause the screen to be opaque / cannot see through / not transparent

Not accepted answers:
- too many layers hence resulting in the screen being too thick / too insensitive
- mere mention of carbon layers can easily slide across one another without specifying property of why “this sliding” is not suitable.

A4

a) I₂ is an oxidizing agent.
The colour change is brown to colourless / decolourises.

b) \[(0.00125) \times (25.4) / \text{conc} (20.0) = 1/1\]
\[\text{conc} = 0.00159 \text{ mol/cm}^2\]
\[0.00159 \times 176 = 0.279 \text{ g/dm}^3\]
Hence mass is 0.279 g

or
\[\text{conc} = (0.00125) \times (0.0254) = 0.00003175 \text{ mol}\]
\[0.00003175 \times 176 = 0.0558 g\]
\[0.0558 \times (1000/20) = 0.279 g\]

c) 0.279 / 1000 * 200 = 0.0558 g (efc from b))
No it doesn’t meet the RDA for vitamin C.

ECF: 1m for use of value from (b) x (1000/200)
1m for stating does not meet RDA

A5

a) i) Ag⁺, NO₃⁻, H⁺, OH⁻
ii) H⁺, OH⁻, Cu²⁺, SO₄²⁻
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Z and X</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>i)</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
| ii) | \[ Z : \text{Ag}^+ + e^- \rightarrow \text{Ag} \]  
  \[ X : \text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} \]  
  X and Z electrodes no need to be mentioned, marks given if correct half equations was written | 1 |
| iii) | Z (silver electrode / cathode) will increase in mass faster. For 1 mole of electrons, mass of silver increases (106g) more than copper (32g). OR For 2 moles of electrons, mass of silver increases (216g) more than copper (64g). OR For the same moles of electrons, mass of silver increases more than copper. OR In the same duration of time, less electrons required by silver ions to form silver atom compared to copper ions to form copper atoms. OR Each silver ion needs only 1 electron to form each silver atom compared to each copper ion needs 2 electrons to form each copper atom. rejected: silver ions need only 1 electron to form silver deposit / atom whereas copper ions need 2 electrons to form copper deposit / atom | 1 |
|   |   |   |
| A6 |   | 1 |
| a) | Warming with \( \text{NaOH} \). Ammonia gas formed turns moist red litmus paper blue. | 1 |
| b) | No. of moles of \( \text{NH}_4\text{NO}_3 \) = \( 0.500 \times 25.0/1000 \)  
  = 0.0125 mol | 1 |
|   | No. of moles of \( \text{N}_2 \) = 0.0125 mol  
  Volume of \( \text{N}_2 \) = 0.0125 x 24 = 0.300 dm\(^3\) (to 3 s.f. with unit) | 1 |
| ci) | Endothermic because enthalpy change is positive. | 1 |
| i) | 1 mark for correct endothermic graph and \( \text{NH}_4\text{NO}_3 \) (s) and (aq)  
  1 mark for labelling \( \text{Ea} \) and correct energy levels (85)  
  1 mark for labelling \( \Delta \text{H} \) and correct energy levels (85) |   |
as the concentration of reactants increases, rate of reaction increases.

Comparing Expts 1, 2, OR 2.4

as the concentration of reactants, \( \text{H}_2\text{O}_2 \) increases, while concentration of \( \text{S}_2\text{O}_5^{2-} \) remain constant, the time taken for the blue colour to appear decreases. OR

as the concentration of reactants, \( \text{S}_2\text{O}_5^{2-} \) increases, while concentration of \( \text{H}_2\text{O}_2 \) remain constant, the time taken for the blue colour to appear decreases.

d) Oxidation state of sulfur increases from \( +2 \) in \( \text{S}_2\text{O}_5^{2-} \) to \( +2.5 \) in \( \text{S}_4\text{O}_6^{2-} \). Sulfur is oxidised.

A8

a) A weak acid partially dissociates/ ionises in water to produce a lesser concentration of \( \text{H}^+ \) ions.
Reject: deionise

b) \( \text{C}_6\text{H}_4(\text{COOH})_2 \rightarrow \text{C}_6\text{H}_4(\text{COO})_2^{2-} + 2\text{H}^+ \)
Accept: \( \text{C}_6\text{H}_4(\text{COO})_2^{2-} \) instead of \( \text{C}_2\text{H}_4(\text{COO})_2^{2-} \)

c) Condensation polymerisation
Accept: Condensation
### Section B: Data-based and Free-response Questions [30 marks]

#### B1  a) ii)

When the electronegativity decreases on going down the group, the reactivity decreases.

This is because the tendency of an atom to attract electrons decreases.

*1 mark deducted if student describes trend up the group.*

- **ii)** The colourless potassium bromide solution turns red-brown
  
- **iii)** $\text{Cl}_2(g) + 2\text{Br}^- (aq) \rightarrow 2\text{Cl}^-(aq) + \text{Br}_2(aq)$ or $\text{Br}_2(l)$
  
*1 mark for equation, 1 mark for S.S. (only if equation correct)*

- **b) i)** The blue solution turns colourless / decolourise / fades.
  
Or the blue solution turns green (assuming iron)

  *Q is more reactive than copper, and hence will displace copper from the solution.*

  *(Copper ions not accepted)*

- **ii)** R reacts with water in the solution to produce hydrogen gas.

- **iii)** P, Cu, Q, R

#### B2  a)

The enzymes are denatured/ yeast died/ yeast enzymes denatured.

*not accepted - enzymes died/ yeast enzymes died*

- **b)** Hydrogen has been gained by ethanal.

Or

Oxidation state of carbon decreases from -1 in ethanal to -2 in ethanol.

- **c)** Glucose can be obtained from sugarcane and is a renewable source of fuel.

- **d)** $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$

- **e)** Energy absorbed for bond breaking:

$$= 5(411) + 346 + 358 + 459 + 3(494) = 4700 \text{ kJ}$$
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy released for bond forming</strong></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>( \Delta H = +4700 + (-5950) = -1250 \text{kJ} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>amount of heat produced</strong></td>
<td>1250 kJ</td>
<td></td>
</tr>
<tr>
<td><strong>Or</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \Delta H = 5(411) + 346 + 356 + 459 + 3(494) - 4(799) - 6(459) = -1250 \text{kJ} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>f)</strong> Straight chained molecules, higher boiling point</td>
<td></td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>or hydroxy being on an end carbon, a higher boiling point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>or more branched the (isomeric) alcohol, the lower the boiling point</td>
<td></td>
<td>1 1</td>
</tr>
<tr>
<td>or inclusion of methyl group, lowers the boiling point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(both structural feature and effect must be correct)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>i)</strong> Predicted boiling point to be 121 - 149 degree celsius.</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>B3</strong> Either</td>
<td></td>
<td>1 1 1</td>
</tr>
<tr>
<td>a) Carbon dioxide is an acidic oxide / acidic gas, and thus zinc oxide reacts with it as a base.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accept: acidic compound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reject: acidic acid/ neutralisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) No. of moles of ZnCO₂ = 12.5 / (35 + 12 + 16×3) = 0.100 mol</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>No. of moles of Zn = 0.100 mol</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Mass of Zn = 65 x 0.1 mol = 6.50g (3s.f)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>c) 1 mark for labelling anode and cathode correctly</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1 mark for correct diagram set-up</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Diagram of an electrochemical cell with zinc and sodium hydroxide as sources.](zinc-cyanide_diagram.png) 0 marks - wrong set up
<table>
<thead>
<tr>
<th></th>
<th>Advantage of electro-galvanisation:</th>
<th>Disadvantage of hot dip galvanisation:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Can be done at room-temperature, require less energy, lower cost</td>
<td>Done at high temperature, more energy is required to maintain it, higher cost</td>
</tr>
<tr>
<td></td>
<td>Layer of zinc is thinner and can be used to coat smaller objects</td>
<td>Layer of zinc is thicker and can only be used for bigger objects</td>
</tr>
<tr>
<td><strong>Disadvantage of electro-galvanisation:</strong></td>
<td><strong>Advantage of hot dip galvanisation:</strong></td>
<td><strong>1 mark for comparison</strong></td>
</tr>
<tr>
<td></td>
<td>The electrolyte, zinc cyanide is poisonous, may pose health threat if not handled carefully.</td>
<td>The reactants are non-toxic, safer to handle.</td>
</tr>
</tbody>
</table>

**Other possible answers:**

hot dip – galvanisation: more malleable

electro- galvanisation: stronger

**Reject:** reasons of more appealing aesthetically.

**Note:** comparison must be made.

---

**B3 OR**

**a)**

Acids contain **free-moving / mobile ions**

---

**ii)**

Hydrogen ions or acid may react with the iron and zinc / metals / electrolytes deposited at the cathode. Lesser zinc to be coated.

or

Hydrogen ions may be selectively discharged at cathode to form hydrogen gas. Hence, slow down electro-galvanisation process.

---

**Empirical formula:** \( C_{20}H_{20}O \)

**Accept:** \( C_{20}H_{20}O \)

---

**b)**

retinoic acid.

**Reject:** retanoic/retinonic acid

acidified potassium manganate (VII) acidified \( KMnO_4 \) / oxygen / atmospheric oxygen / oxygen in air

**Accept:** acidified potassium dichromate (VI) or acidified \( K_2Cr_2O_7 \)

---

**c)**

carbon-cage double bond 

and hydroxyl group

**Reject:** Alkene/alcohol/carbon=carbon double bond/ C-C double bond/ O-H/ hydroxyl/ carbon double bonds

**-1m:** if both name and formula given

**Note:** functional group is not homologous series or family of organic compound. Also, question asked for “Name”

---

**d)**

Red-brown bromine decolourises

**Accept:** Reddish-brown/ brown

Retinol is unsaturated/ contains \( C=O \) bonds which can be broken and bromine atoms added.

**1 mark for completion**
<table>
<thead>
<tr>
<th>Reject: carbon=carbon double bond/ C-C double bond/ carbon double bonds</th>
</tr>
</thead>
<tbody>
<tr>
<td>e) 1 mol of retinol reacts with 5 moles of hydrogen gas.</td>
</tr>
<tr>
<td>No. of moles of retinol = ( \frac{2.86 \text{g}}{(20 \times 12 + 30 + 16)} = 0.0100 \text{mol} )</td>
</tr>
<tr>
<td>No. of moles of hydrogen gas = ( 0.0100 \times 5 = 0.0500 \text{mol} )</td>
</tr>
<tr>
<td>Volume of ( \text{H}_2 \text{ required} = \frac{0.0500 \times 24}{24} \approx 1.20 \text{ dm}^3 )</td>
</tr>
</tbody>
</table>

Note: no ecf is given, as moles are calculated with molar mass (by molecular formula not empirical formula)
CHEMISTRY

Paper 1 Multiple Choice

14 September 2017 Thursday 1 hour

INSTRUCTIONS TO CANDIDATES:

DO NOT OPEN THIS QUESTION PAPER UNTIL YOU ARE TOLD TO DO SO.

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and register number on the Answer Sheet in the spaces provided.

There are forty questions on this paper. Answer all questions. For each question there are four possible answers, A, B, C and D.
Choose the one you consider correct and record your choice in soft pencil on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

A copy of the Periodic Table is printed on page 20.

This question paper consists of 20 printed pages (including this cover page) and 0 blank page.
1. Food dyes, 1 and 2 are known to contain one or more of the three substances X, Y and Z. Two chromatograms are developed; one used water as the solvent, and the other used ethanol. The results are shown in the diagram below.

Which of the following statement(s) is/are correct?

I. Substance Z is likely to be pure.
II. The component in Z is more soluble in water than in ethanol.
III. There is a component in sample 1 that is insoluble in water but soluble in ethanol.

A. I only
B. II only
C. I and III only
D. II and III only

2. Lead(II) sulfate is soluble in hot water, but not in cold water. Lead(II) sulfate boils off at 2670 °C while sodium sulfate boils at 1430 °C.

Which method is most suitable for obtaining a pure, dry sample of lead(II) sulfate from a hot solution of lead(II) sulfate and sodium sulfate?

A. Cool the mixture, filter and collect the residue.
B. Cool the mixture, filter and evaporate the filtrate.
C. Heat the mixture gently and collect the substance which boils off.
D. Heat the mixture gently and collect the substance which is left in the boiling flask.
3. The diagram below shows a cooling curve of carbon disulfide.

Which of the following statements is incorrect?

A. From $t_0$ to $t_1$, the particles are moving further apart.
B. The freezing point of carbon disulfide is -112 °C.
C. The particles are in a disorderly arrangement at -73 °C.
D. The particles can only vibrate about their fixed positions after $t_4$.

4. A beam of particles containing electrons is passed through charged plates. Which path shows how the electrons move through the plates?

5. A sample of a white crystalline substance is heated in the absence of oxygen. It melts sharply at 120 °C, but on further heating, smoky fumes and a black solid are produced.

From this information, we can conclude that the white crystalline substance is

A. a compound which decomposed to form simpler substances.
B. a compound which undergoes combustion to form two products.
C. a mixture of two pure substances.
D. an element which undergoes combustion to form two products.
6 The table shows the number of protons, neutrons and electrons in particles S, T, U and V.

<table>
<thead>
<tr>
<th>particle</th>
<th>S</th>
<th>T</th>
<th>U</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>proton</td>
<td>10</td>
<td>17</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>neutron</td>
<td>10</td>
<td>18</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>electron</td>
<td>10</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

Which of the following pairs of particles combine to form an ionic solid?

A. S and T
B. S and U
C. T and U
D. T and V

7 The figure below shows a molecule of an herbicide called 2,4,5-T which is often used for weed control. How many pairs of shared electrons are present in one molecule of the herbicide?

[Image of the herbicide molecule]

A. 12
B. 15
C. 23
D. 30

8 Silicon carbide, SiC, has a structure similar to diamond. Boron nitride, BN, has a structure similar to graphite. Bronze is an alloy of copper and tin.

Which statements about silicon carbide, boron nitride and bronze are correct?

I. All are bonded covalently.
II. All except silicon carbide conduct electricity when solid.
III. All have high melting points.

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

[Turn Over]
9 The diagram shows the arrangement of ions in an ionic crystal.

Which compound cannot have this arrangement of its ions?

A. copper(II) sulfate  
B. iron(II) chloride  
C. magnesium oxide  
D. zinc carbonate

10 Aerials in portable radios are made of a mixture of oxides of calcium and iron known as ‘ferrite’. It contains 18.5% of calcium and 51.9% of iron by mass.

Calculate the empirical formula of ‘ferrite’.

A. CaFe₂O  
B. CaFe₂O₄  
C. Ca₂FeO₂  
D. Ca₂Fe₂O₃

11 A mixture of 10 cm³ of oxygen and 50 cm³ of hydrogen is sparked continuously.

What is the maximum theoretical decrease in volume at room temperature and pressure?

A. 10 cm³  
B. 15 cm³  
C. 20 cm³  
D. 30 cm³
12 In a pathology laboratory, a sample of urine containing 0.120 g of urea, \( \text{NH}_2\text{CONH}_2 \) (\( M_r = 60 \)) was treated with an excess of nitrous acid. The urea reacted according to the following equation:

\[
\text{NH}_2\text{CONH}_2 + 2\text{HNO}_2 \rightarrow \text{CO}_2 + 2\text{N}_2 + 3\text{H}_2\text{O}
\]

The gas produced was passed through aqueous sodium hydroxide and the final volume measured.

What was the final volume of gas left behind at room temperature and pressure?

A  9.6 cm\(^3\)  
B  14.4 cm\(^3\)  
C  48.0 cm\(^3\)  
D  96.0 cm\(^3\)

13 In an experiment, 4.0 cm\(^3\) of 1.0 mol/dm\(^3\) of aqueous copper(II) sulfate was mixed with 8.0 cm\(^3\) of 1.0 mol/dm\(^3\) of aqueous sodium carbonate. The equation for the reaction is as shown below.

\[
\text{CuSO}_4 + \text{Na}_2\text{CO}_3 \rightarrow \text{Na}_2\text{SO}_4 + \text{CuCO}_3
\]

What did the reaction vessel contain when the reaction was completed?

A  a blue solution only  
B  a green precipitate and a blue solution  
C  a green precipitate and a colourless solution  
D  a white precipitate and a blue solution

14 Astatine is a member of the halogen family. It has a proton number greater than the other halogens. Which of the following statements is true for astatine?

A  It has the lowest melting point.  
B  It is a coloured liquid at room temperature.  
C  It is the halogen with the weakest oxidising power.  
D  It is the most reactive halogen.
15 The chart below shows how a property of the elements Na to Cl varies with proton number.

![Chart showing property variation with proton number.]

What is the property?

A  the masses of their atoms  
B  the number of isotopes present  
C  the oxidation states of particles formed  
D  the oxidising power of the element

16 The table shows the properties of some elements, W, X, Y and Z in Period 3.

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>appearance at room temperature</td>
<td>silvery grey solid</td>
<td>yellow solid</td>
<td>silvery grey solid</td>
<td>yellow green gas</td>
</tr>
<tr>
<td>reaction with cold water</td>
<td>extremely violent reaction</td>
<td>no reaction</td>
<td>no reaction</td>
<td>slow reaction</td>
</tr>
<tr>
<td>nature of oxide</td>
<td>reacts with acids</td>
<td>reacts with bases</td>
<td>reacts with acids and bases</td>
<td>reacts with bases</td>
</tr>
</tbody>
</table>

Which of the following shows the arrangement of these elements in the Periodic Table in increasing order of group number, from the smallest to the largest?

A  W, X, Y, Z  
B  W, Y, X, Z  
C  Y, W, X, Z  
D  Z, X, Y, W
17. Which of the following is/are suitable methods to test the strength of both hydrochloric acid and ethanoic acid of the same concentration?

I. measuring their electrical conductivity
II. titration using sodium hydroxide solution
III. using a pH meter

A. I and II
B. I and III
C. II only
D. I, II and III

18. A mixture of silicon and magnesium was added to a beaker of excess dilute nitric acid as shown in the diagram. At the end of the reaction, the mixture was filtered to obtain the silicon as the residue.

Which of the following options indicates correctly the type of particles present in the substances shown in the diagram?

<table>
<thead>
<tr>
<th></th>
<th>magnesium</th>
<th>silicon</th>
<th>dilute nitric acid</th>
<th>gas Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>atoms</td>
<td>molecules</td>
<td>ions</td>
<td>atoms</td>
</tr>
<tr>
<td>B</td>
<td>ions and electrons</td>
<td>atoms</td>
<td>ions and molecules</td>
<td>molecules</td>
</tr>
<tr>
<td>C</td>
<td>ions and electrons</td>
<td>molecules</td>
<td>ions and molecules</td>
<td>molecules</td>
</tr>
<tr>
<td>D</td>
<td>ions and electrons</td>
<td>atoms</td>
<td>ions</td>
<td>molecules</td>
</tr>
</tbody>
</table>

19. Which pair of compounds could be used in the preparation of calcium sulfate?

A. calcium carbonate and sodium sulfate
B. calcium chloride and ammonium sulfate
C. calcium hydroxide and barium sulfate
D. calcium nitrate and lead(II) sulfate
20 The graph represents the change in pH as 25.0 cm$^3$ of 0.1 mol/dm$^3$ of alkaline solution is titrated against 0.1 mol/dm$^3$ of an acidic solution.

Which of the following acid-alkali pairs could this graph represent?

<table>
<thead>
<tr>
<th>alkali</th>
<th>acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>A aqueous ammonia</td>
<td>ethanoic acid</td>
</tr>
<tr>
<td>B aqueous ammonia</td>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>C sodium hydroxide</td>
<td>ethanoic acid</td>
</tr>
<tr>
<td>D sodium hydroxide</td>
<td>hydrochloric acid</td>
</tr>
</tbody>
</table>

21 When heated, solid X gives off a gas. When this gas is bubbled through limewater, a white precipitate is formed. The residue after heating solid X reacts with dilute acid and also with aqueous alkali.

What is X?

A aluminium oxide
B calcium hydroxide
C magnesium carbonate
D zinc carbonate
22 The table shows the results of adding pieces of zinc metal in salt solutions of metal P, Q and R.

<table>
<thead>
<tr>
<th>salt solution of metal</th>
<th>initial mass of zinc / g</th>
<th>final mass of zinc after 15 minutes / g</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>6.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Q</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>R</td>
<td>6.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Which of the following shows the correct arrangement of metals in decreasing reactivity?
A P, R, zinc, Q  
B Q, zinc, P, R  
C Q, zinc, R, P  
D R, P, zinc, Q

23 The solid carbonate of three metals W, X and Y are heated.

<table>
<thead>
<tr>
<th>carbonate of metal</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>carbon dioxide produced; solid turns from green to black</td>
</tr>
<tr>
<td>X</td>
<td>carbon dioxide produced; solid does not change colour</td>
</tr>
<tr>
<td>Y</td>
<td>carbon dioxide not produced; solid does not change colour</td>
</tr>
</tbody>
</table>

Which of the following statements are correct?

1 Metal W could be used as a catalyst.
2 Metal Y is a stronger reducing agent than metal X.
3 Only the carbonates of W and X produce carbon dioxide when added to dilute nitric acid.

A 1 and 2 only  
B 1 and 3 only  
C 2 and 3 only  
D 1, 2 and 3

24 Scrap iron is often recycled. Which reason for recycling is incorrect?

A It reduces the amount of pollution at the site of the ore extraction.  
B It reduces the amount of waste taken to landfill sites.  
C It reduces the need to collect the scrap iron.  
D It saves natural resources.
25 Iron filings are wrapped in a damp cloth and left to rust in the apparatus as shown below. Where will be the water level after rusting has completed?

26 The diagram shows a method of protecting iron in an underground steel pipe from rusting.

Which statement best explains how this method works?

A  Electrons are flowing to graphite anode to prevent iron in steel from oxidising.
B  Electrons are flowing to iron in steel to prevent the oxidation of iron in steel.
C  The iron in steel loses electrons to graphite as it is more reactive.
D  The iron in steel undergoes oxidation as it is more reactive.
27 Disproportionation reactions occur when an element is simultaneously oxidised and reduced. The oxidation number of the element will change to both a higher value and a lower value respectively.

Which of the following named elements does not undergo disproportionation?

<table>
<thead>
<tr>
<th>element</th>
<th>equation of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A carbon</td>
<td>( \text{H}_2\text{C}_2\text{O}_4 \rightarrow \text{H}_2\text{O} + \text{CO} + \text{CO}_2 )</td>
</tr>
<tr>
<td>B chlorine</td>
<td>( 3\text{C}/\text{O}^+ \rightarrow \text{Cl}_2 + 2\text{Cl}^- )</td>
</tr>
<tr>
<td>C nitrogen</td>
<td>( \text{H}_2\text{O} + 2\text{NO}_2 \rightarrow \text{HNO}_3 + \text{HNO}_2 )</td>
</tr>
<tr>
<td>D sulfur</td>
<td>( 2\text{FeSO}_4 \rightarrow \text{Fe}_2\text{O}_3 + \text{SO}_2 + \text{SO}_3 )</td>
</tr>
</tbody>
</table>

28 In which of the following reaction does \( \text{Fe}^{2+} (\text{aq}) \) act as a reducing agent?

A \( \text{Fe}^{2+} (\text{aq}) + \text{Mg} (\text{s}) \rightarrow \text{Fe} (\text{s}) + \text{Mg}^{2+} (\text{aq}) \)

B \( 4\text{Fe}^{2+} (\text{aq}) + \text{SO}_3^{2-} (\text{aq}) + 6\text{H}^+ (\text{aq}) \rightarrow 4\text{Fe}^{3+} (\text{aq}) + \text{S} (. \text{s}) + 3\text{H}_2\text{O} (\text{l}) \)

C \( \text{Fe}^{2+} (\text{aq}) + 20\text{H}^- (\text{aq}) \rightarrow \text{Fe(OH)}_2 (\text{s}) \)

D \( \text{Fe} (\text{s}) + 2\text{H}^+ (\text{aq}) \rightarrow \text{Fe}^{2+} (\text{aq}) + \text{H}_2 (\text{g}) \)

29 Three electrolytic cells are set up as shown below. In all the cells, only carbon electrodes are used and the electrolytes are aqueous solutions of silver nitrate, copper(II) sulfate and aluminium nitrate respectively.

Which of the following correctly gives the masses of metals deposited at the cathode of each cell if 0.5 mole of electrons flows through the circuit?

<table>
<thead>
<tr>
<th></th>
<th>mass of silver / g</th>
<th>mass of copper / g</th>
<th>mass of aluminium / g</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>54</td>
<td>32</td>
<td>13.5</td>
</tr>
<tr>
<td>B</td>
<td>54</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>54</td>
<td>64</td>
<td>40.5</td>
</tr>
<tr>
<td>D</td>
<td>54</td>
<td>16</td>
<td>4.5</td>
</tr>
</tbody>
</table>
30 The diagram shows the apparatus used to electroplate a metal ring with nickel.

The experiment did not work.

Which change is needed in the experiment to make it work?

A Add solid nickel(II) nitrate to the electrolyte.
B Increases the temperature of the electrolyte.
C Replace the nickel electrode with a platinum electrode.
D Reverse the connection to the battery.

31 Five pieces of unknown metals P, Q, R, S and T were tested using the apparatus shown below.

The results were recorded in the table below.

<table>
<thead>
<tr>
<th>metal</th>
<th>voltage / V</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>1.11</td>
</tr>
<tr>
<td>Q</td>
<td>0.65</td>
</tr>
<tr>
<td>R</td>
<td>-0.50</td>
</tr>
<tr>
<td>S</td>
<td>0.00</td>
</tr>
<tr>
<td>T</td>
<td>-0.77</td>
</tr>
</tbody>
</table>

Which of the following arrangements shows the metals in order of decreasing reactivity?

A P, Q, S, R, T
B Q, P, T, S, R
C R, S, Q, T, P
D T, S, R, Q, P
32  The reaction in the Haber process is represented as

\[ N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g) \quad \Delta H = -92 \text{ kJ} \]

Which of the following statements about the Haber process is incorrect?

A  92 kJ of heat is given off when 2 moles of ammonia are formed.
B  Iron catalyst does not affect the enthalpy change.
C  The process is carried out at a high pressure of 250 atm.
D  When 2 moles of nitrogen and 6 moles of hydrogen are used, 4 moles of ammonia are collected.

33  In the conversion of compound P into compound R, it was found that the reaction proceeded by way of compound Q. The following graph shows the energy profile diagram for the reactions.

\[ \text{energy} \]
\[ \text{progress of reaction} \]

step 1: \( P \rightarrow Q \)
step 2: \( Q \rightarrow R \)

What can be deduced from the diagram?

A  Both steps are endothermic.
B  Step 1 is harder to take place than step 2 because more energy is needed for bond breaking.
C  Step 2 involves breaking of stronger bonds than step 1 because Q is at higher energy level.
D  The overall reaction to convert P to R is exothermic.
A student performed three experiments to produce hydrogen gas using excess zinc carbonate and dilute sulfuric acid at 30 °C.

<table>
<thead>
<tr>
<th>experiment</th>
<th>zinc carbonate</th>
<th>dilute sulfuric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>particle size</td>
<td>volume / cm³</td>
</tr>
<tr>
<td>1</td>
<td>powdered</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>lumps</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>lumps</td>
<td>10</td>
</tr>
</tbody>
</table>

Three graphs were plotted for the volume of hydrogen produced against time.

Which graph best represents each of the three experiments?

<table>
<thead>
<tr>
<th></th>
<th>experiment 1</th>
<th>experiment 2</th>
<th>experiment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>X</td>
<td>Y</td>
<td>Z</td>
</tr>
<tr>
<td>B</td>
<td>Y</td>
<td>X</td>
<td>Z</td>
</tr>
<tr>
<td>C</td>
<td>Y</td>
<td>Z</td>
<td>X</td>
</tr>
<tr>
<td>D</td>
<td>Z</td>
<td>X</td>
<td>Y</td>
</tr>
</tbody>
</table>
35. The table below shows some data about the composition of the mixtures of exhaust gases from two cars, one fitted with a catalytic converter and one without.

<table>
<thead>
<tr>
<th></th>
<th>% by volume of nitrogen monoxide</th>
<th>% by volume of carbon dioxide</th>
<th>% by volume of water vapour</th>
</tr>
</thead>
<tbody>
<tr>
<td>car without catalytic converter</td>
<td>67.60</td>
<td>12.00</td>
<td>11.00</td>
</tr>
<tr>
<td>car with catalytic converter</td>
<td>23.60</td>
<td>32.35</td>
<td>41.10</td>
</tr>
</tbody>
</table>

Which statement does not explain the above data?

A. The percentage of carbon dioxide increases as unburnt hydrocarbons undergo complete combustion in the catalytic converter.
B. The percentage of nitrogen monoxide decreases as it is oxidised to form harmless nitrates, carbon dioxide and water in the catalytic converter.
C. The percentage of nitrogen monoxide decreases as it is reduced to form nitrogen in the catalytic converter.
D. The percentage of water vapour increases as unburnt hydrocarbons undergo complete combustion in the catalytic converter.

36. An ester is made by reacting alcohol P with a carboxylic acid Q. Alcohol P can be oxidised to form Q by warming with acidified potassium manganate(VII), under reflux.

What might be the structural formula for the ester made?

A. CH₃OOCH₃  
B. CH₃COOCH₂CH₃  
C. CH₃CH₂COOCH₂CH₃  
D. CH₃CH₂CH₂COOCH₂CH₃
37 The diagram below represents the process of fractional distillation of crude oil.

fractionating column

<table>
<thead>
<tr>
<th>crude oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>furnace</td>
</tr>
</tbody>
</table>

Which statement about the fractional distillation of crude oil is incorrect?

A A pure compound is obtained at each level of the column.
B The fraction collected at the bottom of the column is the least flammable.
C The fraction collected at the top of the column has the lowest melting point.
D The molecules reaching the top of the column have the smallest relative molecular masses.

38 Aspirin as a drug is commonly used as a general painkiller. The full structural formula of aspirin is shown below.

Which statement about aspirin is incorrect?

A It can undergo substitution reaction with chlorine under UV light.
B It is formed from an organic acid and an alcohol.
C It turns acidified potassium manganate(VII) solution from purple to colourless.
D Its aqueous solution reacts with sodium hydroxide.
Propene reacts with hydrogen bromide to form two products.

\[
\text{C} = \text{C} - \text{C} - \text{C} + \text{HBr} \quad \rightarrow \quad \text{H} - \text{C} - \text{C} - \text{C} - \text{H} \\
\quad \text{propene} \quad \rightarrow \quad \text{H} - \text{C} - \text{C} - \text{C} - \text{Br}
\]

Which of the following alkenes does not form two products on reaction with hydrogen bromide?

A

\[
\text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H}
\]

B

\[
\text{H} - \text{C} - \text{C} = \text{C} - \text{C} - \text{H}
\]

C

\[
\text{H} - \text{C} = \text{C} - \text{C} - \text{C} - \text{H}
\]

D

\[
\text{H} - \text{C} - \text{C} = \text{C} - \text{C} - \text{C} - \text{H}
\]
Polyhydroxyalkanoates are biodegradable plastics. The structure of one type of these plastics is shown below.

\[
\begin{array}{c}
\text{CH}_3 \quad \text{H} \quad \text{O} \\
\text{O} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad [n] \\
\text{H} \quad \text{H} \\
\end{array}
\]

Which of the following molecules could be its monomer?

A
\[
\begin{array}{c}
\text{CH}_3 \quad \text{H} \quad \text{O} \\
\text{H} \quad \text{O} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \\
\text{H} \quad \text{H} \\
\end{array}
\]

B
\[
\begin{array}{c}
\text{CH}_3 \quad \text{H} \quad \text{O} \\
\text{H} \quad \text{O} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{N} \quad \text{H} \\
\text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\
\end{array}
\]

C
\[
\begin{array}{c}
\text{CH}_3 \quad \text{H} \quad \text{O} \\
\text{H} \quad \text{O} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{O} \quad \text{H} \\
\text{H} \quad \text{H} \\
\end{array}
\]

D
\[
\begin{array}{c}
\text{CH}_3 \quad \text{H} \quad \text{O} \\
\text{Cl} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{O} \quad \text{H} \\
\text{H} \quad \text{H} \\
\end{array}
\]

END OF PAPER
### The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>He</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Cl</td>
<td>Ar</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Li</td>
<td>Be</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Ca</td>
<td>Sc</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
<td>Mn</td>
</tr>
<tr>
<td>5</td>
<td>Ca</td>
<td>Sc</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
<td>Mn</td>
<td>Fe</td>
<td>Co</td>
</tr>
<tr>
<td></td>
<td>Sr</td>
<td>Y</td>
<td>Zr</td>
<td>Nb</td>
<td>Mo</td>
<td>Tc</td>
<td>Ru</td>
<td>Rh</td>
</tr>
<tr>
<td>6</td>
<td>Ba</td>
<td>La</td>
<td>Hf</td>
<td>Ta</td>
<td>W</td>
<td>Re</td>
<td>Os</td>
<td>Ir</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re</td>
<td></td>
<td>W</td>
<td>Re</td>
<td>Os</td>
<td>Ir</td>
<td>Pt</td>
</tr>
</tbody>
</table>

Key:
- a = metallic state of element
- b = atomic symbol
- c = atomic number
- d = period (nonmetal number)

*09-113 Periodic Table of Elements*
PRESBYTERIAN HIGH SCHOOL
SCIENCE DEPARTMENT

Subject: Chemistry
Level: 4 Express
Exam: Prelim
Year: 2017

MARKING SCHEME

Paper 1 (40 marks)

<table>
<thead>
<tr>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q11</th>
<th>Q12</th>
<th>Q13</th>
<th>Q14</th>
<th>Q15</th>
<th>Q16</th>
<th>Q17</th>
<th>Q18</th>
<th>Q19</th>
<th>Q20</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>D</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q21</th>
<th>Q22</th>
<th>Q23</th>
<th>Q24</th>
<th>Q25</th>
<th>Q26</th>
<th>Q27</th>
<th>Q28</th>
<th>Q29</th>
<th>Q30</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>C</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>B</td>
<td>D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q31</th>
<th>Q32</th>
<th>Q33</th>
<th>Q34</th>
<th>Q35</th>
<th>Q36</th>
<th>Q37</th>
<th>Q38</th>
<th>Q39</th>
<th>Q40</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>D</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>C</td>
</tr>
</tbody>
</table>
INSTRUCTIONS TO CANDIDATES

Write your class, register number and name on all the work you hand in.
Write in dark blue or black pen.
Do not use correction fluid.

Section A
Answer all questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer all questions.
Write your answers in the spaces provided on the question paper.

You are advised to spend no longer than one hour on Section A and no longer than 45 minutes on Section B.
At the end of the examination, submit Section A and B separately.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is printed on page 23.

This question paper consists of 22 printed pages (including this cover page) and 2 blank pages.
2

SECTION A (50 marks)

Answer all questions in this section in the spaces provided.

1 Table 1.1 gives the composition of three particles.

<table>
<thead>
<tr>
<th>particle</th>
<th>number of protons</th>
<th>number of electrons</th>
<th>number of neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>C</td>
<td>15</td>
<td>15</td>
<td>17</td>
</tr>
</tbody>
</table>

(a) Using the information from Table 1.1, explain why

(i) particle A is an atom;

(ii) A, B and C are all particles of the same element;

(iii) particles A and C are isotopes of the same element.

(b) Is element A, a metal or a non-metal? Give a reason for your answer.

2 Chlorine exists as a gas at room temperature and pressure. A sample of chlorine gas is bubbled into a beaker of aqueous potassium iodide.

(a) Describe the movement of the chlorine molecules.
(b) Describe and explain what you would see when the chlorine is bubbled into the beaker of aqueous potassium iodide.

................................................................................................................................................................................. [2]

(c) The following apparatus can be used to measure the rate of diffusion of a gas.

```
constant pressure applied
```

```
gas syringe  gas  metal foil, gas escapes through small hole in foil
```

The following results were obtained.

<table>
<thead>
<tr>
<th>gas</th>
<th>temperature / °C</th>
<th>rate of diffusion in cm$^3$/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>oxygen</td>
<td>25</td>
<td>0.88</td>
</tr>
<tr>
<td>chlorine</td>
<td>25</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Explain why oxygen gas diffuses faster than chlorine gas.

................................................................................................................................................................................. [2]

[Total: 5]
3. An autocatalytic reaction is one where the reaction is catalysed by one of its products. An example of an autocatalytic reaction is the reaction between acidified potassium manganate(VII) and oxalic acid, \( \text{H}_2\text{C}_2\text{O}_4 \). The ionic equation is as follows:

\[
2\text{MnO}_4^- \text{(aq)} + 5\text{H}^+ \text{(aq)} + 5\text{H}_2\text{C}_2\text{O}_4 \text{(aq)} \rightarrow 2\text{Mn}^{2+} \text{(aq)} + 8\text{H}_2\text{O} \text{(l)} + 10\text{CO}_2 \text{(g)}
\]

In this reaction, \( \text{Mn}^{2+} \) ions act as the catalyst.

Fig. 3.1 shows the changes in concentration of oxalic acid over time when excess acidified potassium manganate(VII) solution is reacted with 1.0 mol/dm\(^3\) of oxalic acid.

![Graph showing concentration over time](image)

**Fig. 3.1**

(a) Explain how, in terms of activation energy and colliding particles, a catalyst speeds up the rate of reaction.

(b) Explain why, in terms of colliding particles,

(i) the rate of reaction increases in the first 50 seconds;

[Turn Over]

Need a home tutor? Visit smiletutor.sg

| Page 276 |
(ii) the rate of reaction decreases after 50 seconds. 

(c) Explain, in terms of oxidation states, why the reaction between acidified potassium manganate(VII) and oxalic acid is a redox reaction.

(d) State how one can tell that the reaction has completed.

[Total: 10]

4 An experiment on electrolysis is carried out using the apparatus shown in Fig. 4.1.

![Diagram of electrolysis apparatus]

A small volume of gas W is evolved at electrode X and is collected over water.
(a) (i) Is electrode Y the cathode or anode? Explain your answer.

......................................................................................................................... [2]

(ii) What will be the colour change in the electrolyte after electrolysis is carried out for some time?

......................................................................................................................... [1]

(iii) State and explain two differences that you will see if electrode X is now replaced by a piece of copper metal and the solution is replaced with dilute copper(II) chloride solution.

......................................................................................................................... [4]

(b) (i) Describe a test for gas W and state the observations.

......................................................................................................................... [1]

(ii) Explain whether the displacement of water is a suitable method to collect gas W.

......................................................................................................................... [1]

[Total: 9]
5 Excess hydrochloric acid is added to powdered zinc. The hydrogen evolved is collected and its volume is measured every 20 seconds.

The experiment is repeated at the same temperature using the same number of moles of powdered magnesium and aluminium.

Fig. 5.1 shows the volume of hydrogen produced from each metal against time.

![Graph showing the volume of hydrogen produced against time for metals A, B, and C.](image)

**Fig. 5.1**

(a) Identify metal B and explain the shape of the graph for metal B.

..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

[3]

(b) Identify metals A and C.

..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

[1]
(c) Use your understanding of number of moles of particles to explain why metals A and C produce the same volume of hydrogen but metal B produces a larger volume.

........................................................................................................................................................................ [2]

[Total: 6]

6 The alkanes are a homologous series of hydrocarbons.

(a) Student 1 and 2 had a discourse on the molecules below.

\[ \text{H-C-C-H} \quad \text{H-C-C-C-C-H} \]

molecule A

molecule B

Student 1 says that both molecules A and B are in the same homologous series while Student 2 believes that molecules A and B are in a different homologous series.

From the information above,

(i) Suggest with a reason which of the two students is correct.

........................................................................................................................................................................ [1]

(ii) State the condition(s) for the chemical reaction between an alkane and chlorine to take place.

........................................................................................................................................................................ [1]
(iii) In terms of bond breaking and bond forming, state whether the chemical reaction between an alkane and chlorine is an exothermic or endothermic reaction.

............................................................................................................................................................................

............................................................................................................................................................................ [2]

(iv) Draw an energy profile diagram for the reaction between molecule A and chlorine. Label the activation energy, enthalpy change and label the axes.

............................................................................................................................................................................

............................................................................................................................................................................

............................................................................................................................................................................ [2]

(b) (i) One mole of undecane, C_{11}H_{24}, is cracked to form a mixture containing one mole of ethene, one mole of propene and one mole of molecule R.

State the formula of molecule R.

............................................................................................................................................................................ [1]

(ii) Draw a branched isomer of molecule R.

............................................................................................................................................................................ [1]
(iii) 'Carbon-neutral' fuels are fuels that do not result in a change of carbon dioxide in the atmosphere.

Unlike obtaining ethanol through hydration of ethene, only obtaining ethanol through fermentation is considered as 'carbon-neutral'.

Explain why obtaining ethanol through fermentation is considered as 'carbon-neutral'.

[2]

[Total: 10]

7 Air bags are used to protect passengers in a car during an accident. When the crash sensor detects an impact, it causes a mixture of chemicals to be heated to a high temperature. Reactions take place which produce nitrogen gas. The nitrogen fills the air bag.

(a) The mixture of chemicals contains sodium azide (NaN₃), which decomposes on heating to form sodium and nitrogen.

\[ 2\text{NaN}_3 \rightarrow 2\text{Na} + 3\text{N}_2 \]

An air bag contains 130 g of sodium azide. When the sodium azide decomposes, 60 dm³ of nitrogen gas is obtained at room temperature and pressure.
Calculate the percentage yield of nitrogen from the decomposition of sodium azide.

(b) The sodium produced when sodium azide decomposes is dangerous. The mixture of chemicals in the air bag contains potassium nitrate and silicon dioxide which help to make the sodium safe. Sodium reacts with potassium nitrate to produce sodium oxide, potassium oxide and nitrogen.

Write the equation for the reaction between sodium and potassium nitrate.

..........................................................................................................................................

[1]

(c) The silicon dioxide reacts with sodium oxide and potassium oxide to form silicates.

Suggest why sodium oxide and potassium oxide are dangerous in contact with the skin.

..........................................................................................................................................

[1]

[Total: 5]

END OF SECTION A
SECTION B (30 marks)

Answer all three questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

8 Read the passage below, which explains the chemistry of how certain foods 'rise' during cooking.

Many food products such as bread, sponge cakes and buns have a honeycomb structure which contains many bubbles. During cooking, these bubbles are formed by a gas and the mixture 'rises'. In some cases, the gas is air which is whipped into the mixture before cooking and expands during cooking. In other cases, the gas is carbon dioxide.

The most common chemical to do this is sodium hydrogen carbonate, NaHCO₃. Sodium hydrogen carbonate is found in both baking soda and baking powder.

Baking soda consists of only sodium hydrogen carbonate. When it is heated, it forms carbon dioxide gas according to the equation:

\[ 2\text{NaHCO}_3 (s) \rightarrow \text{Na}_2\text{CO}_3 (s) + \text{CO}_2 (g) + \text{H}_2\text{O} (l) \]

Since the material is relatively cheap, it seems to be an excellent agent to produce carbon dioxide. The above chemical equation, however, also illustrates the disadvantages of baking soda. When used on its own, only half the available carbon dioxide is released and more seriously, the sodium carbonate produced gives the baked product a slightly bitter and 'soapy' taste. To overcome this problem, baking soda is usually mixed with some honey.

Baking powder consists of a mixture of sodium hydrogen carbonate and a weak acid such as potassium hydrogen tartrate (cream of tartar). The formula of this acid is:

\[
\begin{align*}
\text{HO} & \quad \text{C} \quad \text{COOH} \\
\text{HO} & \quad \text{C} \quad \text{COOK} \\
\text{H} & \\
\end{align*}
\]
Potassium hydrogen tartrate is a solid which means that it is possible to mix it with sodium hydrogen carbonate without the two reacting. The reaction is:

\[
\text{HO} - \text{C} - \text{COOH} + \text{NaHCO}_3 \rightarrow \text{HO} - \text{C} - \text{COONa} + \text{CO}_2 + \text{H}_2\text{O}
\]

One problem with the use of potassium hydrogen tartrate is that it is very soluble in water. As soon as it becomes wet, it dissolves and reacts. This risks all the gas escaping while the cake mix is still in liquid form and before it goes into the oven.

(a) Using kinetic particle theory, explain how air which has been whipped into the mixture makes the dish "rise" upon cooking.

(b) Predict the pH value of sodium carbonate when it is dissolved in water.

(c) The average pH of honey is 3.9. Explain how the addition of honey to baking soda makes the cake taste better.
(d) Besides taste, explain why most bakers prefer to use baking powder instead of baking soda when they are baking cakes.

.................................................................

.................................................................

................................................................. [2]

(e) Potassium hydrogen tartrate can be made from the reaction of potassium hydroxide with tartaric acid. Draw the structural formula of tartaric acid.

.................................................................

.................................................................

.................................................................

.................................................................

(f) The following instruction is found on a bottle of baking powder.

\[\text{Store in a dry place.}\]

Explain why this instruction is important.

.................................................................

.................................................................

.................................................................

.................................................................

................................................................. [2]
(g) Both potassium hydrogen tartrate and hydrochloric acid react with sodium hydrogen carbonate to produce a salt, carbon dioxide and water.

However, the rate of reaction is faster in the reaction between hydrochloric acid and sodium hydrogen carbonate.

Explain the differences in the rate of reaction for the reaction between hydrochloric acid and sodium hydrogen carbonate as compared to potassium hydrogen tartrate and sodium hydrogen carbonate:

[2]

Table 9.1 shows some properties of the noble gases.

<table>
<thead>
<tr>
<th>Element</th>
<th>Electronic configuration</th>
<th>Relative atomic mass</th>
<th>Density / g dm⁻³</th>
<th>Melting point / °C</th>
<th>Boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>helium</td>
<td>2</td>
<td>4</td>
<td>0.17</td>
<td>-272</td>
<td>-269</td>
</tr>
<tr>
<td>neon</td>
<td>2.8</td>
<td>20</td>
<td>0.83</td>
<td>-249</td>
<td>-246</td>
</tr>
<tr>
<td>argon</td>
<td>2.8.8</td>
<td>40</td>
<td>1.67</td>
<td>-189</td>
<td>-186</td>
</tr>
<tr>
<td>krypton</td>
<td>2.8.18.8</td>
<td>84</td>
<td>3.50</td>
<td>-157</td>
<td>-152</td>
</tr>
<tr>
<td>xenon</td>
<td>2.8.18.18.8</td>
<td>131</td>
<td></td>
<td>-112</td>
<td>-105</td>
</tr>
</tbody>
</table>

(a) Using information from Table 9.1, suggest why noble gases are unreactive.

[2]
(b) Complete Table 9.1 by calculating the density of xenon at room temperature and pressure.

(c) All Group 0 elements are gases at room temperature and pressure. State how the information from the table supports this.

(d) Xenon has been found to form a compound xenon difluoride, XeF₂, which has a melting point of 128 °C. Using ideas of bonding and structure, explain the melting point of xenon difluoride.

[Turn Over

Need a home tutor? Visit smiletutor.sg

| Page 289 |
10 **EITHER**

Esters are compounds which give fruits their flavours. They also provide the scent in flowers.

(a) The ester, CH₃(CH₂)₂CO₂CH₃, contributes to the aroma of apples.

(i) Draw the structure of the two starting materials needed to produce this ester.

(ii) State the catalyst required for esterification to take place.

(iii) Apart from their uses as artificial food flavourings, state one major commercial use of esters.

(b) Leaf alcohol is a compound that exists as a colourless oily liquid. It has an intense grassy-green odour of freshly cut green grass and leaves. It is produced in small amounts by most plants and it acts as an attractant to many predatory insects.

The structure of leaf alcohol is as follows:

```
HO—CH₂—CH₂—C≡C—H
|     |     |     |
H ——— CH₂—CH₃
```
(i) Leaf alcohol was reacted to form a product which increased the Mr value by 18 units. 

Suggest a structure for this product and deduce the type of reaction that took place.

structure of product

(ii) Describe a chemical test to distinguish between leaf alcohol and the product formed in b(i).

(iii) Draw two repeat units of the polymer formed when leaf alcohol undergoes polymerisation.
OR

Fumaric acid is a colourless solid which can be extracted from plants.

\[
\begin{align*}
\text{HOOCC} & \quad \text{C} \quad \text{C} \\
\text{H} & \quad \text{C} \quad \text{COOH}
\end{align*}
\]

(a) (i) Describe a chemical test that can be used to confirm that fumaric acid is an unsaturated compound.

.................................................................................................................. [1]

(ii) Draw the product formed between the chemical stated in a(i) and fumaric acid.

..................................................................................................................

(b) A solution of fumaric acid is titrated against aqueous sodium hydroxide.

(i) Construct a chemical equation for the reaction between fumaric acid and sodium hydroxide.

.................................................................................................................. [1]
(ii) 18.0 cm$^3$ of 0.200 mol/dm$^3$ sodium hydroxide solution is required to neutralise 60.0 cm$^3$ of fumaric acid solution.

Calculate the concentration, in mol/dm$^3$, of fumaric acid solution.

(c) Draw the structural formula of the polymer which is made when fumaric acid reacts with ethane-1,2-diol, HO(CH$_2$)$_2$OH. Name the linkage formed.

structural formula of polymer

name of linkage:
(d) Draw the structural formula of the polymer formed when fumaric acid undergoes polymerisation.

(e) Polymers are widely used today.

(i) State a problem caused by disposal of polymers.

(ii) Despite the disadvantages, new polymers are made instead of recycling existing ones. Explain why.

[Total: 10]

END OF PAPER
# PRESBYTERIAN HIGH SCHOOL
## SCIENCE DEPARTMENT
### Marking Scheme

**Subject:** Chemistry  
**Level:** Sec 4 Express  
**Exam:** Prelim Exams  
**Year:** 2017

<table>
<thead>
<tr>
<th>Qn</th>
<th>Section A (50 marks) Scoring Points</th>
<th>Sub-total</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a(i)</td>
<td>Same number of protons and electrons</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>Same number of protons / same proton number / same atomic number</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(iii)</td>
<td>Same number of protons / same proton number / same atomic number; Different number of neutrons / different nucleon or mass number</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>
| b | Non-metal because it gains 3 electrons to form a negative ion / it is in Group V  
   **Note:** need both non-metal and reason for one mark  
   In (a), most students stated the correct answer. However, there are students who mentioned that atom consists of protons, electrons and neutrons with no mention of the need for the charge of an atom to be neutral.  
   Part a ii and iii are better answered  
   Part (b) was a challenging question for the students as they wrote Group V as 5, hence no credit was awarded.  
   Students also did not mentioned the need to gain electrons to form anion, rather just wrote that the non-metal element forms an anion, hence no credit awarded. | 1         |       |
| 2a | Move randomly at high speeds in all directions | 1         |       |
|      | Badly answered as there was missing answer such as speed or the direction of motion. |           |       |
| b  | Colourless (potassium iodida) solution turns brown; Chlorine is more reactive than iodine, displaces iodide ions from potassium iodide solution  
   Many students gained partial credit. Most did not mentioned colourless solution turns brown but wrote brown solution formed.  
   There are students who wrote that iodine crystals are formed.  
   The answer tend to be incomplete as students failed to mention the displacement reaction.  
   There are answers that focused on oxidation and reduction, not answering to the question. | 1         | 5     |
| c  | Oxygen gas has a smaller M, (32) than chlorine gas (71); oxygen gas diffuse / move faster | 1         |       |
### Students who are familiar with diffusion did well.

| 3a | Catalyst provides an alternative pathway of a lower activation energy; More reacting particles have energy equal or greater than $E_a$; Increases number of effective collisions.  
There are students who do not know that catalyst do not take part in the chemical reaction. Most students have the misconception that catalyst lowered the activation energy which is not true as catalyst offers an alternative pathway with lowered $E_a$. There are also quite a number of students who wrote that the reacting particles have more kinetic energy for reaction due to catalyst hence reaction occurred faster. Students needs to better differentiate the difference between $E_a$ and kinetic energy of particles. |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>b(i)</td>
<td>In first 50 s, concentration of $\text{Mn}^{2+}$ increases; More $\text{Mn}^{2+}$ ions per unit volume of solution, results increase in number of effective collisions.</td>
</tr>
<tr>
<td>(ii)</td>
<td>After 50 s, concentration of oxalic acid decreases; Less oxalic acid particles per unit volume, decreases in number of effective collisions.</td>
</tr>
<tr>
<td></td>
<td>Part b(i) and (ii) are poorly answered. For part b(i), the students did not recognised that this question focused on the catalyst that are formed as reaction proceeded.</td>
</tr>
<tr>
<td></td>
<td>There is a tendency for students to write answer for part (ii) that the reactants are used up hence reaction decrease without mentioning which reactants are used up. There is a need to emphasise that per unit volume is an important concept in speed of reaction.</td>
</tr>
</tbody>
</table>
| c | Potassium manganate(VII) is reduced as the oxidation state of Mn decreases from +7 in $\text{MnO}_4^-$ to +2 in $\text{Mn}^{2+}$; oxalic acid is oxidised as oxidation state of C increases from +3 in $\text{H}_2\text{C}_2\text{O}_4$ to +4 in $\text{CO}_2$.  
Able students gained full credit. There is a concern that partial credit is not gained for potassium manganate (VII), a substance that most students are familiar, the os given for $\text{MnO}_4^-$ are wrong. There are instances that maganese ion was given negative charged. |
|  | No more effervescence produced / no bubbles of gas observed Reject: solution turn from purple to colourless.  
There are students who wrote that the solution turn from purple to colourless as answer. |
4a(i) Y is cathode; Cl⁻ are discharged at X, thus Cu²⁺ ions are discharged and reduced at Y

(ii) Solution turns from blue to colorless

(iii) Copper anode becomes smaller; Copper anode ionises and oxidise to form Cu²⁺ ions

Solution remains blue: For every Cu²⁺ ion that is reduced at cathode, one Cu atom from anode ionises and oxidise at anode

Poorly answered as students did not read the question carefully. The question asked for what was observed during the electrolysis, there are responses that mentioned the discharged of copper ions but they did not mentioned the decrease in size fo the electrode or the answer was on the cathode Y.

A number of responses mentioned that the solution becomes diluted and not concentrated leading to gases such as oxygen and hydrogen being formed.

The explanation for the solution remaining blue tends to be incomplete.

b(i) Gas W turns moist blue litmus paper red and bleaches it

Students did not gained credit as they missed out the word “damp litmus” or “moist litmus”. There are also students who used red litmus paper.

(ii) No because gas W is soluble in water

Students are not familiar with gas collection methods, quite a number mentioned that gas W, chlorine is insoluble in water.

5a Metal B is aluminium; Reaction is slower at the start / gradient is less steep as the aluminium oxide is reacting with the acid first; Reaction is faster / gradient gets steeper as the oxide layer is removed, exposes the aluminium which then reacts with the acid

Most students have difficulties explaining why the reaction for aluminium is slower at the start. The students forgot about the insoluble layer that existed on aluminium. Most explanations given involves the charge of the metals to relate to the volume of hydrogen given off.

b Metal A is magnesium, metal C is zinc

c For both magnesium and zinc, 1 mole of metal produces 1 mole of H₂; thus same volume of gas produced; For aluminium, 1 mole of metal produces 1.5 moles of H₂, hence higher volume of gas produced:

\[
2Al + 6HCl \rightarrow 2AlCl₃ + 3H₂ \\
Zn + 2HCl \rightarrow ZnCl₂ + H₂
\]
\[ \text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2 \]

Part C was not well answered as students did not use mole to explain, this was stated in the question.

6a(i) Student Z is correct as the molecules do not have the same general formula and same functional group.

Students need to differentiate between molecular formula, structural formula and general formula to do well.

(ii) UV light

There are students who do not know about UV light, instead radiation or ray was used.

There are quite a number of students who combined UV light with other conditions (meant for other experiments).

(iii) Endothermic reaction as more energy is absorbed in breaking Cl-Cl and C-H bonds; than energy released in forming C-Cl and H-Cl bonds

Students tend to give incomplete answers that do not mentioned the bonds broken or formed. There are students who did not use the terms “energy is absorbed” or “energy released”.

(iv) correct shape with labelled axes; label of activation energy and enthalpy change with single arrow heads

Students need to understand that sketching of graphs require labelled axes. Graphs that are sketched correctly have \( \text{Ea} \) or \( \Delta \text{H} \) not shown, example \( \Delta \text{H} \) is +ve. Arrows drawn for \( \text{Ea} \) and \( \Delta \text{H} \) are not placed in correct positions.

b(i) \( \text{CaH}_4 \)

(ii) Structures shown

any one of the above practice ecc

Well answered by most students.

(iii) the sugar used during fermentation was formed by absorption of carbon
dioxide during photosynthesis.
burning of ethanol and fermentation of glucose to form ethanol releases carbon dioxide that was previously absorbed.

Only some students gained credit as most students did not link photosynthesis (the absorption of CO₂) and combustion of ethanol (released of CO₂). Majority of students focused on the fermentation process.

7a

No. of moles of sodium azide = \( \frac{130}{23 + 3 \times 14} \)
= \( \frac{130}{65} \)
= 2.00 mol

No. of moles of nitrogen = \( \frac{2}{2} \times 3 \)
= 3.00 mol

Theoretical yield of nitrogen = \( 3 \times 24 \)
= 72.0 dm³

Percentage yield = \( \frac{60}{72} \times 100\% \)
= 83.3%

Deduct 1 mark from overall if without units or 3 sig. fig.

Majority of students gained partial credit.

There are students who use number of mole to compute the percentage yield which is not acceptable.

b

\( 10\text{Na} + 2\text{KNO}_3 \rightarrow 5\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{N}_2 \)

Majority of students are not able to balance the equation.

c

Sodium oxide and potassium oxide form strong and corrosive alkalis when in contact with moisture from the skin.

Students did not link the moisture from skin to the question. There are answers that focused on the silicon dioxide.

<table>
<thead>
<tr>
<th>Section B (30 marks) Scoring Points</th>
<th>subtotal</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>8a At higher temperature, air particles gain energy and move faster; Particles move further from each other; increasing volume of air Comment: Most students were able to state the increased movement of the particles due to the gain of thermal energy. However, many failed to mention about the increased spacing of particles that resulted in the volume increase of the gas that caused the rising effect.</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>b 8 Accept pH values from 8-10 Comment: Most students were able to state correct pH value within the range.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>c Honey is acidic; Reacts with sodium carbonate, removing the bitter taste from the cake Accept: honey neutralises sodium carbonate</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Comment: Most students were able to explain the effect of adding honey to the reaction mixture but not stating the nature of honey that caused the neutralisation effect.

d  Using baking powder produces twice the volume of carbon dioxide compared to baking soda;
   Makes the cake rise higher.
   Accept: only half the volume of carbon dioxide gas produced hence not enough to cause the cake to rise.

Comment: The better students were able to make use of the two chemical equations to link the mole ratio between the reactants and products involved in the reaction to come out with the volume of carbon dioxide produced when baking soda and baking powder were used. This question proved to be a challenging one for the weaker students.

e  \[\begin{align*}
   \text{HO} & \quad \text{C} & \quad \text{COOH} \\
   \text{HO} & \quad \text{C} & \quad \text{COOH} \\
   & \quad \text{H} \\
\end{align*}\]

Comment: Most students struggled with the structure of the acid. The students failed to recognise the functional group \((-\text{COOH})\) that is present in all carboxylic acids.

f  When dissolved in water, potassium hydrogen tartrate ionises to produce hydrogen ions;
   Absence of hydrogen ions when dry.
   Accept: dissolves and reacts, thus risking all the gas escaping which causes the rising effect.

Comment: Only a few students were able to mention the ionisation effect of the acid group when the substance is dissolved in water. Most students were given the credit when they used the information from the text.

g  Potassium hydrogen tartrate is a weak acid, partially ionize in water to produce fewer hydrogen ions to react with sodium hydrogen carbonate;
   Hydrochloric acid is a strong acid, completely ionize in water to produce more hydrogen ions.
   Reject: if no comparison is made between the two acids in terms of concentration of hydrogen ions.

Comment: Most students were able to state the difference in the concentrations of hydrogen ions between the two acids due to the ionisation effect. However, some students did not clearly mention which acid produced more hydrogen ions.
<table>
<thead>
<tr>
<th>General comment: A handful of students left a few parts to this question unanswered due to time management issues.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>9a</strong> Noble gases have duplet configuration for helium while octet configuration for neon, argon, krypton and xenon. OR all the noble gases have 8 outer shell/valence electrons except for helium with 2; Noble gases are unlikely to form ions resulting in a lack of reactivity OR noble gases do not need to lose or gain electrons</td>
</tr>
<tr>
<td><strong>b</strong> Density of xenon = ( \frac{131}{24} ) = 5.46 g/dm(^3)</td>
</tr>
<tr>
<td>1 mark for correct calculation (ignore if without units) 1 mark to 3 sig. fig.</td>
</tr>
<tr>
<td>Accept: 0.00546 g/cm(^3)</td>
</tr>
<tr>
<td>Comment: Most students were able to calculate the density of xenon with little difficulties.</td>
</tr>
<tr>
<td><strong>c</strong> All the noble gases have boiling points lower than 25°C / room temperature</td>
</tr>
<tr>
<td>Comment: Many students failed to know that room temperature is 25°C and stated 37°C to be the incorrect room temperature. Students were not given the credit as they did not make a comparison between the boiling points of the noble gases with respect to the room temperature and just simply stated that all the noble gases have low boiling points. Most students are still weak in processing and analysing data in drawing conclusions.</td>
</tr>
<tr>
<td><strong>d</strong> Xenon difluoride exists as discrete covalent molecules / simple covalent molecules / has a simple molecular structure Weak intermolecular forces of attraction / weak van der Waals' forces of attraction between molecules; Little heat energy needed to overcome the weak forces of attraction</td>
</tr>
<tr>
<td>Comment: This question proved to be a challenging one for most students. Many students failed to recognise that the elements involved in xenon difluoride are non-metallic, hence forming covalent compounds. Some students mistook the compound as an ionic substance hence giving the wrong explanation. Many students are still weak in the topic of chemical bonding and structure of materials, hence unable to use the correct terms in explaining the properties of substances in terms of structure and bonding.</td>
</tr>
</tbody>
</table>
### EITHER

<table>
<thead>
<tr>
<th>a(i)</th>
<th><img src="H-C-C-C-C-O-H-H" alt="Chemical Structure" /> <img src="H-C-O-H" alt="Chemical Structure" /></th>
</tr>
</thead>
</table>

(ii) Concentrated sulfuric acid  
(iii) Solvents in perfumes

<table>
<thead>
<tr>
<th>b(i)</th>
<th><img src="HO-CH%E2%82%82CH%E2%82%82C-CH%E2%82%82CH%E2%82%83" alt="Chemical Structure" /> <img src="O-H" alt="Chemical Structure" /></th>
</tr>
</thead>
</table>

Addition reaction  
Reagent: hydration  
Add aqueous bromine to both leaf alcohol and the product;  
Reddish brown aqueous bromine decolourises rapidly in leaf alcohol while aqueous bromine remains reddish brown in the product

<table>
<thead>
<tr>
<th><img src="HOH%E2%82%82CH%E2%82%82C" alt="Chemical Structure" /> <img src="CH%E2%82%82CH%E2%82%83" alt="Chemical Structure" /> <img src="CH%E2%82%82CH%E2%82%83" alt="Chemical Structure" /> <img src="HOH%E2%82%82CH%E2%82%82C" alt="Chemical Structure" /> <img src="CH%E2%82%82CH%E2%82%83" alt="Chemical Structure" /> <img src="CH%E2%82%82CH%E2%82%83" alt="Chemical Structure" /></th>
</tr>
</thead>
</table>

1 mark for each correct repeat unit

Comment: From this question, many students still failed in mastering the organic chemistry content. This was evident when pure recall kind of questions were asked and many students were not able to answer as they refused to memorise the reagents and conditions required for each organic reaction. Students need to spend time and effort in mastering the content in organic chemistry so that they can excel in their national examinations.

### OR

| a(i) | Add aqueous bromine to fumaric acid;  
Reddish brown aqueous bromine decolourises in fumaric acid. |
|------|---------------------------------------------------------------|

<table>
<thead>
<tr>
<th><img src="H-O-C-C-O-H" alt="Chemical Structure" /> <img src="H-C-C-C-H" alt="Chemical Structure" /> <img src="Br" alt="Chemical Structure" /> <img src="Br" alt="Chemical Structure" /></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><img src="H-O-C-C-O-H" alt="Chemical Structure" /> <img src="H-C-C-C-H" alt="Chemical Structure" /> <img src="Br" alt="Chemical Structure" /> <img src="Br" alt="Chemical Structure" /></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>e(i)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
1. A gas Y, is less dense than air, very soluble in water and is alkaline.
   Which method is used to collect a dry sample of the gas?

   ![Diagram A]
   ![Diagram B]
   ![Diagram C]
   ![Diagram D]

2. The table gives data about four substances.
   Which substance has particles that are closely packed in a disorderly arrangement at room temperature?

<table>
<thead>
<tr>
<th></th>
<th>melting point/°C</th>
<th>boiling point/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-114</td>
<td>-80</td>
</tr>
<tr>
<td>B</td>
<td>-15</td>
<td>45</td>
</tr>
<tr>
<td>C</td>
<td>750</td>
<td>1407</td>
</tr>
<tr>
<td>D</td>
<td>1610</td>
<td>2230</td>
</tr>
</tbody>
</table>

3. Which of the following is the best method of obtaining pure water from ink?
   A chromotography
   B distillation
   C filtration
   D sublimation
4. The following measurements are made on a sample pure water: its boiling point, its freezing point, and its pH.

Sodium chloride is now dissolved in the water and the measurements repeated.

How do the measurements change?

<table>
<thead>
<tr>
<th></th>
<th>boiling point</th>
<th>freezing point</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>higher</td>
<td>lower</td>
<td>no change</td>
</tr>
<tr>
<td>B</td>
<td>higher</td>
<td>higher</td>
<td>increases</td>
</tr>
<tr>
<td>C</td>
<td>lower</td>
<td>higher</td>
<td>no change</td>
</tr>
<tr>
<td>D</td>
<td>lower</td>
<td>lower</td>
<td>decreases</td>
</tr>
</tbody>
</table>

5. How many electrons in total are shared between the atoms in a molecule of ethene, \( \text{C}_2\text{H}_4 \), and in a molecule of water, \( \text{H}_2\text{O} \)?

<table>
<thead>
<tr>
<th></th>
<th>ethene</th>
<th>water</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>14</td>
<td>8</td>
</tr>
</tbody>
</table>

6. Which element forms a positive ion with the same electronic configuration as an atom of neon?

A. chlorine
B. magnesium
C. lithium
D. oxygen

7. How does rubidium bond with bromine?

A. Each atom of rubidium receives an electron from a bromine atom.
B. Each atom of rubidium shares a pair of electrons with a bromine atom.
C. Each atom of rubidium shares an electron with a bromine atom.
D. Each atom of rubidium gives an electron to a bromine atom.
8. Given that 1 mole of oxygen contains $6 \times 10^{23}$ molecules, what is the number of molecules in 500 cm$^3$ of oxygen under room conditions?

A. $1.25 \times 10^{22}$
B. $1.34 \times 10^{22}$
C. $3.0 \times 10^{22}$
D. $3.0 \times 10^{25}$

9. When 1 volume of gas X reacts with exactly 5 volumes of oxygen it forms carbon dioxide and water only.

What is gas X?

A. methane, CH$_4$
B. ethane, C$_2$H$_6$
C. propane, C$_3$H$_8$
D. butane, C$_4$H$_{10}$

10. Which sulfide contains the greatest mass of sulfur in a 10 g sample?

<table>
<thead>
<tr>
<th>sulfide</th>
<th>formula</th>
<th>mass of 1 mole/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>NiS</td>
<td>90</td>
</tr>
<tr>
<td>B</td>
<td>FeS$_2$</td>
<td>120</td>
</tr>
<tr>
<td>C</td>
<td>MoS$_2$</td>
<td>160</td>
</tr>
<tr>
<td>D</td>
<td>PbS</td>
<td>239</td>
</tr>
</tbody>
</table>

11. The relative atomic mass of oxygen is 16 and that of hydrogen is 1.
This means that ...(i) ...of oxygen has the same mass as ...(ii) ...of hydrogen.
Which words correctly complete the blanks (i) and (ii)?

<table>
<thead>
<tr>
<th>blank (i)</th>
<th>blank (ii)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>an atom</td>
</tr>
<tr>
<td>B</td>
<td>an atom</td>
</tr>
<tr>
<td>C</td>
<td>a molecule</td>
</tr>
<tr>
<td>D</td>
<td>a molecule</td>
</tr>
</tbody>
</table>
12. A 25 cm$^3$ sample of dilute sulfuric acid contains 0.025 moles of the acid. What is the hydrogen ion concentration in the solution?

- A 0.25 mol/dm$^3$
- B 0.50 mol/dm$^3$
- C 1.00 mol/dm$^3$
- D 2.00 mol/dm$^3$

13. Which statement is most likely to be true for astatine, which is in Group VII of the Periodic Table?

- A Astatine and aqueous potassium chloride react to form aqueous potassium astatide and chlorine.
- B Astatine reacts with hydrogen to form a compound with formula HAt$_2$.
- C Aqueous potassium astatide reacts with aqueous silver nitrate to form aqueous silver astatide.
- D Sodium astatide is less stable than sodium chloride.

14. Which graph shows the number of electrons in the outer shell of an atom, plotted against the proton (atomic) number for the first ten elements in the Periodic Table?
15. A chemist puts a sample of dilute aqueous hydrochloric acid into beaker 1. She adds a sample of zinc and measures the rate of production of hydrogen gas.

She then puts a different sample of dilute aqueous hydrochloric acid into beaker 2. She adds a different sample of zinc of the same mass and measures the rate of production of hydrogen gas.

The rate of the reaction in beaker 1 is slower than the rate of the reaction in beaker 2. Which factors could help to explain this observation?

I. The reaction in beaker 1 takes place at a lower pressure than the reaction in beaker 2.
II. The zinc in beaker 1 is in larger pieces than the zinc in beaker 2.
III. The acid in beaker 1 is at a lower concentration than the acid in beaker 2.

A  I and II only
B  II and III only
C  I and III only
D  I, II and III

16. A liquid X reacts with solid Y to form a gas. Which two diagrams show suitable methods for investigating the speed of the reaction?

A  1 and 3
B  1 and 4
C  2 and 3
D  2 and 4

Need a home tutor? Visit smiletutor.sg
17. The table gives information about the reactivity of three metals P, Q and R.

<table>
<thead>
<tr>
<th>Metal</th>
<th>metal reaction with air</th>
<th>reaction with steam</th>
<th>reaction with dilute hydrochloric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>burns with sparks</td>
<td>forms an oxide</td>
<td>forms hydrogen</td>
</tr>
<tr>
<td>Q</td>
<td>slowly forms an oxide</td>
<td>no reaction</td>
<td>no reaction</td>
</tr>
<tr>
<td>R</td>
<td>slowly forms an oxide</td>
<td>no reaction</td>
<td>forms hydrogen</td>
</tr>
</tbody>
</table>

What is the order of reactivity of P, Q and R?

<table>
<thead>
<tr>
<th></th>
<th>most reactive</th>
<th>least reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>P</td>
<td>Q</td>
</tr>
<tr>
<td>B</td>
<td>P</td>
<td>R</td>
</tr>
<tr>
<td>C</td>
<td>Q</td>
<td>R</td>
</tr>
<tr>
<td>D</td>
<td>R</td>
<td>Q</td>
</tr>
</tbody>
</table>

18. Which of the following oxides can be reduced by heating with hydrogen?

A copper(II) oxide
B calcium oxide
C potassium oxide
D zinc oxide

19. An old railway carriage is being restored. Metal strips are secured on to the outside of the wooden carriage by means of screws. After a few weeks open to the wind and rain, the screws are heavily corroded but the metal strips are not.

Which two metals would give this result?

<table>
<thead>
<tr>
<th></th>
<th>screws</th>
<th>strips</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>aluminium</td>
<td>steel</td>
</tr>
<tr>
<td>B</td>
<td>copper</td>
<td>aluminium</td>
</tr>
<tr>
<td>C</td>
<td>copper</td>
<td>steel</td>
</tr>
<tr>
<td>D</td>
<td>steel</td>
<td>aluminium</td>
</tr>
</tbody>
</table>
20. Which of the following is not a reaction that occurs when iron is extracted from haematite in the blast furnace?
   A  \( \text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 \)
   B  \( \text{CO}_2 + \text{C} \rightarrow 2\text{CO} \)
   C  \( \text{FeO} + \text{CO} \rightarrow \text{Fe} + \text{CO}_2 \)
   D  \( \text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3 \)

21. The oxide \( \text{Pb}_2\text{O}_4 \) reacts with dilute nitric acid to form lead(II) nitrate, lead(IV) oxide and another product.
   What is the equation for this reaction?
   A  \( \text{Pb}_2\text{O}_4 + 4\text{HNO}_3 \rightarrow 2\text{Pb(NO}_3)_2 + \text{PbO}_2 + 2\text{H}_2\text{O} \)
   B  \( \text{Pb}_2\text{O}_4 + 2\text{HNO}_3 \rightarrow 2\text{Pb(NO}_3)_2 + \text{PbO}_2 + \text{H}_2\text{O} \)
   C  \( \text{Pb}_2\text{O}_4 + 4\text{HNO}_3 \rightarrow \text{Pb(NO}_3)_4 + 2\text{PbO} + 2\text{H}_2\text{O} \)
   D  \( 2\text{Pb}_2\text{O}_4 + 2\text{HNO}_3 \rightarrow 2\text{Pb}_2\text{NO}_3 + 2\text{PbO}_2 + \text{H}_2 \)

22. Magnesium oxide is added slowly to a beaker containing hydrochloric acid until the magnesium oxide is in excess.
   Which of the following statements about this reaction are true?
   I  The temperature of the mixture increases.
   II  The pH of the mixture increases till pH 7.
   III  Effervescence is seen.
   IV  A white precipitate is observed.
   A  I and II only
   B  II and III only
   C  III and IV only
   D  I, II and IV only

23. Which reagent, when mixed and heated with ammonium sulfate, liberates ammonia?
   A  aqueous bromine
   B  dilute hydrochloric acid
   C  limewater
   D  acidified potassium dichromate(VI)
24. The diagrams show three experiments using sulfuric acid. Three different powders are added to the acid. The mixtures are stirred.

Which test-tubes will contain aqueous Cu\(^{2+}\) ions?
A  1 and 2 only  
B  2 and 3 only  
C  1 and 3 only  
D  1, 2 and 3  

25. Which of the following reactants could be used to prepare a pure sample of potassium sulfate safely?
A  potassium carbonate and sulfuric acid  
B  potassium and zinc sulfate  
C  potassium and sulfuric acid  
D  potassium nitrate and magnesium sulfate  

26. A steel works and a chemical works are built near to a city. Limestone buildings in the city begin to crumble.

Which gas is most likely to cause this damage?
A  oxygen  
B  carbon dioxide  
C  carbon monoxide  
D  nitrogen dioxide
27. Which of the following statements is true of sulfuric acid?
A  It reacts with aqueous copper(II) chloride to produce a pale blue precipitate.
B  It gives a white precipitate with aqueous barium nitrate.
C  It reacts with aqueous silver nitrate to produce a white precipitate.
D  It releases ammonia from aqueous ammonium sulfate.

26. The presence of nitrates in the soil can be shown by warming the soil with aqueous sodium hydroxide and aluminium foil. Which of the following shows that nitrates are present?
A  A gas that extinguishes a lighted splint with a 'pop' sound is produced.
B  A gas that turns moist red litmus blue is produced.
C  A white precipitate is seen.
D  Effervescence is seen.

29. The following electrolysis circuit is set up, using inert electrodes P, Q, R and S.

![Electrolysis circuit diagram]

molten lead(II) bromide  |  dilute aqueous sodium chloride
A  P only  B  P and R only  C  Q only  D  Q and S only

At which of the electrodes is a Group VII element produced?
30. Two cells were set up as shown in the diagram. The arrow shows the direction of electron flow in the external circuit. Which set of metals would produce an electron flow in the direction shown?

```
metal X  metal Y  metal Z
A  Ag    Cu    Zn
B  Ag    Zn    Cu
C  Cu    Zn    Ag
D  Zn    Cu    Ag
```

31. The table compares the strengths of the bonds for reactions of the type below.

\[ X_2 + Y_2 \rightarrow 2XY \]

Which reaction would be most exothermic?

```
bonds in X_2  bonds in Y_2  bonds in XY
A  strong  strong  strong
B  strong  strong  weak
C  weak   weak   strong
D  weak   weak   weak
```

32. In which reaction is the sign of energy change, \( \Delta H \), correctly shown?

```
equation     \( \Delta H \)
A  \[ 2\text{AgC(s)} \rightarrow 2\text{Ag(s)} + \text{Cl}_2(g) \]  positive
B  \[ \text{CH}_4(g) \rightarrow \text{C(g)} + 4\text{H(g)} \]  negative
C  \[ \text{H}_2\text{O(l)} \rightarrow \text{H}_2\text{O(g)} \]  negative
D  \[ \text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O(l)} \]  positive
```

33. Which compound contains two different elements with identical oxidation states?

A  HClO       B  Mg(OH)_2     C  Na_2SO_4    D  NH_4Cl

Need a home tutor? Visit smiletutor.sg
| Page 313 |
34. In which of the following reactions is the underlined substance reduced?

A. \( \text{FeCl}_2 + \text{Cl}_2 \rightarrow \text{FeCl}_3 \)
B. \( 3\text{CuO} + 2\text{NH}_3 \rightarrow 3\text{Cu} + 3\text{H}_2\text{O} + \text{N}_2 \)
C. \( \text{MnO}_2 + 4\text{HCl} \rightarrow \text{MnCl}_2 + 2\text{H}_2\text{O} + \text{Cl}_2 \)
D. \( 2\text{H}_2\text{S} + \text{SO}_2 \rightarrow 2\text{H}_2\text{O} + 3\text{S} \)

35. Bitumen is a substance obtained from the fractional distillation of crude oil. What are the boiling points and the sizes of the molecules in bitumen?

<table>
<thead>
<tr>
<th></th>
<th>boiling points</th>
<th>sizes of molecules</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>high</td>
<td>large</td>
</tr>
<tr>
<td>B</td>
<td>high</td>
<td>small</td>
</tr>
<tr>
<td>C</td>
<td>low</td>
<td>large</td>
</tr>
<tr>
<td>D</td>
<td>low</td>
<td>small</td>
</tr>
</tbody>
</table>

36. The table shows some properties of four hydrocarbons.

<table>
<thead>
<tr>
<th>hydrocarbon</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>state at room temperature</td>
<td>gas</td>
<td>gas</td>
<td>liquid</td>
<td>liquid</td>
</tr>
<tr>
<td>reaction with aqueous bromine</td>
<td>decolourises bromine</td>
<td>no reaction</td>
<td>decolourises bromine</td>
<td>no reaction</td>
</tr>
</tbody>
</table>

Which of the following statements is true of the hydrocarbons?

A. Hydrocarbons 1 and 2 are in the same homologous series.
B. Hydrocarbons 2 and 4 are unsaturated.
C. Hydrocarbon 1 has a lower relative molecular mass than hydrocarbon 3.
D. Hydrocarbon 3 could be ethene.

37. Which of the following conditions are required to produce ethanol by fermentation?

<table>
<thead>
<tr>
<th>catalyst</th>
<th>temperature</th>
<th>Other condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A phosphoric acid</td>
<td>300°C</td>
<td>65 atm</td>
</tr>
<tr>
<td>B enzymes in yeast</td>
<td>35 °C</td>
<td>Absence of oxygen</td>
</tr>
<tr>
<td>C finely divided iron</td>
<td>450 °C</td>
<td>200 atm</td>
</tr>
<tr>
<td>D nickel powder</td>
<td>150 °C</td>
<td>none</td>
</tr>
</tbody>
</table>
38. Which of the following compounds is produced in a reaction between propanoic acid and butanol?

A  $\text{C}_3\text{H}_6\text{COOC}_2\text{H}_7$
B  $\text{C}_3\text{H}_7\text{COOC}_2\text{H}_7$
C  $\text{C}_3\text{H}_7\text{COOC}_4\text{H}_9$
D  $\text{C}_2\text{H}_5\text{COOC}_4\text{H}_9$

39. The diagram shows ethanol burning in a sealed jar.

The mass of one gas in the jar does not change. Which gas is this?

A  oxygen
B  nitrogen
C  carbon dioxide
D  water vapour

40. Which statement is correct about poly(chloroethene)?

A  It is formed from the monomer chloroethane.
B  It is a polymer formed when unsaturated monomers join together.
C  Water molecules are eliminated in the process of polymerization.
D  It is a macromolecule which conducts electricity like graphite.
### 2017 Sec 4 OLP Chemistry Preliminary Exam P1 answers

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>6-10</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>11-15</td>
<td>B</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>16-20</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>21-25</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>26-30</td>
<td>D</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>31-35</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>36-40</td>
<td>C</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>
SINGAPORE CHINESE GIRLS' SCHOOL
Preliminary Examination
Secondary Four

CANDIDATE NAME

CLASS 4
INDEX NUMBER

CHEMISTRY 5073/02

2 August 2017
1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A
Answer all questions in the spaces provided.

Section B
Answer all three questions, the last question is in the form either/or.
Answer all questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 21.

The use of an approved scientific calculator is expected, where appropriate.

<table>
<thead>
<tr>
<th>For Examiner's Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
</tr>
<tr>
<td>Section B</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

This question paper consists of 20 printed pages and 2 blank pages.
Section A
Answer all questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Sulfur and sulfur compounds are common in the environment.

(a) A sample of sulfur from a volcano contained 86.0% by mass of sulfur-32 and 12.0% by mass of sulfur-34.

(i) Complete the table below to show the atomic structure of each isotope of sulfur.

<table>
<thead>
<tr>
<th>isotope</th>
<th>number of</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>protons</td>
<td>neutrons</td>
<td>electrons</td>
</tr>
<tr>
<td>sulfur-32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sulfur-34</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(ii) Calculate the relative atomic mass of the volcanic sulfur. Your answer should be given to three significant figures.

(b) One of the gases produced during volcanic eruptions is hydrogen sulfide. Hydrogen sulfide is a poisonous, colourless gas which smells of rotten eggs.

(i) Draw a dot-and-cross diagram to represent the bonding in a hydrogen sulfide molecule. Show outer electrons only.
(ii) Using ideas of bonding and structure, explain why hydrogen sulfide gas does not conduct electricity.

(c) Every year, between 20 and 50 million tonnes of sulfur are released into the atmosphere from the oceans in the form of DMS, a compound of carbon, hydrogen and sulfur.

The percentage composition by mass of DMS is 38.8% carbon, 9.7% hydrogen and 51.7% sulfur. Calculate the empirical formula of DMS, showing your working clearly.
A2  Zinc (proton number = 30) is not a typical transition element.

(a) State two properties of zinc that are not typical of transition elements.

................................................................................................................................................. [2]

(b) Name the reagents that can be used to prepare the following zinc salts and briefly describe how to obtain the solid product from the reaction mixture.

(i) Salt to be made: zinc carbonate

   reagent 1: ..........................................................

   reagent 2: ..........................................................

   I could obtain solid zinc carbonate by: .......................................................... ..........................................................

................................................................................................................................................. [4]

(ii) Salt to be made: zinc chloride

   reagent 1: ..........................................................

   reagent 2: ..........................................................

   I could obtain solid zinc chloride by: ..........................................................

................................................................................................................................................. [4]

(c) A student is given a colourless solution T.

(i) Describe one chemical test and its result that would confirm that solution T contains zinc ions.

................................................................................................................................................. [2]
(ii) To identify the anion present, the student performed the following tests:

1. Add aqueous barium chloride to solution T.
2. Measure height of precipitate formed after 5 minutes.
3. Add dilute nitric acid to the above mixture.
4. Measure height of precipitate formed after 5 minutes.

She presented her results obtained in a graph as shown below:

```
height of precipitate / cm
```

```
addition of
aqueous barium chloride
```

```
addition of
dilute nitric acid
```

Deduce the anion present in solution T and explain your deduction with reference to the graph.

[Total: 10]
A3 Poly(propene) and nylon are synthetic polymers. Poly(propene) is an addition polymer. Nylon is a condensation polymer.

(a) Describe two differences between addition polymers and condensation polymers.

(b) Poly(propene) is formed by addition polymerisation of propene.

(i) Draw the structural formula of propene.

(ii) Draw the structural formula of the poly(propene).

(iii) Deduce the maximum mass of poly(propene) that could be produced from 1 kg of propene.
(c) The formula of the two monomers used to make nylon are shown below:

\[ \text{HOOC}(\text{CH}_2)_4\text{COOH} \quad \text{and} \quad \text{H}_2\text{N}(\text{CH}_2)_4\text{NH}_2 \]

(i) Draw the repeat unit of nylon formed from these two monomers.

(ii) During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass of 30 000.

What is the average number of repeat units in the nylon molecules? Show your working.

(d) Most synthetic polymers are non-biodegradable. Suggest one advantage and one disadvantage of using such polymers.

- advantage:

- disadvantage:

[Total: 10]
A4  A car manufacturer conducted tests in which the air/fuel ratio in the engine was varied and the percentage emission of carbon monoxide, CO and nitrogen oxides, NO\textsubscript{x} released was measured. The results are represented below.

![Graph showing CO and NO\textsubscript{x} emissions against air/fuel ratio.]

(a) State and explain the effect of increasing the air/fuel ratio on CO emissions.

(b) Explain why there is an increase followed by a decrease in the percentage emission of nitrogen oxides (NO\textsubscript{x}) as the air/fuel ratio increases from 13 to 16.

(c) Catalytic converters are used in cars to reduce the amounts of carbon monoxide and nitrogen oxides produced.

The equation for one reaction that happens in the catalytic converter is:

\[ 2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2 \]

(i) Use oxidation states to explain why this is a redox reaction.

(ii) Explain why this reaction does not remove all the environmental problems caused by exhaust gases.

[Total: 7]
A student set up two experiments for electroplating steel keychains with copper. She closed both circuits for a period of time.

(a) Complete the table of information about the experiments.

<table>
<thead>
<tr>
<th>experiment</th>
<th>electrodes</th>
<th>ionic equation, for reaction at each electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>carbon rod</td>
<td></td>
</tr>
<tr>
<td></td>
<td>steel keychain</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>copper rod</td>
<td></td>
</tr>
<tr>
<td></td>
<td>steel keychain</td>
<td></td>
</tr>
</tbody>
</table>

(b) Describe and explain the observations seen in the electrolyte in each experiment.

Experiment 1:

Experiment 2:
(c) (i) The student repeated experiment 2 with another keychain. However, she left the keychain there without closing the circuit. Describe and explain one change she would observe.

(ii) Intrigued by what she saw in c(i), the student modified the set-up in experiment 2. She removed the battery, replacing it with a voltmeter. A deflection in the voltmeter is seen immediately upon closing the circuit.

Explain why a deflection in the voltmeter is observed, giving the relevant ionic equations for both electrodes.
Section B

Answer all three questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B5 Fats and oils are triglycerides formed from the condensation reaction of propane-1,2,3-triol with long chain carboxylic acids (fatty acids). Each triglyceride is formed from three fatty acids.

The structural formula of a triglyceride likely to be found in peanut oil is shown below.

\[
\begin{align*}
H_2C\overset{O}{\longrightarrow}C\overset{O}{\longrightarrow}(CH_2)_{14}CH_3 \\
\overset{O}{\longrightarrow}H\overset{O}{\longrightarrow}(CH_2)_{7}CH=CH(CH_2)_{7}CH_3 \\
H_2C\overset{O}{\longrightarrow}C\overset{O}{\longrightarrow}(CH_2)_{7}CH=CHCH_2CH=CH(CH_2)_{4}CH_3
\end{align*}
\]

A triglyceride is considered a fat if it is a solid at 25 °C; it is an oil if it is a liquid at that temperature. These differences in melting points reflect differences in the degree of unsaturation and molar mass of the constituent fatty acids.

One method for checking the unsaturation level in fatty acids is by determining the iodine number. Iodine number is the number of grams of iodine consumed by 100 g of fat or oil. A higher iodine value indicates a higher degree of unsaturation.

The table below shows average figures for the percentage fatty acid composition of some common fats and oils.

<table>
<thead>
<tr>
<th>source of fat or oil</th>
<th>% saturated fatty acids (total)</th>
<th>% monounsaturated fatty acid</th>
<th>% polyunsaturated fatty acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>beef fat</td>
<td>59</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>coconut oil</td>
<td>90</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>corn oil</td>
<td>25</td>
<td>26</td>
<td>47</td>
</tr>
<tr>
<td>cotton seed oil</td>
<td>22</td>
<td>35</td>
<td>43</td>
</tr>
<tr>
<td>olive oil</td>
<td>15</td>
<td>78</td>
<td>7</td>
</tr>
<tr>
<td>soybean oil</td>
<td>14</td>
<td>28</td>
<td>50</td>
</tr>
</tbody>
</table>

The polyunsaturated/saturated (P/S) index of a fat or oil is the ratio of polyunsaturated fat to saturated fat. It is sometimes used to compare the relative health benefits of different fats and oils in the diet.
Passage is adapted from:
1. https://2012books.lardbucket.org/books/introduction-to-chemistry-general-organic-and-
biochemical/s20-lipids.html
2. http://vlab.amrita.edu/?sub=3&brch=63&sim=1111&cnt=1

(a) Propane-1,2,3-triol reacts with fatty acids to form triglyceride.

(i) Based on the structural formula given, name the chemical linkage formed in the 
triglyceride.

(ii) Name the other product formed in this reaction.

(iii) Give the structural formulae of two reactants that are used to produce the 
triglyceride found in peanut oil.

• structural formula of propane-1,2,3-triol:

• structural formula of one of the carboxylic acids:

(b) Deduce, using data given in the table, which fat or oil from the table above has the lowest 
iodine number. Explain your answer.

.............................................. [1]
(c) Cotton seed oil and corn oil have similar iodine numbers but the melting point of cotton seed oil is higher than that of corn oil. Suggest an explanation in terms of the structure and bonding in these two oils.

(d) Linoleic acid is a polyunsaturated fatty acid with molecular formula of $\text{C}_{17}\text{H}_{32}$\text{COOH}.

How many double bonds between carbon atoms are present in one molecule of linoleic acid? Explain your answer.

(e) A P/S value of greater than 1 is considered beneficial for health.

Calculate the P/S index of beef fat and soybean oil, giving your answers to 3 significant figures.

Hence determine which oil is more beneficial to health.

- P/S index of beef fat

- P/S index of soybean oil

[Total: 12]
B7 A series of experiments was carried out to compare the rate of reaction of acid with magnesium carbonate under different conditions.

Excess magnesium carbonate and 25 cm$^3$ of acid were used. The conditions for each experiment are shown in the table below.

<table>
<thead>
<tr>
<th>experiment</th>
<th>magnesium carbonate</th>
<th>type of acid used</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>lumps</td>
<td>0.1 mol/dm$^3$ of HCl</td>
</tr>
<tr>
<td>B</td>
<td>lumps</td>
<td>0.2 mol/dm$^3$ of HCl</td>
</tr>
<tr>
<td>C</td>
<td>lumps</td>
<td>0.1 mol/dm$^3$ of CH$_3$COOH</td>
</tr>
<tr>
<td>D</td>
<td>powder</td>
<td>0.2 mol/dm$^3$ of HCl</td>
</tr>
</tbody>
</table>

The gas given off was collected and its total volume was measured every 30 seconds for 10 minutes. The results obtained for experiment A and B were plotted in Graph 1.

**Graph 1**

(a) Label the curves A and B such that they correspond to the results for experiment A and experiment B. [1]

(b) Sketch and label on graph 1 the curve you would expect for experiment C, assuming that the reaction stopped at the tenth minute. [1]

(c) Explain, in terms of collisions between reacting particles, why there is a difference in the initial rate of reaction between experiments B and D. [2]
The acids from experiments A and C are used in titration experiments with potassium hydroxide.

In experiment A-2, 0.1 mol/dm³ of potassium hydroxide was added from a burette to 24.0 cm³ of dilute hydrochloric acid. A pH probe attached to a computer measured the pH during the titration experiment. Graph 2 below shows the results.

![Graph 2](image)

In experiment C-2, 0.1 mol/dm³ of potassium hydroxide was added from a burette to 24.0 cm³ of dilute ethanoic acid.

(d) State the pH value of hydrochloric acid used in experiment A-2. 

(e) Given that the pH value of the ethanoic acid used in experiment C-2 is 4, sketch the curve you would expect for this experiment. You are to sketch the curve on graph 2.

(f) The acids used in experiment A-2 and C-2 have the same concentration. Explain why they have different pH values.

[Total: 8]

[Turn Over]
EITHER

B8. Petroleum is a naturally occurring yellow-to-black liquid found beneath the earth’s surface. It consists of mainly hydrocarbons of various molecular masses.

(a) What is meant by the term hydrocarbon?

(b) Dodecane is a hydrocarbon with molecular formula of C_{12}H_{26}. It undergoes cracking to produce butane and one other molecule X.

(i) Deduce the formula of X.

(ii) Draw the structure of

- straight chain X

- branched chain isomer of X.

(iii) A few drops of aqueous bromine is added to separate samples of butane and X. Describe your observations.
(c) The complete combustion of hydrocarbons produces carbon dioxide and water only.

10 cm$^3$ of a gaseous hydrocarbon $Y$ was mixed with an excess of oxygen of volume 100 cm$^3$. The mixture was ignited. After cooling, the volume of remaining gases is 70 cm$^3$. When passed over aqueous sodium hydroxide, the total gas volume is further reduced to 20 cm$^3$.

Deduce the formula of the hydrocarbon $Y$, showing your workings clearly. All volumes were measured at r.t.p.

[4]

[Total: 10]
B8 Ethanol is a renewable alcohol fuel made from plant material, such as sugar cane.

(a) Name the process used to produce ethanol from sugar.

(b) The complete combustion of ethanol is represented by the following equation.

\[CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H = -1367 \text{ kJ/mol}\]

(i) Draw an energy profile diagram for the combustion of ethanol.

Your diagram should include labels for the reaction enthalpy change and activation energy.

(ii) Explain, in terms of bond breaking and bond making, why this reaction is exothermic.

[Turn Over]

Need a home tutor? Visit smiletutor.sg

| Page 335 |
(c) Gasohol E10 is a mixture of ethanol and gasoline (petrol). The number after the "E" indicates the percentage of ethanol by volume. Most of the gasoline sold in the United States contains up to 10% ethanol.

Assume that the other 90% by mass of Gasohol E10 is octane, $\text{C}_8\text{H}_{18}$. 1.00 kg of this fuel mixture was burned.

$$\text{CH}_3\text{CH}_2\text{OH}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l) \quad \Delta H = -1367 \text{ kJ/mol}$$

$$\text{C}_8\text{H}_{18}(l) + \frac{12}{2}\text{O}_2(g) \rightarrow 8\text{CO}_2(g) + 9\text{H}_2\text{O}(l) \quad \Delta H = -5470 \text{ kJ/mol}$$

(i) Complete the table by calculating the energy output for 1 g of each fuel, giving your answers to 3 significant figures.

<table>
<thead>
<tr>
<th>name of fuel</th>
<th>enthalpy change of combustion / kJ per mole</th>
<th>energy output / kJ per gram</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethanol</td>
<td>$-1367$</td>
<td></td>
</tr>
<tr>
<td>octane</td>
<td>$-5470$</td>
<td></td>
</tr>
</tbody>
</table>

(ii) Calculate the total amount of energy, in kJ, released when 1.00 kg of the fuel mixture is completely burned, giving your answers to 3 significant figures.

[Total: 10]
Suggested answers:

Section A [50 MARKS]

A1 (a) (i) Sulfur-32: 16, 16, 16 [1]

Sulfur-34: 18, 16, 16 [1]

(ii) Relative atomic mass

\[ \frac{88}{32} \times 32 + \frac{34}{16} \times 34 \] [1]

= 32.24

= 32.2 (3sf) [1]

(b) (i)

- 1M – sharing of electrons between H and S
- 1M – correct valence electrons for S
- Allow: 3 shells for S atom

(ii) Hydrogen sulfide has a simple molecular/covalent structure and exists as neutral molecules [1]
There are no mobile charged particles to conduct electricity. [1]

(c)

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>H</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of moles/mol</td>
<td>38.6/12</td>
<td>9.7/1</td>
<td>51.7/32</td>
</tr>
<tr>
<td>OR</td>
<td>51.7/32.24</td>
<td>= 1.6036</td>
<td></td>
</tr>
<tr>
<td>Simplest ratio</td>
<td>3.2167/1.6156</td>
<td>9.7/1.6156</td>
<td>1.6156</td>
</tr>
</tbody>
</table>

- 1M for correct number of moles
- 1M for correct empirical formula
A2 (a) Any two:
- Zinc does not have variable oxidation state in its compounds / Zinc has only one (fixed) oxidation state in its compounds.
- Zinc does not form coloured compounds.
- Zinc has low melting and boiling points.

(b) (i) Reagent 1: zinc nitrate (or any other solution containing zinc ions)  
Reagent 2: sodium carbonate (or any other solution containing carbonate ions)

Filter the mixture. (Wash the residue with deionised water.) Dry residue with filter papers.

(ii) Reagent 1: zinc / zinc oxide / zinc hydroxide / zinc carbonate
Reagent 2: hydrochloric acid

Filter the mixture. Heat filtrate till saturation. Cool to allow crystals to form. Filter and dry crystals with filter papers.

(c) (i) Add a few drops, then in excess of aqueous ammonia to solution T. [1]

White precipitate formed will dissolve in excess aqueous ammonia to form a colourless solution. [1]

(ii) The height of the precipitate formed remained unchanged on adding barium chloride and dilute
nitric acid. This shows that an insoluble barium salt that does not react with acid is formed. [1]

Hence, the anion present in solution T is sulfate ion \( \text{SO}_4^{2-} \). [1]

A3 (a) Any two:
- Addition polymers are formed from (unsaturated) monomers containing carbon-carbon double bonds while condensation polymers are formed from monomers containing carboxyl and hydroxyl groups or carboxyl and amine groups.
- Only the polymer is formed during the formation of addition polymers while the formation of condensation polymers produces the polymer and small molecules.
- The empirical formula of the addition polymer is the same as its monomer while the empirical formula of condensation polymer is not the same as its monomer.
- Addition polymers contain long chains of carbon-carbon atoms joined together while condensation polymers contain amide (or ester) linkages.

(b) (i) \[
\begin{align*}
\text{H} & \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{H} \\
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H} & \quad \text{OR} \\
\end{align*}
\]

(ii) \[
\begin{align*}
\text{CH}_3 & \quad \text{CH}_3 & \quad \text{CH}_3 \\
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H} \\
\end{align*}
\]

(iii) 1 kg

(c) (i) \[
\begin{align*}
\text{O} & \quad \text{O} \\
\text{C} & \quad \text{-(CH}_2)_4- & \quad \text{C} & \quad \text{NH-(CH}_2)_6- & \quad \text{NH} \\
\end{align*}
\]
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(ii)</td>
<td>M, of each nylon repeating unit</td>
<td></td>
</tr>
</tbody>
</table>
|   | \[ \text{M, of each nylon repeating unit} \]
|   | \[ = (12 \times 6 + 8 + 16 \times 2) + (14 \times 2 + 12 \times 6 + 14) \]
|   | \[ = 226 \] [1] |
|   | Minimum number of repeat units |
|   | \[ = \frac{30980}{226} \]
|   | \[ = 132.7 \]
|   | \[ = 132 \text{ or } 133 \text{ (Allow either)} \] [1] |
| (d) | Advantage: |
|   | The polymers can be used over a long period of time. / The polymers are long lasting / durable. [1] |
|   | Disadvantage: |
|   | More landfills sites will be required for disposal of these polymers, which takes up land space. [1] |

| A4 | (a) | As the air/fuel ratio increase, the percentage of CO emissions decreases. [1] |
|    |   | This is due to higher concentration of oxygen to allow more complete combustion (in car engine). [1] |
| (b) | As air/fuel ratio increases from 13 to 15.2, the amount of air found in car engine increases. As a result, there will be more nitrogen and oxygen to react in the high temperature of the engine, increasing the percentage emission of nitrogen oxides. [1] |
|    | However, as the air/fuel ratio increases from 15.2 to 16, the temperature in engine decreases with less fuel burning. As a result, there will be a decrease in the percentage emission of nitrogen oxides. [1] |
| (c) | (i) | The oxidation state of carbon increase from +2 in CO to +4 in CO\(_2\). [1] |
The oxidation state of nitrogen decreases from +2 in NO to 0 in N₂. [1]
It is a redox reaction as CO is oxidised and NO is reduced.

(ii) Carbon dioxide is produced and it is a greenhouse gas. It traps heat on Earth and causes temperature to rise / global warming.

A5

(a) Experiment 1
Carbon rod: 4OH⁻ → 2H₂O + O₂ + 4e⁻ [1]
Steel keychain: Cu²⁺ + 2e⁻ → Cu

Experiment 2
Copper rod: Cu → Cu²⁺ + 2e⁻ [1]
Steel keychain: Cu²⁺ + 2e⁻ → Cu

(b) Experiment 1
The electrolyte changes from blue to colourless. [1]
This is because the concentration of copper(II) ions decreases as the copper(II) ions are reduced at the cathode. [1]

Experiment 2
No visible change for the electrolyte / The electrolyte remains blue. [1]
This is because the concentration of copper(II) ions remains the same, for every mole of copper(II) ions reduced at the cathode, one mole of copper is oxidised at the anode. [1]

(c) (i) Any one:
- 1st MP:
The steel keychain is coated with a layer of reddish-brown / pink solid. OR Reddish-brown / pink solids are seen in the solution. OR The steel keychain decreases in size.
- 2nd MP:
Iron (from the steel keychain) displaces copper(II) ions from its solution to form iron(II) ions and copper.

1st MP:
Copper(II) sulfate solution changes from blue to pale green.

2nd MP:
Iron (from the steel keychain) displaces copper(II) ions from its solution to form iron(II) ions and copper.

(ii) Iron being more reactive than copper, will oxidise/lose electrons to form iron(II) ions. [1]

\[ \text{Fe} \rightarrow \text{Fe}^{2+} + 2e^- \]

The electrons flow to the copper electrode. Copper(II) ions from the electrolyte gain electrons to form copper. [1]

\[ \text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} \]

The movement of electrons causes the deflection in the voltmeter. [1]

Section B [30 MARKS]

<table>
<thead>
<tr>
<th>B6</th>
<th>(a)</th>
<th>(i) Ester linkage</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ii) Water</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) structural formula of propane-1,2,3-triol: [1M each]</td>
<td>2</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
\text{H}_2\text{C} & \quad \text{O} \quad \text{H} \\
\text{H} \quad \text{O} \quad \text{H} \\
\text{H}_2\text{C} & \quad \text{O} \quad \text{H}
\end{align*}
\]

structural formula of one of the carboxylic acids:
(b) Coconut oil, as the percentage of unsaturation adds up to 10%, which is the lowest.

(c) Both cotton seed molecules and corn oil molecules have similar iodine numbers. Hence, their melting points is not dependent on the degree of unsaturation.

- Cotton seed oil molecules have higher molar mass than corn oil molecules. [1]
- Hence more energy is taken in to overcome the stronger intermolecular forces / Van der Waals’ forces between molecules. [1]

(d) A saturated fatty acid with 18 carbon atoms has a molecular formula of C18H36COOH. [1]

- Since a decrease in 2 hydrogen atoms indicates the present of one carbon-carbon double bond in each molecule, each molecule of linoleic acid will contain two carbon-carbon double bonds. [1]

(e) P/S of beef fat

\[ \frac{3}{59} = 0.0508 \] [1]

P/S of soybean oil

\[ \frac{50+6}{14} = 4.14 \] [1]

- Soybean oil is more beneficial to health. [1]

87 (a) Curve A – Produced 30 cm³ of gas at the end of reaction

\[ 1 \text{ M for both labels} \]
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>Curve B – Produced 60 cm(^3) of gas at the end of reaction</td>
<td>1</td>
</tr>
<tr>
<td>(c)</td>
<td>Curve C – In comparison to curve A: (1) initial gradient to be more gentle &amp; (2) same height</td>
<td>2</td>
</tr>
<tr>
<td>(d)</td>
<td>Experiment B uses lumps of magnesium carbonate, which has bigger particle size and less exposed surface area. [1] This decreases the probability of collisions between magnesium carbonate particles and the hydrogen ions from the acids, which decreases the frequency of effective collisions, leading to a slower initial rate of reaction. [1]</td>
<td>Accept: Reverse argument for experiment D</td>
</tr>
<tr>
<td>(e)</td>
<td>pH 1.1</td>
<td>1</td>
</tr>
<tr>
<td>(f)</td>
<td>Similar curve to A-2, except for an initial pH value of 1.1 (same volume of KOH used &amp; same height at the end of the reaction)</td>
<td>1</td>
</tr>
</tbody>
</table>
|     | **1st MP:**
|     | In experiment A, hydrochloric acid, a strong acid, ionises completely to produce hydrogen ions, while in experiment C, ethanoic acid, a weak acid, ionises partially to produce hydrogen ions. | 2 |
|     | **2nd MP:**
|     | Link pH value to concentration of hydrogen ions:
|     | Any one:  
|     | - Ethanoic acid has a lower concentration of hydrogen ions and therefore has a higher pH value.  
|     | - Hydrochloric acid has a higher concentration of hydrogen ions and therefore has a lower pH value.  
|     | - Since the concentration of hydrogen ions is different, the pH value will be different. | 1M for each Marking Point (MP) |

2017 Sec 4 OLP Chem Prelim Paper 2 Mark Scheme
<table>
<thead>
<tr>
<th>E B8</th>
<th>(a)</th>
<th>Hydrocarbons are organic compounds containing hydrogen and carbon only</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>(i)</td>
<td>$C_3H_8$</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(ii)</td>
<td>Straight chain of $C_8H_{16}$</td>
<td>Correct diagram 1</td>
</tr>
<tr>
<td></td>
<td>(iii)</td>
<td>Any branched chain of $C_8H_{16}$</td>
<td>Correct diagram 1</td>
</tr>
<tr>
<td></td>
<td>(iii)</td>
<td>There will be no visible change when aqueous bromine is added to butane. / Aqueous bromine remains reddish-brown when added to butane. [1] Aqueous bromine will change from reddish brown to colourless rapidly when added to $X$.</td>
<td>2</td>
</tr>
<tr>
<td>(c)</td>
<td></td>
<td>Volume of $CO_2$</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= $70 - 20$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>= $50 \text{ cm}^3$ [1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume of $O_2$</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= $100 - 20$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>= $80 \text{ cm}^3$ [1]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Let the formula of the hydrocarbon be represented by $C_xH_y$.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_xH_y : O_2 : CO_2$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 : 80 : 50</td>
<td>[1]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 : 8 : 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$1C_xH_y + 8O_2 \rightarrow 5CO_2 + __H_2O$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>total no. of C atoms = 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>total no. of O atoms = 16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>no. of O atoms in $H_2O = 16 - 10 = 6$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>total no. of H atoms = 12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Formula of hydrocarbon = $C_8H_{12}$ [1]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>O B8</th>
<th>(a)</th>
<th>Fermentation</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>(i)</td>
<td>Correct diagram</td>
<td>2</td>
</tr>
</tbody>
</table>

- 1M for Reactants,
- $R$ labelled as...
\[
\text{CH}_3\text{CH}_2\text{OH} + 3\text{O}_2 \quad \text{and Products, P} \\
\text{labelled as } 2\text{CO}_2 + 3\text{H}_2\text{O} \text{ AND correct} \\
\text{shape of curve (R} \text{ higher than P) and} \\
- \text{1M for correct} \\
\text{labels for enthalpy} \\
\text{change (R to P) } \\
\text{AND activation} \\
\text{energy (R to tip of} \\
\text{curve)} \\
\]

| (ii) Energy taken in to break bonds in ethanol and oxygen is less than energy given out to form bonds in carbon dioxide and water, [1] | 1M for identifying that the energy taken in is less than energy given out | 2 |
| (c) (i) Energy given out for 1 g of ethanol \\
\[
= \frac{1367}{2 \times 12 + 5 + 16 + 1} = \frac{1367}{46} = 29.7 \text{ kJ / g (3 sf) [1]}
\]
Energy given out for 1 g of octane \\
\[
= \frac{5470}{8 \times 12 + 18} = \frac{5470}{114} = 48.0 \text{ kJ / g (3 sf) [1]}
\] | 2 |
| (ii) Energy released when 1 kg of the fuel mixture is burned \\
\[
= (\frac{10}{100} \times 1000 \times 29.717) + (\frac{60}{100} \times 1000 \times 47.982)
\] \\
\[
= 2971.7 \text{[1]} + 43183.8 \text{[1]}
\]
\[
= 46155.5
\]
\[
= 48200 \text{ kJ [1]}
\] | 3 |
ST. MARGARET'S SECONDARY SCHOOL
Preliminary Examinations 2017

CANDIDATE NAME

CLASS

REGISTER NUMBER

CHEMISTRY 5073/01
Paper 1 Multiple Choice 29 August 2017
Secondary 4 Express 1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and register number on the cover page in the spaces provided.

There are forty questions on this paper. Answer all questions.
For each question, there are four possible answers A, B, C and D.
Choose the one you consider correct and record your choice in soft pencil on the Multiple Choice Answer Sheet provided.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 15.

For Examiner's Use

Total

40

Parent's Signature
1. Jamie wishes to measure the change in pH of solution as 48.0 cm³ of sulfuric acid is added drop-wise to approximately 90 cm³ of aqueous sodium hydroxide.

Which of the following sets of apparatus should she use?

I 25.0 cm³ pipette
II 50 cm³ measuring cylinder
III 50.0 cm³ burette
IV Data Logger

A I and II only
B II and III only
C I, II and IV
D II, III and IV

Use the following information to answer Questions 2, 3 and 4.

Xylene melts at −48°C and boils at 140°C. It has the following structural formula.

![Xylene structural formula]

2. Which of the following rows of information about the temperature and movement of molecules in xylene is correct?

<table>
<thead>
<tr>
<th>temperature / °C</th>
<th>movement of molecules</th>
</tr>
</thead>
<tbody>
<tr>
<td>A −60</td>
<td>sliding over each other</td>
</tr>
<tr>
<td>B −20</td>
<td>vibrating about fixed positions</td>
</tr>
<tr>
<td>C 80</td>
<td>sliding over each other</td>
</tr>
<tr>
<td>D 120</td>
<td>freely and randomly at high speeds</td>
</tr>
</tbody>
</table>

3. Which of the following substances is the least likely to dissolve in xylene?

A iodine
B methyl hexanoate
C octane
D sodium hexanoate

4. How many electrons in xylene are not used to form bonds?

A 8
B 16
C 21
D 42
5. Which of the following statements about condensation is **false**?

A. Average kinetic energy of the molecules decreases during condensation.
B. Condensation is an exothermic process.
C. Distance between particles greatly decreases during condensation.
D. Particles are still in a disorderly arrangement after condensation.

6. Which of the following diagrams correctly shows a pair of isotopes?

A. ![Diagram A](image)

B. ![Diagram B](image)

C. ![Diagram C](image)

D. ![Diagram D](image)

7. Which of the following substances contains only ionic bonds?

A. hydrogen sulfide
B. lithium sulfate
C. manganese(II) oxide
D. water
8. Which of the following can conduct electricity in only one physical state?

A diamond
B magnesium sulfate
C steel
D nitric acid

9. The structural formulae of four acids, I to IV, are shown below.

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>H—O—S—O—H</td>
<td>H—O—C—C—O—H</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>IV</td>
</tr>
<tr>
<td>H—O—P—O—H</td>
<td>H—C/</td>
</tr>
</tbody>
</table>

Which of the following statements about these four acids is false?

A I has the same basicity as II.
B I has a lower basicity than III.
C II is stronger than IV.
D II is weaker than III.

10. Which of the following pairs of reactants react to produce an acidic gas when warmed?

A ammonium chloride and calcium hydroxide
B lithium carbonate and sulfuric acid
C lead and nitric acid
D zinc and iron(II) nitrate
11. Which of the following rows of information correctly displays the reactants used to safely prepare a salt with the highest possible yield?

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Salt to be prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>A calcium oxide and sulfuric acid</td>
<td>calcium sulfate</td>
</tr>
<tr>
<td>B copper and hydrochloric acid</td>
<td>copper(II) chloride</td>
</tr>
<tr>
<td>C lithium and hydrochloric acid</td>
<td>lithium chloride</td>
</tr>
<tr>
<td>D zinc oxide and sulfuric acid</td>
<td>zinc sulfate</td>
</tr>
</tbody>
</table>

12. In which of the following processes is the underlined substance not acting as a basic oxide?

A \( \text{CaO} + 2 \text{HNO}_3 \rightarrow \text{Ca(NO}_3)_2 + \text{H}_2\text{O} \)
B \( \text{CaO} + \text{SO}_2 \rightarrow \text{CaSO}_3 \)
C \( \text{CuO} + \text{ZnO} \rightarrow \text{CuZnO}_2 \)
D \( \text{CuO} + \text{Mg} \rightarrow \text{MgO} + \text{Cu} \)

13. Which of the following pairs of reactants can cause a colour change when mixed together?

A potassium bromide and bromine
B potassium bromide and iodine
C potassium chloride and bromine
D potassium iodide and chlorine

14. Which of the following statements about Group VII elements are true?

I They form diatomic molecules because they have the same number of valence electrons.
II They have increasing density down the group.
III Their strength as oxidising agents increases down the group.

A I only
B I and II only
C II and III only
D i, II and III

15. Which of the following metals reacts most vigorously with a beaker of cold water, without sinking to the bottom of the beaker?

A Li
B Ca
C Na
D Rb

16. Which of the following chemical equations represents a redox reaction?

A \( \text{H}^+ (\text{aq}) + \text{OH}^- (\text{aq}) \rightarrow \text{H}_2\text{O} (\ell) \)
B \( \text{Ag}^+ (\text{aq}) + \text{Cl}^- (\text{aq}) \rightarrow \text{AgCl} (\text{s}) \)
C \( \text{Fe} (\text{s}) + 2 \text{HCl} (\text{aq}) \rightarrow \text{FeCl}_2 (\text{aq}) + \text{H}_2 (\text{g}) \)
D \( \text{CaCO}_3 (\text{s}) + 2 \text{HNO}_3 (\text{aq}) \rightarrow \text{Ca(NO}_3)_2 (\text{aq}) + \text{CO}_2 (\text{g}) + \text{H}_2\text{O} (\ell) \)
17. Which of the following statements about the extraction of iron in the blast furnace is false?

A. The formation of carbon monoxide happens in two steps.
B. Silicon dioxide is removed by adding a basic oxide to it.
C. Carbon monoxide reduces iron(III) oxide.
D. The exhaust gases are composed mainly of carbon dioxide.

18. The following table provides information on the colours displayed by a few pH indicators.

<table>
<thead>
<tr>
<th>pH indicator</th>
<th>Colour in strong acid</th>
<th>pH at which colour changes</th>
<th>Colour in strong alkali</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromophenol Blue</td>
<td>yellow</td>
<td>3.0 - 4.6</td>
<td>blue</td>
</tr>
<tr>
<td>Clayton Yellow</td>
<td>yellow</td>
<td>12.2 - 13.2</td>
<td>orange</td>
</tr>
<tr>
<td>Resorcin Blue</td>
<td>red</td>
<td>4.2 - 6.2</td>
<td>blue</td>
</tr>
<tr>
<td>Thymolphthalein</td>
<td>colourless</td>
<td>9.4 - 10.6</td>
<td>blue</td>
</tr>
</tbody>
</table>

Which of the following statements about these indicators is most likely to be true?

A. Ethanoic acid will cause Bromophenol Blue to turn yellow only.
B. Hydrochloric acid will cause Clayton Yellow to turn yellow.
C. Sodium chloride will cause Resorcin Blue will turn red.
D. Weak alkalis cause Thymolphthalein to turn blue only.

19. Which of the following comprises the largest number of atoms?

A. 2 mol of PCl₅
B. 3 mol of CH₄
C. 4 mol of H₂O
D. 5 mol of CO

20. The equation for the complete combustion of ethane is shown below.

\[
2 \text{C}_2\text{H}_6 + 7 \text{O}_2 \rightarrow 4 \text{CO}_2 + 6 \text{H}_2\text{O}
\]

20 cm³ of C₂H₆ is combusted with 140 cm³ of O₂. The resulting mixture of gases is cooled to room temperature and pressure.

Which of the following statements about this is true?

A. 60 cm³ of liquid H₂O is formed.
B. 70 cm³ O₂ is not reacted.
C. 80 cm³ of gaseous CO₂ is formed.
D. 100 cm³ of gaseous products are left behind.
21. Which of the following substances has the highest percentage composition of the underlined element?

A. C6H12O6
B. CO2
C. NH3
D. NHF2

22. Which of the following statements about Group VII elements is true?

A. Colour intensity decreases down the group.
B. Density decreases down the group.
C. Strength of intermolecular forces of attraction increases down the group.
D. Tendency to gain electrons increases down the group.

23. Which of the following statements best shows that an element is a transition metal?

A. It has good electrical conductivity.
B. It has a high density.
C. It has a tendency to lose electrons.
D. It has variable oxidation states.

24. Which of the following rows of information about the gases in the table below is correct?

<table>
<thead>
<tr>
<th>gas</th>
<th>causes global warming</th>
<th>causes irritation to respiratory system</th>
<th>causes acid rain</th>
<th>is poisonous</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CH4</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>B</td>
<td>CO</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>C</td>
<td>NO2</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>D</td>
<td>O3</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

25. Which of the following chemical equations does not represent a process that occurs in the catalytic converter of a car?

A. \( 2 \text{C}_6\text{H}_{12} + 25 \text{O}_2 \rightarrow 16 \text{CO}_2 + 18 \text{H}_2\text{O} \)
B. \( 2 \text{CO} + \text{O}_2 \rightarrow 2 \text{CO}_2 \)
C. \( 2 \text{N}_2 + \text{O}_2 \rightarrow 2 \text{N}_2\text{O} \)
D. \( 2 \text{NO} + 2 \text{CO} \rightarrow \text{N}_2 + 2 \text{CO}_2 \)
26. In Experiment 1, 10 g of fine powdered CuCO₃ was reacted with excess 1 mol/dm³ HNO₃.

Experiments 2 and 3 were also carried out by using CuCO₃ and excess HNO₃, but with varying masses, particle size and concentration of HNO₃.

The volume of CO₂ evolved in each experiment was measured over time, and the results shown in the corresponding graph below.

![Graph showing volume of CO₂ vs time for three experiments.]

Which of the following sets of conditions corresponds to Experiments 2 and 3?

<table>
<thead>
<tr>
<th>Experiment 2</th>
<th>Experiment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>particle size of CuCO₃</td>
<td>mass of CuCO₃ / g</td>
</tr>
<tr>
<td>A</td>
<td>coarse</td>
</tr>
<tr>
<td>B</td>
<td>coarse</td>
</tr>
<tr>
<td>C</td>
<td>fine</td>
</tr>
<tr>
<td>D</td>
<td>fine</td>
</tr>
</tbody>
</table>
27. Metal X and zinc are connected to a lightbulb, as shown in the following diagram.

Which of the following metals should X be, such that the bulb shines the brightest?

A  Aluminium  
B  Copper  
C  Lead  
D  Magnesium

28. The following information is provided on three metals, X, Y and Z.

X is obtained when its metal oxide is strongly heated.
Y reacts vigorously with cold water.
Z can be extracted from its oxide by reduction with carbon, but not hydrogen.

What is the order of reactivity of the metals, from the most to least reactive?

A  X, Z, Y  
B  Y, X, Z  
C  Y, Z, X  
D  Z, Y, X
29. Four iron bars were coated on one side with different materials and placed in separate test-tubes, as shown below. In which test tube would corrosion of the iron bar be the slowest?

A

![Diagram A]

B

![Diagram B]

C

![Diagram C]

D

![Diagram D]

30. Sulfur dioxide gas is bubbled through solutions of potassium manganate (VII) and potassium iodide separately.

Which of the following observations are correct?

<table>
<thead>
<tr>
<th>potassium manganate (VII)</th>
<th>potassium iodide</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  no visible reaction</td>
<td>colourless solution turns brown</td>
</tr>
<tr>
<td>B  no visible reaction</td>
<td>no visible reaction</td>
</tr>
<tr>
<td>C  purple solution decolourises</td>
<td>no visible reaction</td>
</tr>
<tr>
<td>D  purple solution decolourises</td>
<td>colourless solution turns brown</td>
</tr>
</tbody>
</table>

31. Which of the following molecules has only one other possible isomer?

A

![Molecule A]

B

![Molecule B]

C

![Molecule C]

D

![Molecule D]
32. Which of the following molecules could not have been formed from the reaction of one molecule of bromine with a hydrocarbon?

A
\[ \text{Br} \quad \text{C-H} \quad \text{H} \]

B
\[ \text{Br} \quad \text{C} \quad \text{C} \quad \text{Br} \]

C
\[ \text{H} \quad \text{C} \quad \text{C} \quad \text{Br} \quad \text{H} \]

D
\[ \text{H} \quad \text{C} \quad \text{H} \quad \text{Br} \quad \text{Br} \]

33. Which of the following rows of information about reactions of organic molecules is correct?

<table>
<thead>
<tr>
<th>chemical reaction</th>
<th>temperature / °C</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A addition of steam to alkene</td>
<td>300</td>
<td>none</td>
</tr>
<tr>
<td>B cracking of long chain alkanes</td>
<td>30</td>
<td>SiO₂</td>
</tr>
<tr>
<td>C esterification of alcohols and carboxylic acids</td>
<td>15</td>
<td>H₂SO₄</td>
</tr>
<tr>
<td>D hydrogenation of alkenes</td>
<td>150</td>
<td>Ni</td>
</tr>
</tbody>
</table>
34. The structural formula of a polymer is shown below.

\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H} \\
\text{H} \\
\text{C} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

Which of the following correctly represents the structural formula of the monomer used to make this polymer?

A
\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H} \\
\text{H} \\
\end{array}
\]

B
\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H} \\
\text{H} \\
\end{array}
\]

C
\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H} \\
\text{H} \\
\end{array}
\]

D
\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H} \\
\text{H} \\
\end{array}
\]

35. Which of the following uses of petroleum fractions is incorrect?

<table>
<thead>
<tr>
<th>petroleum fraction</th>
<th>use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A diesel</td>
<td>fuel for road vehicles</td>
</tr>
<tr>
<td>B kerosene</td>
<td>fuel for aircraft</td>
</tr>
<tr>
<td>C naphtha</td>
<td>fuel for candles</td>
</tr>
<tr>
<td>D petroleum gas</td>
<td>fuel for cooking stoves</td>
</tr>
</tbody>
</table>
36. An alcohol, X, was completely oxidised to produce a carboxylic acid. This carboxylic acid was reacted with potassium hydroxide to produce a salt, which has the structural formula displayed below.

\[
\begin{array}{c}
\text{K}^+ \cdot \text{O}^\cdot \text{C} \cdot \text{H} \cdot \text{C} \cdot \text{H} \cdot \text{O}^\cdot \text{C} \cdot \text{K}^+
\end{array}
\]

Which of the following represents the structure of alcohol X?

A
\[
\begin{array}{c}
\text{H} \cdot \text{C} \cdot \text{H} \cdot \text{O}^\cdot \\
\text{H} \cdot \text{H}
\end{array}
\]

B
\[
\begin{array}{c}
\text{H} \cdot \text{O}^\cdot \text{C} \cdot \text{H} \cdot \text{H}
\end{array}
\]

C
\[
\begin{array}{c}
\text{H} \cdot \text{O}^\cdot \text{C} \cdot \text{H} \cdot \text{H} \cdot \text{C} \cdot \text{H} \cdot \text{C} \cdot \text{H} \cdot \text{O}^\cdot \\
\text{H}
\end{array}
\]

D
\[
\begin{array}{c}
\text{H} \cdot \text{O}^\cdot \text{C} \cdot \text{H} \cdot \text{C} \cdot \text{H} \cdot \text{C} \cdot \text{H} \cdot \text{C} \cdot \text{H}
\end{array}
\]

37. Which process would produce water as a by-product?

A formation of an amide from an amine and a carboxylic acid
B manufacture of margarine from vegetable oils
C photosynthesis in plants
D polymerisation of propene

38. Within a simple molecular structure, the strength of the intermolecular forces of attraction is dependent on the Me of the molecules.

Which of the following has the largest intermolecular forces of attraction?

A ethane
B hexane
C monochloroethane
D monochlorohexane
39. Part of the structural formulae of terylene is shown below.

Which statement about terylene is incorrect?

A  Each monomer has a hydroxyl group and a carboxyl group.
B  It is formed from many reactions between carboxyl groups and hydroxyl groups.
C  Terylene contains ester linkages.
D  The process that forms terylene is called condensation polymerisation.

40. Which of the following rows of information about the complete combustion of organic compounds is most likely to be correct?

<table>
<thead>
<tr>
<th>compound</th>
<th>products of complete combustion</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₂C/CONHCH₃</td>
<td>CO₂, NO₂ and H₂O only</td>
</tr>
<tr>
<td>CH₃SH</td>
<td>CO₂ and SO₂ only</td>
</tr>
<tr>
<td>CH₃CH₂Cl</td>
<td>CO₂, H₂O and C₂H₂O only</td>
</tr>
<tr>
<td>C₆H₅NO₂</td>
<td>CO₂ and H₂O only</td>
</tr>
</tbody>
</table>
SMSS 4E Chem 5073 Prelim 2017

P1 Answers

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>C</td>
</tr>
</tbody>
</table>
ST. MARGARET'S SECONDARY SCHOOL
Preliminary Examinations 2017

CANDIDATE NAME

CLASS

REGISTER NUMBER

CHEMISTRY

Paper 2

Secondary 4 Express

5073/02

28 August 2017

1 hour 45 minutes

Additional Materials: NIL; candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer all questions in the spaces provided.

Section B
Answer all three questions, the last question is in the form either/or.
Answer all questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.
The use of an approved scientific calculator is expected, where appropriate.

<table>
<thead>
<tr>
<th>For Examiner's Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A</td>
</tr>
<tr>
<td>Section B</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

This document consists of 20 printed pages.

Need a home tutor? Visit smiletutor.sg

Page 362
Section A

Answer all questions in this section in the spaces provided.
The total mark for this section is 50.

A1. A list of substances is provided for you in the space below. You may use each substance once, more than once, or not at all.

<table>
<thead>
<tr>
<th>zinc hydroxide</th>
<th>sodium chloride</th>
<th>nitrogen dioxide</th>
<th>potassium nitrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>magnesium oxide</td>
<td>ammonium sulfate</td>
<td>lead(II) hydroxide</td>
<td>carbon monoxide</td>
</tr>
<tr>
<td>iron(II) carbonate</td>
<td>carbon dioxide</td>
<td>calcium carbonate</td>
<td>hydrogen peroxide</td>
</tr>
</tbody>
</table>

From the list above, choose one substance that

(a) forms a green solution when added to hydrochloric acid. [1]

(b) causes an aqueous solution of Universal Indicator to turn red when added to it. [1]

(c) reacts separately with sulfuric acid and sodium hydroxide to form salts. [1]

(d) dissolves in excess sodium hydroxide, but not in excess aqueous ammonia. [1]

(e) produces an alkaline gas only when heated with sodium hydroxide and a piece of aluminium foil. [1]

(f) can be used to extract iron from its oxide. [1]

[Total: 6 marks]
A2. Refractory materials are used to line the insides of ovens and furnaces, due to their ability to withstand high temperatures without melting. One example of this is magnesite, an ionic compound which has the formula MgCO₃.

(a) Draw the electronic structure of the positive ion in magnesite. Show only the valence electrons.

(b) The carbonate ion has the structural formula shown below.

\[
\begin{array}{c}
\text{O} = \text{C} = \text{O} \\
\text{carbonate ion}
\end{array}
\]

The negative charge on each single bonded oxygen atoms show that an electron has been gained by that oxygen atom.

Hence, complete the dot-and-cross diagram for the carbonate ion below, showing only the valence electrons.
(c) With prolonged exposure high temperature, magnesite decomposes to form two compounds, solid A and gas B.

(i) Identify A and B.

A: 

B: 

(ii) Describe a chemical test for the formation of gas B.

(iii) Magnesite decomposes to form solid A, which still can be used as a refractory material. Explain why, using ideas about the bonding, structure and particles present in solid A.

[Total: 10 marks]
A3. The outcome of an electrolysis experiment can be affected by two factors: the type of electrolyte used and the type of electrode used.

(a) In three separate experiments, molten zinc chloride, dilute zinc chloride and concentrated zinc chloride were electrolysed using inert graphite electrodes.

(i) Explain what is meant by inert electrode.

(ii) Complete the table below.

<table>
<thead>
<tr>
<th>electrolyte</th>
<th>molten zinc chloride</th>
<th>dilute zinc chloride</th>
<th>concentrated zinc chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>product formed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at cathode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>product formed</td>
<td></td>
<td>chlorine</td>
<td></td>
</tr>
<tr>
<td>at anode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>substance left</td>
<td>none</td>
<td>zinc chloride</td>
<td></td>
</tr>
<tr>
<td>behind after</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>electrolysis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Gold electrodes are used in the electrolytic refining of gold metal. The electrolyte used is dilute aqueous gold(III) chloride, an orange solution. This is shown in the diagram below.

(i) Write down half equations, with state symbols, for the reactions occurring at the anode and cathode.

Anode: ____________________________

Cathode: ____________________________
(ii) Describe what is observed at the positive and negative electrodes, when the setup shown above is used for electrolysis.

[1]

(iii) Describe what is observed at the positive electrode and in the electrolyte, when an inert platinum electrode is used instead of an impure gold electrode.

[2]

[Total: 10 marks]
A4. (a) For most metallic objects in everyday use, great care is taken to prevent or slow down the effect of corrosion on the metal.

(i) Most chefs “season” their iron cooking pans by strongly heating a thin layer of cooking oil until it forms a coating on the surface of the pan.

Explain how this coating slows down the effect of corrosion.

(ii) The steel hulls of ships usually protected from corrosion by attaching a block made of magnesium to the hull.

Explain how this prevents the corrosion of the steel hull.

(b) In the early 1800s, Sir Humphry Davy discovered that sodium metal could be added to water to produce an alkali and a gas.

(i) Write down a balanced chemical equation for this reaction.

(ii) 23.85 cm³ of 1.5 mol/dm³ of the alkali mentioned in (b)(i) is required to neutralise 1.82 g of C₆H₆O₆, which is a carboxylic acid.

Determine the number of –COOH groups present in one molecule of C₆H₆O₆.
A5. Ethanoic acid is a weak acid. It can be used to prepare lead(II) ethanoate, a soluble ionic compound.

(a) Define the term weak acid.

(b) Describe what will be observed when a few drops of Universal Indicator are added to a 1 mol/dm³ solution of ethanoic acid.

(c) Briefly outline a method for the preparation of an aqueous solution of lead(II) ethanoate from ethanoic acid.

(d) The lab technician has discovered that the labels on the bottles of ethanoic acid and nitric acid have fallen off.

Describe a test to show how you would distinguish between both acids, without the use of a data logger or pH indicators.

[Total: 7 marks]
A6. Among the Period 2 elements, nitrogen possesses the rare property of being able to form a few different types of oxides. These oxides of nitrogen can be found in waste gases that are produced by factories that operate at high temperature.

(a) An oxide of nitrogen was discovered to contain 69.6% of oxygen by mass.

(i) Calculate its empirical formula.

(ii) Given that the Mr of this oxide of nitrogen is 92, determine its molecular formula.

(iii) Hence write down a balanced chemical equation for the formation of this oxide of nitrogen, from nitrogen and oxygen.

(b) Write down the chemical formula of a solid substance that can be used to remove this oxide of nitrogen from factory waste gases.
(c) Apart from waste gases from factories, suggest one other source that produces oxides of nitrogen as a pollutant.

(d) Describe one negative impact of the release of oxides of nitrogen into the atmosphere.

[Total: 8 marks]
Section B

Answer all three questions from this section. The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7. Thiols are organic compounds that contain the sulfhydryl functional group, \(-\text{S}–\text{H}\). They are considered to be similar to alcohols in some aspects. The table below shows the structural formulae of the first three members of the thiol homologous series.

<table>
<thead>
<tr>
<th>name</th>
<th>structural formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>methanethiol</td>
<td>![Structural formula of methanethiol]</td>
</tr>
<tr>
<td>ethanethiol</td>
<td>![Structural formula of ethanethiol]</td>
</tr>
<tr>
<td>propanethiol</td>
<td>![Structural formula of propanethiol]</td>
</tr>
</tbody>
</table>

The chemical reactions of thiols have been studied widely by chemists, due to their ability to be synthesised into various products.

Thiols are able to react with carboxylic acids to form thioesters. Figure 7.2 shows the reaction between propanethiol and ethanoic acid, to form propyl ethanethiolate and product A.

![Chemical reaction between propanethiol, ethanoic acid, and product A]

Figure 7.2: Formation of propyl ethanethiolate, a thioester

Thiols undergo oxidation to form sulfonic acids, as shown in Figure 7.3 below.

![Oxidation of ethanethiol to ethanesulfonic acid]

Figure 7.3: Formation of ethanesulfonic acid, a sulfonic acid
(a) Write down the name of the thiol with the formula C₆H₁₃SH.

(b) Draw the structural formula of product A, which is shown in Figure 7.2.

(c) Propanethiol can be formed from an addition reaction between an alkene and molecule B. Write down the name of molecule B.

(d) Molecules C and D are two possible isomers of propanethiol.
   C contains the sulphydryl functional group, while D does not.
   (i) Define the term isomer.

(ii) Draw the structural formulae of C and D in the spaces below.

<table>
<thead>
<tr>
<th>C:</th>
<th>D:</th>
</tr>
</thead>
</table>

(e) Predict and explain the electrical conductivity of methanethiol.
(f) Based on the data in Figure 7.3, list two differences between the reactions of alcohols and thiols.

[2]

[Total: 10 marks]
B8. Concentrated nitric acid is able to oxidise unreactive metals like copper, to form nitrogen dioxide, a salt and water. An equation for this reaction is shown below:

\[ \text{Cu} + 4 \text{HNO}_3 \rightarrow \text{Cu(NO}_3)_2 + 2 \text{NO}_2 + 2 \text{H}_2\text{O} \]

(a) Explain, in terms of oxidation state, why this is a redox reaction.

(b) Write down an ionic equation, with state symbols, for this reaction.

(Assume that this reaction occurs at room temperature and pressure)

(c) A 1000 g bar of copper was placed into a beaker of concentrated nitric acid, and the gas evolved was collected and measured at room temperature and pressure.

At the end of the reaction, the remaining copper was collected by filtration and weighed. The temperature of the acid was also measured, before and after the experiment.

The results are shown in the table below.

<table>
<thead>
<tr>
<th></th>
<th>before experiment</th>
<th>after experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass of copper / g</td>
<td>1000</td>
<td>344</td>
</tr>
<tr>
<td>temperature of</td>
<td>25</td>
<td>121</td>
</tr>
<tr>
<td>concentrated nitric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>acid / °C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(i) Calculate the volume of NO₂ collected at room temperature and pressure.

(ii) Before the gas is cooled to room temperature and pressure, its volume is approximately double that of the value calculated in (c)(i). Apart from expansion of gas due to heat, suggest another reason for this.

[Total: 10 marks]
B9. Hydrogen peroxide, H₂O₂, decomposes when exposed to sunlight, to form water and oxygen gas.

Four experiments were conducted to investigate the decomposition of H₂O₂. The concentrations of H₂O₂ were measured and recorded at the start of the experiment and after 60 seconds. The results are shown in the table below.

In Experiment 2, the temperature of H₂O₂ at the start of the reaction was increased to 30.0 °C.

In Experiment 4, a small amount of MnO₂ was mixed with the H₂O₂ at the start of the experiment.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>concentration of H₂O₂ / (mol/dm³)</th>
<th>decrease in concentration of H₂O₂ after 60 s / (mol/dm³)</th>
<th>mass of MnO₂ / g</th>
<th>initial</th>
<th>after 60 s</th>
<th>initial</th>
<th>after 60 s</th>
<th>initial temperature of H₂O₂ / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.00</td>
<td>4.31</td>
<td></td>
<td>-</td>
<td>-</td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5.00</td>
<td>3.49</td>
<td></td>
<td>-</td>
<td>-</td>
<td>30.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10.00</td>
<td>8.62</td>
<td>1.38</td>
<td>-</td>
<td>-</td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10.00</td>
<td>0.00</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Calculate the decrease in concentration of H₂O₂ for Experiments 1, 2 and 4. Fill in your answers in the table above. [1]

(b) Explain the effect of concentration of H₂O₂ on the rate of reaction by comparing the data from two appropriate experiments.

[4]
(c) (i) State the role of MnO₂ in Experiment 4.

(ii) With reference to the data from two appropriate experiments, give two reasons to explain your answer in (c)(i).

(d) Explain the effect of the difference in temperature between Experiments 1 and 2 on the rate of reaction, using ideas about energy and reacting particles.

[Total: 10 marks]
B9. The table below displays the average bond energies for various covalent bonds.

<table>
<thead>
<tr>
<th>bond</th>
<th>energy / (kJ/mol)</th>
<th>bond</th>
<th>energy / (kJ/mol)</th>
<th>bond</th>
<th>energy / (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Br-Br</td>
<td>193</td>
<td>C-I-C</td>
<td>358</td>
<td>I-I</td>
<td>151</td>
</tr>
<tr>
<td>C-C</td>
<td>348</td>
<td>F-F</td>
<td>155</td>
<td>O-O</td>
<td>146</td>
</tr>
<tr>
<td>C-H</td>
<td>413</td>
<td>H-H</td>
<td>436</td>
<td>C=O</td>
<td>799</td>
</tr>
<tr>
<td>C=O</td>
<td>358</td>
<td>O-H</td>
<td>463</td>
<td>C=C</td>
<td>614</td>
</tr>
</tbody>
</table>

(a) “The strength of the X-X covalent bond decreases down the Group, where X represents a Group VII element.”

Comment on whether the data in the table fully supports this statement.

__________________________________________________________________________

__________________________________________________________________________

(b) “Hydrogenation of alkenes is always exothermic.”

(i) Use data from the table above, with suitable calculations, to show that this statement is true.
(ii) Hence, draw a labelled energy profile diagram for the hydrogenation of propene, on the axes below.

```
progress of reaction

energy (kJ/mol)
```

(iii) "The size of the enthalpy change is always smaller than the activation energy for endothermic reactions."

By drawing an appropriate energy profile diagram, and using ideas about energy levels, briefly explain why this statement is true.

[Total: 10 marks]
P2 Answers

| Qn | Ans | Mk
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Iron(II) carbonate</td>
<td>1</td>
</tr>
<tr>
<td>1b</td>
<td>Nitrogen dioxide (reject: carbon dioxide, as it dissolves to give a weakly acidic solution)</td>
<td>1</td>
</tr>
<tr>
<td>1c</td>
<td>Zinc hydroxide OR lead(II) hydroxide</td>
<td>1</td>
</tr>
<tr>
<td>1d</td>
<td>Lead(II) hydroxide</td>
<td>1</td>
</tr>
<tr>
<td>1e</td>
<td>Potassium nitrate</td>
<td>1</td>
</tr>
<tr>
<td>1f</td>
<td>Carbon monoxide</td>
<td>1</td>
</tr>
</tbody>
</table>

2a

\[
\text{Mg}^{2+} \quad \text{1m for correct charge} \\
1 \text{m for everything else correct}
\]

2b

\[
2^- \quad \text{1m for correct covalent bonding electrons} \\
1 \text{m for correct non-covalent bonding electrons}
\]

(The electrons gained in by oxygen have to be drawn using a different symbol, e.g. symbols other than cross.)

2ci

A: Magnesium oxide / MgO 1m for both
B: carbon dioxide / CO₂

2cii

Bubble the gas through aqueous calcium hydroxide (accept limewater)
A white precipitate will be formed (reject: turns chalky / milky)

2ciii

The magnesium oxide left behind has a giant ionic lattice structure.
A high amount of (reject: "more") thermal energy is required to overcome the strong electrostatic forces of attraction between the oppositely charged ions.

(max 1m if students have stated Mg in 2ci instead of MgO)

3ai

The electrode is unreactive / does not react.
<table>
<thead>
<tr>
<th>3aii</th>
<th>Electrolyte</th>
<th>Moren in Zinc Chloride</th>
<th>Unam Amernic Zinc Chloride</th>
<th>Concentrated Aqueous Zinc Chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>3aii</td>
<td>Product formed at cathode</td>
<td>Zinc</td>
<td>Hydrogen</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>3aii</td>
<td>Product formed at anode</td>
<td>Chlorine</td>
<td>Oxygen (and water)</td>
<td>Chlorine</td>
</tr>
<tr>
<td>3aii</td>
<td>Substance left behind after electrolysis</td>
<td>None</td>
<td>Zinc chloride</td>
<td>Zinc hydroxide</td>
</tr>
</tbody>
</table>

(2 – 3 correct - 1m; 4 – 5 correct - 2m; all correct - 3m)

<table>
<thead>
<tr>
<th>3bi</th>
<th>Anode: Au (s) → Au^{2+} (aq) + 3e(^{-}) (1m) for each equation, consequential 1m for state symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>3bi</td>
<td>Cathode: Au^{2+} (aq) + 3e(^{-}) → Au (s)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3bii</th>
<th>The positive electrode becomes smaller in size (accept: wears down), while the negative electrode increases in size (accept: becomes bigger).</th>
</tr>
</thead>
<tbody>
<tr>
<td>3biii</td>
<td>Bubbles of gas are formed at the positive electrode (reject: it does not wear down). The orange colour of the electrolyte fades (reject: electrolyte becomes acidic).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4ai</th>
<th>The coating provides a physical barrier which prevents contact between the iron and molecules of oxygen and water (reject: air).</th>
</tr>
</thead>
<tbody>
<tr>
<td>4aii</td>
<td>The magnesium reacts preferentially over the iron present in steel (reject: reacts faster) as it is more reactive than iron.</td>
</tr>
<tr>
<td>4bi</td>
<td>2 Na + 2 H(_2)O → 2 NaOH + H(_2)</td>
</tr>
<tr>
<td>4bi</td>
<td>Moles of alkali = 1.5 \times (23.85 / 1000) = 0.03578 mol</td>
</tr>
<tr>
<td>4bi</td>
<td>Moles of C(_6)H(_2)O(_2) = 1.82 / [(6 \times 12) + (4 \times 1) + (8 \times 16)] = 0.008522 mol</td>
</tr>
<tr>
<td>4bi</td>
<td>Mole ratio of alkali : C(_6)H(_2)O(_2) = 0.03578 : 0.008522 = 4.01 : 1</td>
</tr>
<tr>
<td>4bi</td>
<td>There are 4 -COOH groups</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5a</th>
<th>It undergoes partial ionisation to produce a low concentration of (accept: some) H(^+).</th>
</tr>
</thead>
<tbody>
<tr>
<td>5b</td>
<td>The indicator changes colour from green to orange (accept yellow, reject red) (accept: Solution turns from colourless to orange/yellow)</td>
</tr>
<tr>
<td>5c</td>
<td>Add an excess of lead(II) carbonate (accept: lead(II) oxide &amp; reject: lead metal) to the ethanoic acid.</td>
</tr>
<tr>
<td>5c</td>
<td>Filter the mixture to remove the excess lead(II) carbonate, and obtain lead(II) ethanoate as the filtrate.</td>
</tr>
<tr>
<td>5d</td>
<td>Add a strip of magnesium metal (accept: add a metal) to a beaker of each acid. The magnesium ribbon takes a longer time to completely react with the ethanoic acid (accept: nitric acid reacts faster)</td>
</tr>
<tr>
<td>5d</td>
<td>(accept any reasonable answer that shows that ethanoic acid possesses a lower concentration of H(^+). E.g., add ethanol and conc. H(_2)SO(_4) / add NaOH and A(_2)F)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6ai</th>
<th>N</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of atoms / (g per 100g)</td>
<td>30.4</td>
<td>69.6</td>
</tr>
<tr>
<td>Number of moles</td>
<td>30.4 / 14 = 2.171</td>
<td>69.6 / 16 = 4.35</td>
</tr>
<tr>
<td>Mole ratio</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Empirical formula is NO(_2).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(common mistake: Using N(_2) and O(_2) instead of their atoms)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6aii</th>
<th>Molecular formula is N(_2)O(_4) (working not required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6aiii</td>
<td>N(_2) + 2 O(_2) → N(_2)O(_4)</td>
</tr>
<tr>
<td>6b</td>
<td>CaO (or any basic oxide / metal carbonate)</td>
</tr>
</tbody>
</table>

Need a home tutor? Visit smiletutor.sg
6c Lightning activity OR car
6d It causes acid rain, which can cause harm to crops / buildings made out of limestone or metal / aquatic life
(Award only 1m if students state breathing difficulties as answer)

7a Hexanethiol (no mark for wrong spelling)
7b H–O–H
7c Dihydrogen monosulfide (accept: hydrogen sulfide, sulfur dihydride)
(if prefixes are used, they have to be used consistently)
7di They have the same molecular (reject: “chemical”) formula but different structural formula (accept “different structure”)
7dii C:


D:


1m

2

7e It has poor electrical conductivity in all states. Methanethiol is composed of simple molecules that are neutral.

7f Oxidation of thiols
sulfur-oxygen double bonds are formed
two double bonds to oxygen are formed
sulfur atom in sulfonic acid has 12 valence electrons (OR has 6 covalent bonds in total)
sulfonyl functional group has three oxygen atoms (OR: gains three O atoms, does not lose H atoms)
(carbon-oxygen double bonds are formed)
(only one double bond to oxygen is formed)
(carbon atom in carboxylic acid still has only 8 valence electrons (OR has 4 covalent bonds in total)
sulfonyl functional group has two oxygen atoms (OR: gains one O atom, loses two H atoms)
(any two differences)
(answers must make reference to elemental composition of the functional group)
(reject: water is not formed when thiols are oxidised)
(reject: answers referring to Figure 7.2)

8a Oxidation state of copper increases from 0 in Cu to +2 in Cu(NO₃)₂
Oxidation state of nitrogen decreases from +5 in HNO₃ to +4 in NO₂.

8b Cu(s) + 4 H⁺ (aq) + 2 NO₃⁻ (aq) → Cu²⁺ (aq) + 2 NO₂ (g) + 2 H₂O (l)

(1m for correct equation, 1 mark for correct state symbols)

Mark for state symbols will only be given if basic concept of writing ionic equation is right.
E.g., writing CuSO₄ (aq) will not give students any mark unless they split it into Cu²⁺ (aq) + SO₄²⁻ (aq)

8ci Mass of Cu reacted = 1000 - 344 = 656 g
Mol of Cu reacted = 656 / 64 = 10.25 mol
Mol of NO₂ = 2 x 10.25 = 20.5 mol (ECF, max 1m)
Volume of NO₂ = 20.5 x 24 dm³ = 492 dm³

8cii Water vapour (accept: water in the gaseous state) also makes up part of the gas collected before it is cooled.

8d Expt 1: 0.69
Expt 2: 1.51
Expt 4: 10.00

9a

Need a home tutor? Visit smiletutor.sg

Page 383
E9b

Comparing Experiment 2 and Experiment 3, the concentration of \( \text{H}_2\text{O}_2 \) shows a greater decrease in concentration after 60 s. However, if you are quoting values of initial concentrations of Experiment 1 and 3, and decrease in concentration after 50 s. The higher the initial concentration of reactants, the faster the initial rate.

E9ci

Addition of MnO\(_2\) in Expt 4 causes concentration of \( \text{H}_2\text{O}_2 \) to decrease by a greater amount than in Expt 3. Mass of MnO\(_2\) stays constant at 0.5 g from start to end of Expt 4.

E9d

As temperature increases, rate of reaction increases. More reacting particles have energy equal to or greater than activation energy. Thus, frequency of effective collisions increases.

O9a

This statement is not fully supported. Bond energy decreases from Cl–Cl to Br–Br to I–I, showing a decrease in bond strength. However, the F–F bond is weaker than the Cl–Cl bond.

1m – inconsistent trend
1m – relate bond strength to bond energy

O9bi

Enthalpy change for hydrogenation
\[ \Delta H = \left( 2 \times \text{C} - \text{H} \right) - \left( 2 \times \text{C} - \text{H} \right) - \left( 1 \times \text{C} - \text{C} \right) - \left( 1 \times \text{C} - \text{C} \right) - \left( 4 \times \text{H} - \text{H} \right) \]
\[ = 614 + 436 - 348 - 2(413) \]
\[ = -124 \text{ kJ} \]

1m only if calculation are for a specific alkene

O9bii

\[ \text{C}_3\text{H}_6 + \text{H}_2 \rightarrow \text{C}_3\text{H}_8 \]

\[ \Delta H = -124 \text{ kJ/mol} \]

1m – shape of graph
1m – \( E_A \) and \( \Delta H \)
1m – reactants and products labelled

O9bii

Maximum point on the graph is always higher than product energy level. Activation energy must always be larger than the difference between energy levels for an endothermic reaction.
Name: _______________________________ (          )               Class:___________

CHIJ ST. NICHOLAS GIRLS’ SCHOOL
Secondary 4
Preliminary Examination (40 Marks)

CHEMISTRY (SPA)5073

29 August 2017
1 hour

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class on the OAS sheet using a soft pencil.

There are forty questions in this paper.
Answer all questions.
For each question there are four possible answers A, B, C and D.
Choose the correct answer and record the corresponding letter using a soft pencil on
the OAS sheet.
Amendments may be done using a soft eraser.

Each correct answer will score one mark. A mark will not be deducted for a wrong
answer.
A calculator may be used.

A copy of the Periodic Table is provided on page 2.
The total number of marks for this paper is 40.

This document consists of 20 printed pages.

<table>
<thead>
<tr>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (40)</td>
</tr>
</tbody>
</table>
The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>Period</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>H (Hydrogen)</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>Li (Lithium), Be (Beryllium), Mg (Magnesium), Ca (Calcium), Sr (Strontium), Ba (Barium)</td>
</tr>
<tr>
<td>III</td>
<td>3</td>
<td>Na (Sodium), K (Potassium), Rb (Rubidium), Cs (Cesium), Fr (Francium)</td>
</tr>
<tr>
<td>IV</td>
<td>4</td>
<td>Al (Aluminum), Si (Silicon), P (Phosphorus), S (Sulfur), Cl (Chlorine), Ar (Argon)</td>
</tr>
<tr>
<td>V</td>
<td>5</td>
<td>C (Carbon), N (Nitrogen), O (Oxygen), F (Fluorine), Ne (Neon)</td>
</tr>
<tr>
<td>VI</td>
<td>6</td>
<td>Mg (Magnesium), Si (Silicon), P (Phosphorus), S (Sulfur), Cl (Chlorine)</td>
</tr>
<tr>
<td>VII</td>
<td>7</td>
<td>Fe (Iron), Co (Cobalt), Ni (Nickel), Cu (Copper), Zn (Zinc), Ga (Gallium), Ge (Germanium)</td>
</tr>
<tr>
<td>O</td>
<td>8</td>
<td>Mn (Manganese), Cr (Chromium), Mo (Molybdenum), Tc (Technetium), Ru (Ruthenium), Rh (Rhenium), Pd (Palladium), Ag (Silver)</td>
</tr>
<tr>
<td>IIA</td>
<td>9</td>
<td>Ca (Calcium), Sr (Strontium), Ba (Barium), Ra (Radium)</td>
</tr>
<tr>
<td>IIB</td>
<td>10</td>
<td>Sc (Scandium), Ti (Titanium), V (Vanadium), Cr (Chromium), Mn (Manganese), Fe (Iron), Co (Cobalt), Ni (Nickel)</td>
</tr>
<tr>
<td>IB</td>
<td>11</td>
<td>Be (Beryllium), Mg (Magnesium), Ca (Calcium), Sr (Strontium), Ba (Barium), Lu (Lutetium)</td>
</tr>
<tr>
<td>IIB</td>
<td>12</td>
<td>Zn (Zinc), Cd (Cadmium), In (Indium), Sn (Tin), Sb (Antimony), Te (Tellurium)</td>
</tr>
<tr>
<td>IIA</td>
<td>13</td>
<td>Y (Yttrium), Zr (Zirconium), Nb (Nickel), Mo (Molybdenum), Tc (Technetium), Re (Rhenium)</td>
</tr>
<tr>
<td>IIA</td>
<td>14</td>
<td>Zr (Zirconium), Nb (Nickel), Mo (Molybdenum), Tc (Technetium), Re (Rhenium), Os (Osmium)</td>
</tr>
<tr>
<td>IIB</td>
<td>15</td>
<td>H (Hydrogen), He (Helium), Ne (Neon), Ar (Argon), Kr (Krypton), Xe (Xenon)</td>
</tr>
<tr>
<td>IIB</td>
<td>16</td>
<td>He (Helium), Ne (Neon), Ar (Argon), Kr (Krypton), Xe (Xenon), Rn (Radon)</td>
</tr>
</tbody>
</table>

*58-71 Lanthanoid series
†90-103 Actinoid series

Key:
- a = atomic mass
- b = atomic number
- X = symbol

References:
- 232 Th (Thorium), 236 U (Uranium), 90 Th (Thorium), 92 U (Uranium)
The diagram shows apparatus used to separate ethanol (boiling point, 78 °C) and propanol (boiling point, 98 °C).

Which graph best shows the change in concentration of the ethanol in the round-bottomed flask as the distillation proceeds from room temperature?
2. A drug substance has an $R_f$ value of 0.375 using water as the solvent.

What would be the position of this drug substance in the chromatogram shown below?

![Chromatogram Diagram]

3. The apparatus below consists of a porous pot containing butane which is surrounded by air in a beaker.

![Apparatus Diagram]

Over a period of time, which one of the following series of changes of water level at $X$ will be observed?

A. falls and remains at a lower level
B. rises and remains at higher level
C. falls then rises and returns to $X$
D. rises then falls and returns to $X$
4 The diagram below shows an apparatus in which ammonium bromide is formed by the reaction between ammonia gas and hydrogen bromide gas. The chemical equation is shown below.

\[
\text{NH}_3 + \text{HBr} \rightarrow \text{NH}_4\text{Br}
\]

At which position in the apparatus is ammonium bromide most likely to be found?

5 The boiling points of some elements are given below.

<table>
<thead>
<tr>
<th>element</th>
<th>boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>-137</td>
</tr>
<tr>
<td>Y</td>
<td>-152</td>
</tr>
<tr>
<td>Z</td>
<td>-141</td>
</tr>
</tbody>
</table>

A mixture of elements X, Y and Z is heated gradually from -159 °C to -139 °C. Which of the element(s) would still remain as a liquid at -139 °C?

A. Element X only
B. Elements X and Y only
C. Elements Y and Z only
D. Elements X, Y and Z

6 What is the atomic structure of X^{2+} ion if it has atomic number 13 and mass number 27?

<table>
<thead>
<tr>
<th>Number of protons</th>
<th>Number of neutrons</th>
<th>Number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>B</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>D</td>
<td>13</td>
<td>27</td>
</tr>
</tbody>
</table>
7 An element \( X \) which has 2 different isotopes, \( X-11 \) and \( X-12 \), exists as diatomic molecules, \( X_2 \). The relative molecular mass of \( X_2 \) is 22.48.

What is the relative abundance of \( X-11 \)?

A 24.0%  
B 38.0%  
C 48.0%  
D 76.0%

8 The following diagram shows structure of diamond and white phosphorus. Both structures show atoms bonded in a tetrahedral arrangement. However, diamond has a high melting point of 4723 °C while white phosphorus has a low melting point of 280 °C.

Which of the option explains the difference in the melting point of diamond and white phosphorus?

A Both diamond and white phosphorus have covalent bonds between atoms.  
B Diamond has covalent bonds in between carbon atoms in a vast network, whereas white phosphorus has Van der Waals’ forces between phosphorus atoms in a vast network.  
C Diamond has covalent bonds in between carbon atoms in a vast network, whereas white phosphorus has Van der Waals’ forces between the discrete molecules.  
D Diamond has ionic bonds in between carbon atoms in an ionic lattice, whereas white phosphorus has Van der Waals’ forces between phosphorus atoms in a vast network.
The reaction between magnesium and dilute nitric acid is as shown below:

\[ \text{Mg(s)} + 2\text{HNO}_3(\text{aq}) \rightarrow \text{Mg(NO}_3)_2(\text{aq}) + \text{H}_2(\text{g}) \]

From the equation, it can be deduced that

A. 1 g of magnesium reacts with 2 g of nitric acid in a complete reaction.
B. 6 g of magnesium reacts with 31.5 g of nitric acid in a complete reaction.
C. 24 dm\(^3\) of magnesium reacts with 48 dm\(^3\) of nitric acid in a complete reaction.
D. 1 mol of magnesium reacts with 0.5 mol of nitric acid in a complete reaction.

In a titration, it was found that 8 cm\(^3\) of 0.5 mol/dm\(^3\) of acid \(X\) needed 20 cm\(^3\) of 0.4 mol/dm\(^3\) of potassium hydroxide solution for complete reaction.

Which of the following is the molecular formula of acid \(X\)?

A. \(\text{HCl}\)
B. \(\text{H}_2\text{SO}_4\)
C. \(\text{H}_3\text{PO}_4\)
D. \(\text{CH}_3\text{COOH}\)

Which experiment does not show a redox reaction?

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>aqueous chlorine added to sodium iodide solution</td>
</tr>
<tr>
<td>B</td>
<td>copper solid dipped into a beaker of silver nitrate solution</td>
</tr>
<tr>
<td>C</td>
<td>aqueous hydrogen peroxide added to a mixture of potassium manganate(VII) and dilute sulfuric acid</td>
</tr>
<tr>
<td>D</td>
<td>aqueous barium nitrate added to copper(II) sulfate solution</td>
</tr>
</tbody>
</table>
12 Transition metals are well known for having several stable oxidation states and manganese has more than any other. In its compounds, manganese exhibits oxidation states from +2 to +7.

The common oxidation states are +2, +4, and +7, while the less common oxidation states are +3, +5, and +6.

Which of the following contains manganese in all six oxidation states?

A  KMnO₄, MnO, MnO₂, MnCl₂, Mn(SO₄)₃, Mn(NO₃)₂
B  KMnO₄, NaMnO₄, Mn(SO₄)₂, Mn(SO₄)₃, Mn(NO₃)₂, Mn(NO₃)₂•4H₂O
C  MnO, MnO₂, MnF, NaMnO₄, Mn(SO₄)₃, MnCl₂
D  KMnO₄, MnO₂, MnF₃, Mn₂(CO₃)₅, Mn(SO₄)₃, Mn(NO₃)₂•4H₂O

13 In a reaction between copper(II) oxide and carbon monoxide, which of the following is the reducing agent?

A  CuO
B  CO
C  Cu
D  CO₂

14 In a chemical analysis, excess silver nitrate solution is added to dilute hydrochloric acid. The reaction mixture is then filtered.

What are the ions present in the filtrate after filtration?

A  H⁺ and NO₃⁻ only
B  Ag⁺, Cl⁻ and NO₃⁻ only
C  Ag⁺ and NO₃⁻ only
D  H⁺, Ag⁺ and NO₃⁻ only

15 Which of the following substances would not produce copper(II) nitrate crystals with dilute nitric acid?

A  copper(II) hydroxide
B  copper(II) sulfate
C  copper(II) carbonate
D  copper(II) oxide
16 Which one of the options below matches the correct salt preparation methods used to prepare the salts?

<table>
<thead>
<tr>
<th>Method</th>
<th>Ammonium Nitrate</th>
<th>Lead(II) Sulfate</th>
<th>Sodium Chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Titration</td>
<td>Precipitation</td>
<td>Adding excess base to acid</td>
</tr>
<tr>
<td>B</td>
<td>Calcium Carbonate</td>
<td>Lead(II) Chloride</td>
<td>Magnesium Chloride</td>
</tr>
<tr>
<td>C</td>
<td>Copper(II) Sulfate</td>
<td>Lead(II) Nitrate</td>
<td>Lead(II) Nitrate</td>
</tr>
<tr>
<td>D</td>
<td>Potassium Ethanoate</td>
<td>Lead(II) Bromide</td>
<td>Zinc Sulfate</td>
</tr>
</tbody>
</table>

17 Which statement correctly describes the changes in the elements from left to right across a period of the Periodic Table?

A The size of atoms increases.
B The number of electron shells increases.
C The number of valence electrons increases.
D The elements change from non-metallic to metallic.

18 Each of the halogens, X₂, Y₂ and Z₂ was added to separate solutions containing ions of one of the other two halogens. The table shows the results.

<table>
<thead>
<tr>
<th>Halogen added</th>
<th>NaX solution</th>
<th>NaY solution</th>
<th>NaZ solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>X₂</td>
<td>–</td>
<td>Y₂ displaced</td>
<td>No visible reaction</td>
</tr>
<tr>
<td>Y₂</td>
<td>No visible reaction</td>
<td>–</td>
<td>No visible reaction</td>
</tr>
<tr>
<td>Z₂</td>
<td>X₂ displaced</td>
<td>Y₂ displaced</td>
<td>–</td>
</tr>
</tbody>
</table>

Which of the following shows the order of increasing reactivity of elements X, Y and Z?

A Y, X, Z
B Y, Z, X
C X, Y, Z
D Z, X, Y
19 The chemical equation below shows the reaction between element X and cold water. The element X has an atomic number of 55.

\[ 2X + 2H_2O \rightarrow 2XOH + H_2 \]

Which statement about element X is correct?

A It displaces metallic potassium from aqueous potassium chloride.
B It is produced during the electrolysis of XCl(aq).
C It forms a carbonate that is readily decomposed by heat.
D Its reactivity with cold water is the same as potassium.

20 Astatine (At) is a member of the halogen family. It has a proton number greater than the other halogens. It is expected that astatine

A has the lowest melting point.
B is a coloured liquid at room temperature.
C is the halogen with the weakest oxidising power.
D is the most reactive halogen.

21 The diagram shows the structure of bronze.

Why is bronze harder than pure copper?

A The tin atoms form strong covalent bonds with the copper atoms.
B The tin atoms prevent layers of copper atoms from sliding past one another easily.
C The tin atoms prevent the sea of delocalised electrons from moving freely among the copper atoms.
D Tin atoms have more electrons than the copper atoms.
22 Which of the following reactions produce both carbon dioxide and oxygen gas?

A decomposition of hydrogen peroxide  
B decomposition of copper(II) carbonate  
C decomposition of silver carbonate  
D reaction between hydrochloric acid and sodium carbonate

23 The diagram below shows two metal strips, iron and lead, placed in a beaker containing a mixture of cations.

In which of the following mixture of cations, would the two metal strips remain unchanged?

A $\text{Na}^+, \text{Ca}^{2+}, \text{Al}^{3+}, \text{K}^+$  
B $\text{Ag}^+, \text{Zn}^{2+}, \text{Ca}^{2+}, \text{Mg}^{2+}$  
C $\text{Fe}^{2+}, \text{Pb}^{2+}, \text{Cu}^{2+}, \text{Zn}^{2+}$  
D $\text{Zn}^{2+}, \text{Ag}^+, \text{Cu}^{2+}, \text{Ca}^{2+}$

24 When a current was passed through acidified aqueous copper(II) sulfate, there was simultaneous liberation, at the cathode, of $x$ mol of copper and $y$ dm$^3$ of hydrogen (measured at room temperature and pressure).

How many moles of electrons passed through the solution?

A $x + \frac{y}{24}$  
B $x + \frac{y}{12}$  
C $2x + \frac{y}{12}$  
D $2x + \frac{y}{24}$
25 The apparatus was set up in the diagram shown below.

![Diagram of zinc and iron electrodes in aqueous iron(II) nitrate]

Which of the following observation(s) would be seen?

1. Bubbles of colourless gas are formed around the zinc electrode.
2. The aqueous iron(II) nitrate fades from green to colourless.
3. The iron electrode decreases in size.

A 2 only  
B 1 and 3 only  
C 1, 2 and 3  
D None of the above

26 In the diagram below, each cell contains an aqueous solution of a single salt and all four electrodes are graphite. Electrodes R and Y increase in mass during the electrolysis but no gas is given off at R and Y.

![Diagram of Q R X Y cells]

If an increase in mass of R is greater than the increase in mass of Y in the same time, which of the following statements is necessarily true?

A The anions of the solutions in cells 1 and 2 are different.  
B The cations of the solutions in cells 1 and 2 are different.  
C The current flowing in cell 1 is greater than the current flowing in cell 2.  
D The solution in cell 1 is more concentrated than the solution in cell 2.
Dilute sodium chloride was electrolysed using inert electrodes. After some time, the remaining electrolyte was then added in excess to an unknown colourless solution.

The graph of mass of precipitate formed against volume of electrolyte added was plotted. Which of the following shows the correct graph and the possible identity of the cation in the unknown colourless solution?

<table>
<thead>
<tr>
<th>Graph</th>
<th>Possible cation in unknown solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph A" /></td>
<td>Zn$^{2+}$</td>
</tr>
<tr>
<td><img src="image" alt="Graph B" /></td>
<td>Ag$^+$</td>
</tr>
<tr>
<td><img src="image" alt="Graph C" /></td>
<td>Al$^{3+}$</td>
</tr>
<tr>
<td><img src="image" alt="Graph D" /></td>
<td>Cu$^{2+}$</td>
</tr>
</tbody>
</table>
28 The diagram below represents the energy profile diagram for the following reaction:

\[ Y + Z \rightarrow 2X \]

What is the enthalpy change for the decomposition of 4 moles of \( X \) to substances \( Y \) and \( Z \)?

A. +40 kJ  
B. -40 kJ  
C. +80 kJ  
D. -80 kJ

29 Which of the following processes are endothermic?

1. \( F_2 \rightarrow 2F \)  
2. combustion of ethane  
3. obtaining lime (CaO) from limestone (CaCO\(_3\))  
4. reacting hydrogen with oxygen

A. 1 and 2  
B. 1 and 3  
C. 2 and 4  
D. 3 and 4
30 Nonane is a hydrocarbon with molecular formula, C\textsubscript{9}H\textsubscript{20}.
One of the reactions of nonane is shown by the equation below.

\[ \text{C}_9\text{H}_{20} \rightarrow \text{C}_5\text{H}_{12} + \text{C}_4\text{H}_8 \quad \Delta H = +114 \text{ kJ/mol} \]

Which of the following statements about the reaction is correct?

A It is a substitution reaction.
B The enthalpy change of combustion is 114 kJ per mole of nonane.
C The products possess more energy than the reactants.
D The total energy change in bond formation is more than that in bond breaking.

31 In an experiment, magnesium powder is added to dilute hydrochloric acid at room temperature. When the temperature of the same reaction was increased to 50 °C, the speed of the reaction increased.

This is because an increase in temperature

A results in the particles to possess more kinetic energy which in turn increases the frequency of collision between the particles.
B lowers the activation energy of the reaction which in turn increases the frequency of effective collisions.
C produces chemical energy which causes the particles to move faster which in turn increases the frequency of collision between the particles.
D causes magnesium to expand resulting in larger surface area to volume ratio which in turn increases the frequency of collision between the particles.
32 Curve I shows the total volume of hydrogen gas produced after 1.0 g of zinc strips were added to 25 cm$^3$ of 1.0 mol/ dm$^3$ hydrochloric acid.

The equation for this reaction is: Zn (s) + 2HCl (aq) \(\rightarrow\) ZnCl$$_2$$ (aq) + H$$_2$$ (g)

A second experiment was conducted using 5.0 g of zinc powder with 25 cm$^3$ of 1.0 mol/ dm$^3$ hydrochloric acid.

Which of the curves, A, B, C or D, would be obtained for the second experiment?

33 Potassium chlorate, KC$\text{O}_3$, undergoes thermal decomposition as shown in the chemical equation below:

\[
2\text{KC} \text{O}_3\text{(s)} \rightarrow 2\text{KCl}\text{(s)} + 3\text{O}_2\text{(g)}
\]

A student would like to investigate the factors affecting the rate of thermal decomposition of potassium chlorate, KC$\text{O}_3$, in the presence of manganese(IV) oxide as catalyst. The student performs the investigation as follows:

<table>
<thead>
<tr>
<th>Experiment 1</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 cm$^3$ of 0.50 mol/dm$^3$ of KC$\text{O}_3$ and powdered manganese(IV) oxide</td>
<td>50 cm$^3$ of 0.50 mol/dm$^3$ of KC$\text{O}_3$ and lump manganese(IV) oxide</td>
</tr>
</tbody>
</table>

What would be the effect on the rate and on the final volume of O$_2$ released in experiment 2 compared to experiment 1?

<table>
<thead>
<tr>
<th>Rate of reaction</th>
<th>Volume of O$_2$ released</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Decrease</td>
<td>Unchanged</td>
</tr>
<tr>
<td>B Decrease</td>
<td>Increase</td>
</tr>
<tr>
<td>C Increase</td>
<td>Unchanged</td>
</tr>
<tr>
<td>D Increase</td>
<td>Increase</td>
</tr>
</tbody>
</table>
The diagram below shows the setup of manufacturing ammonia using the Haber Process.

Which of the following statements is true?

A  P dissolves in water to form an alkaline solution.
B  Q is a compound consisting of two elements.
C  R is a compound of a transition metal.
D  X is obtained from the distillation of air.
35 A sample of dry air trapped in a syringe is slowly passed over excess heated iron filings in a tube until there is no further decreased in volume.

The original volume of dry air is 150 cm³. When the tube is cooled to room temperature, what is the expected volume left in the syringe?

A 30 cm³  
B 45 cm³  
C 80 cm³  
D 120 cm³

36 Which atmospheric pollutants, emitted by internal combustion engines, may react together in the presence of palladium catalyst to convert them into more environmentally-friendly products?

A carbon monoxide and unburnt hydrocarbons  
B carbon monoxide and nitrogen dioxide  
C nitrogen dioxide and sulfur dioxide  
D sulfur dioxide and unburnt hydrocarbons
37 Which of the following shows the correct uses of paraffin?

A fuel for jet engines and cooking
B fuel for car engines and heating
C for making waxes and road surfaces
D feedstock for petrochemicals and fuel for cooking

38 Which of the following structural formulae is not an isomer of each other?

A  B
C D

39 Which substance is formed when butan-1-ol, C₄H₉OH, is oxidised by aqueous acidified potassium manganate(VII), KMnO₄?

A C₄H₁₀
B C₃H₇CO₂K
C C₃H₇CO₂H
D C₄H₉CO₂H
40 The diagram below shows the structure of a part of polymer X.

Which is the monomer that makes up polymer X?

A

B

C

D

~~End of Paper~~
**Answers (2017 Prelim Paper 1)**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
</tr>
<tr>
<td>9</td>
<td>B</td>
</tr>
<tr>
<td>10</td>
<td>B</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
</tr>
<tr>
<td>12</td>
<td>D</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
</tr>
<tr>
<td>14</td>
<td>D</td>
</tr>
<tr>
<td>15</td>
<td>B</td>
</tr>
<tr>
<td>16</td>
<td>D</td>
</tr>
<tr>
<td>17</td>
<td>C</td>
</tr>
<tr>
<td>18</td>
<td>A</td>
</tr>
<tr>
<td>19</td>
<td>A</td>
</tr>
<tr>
<td>20</td>
<td>C</td>
</tr>
<tr>
<td>21</td>
<td>B</td>
</tr>
<tr>
<td>22</td>
<td>C</td>
</tr>
<tr>
<td>23</td>
<td>A</td>
</tr>
<tr>
<td>24</td>
<td>C</td>
</tr>
<tr>
<td>25</td>
<td>A</td>
</tr>
<tr>
<td>26</td>
<td>B</td>
</tr>
<tr>
<td>27</td>
<td>B</td>
</tr>
<tr>
<td>28</td>
<td>C</td>
</tr>
<tr>
<td>29</td>
<td>B</td>
</tr>
<tr>
<td>30</td>
<td>C</td>
</tr>
<tr>
<td>31</td>
<td>A</td>
</tr>
<tr>
<td>32</td>
<td>B</td>
</tr>
<tr>
<td>33</td>
<td>B</td>
</tr>
<tr>
<td>34</td>
<td>A</td>
</tr>
<tr>
<td>35</td>
<td>D</td>
</tr>
<tr>
<td>36</td>
<td>B</td>
</tr>
<tr>
<td>37</td>
<td>A</td>
</tr>
<tr>
<td>38</td>
<td>D</td>
</tr>
<tr>
<td>39</td>
<td>C</td>
</tr>
<tr>
<td>40</td>
<td>D</td>
</tr>
</tbody>
</table>
Name: _________________________ (            )
Class: ________________

CHIJ ST. NICHOLAS GIRLS’ SCHOOL
Secondary 4
Preliminary Examination (80 Marks)

CHEMISTRY (SPA) 5073

21 August 2017

1hour 45minutes

READ THESE INSTRUCTIONS FIRST

Write your name, register number, and class clearly in the spaces provided at the top of this page.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use highlighters, glue, and correction fluid or correction tape.

Section A
Answer all questions in the spaces provided.

Section B
Answer all three questions, the last question is in the form of either/or.
Answer all questions in the spaces provided.

A copy of Periodic Table is provided on page 2.
The number of marks is given in brackets [ ] at the end of each question or part question.
The use of a scientific calculator is expected, where appropriate.

<table>
<thead>
<tr>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A (50)</td>
</tr>
<tr>
<td>Section B (30)</td>
</tr>
<tr>
<td>Total (80)</td>
</tr>
</tbody>
</table>

This document consists of 22 printed pages.
The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group 0</th>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period 1</td>
<td>H</td>
<td>He</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
</tr>
<tr>
<td>Period 2</td>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Cl</td>
<td>Ar</td>
<td>K</td>
</tr>
<tr>
<td>Period 3</td>
<td>Ca</td>
<td>Sc</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
<td>Mn</td>
<td>Fe</td>
<td>Co</td>
<td>Ni</td>
</tr>
<tr>
<td>Period 4</td>
<td>Zn</td>
<td>Ga</td>
<td>Ge</td>
<td>As</td>
<td>Se</td>
<td>Br</td>
<td>Rb</td>
<td>Sr</td>
<td>Y</td>
</tr>
<tr>
<td>Period 5</td>
<td>Ba</td>
<td>La</td>
<td>Ce</td>
<td>Pr</td>
<td>Nd</td>
<td>Pm</td>
<td>Sm</td>
<td>Eu</td>
<td>Gd</td>
</tr>
</tbody>
</table>

**Key**
- g = relative atomic mass
- X = atomic symbol
- a = proton (atomic) number

**158-71 Lanthanoid series**

Need a home tutor? Visit smiletutor.sg
Section A

Answer all the questions in this section in the space provided.

The total mark for this section is 50.

A1 Using only the substances in the following list, answer the questions below. Each substance may be used once, more than once or not at all.

propanol    sodium iodide    methyl ethanoate
silicon dioxide    carbon monoxide    water
bromine    hydrogen peroxide    lead(II) sulfate

(a) Which substance is an insoluble compound that contains both ionic and covalent bonds? [1]

..........................................................................................................................................

(b) Which substances excluding water, when mixed together, can be separated by fractional distillation? [1]

..........................................................................................................................................

(c) Which substance can be separated from water by a separating funnel? [1]

..........................................................................................................................................

(d) Which substance is best obtained by simple distillation when mixed with potassium chloride? [1]

..........................................................................................................................................

(e) Which two substances can react to form a brown solution? [1]

.............................................................................................................................................
(f) Which substance is removed by limestone in the extraction of iron? Explain why this substance has a very high melting point in terms of bonding and structure.

A2 The relative atomic mass of magnesium can be determined in the laboratory by finding the volume of hydrogen given off when magnesium reacts with dilute hydrochloric acid.

0.0360 g of magnesium reacts at room temperature and pressure with excess dilute hydrochloric acid to produce 36 cm$^3$ of hydrogen.

(a) (i) Define the term relative atomic mass.

(ii) Write a balanced equation, including state symbols, for the reaction of magnesium and dilute hydrochloric acid.

(iii) Show, by calculation, that the relative atomic mass of magnesium is 24.0
(b) Magnesium reacts with oxygen in the air to form magnesium oxide. If the yield of the reaction is 75%, calculate the mass of magnesium oxide formed when 12 kg of magnesium burns in excess air.

(c) Another magnesium compound can also be formed when magnesium burns in air. One mole of this magnesium compound reacts with excess water to produce magnesium hydroxide and a colourless gas in the mole ratio 3:2. The gas turns damp red litmus paper blue.

(i) State the name of the gas evolved and suggest the chemical formula of the magnesium compound.

...................................................................................................................................................
.......................................................................................................................................................

(ii) Explain how this magnesium compound is formed when magnesium burns in air.

.......................................................................................................................................................

[Total: 10 marks]
Aluminium has a low density, high ductility, good corrosion resistance and good conductivity, which makes it suitable to be used as an electric conductor for transmission and distribution of electricity. Aluminium is also able to react with fluorine to form aluminium fluoride. The physical properties of aluminium fluoride and fluorine are shown in the table below.

<table>
<thead>
<tr>
<th></th>
<th>melting point / °C</th>
<th>conducts electricity in molten state</th>
</tr>
</thead>
<tbody>
<tr>
<td>aluminium fluoride</td>
<td>1290</td>
<td>Yes</td>
</tr>
<tr>
<td>fluorine</td>
<td>-220</td>
<td>No</td>
</tr>
</tbody>
</table>

(a) Explain, in terms of bonding and structure, why aluminium is often used in electrical transmission.

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

(b) In terms of kinetic particle theory, explain how the arrangement and movement of particles in fluorine change when the temperature increases from -240 °C to -200 °C.

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
(c) Draw a ‘dot-and-cross’ diagram to show the bonding in aluminium fluoride. You only need to show the outer shell electrons. [2]

(d) Explain, in terms of bonding and structure, the difference between the melting points of aluminium fluoride and fluorine. [3]

[Total: 10 marks]

A4 In chemical analysis, the identity of aqueous cations can be found by using aqueous ammonia.

A colourless sulfate solution with missing label is suspected to contain either aluminium or zinc ions.

(a) A student suggested that lead(II) ion is another possible cation in the salt solution. [1]

Do you agree with this student? Explain your answer.
(b) The student conducted an experiment to identify the cation:

**Step 1:**
Several salt solutions of the same volume and same concentration were prepared.

**Step 2:**
To each of the salt solutions, a known volume of aqueous ammonia was added and the mass of any resulting precipitate was measured.

The results of the experiment is shown in the graph below.

(i) State the formula of the cation present in the salt solution.  

(ii) Write an ionic equation, with state symbols, for the formation of precipitate when $x$ cm$^3$ of aqueous ammonia was added.

Need a home tutor? Visit smiletutor.sg
(iii) State your observations as 2x cm³ of aqueous ammonia was added drop-wise to the salt solution.

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

(c) A second experiment was conducted replacing aqueous ammonia with aqueous potassium carbonate.

Sketch a graph in the axes below to show the change in mass of precipitate when aqueous potassium carbonate was added drop-wise to the salt solution until no further change was observed.

Mass of precipitate / mg

Volume of aqueous potassium carbonate / cm³

[Total: 7 marks]
Propyne (C₃H₄), can undergo combustion according to the equation below:

\[ \text{C}_3\text{H}_4 + 4\text{O}_2 \rightarrow 3\text{CO}_2 + 2\text{H}_2\text{O} \]

A student carried out an experiment to determine the enthalpy change of combustion for one mole of gaseous propyne in the gas cylinder. A beaker of water was heated during the reaction and the initial and highest temperature reached were recorded. The gas cylinder containing propyne was also weighed before and after the experiment.

The following data was recorded by the student.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of propyne before combustion / g</td>
<td>4.60</td>
</tr>
<tr>
<td>Mass of propyne after combustion / g</td>
<td>2.16</td>
</tr>
<tr>
<td>Mass of water in beaker / g</td>
<td>750</td>
</tr>
<tr>
<td>Initial temperature of water / °C</td>
<td>28.0</td>
</tr>
<tr>
<td>Highest temperature of water / °C</td>
<td>48.5</td>
</tr>
</tbody>
</table>

(a) Given that 4.18 J of energy is needed to raise the temperature of 1 g of water by 1 °C, calculate the heat absorbed by the water.
(b) Calculate the number of moles of propyne burnt in this experiment. [1]

(c) Using your answers in (a) and (b), calculate the enthalpy change of combustion for propyne in kJ/mol. [1]

(d) The expected enthalpy change of combustion for propyne is -1850 kJ/mol. [1]
   Suggest a reason for the difference between this expected value and the value calculated in (c).

……………………………………………………………………………………………………
……………………………………………………………………………………………………

(e) Sketch the energy level diagram of the combustion of propyne. [3]

[Total: 8 marks]
A6 Thallium is a metal in Group III of the Periodic Table. It has oxidation states of +1 and +3.

(a) Thallium(I) chloride is a white solid which is insoluble in water. It can be prepared using thallium(I) sulfate solution.

Describe how you would obtain a pure dry sample of thallium(I) chloride from thallium(I) sulfate solution.

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

(b) Thallium(I) hydroxide is an alkali. It has similar properties as aqueous sodium hydroxide.

Aqueous thallium(I) hydroxide was added in excess to a sample of aqueous iron(II) sulfate and left to stand.

(i) Describe your observations for this chemical reaction.

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

(ii) Explain your observations in b(i).

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

[Total: 7 marks]
Section B
Answer all three questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 The Pollutant Standards Index (PSI) is an air quality indicator. It is based on five pollutants: particulate matter (PM10), sulfur dioxide, carbon monoxide, ozone and nitrogen dioxide.

This table below gives some information about the overall PSI and the corresponding concentrations for each of the five pollutants.

<table>
<thead>
<tr>
<th>i</th>
<th>PSI value ($P_i$)</th>
<th>Concentration ($C_i$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PM10 (µg/m³)</td>
<td>SO₂ (µg/m³)</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>200</td>
<td>350</td>
</tr>
<tr>
<td>4</td>
<td>300</td>
<td>420</td>
</tr>
<tr>
<td>5</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>6</td>
<td>500</td>
<td>600</td>
</tr>
</tbody>
</table>

Table 1: Overall PSI and the corresponding concentrations for each of the five pollutants.

\[ 1 \mu g = 1 \times 10^{-6} g; 1 \text{mg} = 1 \times 10^{-3} g \]

To calculate the overall PSI, the PSI value is first calculated for each of the five pollutants. The overall PSI is the maximum value out of the 5 calculated PSI pollutant values.

Given the concentration of a pollutant (with units stated as above), the PSI of pollutant can be calculated as follows:

\[
\text{PSI of Pollutant} = \left( \frac{(P_{i+1} - P_i)}{(C_{i+1} - C_i)} \times (\text{concentration of pollutant} - C_i) \right) + 100
\]

where $C_{i+1} > \text{concentration of pollutant} > C_i$
In Singapore, the 24-hour PSI is used by the National Environment Agency (NEA) to provide health advisory to different groups of people. This can be summarised as shown in the table:

<table>
<thead>
<tr>
<th>24-hr PSI</th>
<th>Healthy Persons</th>
<th>Elderly, Pregnant women, Children</th>
<th>Persons with chronic lung disease, heart disease, stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100</td>
<td>Normal activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101 - 200</td>
<td>Reduced prolonged or strenuous outdoor physical exertion.</td>
<td>Reduced prolonged or strenuous outdoor physical exertion.</td>
<td>Avoid prolonged or strenuous outdoor physical exertion.</td>
</tr>
<tr>
<td>201 - 300</td>
<td>Minimise prolonged or strenuous outdoor physical exertion.</td>
<td>Minimise all outdoor activities.</td>
<td>Avoid outdoor activities.</td>
</tr>
<tr>
<td>&gt; 301</td>
<td>Minimise all outdoor activities</td>
<td>Avoid outdoor activities.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Health advisory based on 24-hour PSI.

Sources:
Table 2: [http://www.haze.gov.sg/](http://www.haze.gov.sg/)

(a) (i) Explain why, when the 24-hour PSI exceeds 301, NEA would advise people to avoid outdoor activities.
(ii) Unlike nitrogen dioxide, sulfur dioxide is present in air even at PSI less than 100. Suggest a source for the production of sulfur dioxide.

(iii) Describe a simple chemical test to show that sulfur dioxide is present in a sample of air. State all your observations.

(iv) Desulfurisation can reduce the concentration of sulfur dioxide in air. Write two chemical equations to show the reactions that occur in the desulfurisation process.

(b) (i) Given that in a 1 m$^3$ sample of air, the PSI value of PM10, sulfur dioxide, carbon monoxide, ozone and nitrogen dioxide are 100, 150, 190, 112 and 133 respectively. Determine the overall PSI and explain your answer.

(ii) Assuming that the current PSI is according to your answer in (b)(i), what advice would you give to a 8 year old who wants to play at the outdoor playground?

[Total: 10 marks]
B8 Hydroxypropanoic acid, also known as lactic acid, can be produced through anaerobic metabolism. It has the following structure:

(a) Draw the full structural formula of an isomer of hydroxypropanoic acid which will react with aqueous sodium hydroxide. [1]

(b) Describe a chemical test to show the similar chemical property shown by both hydroxypropanoic acid and propanoic acid. [2]

(c) Describe a chemical test to show the difference in chemical property shown by both hydroxypropanoic acid and propanoic acid. [2]
(d) PLA, or poly(lactic acid), is a biodegradable plastic that is used in medical implants and decomposable packaging materials.

(i) Name the reaction that produces this plastic from hydroxypropanoic acid. [1]

(ii) Draw 3 repeating units of PLA. [2]

(iii) What is the name of the group that links the monomers together in PLA? [1]

(e) Explain if the percentage mass of carbon changes when lactic acid forms PLA. [1]

[Total: 10 marks]
EITHER

B9 An application of electrolysis is in electroplating, which is a process of depositing a thin layer of metal over another metal with the help of electric current.

(a) Draw a well labelled diagram, including all the chemical reagents used, to show how copper can be plated on a steel spoon.

(b) Explain how galvanising prevents the rusting of the steel spoon.

(c) Besides electroplating, electrolysis can also be used to extract metals from its ore. One example would be the extraction of aluminium from bauxite. The diagram below shows an electrolysis tank used industrially to produce aluminium from aluminium oxide.

(i) Write the ionic equation for the reaction at the anode.
(ii) Hence, explain why the graphite anodes need to be replaced regularly. [1]

............................................................................................................................
............................................................................................................................

(iii) Construct a balanced overall chemical equation for the decomposition of aluminium oxide. [1]

............................................................................................................................
............................................................................................................................

(iv) Hence, calculate the mass of aluminium obtained if 1020 g of electrolyte is being electrolysed. [1]

(d) In another experiment, rubidium chloride was electrolysed using inert electrodes. Write the ionic equation for the reaction occurring at the anode if

(i) dilute rubidium chloride solution was electrolysed, [1]

............................................................................................................................

(ii) molten rubidium chloride solution was electrolysed. [1]

............................................................................................................................

[Total: 10 marks]
B9 The table below shows the displayed formulae of organic compounds from three homologous series: alkenes, cycloalkanes and cycloalkenes.

<table>
<thead>
<tr>
<th>homologous series</th>
<th>name</th>
<th>displayed formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>alkenes</td>
<td>butene</td>
<td><img src="image" alt="butene" /></td>
</tr>
<tr>
<td>cycloalkanes</td>
<td>cyclobutane</td>
<td><img src="image" alt="cyclobutane" /></td>
</tr>
<tr>
<td>cycloalkenes</td>
<td>cyclobutene</td>
<td><img src="image" alt="cyclobutene" /></td>
</tr>
</tbody>
</table>

(a) Suggest a test that can be used to distinguish between cyclobutane and cyclobutene.
(b) Butene is one of the components found in petroleum gas which is commonly used as fuel for heating and cooking. There is a large demand for petroleum gas and cracking ensures that the supply meets demand.

Explain how cracking helps to meet the demand for petroleum gas.

(c) Butene and cyclobutene can undergo an addition reaction to produce alcohols.

(i) State the conditions for this addition reaction.

(ii) Draw the structural formulae of all the possible products of the addition reaction.

(iii) Using a product from (c)(ii), draw the structure of the compound formed when it reacts with propanoic acid.
(d) Butene and cyclobutene can undergo combustion according to the equations: [1]

\[
\begin{align*}
\text{C}_4\text{H}_8 + 6\text{O}_2 & \rightarrow 4\text{CO}_2 + 4\text{H}_2\text{O} \\
2\text{C}_4\text{H}_6 + 11\text{O}_2 & \rightarrow 8\text{CO}_2 + 6\text{H}_2\text{O}
\end{align*}
\]

Using the equations, explain which compound will burn with a more smoky flame.

[Total: 10 marks]
A1(a) Lead(II) sulfate

(b) Propanol, methyl ethanoate
    Bromine, Methyl Ethanoate
    Bromine, Propanol

(c) Methyl ethanoate

(d) Water

(e) Bromine and sodium iodide
    Hydrogen peroxide and sodium iodide

(f) Silicon dioxide
    It has a giant molecular structure / giant covalent structure/compound
    Si and O atoms are bonded by strong covalent bonds in a vast/giant network.
    A lot of energy is required to overcome the strong covalent bonds hence boiling point is very high.

A2(a) (i) Average mass of one atom of the element compared with 1/12 of the mass of a carbon-12 atom.

(ii) \( \text{Mg} (s) + 2\text{HCl} (aq) \rightarrow \text{MgCl}_2 (aq) + \text{H}_2 (g) \)

(iii) No of moles of \( \text{H}_2 = \frac{36}{1000} \div 24 = 0.0015 \text{ mol} \)
    No of moles of Mg = 0.0015 mol
    Relative atomic mass of Mg = \( 0.0360 + 0.0015 = 24.0 \) [shown]
(b) \[2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}\]

No of moles of magnesium burnt: \(12000 \div 24 = 500\) mol

No of theoretical moles of magnesium oxide formed = 500 mol

Actual mass of magnesium oxide formed = \(0.75 \times [500 \times (24 + 16)] = 15000\) g

(c) (i) Ammonia gas

\[\text{X} + 6\text{H}_2\text{O} \rightarrow 3\text{Mg(OH)}_2 + 2\text{NH}_3\]

Hence, the compound is \(\text{Mg}_3\text{N}_2\)

(ii) Magnesium reacts with nitrogen present in the air.

A3 aluminium has a giant metallic structure.

(a) The metallic cations are surrounded by a sea of delocalised electrons that are free / mobile to conduct electricity.

(b) At -240 °C, the fluorine molecules are closely and orderly/regularly arranged vibrating about their fixed position. As temperature increases, the molecules gain kinetic energy which causes them to vibrate faster.

At -220 °C, the fluorine molecules are able to overcome the forces of attraction to move out of their fixed position, to slide and roll over each other in a disorderly/random manner but closely arranged.

(c) ![Diagram](image)
(d) Aluminium fluoride has a giant ionic structure. Strong electrostatic forces of attraction/strong ionic bonds between oppositely charged ions. A lot of energy required to overcome the strong electrostatic forces of attraction. Fluorine has a simple covalent / molecular structure. Weak intermolecular forces of attraction / VDW between discrete molecules. Little amount of energy required to overcome the weak IMF / VDW. Aluminium fluoride has high mp while fluorine has low mp.

A4 Disagree. (a) Lead(II) sulfate is insoluble / is a precipitate but this is a solution.

(b) (i) \(Zn^{2+}\)

(ii) \(Zn^{2+} (aq) + 2OH^- (aq) \rightarrow Zn(OH)_2 (s)\)

(iii) A white precipitate is formed. dissolves in excess aqueous ammonia to form a colourless solution.

(c) Mass of precipitate / mg

| Volume of aqueous potassium carbonate / cm³ |

Need a home tutor? Visit smiletutor.sg
A5

(a) Temperature change = 48.5 - 28.0 = 20.5
Heat absorbed = 4.18 x 750 x (20.5)
= 64267.5 J
= 64.3 KJ

(b) Mass of propyne burnt = 4.60 – 2.16 = 2.44 g
No of moles of propyne burnt = 2.44 ÷ 40 = 0.0610 mol

(c) Enthalpy change = 64.3 ÷ 0.0610 = - 1054 kJ/mol

(d) Heat is lost to the surrounding (0.5m), hence the heat released is lower than expected (0.5m).

(e) [Diagram showing energy levels and reaction: \( \text{C}_3\text{H}_4 + 4\text{O}_2 \rightarrow 3\text{CO}_2 + 2\text{H}_2\text{O} \), \( \Delta H = -1850 \text{ KJ/mol} \)]
A6

(a) Add aqueous sodium chloride (or any identified Group I chloride / ammonium chloride or hydrochloric acid) to thallium(I) sulfate solution to obtain a white precipitate of thallium(I) chloride.

Filter the mixture to obtain the residue thallium(I) chloride.

Wash the residue with plenty of distilled water.

Dry the residue in between sheets of filter paper.

(b) (i) Dirty green precipitate formed which is insoluble in excess thallium(I) hydroxide.

Upon standing, dirty green precipitate turns reddish brown.

(ii) Fe(OH)$_2$ an insoluble base is formed as the dirty green precipitate

Fe(OH)$_2$ will oxidised (0.5m) upon standing to form Fe(OH)$_3$.

Section B

B7 (a) (i) Higher concentration of SO$_2$, CO and NO$_2$

NO$_2$ and SO$_2$ will cause respiratory problems

CO will combine with haemoglobin in red blood cells to form a very stable compound, carboxyhaemoglobin and it reduces the red blood cells’ ability to transport oxygen around the body, eventually leading to death

(ii) Combustion/burning of fossil fuels/coal in power stations / factories

Volcanic activities

(iii) Bubble gas through acidified aqueous potassium manganate (VII) / filter paper with acidified aqueous potassium manganate (VII)

Purple acidified aqueous potassium manganate (VII) turns colourless / decolourises
(iv) \[ \text{SO}_2 + \text{CaCO}_3 \rightarrow \text{CaSO}_3 + \text{CO}_2 \]
2\[ \text{CaSO}_3 + \text{O}_2 \rightarrow 2\text{CaSO}_4 \]

OR

\[ \text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3 \]

\[ \text{H}_2\text{SO}_3 + \text{CaCO}_3 \rightarrow \text{CaSO}_3 + \text{H}_2\text{O} + \text{CO}_2 \]

OR

\[ \text{SO}_2 + \text{H}_2\text{O} + \text{O}_2 \rightarrow \text{H}_2\text{SO}_4 \]

\[ \text{H}_2\text{SO}_4 + \text{CaCO}_3 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2 \]

(b) (i) Since the overall PSI is the maximum value out of the 5 calculated PSI pollutant values, the overall PSI is **190**.

(ii) Advise the child to reduce playing outdoor for too long.

B8

(a)

(b) Add Zn (other metals not accepted) to an aqueous solution of the acids. Both reactions will produce effervescence of a colourless and odourless gas that will extinguish a lighted splint with a pop sound.

OR

Add aqueous sodium carbonate (or any identified aqueous carbonate) to the acids. Both reactions will produce effervescence of a colourless and odourless gas which will produce a white precipitate in limewater.
(c) Add **aqueous acidified potassium manganate (VII)** to both solutions and **warm**. 
Hydroxypropanoic acid will **decolourise purple potassium manganate (VII)** solution while there will be **no visible change** when added to propanoic acid.

(d) **(i)** Condensation polymerisation

**(ii)**

![Diagram](image)

**(iii)** ester

(e) The percentage mass of C will not be the same.

There is **loss of water / loss of H and O atoms** during the polymerisation process, resulting in a decrease in the number of O and H atoms.

**EITHER**

**B9**

(a) Diagram of electrolysis set up with copper as the anode, spoon as the cathode immersed in electrolyte

Identified electrolyte (e.g. aq CuSO₄ / Cu(NO₃)₂)

(b) **Zinc is more reactive than iron**

Zinc loses electrons more easily than iron.

Zinc **corrodes in place of iron**.

(c) **(i)** \(2O^{2-} \rightarrow O_2 + 4e\)

**(ii)** The graphite anodes will **react with oxygen produced / oxidised** under high temperature to from oxides of carbon.

**(iii)** \(2Al_2O_3 \rightarrow 4Al + 3O_2\)
(iv) no. of moles of $\text{Al}_2\text{O}_3 = 1020 \div 102 = 10 \text{ mol}$

no. of moles of $\text{Al} = 20 \text{ mol}$

mass of $\text{Al} = 20 \times 27 = 540 \text{ g}$

(d) (i) dilute rubidium chloride solution was electrolysed.

$$4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^-$$

(ii) Molten rubidium chloride was electrolysed.

$$2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$$

OR

B9 Aqueous bromine / bromine water

(a) Reddish brown aqueous bromine will **decolourise spontaneously** when added to cyclobutene.

Remain reddish brown / no visible change in cyclobutane.

(b) Large alkanes are low in demand

Cracking of large chain alkanes results in **smaller alkanes / short chained alkanes** [0.5m] which are **higher in demand**.

This helps to match the higher demand and **lower supply** for smaller chained alkanes.

(c) (i) Phosphoric(V) acid, $350^\circ\text{C}$, 65 atm

(ii) Draw all the possible products of the addition reaction mentioned in (c)(i). [3]
(iii) Using a product from (c)(ii), draw the structure of the product formed when it reacts with propanoic acid.

![Chemical structures](image)

(d) Butene requires more moles of oxygen (6 moles) than cyclobutene (5.5 moles) for complete combustion, so it will have a higher tendency to burn incompletely and produce soot, thus butene will burn with a smokier flame than butene.
READ THESE INSTRUCTIONS FIRST

Do not open the booklet until you are told to do so.

Write your name, index number and class on the Optical Answer Sheet.
Write in soft pencil.
Do not use staples, paper clips, highlighters, and glue or correction fluid.

You are not required to hand in this booklet at the end of the examination.

There are forty questions on this paper. Answer all questions. For each question there are four possible answers A, B, C and D.
Choose the one you consider correct and record your choice in soft pencil on the separate answer sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done on this booklet.

A copy of the Periodic Table is printed on page 21.
1. Gas A is very soluble in water whereas gas B is only slightly soluble in water. Which diagram shows the correct method to obtain dry gas B from a mixture of damp gases A and B?

![Diagram A]

![Diagram B]

![Diagram C]

![Diagram D]

2. A solid sample of a compound was washed and dried. A first melting point determination of the resulting sample gave a value of 197°C. The sample was then washed and dried again. The melting point was found to be 220°C this time.

Which statement best explains the above observation?

A. A lower mass of the sample was used during the first melting point determination.

B. The sample contained less impurities during the first melting point.

C. The sample was not dried properly after the second rinsing, resulting in more impurities present.

D. More impurities were removed during the second rinsing, before the second melting point determination was carried out.
3. Paper chromatography was used to separate the pigments in purple ink. A chromatogram was obtained after 15 minutes as is shown opposite.

Which one of the diagrams below is most likely to indicate the appearance of the chromatogram after a further 15 minutes?

A

B

C

D

4. The rate of diffusion of gas X (Mr : 17) and gas Y (Mr : 28) was compared at 25°C and 50°C.

Which would have the highest rate of diffusion?

A  gas X at 25°C
B  gas X at 50°C
C  gas Y at 25°C
D  gas Y at 50°C
5. The table below shows the melting and boiling points of substances W to Z.

<table>
<thead>
<tr>
<th>substance</th>
<th>melting point /°C</th>
<th>boiling point /°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>-120</td>
<td>-15</td>
</tr>
<tr>
<td>X</td>
<td>-4</td>
<td>42</td>
</tr>
<tr>
<td>Y</td>
<td>40</td>
<td>229</td>
</tr>
<tr>
<td>Z</td>
<td>413</td>
<td>899</td>
</tr>
</tbody>
</table>

Which of the following statements are true?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>X is a volatile liquid.</td>
</tr>
<tr>
<td>II.</td>
<td>Particles of Y and Z vibrate in fixed positions at room temperature</td>
</tr>
<tr>
<td>III.</td>
<td>Two of the above substances undergo a change in state when heated from room temperature to 80°C.</td>
</tr>
</tbody>
</table>

A  I and II only  
B  I and III only  
C  II and III only  
D  All of the above  

6. Which of the following options contains diatomic molecules only?

A  Ammonia, carbon dioxide, water  
B  Carbon monoxide, hydrogen, iodine  
C  Methane, nitrogen, water  
D  Ozone, phosphorus, sulfur
7. The boiling points of some gases present in air are given in the table below.

<table>
<thead>
<tr>
<th>Gas</th>
<th>nitrogen</th>
<th>oxygen</th>
<th>argon</th>
<th>xenon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling point/°C</td>
<td>-196</td>
<td>-182</td>
<td>-186</td>
<td>-108</td>
</tr>
</tbody>
</table>

A mixture containing liquefied air at -200 °C is fractionally distilled.

Which one of the following would still remain as a liquid when the temperature is increased by 15 °C?

A nitrogen and argon
B oxygen and xenon
C oxygen and argon
D argon, oxygen and xenon

8. At room temperature, tin exists as white tin. Below 18 °C, tin changes slowly to grey tin. The diagrams below show the structures of both types of tin.

![White tin diagram](image1)

![Grey tin diagram](image2)

Which one of the following best describes the two types of tin?

I. White tin is hard while grey tin is soft.
II. White tin is soft and malleable but grey tin is hard.
III. Both types of tin are insoluble in organic solvents and water.
IV. White tin can acts as a lubricant.

A I and II only
B I and III only
C II and III only
D II and IV only
9. The structural formula of a substance is shown below.

```
Z — W ≡ W — W — X — W — Z
```

To which group of the Periodic Table do elements W, X, Y and Z belong to?

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Group III</td>
<td>Group V</td>
<td>Group VI</td>
<td>Group I</td>
</tr>
<tr>
<td>B</td>
<td>Group V</td>
<td>Group VI</td>
<td>Group IV</td>
<td>Group VII</td>
</tr>
<tr>
<td>C</td>
<td>Group III</td>
<td>Group V</td>
<td>Group II</td>
<td>Group I</td>
</tr>
<tr>
<td>D</td>
<td>Group IV</td>
<td>Group V</td>
<td>Group VI</td>
<td>Group VII</td>
</tr>
</tbody>
</table>

10. Buckminsterfullerene has the chemical formula C_{60}.

Which of the following best describes buckminsterfullerene?

<table>
<thead>
<tr>
<th>Structure</th>
<th>Ability to conduct electricity</th>
<th>Used as a lubricant</th>
</tr>
</thead>
<tbody>
<tr>
<td>A        a covalent compound</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>B        an ionic compound</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>C        simple discrete molecule</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>D        macromolecule</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
11. The chemical equation for the complete combustion of methane is

\[ \text{CH}_4 (g) + 2\text{O}_2 (g) \rightarrow \text{CO}_2 (g) + 2\text{H}_2\text{O} \ (g) \]

25 cm\(^3\) of methane gas is mixed with 20 cm\(^3\) of oxygen gas in a sealed vessel and burnt.

What is the volume of the final mixture?

A. 40 cm\(^3\)
B. 45 cm\(^3\)
C. 50 cm\(^3\)
D. 80 cm\(^3\)

12. The equation for the reduction of iron ore in the blast furnace is:

\[ \text{Fe}_2\text{O}_3(s) + 3\text{CO}(g) \rightarrow 2\text{Fe}(l) + 3\text{CO}_2(g) \]

When 80 tonnes of the iron ore were reduced, 28 tonnes of molten iron were produced.

What is the percentage purity of the iron ore?

A. 25%
B. 35%
C. 50%
D. 75%

13. Different volumes of 2.0 mol/dm\(^3\) potassium hydroxide solution and 2.0 mol/dm\(^3\) sulfuric acid are mixed in a polystyrene cup.

In which combination would the temperature rise be the greatest?

<table>
<thead>
<tr>
<th>volume of KOH (aq) / cm(^3)</th>
<th>volume of H(_2)SO(_4) (aq) / cm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 20.0</td>
<td>40.0</td>
</tr>
<tr>
<td>B 30.0</td>
<td>30.0</td>
</tr>
<tr>
<td>C 40.0</td>
<td>20.0</td>
</tr>
<tr>
<td>D 45.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>
14. 216 g of silver is deposited when an electric current is passed through a solution of silver nitrate.

What is the mass of magnesium formed when the same current is passed through molten magnesium chloride?

A  24 g  
B  48 g  
C  72 g  
D  96 g  

15. The apparatus shown below is used to investigate the electrolysis of concentrated hydrochloric acid. Two different gases are obtained and collected at syringes M and N.

Which statement is true about the above electrolysis?

A  Copper is used as both electrodes.  
B  The gas collected in syringe M is highly soluble in water.  
C  The gas collected in syringe N will turn moist blue litmus red, then bleaches it.  
D  pH of the electrolyte decreases after the electrolysis has been carried out for some time.
16. Three cells were set up as shown in the diagram. The arrows show the direction of electron flow in the external circuit.

Which of the following correctly shows the direction of electron flow and numerical value on voltmeter in set-up 3?

- **A** from metal Z to Y, smaller than V1 reading
- **B** from metal Z to Y, between V1 and V2 readings
- **C** from metal Z to Y, greater than V2 reading
- **D** from metal Z to Y, greater than V1 and V2 readings

17. The table below compares the strengths of the bonds for reaction of the type shown below.

\[ R_2 + Q_2 \rightarrow 2RQ \]

Which reaction is the most endothermic?

<table>
<thead>
<tr>
<th></th>
<th>Bonds in ( R_2 )</th>
<th>Bonds in ( Q_2 )</th>
<th>Bonds in ( RQ )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>strong</td>
<td>strong</td>
<td>strong</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>strong</td>
<td>strong</td>
<td>weak</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>weak</td>
<td>weak</td>
<td>strong</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>weak</td>
<td>weak</td>
<td>weak</td>
</tr>
</tbody>
</table>
18. Which of the following reactions are exothermic?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>$\text{CuSO}_4 + 5\text{H}_2\text{O} \rightarrow \text{CuSO}_4\cdot 5\text{H}_2\text{O}$</td>
</tr>
<tr>
<td>II.</td>
<td>$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_12\text{O}_6$</td>
</tr>
<tr>
<td>III.</td>
<td>$\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$</td>
</tr>
<tr>
<td>IV.</td>
<td>$\text{Cl}_2 \rightarrow 2\text{Cl}$</td>
</tr>
</tbody>
</table>

A  I and II only  
B  I and III only  
C  II and IV only  
D  III and IV only  

19. What change will decrease the speed of the following reaction?

$$\text{CH}_4(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{CH}_3\text{Cl}(\text{g}) + \text{HCl}(\text{g})$$

A  increasing the amount of chlorine used  
B  using a larger reaction vessel  
C  increasing the temperature  
D  increasing the intensity of sunlight
20. Group I metals tarnish in air to form different types of oxides as shown in the table below.

<table>
<thead>
<tr>
<th>Element</th>
<th>Oxides formed</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>lithium</td>
<td>Lithium oxide</td>
<td>Li₂O</td>
</tr>
<tr>
<td>sodium</td>
<td>sodium oxide</td>
<td>Na₂O</td>
</tr>
<tr>
<td></td>
<td>sodium peroxide</td>
<td>Na₂O₂</td>
</tr>
<tr>
<td>potassium</td>
<td>potassium superoxide</td>
<td>KO₂</td>
</tr>
</tbody>
</table>

Which of the following shows the correct oxidation states of the metal and oxygen in each metal oxide?

<table>
<thead>
<tr>
<th>Sodium oxide, Na₂O</th>
<th>Sodium peroxide, Na₂O₂</th>
<th>Potassium superoxide, KO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>formula of oxide</td>
<td>oxidation state of oxygen</td>
<td>formula of oxide</td>
</tr>
<tr>
<td>A O⁻</td>
<td>-1</td>
<td>O⁻</td>
</tr>
<tr>
<td>B O²⁻</td>
<td>-2</td>
<td>O²⁻</td>
</tr>
<tr>
<td>C O²⁻</td>
<td>-2</td>
<td>O₂²⁻</td>
</tr>
<tr>
<td>D O³⁻</td>
<td>-2</td>
<td>O₂²⁻</td>
</tr>
</tbody>
</table>

21. Which substance will dissolve in water to produce H⁺ ions?

A Calcium oxide
B Carbon monoxide
C Lead(II) oxide
D Nitrogen dioxide

22. Which reactants could be used safely to prepare sodium chloride?

A Sodium and potassium chloride.
B Sodium and dilute hydrochloric acid.
C Aqueous sodium nitrate and dilute hydrochloric acid.
D Aqueous sodium carbonate and dilute hydrochloric acid.
23. Which of the following statements about the Haber process is incorrect?
   A. The pressure in the reaction chamber is increased to speed up the reaction.
   B. At the optimum conditions, the yield of ammonia is 100%.
   C. Nitrogen is obtained as a raw material from the fractional distillation of liquid air.
   D. Higher pressure produces a higher percentage yield of ammonia.

24. Which of the following are true of the Haber process?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Ammonia formed is condensed and obtained as a liquid.</td>
</tr>
<tr>
<td>II.</td>
<td>Hydrogen is obtained from the cracking of some fractions of crude oil.</td>
</tr>
<tr>
<td>III.</td>
<td>Nitrogen is oxidized to form ammonia</td>
</tr>
<tr>
<td>IV.</td>
<td>Nitrogen and hydrogen react in the volume ratio of 3:1</td>
</tr>
</tbody>
</table>

A. I and II only
B. I and III only
C. II and IV only
D. III and IV only

25. The graph below shows a trend across the elements in Period 2.

![Graph showing a trend across elements in Period 2]

Which of the following represents this trend?

<table>
<thead>
<tr>
<th></th>
<th>horizontal axis</th>
<th>vertical axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>atomic mass</td>
<td>boiling point</td>
</tr>
<tr>
<td>B</td>
<td>atomic mass</td>
<td>solubility in water</td>
</tr>
<tr>
<td>C</td>
<td>number of valence electrons</td>
<td>atomic size</td>
</tr>
<tr>
<td>D</td>
<td>proton number</td>
<td>melting point</td>
</tr>
</tbody>
</table>
26. Which of the following is not true?

A. E is a metal and F is a non-metal. E and F can be in the same group.

B. W reacts with hydrogen to form a compound with the formula \( \text{H}_2\text{W} \). W can be in group VI.

C. T and U are two consecutive elements in the Periodic Table. U has a greater atomic number. The relative atomic mass of U must be higher than that of T.

D. I and J are in the same period. I and J can have the same valency.

27. Which one of the following correctly describes the trend down group VII?

\begin{itemize}
  \item [A.] colour intensity
  \item [B.] oxidising power
  \item [C.] density
  \item [D.] strength of intermolecular force of attraction
\end{itemize}

28. Which one of the following statements about the elements lithium, rubidium and caesium is correct?

A. They are in the same period of the Periodic Table.

B. They react with cold water to form oxides and hydrogen.

C. When exposed to air, they react to form a grey oxide which is insoluble in water.

D. Rubidium has a higher melting point than caesium.
29. Metals can be protected against corrosion by sacrificial protection. In the diagram shown below, metal X is being protected from corrosion by metal Y.

![Diagram of metal Y protecting metal X]

What are the possible identities of metal X and Metal Y?

<table>
<thead>
<tr>
<th>A</th>
<th>Metal X</th>
<th>Metal Y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aluminum</td>
<td>Iron</td>
</tr>
<tr>
<td>B</td>
<td>Copper</td>
<td>Silver</td>
</tr>
<tr>
<td>C</td>
<td>Iron</td>
<td>Copper</td>
</tr>
<tr>
<td>D</td>
<td>Zinc</td>
<td>Magnesium</td>
</tr>
</tbody>
</table>

30. Four metals W, X, Y and Z and their compounds behaved as described.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Only X, Y and Z reacted with dilute hydrochloric acid.</td>
</tr>
<tr>
<td>II.</td>
<td>The oxides of W, X and Y were reduced to the metal when heated with carbon powder. The oxide of Z did not react.</td>
</tr>
<tr>
<td>III.</td>
<td>A displacement reaction occurred when X was added to an aqueous solution of the nitrate of Y.</td>
</tr>
</tbody>
</table>

Arrange the metals in ascending order based on their ease of undergoing oxidation.

<table>
<thead>
<tr>
<th>A</th>
<th>W, X, Y, Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>W, Y, X, Z</td>
</tr>
<tr>
<td>C</td>
<td>Z, X, Y, W</td>
</tr>
<tr>
<td>D</td>
<td>Z, Y, X, W</td>
</tr>
</tbody>
</table>
31. The diagram shows the apparatus for measuring the volume of hydrogen given off when excess dilute hydrochloric acid is added to powdered metal. The volume of gas is measured at room temperature and pressure.

The experiment is carried out three times, using different metal powders of the same mass based on the table below.

| Reaction 1 | 5.0 g of Magnesium |
| Reaction 2 | 5.0 g of Zinc |
| Reaction 3 | 5.0 g of Zinc and 5.0 g Magnesium |

Which reaction will there be fastest rate of hydrogen production and the greatest volume of hydrogen produced?

<table>
<thead>
<tr>
<th>fastest rate of hydrogen production</th>
<th>greatest volume of hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Reaction 1</td>
</tr>
<tr>
<td>B</td>
<td>Reaction 2</td>
</tr>
<tr>
<td>C</td>
<td>Reaction 1</td>
</tr>
<tr>
<td>D</td>
<td>Reaction 3</td>
</tr>
</tbody>
</table>
32. The set-up of an experiment is shown below. At room temperature, the system initially contains 80 cm\(^3\) of nitrogen, 60 cm\(^3\) of oxygen and 20 cm\(^3\) of argon.

The plungers of the gas syringes are moved to and fro until there is no further change in the system. The system is then allowed to cool to room temperature.

Which of the following statements concerning the experiment are correct?

1. A black solid would be formed in the glass tube.
2. The total volume of the gases in the system would decrease by 60 cm\(^3\).
3. The same change in total volume of gases would be observed if excess copper is replaced with excess zinc powder.

A 1 and 2
B 1 and 3
C 2 and 3
D 1, 2 and 3

33. Which one of the following is not responsible for the destruction of the ozone layer in the stratosphere?

A chlorine atoms
B fluorine atoms
C CFCs
D UV light

34. Which of the following cannot be removed from the exhaust of a petrol powered car by its catalytic converter?

A carbon monoxide
B hydrocarbons
C oxides of nitrogen
D carbon dioxide
35. Which of the following can be used to reduce atmospheric pollution by gases released from the factories which burn fossil fuels?

A ammonium carbonate and ammonium sulfate
B ammonium sulfate and calcium carbonate
C ammonium sulfate and calcium oxide
D calcium carbonate and calcium oxide

36. The diagram below shows two fractions, P and Q, obtained from the fractional distillation of crude oil.

What is the difference between fractions P and Q?

A Fraction P is darker than fraction Q.
B Fraction P is less viscous than fraction Q.
C Fraction P burns less readily than fraction Q.
D Fraction P has a higher boiling point than fraction Q.
37. The table below shows some of the members in the homologous series called alkanals.

<table>
<thead>
<tr>
<th>Name</th>
<th>Chemical formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanal</td>
<td>CH₃CHO</td>
</tr>
<tr>
<td>Butanal</td>
<td>CH₃CH₂CH₂CHO</td>
</tr>
<tr>
<td>Hexanal</td>
<td>CH₃CH₂CH₂CH₂CH₂CHO</td>
</tr>
</tbody>
</table>

What is the general formula for alkanals?
A  CₙH₂n+1COOH  
B  CₙH₂nCHO       
C  CₙH₂n+1CHO      
D  Cₙ₋₁H₂n₊₂CHO    

38. The structural formula of butenedioic acid is shown.

Which statement about butenedioic acid is not correct?
A  It decolourises aqueous bromine.  
B  Its solution reacts with sodium carbonate.  
C  It decolourises cold acidified potassium manganate(VII).  
D  It forms an addition polymer.  

39. The structure below shows a section of a polymer.

Which of the following monomers was used to make the polymer?

A

\[
\begin{align*}
\text{H} & \quad \text{COOH} \\
\text{CH}_3 & \quad \text{H}
\end{align*}
\]

B

\[
\begin{align*}
\text{H} & \quad \text{COOH} \\
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{CH}_3
\end{align*}
\]

C

\[
\begin{align*}
\text{H} & \quad \text{COOH} \\
\text{CH}_3 & \quad \text{H}
\end{align*}
\]

D

\[
\begin{align*}
\text{H} & \quad \text{COOCH}_3 \\
\text{CH}_3 & \quad \text{H}
\end{align*}
\]

40. In the polymerisation of butene to poly(butene), which variable remains unchanged?

A density

B boiling point

C molecular formula

D percentage composition of elements by mass

END OF PAPER 1
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>A</td>
<td>B</td>
<td>D</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>D</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>B</td>
</tr>
<tr>
<td>B</td>
<td>D</td>
<td>D</td>
<td>B</td>
<td>D</td>
<td>D</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>
TEMASEK SECONDARY SCHOOL
Preliminary Examination 2017
Secondary 4 Express

CHEMISTRY

Paper 2 (Section A)

Total duration for Sections A and B:
1 hour 45 minutes

Question and Answer Booklet

READ THESE INSTRUCTIONS FIRST

Do not open the booklet until you are told to do so.

You are required to submit this booklet at the end of the paper.

Write your name, index number and class in all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.

Section A
Answer all questions in the spaces provided on the question paper.

At the end of the examination, submit Section A and B separately.
The number of marks is given in brackets [ ] at the end of each question or part question.
The use of an approved scientific calculator is expected, where appropriate.
A copy of the Periodic Table is printed on page 17.

FOR EXAMINER’S USE

| Section A | /50 |

This document consists of 16 printed pages and 2 blank pages.
Section A

Answer all the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The table below gives some information about five substances.

<table>
<thead>
<tr>
<th>substance</th>
<th>melting point / °C</th>
<th>boiling point / °C</th>
<th>solubility in water</th>
<th>electrical conductivity when molten</th>
<th>electrical conductivity when solid</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>-97</td>
<td>65</td>
<td>very soluble</td>
<td>does not conduct</td>
<td>does not conduct</td>
</tr>
<tr>
<td>G</td>
<td>1600</td>
<td>2230</td>
<td>insoluble</td>
<td>does not conduct</td>
<td>does not conduct</td>
</tr>
<tr>
<td>H</td>
<td>801</td>
<td>1413</td>
<td>soluble</td>
<td>conducts</td>
<td>does not conduct</td>
</tr>
<tr>
<td>I</td>
<td>-57</td>
<td>126</td>
<td>insoluble</td>
<td>does not conduct</td>
<td>conducts</td>
</tr>
<tr>
<td>J</td>
<td>1085</td>
<td>2562</td>
<td>insoluble</td>
<td>conducts</td>
<td>conducts</td>
</tr>
</tbody>
</table>

(a) Which substance in the table has ionic bonding? ................................................................. [1]

(b) Which substance in the table has giant covalent structure? ......................................................... [1]

(c) (i) Name a method which you could use to obtain substance F from a mixture of F and water.
........................................................................................................................................................................... [1]

(ii) State the condition which must be present for the method you named in (c)(i) to be successful.
........................................................................................................................................................................... [1]

(d) Explain why substance J is able to conduct electricity in solid state.
........................................................................................................................................................................... [1]
A2 An ion of element A has the following electronic arrangement.

(a) Name subatomic particles, X and Z.  

(b) State the formula for the compound formed between A and oxygen.  

(c) What is the industrial method used to extract A from compound in (b)?  

A3 Until recently, arsenic poisoning, either deliberate or accidental, has been a frequent cause of death. The symptoms of arsenic poisoning are identical to those of a common illness, cholera. A reliable test was needed to prove the presence of arsenic in a body.

(a) In 1840, Marsh devised a reliable test for arsenic as shown below.
Hydrogen is formed in this reaction. Any arsenic compound reacts with this hydrogen to form arsine which is arsenic hydride, AsH₃.

The mixture of hydrogen and arsine is burnt at the jet and arsenic forms as a black stain on the glass.

Write an equation for the reaction which forms hydrogen.

........................................................................................................... [1]

(b) Another hydride of arsenic has the composition below.

arsenic 97.4 %  hydrogen 2.6 %

(i) Calculate the empirical formula of this hydride from the above data. Show your working.

........................................................................................................... [2]

(ii) The mass of one mole of this hydride is 154 g.

What is its molecular formula?
A4  (a) Manganese(IV) oxide, MnO₂, is used in the preparation of both chlorine and oxygen.

\[
\text{Reaction 1} \quad \text{MnO}_2(\text{s}) + 4\text{HCl(aq)} \rightarrow \text{Cl}_2(\text{g}) + 2\text{H}_2\text{O(l)} + \text{MnCl}_2(\text{aq})
\]

\[
\text{Reaction 2} \quad 2\text{H}_2\text{O}_2(\text{aq}) \rightarrow \text{O}_2(\text{g}) + 2\text{H}_2\text{O(l)}
\]

In reaction 2, manganese(IV) oxide acts as a catalyst.

(i) Reaction 1 is investigated using different masses of MnO₂. The results are shown in the table.

<table>
<thead>
<tr>
<th>Volume of HCl / cm³</th>
<th>Concentration of HCl / mol/dm³</th>
<th>Mass of MnO₂ used / g</th>
<th>Volume of Cl₂ formed at room temperature and pressure / dm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.0</td>
<td>1.74</td>
<td>0.48</td>
</tr>
<tr>
<td>100</td>
<td>1.0</td>
<td>0.87</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Explain the difference in the volume of chlorine formed.

(ii) Reaction 2 is carried out using the following conditions. The results are shown in the table.

<table>
<thead>
<tr>
<th>Volume of H₂O₂ / cm³</th>
<th>Concentration of H₂O₂ / mol/dm³</th>
<th>Mass of MnO₂ used / g</th>
<th>Volume of O₂ formed at room temperature and pressure / dm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.0</td>
<td>1.74</td>
<td>0.12</td>
</tr>
</tbody>
</table>
On the grid below, sketch a graph of reaction 2 and label it as Graph 2.

On the same grid, sketch how the graph would differ if 50 cm$^3$ of 1.5 mol/dm$^3$ of H$_2$O$_2$ were used instead. Label it as Graph 3.

![Graph of Volume of O$_2$/dm$^3$ vs Time /s]

(III) Reaction 2 has an activation energy of 58.0 kJ/mol and 120 kJ/mol using manganese(IV) oxide and copper(II) oxide respectively as catalysts. Suggest which is a less effective catalyst.

Explain your answer and state how this would affect the rate of reaction based on the collision theory.

........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................

[3]
(b) Sodium carbonate reacts with dilute hydrochloric acid:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

The following method was used:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Place a known mass of sodium carbonate in a conical flask.</td>
</tr>
<tr>
<td>2.</td>
<td>Measure 10 cm$^3$ of dilute hydrochloric acid using a measuring</td>
</tr>
<tr>
<td></td>
<td>cylinder.</td>
</tr>
<tr>
<td>3.</td>
<td>Add the acid into the conical flask.</td>
</tr>
<tr>
<td>4.</td>
<td>Place a bung in the flask and collect the gas using the set-up</td>
</tr>
<tr>
<td></td>
<td>shown below until the reaction is complete.</td>
</tr>
</tbody>
</table>

![Diagram of the experiment setup including a delivery tube, conical flask, dilute hydrochloric acid, sodium carbonate, bung, measuring cylinder, and water.]

The student's results are shown in the table below:

<table>
<thead>
<tr>
<th>mass of sodium carbonate / g</th>
<th>volume of carbon dioxide gas / cm$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.07</td>
<td>16.0</td>
</tr>
<tr>
<td>0.12</td>
<td>27.5</td>
</tr>
<tr>
<td>0.23</td>
<td>52.0</td>
</tr>
<tr>
<td>0.29</td>
<td>12.5</td>
</tr>
<tr>
<td>0.34</td>
<td>77.0</td>
</tr>
<tr>
<td>0.54</td>
<td>95.0</td>
</tr>
<tr>
<td>0.59</td>
<td>95.0</td>
</tr>
<tr>
<td>0.65</td>
<td>95.0</td>
</tr>
</tbody>
</table>
(i) The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this result.

..................................................................................................................

..................................................................................................................

[1]

(ii) What further work could the student do to be more certain about the minimum mass of sodium carbonate needed to produce 95.0 cm³ of carbon dioxide?

..................................................................................................................

..................................................................................................................

[1]

(iii) Explain how and why the expected volumes of carbon dioxide produced differ from the actual values obtained in the table shown.

..................................................................................................................

..................................................................................................................

[1]

(iv) Suggest one improvement that could be made to the apparatus used that would give more accurate results.

Give a reason for your answer.

..................................................................................................................

..................................................................................................................

[1]

A5 The diagram shows the changes in pH in a student’s mouth after she has eaten an acidic sweet.

![Diagram showing pH changes over time](image-url)
(a) Chewing an acidic sweet stimulates the formation of saliva. Saliva is slightly alkaline.

Use this information to describe and explain the shape of the graph.

................................................................................................................................................................. [2]

(b) Many sweets contain soluble calcium citrate additives.

Provide a detailed procedure as to how a pure, dry sample of the above additive can be synthesized safely in the laboratory.

................................................................................................................................................................. [3]
A6 The following table summarises the reaction between 0.004 moles of various metals and 50 cm³ (an excess) of dilute hydrochloric acid at room temperature and pressure. Use this information to answer the questions given below.

<table>
<thead>
<tr>
<th>experiment</th>
<th>metal added</th>
<th>rise in temperature / °C</th>
<th>total volume of hydrogen given off / cm³</th>
<th>observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Aluminium</td>
<td>15</td>
<td>144</td>
<td>Reaction very slow at first. Sudden violent reaction after 20 minutes.</td>
</tr>
<tr>
<td>B</td>
<td>Copper turnings</td>
<td>0</td>
<td>0</td>
<td>No reaction.</td>
</tr>
<tr>
<td>C</td>
<td>Copper powder</td>
<td>1</td>
<td>0</td>
<td>Pink powder changes to black powder when exposed to air. Black powder reacts with acid to form blue solution.</td>
</tr>
<tr>
<td>D</td>
<td>Iron filings</td>
<td>5</td>
<td>96</td>
<td>Slow reaction at first, then fairly rapid.</td>
</tr>
<tr>
<td>E</td>
<td>Chromium powder</td>
<td>6</td>
<td>144</td>
<td>Fairly rapid reaction.</td>
</tr>
<tr>
<td>F</td>
<td>Zinc powder</td>
<td>9</td>
<td>96</td>
<td>Moderately rapid reaction.</td>
</tr>
</tbody>
</table>

(a) Place these five metals in increasing order of reactivity putting the most reactive metal first.

................................................................................................................. [1]
(b) Explain the observation in

(i) experiment A.

................................................................................................................................................
................................................................................................................................................ [2]
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]

(ii) experiment C.

................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]

(c) What is the charge on the chromium ion formed in experiment E?

Give reasons for your answer.

................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]

(d) Suggest what would be observed if a magnesium strip is dipped into the blue solution formed in experiment C.

................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................
................................................................................................................................................ [2]
A7 Fats are solids at room temperature and pressure. They contain mainly saturated fat molecules. Oils are liquids at room temperature and pressure. They contain a larger proportion of unsaturated fat molecules.

(a) The structure of a fat or oil molecule is shown below.

\[
\begin{align*}
H_2C &\quad O &\quad C &\quad R \\
& & & \\
& & & \\
H_2C &\quad O &\quad C &\quad R' \\
& & & \\
& & & \\
H_2C &\quad O &\quad C &\quad R'' \\
\end{align*}
\]

(i) Identify the functional group which is present in the molecule.

(ii) Soap is a mixture of the sodium salts of the long-chain fatty acids produced from the hydrolysis of animal fat with aqueous sodium hydroxide.

\[
\text{Fat} + 3\text{NaOH} \rightarrow \text{RCO}_2\text{Na} + \text{R'}\text{CO}_2\text{Na} + \text{R''CO}_2\text{Na} + \text{Glycerol}
\]

Draw the full structural formula of glycerol.
(b) One mole of iodine will react with one mole of carbon-carbon double bonds in oil. The degree (or amount) of unsaturation in oil can be found by reacting the oil with a known amount of iodine. The **excess** iodine is determined by titrating with sodium thiosulfate (Na₂S₂O₃) solution.

\[ \text{I}_2 + 2\text{Na}_2\text{S}_2\text{O}_3 \rightarrow \text{Na}_2\text{S}_4\text{O}_6 + 2\text{NaI} \]

The number of grams of iodine that react with 100 g of oil is called the iodine number.

42.5 g of iodine was added to 35.1 g of corn oil. The **excess** iodine needed 24.2 cm³ of 0.121 mol/dm³ sodium thiosulfate solution for complete reaction.

(i) Calculate the number of moles of iodine that reacted with the corn oil.

(ii) Hence, calculate the iodine number of the corn oil. [3]
A8 The petrol that is used as fuels for car engines is a complex mixture of a hundred different hydrocarbons, which can include molecules such as pentane, octane and benzene.

The extent to which a particular type of gasoline will burn smoothly in an engine is indicated by using the octane rating. Brands of petrol are typically available with octane ratings in the range of 83 to 98.

The table below lists the octane ratings of three organic compounds which can be used as fuels.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Octane rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Compound" /></td>
<td>62</td>
</tr>
<tr>
<td><img src="image2" alt="Compound" /></td>
<td>92</td>
</tr>
<tr>
<td><img src="image3" alt="Compound" /></td>
<td>116</td>
</tr>
</tbody>
</table>

(a) Explain why the above compounds are classified as isomers.

........................................................................................................................................................................ [1]
(b) Using information from the table, suggest a relationship between the structure of the compound and the octane rating.

................................................................. [2]

(c) Suggest the octane number for the following hydrocarbon. Explain your answer.

\[
\begin{align*}
    &\text{H} \\
    \text{CH}_3 &-\text{C}-\text{CH}_2-\text{CH}_3 \\
    &\text{CH}_3
\end{align*}
\]

................................................................. [2]

END OF SECTION A
Name: ___________________________ Index Number: _______ Class: _______

TEMASEK SECONDARY SCHOOL
Preliminary Examination 2017
Secondary 4 Express

CHEMISTRY

Paper 2 (Section B)

Total duration for Sections A and B: 1 hour 45 minutes

Question and Answer Booklet

READ THESE INSTRUCTIONS FIRST

Do not open the booklet until you are told to do so.

You are required to submit this booklet at the end of the paper.

Write your name, index number and class in all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.

Section B
Answer three questions from this section.
Question B11 is in the form of either/or and only one of the alternatives should be attempted.
Write your answers in the spaces provided.
At the end of the examination, submit Section A and B separately.

The number of marks is given in brackets [ ] at the end of each question or part question.
The use of an approved scientific calculator is expected, where appropriate.
A copy of the Periodic Table is printed on page 17 of Section A.

FOR EXAMINER'S USE

| Section B | /30 |

This document consists of 10 printed pages.
Section B
Answer three questions from this section.
Question B11 is in the form of either/or and only one of the alternatives should be attempted.
Write your answers in the spaces provided.

B9 Aluminium is obtained by the electrolysis of molten mixture of aluminium oxide and cryolite using carbon as electrodes.

(i) Explain why the addition of cryolite is necessary for the process.

(ii) Calculate the number of moles of electrons which are needed to produce 2.00 kg of aluminium.

[2]
(iii) During the electrolysis, the anode has to be replaced at regular intervals. Suggest a reason for doing so with the aid of balanced chemical equations.

...........................................................................................................................................................

........................................................................................................................................................... [2]

(iv) Explain why the set up will fail to extract aluminium if the electrodes are changed to copper.

...........................................................................................................................................................

........................................................................................................................................................... [2]

(b) Electrolysis can be used to remove unwanted hair. A needle, which serves as a negative electrode is held by the operator while the customer holds the metal bar which serves as the positive electrode.

An aqueous solution of concentrated sodium chloride is applied on the tip of the needle. The change in pH of the area around the hair leads to the removal.
Account for the removal of hair through the process above, detailing the chemistry behind it as well as the different products formed.
B10 The equation for the formation of ammonia in the Haber Process is shown below.

\[ \text{N}_2 (g) + 3\text{H}_2 (g) \rightleftharpoons 2\text{NH}_3 (g) \]

A series of experiments were carried out using different temperatures and catalysts to determine the percentage yield of ammonia. The table below shows the results obtained.

<table>
<thead>
<tr>
<th>experiment</th>
<th>catalyst</th>
<th>temperature (^\circ\text{C})</th>
<th>Percentage yield of ammonia after 3h</th>
<th>after 24h</th>
<th>after 30 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>none</td>
<td>400</td>
<td>2</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>none</td>
<td>500</td>
<td>3</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>aluminium</td>
<td>400</td>
<td>2</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>aluminium</td>
<td>500</td>
<td>3</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>calcium</td>
<td>400</td>
<td>3</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>calcium</td>
<td>500</td>
<td>4</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>7</td>
<td>iron</td>
<td>400</td>
<td>18</td>
<td>21</td>
<td>23</td>
</tr>
<tr>
<td>8</td>
<td>iron</td>
<td>500</td>
<td>7</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>9</td>
<td>osmium</td>
<td>400</td>
<td>20</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>10</td>
<td>osmium</td>
<td>500</td>
<td>8</td>
<td>10</td>
<td>17</td>
</tr>
</tbody>
</table>

(a) Transition metals are more effective than main group metals as catalysts. Explain how the information in the table supports this statement.
(b) A student wrote this conclusion from the results in the table:

*Catalysts speed up reactions but do not affect the final yield.*

Do you agree with this conclusion? Use the results to explain your reasoning.

...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
[2]

(c) The energy profile diagram for the uncatalysed reaction at 400°C is shown below.

```
<table>
<thead>
<tr>
<th>Energy</th>
<th>Progress of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>460 kJ/mol</td>
<td></td>
</tr>
<tr>
<td>552 kJ/mol</td>
<td></td>
</tr>
</tbody>
</table>
```

(i) Use the graph to explain whether the forward reaction is exothermic or endothermic.

...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
...........................................................................
[2]
(ii) Calculate the energy change when 540 cm$^3$ of ammonia is formed.

(iii) In the presence of iron catalyst, the activation energy for the reverse reaction is 298 kJ/mol. Suggest a value for the activation energy for the formation of ammonia under these conditions.

B11 EITHER

Refer to the following flow chart and answer the questions below.

(a) State the identity of A, B and C.

A : ............................................

B : ............................................

C : ............................................ [3]
(b) (i) Describe a test to identify gas D.

........................................................................................................................................... [1]

(ii) Write the equation for the observation in (b)(i).

........................................................................................................................................... [1]

(c) Explain the presence of the brown solution upon adding acidified potassium manganate (VII) in terms of electron transfer.

........................................................................................................................................... [3]

(d) Suggest what would happen if aqueous bromine were added to a solution of compound C? Explain your answer.

........................................................................................................................................... [2]
B11 OR

The flow diagram below shows a series of reaction of substance A which contains two cations and two anions.

![Flow diagram]

(a) (i) Identify the cation responsible for the yellow colour in solution A. .................................................. [1]

(ii) Identify B and F.
B : ...........................................................
F : ........................................................... [2]

(b) Suggest the role of compound C. Explain your answer in terms of electron transfer.
........................................................................................................................................................................ [2]
(c) Explain, in terms of oxidation state, the formation of the black precipitate upon adding acidified potassium manganate (VII) to the colourless filtrate containing salt D.

................................................................. [3]

(d) Suggest a possible identity of an anion in solution A, other than the one mentioned in (c).

................................................................. [1]

(e) Gas B reacts with dilute nitric acid to form a fertilizer. State the chemical formula of the fertilizer formed.

................................................................. [1]

END OF SECTION B
## Answer Scheme for Section A

### A1
- **(a)** H [1]
- **(b)** G [1]
- **(c)**
  - (i) Fractional distillation [1]
  - (ii) F and water must have different boiling points [1]
- **(d)** J consists of a lattice of positive ions surrounded by a sea of delocalized electrons. Electrons are free to move to conduct electricity [1]

### A2
- **(a)** X: Proton [1]
  - Z: Electron [1]
- **(b)** AsO [1]
- **(c)** Electrolysis of its molten compound [1]

### A3
- **(a)** Zn + 2HCl $\rightarrow$ ZnCl₂ + H₂
- **(b)**
  - (i) | Elements | As | H |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage Mass (%)</td>
<td>97.4</td>
<td>2.6</td>
</tr>
<tr>
<td>No. of moles</td>
<td>$\frac{97.4}{2}$ = 4.85</td>
<td>$\frac{2.6}{2}$ = 1.3</td>
</tr>
<tr>
<td>Mol ratio</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Empirical Formula</td>
<td>AsH₂</td>
<td></td>
</tr>
</tbody>
</table>

- (ii) Mr of AsH₂ = 75 + 2 = 77
  - $n = \frac{154}{77} = 2$
  - Molecular formula = As₂H₄ [1]

### A4
- **(a)**
  - (i) MnO₂ is the limiting reagent [1]
  - Volume of Cl₂ produced is halved, from 0.48 dm³ to 0.24 dm³ as number of moles of MnO₂ used is halved. [1]
(ii)

![Graph](image)

Volume of $O_2$ $\text{dm}^3$

- **Graph 1**
- **Graph 2**
- **Graph 3**

Time $\text{s}$

[1] for correct shape for Graph 2 with volume indicated.
[2] for Graph 3 with steeper gradient + smaller volume of $O_2$

(iii)

- Copper(II) oxide is a less effective catalyst with a higher activation energy of 120 kJ/mol compared to manganese(IV) oxide with a lower activation energy 58.0 kJ/mol [1]
- Fewer particles possess energy greater than or equal to the activation [1]
- Frequency of effective collisions is lower + rate of reaction is lower [1]

(b) (i)

- bung not put in firmly
- gas lost before bung was placed in position
- there was a leak from the delivery tube
  
  [ Any one ] [1]

(ii) Take more readings for masses of sodium carbonate ranging from 0.34 g to 0.54 g [1]

(iii) Expected volumes of carbon dioxide produced should be greater than the actual values obtained as some carbon dioxide dissolves back into the water. [1]

(iv) Use a pipette/burette to measure the acid [1] as it measures volume to a higher degree of accuracy compared to the measuring cylinder [1]

**OR**

use a gas syringe to collect the gas [1] so it will not dissolve in water [1]

A5 (a) Initially pH drops sharply from 7 to 5.1/5.2/5.3 then rises gradually to 7.2/7.3 [1]
This is due to acidic sweet producing H⁺ ion to lower the pH, and the rise is due to alkali saliva neutralizing the H⁺ from the sweet. [1]

(b) Add excess calcium carbonate to citric acid and stir the mixture. Filter the mixture to obtain the calcium citrate solution as the filtrate [1]. Heat the filtrate until saturated, allow saturated solution to cool and crystallisation to occur. [1]. Filter the mixture to obtain calcium citrate crystals as residue. Wash the crystals with cold distilled water and dry between 2 pieces of filter paper [1].

[Can be done using calcium oxide] [0 for calcium metal. Not safe]

<table>
<thead>
<tr>
<th>A6</th>
<th>(a)</th>
<th>Copper, Iron, Chromium, Zinc, Aluminium</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(b)</td>
<td>(i) The initial reaction is slow because the aluminium metal is protected by an inert and non-porous layer of aluminium oxide which prevent contact between aluminium and acid. The reaction became violet after all the aluminium oxide has reacted with the acid, exposing the aluminium metal to the acid. Aluminium reacts vigorously with acid.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Pink copper is oxidised by oxygen in air to form black copper (II) oxide. Black copper (II) oxide reacts with acid to form copper (II) chloride and water. The copper (II) chloride is soluble in water and hence forms a blue solution.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(c)</td>
<td>+3; (zero marks for qn if charge is wrong) Chromium and aluminium gives off the same volume of hydrogen gas when reacting with the acid, hence chromium will form ions of the same charge as aluminium;</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(d)</td>
<td>Blue solution will turn colourless/ Blue solution will fade; Magnesium strip will be coated with reddish brown deposit;</td>
<td>1</td>
</tr>
</tbody>
</table>

| A7 | (a) | (i) ester ALLOW: -COO- | 1 |
All covalent bonds must be shown.

(b) (i) Number of moles of iodine added = \( \frac{42.5}{127} \times 2 \)
     \[ = 0.1673 \text{ mol} \]

Number of moles of sodium thiosulfate = \( \frac{24.2}{1000} \times 0.121 \)
     \[ = 2.928 \times 10^{-3} \text{ mol} \]
     \[ \approx 2.93 \times 10^{-3} \text{ mol} \]

Number of moles of excess iodine = \( 0.5 \times 2.928 \times 10^{-3} \text{ mol} \)
     \[ = 1.464 \times 10^{-3} \text{ mol} \]

Number of moles of iodine that reacted = \( 0.1673 - 1.464 \times 10^{-3} \text{ mol} \)
     \[ = 0.1659 \]
     \[ = 0.166 \text{ mol} \]

ALLOW: ecf.

(ii) Mass of iodine that reacted = \( 0.1659 \times (127 \times 2) \)
     \[ = 42.13 \text{ g} \]
     \[ = 42.1 \text{ g} \]

35.1 g of corn oil \( \rightarrow \) 42.13 g of iodine
100 g of corn oil \( \rightarrow \) \( \frac{42.13}{35.1} \times 100 = 120 \text{ g of iodine} \)

\[ \therefore \text{ iodine number of corn oil is 120.} \]

ALLOW: ecf.

A8 (a) They are organic compounds with the same molecular formulae but different structural formulae. [all or nothing]

(b) As the amount of branching to the hydrocarbon increases, the octane number increases [1],
    as seen in the straight chain hydrocarbon at 82 octane number,
    increasing to 92 and 116 with 1 and 2 branch alkyl groups respectively. [1]

(c) 92 [1]
    It has the same structural formula as the 2nd compound in the table. [1]
### Answer Scheme for Section B

#### B1
1. **(a) (i)** Cryolite acts as an impurity which will help to lower the melting point of aluminium oxide, hence reducing the amount of energy needed for melting. [1]

   2. **(ii)** $\text{Al}^{3+} + 3e^- \rightarrow \text{Al}$ [1]

   - No of moles of aluminium = $\frac{2000}{27}$
   - $= 74.074 = 74.07 \text{ mol}$
   - No of moles of electrons = $74.074 \times 3$
   - $= 222.22$
   - $= 222 \text{ mol}$ [1]

   3. **(iii)** $6\text{O}_2^2- \rightarrow 3\text{O}_3^- + 12e^-$

   - $\text{O}_2 + \text{C} \rightarrow \text{CO}_2$ [1] [both eqn necessary for 1 m]

   - The hot oxygen can react with the carbon anode to form carbon dioxide gas. [1]

4. **(iv)** When copper is used as the anode, it is a reactive anode and will be oxidized to form $\text{Cu}^{2+}$ ions. [1] These ions will be displaced by more reactive aluminium metal to form $\text{Al}^{3+}$, hence lowering the yield of aluminium obtained [1]

#### B2
1. **(a)** At 400°C, the percentage yield of ammonia increases at a higher rate [1]

   - of 18% after 3h for iron, a transition metal than for aluminium, a Group II metal which ammonia increases at a much lower rate of 2% after 3h [1]

   **OR**

   [1] for the correct comparison/trend between a transition metal and a main group metals

   [1] for substantiating with data from the table

2. **(b)** At 400°C, the percentage yield of ammonia remains the same at 23% after 30 days [1]
• for both iron and osmium which are transition metals and for calcium and aluminium which are Group II and Group III metals respectively [1]

OR:

• At 500°C, the percentage yield of ammonia remains the same at 17% after 30 days [1]

• for both iron and osmium which are transition metals and for calcium and aluminium which are Group II and Group III metals respectively [1]

<table>
<thead>
<tr>
<th>(c)</th>
<th>(i)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exothermic [1]</td>
</tr>
<tr>
<td></td>
<td>The reactants possess more energy than the products + energy lost to the surroundings. [1]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(ii)</th>
<th>$\Delta H$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$= -(552 -460)$</td>
</tr>
<tr>
<td></td>
<td>$= -82.0 \text{ kJ/mol} [1]$</td>
</tr>
</tbody>
</table>

No of moles of ammonia

$\frac{540}{1000} \div 24$

$=0.0225$ moles

Energy released

$= 0.0225 \times 92.0$

$= 2.07 \text{ kJ} [1]$ (OR if student indicated $\Delta H$ with a negative sign without stating energy was released)

<table>
<thead>
<tr>
<th>(iii)</th>
<th>Activation energy for catalysed formation of ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$= 298 - 92.0$ [1]</td>
</tr>
<tr>
<td></td>
<td>$= 206 \text{ kJ/mol} [1]$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B3</th>
<th>EITHER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(e)</td>
</tr>
<tr>
<td>A</td>
<td>: HI [1]</td>
</tr>
<tr>
<td>B</td>
<td>: AgI / silver iodide [1]</td>
</tr>
<tr>
<td>C</td>
<td>: NaI / sodium iodide [1] [3]</td>
</tr>
</tbody>
</table>

Need a home tutor? Visit smiletutor.sg

| Page 487 |
(b) | (i) Bubbling the gas through limewater + if a white ppt is formed, gas is carbon dioxide. [1]  
| (ii) \( \text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 \) [1]  

(c)  
- I in compound A is oxidized by acidified potassium manganate (VII) \( \text{KMnO}_4 \) [3]  
  - as I in A has lost electrons to form \( \text{I}_2 \) [1]  
  - which dissolves in the solution to form brown aqueous iodine. [1]  

(d)  
- Bromine is more reactive than iodine. [1]  
- It displaces iodine/iodide ions from solution C/aqueous sodium iodide to form aqueous iodine. [1]  

### B3 OR

(a) | (i) Iron(III) ion / \( \text{Fe}^{3+} \) [1]  
| (ii) E: Ammonia / \( \text{NH}_3 \) [1]  
| F: Iron(II) hydroxide / \( \text{Fe(OH)}_2 \) [1] [2]  

(b)  
- C is a reducing agent. [1]  
- It reduces \( \text{Fe}^{3+} \) to \( \text{Fe}^{2+} \) as \( \text{Fe}^{3+} \) in A has gained electrons to form \( \text{Fe}^{2+} \) in E. [1]  

(c)  
- Acidified potassium manganate (VII) oxidizes iodide ions /\( \text{I}^- \)/ in D to iodine [1] as  
  - the oxidation state of iodine increases from -1 in \( \text{I}^- \) to 0 in \( \text{I}_2 \). [1]  
  - Iodine is only slightly soluble in water, and precipitates out as a black solid. [1]  

(d) Nitrate ion /\( \text{NO}_3^- \) [1] [1]  
(e) \( \text{NH}_4\text{NO}_3 \) [1]
TANJONG KATONG GIRLS’ SCHOOL

PRELIMINARY EXAMINATION 2017
SECONDARY FOUR

5073/01 CHEMISTRY

Thursday 14 September 2017 1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and index number on the Answer Sheet in the spaces provided.

There are forty questions in this paper. Answer all questions.
For each question, there are four possible answers, A, B, C and D.
Choose the one you consider correct and record your choice in soft pencil on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 2.
The use of an approved scientific calculator is expected, where appropriate.

This Question Paper consists of 22 printed pages, including this page.
The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Li</td>
<td>H</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
<td>Ne</td>
</tr>
<tr>
<td>8</td>
<td>Be</td>
<td>Beryllium</td>
<td>9</td>
<td>Mg</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>Na</td>
<td></td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>13</td>
<td>Al</td>
<td></td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>15</td>
<td>Si</td>
<td></td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>17</td>
<td>Cl</td>
<td></td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>19</td>
<td>K</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>82</td>
<td>Rb</td>
<td></td>
<td>83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>85</td>
<td>Cs</td>
<td></td>
<td>86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>55</td>
<td>Fr</td>
<td></td>
<td>88</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18</td>
</tr>
</tbody>
</table>

Key
- a = radioactive series
- X = actinide series
- b = prime (stable) isotope

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).
1. A gaseous mixture of ethene, oxygen and sulfur dioxide is passed through the apparatus shown. Only one of the gases is collected.

Which of the following is a property of the gas collected?

A. It turns brown bromine solution colourless.
B. It relights a glowing splint.
C. It turns acidified potassium manganate(VII) solution colourless.
D. It forms a white precipitate in limewater.

2. Two identical bottles filled with gas X and gas Y were put on a balance at room temperature and pressure. The result is shown below.

Which statement is correct?

A. The number of gas particles in bottle A is greater than the number of gas particles in bottle B.
B. The number of moles of gas particles in bottle A is greater than the number of moles of gas particles in bottle B.
C. The molar mass of gas particles in bottle A is greater than the molar mass of gas particles in bottle B.
D. The molar volume of gas particles in bottle A is greater than the molar volume of gas particles in bottle B.
3 Hard water contains calcium ions and hydrogencarbonate ions arising from dissolved calcium hydrogencarbonate, Ca(HCO₃)₂.

How many electrons are present in the hydrogencarbonate ion?

A 30  
B 31  
C 32  
D 33

4 The diagrams show the spacing of particles in a substance at two different temperatures.

at -132°C  

at -115°C  

Which graph shows how the temperature of the substance changes with time when it is heated?

A  

B  

C  

D  

Tanjong Katong Girls’ School
5. Titanium has five stable isotopes and shows three oxidation states, $+2$, $+3$ and $+4$. Below is the particle formed from the most abundant isotope.

\[
\frac{48}{22}\text{Ti}^{4+}
\]

Which of the following shows the number of protons, neutrons and electrons of the particle formed by a different isotope of titanium?

<table>
<thead>
<tr>
<th></th>
<th>Protons</th>
<th>Neutrons</th>
<th>Electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>22</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>B</td>
<td>22</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>C</td>
<td>22</td>
<td>26</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>18</td>
<td>20</td>
<td>22</td>
</tr>
</tbody>
</table>

6. Chromatogram 1 below shows the separation of coloured links in mixture Q using solvent A.

Chromatogram 2 shows further separation using the same piece of paper but after it has been rotated anti-clockwise 90° in another solvent B.

How many different types of ink are present in mixture Q?

A. 3
B. 4
C. 5
D. 6
7. Which mixture can be best separated by fractional distillation?

A. water and butanol
B. water and butane
C. seawater and paraffin
D. sulfur and naphthalene

8. Oxygen consists of the isotopes $^{16}\text{O}$, $^{17}\text{O}$ and $^{18}\text{O}$. Carbon consists of the isotopes $^{12}\text{C}$ and $^{13}\text{C}$. How many different carbon dioxide molecules can be obtained from these isotopes?

A. 5
B. 6
C. 10
D. 12

9. Elements $G$ and $J$ form a compound with formula $G\text{J}$. At room temperature, the particles in $G\text{J}$ slide over one another in a disorderly manner. From the information given, what are the possible electronic structures of $G$ and $J$?

<table>
<thead>
<tr>
<th></th>
<th>$G$</th>
<th>$J$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>B</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>C</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>D</td>
<td>2.3</td>
<td>2.5</td>
</tr>
</tbody>
</table>

10. If the gas volume of argon is twice that of hydrogen at the same temperature and pressure, what is the numerical ratio of argon atoms to hydrogen atoms?

A. 1 : 1
B. 2 : 1
C. 1 : 2
D. 20 : 1
11 Solutions of 1 mol/dm$^3$ silver nitrate and 0.5 mol/dm$^3$ sodium chloride were prepared. 20 cm$^3$ of silver nitrate solution and 30 cm$^3$ of sodium chloride solution were mixed together in a beaker.

The ions in each of the initial solutions are shown below:

- Na$^+$
- Cl$^-$
- Ag$^+$
- NO$_3^-$

Which diagram best represents the particles of the contents of the beaker after the two solutions were mixed?

( water molecules are not shown )

![Diagram options]

12 A mixture of barium chloride and barium nitrate, with a total mass of 2.00 g, is dissolved in water and treated with excess silver nitrate solution. The precipitate is dried and found to weigh 0.688 g.

What was the mass of barium chloride in the original mixture?

A 0.499 g  
B 0.688 g  
C 1.00 g  
D 2.00 g

13 When the oxide Cl$_2$O$_3$ is added to water, a reaction takes place which is not a redox process.

What could the product(s) of the reaction be?

A HCIO$_4$  
B HOCI  
C Cl$_2$ and O$_2$  
D HC$_2$ and O$_2$
14. The enthalpy change when one mole of hydrogen ions is neutralised is known as the enthalpy of neutralisation.

\[ \text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(l) \quad \Delta H = -57 \text{ kJ/mol} \]

How much energy is released if one mole of sulfuric acid is completely neutralised?

A. 28.5 kJ  
B. 57 kJ  
C. 114 kJ  
D. 228 kJ

15. The table below shows some of the physical properties of four unknown substances A, B, C and D.

<table>
<thead>
<tr>
<th>Unknown substance</th>
<th>Melting point / °C</th>
<th>Boiling point / °C</th>
<th>Electrical conductivity</th>
<th>Solubility in water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Solid state</td>
<td>Liquid state</td>
</tr>
<tr>
<td>A</td>
<td>163</td>
<td>440</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td>B</td>
<td>580</td>
<td>1800</td>
<td>poor</td>
<td>good</td>
</tr>
<tr>
<td>C</td>
<td>1823</td>
<td>2380</td>
<td>poor</td>
<td>poor</td>
</tr>
<tr>
<td>D</td>
<td>1553</td>
<td>2980</td>
<td>good</td>
<td>good</td>
</tr>
</tbody>
</table>

Which statement about the four substances is correct?

A. Substance A is a simple molecular compound containing weak covalent bonds between molecules.
B. Substance B is an ionic compound with mobile electrons held by strong electrostatic forces.
C. Substance C is a giant covalent compound with mobile ions.
D. Substance D is a giant covalent compound with mobile electrons.
16. The diagram below shows the set-up of an electric cell, making use of copper and a metal T as electrodes.

![Diagram of electric cell]

Which statement is correct about the above electric cell?

A. The mass of copper electrode will increase.
B. The electrode made of metal T is the negative electrode.
C. Reduction takes place at the electrode made of metal T.
D. Copper is less reactive than metal T.

17. P, Q and R are elements found in Group VII of the Periodic Table. Three experiments were carried out to determine the reactivity of P, Q and R. The three reactions are represented by the three equations shown below.

I \[ R(aq) + Q_{2}(aq) \rightarrow \text{no reaction} \]

II \[ P(aq) + R_{2}(aq) \rightarrow \text{no reaction} \]

III \[ 2Q(aq) + P_{2}(aq) \rightarrow Q_{2}(aq) + 2P(aq) \]

Which statement about P, Q and R is correct?

A. \( P_{2} \) is a solid at room temperature.
B. \( R_{2} \) is a stronger oxidising agent than \( Q_{2} \).
C. Aqueous \( HQ \) turns red litmus paper blue.
D. \( P_{2} \) is a reducing agent for reaction III.
18 The table shows the properties of some metal oxides, W, X, Y and Z.

<table>
<thead>
<tr>
<th>Oxide</th>
<th>Colour of oxide</th>
<th>Change on heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>black</td>
<td>remains black</td>
</tr>
<tr>
<td>X</td>
<td>red</td>
<td>oxygen evolved and silvery liquid remains</td>
</tr>
<tr>
<td>Y</td>
<td>white</td>
<td>solid turns yellow when hot but becomes white again when cold</td>
</tr>
<tr>
<td>Z</td>
<td>brown</td>
<td>oxygen evolved and solid turns yellow</td>
</tr>
</tbody>
</table>

Which of these oxides are chemically unchanged when heated?

A. W only  
B. Y only  
C. X and Z only  
D. W and Y only

19 The rate of reaction between a given mass of metal and an excess of hydrochloric acid is studied by collecting the hydrogen gas in a graduated syringe. The results are as shown in the table below.

<table>
<thead>
<tr>
<th>Time taken / s</th>
<th>Volume of hydrogen gas / cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td>60</td>
<td>38</td>
</tr>
<tr>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>100</td>
<td>40</td>
</tr>
</tbody>
</table>

How much time is required for half of the given mass of metal to react?

A. 20 s  
B. 40 s  
C. 50 s  
D. 100 s
20 25.0 cm\(^3\) of 0.2 mol/dm\(^3\) of an aqueous carbonate reacts completely with 50.0 cm\(^3\) of 0.1 mol/dm\(^3\) of an acid. What is the charge of the anion of the acid?

A  1+
B  2+
C  1−
D  2−

21 A student mixed two aqueous solutions of ionic compounds at a time and made the following observations.

<table>
<thead>
<tr>
<th>Solution A</th>
<th>Solution B</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr(C/O(_3))(_2)</td>
<td>Mg(I/O(_3))(_2)</td>
<td>a precipitate observed</td>
</tr>
<tr>
<td>Mg(I/O(_3))(_2)</td>
<td>Ni(C/O(_3))(_2)</td>
<td>a precipitate observed</td>
</tr>
<tr>
<td>MgCrO(_4)</td>
<td>Pb(C/O(_3))(_2)</td>
<td>a precipitate observed</td>
</tr>
<tr>
<td>MgCrO(_4)</td>
<td>Ca(C/O(_3))(_2)</td>
<td>no visible change</td>
</tr>
</tbody>
</table>

Which conclusion is correct based on these observations?

A  Only Ni(I/O\(_3\))\(_2\) and Mg(C/O\(_3\))\(_2\) are insoluble.
B  Only Ni(I/O\(_3\))\(_2\) and PbCrO\(_4\) are insoluble.
C  Sr(I/O\(_3\))\(_2\), Ni(I/O\(_3\))\(_2\) and PbCrO\(_4\) are insoluble.
D  Sr(I/O\(_3\))\(_2\), Ni(I/O\(_3\))\(_2\), PbCrO\(_4\) and CaCrO\(_4\) are insoluble.
Excess zinc was added to 100 cm³ of 1 mol/dm³ hydrochloric acid. Graph X refers to this reaction. Another experiment was conducted and the result was represented by Graph Y.

Which experiment refers to graph Y?

A. excess zinc reacting with 100 cm³ of 2 mol/dm³ hydrochloric acid
B. excess zinc reacting with 100 cm³ of 1 mol/dm³ sulfuric acid
C. excess zinc reacting with 100 cm³ of 1 mol/dm³ ethanoic acid
D. excess magnesium reacting with 100 cm³ of 1 mol/dm³ hydrochloric acid
The diagram below shows part of the structure of a solid consisting of particles of two elements (represented by ● and ○).

Which statements can be concluded from the diagram?

I. The solid has a giant structure.
II. Each particle in the structure is surrounded by four particles of the other type.
III. There are equal numbers of each type of particle present in a crystal of the solid.
IV. The arrangement of particles is like that of the sodium and chloride ions in sodium chloride.

A. I and IV only
B. II and IV only
C. I, III and IV only
D. I, II, III and IV

An aqueous solution contains barium iodide. Ken wants to obtain a solution that contains I⁻ ions (aq) but no Ba²⁺ ions (aq).

What should he add to the solution?

A. aqueous chlorine
B. hydrochloric acid
C. acidified lead(II) nitrate solution
D. sulfuric acid
25 Two electrolytic cells were connected such that the same amount of current is passed through the two cells. Cell I contains aqueous XSO₄ and Cell II contains aqueous Y₂SO₄.

What is the ratio of the moles of X liberated to that of Y liberated?

<table>
<thead>
<tr>
<th>moles of X liberated</th>
<th>moles of Y liberated</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>1/3</td>
</tr>
</tbody>
</table>

26 A lump of sulfur is burnt inside a gas jar. Some Universal Indicator solution is added to the water. Which of the following would be observed?

<table>
<thead>
<tr>
<th>Water level in the gas jar</th>
<th>Solution shows</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>remains unchanged</td>
</tr>
<tr>
<td>B</td>
<td>drops</td>
</tr>
<tr>
<td>C</td>
<td>rises</td>
</tr>
<tr>
<td>D</td>
<td>rises</td>
</tr>
</tbody>
</table>

*Tanjong Katong Girls' School 14 Sec 4 Preliminary Examination 2017*
27 An old garden gate is being restored. A metal strip was secured on the exterior of the wooden gate using screws. After a few weeks of being exposed to the atmosphere, the screws are heavily corroded but the strips are not.

Which two metals below would give this result?

<table>
<thead>
<tr>
<th></th>
<th>Screws</th>
<th>Strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>copper</td>
<td>steel</td>
</tr>
<tr>
<td>B</td>
<td>steel</td>
<td>zinc</td>
</tr>
<tr>
<td>C</td>
<td>copper</td>
<td>zinc</td>
</tr>
<tr>
<td>D</td>
<td>zinc</td>
<td>copper</td>
</tr>
</tbody>
</table>

28 Pain is often felt when a piece of aluminium foil touches a tin amalgam filing in a tooth. An electric current momentarily flows.

Which statement about what happens is not correct?

A Electrons flow from aluminium to tin amalgam.
B Oxidation state of aluminium increases.
C Aluminium acts as an oxidising agent.
D The current flow is smaller if a piece of zinc foil touches the tin amalgam.

29 What ion can be identified using a reduction process?

A ammonium
B chloride
C nitrate
D sulfate
The following diagram shows a simplified process of desulfurisation.

Which observation at the outlet X best describes the nature of the gases to chimney?

A  Gases turned red litmus blue.
B  Gases turned acidified potassium manganate (VII) purple.
C  Gases turned acidified potassium iodide brown.
D  Gases formed white precipitate with lime water.

A student conducted three experiments to compare the reactivities of four different metals – copper, magnesium, metal Y and metal Z.

A deposit was observed on the metal strip for each experiment.

How many of these metals that were investigated will be able to react with acid?

A  1
B  2
C  3
D  4
Ammonia is produced from hydrogen and nitrogen, according to the equation:

\[ 3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g) \]

The graph shows the yield of ammonia at 200°C and 1 atm.

Which graph below shows a correct comparison of the yield of ammonia produced at temperature of 400°C with the yield at 200°C, keeping the pressure at 1 atm?
Some reactions of the metals $Q$, $R$ and $S$ are given below.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Reaction in air</th>
<th>Reaction with water</th>
<th>Reaction with dilute hydrochloric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q$</td>
<td>burns to form metallic oxide</td>
<td>reacts with steam to form hydrogen</td>
<td>hydrogen formed</td>
</tr>
<tr>
<td>$R$</td>
<td>reacts slowly to form metallic oxide</td>
<td>does not react</td>
<td>does not react</td>
</tr>
<tr>
<td>$S$</td>
<td>reacts to form metallic oxide</td>
<td>does not react</td>
<td>hydrogen formed</td>
</tr>
</tbody>
</table>

In the galvanic cell, $Q^+$, $R^+$ and $S^+$ would represent cations of these three metals.

Which simple cell will produce the greatest voltage?
Different indicators change colour over different pH ranges and it is important to choose the correct indicator to obtain an accurate result in a titration.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>pH range for the colour change</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>lower pH</td>
</tr>
<tr>
<td>Indigo carmine</td>
<td>11.6 to 14.0</td>
<td>blue</td>
</tr>
<tr>
<td>Methyl red</td>
<td>4.2 to 6.3</td>
<td>red</td>
</tr>
<tr>
<td>Methyl violet</td>
<td>0.3 to 3.0</td>
<td>yellow</td>
</tr>
<tr>
<td>Phenolphthalein</td>
<td>8.2 to 10.0</td>
<td>colourless</td>
</tr>
</tbody>
</table>

If a certain weak base is added to a strong acid, the following curve is obtained showing the variation of pH with the volume of weak base added.

![Graph showing pH variation with volume of weak base added]

Which indicator would be the best choice to use in the titration?

A. Indigo carmine
B. Methyl red
C. Methyl violet
D. Phenolphthalein
The table below shows the results of a series of electrolysis experiments.

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Anode (+ve)</th>
<th>Cathode (-ve)</th>
<th>Observation at anode</th>
<th>Observation at cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>platinum</td>
<td>carbon</td>
<td>oxygen gas</td>
<td>hydrogen gas</td>
</tr>
<tr>
<td>aqueous copper(II) nitrate</td>
<td>Y</td>
<td>Y</td>
<td>anode dissolves in the solution</td>
<td>pink copper deposit</td>
</tr>
<tr>
<td>concentrated aqueous magnesium chloride</td>
<td>carbon</td>
<td>platinum</td>
<td>chlorine gas</td>
<td>Z</td>
</tr>
</tbody>
</table>

Which could X, Y and Z be?

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>nitric acid</td>
<td>copper</td>
<td>hydrogen gas</td>
</tr>
<tr>
<td>B</td>
<td>aqueous sodium chloride</td>
<td>copper</td>
<td>grey magnesium deposit</td>
</tr>
<tr>
<td>C</td>
<td>nitric acid</td>
<td>carbon</td>
<td>grey magnesium deposit</td>
</tr>
<tr>
<td>D</td>
<td>aqueous sodium chloride</td>
<td>platinum</td>
<td>hydrogen gas</td>
</tr>
</tbody>
</table>

36 A compound $X_2Y$ was decomposed as follows:

$$X_2Y(g) \rightarrow X_2(g) + Y(g) \quad \Delta H = \text{positive}$$

What difference would there be if the same amount of $X_2Y$ were decomposed in the presence of a catalyst?

A More $X_2$ would be present at the end of the reaction.
B Less heat would be absorbed during the reaction.
C $\Delta H$ would become negative.
D Time taken to decompose $X_2Y$ would be shorter.
37 An organic compound has the following structure.

\[
\begin{array}{cccc}
H & H & H & O \\
\text{H} & \text{C} & \text{C} & \text{O} & \text{C} & \text{CH}_2 & \text{OH} \\
\end{array}
\]

Which observation is correct when the organic compound is tested with zinc, aqueous bromine and acidified potassium manganate(VII) solution?

<table>
<thead>
<tr>
<th></th>
<th>With solid zinc</th>
<th>With aqueous bromine</th>
<th>Warmed with acidified potassium manganate(VII) solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>effervescence</td>
<td>turned colourless</td>
<td>turned colourless</td>
</tr>
<tr>
<td>B</td>
<td>effervescence</td>
<td>no reaction</td>
<td>remained purple</td>
</tr>
<tr>
<td>C</td>
<td>no reaction</td>
<td>turned colourless</td>
<td>turned colourless</td>
</tr>
<tr>
<td>D</td>
<td>no reaction</td>
<td>no reaction</td>
<td>remained purple</td>
</tr>
</tbody>
</table>

38 When iodine, I₂, reacts with an unsaturated compound, one molecule of iodine adds across each double bond.

Unsaturated fatty acids react similarly with iodine. 0.150 mol of a particular fatty acid reacts with exactly 0.300 mol of I₂.

What could the fatty acid be?

A lauric acid: \( \text{CH}_3(\text{CH}_2)_{16}\text{CO}_2\text{H} \)
B linoleic acid: \( \text{CH}_3(\text{CH}_2\text{CH}═\text{CH}_2)_{16}\text{CO}_2\text{H} \)
C palmitoleic acid: \( \text{CH}_3(\text{CH}_2)_{15}\text{CH}═\text{CH}(\text{CH}_2)_{16}\text{CO}_2\text{H} \)
D arachidonic acid: \( \text{CH}_3(\text{CH}_2\text{CH}═\text{CH})_{15}\text{CO}_2\text{H} \)
39 The reaction between a carboxylic acid, \( C_xH_{2y+1}CO_2H \) and an alcohol, \( C_nH_{2n+1}OH \), produces an ester. How many hydrogen atoms does one molecule of the ester contain?

A \( y + 2n \)  
B \( y + 2n + 1 \)  
C \( y + 2n + 2 \)  
D \( y + 2n + 3 \)

40 Cuts and wounds are often stitched using a biodegradable polymer with the formula shown below.

\[
\begin{array}{c}
| & CH_3 & O \\
\hline
\hline
CH_2 & C & O \quad CH & C & O
\end{array}
\]

It is made from a condensation polymerisation reaction between lactic acid, \( HOCH(CH_3)COOH \), and glycolic acid.  

What is the formula of glycolic acid?

A \( HOCH_2COOH \)  
B \( HOCH_2CH_2OH \)  
C \( HOOCCH_2COOH \)  
D \( HOOCCH_2CH_2OH \)
## Answers

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>11</td>
<td>C</td>
<td>21</td>
<td>C</td>
<td>31</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>12</td>
<td>A</td>
<td>22</td>
<td>D</td>
<td>32</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>13</td>
<td>A</td>
<td>23</td>
<td>C</td>
<td>33</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>14</td>
<td>C</td>
<td>24</td>
<td>D</td>
<td>34</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>15</td>
<td>D</td>
<td>25</td>
<td>B</td>
<td>35</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>16</td>
<td>C</td>
<td>26</td>
<td>C</td>
<td>36</td>
<td>D</td>
</tr>
<tr>
<td>7</td>
<td>A</td>
<td>17</td>
<td>B</td>
<td>27</td>
<td>D</td>
<td>37</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>18</td>
<td>D</td>
<td>28</td>
<td>C</td>
<td>38</td>
<td>B</td>
</tr>
<tr>
<td>9</td>
<td>B</td>
<td>19</td>
<td>A</td>
<td>29</td>
<td>C</td>
<td>39</td>
<td>B</td>
</tr>
<tr>
<td>10</td>
<td>A</td>
<td>20</td>
<td>D</td>
<td>30</td>
<td>D</td>
<td>40</td>
<td>A</td>
</tr>
</tbody>
</table>
TANJONG KATONG GIRLS’ SCHOOL
PRELIMINARY EXAMINATION 2017
SECONDARY FOUR

5073/02 CHEMISTRY Paper 2

Tuesday 12 September 2017 1 h 45 min

INSTRUCTIONS TO CANDIDATES
Write your name, class and register number at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use papers clips, glue or correction fluid.

Section A
Answer all questions in the space provided.

Section B
Answer all the questions in the space provided, the last question is in the form of
either/or.
The number of marks is given in brackets [ ] at the end of each question or part
question.

INFORMATION FOR CANDIDATES
A copy of the Periodic Table is printed on page 23.
The use of an approved scientific calculator is expected, where appropriate.

The total marks for this paper is 80.

This Question Paper consists of 23 printed pages, including this page.
SECTION A

Answer all the questions in this section in the spaces provided.
The total marks for this section is 50.

A1 Suggest suitable chemical reagents to prepare the following salts:
In choosing the chemical reagents, you should take into consideration the need
to achieve optimal yield as well as safety.

(a) (i) copper(II) sulfate

.................................................. and ..................................................

(ii) copper(II) carbonate

.................................................. and ..................................................

(iii) sodium nitrate

.................................................. and .................................................. [3]

(b) Name a reagent that would react with ammonium carbonate to produce

(i) ammonia gas

..................................................

(ii) carbon dioxide gas

.................................................. [2]

[total: 5]
In 2010, the Nobel Prize for Physics was awarded to two researchers, Andre Geim and Konstantin Novoselov, from Manchester University for their work on preparing graphene from graphite. The structures of graphite and graphene are shown.

(a) Describe the structure of graphite.

(b) State one common physical property that you would expect from graphite and graphene.

(c) Graphene can be prepared from graphite by using sticky tape. Use your knowledge of the bonding in graphite to explain why it is possible to create graphene by this method.

[total: 3]
A3
(a) A student sets up a simple cell between a copper electrode and an unknown metal M electrode shown below. The copper electrode is found to be the positive electrode.

\[
\begin{array}{c}
\text{direction of} \\
\text{electron flow}
\end{array}
\]

\[
\begin{array}{c}
\text{unknown} \\
\text{metal, M}
\end{array}
\]

\[
\begin{array}{c}
\text{M} \text{SO}_4 \\
(1 \text{ mol dm}^{-3})
\end{array}
\]

\[
\begin{array}{c}
\text{C} \text{u} \text{SO}_4 \\
(1 \text{ mol dm}^{-3})
\end{array}
\]

(i) In the box over the voltmeter symbol, draw an arrow to show the direction of the electron flow through the voltmeter. [1]

(ii) The student made the following conclusion:

M is more reactive than copper.

Do you agree with this conclusion? Explain your answer. [2]

(iii) Describe what might be observed if a rod of metal M is dipped into a 1 mol dm\(^{-3}\) CuSO\(_4\) solution. Write ionic equation(s) for any reactions that occur. [2]
(iv) The student was told that \( M \) could either be silver, zinc or lead. He added powdered sample of \( M \) to dilute sulfuric acid and observed that \( M \) dissolved with rapid effervescence to form a colourless solution. Deduce which metal \( M \) could be. Explain your answer.

.................................................................................................................................................
.................................................................................................................................................
.................................................................................................................................................
.................................................................................................................................................

(b) To enhance the appearance of a plastic ornament that the student plans to give away as a gift, he silver-plates it as a cheaper alternative to using solid silver metal. The diagram below shows the apparatus for the silver-plating process.

\[ \text{d.c. source} \]
\[ \text{plastic ornament to be plated} \]
\[ \text{electrolyte} \]

(i) Indicate clearly on the diagram, the polarity (+/-) of the power source. [1]

(ii) Suggest a suitable electrolyte. [1]

Electrolyte: ........................................

(iii) For the ornament to be silver-plated, it has to be first coated with a thin layer of graphite. Why is the ornament first coated with graphite? [1]

.................................................................................................................................................
.................................................................................................................................................
.................................................................................................................................................
.................................................................................................................................................

[total: 11]
A4. The percentage yield of the product in a gas-phase reversible reaction varies with changes in temperature and pressure as shown below.

% yield of product

Pressure (atmospheres)

(a) Use the information given above to deduce whether the forward reaction is exothermic or endothermic. Explain your answer.

(b) Sketch a labelled energy profile diagram of the forward reaction. You may use A(g) → B(g) to represent the reactants and C(g) to represent the product.
(c) The graph below shows how the number of moles of the product, \( C(g) \) of the gas-phase reaction changes during the course of the reaction under certain conditions.

Use the information on page 6, sketch a graph on the same axes to illustrate what happens when the reaction is carried out at a higher pressure – label this as graph I. [1]

(d) With reference to collision theory, explain the shape of graph I. [3]

[total: 8]
A5 Many compounds of chlorine are manufactured from brine, NaCl(aq). The electrolysis of brine produces chlorine and sodium hydroxide. The diagram below shows the set-up of the electrolysis of brine using platinum electrodes.

(a) (i) Write the equations of the reactions taking place at the cathode and anode.

cathode: ................................................................. [2]
anode: ................................................................. [2]

(ii) Suggest how sodium hydroxide is formed.
................................................................. [1]

(b) In some industrial electrolytic cells, the products, chlorine and sodium hydroxide, are allowed to react further. Different compounds are formed when chlorine and sodium hydroxide react under different conditions.

With cold dilute sodium hydroxide,

\[ \text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaClO} + \text{NaCl} + \text{H}_2\text{O} \]

With hot, concentrated sodium hydroxide,

\[ 3\text{Cl}_2 + 6\text{NaOH} \rightarrow \text{NaClO}_3 + 5\text{NaCl} + 3\text{H}_2\text{O} \]

Explain with reasons, whether you agree with the following statements:

(i) With hot concentrated sodium hydroxide, chlorine is oxidised.
................................................................. [1]
(ii) Chlorine is oxidised to a larger extent when reacted with hot, concentrated sodium hydroxide than when reacted with cold, dilute sodium hydroxide.

A6

This question is about reactions of Group VII elements.

(a) Interhalogen compounds are formed between atoms of different elements in Group VII such as chlorine, bromine and fluorine.

Chlorine and fluorine react vigorously to form chlorine trifluoride, CF₃. When gaseous CF₃ is added to water, three gases are formed. The following observations are made when the gases are tested:

- Damp blue litmus turned red and bleached.
- Glowing splint rekindled.

The third gas is hydrogen fluoride.

Write a balanced equation, including state symbols, for the reaction between chlorine trifluoride and water.

(b) Astatine is an element found below iodine in Group VII of the Periodic Table. Suggest with reason what you would observe when aqueous chlorine is added to aqueous sodium astatide. Support your answer with relevant equation(s).
c) Labels of test tubes containing liquids hexene, C₆H₁₂ and hexane, C₆H₁₄ have fallen off. Suggest a chemical test to distinguish between the two liquids.

.................................................................[2]

A7 In recent years, there has been worldwide interest in the possible extraction of 'shale gas' (a form of natural gas) as an important energy source.

(a) One of the problems associated with using shale gas is its variable composition. **Table 1** shows the percentage composition of shale gas from three different sources J, K and L.

<table>
<thead>
<tr>
<th>Source</th>
<th>CH₄</th>
<th>C₆H₁₂</th>
<th>C₆H₁₄</th>
<th>CO₂</th>
<th>N₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>80.3</td>
<td>6.1</td>
<td>2.3</td>
<td>1.4</td>
<td>7.9</td>
</tr>
<tr>
<td>K</td>
<td>82.1</td>
<td>14.0</td>
<td>3.5</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>L</td>
<td>77.5</td>
<td>4.0</td>
<td>0.9</td>
<td>3.3</td>
<td>14.3</td>
</tr>
</tbody>
</table>

In the formulae above, x and y are variables. **Table 1**

(i) Which source of shale gas, J, K or L, will provide the most energy when burned? Explain your answer. .................................................................[1]

(ii) Suggest a method by which carbon dioxide can be removed from shale gas. .................................................................[1]
(iii) Draw a ‘dot and cross’ diagram to show the arrangement of electrons in a molecule of carbon dioxide.

You only need to show outer shell electrons. [2]

(b) Table 2 shows a comparison of the relative amounts of pollutants produced when shale gas, fuel oil and coal are burned to produce the same amount of energy.

<table>
<thead>
<tr>
<th>air pollutant</th>
<th>shale gas</th>
<th>fuel oil</th>
<th>coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>117</td>
<td>0.64</td>
<td>208</td>
</tr>
<tr>
<td>CO</td>
<td>0.040</td>
<td>0.033</td>
<td>0.208</td>
</tr>
<tr>
<td>NO₂</td>
<td>0.092</td>
<td>0.548</td>
<td>0.457</td>
</tr>
<tr>
<td>SO₂</td>
<td>0.001</td>
<td>1.12</td>
<td>2.59</td>
</tr>
<tr>
<td>particulates</td>
<td>0.007</td>
<td>0.84</td>
<td>2.74</td>
</tr>
</tbody>
</table>

Table 2

(i) Suggest why shale gas produces the smallest amount of CO₂. [1]

(ii) Explain which of the three fuels, shale gas, fuel oil or coal, is the largest contributor to ‘acid rain’. fuel...

............................................................................................................................................ [1]

(iii) Suggest a reason why fuel oil and coal produce more NO₂ than shale gas. 

............................................................................................................................................ [1]
(iv) Explain why carbon monoxide causes breathing problems.

............................................................................................................[1]

(c) Butane is used as fuel for a common lighter or butane torch.

A 30 cm$^3$ sample of butane, C$_4$H$_{10}$, was completely reacted in a limited supply of oxygen to produce 60 cm$^3$ of carbon dioxide and 50 cm$^3$ of carbon monoxide.

Calculate the volume of oxygen used. (All volumes were measured at room temperature and pressure.)
Section B

Answer all three questions in this section.

The last question is in the form of either/or and only one of the alternatives should be attempted.

The total marks for this section is 30.

B8 Sodium chloride, sodium bromide, sodium iodide and magnesium oxide are ionic compounds.

An estimate of the strength of the bonds in an ionic compound can be obtained by measuring the lattice energy of the compound, which is the energy evolved when oppositely charged ions in the gas phase come together to form a solid.

For example, the lattice energy of NaCl is the energy evolved when Na\(^+\) and Cl\(^-\) ions in the gas phase come together to form the lattice of alternating Na\(^+\) and Cl\(^-\) ions in the NaCl crystal.

\[
\text{Na}^+(g) + \text{Cl}^-(g) \rightarrow \text{NaCl} (s)
\]

The magnitude of the lattice energy is 781 kJ mol\(^{-1}\).

The magnitude of lattice energy is directly proportional to the charges on the ions (q\(_1\) and q\(_2\)) and inversely proportional to distance between the ions (r\(^2\)). The greater the ionic radius, the greater the distance between the ions.

\[
\text{Lattice Energy} = \frac{q_1 \times q_2}{r^2}
\]

(a) Describe the bonding and structure of NaCl.

...................................................................................................................................................................................... [2]

(b) (i) Suggest with reason whether you expect the value of the lattice energy to be negative or positive.

...................................................................................................................................................................................... [1]
(ii) Hence, complete the energy level diagram below for the reaction:

\[ \text{Na}^+ (g) + \text{Cl}^- (g) \rightarrow \text{NaCl}^- (s) \]

(c) (i) Explain why the magnitude of lattice energies of the sodium halides decreases from NaCl to NaI.

(ii) The table shows the ionic radius of some ions:

<table>
<thead>
<tr>
<th>Ion</th>
<th>Mg^{2+}</th>
<th>Na^{+}</th>
<th>Cl^{-}</th>
<th>I^{-}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionic radius (pm)</td>
<td>72</td>
<td>102</td>
<td>140</td>
<td>184</td>
</tr>
</tbody>
</table>

Using the information above and the data from the table, suggest how you would expect the magnitude of the lattice energy of MgO to be compared to that of NaCl. Explain your answer.
(iii) Hence, suggest with reason how you would expect the melting point of MgO to be compared to NaCl.

.................................................................

.................................................................

................................................................. [2]

[total:10]
B9 Amines belong to a homologous series which has a general formula of 
\( C_nH_{2n+1}NH_2 \), when \( n \) is the number of carbon atoms per molecule.

Amines and their salts have chemical properties similar to those of ammonia and 
ammonium salts.

For example, methylamine dissociates in water to form an alkali.

\[ CH_3NH_2 + H_2O = CH_3NH_3^+ + OH^- \]

(a) Would you expect the solution formed by amines to be a weak or strong alkali? 
Explain your answer.

.............................................................................................................................................................................. [2]

(b) Methylamine reacts with acids to form salts.

\[ CH_3NH_2 + HCl \rightarrow CH_3NH_3Cl \]

methylammonium chloride

(i) Write a balanced chemical reaction between sulfuric acid and methylamine. 
Name the salt formed.

Equation: .............................................................................................................................................................................. Name of salt: ................................................................................................................... [2]

(ii) Suggest a reagent that could be used to displace methylamine, from its 
salt methylammonium chloride.

............................................................................................................................................................................................ [1]
(iii) When the colourless gases hydrogen bromide and methylamine come into contact, a white solid is formed.

\[ \text{CH}_3\text{NH}_2(g) + \text{HBr}(g) \rightarrow \text{CH}_3\text{NH}_3\text{Br}(s) \]
white solid

The following apparatus can be used to compare the rates of diffusion of the two gases methylamine and hydrogen bromide.

gives off CH₃NH₂(g)  gives off HBr(g)
cotton wool soaked in methylamine (aq)  cotton wool soaked in conc. hydrobromic acid

cotton wool soaked in methylanime (aq)

Predict at which position, A, B or C, the white solid will form. Explain your choice.

[2]

(c) Under different conditions, amines can react with carboxylic acids to form a product that has the same linkage as nylon.

(i) Draw the full structural formula of the organic product formed from the reaction between methylamine and ethanoic acid. Name the functional group of the organic product.

functional group: .................................................. [2]
(ii) Another homologous series called diamine has a general formula of \( \text{H}_2\text{NC}_n\text{H}_{2n}\text{NH}_2 \).

Draw the full structural formula of the organic product from the reaction between \( \text{H}_2\text{NCH}_2\text{NH}_2 \) and the dicarboxylic acid, \( \text{HOOC}(\text{CH}_2)\text{COOH} \).
B10 EITHER

As there are millions of different organic compounds, it is useful to classify and group these organic compounds into families called homologous series. An example of a homologous series is carboxylic acids.

(a) Define the term homologous series.

(b) Lactic acid is present in certain plant juices as well as in the blood and muscles of animals.

(i) Dehydration of lactic acid removes a water molecule. This produces CH₂=CHCOOH.

Draw the structural formula of the repeat unit for the polymer formed by addition polymerisation of CH₂=CHCOOH.

(ii) Under suitable conditions, lactic acid may react with ethanol to form a sweet-smelling compound.

Write a chemical equation, using structural formula to show this reaction. State the reagent and conditions required to form the sweet-smelling compound.

reagent and conditions: ............................................................  [3]
(iii) W is an isomer of lactic acid. Under suitable conditions, W undergoes oxidation to form malonic acid.

\[
\begin{array}{c}
\text{HO} \\
\text{C} \\
\text{CH}_2 \\
\text{C} \\
\text{OH}
\end{array}
\]

malonic acid

Write the structural formula of W and suggest the reagent and conditions for W to form malonic acid.

structural formula of W:

reagent and conditions: .......................................................... [2]

(iv) 1.97 g of an impure sample of malonic acid was dissolved in water and the resulting solution titrated with 1.00 mol dm\(^{-3}\) NaOH. 27.5 cm\(^3\) of 1.00 mol dm\(^{-3}\) NaOH was required for complete neutralisation.

Use these data to calculate the percentage purity of malonic acid. [3]

[total: 10]
B10 OR

Long chain alkanes such as octane, \( \text{C}_8\text{H}_{18} \) can be 'cracked' to produce shorter chain hydrocarbons which could then be separated by fractional distillation.

\[
\text{octane} \rightarrow \quad \text{B} \quad + \quad \text{a mixture of C, D and E} \\
\text{C}_8\text{H}_{18} \quad \quad \text{C}_3\text{H}_6 \quad \quad \text{(isomers of C}_5\text{H}_{12})
\]

(a) State the conditions necessary for this reaction to take place. 

................................................................................................................................. [1]

(b) Write the structural formula of B. 

................................................................................................................................. [1]

(c) Outline how the mixture may be separated by fractional distillation in the laboratory. 

................................................................................................................................. [3]
(d) C, D and E exhibit structural isomerism. They are isomers of pentane, C₅H₁₂.

(i) Define the term isomerism.

(ii) Complete the table to show all possible isomers for pentane.

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(e) In a separate experiment, one of the alkanes C, D or E reacted with bromine under ultraviolet light and produced only one bromopentane compound F, with the formula, C₅H₁₁Br.

Suggest the structure of F and the alkane it was produced from.

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>Alkane (C₅H₁₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[total: 10]
The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>Period</th>
<th>Element</th>
<th>Atomic Number</th>
<th>Symbol</th>
<th>Mass Number</th>
</tr>
</thead>
</table>

Tanjong Katong Girls' School

Preliminary Examination 2017
SUGGESTED SOLUTIONS

Paper 2
Section A (50 marks)

<table>
<thead>
<tr>
<th>Q No.</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>(a)(i)</td>
<td>copper(II) oxide/copper(II) carbonate and sulfuric acid</td>
</tr>
<tr>
<td>(ii)</td>
<td>any soluble copper(II) salt and any soluble carbonate</td>
</tr>
<tr>
<td>(iii)</td>
<td>sodium hydroxide (not sodium metal) and nitric acid</td>
</tr>
<tr>
<td>(b)(i)</td>
<td>any alkalis</td>
</tr>
<tr>
<td>(ii)</td>
<td>any acids</td>
</tr>
<tr>
<td>A2</td>
<td>Graphite exists as a giant molecular structure made up of layers of carbon atoms held together by strong covalent bonds in hexagonal rings.</td>
</tr>
<tr>
<td>(b)</td>
<td>High electrical conductivity; High melting point</td>
</tr>
<tr>
<td>(c)</td>
<td>The Van der Waals forces holding together the layers of carbon atoms are weak. Hence, they are easily overcome by physical force.</td>
</tr>
<tr>
<td>A3</td>
<td>(a)(i)</td>
</tr>
<tr>
<td></td>
<td>Agree (no marks)</td>
</tr>
<tr>
<td></td>
<td>M is the negative electrode suggests that M has undergone oxidation as M loses electrons.</td>
</tr>
<tr>
<td></td>
<td>Therefore M must have a higher tendency to form M^{2+} as compared to Cu.</td>
</tr>
<tr>
<td>(ii)</td>
<td>Pink solid of Cu deposited. Blue solution decolourises.</td>
</tr>
<tr>
<td></td>
<td>M(s) + Cu^{2+}(aq) → M^{2+} (aq) + Cu(s)</td>
</tr>
<tr>
<td>(iv)</td>
<td>M is Zn as Zn will react with sulfuric acid to form a colourless solution with effervescence of H_2.</td>
</tr>
<tr>
<td></td>
<td>M cannot be Ag as M is more reactive than Cu or the charge of M^{2+} is +2 while the charge of Ag^{+} is +1.</td>
</tr>
<tr>
<td></td>
<td>M cannot be Pb as Pb will react with sulfuric acid and form a precipitate of PbSO_4.</td>
</tr>
<tr>
<td>(b)(i)</td>
<td>Ornament is connected to the negative electrode.</td>
</tr>
<tr>
<td>(ii)</td>
<td>Electrolyte: silver nitrate</td>
</tr>
<tr>
<td>(iii)</td>
<td>The ornament is plastic which does not conduct electricity. It has to be coated with graphite for it to conduct electricity before it can be silver-plated.</td>
</tr>
<tr>
<td>A4</td>
<td>(a)</td>
</tr>
</tbody>
</table>
|       | The forward reaction is exothermic as % yield decreases when temperature increases.
<table>
<thead>
<tr>
<th>Q No.</th>
<th>Answer</th>
</tr>
</thead>
</table>
| (b)   | **Energy**<br><br>![Energy Diagram](image)
| (c)   | **Number of moles of C (g)**
<p>| (d)   | As pressure increases, the gas particles are closer together and there is increase in the frequency of collisions between the gas particles. As a result, the frequency of the effective collision increases, rate of reaction increases, steeper gradient for graph I. At a higher pressure, the yield also increases. |
| A6 (a) | Cathode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$&lt;br&gt;Anode: $2Cl^-(g) \rightarrow Cl_2(g) + 2e^-$ |
| (ii)  | Sodium hydroxide is formed as $H^+$ and $Cl^-$ are discharged at the electrodes leaving behind $Na^+$ and $OH^-$ in the solution. |
| (b)   | Disagree&lt;br&gt;With hot $NaOH(aq)$, chlorine is oxidised to $NaCl/O$ and reduced to $NaCl.$ |
| (ii)  | Agree&lt;br&gt;With cold dilute $NaOH(aq)$, the oxidation state of chlorine increased from 0 to +1.&lt;br&gt;With hot concentrated $NaOH(aq)$, the oxidation state of chlorine increased to a greater extent compared to cold dilute sodium hydroxide from 0 to +5. |
| A6 (a) | $4ClF_3(g) + 6H_2O(l) \rightarrow 2Cl_2(g) + 3O_2(g) + 12HF(g)$ |
| (b)   | The more reactive chlorine displaces the less reactive astatine from its salt. Black solid of $At_2$ formed. |</p>
<table>
<thead>
<tr>
<th>Q No.</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>C/₂ + 2Na₂At → 2NaCl + At₂</td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>Add bromine to the test tubes in the absence of UV light. Hexane will decolourise the reddish-brown bromine. Hexane will not decolourise the reddish-brown bromine.</td>
</tr>
<tr>
<td>A7</td>
<td></td>
</tr>
<tr>
<td>(a)(i)</td>
<td>K since it has the greatest % of hydrocarbons / carbon-containing compounds or 99.6 % of it is burnt for energy or greatest % of CH₄</td>
</tr>
<tr>
<td>(i)</td>
<td>React with lime / CaO / soda lime / Ca(OH)₂ / KOH / NaOH / limewater</td>
</tr>
<tr>
<td>(iii)</td>
<td>![Diagram]</td>
</tr>
<tr>
<td>Legend :</td>
<td></td>
</tr>
<tr>
<td>x - electrons of carbon</td>
<td></td>
</tr>
<tr>
<td>* - electrons of oxygen</td>
<td></td>
</tr>
<tr>
<td>(b)(i)</td>
<td>‘Shale’ gas have a shorter carbon / hydrocarbon chain or shorter hydrocarbon or fewer carbon atoms in its chain or have high H / C ratio or majority of CH₄ present in shale gas</td>
</tr>
<tr>
<td>(ii)</td>
<td>Coal produces the largest amount of SO₂ or largest combined amount of SO₂ and NO₂</td>
</tr>
<tr>
<td>(iii)</td>
<td>They burn at higher temperatures</td>
</tr>
<tr>
<td>(iv)</td>
<td>CO combines with haemoglobin in the red blood cells, causing the red blood cells to be unable to transport oxygen to the rest of the body.</td>
</tr>
<tr>
<td>(c)</td>
<td>2C₄H₁₀ + 11O₂ → 4CO₂ + 4CO + 10H₂O</td>
</tr>
<tr>
<td>Number of moles of O₂ = 60/4 x 11 = 165 cm³</td>
<td></td>
</tr>
</tbody>
</table>
Section B (30 marks)

<table>
<thead>
<tr>
<th>Q No.</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>B8</td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Sodium chloride exists as giant ionic structure made up of oppositely charged ions held together by strong electrostatic forces of attraction (or ionic bonds).</td>
</tr>
<tr>
<td>(b)(i)</td>
<td>The value of lattice energy is negative as energy is given out when ionic bonds are formed between the gaseous ions.</td>
</tr>
<tr>
<td>(ii)</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>(c)(i)</td>
<td>The ionic radius increases from $\text{Cl}^-$ to $\text{I}^-$ due to increasing number of electron shells. Based on the equation.</td>
</tr>
<tr>
<td>(ii)</td>
<td>The magnitude of the lattice energy of MgO is larger than that of the lattice energy of NaCl. (no marks) The charges of Mg$^{2+}$ and O$^{2-}$ are higher than Na$^+$ and Cl$^-$. while the ionic radii of Mg$^{2+}$ and O$^{2-}$ are smaller than that of Na$^+$ and Cl$^-$.</td>
</tr>
<tr>
<td>(iii)</td>
<td>The melting point of MgO is higher than that of NaCl as more energy is required to overcome the stronger forces of attraction.</td>
</tr>
<tr>
<td>B9</td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>Amines are weak alkalis. Amines dissociate partially in aqueous solutions to form hydroxide ions.</td>
</tr>
<tr>
<td>(b)(i)</td>
<td>$2\text{CH}_3\text{NH}_2 + \text{H}_2\text{SO}_4 \rightarrow (\text{CH}_3\text{NH}_3)_2\text{SO}_4$ methylammonium sulfate</td>
</tr>
<tr>
<td>(b)(ii)</td>
<td>NaOH or Ca(OH)$_2$ or sodium hydroxide or calcium hydroxide</td>
</tr>
<tr>
<td>(b)(iii)</td>
<td>C Methylamine or CH$_3$NH$_2$ has a lower relative molecular mass (31) than hydrogen bromide or HBr (81); methylamine diffuses faster.</td>
</tr>
<tr>
<td>(c)(i)</td>
<td><img src="image" alt="Functional group diagram" /> name of functional group: amide</td>
</tr>
<tr>
<td>(c)(ii)</td>
<td><img src="image" alt="Monomer structure" /> where $n$ is a large number</td>
</tr>
<tr>
<td>Q No.</td>
<td>Answer</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td><strong>B10</strong> Either</td>
<td></td>
</tr>
<tr>
<td>(a)</td>
<td>A homologous series is a family of organic compounds with the same functional group and similar chemical properties.</td>
</tr>
<tr>
<td>(b)(i)</td>
<td><img src="image" alt="Chemical structure of a homologous series" /></td>
</tr>
<tr>
<td>(ii)</td>
<td><img src="image" alt="Chemical reaction" /> conditions: concentrated sulfuric acid; warm</td>
</tr>
<tr>
<td>(iii)</td>
<td><img src="image" alt="Acidified potassium permanganate reaction" /> acidified potassium manganate (VII), heat</td>
</tr>
</tbody>
</table>
| (iv) | As there are two -COOH in malonic acid, 1 mole of malonic acid requires 2 moles of NaOH.  
\[ \text{no. of mol of NaOH} = \frac{27.5}{1000} \times 1.00 = 0.0275 \text{ mol} \]  
\[ \text{no of mol of malonic acid} = \frac{0.0275}{2} = 0.01375 \text{ mol} \]  
\[ \text{mass of pure malonic acid} = 0.01375 \times 104 = 1.43 \text{ g} \]  
\[ \% \text{ purity of malonic acid} = \frac{1.43}{1.97} \times 100\% = 72.6\% \] |
| **B10 or** | |
| (a) | aluminium oxide/silicon dioxide and high temperature/600°C |
| (b) | CH₂=CHCH₃ |
| (c) | During fractional distillation, the liquid with the lowest boiling point will vaporise first and distil over as the first fraction (or distillate).  
Vapours of liquids with higher boiling points condense along the fractionating column and fall back into the round-bottomed flask. |
<table>
<thead>
<tr>
<th>Q No.</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After all of the liquid with the lowest boiling point is distilled, the temperature of the mixture increases again to the next lowest boiling point where it will vaporise and be collected as the second fraction</td>
</tr>
<tr>
<td>(d)(i)</td>
<td>Isomerism is the existence of two or more compounds with the same molecular formula but with different structural formulae.</td>
</tr>
</tbody>
</table>

(i)

![Chemical structures](image1)

(e)

F:

![Chemical structures](image2)
Chemistry Paper 1

Thursday 3 August 2017 1 hour

Victoria School
Preliminary Examination Two (Secondary Four)

Additional materials: Multiple Choice Answer Sheet

Read these instructions first

Write in soft pencil.
Write your name, class and index number on all the work you hand in.
Do not use staples, paper clips, glue or correction fluid.

There are forty questions on this paper. Answer all questions. For each question, there are four possible answers A, B, C and D. Choose the one that you consider correct and record your choice in soft pencil on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

A copy of Periodic Table is printed on page 13.

This question paper consists of 13 printed pages (including this cover page)
An unknown white solid, M, melts between 171 °C and 174 °C. When chromatography is performed with water as the solvent, M produces only one spot on the chromatogram.

Which statement must be true about M?

A. M can sublime.
B. M is an ionic compound.
C. M is impure as it melts over a range of temperatures.
D. M is pure as it produces only 1 spot on the chromatogram.

A beaker containing hydrogen chloride gas was placed over a porous pot containing oxygen as shown below.

![Diagram of a beaker with hydrogen chloride and oxygen]

How would the water levels at P and Q change after a few minutes and three hours?

<table>
<thead>
<tr>
<th></th>
<th>after a few minutes</th>
<th>after three hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>higher at P than Q</td>
<td>higher at P than Q</td>
</tr>
<tr>
<td>B</td>
<td>higher at P than Q</td>
<td>same at P and Q</td>
</tr>
<tr>
<td>C</td>
<td>higher at Q than P</td>
<td>higher at Q than P</td>
</tr>
<tr>
<td>D</td>
<td>higher at Q than P</td>
<td>same at Q and P</td>
</tr>
</tbody>
</table>

Paper chromatography is performed on a substance. However, it was observed that the sample had failed to move up from the start line.

What is the best explanation for this observation?

A. The sample is insoluble in the solvent.
B. The solvent level was above the start line.
C. The start line was drawn in pen.
D. The test tube was not stoppered.
4 Which of the following pairs of substances can be separated by sublimation?

A copper(II) chloride and copper(II) oxide
B ethanol and ethene
C silver chloride and aluminium oxide
D sodium chloride and ammonium chloride

5 Which statement about an atom is correct?

A Each element has only one nucleon number.
B The nucleon number can be less than the atomic number.
C The nucleon number can be equal to the atomic number.
D The number of neutrons is never equal to the number of electrons.

For questions 6, 7 and 8, use the table below which shows the electronic configuration of elements P to T.

<table>
<thead>
<tr>
<th>elements</th>
<th>electronic configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>2.8.1</td>
</tr>
<tr>
<td>Q</td>
<td>2.8.8.1</td>
</tr>
<tr>
<td>R</td>
<td>2.8</td>
</tr>
<tr>
<td>S</td>
<td>2.4</td>
</tr>
<tr>
<td>T</td>
<td>2.8.6</td>
</tr>
</tbody>
</table>

6 Which two elements are from the same group?

A P and Q
B P and T
C R and S
D S and T

7 How many protons are present when element T forms an ion?

A 6
B 14
C 16
D 18

8 Which elements will react to form a ionic compound with formula X₂Y?

A P and R
B P and T
C R and S
D S and T
9. The diagrams below show the structures of a solid element in two forms, P and Q.

![Diagram showing structures of P and Q]

What are the uses of P and Q based on their structures as shown above?

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>drilling</td>
<td>drilling</td>
</tr>
<tr>
<td>B</td>
<td>drilling</td>
<td>lubricating</td>
</tr>
<tr>
<td>C</td>
<td>lubricating</td>
<td>drilling</td>
</tr>
<tr>
<td>D</td>
<td>lubricating</td>
<td>lubricating</td>
</tr>
</tbody>
</table>

10. Ammonium perchlorate has a formula of NH₄ClO₄. What is the formula of iron(III) perchlorate?

A. FeClO₄   B. Fe(ClO₄)₂   C. Fe₃ClO₄   D. Fe₆H₆(ClO₄)₃

11. Which reagent can be used to demonstrate that zinc oxide is amphoteric?

A. hydrochloric acid
B. sodium hydroxide
C. universal indicator
D. water

12. Which reaction does not produce a salt?

A. CH₃COOH + CH₃OH → CH₃COOCH₃ + H₂O
B. CH₃COOH + NaOH → CH₃COONa + H₂O
C. 2CH₃COOH + Mg → (CH₃COO)₂Mg + H₂
D. 2CH₃COOH + CaCO₃ → (CH₃COO)₂Ca + H₂O + CO₂
13 Which statements correctly describe the rate of reaction and volume of hydrogen gas produced when 100 cm$^3$ of 1.00 mol dm$^{-3}$ sulfuric acid and 100 cm$^3$ of 1.00 mol dm$^{-3}$ nitric acid are reacted separately with excess magnesium?

<table>
<thead>
<tr>
<th>rate of reaction</th>
<th>volume of H$_2$ obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> both reactions would proceed at the same rate</td>
<td>the same volume of H$_2$ would be obtained for both acids</td>
</tr>
<tr>
<td><strong>B</strong> both reactions would proceed at the same rate</td>
<td>twice the volume of H$_2$ would be obtained when sulfuric acid is used</td>
</tr>
<tr>
<td><strong>C</strong> the reaction with sulfuric acid would proceed at a faster rate</td>
<td>the same volume of H$_2$ would be obtained for both acids</td>
</tr>
<tr>
<td><strong>D</strong> the reaction with sulfuric acid would proceed at a faster rate</td>
<td>twice the volume of H$_2$ would be obtained when sulfuric acid is used</td>
</tr>
</tbody>
</table>

14 Which pH curve best represents excess lead(II) oxide being added to 1.00 mol dm$^{-3}$ nitric acid?

A

B

C

D

15 What is the best method to produce iron(II) hydroxide?

A react aqueous iron(II) nitrate with aqueous sodium hydroxide
B react aqueous iron(II) nitrate with copper(II) hydroxide
C react excess iron metal with aqueous sodium hydroxide
D react excess iron metal with dilute hydrochloric acid
16 A student tried unsuccessfully to prepare silver chloride by reacting silver metal with dilute hydrochloric acid.

Which statement below explains what the student did wrong?

A An insoluble and impervious layer of silver chloride prevents further reaction.
B Silver is an unreactive metal and does not react with dilute hydrochloric acid.
C The silver metal was not powdered to speed up rate of reaction.
D The student did not catalyse the reaction.

17 20.0 cm³ of 0.100 mol dm⁻³ sulfuric acid was titrated against 25.0 cm³ of 0.100 mol dm⁻³ aqueous potassium hydroxide.

Which statement is true for the titration?

A Effervescence of colourless gas will be observed.
B Sulfuric acid is the limiting reagent.
C The final pH of the solution will be 2.
D Universal indicator is a suitable indicator for the titration.

18 Three unlabelled bottles are known to contain aqueous solutions of lead(II) nitrate, aluminium nitrate and zinc nitrate.

Which pair of reagents can be used to identify the contents of the three bottles?

A excess aqueous ammonia and aqueous potassium iodide
B excess aqueous ammonia and dilute nitric acid
C excess aqueous sodium hydroxide and aqueous potassium iodide
D excess aqueous sodium hydroxide and dilute nitric acid

19 Oxide X is a gas at room temperature. It turns moist blue litmus paper red and can change the colour of acidified potassium dichromate(VI).

What is the most likely identity of oxide X?

A carbon monoxide
B carbon dioxide
C sodium oxide
D sulfur dioxide

20 Vanadium and chlorine can react to form a red substance that is liquid at room temperature.

Why is this unusual?

A Vanadium and chlorine should form an ionic compound and thus is likely to be a solid.
B Vanadium and chlorine should form a simple molecule and thus is likely to be a gas.
C Vanadium and chlorine should form a macromolecule and thus is likely to be a solid.
D Vanadium has a fully filled valence electron shell and thus is unlikely to react.
The flow chart below shows some reactions that blue solution W undergoes.

What are the identities of W, X, Y and Z?

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cu(NO₃)₂</td>
<td>NaNO₃</td>
<td>Cu(OH)₂</td>
<td>CuSO₄</td>
</tr>
<tr>
<td>B</td>
<td>CuSO₄</td>
<td>Na₂SO₄</td>
<td>Cu(OH)₂</td>
<td>CuSO₄</td>
</tr>
<tr>
<td>C</td>
<td>Fe(NO₃)₂</td>
<td>NaNO₃</td>
<td>Fe(OH)₂</td>
<td>FeSO₄</td>
</tr>
<tr>
<td>D</td>
<td>(NH₄)₂SO₄</td>
<td>NH₄OH</td>
<td>Cu(OH)₂</td>
<td>CuSO₄</td>
</tr>
</tbody>
</table>

Read the passage below about the Hunter process and answer questions 22, 23 and 24.

The Hunter process was the first industrial process to produce pure ductile metallic titanium. It was invented in 1910 by Matthew A. Hunter, a New Zealand born chemist.

The process involves reacting titanium tetrachloride with sodium in a batch reactor with an inert atmosphere at a temperature of 1000 °C. Dilute hydrochloric acid is then used to leach the salt from the product.

\[ TiCl₄ + 4Na \rightarrow 4NaCl + Ti \]

22 1 ton (1000 kg) of titanium tetrachloride is reacted in the reactor.

If the percentage yield is 90.0 %, what is the mass of Ti formed?

A 0.121 ton  B 0.243 ton  C 0.960 ton  D 1.00 ton

23 What is the reducing agent in the Hunter process?

A Na  B NaCl  C Ti  D TiCl₄

24 Which gas is suitable to be used in the batch reactor?

A carbon monoxide  B chlorine  C neon  D oxygen
25. The table below shows the reactions of manganese with different substances and their observations.

<table>
<thead>
<tr>
<th>reaction with</th>
<th>products formed</th>
</tr>
</thead>
<tbody>
<tr>
<td>dilute acid</td>
<td>hydrogen gas evolved</td>
</tr>
<tr>
<td>cold water</td>
<td></td>
</tr>
<tr>
<td>steam</td>
<td>hydrogen gas evolved</td>
</tr>
</tbody>
</table>

Which of the following gives the correct arrangement of the metals in ascending order of reactivity?

A. calcium, manganese, lead
B. lead, calcium, manganese
C. lead, manganese, calcium
D. manganese, calcium, lead

26. In which substances do nitrogen have an oxidation state of -3?

1. Ca(NO₃)₂
2. N₂
3. NH₃
4. (NH₄)₂CO₃

A. 1 only
B. 4 only
C. 2 and 3 only
D. 3 and 4 only

27. Electron affinity is defined as the amount of energy released when an electron is added to a neutral atom to form a negative ion.

What are the trends in the following properties of elements down Group VII?

<table>
<thead>
<tr>
<th>colour intensity</th>
<th>electron affinity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decreases</td>
</tr>
<tr>
<td>B</td>
<td>decreases</td>
</tr>
<tr>
<td>C</td>
<td>increases</td>
</tr>
<tr>
<td>D</td>
<td>increases</td>
</tr>
</tbody>
</table>

28. During the thermite reaction, iron(III) oxide reacts with aluminium to produce extremely high temperatures.

Why does the reaction produce such high temperatures?

A. The thermite reaction absorbs heat from the surroundings.
B. The thermite reaction gives out heat to the surroundings.
C. The thermite reaction undergoes combustion.
D. The thermite reaction undergoes decomposition.
29. Which graph shows the correct activation energy and energy change for the reaction \( X + Y \rightarrow Z \)?

A

\[
\begin{align*}
\text{energy} / \text{kJ} & \quad \text{progress of reaction} \\
E_a & \quad \Delta H \\
X + Y & \\
E & \quad \Delta H \\
& \quad \text{progress of reaction}
\end{align*}
\]

B

\[
\begin{align*}
\text{energy} / \text{kJ} & \quad \text{progress of reaction} \\
E_a & \quad \Delta H \\
X + Y & \\
E & \quad \Delta H \\
& \quad \text{progress of reaction}
\end{align*}
\]

C

\[
\begin{align*}
\text{energy} / \text{kJ} & \quad \text{progress of reaction} \\
E_a & \quad \Delta H \\
X + Y & \\
E & \quad \Delta H \\
& \quad \text{progress of reaction}
\end{align*}
\]

D

\[
\begin{align*}
\text{energy} / \text{kJ} & \quad \text{progress of reaction} \\
E_a & \quad \Delta H \\
X + Y & \\
E & \quad \Delta H \\
& \quad \text{progress of reaction}
\end{align*}
\]

30. What are the products formed at the anode and cathode when concentrated copper(II) sulfate solution undergoes electrolysis using copper electrodes?

<table>
<thead>
<tr>
<th></th>
<th>anode</th>
<th>cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>copper(II) ions</td>
<td>copper metal</td>
</tr>
<tr>
<td>B</td>
<td>copper(II) ions</td>
<td>hydrogen gas</td>
</tr>
<tr>
<td>C</td>
<td>oxygen gas</td>
<td>copper metal</td>
</tr>
<tr>
<td>D</td>
<td>oxygen gas</td>
<td>hydrogen gas</td>
</tr>
</tbody>
</table>

31. What is a suitable electrolyte to electroplate an aluminium trophy with silver?

A. aqueous aluminium nitrate
B. aqueous silver nitrate
C. molten silver nitrate
D. molten silver
32 Which pair of metal electrodes will make the electrons flow clockwise around the circuit as shown in the diagram?

<table>
<thead>
<tr>
<th>electrode A</th>
<th>electrode B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: carbon</td>
<td>B: silver</td>
</tr>
<tr>
<td>B: copper</td>
<td>C: magnesium</td>
</tr>
<tr>
<td>C: iron</td>
<td>D: calcium</td>
</tr>
<tr>
<td>D: zinc</td>
<td>B: iron</td>
</tr>
</tbody>
</table>

33 When starting a campfire, kindling, which is usually comprised of fine shavings of wood and shredded paper is used to ignite the large pieces of wood.

Why is it necessary that pieces of kindling be as fine as possible?

A to decrease the activation energy of the kindling
B to decrease the mass of kindling needed to start the fire
C to increase the average kinetic energy of the kindling particles
D to increase the total exposed surface area of the kindling

34 Three strips of the same metal were dipped into three different aqueous solutions containing CuSO₄, MgSO₄, and Fe(NO₃)₂, respectively.

A metallic deposit was observed on the metallic strips dipped into the CuSO₄ and Fe(NO₃)₂ solutions.

What could the metal be?

A Pb  B Ca  C Fe  D Zn

35 What are the correct reaction conditions and catalyst for the Haber process?

<table>
<thead>
<tr>
<th>temperature / °C</th>
<th>pressure / atm</th>
<th>catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 250</td>
<td>250</td>
<td>nickel</td>
</tr>
<tr>
<td>B 250</td>
<td>450</td>
<td>iron</td>
</tr>
<tr>
<td>C 450</td>
<td>250</td>
<td>iron</td>
</tr>
<tr>
<td>D 450</td>
<td>450</td>
<td>nickel</td>
</tr>
</tbody>
</table>
36 Excess calcium carbonate is added to two different dilute acids. The graphs show the volume of carbon dioxide being produced at regular intervals.

If graph P corresponds to 100 cm$^3$ of 2.0 mol dm$^{-3}$ dilute hydrochloric acid, which acid will graph Q correspond to?

A 50 cm$^3$ of 2.0 mol dm$^{-3}$ dilute ethanoic acid  
B 100 cm$^3$ of 2.0 mol dm$^{-3}$ dilute ethanoic acid  
C 50 cm$^3$ of 1.0 mol dm$^{-3}$ dilute sulfuric acid  
D 100 cm$^3$ of 2.0 mol dm$^{-3}$ dilute sulfuric acid

37 Which of the following reactions is not an addition reaction?
A combustion of ethene  
B formation of pentanol from pentene  
C manufacture of margarine  
D propene decolourising aqueous bromine

38 Which of the following is not an isomer of the other three?

A

\[ \text{H}_3\text{C} - \text{C} - \text{C} - \text{H}_3 \quad \text{B} \]

\[ \text{H}_3\text{C} - \text{C} - \text{H} \quad \text{C} \quad \text{H} - \text{C} - \text{H}_3 \]

\[ \text{H}_3\text{C} - \text{C} - \text{H} \quad \text{D} \quad \text{H}_3\text{C} - \text{C} - \text{H}_3 \]

\[ \text{H}_3\text{C} - \text{C} - \text{H}_3 \quad \text{H}_3\text{C} - \text{C} - \text{CH}_3 \]

\[ \text{H}_3\text{C} - \text{C} - \text{H}_3 \quad \text{H}_3\text{C} - \text{C} - \text{H}_3 \]

\[ \text{H}_3\text{C} - \text{C} - \text{H}_3 \quad \text{H}_3\text{C} - \text{C} - \text{H}_3 \]
39. The molecule below is lysine.

How many different functional groups are there in this molecule?

\[
\begin{align*}
\text{H}_2\text{N} & - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{OH} \\
& \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\
\end{align*}
\]

A  2  B  3  C  4  D  5

40. What is the repeating unit of the polymer formed when molecule R undergoes polymerisation with the loss of water?

\[
\begin{align*}
\text{HO} - \text{C} = \text{C} - \text{C} - \text{C} - \text{OH} \\
\text{molecule R} \\
\end{align*}
\]

A  B  C  D

\[
\begin{align*}
\text{CH}_3 & - \text{CH}_3 & \text{O} \\
\text{O} - \text{C} = \text{C} - \text{C} & \text{C} \\
\text{CH}_3 & - \text{CH}_3 & \text{O} \\
\text{CH}_3 & - \text{CH}_3 & \text{O} \\
\text{HO} & \text{C} = \text{O} & \text{OH} \\
\text{HO} & \text{C} = \text{O} & \text{OH} \\
\end{align*}
\]

- End of Paper -
Victoria School
2017 Sec 4 Chemistry Prelim 2 Answer Scheme

Paper 1

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>D</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>32</td>
<td>33</td>
<td>34</td>
<td>35</td>
<td>36</td>
<td>37</td>
<td>38</td>
<td>39</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHEMISTRY
PAPER 2
Thursday
3 August 2017
1 hour 45 minutes

VICTORIA SCHOOL
PRELIMINARY EXAMINATION TWO
(SECONDARY FOUR)

INSTRUCTIONS TO CANDIDATES
Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer all questions in the spaces provided.

Section B
Answer all three questions, the last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

The use of an approved scientific calculator is expected, where appropriate.
A copy of Periodic Table is printed on page 20.

<table>
<thead>
<tr>
<th>Section A</th>
<th>/ 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section B</td>
<td>/ 30</td>
</tr>
<tr>
<td>Total</td>
<td>/ 80</td>
</tr>
</tbody>
</table>

Deductions
Presentation
Significant Figures
Units

This question paper consists of 20 printed pages (including this cover page).
Section A (50 marks)

Answer all the questions in this section in the spaces provided.

A1 In 1985, fullerenes were discovered. They are solid forms of the element carbon. The structure of the C_{60} fullerene is given below.

(a) Explain, in terms of structure and bonding, why fullerenes sublime at a relatively low temperature of 600 °C.

................................................................................................................................................................................................................................................................................................................................................................................................................................................ [2]

(b) Another fullerene has a relative molecular mass of 840.

How many carbon atoms are there in one molecule of this fullerene?

................................................................................................................................................................................................................................................................................................................................................................................................................................................ [1]

(c) Fullerenes are soluble in liquid hydrocarbons such as octane. The other solid forms of carbon are insoluble.

Describe how you could obtain crystals of fullerenes from soot which is a mixture of fullerenes and other solid forms of carbon.

................................................................................................................................................................................................................................................................................................................................................................................................................................................ [2]
(d) A mixture of fullerene and potassium is a good conductor of electricity.

(i) Which other form of solid carbon is a good conductor of electricity?

..................................................................................................................[1]

(ii) Explain, in terms of structure, why a mixture of a fullerene and potassium, is a good conductor of electricity.

..................................................................................................................[2]

(iii) The mixture of fullerene and potassium has to be stored out of contact with air as there are substances in unpolluted air which will react with potassium.

Name two potassium compounds which can be formed when potassium is exposed to air.

..................................................................................................................[1]

[Total: 9]
A2 The iron produced from the blast furnace is impure. It contains about 5% of impurities, mainly carbon, sulfur, silicon and phosphorus, which have to be removed before iron is converted into steel.

(a) Explain how the addition of oxygen and calcium oxide can remove these impurities.

.................................................................................................................................[2]

(b) High carbon steel contains 2% of carbon. It is less malleable and much harder than mild steel.

(i) Give a use of

mild steel ...............................................................................................................

high carbon steel ..................................................................................................[2]

(ii) Suggest an explanation why high carbon steel is less malleable than mild steel.

........................................................................................................................................

........................................................................................................................................[2]

(c) Samples of iron were placed in aqueous solutions having different pH values.

The table shows how the speed of rusting of iron varies with the pH of the solutions.

<table>
<thead>
<tr>
<th>speed of rusting / cm per year</th>
<th>0.043</th>
<th>0.020</th>
<th>0.012</th>
<th>0.010</th>
<th>0.010</th>
<th>0.010</th>
<th>0.000</th>
<th>0.006</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>

Describe how pH affects the speed of rusting of iron.

.................................................................................................................................

.................................................................................................................................[2]

[Total: 8]
A3 Hydrazine, $\text{N}_2\text{H}_4$, is a liquid that is used as a rocket fuel. It reacts with oxygen as shown in the equation below.

$$\text{N}_2\text{H}_4 + \text{O}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O} \quad \Delta H = -622.2 \text{ kJ/mol}$$

(a) Suggest why the combustion of hydrazine has very little negative environmental impact.

................................................................................................................................................[1]

(b) Explain, in terms of the energy changes which occur during bond breaking and bond forming, why the combustion of hydrazine is exothermic.

................................................................................................................................................[2]

(c) (i) Calculate the energy released when 100 kg of hydrazine is burnt.

................................................................................................................................................[2]

(ii) A rocket burns hydrazine in an oxygen atmosphere. Both hydrazine and oxygen are stored in the rocket as liquids.

Suggest why oxygen is stored as a liquid rather than as a gas.

................................................................................................................................................[1]
(d) Hydrazine, $\text{N}_2\text{H}_4$, has similar chemical properties to ammonia.

(i) Hydrazine reacts with hydrochloric acid.

Suggest the formula of the product of this reaction.

..............................................................................................................[1]

(ii) Given two aqueous solutions of hydrazine and sodium hydroxide, describe how you could conduct a 'fair' experiment to identify the pH of the two solutions.

..............................................................................................................

..............................................................................................................

..............................................................................................................

..............................................................................................................[2]

(iii) Draw a 'dot-and-cross' diagram to represent the bonding in hydrazine. Show only the valence electrons.

..............................................................................................................

..............................................................................................................[2]

[Total: 11]
A4. Super-absorbent polymers have the ability to absorb 200 to 300 times their own mass of water.

They are classified as hydrogels and they are widely used in personal disposable hygiene products such as babies' diapers.

These addition polymers are commonly made by the polymerisation of compound K, acrylic acid, mixed with sodium hydroxide in the presence of an initiator.

\[ \text{CH}_2\text{C} = \text{C} \text{H}_2 \text{CO}_2\text{H} \]

compound K

(a) (i) Explain what is meant by the term 'polymerisation'.

(ii) Describe the changes in chemical bonding that occur during the polymerisation of K.

(b) (i) Draw the structure of the product when K is mixed with aqueous sodium hydroxide.

(ii) Draw the full structure of at least two repeating units of the polymer formed by the product in (b)(i).
Another polymer Kevlar® is known for its variety of applications such as in bicycle tyres and bullet proof vests. The structure of Kevlar® is shown below:

If the formation of Kevlar® releases hydrogen chloride as a by-product, draw the structural formula of the two monomers that make up Kevlar® which one of the monomer contains an amine functional group.

[2]

[Total: 6]
A5 The diagram below shows an experimental set-up of an electrolytic cell (cell A) connected to a simple cell (cell B).

(a) Show the direction of electron flow on the diagram above. [1]

(b) (i) Give the ionic equations with state symbols for the reactions occurring at the silver and zinc plates in cell B.

| ionic equations |  
|-----------------|-----------------|
| zinc            | silver          |

(ii) What are the observations for the electrolyte in cell B after electrolysis has taken place for some time? [1]

(c) (i) Mark on the diagram above to show the relative volumes of gases collected in tubes X and Y.

Label clearly the identity of the gases collected. [2]

(ii) Explain why the solution in cell A turns blue. [2]

[Total: 8]
A6 Nickel carbonyl, \( \text{Ni}(\text{CO})_4 \), reacts with hydrogen iodide.

\[
\text{Ni}(\text{CO})_4(l) + 2\text{HI}(g) \rightarrow \text{NiI}_2(s) + \text{H}_2(g) + 4\text{CO}(g)
\]

(a) Explain how hydrogen iodide acts as an oxidising agent in terms of electron transfer.

(b) The proton numbers and accurate relative atomic masses of cobalt and nickel are shown in the table.

<table>
<thead>
<tr>
<th>element</th>
<th>cobalt</th>
<th>nickel</th>
</tr>
</thead>
<tbody>
<tr>
<td>proton number</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>relative atomic mass</td>
<td>58.9</td>
<td>58.7</td>
</tr>
</tbody>
</table>

(i) Suggest why cobalt has a higher relative atomic mass than nickel.

(ii) State a property of these two transition metals.

(c) Hydrogen iodide is a colourless gas at room temperature. It can dissolve in water to form an aqueous solution.

(i) Describe the changes in the arrangement and movement of the particles when hydrogen iodide dissolves in water.

(ii) Chlorine gas is bubbled into a beaker of aqueous solution of hydrogen iodide.

Describe and explain the observations.

[Total: 7]
Section B (30 marks)

Answer all three questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Copper and aluminium are two important metals in the industry. The global production of copper peaked at 19.4 million tonnes while aluminium at 59 million tonnes in 2018.

The table below lists some information on the extraction of copper and aluminium from their metal ores.

<table>
<thead>
<tr>
<th>metal ore</th>
<th>copper</th>
<th>aluminium</th>
</tr>
</thead>
<tbody>
<tr>
<td>chalcocite, containing</td>
<td>bauxite, containing</td>
<td></td>
</tr>
<tr>
<td>17% by mass of Cu₂S</td>
<td>25% by mass of Al₂O₃</td>
<td></td>
</tr>
</tbody>
</table>

 extraction  
1 The ore is concentrated by froth flotation to obtain high grade Cu₂S.  
2 The Cu₂S is roasted in air to obtain Cu₂O.  
3 Copper is extracted from Cu₂O in a furnace by heating with carbon.  
4 Copper is purified by electrolysis.  
1 Impurities in ore are removed by filtration after dissolving Al₂O₃ in aqueous sodium hydroxide.  
2 Water is added to the solution to precipitate out aluminium hydroxide.  
3 The aluminium hydroxide is then roasted in air to obtain Al₂O₃.  
4 Aluminium is extracted from Al₂O₃ by electrolysis.

| cost of metal |  |  |
|---------------|---------------|
| S$8200 per tonne | S$2700 per tonne |

Both copper and aluminium are widely used in wiring and electrical devices. However, one metal is sometimes favoured over the other in some applications. The table below compares some physical properties of copper and aluminium.

<table>
<thead>
<tr>
<th>metal</th>
<th>copper</th>
<th>aluminium</th>
</tr>
</thead>
<tbody>
<tr>
<td>tensile strength / kg cm⁻²</td>
<td>3667</td>
<td>1758</td>
</tr>
<tr>
<td>density / g cm⁻³</td>
<td>8.98</td>
<td>2.70</td>
</tr>
<tr>
<td>electrical conductivity / S m⁻¹</td>
<td>5.85 x 10⁷</td>
<td>3.69 x 10⁷</td>
</tr>
</tbody>
</table>

other information
- higher electrical conductivity allows smaller conductor to be used  
- expand 35% lesser than aluminium  
- oxidised easily causing resistance of wire to increase. Overheating in wire can melt insulation and trigger a fire

* The tensile strength is a measurement of the amount of force required to pull something to the point where it breaks.
Transmission lines are widely used to transmit TV signals, radio signals, phone signals and power. The cables used in overhead transmission lines can either be made of copper or aluminium. They can run from 50 km to 150 km depending on the voltages they carry. These lines always hang loosely instead of stretched tightly due to the tension caused by their own weights. Thermal contraction and expansion due to climatic changes also have a part to play in the sagging cables.

(a) Show by calculation that the mass of copper obtained from 1 tonne of chalcocite is larger than the mass of aluminium from 1 tonne of bauxite.

\[1 \text{ tonne} = 1,000,000 \text{ g}\]

(b) (i) What property of \( \text{Al}_2\text{O}_3 \) allows it to dissolve in aqueous sodium hydroxide?

........................................................................................................[1]

(ii) Write the ionic equation for the precipitation of aluminium hydroxide in step 2 in the extraction of aluminium from its ore.

[1]
(c) Suggest one problem that the extraction of copper from chalccocite has on the environment.

(d) Aluminium wires which are exposed pose the risk of electrocution.

Explain why these wires are also fire hazards.

(e) (i) State the advantages of using copper instead of aluminium in making the cables for transmission lines.

(ii) State the disadvantages of using copper instead of aluminium in making the cables for transmission lines.

(f) (i) Copper can be extracted from its oxide by heating it with aluminium.

Explain why this is possible.

(ii) Suggest why this method is not employed in the mass extraction of copper from its oxide?
B8 (a) Describe a chemical reaction which occurs very slowly.

(b) The reaction between potassium hypochlorite and potassium iodide in the presence of OH\(^-\) catalyst is represented by the following ionic equation.

\[
\text{OCl}^- (aq) + \text{I}^- (aq) + \text{OH}^- \rightarrow \text{IO}^- (aq) + \text{Cl}^- (aq)
\]

30.0 cm\(^3\) each of aqueous OCl\(^-\) and aqueous I\(^-\) are reacted with 1.0 cm\(^3\) of aqueous OH\(^-\). The table below shows the results of each experiment when different concentrations of each reactant are used.

<table>
<thead>
<tr>
<th>experiment</th>
<th>concentration / mol dm(^{-3})</th>
<th>rate / mol dm(^{-3}) s(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OCl(^-)</td>
<td>I(^-)</td>
</tr>
<tr>
<td>1</td>
<td>0.0040</td>
<td>0.0020</td>
</tr>
<tr>
<td>2</td>
<td>0.0020</td>
<td>0.0040</td>
</tr>
<tr>
<td>3</td>
<td>0.0020</td>
<td>0.0020</td>
</tr>
<tr>
<td>4</td>
<td>0.0020</td>
<td>0.0020</td>
</tr>
<tr>
<td>5</td>
<td>0.0020</td>
<td>0.0020</td>
</tr>
</tbody>
</table>

(i) Using information from the table, describe how the concentrations of OCl\(^-\), I\(^-\) and OH\(^-\) affect the rate of the reaction.

(ii) Explain how OH\(^-\) helps to catalyse the reaction between OCl\(^-\) and I\(^-\).
(iii) Another experiment was conducted with the following concentrations of the reactants.

<table>
<thead>
<tr>
<th>concentration / mol dm$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCl$^-$</td>
</tr>
<tr>
<td>0.0010</td>
</tr>
</tbody>
</table>

Predict what will be the rate of the reaction.

.................................................................[1]

(iv) In experiment 5, a small volume of reaction mixture was extracted and placed in a test-tube.

A few drops of aqueous silver nitrate were then added.

Explain why this method allows one to determine whether the reaction has completed.

.................................................................[1]

[Total: 8]
EITHER

B9 Palm wine is an alcoholic beverage created from the sap of various species of palm trees.

The palm sap is extracted and left to ferment. Within two hours, fermentation yields an aromatic wine of up to 4% alcohol content, mildly intoxicating and sweet.

The wine may be allowed to ferment longer, up to a day, to yield a stronger, sourer taste, which some people prefer.

Fermentation longer than a day produces vinegar instead of stronger wine.

(a) (i) Write a balanced equation for the fermentation reaction, indicating the conditions required.

[2]

(ii) The article says 'Fermentation longer than a day produces vinegar instead of stronger wine.'

Do you agree with this statement? Explain your reasoning.

........................................................................................................................................................................
........................................................................................................................................................................
...........................................................................................................................................................................[2]

(iii) Explain why aluminium cans cannot be used to contain the vinegar produced.

........................................................................................................................................................................
...........................................................................................................................................................................[1]
(b) Stronger wine can instead be made through the following steps.

![Diagram showing the process of making strong palm wine from raw palm wine to concentrated ethanol solution to strong palm wine with water dilution and other additives.]

(i) What is the name of process A?

(ii) 500 cm$^3$ of a concentrated ethanol solution has a concentration of 4.00 mol/dm$^3$ of ethanol. Calculate the volume of water that must be added to obtain a strong palm wine with concentration of 2.50 mol/dm$^3$ of ethanol.

(c) Ethanol can be combined with carboxylic acids to form esters.

(i) Draw the full structural formula of the ester that is formed when ethanol reacts with propanoic acid.

(ii) Name the ester formed in (c)(i).

[Total: 10]
OR

B9 Hydrocarbon B has a percentage by mass of 85.7% carbon and 14.3% hydrogen. It has a relative molecular mass of 84.

(a) (i) Determine the empirical formula of the hydrocarbon B.

(ii) Hence determine the molecular formula of hydrocarbon B.
Another hydrocarbon butene can be formed when butanol undergoes dehydration in the presence of concentrated sulfuric acid.

(i) Explain how you could use acidified aqueous potassium manganate(VII) to confirm that all of the butanol has undergone dehydration.

(ii) Both butene and butanol can be used as fuels. Which is a cleaner fuel? Explain your choice.

(iii) Write a balanced equation for the incomplete combustion of butene, showing the organic compounds as displayed formulae. Explain an environmental problem this will cause.

[Total: 10]
### Victoria School
2017 Sec 4 Chemistry Prelim 2 Answer Scheme

#### Paper 1

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>11</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>21</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>31</td>
<td>B</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

#### Paper 2 Section A

<table>
<thead>
<tr>
<th>Qn</th>
<th>Suggested answers</th>
<th>Mark</th>
</tr>
</thead>
</table>
| 1a | * simple molecular structure  
* small amount of energy needed to overcome  
* weak intermolecular forces of attraction                                                                                                                                                       | 2 pts -1  
3 pts -2   |
| b  | 70                                                                                                                                                                                                                | 1       |
| c  | Add octane (or other liquid hydrocarbon) to **dissolve** the fullerenes and filter (to remove insoluble forms of carbon); evaporate/heat/warm till saturated and filter and rinse with distilled water to collect the crystals. Or leave in sun to get crystals of fullerene                                                                 | 1       |
| d  | Graphite                                                                                                                                                                                                       | 1       |
| ii | Fullerene: 1 carbon atom covalently bonded to 3 other carbon atoms, leaving free unbonded electrons to **move** to conduct  
Potassium: free delocalised electrons **move** to conduct                                                                                                                                               | 1       |
| iii| potassium oxide, potassium hydroxide, potassium carbonate, potassium hydrogen carbonate (bicarbonate)                                                                                                           | Any two -1 |
|    | Total                                                                                                                                                                                                         | 9       |
| 2a | Form **acidic oxides** with oxygen;  
Calcium oxide, a **basic oxide**, neutralise them away                                                                                                                                                    | 1       |
| b  | Mild steel:  
car bodies/nuts & bolts /pipes /chains/ bridges  
High carbon steel: cutting tools /drills /chisels /knives                                                                                                                                              | 1       |
| ii | In low carbon steel alloy:  
carbon atoms of **different atomic radii** **disrupt** the regular arrangement of the atoms;  
layers of iron atoms cannot slide over each other easily when force is applied;  
**more carbon atoms** causes **more disruptions** in the regular arrangement of iron atoms                                                                 | 1       |
<table>
<thead>
<tr>
<th>Qn</th>
<th>Suggested answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>the higher the pH the slower the speed of rusting/the lower the pH the faster the speed of rusting; between pH 5 and 8 there is no difference in speed of rusting; Note: reject answer that states the more acidic/alkaline the solution, the faster/slower the speed of rusting. answer must make specific reference to pH rather than acid, acidic, alkali or alkaline</td>
<td>1</td>
</tr>
<tr>
<td>3a</td>
<td>non-polluting/harmless gases/products (nitrogen and water) formed</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>NOT: nitrogen and water less harmful / nitrogen and water are formed (without qualification)/ environmentally friendly products</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>bond breaking reaction absorbs energy, hence its endothermic AND bond making reaction releases energy, hence its exothermic; more energy is released than absorbed</td>
<td>1</td>
</tr>
<tr>
<td>ci</td>
<td>No. of moles of hydrazine = 100 000/32 = 3125 mol Energy released = 3125 x 622.2 = 1 944 375 kJ = 1.94 x 10^6 kJ or 1940 000 kJ (3 s.f.)</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>able to store more in liquid form / gaseous volume too high / maximum storage capacity / liquid occupies smaller volume</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>IGNORE: less easily spread out/no gas can escape / less possibility of an explosion / to prevent reaction with other substances</td>
<td>1</td>
</tr>
<tr>
<td>cli</td>
<td>N₂H₅Cl</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>REJECT: N₂H₅Cl in equation if more than one product given N₂H₄ + HCl → N₂H₅Cl</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>* Place a pH meter into the 2 solutions: pH of hydrazine, pH range of 9-12 is lower than pH of NaOH, pH range of 13-14 Or * Adding a few drops of Universal Indicator into the 2 solutions and compare with pH chart: Hydrazine – blue, pH range of 9-12, NaOH – violet, pH range of 13-14</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bonded 1 - unbonded</td>
<td>1</td>
</tr>
<tr>
<td>4ai</td>
<td>Process of joining together many small molecules(monomers) by covalent bonding to form a large molecule</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>C=C bond is broken and new C-C single bonds are formed</td>
<td>1</td>
</tr>
<tr>
<td>Qn</td>
<td>Suggested answers</td>
<td>Mark</td>
</tr>
<tr>
<td>----</td>
<td>-------------------</td>
<td>------</td>
</tr>
<tr>
<td>bi</td>
<td><img src="image1.png" alt="Chemical Structure" /></td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td><img src="image2.png" alt="Chemical Structure" /></td>
<td>1</td>
</tr>
<tr>
<td>c</td>
<td><img src="image3.png" alt="Chemical Structure" /></td>
<td>1</td>
</tr>
<tr>
<td>5a</td>
<td>Electrons out from zinc, enter into silver</td>
<td>1</td>
</tr>
<tr>
<td>bi</td>
<td>Zinc: $\text{Zn}(e) \rightarrow \text{Zn}^{2+} \text{(aq)} + 2e^-$</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Silver: $\text{Cu}^{2+} \text{(aq)} + 2e^- \rightarrow \text{Cu} \text{(s)}$</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Cell B: blue solution fades/turns colourless gradually</strong></td>
<td>1</td>
</tr>
<tr>
<td>ci</td>
<td><img src="image4.png" alt="Diagram" /></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>$[1]$ for vol; $[1]$ for labelling (ect from bi)</td>
<td></td>
</tr>
<tr>
<td>ii</td>
<td>- Hydrogen ions are (preferentially) discharged to form hydrogen gas (at the cathode); - Concentration of hydroxide ions is higher</td>
<td>1</td>
</tr>
<tr>
<td>6a</td>
<td>Hydrogen ions gain (two) electrons to form hydrogen, hence is reduced.</td>
<td>1</td>
</tr>
<tr>
<td>bi</td>
<td>Cobalt has greater proportion of heavier isotopes than nickel. Nickel has lower proportion of lighter isotopes than cobalt.</td>
<td>1</td>
</tr>
<tr>
<td>ii</td>
<td>- Its compounds exist as variable oxidation states - Form coloured compounds - High melting and boiling points - Used as catalyst</td>
<td>Any 1 - 1</td>
</tr>
</tbody>
</table>
### Paper 2 Section B

<table>
<thead>
<tr>
<th>Qn</th>
<th>Suggested answers</th>
<th>Mark</th>
</tr>
</thead>
</table>
| 7a  | mass of Cu = 0.17 \times (128/160) \times 1  
  = 0.136 tonne  
  mass of Al = 0.25 \times (54/102) \times 1  
  = 0.132 tonne | 1 |
| bi  | It is amphoteric. | 1 |
| ii  | \( \text{Al}^{3+} + 3\text{OH}^- \rightarrow \text{Al(OH)}_3 \) | 1 |
| c   | Roasting \( \text{Cu}_2\text{S} \) in air produces \( \text{SO}_2 \) which can cause acid rain.  
  Accept \( \text{CO}_2 \) and CO  
  Reject: CO oxidised to \( \text{CO}_2 \) by \( \text{O}_2 \) in air | 1 |
| d   | The aluminium will be oxidised causing the resistance of wire to increase. Overheating in the wire can melt the insulation and cause a fire. | 1 |
| e i | high tensile strength and does not break easily  
  / higher conductivity OR thinner wires can be used  
  / does not oxidise easily when exposed  
  [any 2] | 2 |
| ii  | expensive / heavy due to high density | 2 |
| f i | Aluminium is more reactive than copper and hence able to displace copper from oxides of copper | 1 |
| ii  | Aluminium is expensive. | 1 |
| 8a  | any slow chemical reactions (e.g. ageing, fruit ripening, rusting) | 1 |
| bi  | Using expt 3, 4 & 5, when concentrations of \( \text{OCF}_3 \) and \( \Gamma^- \) are constant, decreasing concentration of \( \text{OH}^- \) will cause rate of reaction to increase.  
  Using expt 2 & 3, when concentrations of \( \text{OCF}_3 \) and \( \text{OH}^- \) are constant, decreasing concentration of \( \Gamma^- \) will cause rate of reaction to decrease.  
  Using expt 1 & 3, when concentrations of \( \Gamma^- \) and \( \text{OH}^- \) are constant, decreasing concentration of \( \text{OCF}_3 \) will cause rate of reaction to decrease. | 1 |
| ii  | by providing an alternative pathway of lower activation energy so that ions/particles of lower energy can also overcome the energy barrier and undergo effective collision for reaction. | 1 |
| iii | \( 1.2 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1} \) | 1 |
| iv  | As long as yellow precipitate is formed, the reaction has not completed. | 1 |
|     | **Total** | **12** |

**Total** **8**
<table>
<thead>
<tr>
<th>Either</th>
<th>( 	ext{C}_8\text{H}_12\text{D}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>aii</td>
<td>Yeast, 37°C, absence of oxygen (anaerobic)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>ethanol is oxidised by oxygen (in the presence of bacteria) in the air to form ethanoic acid</td>
</tr>
<tr>
<td></td>
<td>yeast dies when concentration of alcohol is more than 15%</td>
</tr>
<tr>
<td>aiii</td>
<td>Aluminium can react with the ethanoic acid to form soluble salts/ corrode the cans.</td>
</tr>
<tr>
<td>bi</td>
<td>Fractional distillation</td>
</tr>
<tr>
<td>bii</td>
<td>( \frac{c_2v_1}{c_2v_2} = 2.5 \times v_2 )</td>
</tr>
<tr>
<td></td>
<td>( v_2 = 800 \text{ cm}^3 )</td>
</tr>
<tr>
<td></td>
<td>Volume of water to be added</td>
</tr>
<tr>
<td></td>
<td>( 800 - 500 = 300 \text{ cm}^3 )</td>
</tr>
<tr>
<td>ci</td>
<td><img src="image" alt="Structure" /></td>
</tr>
<tr>
<td>cii</td>
<td>Ethyl propanoate</td>
</tr>
<tr>
<td>OR</td>
<td><a href="#">Table</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OR B9ai</th>
<th>C</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass/g</td>
<td>85.7</td>
<td>14.3</td>
</tr>
<tr>
<td>no of moles/mol</td>
<td>85.7/12</td>
<td>14.3/1</td>
</tr>
<tr>
<td>molar ratio</td>
<td>1.411</td>
<td>1.43</td>
</tr>
<tr>
<td>simplest ratio</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Empirical formula: \( \text{CH}_2 \)

| ii       | Relative molecular mass: 84                     |
|          | Empirical formula mass: 14                     |
|          | \( 84 = n \times 14 \)                         |
|          | \( n = 6 \)                                    |
|          | Molecular formula: \( \text{C}_6\text{H}_{12} \) |
| bi      | Acidified aqueous potassium manganate(VII) react with oxidise butanol to butanoic acid from purple to colourless; |
|         | If all the butanol has been dehydrated to butane, there will be no colour change when acidified aqueous potassium manganate(VII) is added. |
| bii     | Butanol is a cleaner fuel as it has a lower percentage by mass of carbon; |
|         | Less chances of incomplete combustion           |
| biii    | \[ \text{H}_3\text{C}-\text{C}-\text{H}_3 + 4\text{O}_2 \rightarrow 4\text{CO} + 4\text{H}_2\text{O} \] |
|         | Carbon monoxide bonds readily and irreversibly with haemoglobin(RBC), forming carboxyhaemoglobin/stable compound. |
|         | This reduces oxygen intake around the body, leading to dizziness and then death. |

Total 10
Anglo-Chinese School
(INDEPENDENT)

Year 4 Express
Preliminary Examination 2017

CHEMISTRY
PAPER 1  Multiple Choice

Wednesday 16 August 2017  1 hour

Additional materials:
Calculator
Multiple Choice answer sheet
Soft clean eraser
Soft pencil (type 2H recommended)

TIME  1 hour

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.
Write and shade Candidate number on the answer sheet in the spaces provided.

There are forty questions in this paper. Answer all questions. For each question there are four possible answers, A, B, C and D. Choose the one you consider correct and record your choice in soft pencil on the separate answer sheet.

Read very carefully the instructions on the answer sheet.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
You may use a calculator.
A copy of the Periodic Table is printed on page 14.

This question paper consists of 14 printed pages.

[Turn Over

Need a home tutor? Visit smiletutor.sg | Page 578
1. Which of the following diagrams represents a reaction between two elements which is not yet completed?

   A  B  C  D

   ![Diagram A]  ![Diagram B]  ![Diagram C]  ![Diagram D]

2. The following table shows the melting points and boiling points of some substances.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting point / °C</th>
<th>Boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>5</td>
<td>78</td>
</tr>
<tr>
<td>Q</td>
<td>780</td>
<td>1413</td>
</tr>
<tr>
<td>R</td>
<td>-186</td>
<td>102</td>
</tr>
<tr>
<td>S</td>
<td>-185</td>
<td></td>
</tr>
</tbody>
</table>

From the data given above, which of the following statements is incorrect?

A. P is a liquid at 100°C.
B. S is a gas at room temperature.
C. R is a liquid at room temperature.
D. Q is a solid at 100°C.

3. Trichloroethane is a solvent used to remove grease from clothing during the dry cleaning process. How is the solvent separated from the grease after the process?

A. Chromatography  C. Distillation
B. Crystallization  D. Filtration

4. You are given a mixture of silver and silver oxide. Which of the following sequences would enable you to obtain a pure dry sample of silver?

A. Add aqueous sodium chloride, filter, crystallize.
B. Add aqueous sodium chloride, stir, filter.
C. Add dilute hydrochloric acid, stir, filter.
D. Add dilute nitric acid, stir, filter.
5 Which one of the following statements is incorrect?
A A cation has more protons than electrons.
B Every atom has at least one neutron in its nucleus.
C Isotopes of the same element have the same number of protons.
D An anion of a non-metal has more electrons than its atom.

6 Which of the following has the highest electrical conductivity?
A Aqueous sugar solution
B Pure water
C Solid sodium chloride
D Solid graphite

7 The diagram shows part of the structure of the compound silicon carbide.

A sample of silicon carbide underwent complete combustion in oxygen to form a gaseous oxide and a solid oxide. Which of the following are the structures of silicon carbide, the gaseous oxide and the solid oxide?

<table>
<thead>
<tr>
<th></th>
<th>Silicon carbide</th>
<th>The gaseous oxide</th>
<th>The solid oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Giant molecular structure</td>
<td>Simple molecular structure</td>
<td>Giant molecular structure</td>
</tr>
<tr>
<td>B</td>
<td>Ionic structure</td>
<td>Ionic structure</td>
<td>Giant molecular structure</td>
</tr>
<tr>
<td>C</td>
<td>Giant molecular structure</td>
<td>Simple molecular structure</td>
<td>Simple molecular structure</td>
</tr>
<tr>
<td>D</td>
<td>Ionic structure</td>
<td>Giant molecular structure</td>
<td>Ionic structure</td>
</tr>
</tbody>
</table>
8 Which solid does not contain covalent bonds?
   A Gold  B Graphite
   C Ice  D Calcium carbonate

9 In Group VII, chlorine exists as a gas while iodine exists as a solid at room temperature. This is due to
   A greater number of neutrons present in the iodine atoms.
   B more covalent bonds present in the iodine molecules.
   C stronger covalent bonds present in the iodine molecules.
   D stronger forces of attraction present between iodine molecules.

10 The mass of a diamond is expressed in a unit called the carat. One carat is equivalent to a mass of 0.200 g. Which of the following is closest to the number of atoms in a 0.500 carat diamond? (1 mole = $6 \times 10^{23}$ particles)
   A $2.50 \times 10^{21}$  C $1.00 \times 10^{22}$
   B $5.00 \times 10^{21}$  D $2.00 \times 10^{22}$

11 20.0 cm$^3$ of Ba(OH)$_2$ solution was titrated with 0.200 mol/dm$^3$ H$_2$SO$_4$ solution in a conductivity cell. The data obtained were plotted to give the graph shown below.

![Graph](image)

The equation for the reaction is shown below:
$$\text{Ba(OH)}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{H}_2\text{O}$$

What is the concentration of the Ba(OH)$_2$ solution?
   A 0.300 mol/dm$^3$  C 0.120 mol/dm$^3$
   B 0.150 mol/dm$^3$  D 0.075 mol/dm$^3$
12 0.2 mol of CuSO₄ and 0.1 mol of Na₂SO₄ were dissolved in water and the solution made up to 500 cm³. Which is the correct statement?

A The solution contained 0.1 mol of sodium ions.
B The solution contained equal number of positive and negative ions.
C The concentration of copper(II) ions in the solution is 0.4 mol/dm³.
D The concentration of sulfate ions in the solution is 0.8 mol/dm³.

13 Phosphine, PH₃, is a gas which has similar properties as ammonia. Which ions would be produced when phosphine dissolves in water?

A PH₃⁺, H⁺
B PH₄⁺, H⁺
C PH₃⁻, OH⁻
D PH₄⁻, OH⁻

14 When dry hydrogen chloride dissolves in methylbenzene, the solution formed

A contains hydrogen chloride molecules.
B conducts electricity.
C is greenish yellow in colour due to the chlorine gas evolved.
D contains high concentration of hydrogen ions.

15 Which of the following substances would react with copper?

I Dilute hydrochloric acid
II Oxygen
III Aqueous silver nitrate
IV Cold water

A I and II only
B II and III only
C III and IV only
D All of the above

16 A precipitate of lead(II) hydroxide dissolves in aqueous sodium hydroxide to form a colourless solution. Which property of lead(II) hydroxide can be deduced from the reaction?

A Lead(II) hydroxide is a reducing agent.
B Lead(II) hydroxide is basic.
C Lead(II) hydroxide is soluble in water.
D Lead(II) hydroxide is amphoteric.
17 When solid Y was added to a dilute sulfuric acid, effervescence was observed and a colourless solution was obtained. When solid Y was warmed with aqueous sodium hydroxide and potassium nitrate, a pungent gas which turned damp red litmus paper blue was evolved. What could Y be?

A. Lead  
B. Copper  
C. Aluminium  
D. Iron

18 Which of the following is a redox reaction?

A. NaOH + HCl → NaCl + H₂O  
B. FeCl₃ + 3 NaOH → Fe(OH)₃ + 3 NaCl  
C. 2 Na₂CrO₄ + 2 HCl → Na₂Cr₂O₇ + 2 NaCl + H₂O  
D. 2 SO₂ + O₂ → 2 SO₃

19 The following are four reactions that can occur in the industrial conversion of ammonia into nitric acid. Which one of these reactions shows the greatest change in the oxidation number of nitrogen?

A. 4 NH₃ + 5 O₂ → 4 NO + 6 H₂O  
B. 3 NO₂ + H₂O → 2 HNO₃ + NO  
C. 2 NO + O₂ → 2 NO₂  
D. 4 NH₃ + 6 NO → 5 N₂ + 6 H₂O

20 Why does an aqueous solution of potassium iodide turn brown with black solid particles when chlorine gas is bubbled into it?

A. A compound is formed between chlorine and iodine.  
B. The chlorine oxidizes iodide ions to iodine.  
C. A solution of potassium chloride is formed.  
D. The solution of potassium iodide is reduced.

21 Hydrazine reacts with fluorine as shown in the equation below:

\[ \text{N}_2\text{H}_4 (g) + 2 \text{F}_2 (g) \rightarrow \text{N}_2 (g) + 4 \text{HF(g)} \quad \Delta H = +500 \text{kJ} \]

If 1 mole of hydrazine and 1 mole of fluorine are used, what is the energy absorbed?

A. 125 kJ  
B. 250 kJ  
C. 500 kJ  
D. 1000 kJ
22 The following energy level diagram represents the reaction between hydrogen and oxygen to form steam.

\[ 2 \text{H}_2 (g) + \text{O}_2 (g) \rightarrow 2 \text{H}_2\text{O} (g) \]

Which of the following represents the energy required for bond breaking and the energy released when new bonds are formed?

<table>
<thead>
<tr>
<th></th>
<th>energy required for bond breaking</th>
<th>energy released for bond formation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>$\Delta H_2$</td>
<td>$\Delta H_3$</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>$\Delta H_2$</td>
<td>$\Delta H_1$</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>$\Delta H_1$</td>
<td>$\Delta H_2$</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>$\Delta H_1$</td>
<td>$\Delta H_3$</td>
</tr>
</tbody>
</table>

23 The rate of a chemical reaction can sometimes be determined by measuring the change in mass of the reaction flask and its content with time. For which of the following reactions would this technique be most successful?

A. Copper(II) oxide and dilute sulfuric acid.
B. Aqueous sodium chloride and aqueous silver nitrate.
C. Magnesium carbonate and dilute hydrochloric acid.
D. Zinc and aqueous copper(II) sulfate.
24 Excess magnesium was added to a beaker of dilute hydrochloric acid on an electronic balance. A graph of the mass of the beaker and contents was plotted against time (curve 1).

![Graph showing mass of beaker and contents over time](image)

What change in the experiment could give curve 2?

I The same mass of magnesium but in smaller pieces.
II The same volume of a more concentrated solution of hydrochloric acid.
III A lower temperature.

A I only.  C I and II only.
B II only.  D II and III only.

25 A current is passed through each of the following electrolytes using inert electrodes. Which one will produce an alkaline solution at the end of the electrolysis?

A Aqueous sodium sulfite
B Concentrated potassium chloride solution
C Dilute sulfuric acid
D Aqueous copper(II) nitrate solution

26 Which of the following could be formed at the electrodes during the electrolysis of aqueous sodium hydroxide using carbon electrodes?

<table>
<thead>
<tr>
<th></th>
<th>Cathode</th>
<th>Anode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hydrogen</td>
<td>Oxygen</td>
</tr>
<tr>
<td>B</td>
<td>Oxygen</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>C</td>
<td>Sodium</td>
<td>Oxygen</td>
</tr>
<tr>
<td>D</td>
<td>Sodium</td>
<td>Hydrogen</td>
</tr>
</tbody>
</table>

Need a home tutor? Visit smiletutor.sg
27 Francium is the last element of Group 1 in the Periodic Table. Which of the following properties will francium be likely to exhibit?
A. Francium has a high melting point.
B. Francium will form an acidic oxide.
C. Francium conducts electricity.
D. Francium reacts less explosively with cold water than caesium.

28 A solid X has the following properties.
- It does not react with cold water.
- Its hydroxide is insoluble in water.
- It can be obtained by heating the oxide of X with carbon.
What is X?
A. Sodium
B. Calcium
C. Iron
D. Magnesium

29 Pure iron is obtained from a blast furnace that is filled with the respective raw materials. Which of the following reactions do not occur in the blast furnace?
A. \( \text{CO}_2 + \text{C} \rightarrow 2 \text{CO} \)
B. \( \text{C} + \text{O}_2 \rightarrow \text{CO}_2 \)
C. \( \text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3 \)
D. \( 2 \text{CaCO}_3 \rightarrow 2 \text{CaO} + 2 \text{CO} + \text{O}_2 \)

30 Molecules present in car exhaust fumes include carbon dioxide, carbon monoxide, nitrogen, nitrogen dioxide, unburned hydrocarbons, and water. Which of these molecules are not treated after passing through the catalytic converter of the car?
A. Nitrogen dioxide and carbon monoxide only.
B. Nitrogen and water only.
C. Nitrogen, carbon dioxide, unburned hydrocarbons and water only.
D. Nitrogen, carbon dioxide and water only.

31 Which gas is produced in the atmosphere by lightning activities?
A. Nitrogen monoxide
B. Carbon dioxide
C. Methane
D. Ozone
32 Which of the following conditions are normally used in the manufacture of ammonia in the Haber Process?

<table>
<thead>
<tr>
<th></th>
<th>Temperature /°C</th>
<th>Pressure /atm</th>
<th>Catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>450</td>
<td>1</td>
<td>Iron</td>
</tr>
<tr>
<td>B</td>
<td>450</td>
<td>200</td>
<td>Iron</td>
</tr>
<tr>
<td>C</td>
<td>450</td>
<td>1</td>
<td>Iron (II) oxide</td>
</tr>
<tr>
<td>D</td>
<td>450</td>
<td>200</td>
<td>Iron (III) oxide</td>
</tr>
</tbody>
</table>

33 The energy profile diagram for the following reversible reaction is given below:

\[ \text{P} \rightleftharpoons \text{Q} + \text{R} \]

What is the activation energy for the following reaction?

\[ \text{Q} + \text{R} \rightleftharpoons \text{P} \]

<table>
<thead>
<tr>
<th></th>
<th>40 kJ</th>
<th>C: 100 kJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40 kJ</td>
<td>C: 100 kJ</td>
</tr>
<tr>
<td>B</td>
<td>80 kJ</td>
<td>D: 140 kJ</td>
</tr>
</tbody>
</table>

34 As the number of carbon atoms in the homologous series of alkane molecules increases, which property of the alkanes decreases?

A: Density  B: Boiling point  C: Flammability  D: Number of isomers

35 Which of the following is not a product of cracking?

A: \( \text{H}_2 \)  B: \( \text{C}_6\text{H}_{16} \)  C: \( \text{C}_4\text{H}_4 \)  D: \( \text{C}_2\text{H}_5\text{OH} \)
36 Useful fractions are obtained by the fractional distillation of petroleum oil. Which fraction and use are correct?

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Bitumen</td>
<td>Fuel in cars</td>
</tr>
<tr>
<td>B Petrol (gasoline)</td>
<td>Aircraft fuel</td>
</tr>
<tr>
<td>C Paraffin (kerosene)</td>
<td>For making roads</td>
</tr>
<tr>
<td>D Lubricating fraction</td>
<td>For making waxes and polishes</td>
</tr>
</tbody>
</table>

37 A molecule of hydrocarbon, C_{30}H_{40}, undergoes cracking to produce a molecule of butane and the rest are ethene molecules. How many ethene molecules are produced?

A 2   C 8
B 4   D 16

38 Which of the following substances will hinder the fermentation of sugars?

A Yeast   C Water
B Oxygen  D A temperature of 37°C

39 A compound with molecular formula C_{2}H_{4}O_{2} dissolves readily in water to form an aqueous solution. When this aqueous solution reacts with magnesium and limestone respectively, bubbles of colourless gas are observed. What is the structural formula of this compound?

A

\[
\begin{align*}
\text{O} & \quad \text{H} \\
\text{O} & \quad \text{C} - \text{C} - \text{C} - \text{H} \\
\text{H} & \quad \text{H}
\end{align*}
\]

B

\[
\begin{align*}
\text{H} & \quad \text{O} - \text{C} - \text{C} - \text{OH} \\
\text{H} & \quad \text{H}
\end{align*}
\]

C

\[
\begin{align*}
\text{O} & \quad \text{H} \\
\text{H} & \quad \text{O} - \text{C} - \text{O} - \text{C} - \text{H} \\
\text{H} & \quad \text{H}
\end{align*}
\]

D

\[
\begin{align*}
\text{C} & \quad \text{H} \\
\text{O} & \quad \text{H} \\
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{H}
\end{align*}
\]
40 Which of the following structures represents nylon?

A

B

C

D
### ACS (Independent) Year 4 Express 2017 Prelim Exam

#### P1

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>A</td>
<td>C</td>
<td>D</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>21</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>C</td>
</tr>
</tbody>
</table>
ST JOSEPH'S INSTITUTION
PRELIMINARY EXAMINATION 2017
SECONDARY 4 (‘O’ Level Programme)

CHEMISTRY

Paper 1  Multiple Choice

5073 / 01
23 August 2017
1 hour

Additional materials: Multiple Choice Answer Sheet

1045 – 1145 h

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

There are forty questions on this paper. Answer all questions. For each question, there are four possible answers A, B, C and D.
Choose the one you consider correct and record your choice in soft pencil on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in the question paper.
The use of an approved scientific calculator is expected, where appropriate.
A copy of the Periodic Table is printed on page 2.

This question paper consists of 24 printed pages including the Cover Sheet.

[Turn over]
### DATA SHEET
The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
<td>Ne</td>
</tr>
<tr>
<td></td>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Cl</td>
<td>Ar</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>Ca</td>
<td>Sc</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
<td>Mn</td>
<td>Fe</td>
</tr>
<tr>
<td></td>
<td>Mn</td>
<td>Co</td>
<td>Ni</td>
<td>Cu</td>
<td>Zn</td>
<td>Ga</td>
<td>Ge</td>
<td>As</td>
</tr>
<tr>
<td></td>
<td>Zr</td>
<td>Nb</td>
<td>Mo</td>
<td>Tc</td>
<td>Ru</td>
<td>Rh</td>
<td>Pd</td>
<td>Ag</td>
</tr>
<tr>
<td></td>
<td>Pm</td>
<td>Sm</td>
<td>Eu</td>
<td>Gd</td>
<td>Tb</td>
<td>Dy</td>
<td>Ho</td>
<td>Er</td>
</tr>
<tr>
<td></td>
<td>Dy</td>
<td>Ho</td>
<td>Er</td>
<td>Tm</td>
<td>Yb</td>
<td>Lu</td>
<td>Ce</td>
<td>Pr</td>
</tr>
<tr>
<td></td>
<td>Tb</td>
<td>Dy</td>
<td>Ho</td>
<td>Er</td>
<td>Tm</td>
<td>Yb</td>
<td>Lu</td>
<td>Ce</td>
</tr>
<tr>
<td></td>
<td>Sm</td>
<td>Eu</td>
<td>Gd</td>
<td>Tb</td>
<td>Dy</td>
<td>Ho</td>
<td>Er</td>
<td>Tm</td>
</tr>
<tr>
<td></td>
<td>Nd</td>
<td>Pm</td>
<td>Sm</td>
<td>Eu</td>
<td>Gd</td>
<td>Tb</td>
<td>Dy</td>
<td>Ho</td>
</tr>
<tr>
<td></td>
<td>Gd</td>
<td>Tb</td>
<td>Dy</td>
<td>Ho</td>
<td>Er</td>
<td>Tm</td>
<td>Yb</td>
<td>Lu</td>
</tr>
</tbody>
</table>

*58-71 Lanthanoid series
190-103 Actinoid series

**Key**
- X: relative atomic mass
- K: atomic symbol
- D: position (period) number

The volume of one mole of any gas is 24 cm$^3$ at room temperature and pressure (r.t.p.).
1. The apparatus shown in the diagram below was set up by Peter to measure the volume of carbon dioxide gas made when different masses of marble chips were added to 25 cm$^3$ of dilute hydrochloric acid.

Which other apparatus did he use for his experiment?

A. Filter funnel and mass balance  
B. Filter funnel and stopwatch  
C. Measuring cylinder and mass balance  
D. Measuring cylinder and stopwatch

2. The table gives data about four substances. In which substance are the particles closely packed and arranged randomly at room temperature?

<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting point / °C</th>
<th>Boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>145</td>
</tr>
<tr>
<td>B</td>
<td>40</td>
<td>1407</td>
</tr>
<tr>
<td>C</td>
<td>-114</td>
<td>-30</td>
</tr>
<tr>
<td>D</td>
<td>-20</td>
<td>10</td>
</tr>
</tbody>
</table>
3. The nucleon number and number of electrons of an atom of X and an atom of Y are shown.

<table>
<thead>
<tr>
<th>Atom</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleon number</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>Number of electrons</td>
<td>23</td>
<td>27</td>
</tr>
</tbody>
</table>

Which statement about X and Y is incorrect?

A. An atom of X has fewer protons than an atom of Y.
B. An atom of Y has fewer neutrons than an atom of X.
C. X is above Y in the same group of the Periodic Table.
D. X is in the same period in the Periodic Table as Y.

4. Which of the following statements describes a particle with the following electronic structure?

\[
\begin{array}{c}
\text{1s}^2 \text{2s}^2 \text{2p}^6 \text{3s}^2 \text{3p}^1 \\
\end{array}
\]

A. an anion with an oxidation state of \(-1\)
B. a cation with an oxidation state of \(+1\)
C. an atom in the second period
D. an inert gas atom
5. The dot-cross diagram (with only the outer electrons) of the compound formed between element X and Z is shown.

Which of the following is the correct set of formula of the chloride of X and Z?

A. \( \text{XCl}, \text{Z}_3\text{Cl} \)
B. \( \text{XCl}, \text{ZCl}_3 \)
C. \( \text{XCl}_2, \text{Z}_3\text{Cl} \)
D. \( \text{XCl}_2, \text{ZCl}_3 \)
6. The diagram shows the molecule propyl ethanoate.

![Propyl Ethanoate](image)

How many pairs of electrons are used in bonding in the molecule?

A. 1
B. 7
C. 14
D. 17

7. The table below shows the physical properties of substances P, Q, R and S.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting point °C</th>
<th>Electrical Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>in solid state</td>
</tr>
<tr>
<td>P</td>
<td>High</td>
<td>Poor</td>
</tr>
<tr>
<td>Q</td>
<td>High</td>
<td>Good</td>
</tr>
<tr>
<td>R</td>
<td>High</td>
<td>Poor</td>
</tr>
<tr>
<td>S</td>
<td>Low</td>
<td>Poor</td>
</tr>
</tbody>
</table>

Using the information from the table, which statement is true about substances P, Q, R and S?

A. Substance R consists of weak bonds between the atoms.
B. Substance S exists in a simple molecular structure.
C. Substance P contains mobile electrons to conduct electricity when in molten state.
D. Substance Q consists of strong electrostatic attractions between oppositely charged particles.
8 Chlorine gas is a severe irritant to the eyes and respiratory system. The maximum safe toleration level of chlorine gas in air is 0.005 mg dm$^{-3}$.

How many molecules of chlorine gas are present in 1 dm$^3$ of air at the toleration level? (Note: 1g = 1000 mg)

A $\frac{0.005}{6 \times 10^{22}} \times 71$

B $\frac{0.005}{71} \times 6 \times 10^{23}$

C $\frac{0.005}{1000} \times \frac{1}{71} \times 6 \times 10^{23}$

D $\frac{0.005}{1000} \times 71 \times 6 \times 10^{23}$

9 Dinitrogen tetroxide, N$_2$O$_4$ is a poisonous gas. It can be disposed of safely by reaction with sodium hydroxide. In the experiment, the concentration of aqueous sodium hydroxide used is 1.5 mol/dm$^3$.

N$_2$O$_4$ (g) + 2NaOH (aq) → NaNO$_3$ (aq) + NaNO$_2$ (aq) + H$_2$O (l)

Which of the following is the least volume of aqueous sodium hydroxide required to dispose of 300 cm$^3$ of N$_2$O$_4$ at room temperature and pressure?

A 10 cm$^3$

B 20 cm$^3$

C 200 cm$^3$

D 600 cm$^3$
10 Sulfuric acid and nitric acid are both strong acids. Ethanoic acid is a weak acid.

20.00 cm$^3$ solutions of 0.10 mol/dm$^3$ concentration of each of these three acids were separately titrated with a 0.10 mol/dm$^3$ solution of sodium hydroxide.

In order to react completely

A all three acids would require the same volume of sodium hydroxide solution.

B ethanoic acid and nitric acid would require the same volume of sodium hydroxide solution but sulfuric acid would require more.

C nitric acid would require more sodium hydroxide solution than ethanoic acid but less than sulfuric acid.

D sulfuric acid and nitric acid would require the same volume of sodium hydroxide solution but ethanoic acid would require less.

11 Solution X and solid Y are mixed in a beaker. After mixing, the final mass of the substances and the beaker is lesser than the initial mass.

What could solution X and solid Y be?

<table>
<thead>
<tr>
<th>solution X</th>
<th>solid Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>A hydrochloric acid</td>
<td>iron(III) hydroxide</td>
</tr>
<tr>
<td>B nitric acid</td>
<td>magnesium oxide</td>
</tr>
<tr>
<td>C potassium hydroxide</td>
<td>ammonium carbonate</td>
</tr>
<tr>
<td>D sulfuric acid</td>
<td>copper</td>
</tr>
</tbody>
</table>
The graph below shows the change in pH of a reaction solution during a titration of 0.10 mol/dm$^3$ sodium hydroxide solution with 0.10 mol/dm$^3$ ethanoic acid.

Below are the approximate pH changes for a few indicators.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Approximate pH range for colour change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl orange</td>
<td>3.2-4.4</td>
</tr>
<tr>
<td>Phenolphthalein</td>
<td>8.2-10</td>
</tr>
<tr>
<td>Litmus solution</td>
<td>5.5-8.2</td>
</tr>
<tr>
<td>Bromocresol green</td>
<td>3.8-5.4</td>
</tr>
</tbody>
</table>

Which indicator is the most suitable to identify the end point of this titration?

A. Bromocresol green
B. Litmus solution
C. Methyl orange
D. Phenolphthalein
13. An excess of sodium hydroxide is added to an aqueous solution of salt L and boiled. Ammonia gas is only given off after aluminium foil is added to the hot solution. What could be salt L?

A. Ammonium chloride
B. Ammonium nitrate
C. Sodium chloride
D. Sodium nitrate

14. Excess dilute sulfuric acid was added to a fixed volume of aqueous barium hydroxide.

Which graph best represents the variation in the total number of mobile ions present in the solution?

A. ![Graph A]
B. ![Graph B]
C. ![Graph C]
D. ![Graph D]
15 Elements Q, X, Y and Z are found in consecutive groups of the Periodic Table starting from group IV. They also belong to the same period. In which molecule are all the outer electrons of the atoms involved in bonding?

A. QH₄
B. XH₃
C. YH₂
D. ZH

16 X is a Group I element while Y is a transition element. Which of the following states the correct similarity and difference in their properties?

<table>
<thead>
<tr>
<th></th>
<th>Similarity</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>X and Y have high melting point.</td>
<td>Y has higher density than X.</td>
</tr>
<tr>
<td>B</td>
<td>X and Y have high melting point.</td>
<td>Y is harder than X.</td>
</tr>
<tr>
<td>C</td>
<td>X and Y conduct electricity.</td>
<td>X is soluble in water while Y is insoluble in water.</td>
</tr>
<tr>
<td>D</td>
<td>X and Y form coloured compounds.</td>
<td>X does not conduct electricity while Y conducts electricity.</td>
</tr>
</tbody>
</table>
17 Adrian carried out four experiments to arrange metals X, Y and Z in order of decreasing reactivity.

The table shows the results of his experiments:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the metal react with dilute hydrochloric acid?</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Is the oxide of the metal reduced by heating with carbon?</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

What is the order of reactivity of the metals?

```
Most reactive
A X
B Y
C Z
D Z

Least reactive
A
B Y
C Z
D Y
```

18 Joseph performed four experiments on rusting as shown below.

Which two of these experiments can Joseph use to show that air is needed for iron to rust?

A 1 and 2
B 1 and 3
C 2 and 3
D 2 and 4
19 Which of the following is a redox reaction?

A $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$

B $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$

C $\text{NH}_4^+ + \text{Cl}^- \rightarrow \text{NH}_4\text{Cl}$

D $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_4\text{OH}$

20 A piece of clean copper wire is suspended in a beaker of aqueous silver nitrate. Crystals of silver are deposited on the copper wire and the solution in the beaker gradually turns blue.

Which deduction is not correct?

A Copper is oxidised.

B Silver nitrate is reduced.

C The total number of negative ions in the solution is unchanged.

D The total number of positive ions in the solution is unchanged.
Aqueous potassium iodide and acidified potassium manganate (VII) were added to separate samples of hydrogen peroxide.

The observations are summarised in the table:

<table>
<thead>
<tr>
<th>Reagent added to hydrogen peroxide</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueous potassium iodide</td>
<td>Aqueous potassium iodide turns from colourless to brown</td>
</tr>
<tr>
<td>Acidified potassium manganate (VII)</td>
<td>Acidified potassium manganate (VII) turns from purple to colourless.</td>
</tr>
</tbody>
</table>

Which of the following set of properties is correct for the above observations?

<table>
<thead>
<tr>
<th></th>
<th>Aqueous potassium iodide</th>
<th>Acidified potassium manganate (VII)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Oxidising agent</td>
<td>Reducing agent</td>
</tr>
<tr>
<td>B</td>
<td>Oxidising agent</td>
<td>Oxidising agent</td>
</tr>
<tr>
<td>C</td>
<td>Reducing agent</td>
<td>Oxidising agent</td>
</tr>
<tr>
<td>D</td>
<td>Reducing agent</td>
<td>Reducing agent</td>
</tr>
</tbody>
</table>

In the electrolysis of molten aluminium oxide, 4 moles of aluminium ions (Al^{3+}) were discharged at the cathode.

Which one of the following would be discharged by the same amount of electricity?

A 4 moles copper(II) ions (Cu^{2+}) in the electrolysis of aqueous copper (II) sulfate

B 6 moles of lead ions (Pb^{2+}) in the electrolysis of molten lead(II) bromide

C 6 moles of silver ions (Ag^{+}) in the electrolysis of aqueous silver nitrate

D 12 moles of zinc ions (Zn^{2+}) in the electrolysis of molten zinc sulfate
A current is passed through two electrolytic cells, R and T, for some time. The electrolyte in both cells is green nickel(II) sulfate solution of the same concentration. Cell R has two nickel electrodes, while Cell T has a nickel and a platinum electrode.

The results are summarised in the table below.

<table>
<thead>
<tr>
<th>Cell</th>
<th>Cathode</th>
<th>Anode</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>4.0 g of nickel is deposited.</td>
<td>Nickel dissolves.</td>
</tr>
<tr>
<td>T</td>
<td>Nickel is deposited.</td>
<td>Oxygen evolved.</td>
</tr>
</tbody>
</table>

Which statement about the reactions above is not true?

A  The oxygen evolved at the anode of Cell T burns the platinum.

B  The cathode in Cell R increases in mass by 4.0 g.

C  The concentration of the nickel(II) sulfate solution in Cell R remains the same.

D  The green colour of the nickel(II) sulfate solution in Cell T fades slowly and eventually disappears.
24 Four metals tin, $x$, $y$ and $z$ were connected in pairs and the voltages were recorded.

\[ \text{Metal electrode } \stackrel{\text{V}}{\leftrightarrow} \text{Salt Bridge } \stackrel{\text{Metal electrode}}{\leftrightarrow} \]

The results obtained are shown in the table below:

<table>
<thead>
<tr>
<th>negative terminal</th>
<th>positive terminal</th>
<th>Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>tin</td>
<td>$y$</td>
<td>+ 1.10</td>
</tr>
<tr>
<td>$x$</td>
<td>tin</td>
<td>+ 0.90</td>
</tr>
<tr>
<td>$z$</td>
<td>tin</td>
<td>+ 2.50</td>
</tr>
</tbody>
</table>

What is the order of reactivity of the four metals with the most reactive first?

A $x, \text{tin}, y, z$
B $y, \text{tin}, x, z$
C $z, \text{tin}, y, x$
D $z, x, \text{tin}, y$
25 The table below shows the differences in the composition of the mixtures of exhaust gases from two cars, one fitted with a catalytic converter and one without.

<table>
<thead>
<tr>
<th></th>
<th>% by volume of nitrogen monoxide</th>
<th>% by volume of carbon dioxide</th>
<th>% by volume of water vapour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car without catalytic converter</td>
<td>67.60</td>
<td>12.00</td>
<td>11.00</td>
</tr>
<tr>
<td>Car with catalytic converter</td>
<td>23.60</td>
<td>32.25</td>
<td>41.10</td>
</tr>
</tbody>
</table>

Which statement does not explain the differences in the data above?

A  The percentage of nitrogen monoxide decreases as it is oxidised to form nitrogen in the catalytic converter.

B  The percentage of nitrogen monoxide decreases as it is reduced to form nitrogen in the catalytic converter.

C  The percentage of carbon dioxide increases as unburnt hydrocarbons undergo complete combustion in the catalytic converter.

D  The percentage of water vapour increases as unburnt hydrocarbons undergo complete combustion in the catalytic converter.

26 To reduce atmospheric pollution, the following waste gases from a coal burning power station are passed through wet powdered calcium carbonate.

How many of the following waste gases will not be removed by the wet powdered calcium carbonate?

- carbon monoxide
- nitrogen monoxide
- sulfur dioxide
- carbon dioxide
- nitrogen dioxide
- phosphorus(V) oxide

A  1
B  2
C  3
D  4
27 The enthalpy of vaporization, \( \Delta H_{\text{vap}} \), is the amount of energy absorbed to convert one mole of a liquid substance into a gas. The \( \Delta H_{\text{vap}} \) for water is +40.7 kJ/mol at 100°C and 1 atm. Which of the following statements is true?

A  The \( \Delta H_{\text{vap}} \) for water is positive as energy is absorbed to break O-H bonds.

B  226 kJ of heat is absorbed to convert 100g of water into steam at 100°C and 1 atm.

C  Less than 226 kJ of heat is absorbed to convert 100g of water at 25°C into steam at 1 atm.

D  Energy is absorbed to transform water molecules vibrating in fixed positions into molecules moving randomly at high speeds.

28 Which of the following processes are exothermic in nature?

I. Rusting of iron metal
II. Neutralisation of butanoic acid with alkali
III. Thermal decomposition of calcium carbonates
IV. Breaking down of hydrogen chloride into its constituent atoms
V. Combustion of sulfur to form an acidic gas

A  I, II and III

B  I, II and V

C  I, II, III, IV

D  All of the above
29 A piece of zinc foil dissolved completely in 20 cm³ of a dilute sulfuric acid solution, and the volume of hydrogen evolved was noted at equal, short time intervals.

Another piece of zinc foil of the same surface area and mass was added to 40 cm³ of the same solution of dilute sulfuric acid.

How will the initial rate of reaction and the total volume of hydrogen evolved in this second experiment compare to the first experiment?

<table>
<thead>
<tr>
<th>initial rate of reaction</th>
<th>total volume of hydrogen evolved</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>no change</td>
</tr>
<tr>
<td>B</td>
<td>no change</td>
</tr>
<tr>
<td>C</td>
<td>increase</td>
</tr>
<tr>
<td>D</td>
<td>increase</td>
</tr>
</tbody>
</table>

30 When sodium thiosulfate reacts with dilute hydrochloric acid, a fine suspension of sulfur is formed.

An experiment was carried out at various temperatures and the time taken for the suspension to appear was recorded in the table below.

<table>
<thead>
<tr>
<th>Temperature / °C</th>
<th>Time taken / s</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>97</td>
</tr>
<tr>
<td>35</td>
<td>52</td>
</tr>
<tr>
<td>40</td>
<td>42</td>
</tr>
<tr>
<td>50</td>
<td>24</td>
</tr>
</tbody>
</table>

Which one of the following conclusions about the experiment can be drawn from the above table?

A The shorter the time taken, the higher the temperature rise of the reaction.
B The longer the time taken, the lower the temperature rise of the reaction.
C The higher the temperature, the lower the rate of formation of sulfur.
D The higher the temperature, the higher the rate of formation of sulfur.
31 In the graph shown below, curve X represents the result of the reaction between 2.5g of magnesium ribbon and 50 cm$^3$ of 1 mol/dm$^3$ sulfuric acid at 50°C.

![Graph showing gas production over time]

Which reaction could produce curve Y?

A  2.5g of magnesium powder at 50°C
B  2.5g of magnesium ribbon at 60°C
C  12.5 cm$^3$ of 2 mol/dm$^3$ sulfuric acid at 60°C
D  25 cm$^3$ of 2 mol/dm$^3$ sulfuric acid at 50°C

32 Which statement about speed of reaction is correct?

A  Increasing the concentration of a reactant increases the speed because there are more rapidly moving particles.
B  Increasing the size of particles of a solid increases the speed because there are more particles.
C  Increasing temperature increases the speed because it increases the number of particles.
D  Increasing temperature increases the speed because there are more collisions.
33 Why is it wasteful to add ammonium nitrate fertiliser to soil which has recently been treated with slaked lime?

A Ammonium nitrate can be easily decomposed.
B Ammonium nitrate will react with slaked lime and ammonia is released into the air.
C Slaked lime has made the soil too basic for ammonium nitrate to be useful.
D The percentage by mass of nitrogen in ammonium nitrate is low.

34 Which of the following statements about alkanes and alkenes is true?

A Alkanes are unsaturated but alkenes are saturated.
B Alkanes undergo substitution while alkenes undergo addition.
C Alkanes and alkenes belong to the same homologous series.
D Alkanes have a higher percentage composition of carbon than the corresponding alkene.

35 The structure of but-2-ene is as shown. But-2-ene undergoes an addition reaction with hydrobromic acid, HBr, in a similar way that it reacts with bromine.

\[
\begin{align*}
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H} \\
\text{H} & \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{H} \\
\text{H} & \quad \text{H} & \quad & \quad & \\
\end{align*}
\]

Which of the following statements is true about the reaction between but-2-ene and HBr?

A The product is a mixture of two structural isomers
B Both the reactants and products are unsaturated.
C The product has a higher boiling point than the reactant.
D The product can undergo addition reaction with hydrogen.
36 An open can of beer is left exposed to the air for several days and was found to acquire a sour taste. Which of the following statements best explains this phenomenon?

A The fermentation of glucose takes place in the can of beer.
B The oxidation of ethanol occurs to form ethanoic acid.
C The decomposition of carbohydrates in the beer occurs to form ethanoic acid.
D Carbon dioxide from the fermentation reacts with water to form carbonic acid.

37 The smell in citrus fruits is due to an organic compound, limonene, found in them. Which of the following statements apply to limonene?

![Chemical structure of limonene]

I. Limonene undergoes addition polymerisation.
II. Limonene decolourises brown bromine water.
III. Limonene is saturated hydrocarbon.
IV. Limonene reacts with excess hydrogen gas to form a saturated product.
V. Limonene reacts with steam under suitable conditions to form an acid.

A I, II, IV
B II, IV, V
C I, II, III, V
D All of the above.
38 Ethane undergoes substitution reaction with bromine gas under certain conditions to form bromoethane.

\[
\begin{array}{c}
\text{Br} \\
\text{H} \\
\text{H} - \text{C} - \text{C} - \text{H} \\
\text{H} \\
\text{H}
\end{array}
\]

Which of the following statements about the above reaction is true?

A. The reaction should be carried out at room temperature in darkness.

B. The side product of this reaction is hydrogen bromide, HBr.

C. There are two possible isomers of bromoethane.

D. A suitable solvent for the reactant mixture is water.

39 Which of the following physical property of the alcohols increases when the number of carbon atoms increases?

A. Boiling Point

B. Fluidity

C. Flammability

D. Water solubility
The structure shown below is maleic acid. It can be used as a monomer to make polymers. Which of the following statements is true?

\[
\begin{align*}
&\text{HOOC} \\
&\quad\quad\quad C \quad C \\
&\quad\quad\quad \quad\quad H \\
&\text{COOH}
\end{align*}
\]

- A. It can undergo addition polymerisation with \( \text{HN}_2\text{CH}_2\text{CH}_2\text{NH}_2 \).
- B. It can undergo condensation polymerisation with \( \text{HOCH}_2\text{CH}_2\text{OH} \).
- C. When maleic acid undergoes addition polymerisation, it loses water molecules.
- D. When maleic acid undergoes condensation polymerisation, polymaleic acid is formed.
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>21</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>22</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>23</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>24</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>25</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>26</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>B</td>
<td>27</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>28</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>B</td>
<td>29</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>B</td>
<td>30</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>C</td>
<td>31</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>D</td>
<td>32</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>D</td>
<td>33</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>C</td>
<td>34</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>A</td>
<td>35</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>C</td>
<td>36</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>C</td>
<td>37</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>C</td>
<td>38</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>B</td>
<td>39</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>D</td>
<td>40</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>
Section A
Answer all the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 P, Q, R, S and T are elements.
- P is a halogen which is a black solid at room temperature.
- Q is an alkali metal which displaces sodium from its salt solution.
- R is a transition metal that forms an anion of the type RO₄⁻.
- S is a non-metal that conducts electricity.
- T is a non-metal that has a maximum oxidation state of +7.

Give the chemical symbols of P, Q, R, S and T.

P: ____________________________
Q: ____________________________
R: ____________________________
S: ____________________________
T: ____________________________

[Total: 5]

A2 Paper chromatography was used to separate 3 food colourings which are very soluble in ethanol, but only slightly soluble in water. The experiment was allowed to run for 10 minutes with water as a solvent, and the result obtained is shown below.

a) What is the purpose of the plastic cover on the bottle?  

_____________________________
b) Describe the effect on the $R_f$ value of the dyes if

i) the paper used for the experiment was twice the length. \[1\]

ii) the solvent was changed to ethanol. \[1\]

c) The blue dye in the chromatogram has the formula $\text{KFe[Fe(CN)_6]}_6$, which consists of potassium ions, iron ions and $\text{Fe(CN)}_{6}^{3-}$ ions (which are slightly yellow in colour).

When a moist chromatogram containing the blue dye is electrolysed, a faint spot migrates to each electrode as seen in the diagram below.

```
+-----------------+
| negative        |
| electrode       |
|                 |
|                 |
| spot 1 blue     |
|                 |
| spot 2          |
|                 |
| positive        |
| electrode       |
+-----------------+
```

i) State the charge of iron ions found in the blue dye. \[1\]

ii) Is the blue dye a mixture or a compound? Justify your answer using information from the paper chromatography and electrolysis experiments. \[2\]

[Total: 6]
A3 A series of experiments was carried out on an element T. It is found that T can conduct electricity in the solid state, under room conditions. It dissolves very readily in water to form alkaline solutions.

a) Draw a diagram to represent the structure of T. [2]

b) Draw a “dot-and-cross” diagram of the sulfide of T. [2]

[Total: 4]
A4 a) $^{16}\text{O}$ and $^{18}\text{O}$ are isotopes of oxygen. Complete the table below.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Number of protons</th>
<th>Number of neutrons</th>
<th>Number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{16}\text{O}$</td>
<td>8</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>$^{18}\text{O}^2-$</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>$^{18}\text{O}_2$</td>
<td></td>
<td>20</td>
<td>16</td>
</tr>
</tbody>
</table>

b) To study the reaction between carboxylic acids and alcohols, ethanol was added to propanoic acid and heated with concentrated sulfuric acid. The oxygen atoms in ethanol are made of the heavy oxygen isotope, i.e. $^{18}$O.

Draw the organic product formed during this reaction, and mark the heavy oxygen atom with a **.”**

ii) The ethanol used in (i) can be made by fermentation of glucose. Explain why fermentation alone is not used to produce most of the ethanol used in industry.

Total: 5

A5. Propane and methane are sometimes transported in the liquid state.
<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting point/°C</th>
<th>Boiling point/°C</th>
<th>Where transported as a liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>-188</td>
<td>-42</td>
<td>In ships</td>
</tr>
<tr>
<td>Methane</td>
<td>-182</td>
<td>-162</td>
<td>In road tankers and ships</td>
</tr>
</tbody>
</table>

Propane is transported as a liquid at room temperature by keeping it under pressure. It is not practical to keep methane liquid in a tanker by the same method.

a) Suggest how methane is kept as a liquid in a tanker. [1]

b) In terms of arrangement and movement of particles, describe the changes when methane turns from gas to liquid. [2]

[Total: 3]
A6a) If concentrated acid is spilled onto the skin of someone on the streets, it must be washed as quickly as possible by lots of running water. Give 1 reason why water is used in this case, instead of a solution of potassium hydroxide.

b) Outline the procedure involved in disposing of concentrated acid spilled on the street without leaving excess alkaline solution. Describe how total acid removed is ensured.

c)i) State whether the following statement is true or false and explain your answer:

*Given same concentration of acid X and Y, if X is a stronger acid than Y, then the pH of an aqueous solution of X must be lower than that of Y.*

ii) Describe a simple test to differentiate between X and Y.

[Total: 6]
A7 This question is about making salts. For each salt, suggest the name of the missing reagent and briefly describe how to obtain the solid product from the reaction mixture.

a) Salt to be made: caesium chloride.
Reagent 1: dilute hydrochloric acid
Reagent 2: 
I could obtain solid caesium chloride by:

b) Salt to be made: iron(II) sulfate crystals.
Reagent 1: dilute sulfuric acid
Reagent 2: 
I could obtain iron(II) sulfate crystals by:

[Total: 4]
A8 The diagram below shows the Blast Furnace.

[a) Identify raw material A and explain why it is added to the blast furnace. [2]

[b) Iron produced from the blast furnace is impure as it contains carbon as impurities. In order to get rid of the carbon, oxygen is blown on the molten iron. Carbon dioxide is then produced.

As the oxygen is blown into it, the temperature of the molten iron rises. Explain this observation. [1]
c) To recycle iron, scrap steel is added to the molten iron produced from the blast furnace. The graph below shows the changes in temperature of the molten iron during the oxygen blow.

Describe how the temperature of the molten iron changes during the oxygen blow. Suggest a reason for the change.

____________________________________

____________________________________
d) Silicon can be added to iron to make electrical steel. The table below shows the types of electrical steel and their composition.

<table>
<thead>
<tr>
<th>Steel type</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1% Si</td>
</tr>
<tr>
<td>2</td>
<td>2.3% Si</td>
</tr>
</tbody>
</table>

Sketch diagrams to illustrate the arrangement of atoms in:

i) Steel Type 1.

ii) Steel Type 2

[Total: 8]
A9  
Titanium can be manufactured by heating titanium(IV) chloride with magnesium.

a)  Construct the equation for this reaction.  

[1]

b)  Explain why this reaction involves both oxidation and reduction.  

[2]

c)  What mass of titanium can be made from 125g of titanium(IV) chloride?  

[2]

[Total: 5]
A10 Ammonia is manufactured by reacting a mixture of nitrogen and hydrogen together in the Haber Process.

\[ \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g}) \]

The reaction can be demonstrated in the laboratory by the method shown in the diagram.

The mixture of nitrogen and hydrogen is passed backwards and forwards over the hot iron wool until there is no further reaction. The iron wool is heated to the same temperature as the iron used in the industrial process.

a) State a source of hydrogen. [1]

b) Suggest why it is important that no air is to be present in the apparatus when the iron is heated. [1]

c) In the industrial process, a yield of 15% is obtained. If the same percentage conversion takes place in the laboratory demonstrations, what volume of ammonia (measured at r.t.p.) would be produced? [1]
cii) How would you expect the actual volume of ammonia produced in the laboratory demonstration to compare with the calculated volume in c(i)? Explain your answer.

[Total: 4]
Section B
Answer all three questions from this section. The last question is in the form of either/or and only one of the alternatives should be attempted.

B11 The Green Vehicle Trend

All-electric car

Electricity has been explored as an alternative power source to replace or complement the internal combustion engine for decades. There are two types of electrically powered vehicles, including hybrid cars and electric cars.

![Plug-in Electric Vehicles Table]

Figure 1: The performances of new electric vehicles (Source: Madslien, 2009)

Fuel Consumption Reduction
Hybrid systems can reduce fuel consumption and CO₂ emissions by up to 35%, equivalent to more than a 50% increase in fuel economy.
Figure 2: A graph of fuel consumption against vehicle size (footprint) for current hybrid and non-hybrid models (Source: U.S. EPA’s 2014 Fuel Economy Trends Report, 2014)

**Nickel Metal Hydride (NiMH) Battery in Electric Cars**

The principles in which NiMH cells operate are based on their ability to absorb, release, and transport (move) hydrogen between the electrodes within the cell. The following sections will discuss the chemical reactions occurring within the cell when charged and discharged.

**Charging Chemical Reaction**

An aqueous solution of potassium hydroxide is the major component of the electrolyte of a nickel metal hydride battery. When a NiMH cell is charged, the positive electrode releases hydrogen into the electrolyte. The hydrogen in turn is absorbed and stored in the negative electrode. The reaction begins when solid nickel hydroxide (Ni(OH)₂) in the positive electrode and hydroxide (OH⁻) from the electrolyte combine. This produces solid nickel oxyhydroxide (NiOOH) within the positive electrode, water (H₂O) in the electrolyte, and one free electron (e⁻). At the negative electrode the metal alloy (M) in the negative electrode, water (H₂O) from the electrolyte, and an electron (e⁻) react to produce aqueous metal hydride (MH) in the negative electrode and hydroxide (OH⁻) in the electrolyte.

Because heat is generated as a part of the overall chemical reaction during the charge of a NiMH cell, the charging reaction described above is exothermic.
Discharge Chemical Reaction
When a NiMH cell is discharged, the chemical reactions are the reverse of what occurs when charged. Hydrogen stored in the metal alloy of the negative electrode is released into the electrolyte to form water. This water then releases a hydrogen ion that is absorbed into the positive electrode to form nickel hydroxide.

For NiMH cells, the process of moving or transporting hydrogen from the negative electrode to the positive electrode absorbs heat and is therefore endothermic.

Figure 3: Transport Diagram
a) State the name of the electric car that covers the least distance per hour of charging. [1]  

b) Deduce the relationship between fuel consumption and the size of a vehicle. [1]  

c) The electrolyte used in the Nickel Metal Hydride (NiMH) batteries is an aqueous solution of potassium hydroxide. Briefly explain why aqueous potassium hydroxide is used as the electrolyte and not pure water. [2]  

d) Write ionic equations for the reactions at the positive and negative electrodes when the NiMH cell is charging. At the positive electrode: [2]  

At the negative electrode:
ii) Hence, construct the overall equation for the charging process. [1]

iii) What happens to the concentration of nickel hydroxide during the charging process? Explain your reasoning. [1]


e) State one difference between a NiMH cell and an electrolytic cell. [1]

f) Explain why it is not advisable to overcharge NiMH cells. [1]

[Total: 12]
B12a) Styrene-butadiene rubber is a synthetic rubber. It is produced by polymerising a mixture of the monomers styrene and butadiene.

\[ \text{CH} = \text{CH}_2 \]

Styrene (C₆H₆)

\[ \text{H} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \quad \text{H} \]

Butadiene

a) Butadiene is said to be a polyunsaturated compound. Explain what is meant by 'polyunsaturated'. [1]

b) One possible structure for the polymer is shown below.

\[ \text{styrene} \quad \text{butadiene} \quad \text{styrene} \quad \text{butadiene} \]

j) Give the structural formula of 1 repeating unit in this polymer. [2]
ii) During the manufacturing process, the chain length of the polymer is controlled so that the polymer molecules have an average relative molecular mass in the range 13000 to 20000. What is the range of the average number of repeating units in the polymer?

Show your working.

iii) When the mixture of styrene and butadiene polymerises, the polymer is unlikely to contain only this regular, repeating pattern. Explain why this is impossible.

c) Butadiene can be made by cracking butane in a cracking tower. Butane cracks to form butadiene and one other product. Write an equation for this reaction.

d) Hydrogen was added to a sample of styrene at 200°C with nickel catalyst. Draw a product that can be formed in this reaction.

[Total: 8]
B13 **EITHER**

a) A student performed an experiment to investigate the rate of reaction between zinc and an acid. 5 g of zinc granules was added to a conical flask containing 100 cm³ of 2 mol/dm³ hydrochloric acid at 25 °C. Calculate the mass of zinc chloride formed in this reaction. [2]

b) A standard solution was prepared by dissolving 2.12g of anhydrous sodium carbonate in distilled water and making up to a total of 250 cm³. [3]

A 25.0 cm³ portion of this solution was titrated against hydrochloric acid solution, using methyl orange as indicator. This indicator changes colour when sodium carbonate has been completely converted into sodium chloride.

20 cm³ of the acid were required for neutralization. What is the concentration of the acid?
ci) Three beakers containing the following acid solutions were prepared.

Beaker A : 50 cm$^3$ of 1.0 mol/dm$^3$ hydrochloric acid
Beaker B : 50 cm$^3$ of 1.0 mol/dm$^3$ sulfuric acid
Beaker C : 50 cm$^3$ of 1.0 mol/dm$^3$ ethanoic acid

0.48 g of magnesium was added to each beaker. Arrange the beakers in order of decreasing rate of reaction and explain why the rate of reaction differs in each beaker. [3]

ii) A student mentioned:

"Sulfuric acid produced greater mass of gaseous products than the other 2 acids when reacted with 0.48 g of magnesium".

Do you agree with this statement? Explain why you agree or disagree with the help of balanced chemical equations and working(s). [2]
B13 OR

a) The volume of sulfur dioxide in air can be determined by bubbling a sample of the air through sodium hydroxide solution, where it reacts according to the equation below.

\[ \text{SO}_2 (g) + 2\text{NaOH} (aq) \rightarrow \text{Na}_2\text{SO}_3 (aq) + \text{H}_2\text{O} (l) \]

The concentration of the unreacted sodium hydroxide can be determined by titration against a standard solution of hydrochloric acid.

1000 dm\(^3\) of air were bubbled through 200 cm\(^3\) of 1 mol/dm\(^3\) solution of sodium hydroxide. The resulting solution was diluted to 1000 cm\(^3\) with water and 25.0 cm\(^3\) of this solution was neutralized by 20.0 cm\(^3\) of a 0.1 mol/dm\(^3\) solution of hydrochloric acid.

i) Calculate the total number of moles of unreacted sodium hydroxide. [1]

ii) Find the number of moles of sulfur dioxide in 1000 dm\(^3\) of air. [2]

iii) Calculate the percentage by volume of sulfur dioxide in the air at room temperature and pressure. [2]
b) A typical cold-pack consists of ammonium nitrate and water. They are stored in separate compartments. To make the cold-pack work, we need to twist the pack so that the inner membrane breaks.

i) If a cold pack consists of 0.1 kg of ammonium nitrate, the maximum amount of heat that it can absorb during activation is 31.9 kJ. Calculate the enthalpy change in dissolving 1 mole of ammonium nitrate.

ii) Draw the energy profile diagram when 1 mole of ammonium nitrate is dissolved in water. Your diagram should show and label the following:

- product
- activation energy of reaction
- enthalpy change of reaction.
The Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td></td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>He</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
<td>F</td>
</tr>
<tr>
<td>4</td>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Cl</td>
</tr>
<tr>
<td>5</td>
<td>K</td>
<td>Ca</td>
<td>Sc</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
<td>Mn</td>
</tr>
<tr>
<td>6</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
<td>Mn</td>
<td>Fe</td>
<td>Co</td>
<td>Ni</td>
</tr>
<tr>
<td>7</td>
<td>Zn</td>
<td>Ga</td>
<td>Ge</td>
<td>As</td>
<td>Se</td>
<td>Br</td>
<td>Kr</td>
</tr>
<tr>
<td>8</td>
<td>Rb</td>
<td>Sr</td>
<td>Y</td>
<td>Zr</td>
<td>Nb</td>
<td>Mo</td>
<td>Ru</td>
</tr>
<tr>
<td>9</td>
<td>Cs</td>
<td>Ba</td>
<td>La</td>
<td>Hf</td>
<td>Ta</td>
<td>W</td>
<td>Re</td>
</tr>
<tr>
<td>10</td>
<td>Fr</td>
<td>Ra</td>
<td>Ac</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*58-71 Lanthanoid series
*190-207 Actinoid series

Key:
a = relative atomic mass
b = proton (atomic) number
X = atomic symbol

<table>
<thead>
<tr>
<th>140</th>
<th>141</th>
<th>144</th>
<th>147</th>
<th>150</th>
<th>152</th>
<th>153</th>
<th>155</th>
<th>156</th>
<th>157</th>
<th>159</th>
<th>161</th>
<th>162</th>
<th>164</th>
<th>165</th>
<th>166</th>
<th>167</th>
<th>169</th>
<th>173</th>
<th>175</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ce</td>
<td>Pr</td>
<td>Nd</td>
<td>Pm</td>
<td>Sm</td>
<td>Eu</td>
<td>Gd</td>
<td>Tb</td>
<td>Dy</td>
<td>Ho</td>
<td>Er</td>
<td>Tm</td>
<td>Yb</td>
<td>Lu</td>
<td>Ce</td>
<td>Pr</td>
<td>Nd</td>
<td>Pm</td>
<td>Sm</td>
<td>Eu</td>
</tr>
<tr>
<td>58</td>
<td>59</td>
<td>60</td>
<td>61</td>
<td>62</td>
<td>63</td>
<td>64</td>
<td>65</td>
<td>66</td>
<td>67</td>
<td>68</td>
<td>69</td>
<td>70</td>
<td>71</td>
<td>58</td>
<td>59</td>
<td>60</td>
<td>61</td>
<td>62</td>
<td>63</td>
</tr>
<tr>
<td>Qn</td>
<td>Answer</td>
<td>Mark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>--------</td>
<td>------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| A1 | P: At / I or At₂ / I₂  
Q: K / Fr / Cs / Rb  
R: Mn  
S: C / Si  
T: Cl / Br / I / At | 1m each |
| A2a) | To keep atmosphere in jar saturated (with solvent vapour). Allow to **reduce / prevent solvent/water evaporation** | [1] |
|   | R₁ values would remain the same / no change / no effect | [1] |
|   | R₂ values would increase (because the dyes are readily soluble in ethanol) | [1] |
|   | 2⁺ or (+2) | [1] |
|   | The blue dye is a **compound**.  
It **cannot be separated by paper chromatography / has only 1 spot on chromatogram**. (1m)  
Its components can be separated by **electrolysis / to give two substances/spots**. (1m)  
-1m for "dot" | [2] |
| A3 |  
(a) **Fixed cation**  
\[ \begin{array}{c}  
+ & + & + & +  
+ & + & + & +  
\end{array} \]  
*Sea of electrons*  
Regular closely packed cations in sea of electrons (some must be in between cations) – 1m  
Balance charges – 1m  
-1m for wrong labelling | [2] |
|   | 1m – correct number of electrons transferred & total number of electrons (accept: all Group I, Ca, Sr, Ba, Ra for T) | [2] |

**Total:** [5]  
**Total:** [6]  
**Total:** [4]
A4a)  |  Formula  | Number of protons | Number of neutrons | Number of electrons |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>O²⁻</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>O₂</td>
<td>16</td>
<td>20</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

1 correct is 0m
2 or 3 correct is 1m

b) ![Chemical structure](image)

ii) When the concentration of ethanol exceeds 15% / high concentration of ethanol, the yeast dies/stop working/denatured and fermentation stops.

Or

Because the ethanol produced is too dilute/cannot meet the demand, hence require fractional distillation instead of just fermentation alone

Or

Fermentation alone cannot meet the demand in the industry, therefore hydration of ethene is also used to produce ethanol.

Total: [5]

A5a) By cooling it below -162°C (and above -182°C), where it is in the liquid state.

b) Arrangement: Particles are closer together/very far apart to more closely packed in a disorderly/irregular/random manner.

Movement: The particles move rapidly in any direction to move freely throughout the liquid or slide over each other / particles move slower

Total: [3]

A6a) (Any one)
- KOH can be used to neutralise the acid but much heat will be generated/produced during the neutralisation reaction (1m) and this heat can damage the skin. Heat is also generated during the process of dilution but if large volume of water are used, most of this heat is absorbed by the water (1m). Accept similar phrasing
- KOH can be used to neutralise the acid but excess of KOH is corrosive/alkaline (1m) to the skin and it would be hard to estimate when
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>b)</td>
<td>Add ( \text{CaCO}_3/ \text{any insoluble carbonate/ CaO/ any insoluble base} ) powders to soak up the spilled liquid and thus prevent it from spreading (unlike liquid bases). Also, when reagent is added in excess. OR continuously until effervescence stops/solid does not decrease in size anymore (due to the formation of ( \text{CO}_2 ) with the acid), this indicated that neutralisation is complete (1m) and total acid removal is ensured.</td>
</tr>
<tr>
<td>c)</td>
<td>True. &quot;( X ) is stronger than ( Y )&quot; only means the degree of ionisation of ( X ) is higher than that of ( Y ). pH of an acid solution depends on the degree of ionisation/dissociation (1m) or ( X ) dissociates more completely in water than ( Y ) to produce ( H^+ ), or ( X ) has a higher concentration of ( H^+ ) than ( Y ).</td>
</tr>
<tr>
<td>i)</td>
<td>Use universal indicator. If ( \text{pH} ) turns from green solution to yellow/orange, the acid is ( Y ). If ( \text{pH} ) turns from green solution to red, the acid is ( X ). Accept pH meter (pH of ( Y &gt; \text{pH of } X ))</td>
</tr>
<tr>
<td>Total:</td>
<td>[6]</td>
</tr>
<tr>
<td>A7a)</td>
<td>(Aqueous) caesium hydroxide/ caesium carbonate (solution) (1m) Evaporate/heat the caesium chloride solution until it is saturated. Allow the saturated solution to cool so that the salt can crystallise. (1m)</td>
</tr>
<tr>
<td>b)</td>
<td>Iron(II) oxide/ iron(II) hydroxide/ iron(II) carbonate/ iron (1m) Filter to remove the excess iron(II) oxide/ carbonate/ hydroxide/ iron, collect the filtrate/aqueous iron(II) sulfate. Heat the solution/ filtrate until it is saturated and leave it to cool and crystallise (1m) Wrong reagent 0m</td>
</tr>
<tr>
<td>Total:</td>
<td>[4]</td>
</tr>
<tr>
<td>A8a)</td>
<td>Limestone/calcium carbonate/ ( \text{CaCO}_3 ) [1] When heated, it produces calcium oxide, which is basic and removes acidic impurities/sand/ ( \text{SiO}_2 ) [1]</td>
</tr>
<tr>
<td>b)</td>
<td>Oxidation of carbon is exothermic/heat is produced. Penalise for ‘Combustion of C’</td>
</tr>
<tr>
<td>c)</td>
<td>From ( t = 0 ) to ( t = 10 ) minutes, the temperature of molten iron increases slowly. From ( t = 10 ) minutes onwards, the temperature of molten iron increase was faster. [1] Heat used to melt scrap steel but after 10min, all the scrap steel had melted. [1]</td>
</tr>
<tr>
<td>d)</td>
<td>1m - disruption 1m - size of atoms (Iron is bigger than Silicon) + closely packed</td>
</tr>
<tr>
<td>Total:</td>
<td>[3]</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>A9a)</td>
<td>( TiCl_4 + 2Mg \rightarrow 2MgCl_2 + Ti )</td>
</tr>
<tr>
<td>b) Reduction because ( Ti^{4+} ) ions gain electrons to form ( Ti ). Oxidation since ( Mg ) loses electrons to form ( Mg^{2+} ). OR Oxidation state of ( Ti ) decreases from +4 in ( TiCl_4 ) to 0 in ( Ti ), reduction Oxidation state of ( Mg ) increases from 0 in ( Mg ) to +2 in ( MgCl_2 ), oxidation Penalise 1m for use of ‘change’.</td>
<td></td>
</tr>
<tr>
<td>c) No. of moles of ( TiCl_4 ) = ( \frac{125}{190} = 0.65789 ) mol (1m) Mole ratio ( \rightarrow TiCl_4 : Ti \rightarrow 1:1 ) Mass of ( Ti ) = ( 0.65789 \times 48 = 31.8g ) (1m)</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>8</td>
</tr>
<tr>
<td>A10a)</td>
<td>• Cracking of (long-chain) alkene/ hydrocarbons/crude oil/ petroleum in the presence of ( Al_2O_3 ) / ( SiO_2 ) at 600(^\circ)C • Electrolysis of water • Steam reforming (Any one)</td>
</tr>
<tr>
<td>b) The hydrogen/iron would react with the oxygen/ in the air/ oxidised.</td>
<td></td>
</tr>
<tr>
<td>c) Volume of ammonia produced = ( 2 \times 25 \times 15/100 = 7.5cm^3 )</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>5</td>
</tr>
<tr>
<td>B11a)</td>
<td>Think City</td>
</tr>
<tr>
<td>(b) Fuel consumption increases as the vehicle size increase. [1]</td>
<td></td>
</tr>
<tr>
<td>(bii) <strong>Non-hybrid cars</strong> consume more fuel for the same vehicle size. [1] From Figure 2, for hybrid cars of vehicle size 40m(^2) consumes 1.5 litres/100km, while non-hybrid cars of the same vehicle size consumes 4 litres/100km. [1] Accepts other information when vehicle size is 50m(^2), 60m(^2) only.</td>
<td></td>
</tr>
<tr>
<td>(c) Pure water <strong>does not conduct electricity</strong>. Water exists as <strong>molecules</strong> / does</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>4</td>
</tr>
</tbody>
</table>

Need a home tutor? Visit smiletutor.sg

| Page 645 |
not contain any mobile electrons or ions [1].

Aqueous potassium hydroxide conducts electricity. It contains mobile potassium ions and hydroxide ions [1].

(dii) At the positive electrode: \( \text{Ni(OH)}_2(s) + \text{OH}^-(aq) \rightarrow \text{NiOOH}(s) + H_2O(l) + e^- \) [2]

At the negative electrode: \( M(s) + H_2O(l) + e^- \rightarrow MH(aq) + OH^-(aq) \)

(diii) \( \text{Ni(OH)}_2(s) + M(s) \rightarrow \text{NiOOH}(s) + MH(aq) \) [1]

The concentration of nickel hydroxide will decrease as it will be oxidised/reacted to form nickel oxyhydroxide. [1]

(e)  
- Electrolytic cells rely upon external power sources instead of stored chemical reactants in NIMH cells.
- NIMH cells are rechargeable/can be reused while electrolytic cells will stop functioning once the reactants are used up.
- Electrical energy is produced in NIMH cells while electrical energy is consumed in electrolytic cells.
- In NIMH cells, the redox reactions are spontaneous. In electrolytic cells, the redox reactions are non-spontaneous and take place only when energy is supplied.

[Any 1 point]

(f) Extreme elevated temperatures/too much heat/overheating will be experienced when NIMH cells are overcharged. [1]

Reject: exothermic/explosion

Total: [12]

B12a) More than one carbon-carbon double bond or C=C double bond

Reject: C-C double bond [1]

bi) 1m – for each “monomer” drawn correctly [2]

Penalise 1m if no side bonds drawn.

ii) \[ \frac{13000}{158} = 82.28 \]

\[ \frac{20000}{158} = 126.58 \]

1m – if both above workings are correct

Hence the range is 83 to 126. [1]

iii) It is because the same type of monomer may join to each other, instead of only having the styrene and butadiene joining to each other in alternate positions.

C₆H₆ → C₆H₆ + 2H₂ [1]
<table>
<thead>
<tr>
<th>Total: [8]</th>
</tr>
</thead>
<tbody>
<tr>
<td>d) <img src="" alt="Chemical Structure" /></td>
</tr>
<tr>
<td>Either</td>
</tr>
<tr>
<td>B13a) ( \text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2 )</td>
</tr>
</tbody>
</table>

- No. of moles of \( \text{Zn} = \frac{5\text{g}}{65} = 0.076923 \text{ mol} \)
- No. of moles of \( \text{HCl} = 2 \times 0.1 = 0.2 \text{ mol (1m)} \)
- \( \text{Zn} \) is the limiting reagent.
- No. of moles of \( \text{Zn} = \) No. of moles of \( \text{ZnCl}_2 = 0.076923 \text{ mol} \)
- Mass of \( \text{ZnCl}_2 = 0.076923 \times (65 + 71) = 10.461 = 10.5 \text{ g (1m)} \)

<table>
<thead>
<tr>
<th>Total: [10]</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Molar mass of ( \text{Na}_2\text{CO}_3 = 106 \text{g} )</td>
</tr>
</tbody>
</table>

- Concentration of standard solution = \( \text{mol of Na}_2\text{CO}_3 \div \text{volume} \)
  - \( = \frac{2.12}{106} + \frac{250}{1000} \)
  - \( = 0.08 \text{ mol/dm}^3 \) (1m)

- Since \( \text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O} \)
- No. of moles of \( \text{Na}_2\text{CO}_3 = \frac{250}{1000} \times 0.08 \text{ mol} = 0.002 \text{ mol} \)
- No. of moles of \( \text{HCl} = 2 \times 0.002 = 0.004 \text{ mol (1m)} \)

- Concentration of acid = \( 0.004 \text{ mol} \div 0.02 \text{ dm}^3 = 0.200 \text{ mol/dm}^3 \) (1m)

<table>
<thead>
<tr>
<th>Total: [10]</th>
</tr>
</thead>
<tbody>
<tr>
<td>c) <img src="" alt="Reactions" /></td>
</tr>
<tr>
<td>B.A.C [1]</td>
</tr>
</tbody>
</table>

- Ethanoic acid is a weak acid while hydrochloric acid and sulfuric acid are strong. [1]
- Sulfuric acid is dibasic while hydrochloric acid is monobasic, hence concentration of \( H^+ \) ions in sulfuric acid is double/more that of hydrochloric acid. [1]

<table>
<thead>
<tr>
<th>Total: [10]</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Disagree.</td>
</tr>
</tbody>
</table>

- \( \text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2 \)
- \( \text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2 \)
- \( \text{Mg} + 2\text{CH}_3\text{COOH} \rightarrow (\text{CH}_3\text{COO})_2\text{Mg} + \text{H}_2 \) [1m-for 3 balanced equations]

[1m-for working + stating Mg is LR] E.g.

- No. of mole of Mg = \( 0.48 \div 24 = 0.02 \text{ mol} \)
- No. of mole of HCl / \( \text{H}_2\text{SO}_4 / \text{CH}_3\text{COOH} = 0.05 \times 1 = 0.05 \text{ mol} \)

Hence, Mg is the limiting reactant in the 3 experiments.
<table>
<thead>
<tr>
<th><strong>B.13 OR</strong></th>
<th>( \text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>No. of moles of NaOH unreacted in 25 cm(^3) = no. of moles of HCl used in titration = 0.1 \times 0.02 = 0.002 mol</td>
</tr>
<tr>
<td></td>
<td>No. of moles of NaOH unreacted = 0.002 \times 1000/25 = 0.08 mol (1m)</td>
</tr>
<tr>
<td>ii)</td>
<td>No. of moles of NaOH = 0.2 \times 1 = 0.2 mol</td>
</tr>
<tr>
<td></td>
<td>No. of moles of NaOH reacted = 0.2 - 0.08 = 0.12 (1m)</td>
</tr>
<tr>
<td></td>
<td>From the equation: ( \text{SO}_2 (g) + 2\text{NaOH (aq)} \rightarrow \text{Na}_2\text{SO}_3 (aq) + \text{H}_2\text{O (l)} )</td>
</tr>
<tr>
<td></td>
<td>No. of moles of ( \text{SO}_2 ) = ( \frac{1}{2} ) no. of moles of NaOH used up</td>
</tr>
<tr>
<td></td>
<td>= ( \frac{1}{2} \times 0.12 = 0.06 ) mol (1m)</td>
</tr>
<tr>
<td>iii)</td>
<td>Volume of ( \text{SO}_2 = 0.06 \times 24 = 1.44 \text{ dm}^3 ) (1m)</td>
</tr>
<tr>
<td></td>
<td>% by volume = ( \frac{1.44}{1000} \times 100% = 0.144 % ) (1m)</td>
</tr>
<tr>
<td>b)</td>
<td>Enthalpy change in dissolving ( \text{NH}_3\text{NO}_3 ) = ( \text{kJ/g x g/mol = (+31.9/100)} \times 80 ) (1m)</td>
</tr>
<tr>
<td></td>
<td>= + 25.52 kJ/mol or + 25.5 kJ/mol (1m)</td>
</tr>
<tr>
<td></td>
<td>Accept kJ</td>
</tr>
</tbody>
</table>

**Diagram:**

- **Energy**
- **Activation energy**
- **ENTHALPHY CHANGE**
- **Progress of reaction**

1m – activation energy (single-headed arrow)
1m – enthalpy change (single-headed arrow) with correct shape
1m – \( \text{NH}_3\text{NO}_3 (aq) \)
Penalise max 1m if label \( E_a \)

**Total:** [10]
READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

There are forty questions on this paper. Answer all questions. For each question, there are four possible answers A, B, C, and D.
Choose the one you consider correct and record your choice in soft pencil on the separate Answer sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 14.
The use of an approved scientific calculator is expected, where appropriate.
1 A particle contains 52 protons, 76 neutrons and 54 electrons. Which is the correct symbol for this particle?

A $^{76}_{52}\text{Te}$  B $^{76}_{52}\text{Te}^{2+}$  C $^{128}_{52}\text{Te}^{2+}$  D $^{128}_{52}\text{Te}^{2-}$

2 Which compound contains only eight covalent bonds?

A  

B  

C  

D  

3 Which of the following pairs of substances can be separated by heating?

A ammonium chloride and potassium iodide  
B copper (II) nitrate and potassium iodide  
C ammonium chloride and iodine  
D sodium chloride and copper (II) nitrate

4 Which substance has metallic bonding?

<table>
<thead>
<tr>
<th>Substance</th>
<th>State of product formed on reacting with oxygen</th>
<th>Conducts electricity when solid?</th>
<th>Conducts electricity when liquid?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>gas</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>B</td>
<td>No reaction</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>C</td>
<td>solid</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>D</td>
<td>solid</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

5 Element X has proton number n and is virtually unreactive under most conditions. Another element Y has proton number (n + 2). What is the likely formula of the phosphide of Y?

A $Y_3P_2$  
B $Y_2P_3$  
C $YP$  
D $Y_5P$
6 The table below shows the properties of four substances A, B, C and D. Which one of the following could be silver iodide?

<table>
<thead>
<tr>
<th>Substance</th>
<th>Melting point/°C</th>
<th>Boiling point/°C</th>
<th>Conducts electricity when molten?</th>
<th>Conducts electricity when placed in water?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-31</td>
<td>66</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>B</td>
<td>502</td>
<td>953</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>C</td>
<td>920</td>
<td>1400</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>D</td>
<td>3252</td>
<td>4938</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

7 In an experiment, 5 cm³ of a gaseous hydrocarbon reacted with excess oxygen to form 30 cm³ of carbon dioxide and 15 cm³ of steam. Assuming all volumes of gases were measured at the same temperature and pressure, what is the formula of the hydrocarbon?

A CH₄  
B C₂H₄  
C C₂H₆  
D C₆H₆

8 The reaction between sodium carbonate and nitric acid is as shown below:

\[ \text{Na}_2\text{CO}_3 + 2\text{HNO}_3 \rightarrow 2\text{NaNO}_3 + \text{H}_2\text{O} + \text{CO}_2 \]

Given that 0.8 g of hydrated sodium carbonate (Na₂CO₃.nH₂O) requires 10 cm³ of 1 mol/dm³ of dilute nitric acid for the above reaction, what is the value of n?

A 3  
B 5  
C 7  
D 10

9 In an experiment to determine the concentration of hydrochloric acid, 20 cm³ hydrochloric acid in a conical flask was titrated with 0.1 mol/dm³ aqueous sodium hydroxide. Which of the steps would cause the calculated concentration of hydrochloric acid to be lower than its true value?

A The burette was rinsed with distilled water followed by 0.1 mol/dm³ aqueous sodium hydroxide.
B The conical flask was rinsed with distilled water followed by aqueous sodium hydroxide before the hydrochloric acid is pipetted into the flask.
C There is an air bubble in the burette jet.
D The titration reading was taken at the end point.
10 A gaseous mixture of ethene, oxygen and sulfur dioxide is passed through the apparatus shown. Only one of the gases is collected.

What is a property of the gas collected?

A burns with a yellow flame
B relights a glowing splint
C turns limewater chalky
D turns acidified potassium dichromate (VI) solution green

11 The results of a paper chromatography experiment shown below were obtained.

Given that the $R_f$ values of dye P is 0.40, determine the $R_f$ value of dye Q.

A 0.5
B 0.6
C 0.7
D 0.8
12 Aqueous copper (II) sulfate is electrolysed using a copper cathode and a platinum anode. Which observation will be made?

<table>
<thead>
<tr>
<th></th>
<th>at anode</th>
<th>at cathode</th>
<th>the electrolyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>anode dissolves</td>
<td>pink solid forms</td>
<td>no change</td>
</tr>
<tr>
<td>B</td>
<td>anode dissolves</td>
<td>pink solid forms</td>
<td>blue colour fades</td>
</tr>
<tr>
<td>C</td>
<td>colourless gas forms</td>
<td>colourless gas forms</td>
<td>no change</td>
</tr>
<tr>
<td>D</td>
<td>colourless gas forms</td>
<td>pink solid forms</td>
<td>blue colour fades</td>
</tr>
</tbody>
</table>

13 With reference to the diagram below, which of the following statements is correct?

**Diagram:**
- Electron flow
- Copper electrode
- Electrode made of metal X
- Dilute sulfuric acid

A. Copper electrode is the negative electrode.
B. Metal X is below copper in the reactivity series.
C. The mass of the copper electrode decreases.
D. The mass of the X electrode decreases.

14 It was found that the heat required to boil 7.4 g of ethoxyethane \((\text{C}_2\text{H}_5)_2\text{O}\) was 2.6 kJ while that required to boil 4.6 g of ethanol was 3.9 kJ. From this evidence, which of the following would you judge to be the most correct conclusion? \([M_r \text{ of } (\text{C}_2\text{H}_5)_2\text{O} = 74; \text{C}_2\text{H}_5\text{OH} = 46]\)

A. The atoms in ethanol molecules are more difficult to break apart than those in ethoxyethane molecules.
B. The molecules of ethanol are bound together more strongly than those of ethoxyethane.
C. The molecules of ethoxyethane are bound together more strongly than those of ethanol.
D. The more carbon atoms there are in a molecule, the easier it is to evaporate the substance.
15 When 1 g of methane is burnt, 56 kJ of energy is released. How much heat is released when 1 mole of methane is burnt?

A  28 kJ/mol   B  224 kJ/mol
C  504 kJ/mol   D  896 kJ/mol.

16 A student measured the rate of reaction between a given mass of zinc and an excess of hydrochloric acid by recording the volume of hydrogen produced. The results are shown in the graph below.

How long did it take for half of the zinc to react?

A  1.0 min   B  1.5 min
C  2.0 min   D  2.5 min

17 In which of the following pairs of compounds do the two elements underlined have the same oxidation state?

A  CrO₃ and KClO₃
B  CuCl₂ and Na₂CO₃
C  KMnO₄ and K₂Cr₂O₇
D  MnSO₄ and FeSO₄
18 In the graph, curve Y represents the results of reacting 1.0 g of magnesium granules with an excess of acid at 40°C.

![Graph showing reaction curve]

Which changes could produce curve Z?

A. using 1.0 g of magnesium granules and an excess of acid at 30°C  
B. using 1.0 g of magnesium powder and an excess of acid at 30°C  
C. using 0.5 g of magnesium granules and an excess of acid at 50°C  
D. using 0.5 g of magnesium granules and an excess of acid at 30°C

19 When acidified potassium dichromate (VI) is added to ethanol and warmed, the mixture changes colour from orange to green. This shows that ethanol is

A. a catalyst  
B. a neutralising agent  
C. an oxidising agent  
D. a reducing agent

20 Which of the following mixtures gives the best yield of zinc carbonate?

A. Aqueous zinc chloride and aqueous sodium carbonate  
B. Powdered zinc and powdered calcium carbonate  
C. Powdered zinc chloride and aqueous sodium carbonate  
D. Powdered zinc oxide and aqueous potassium carbonate

21 In which reaction is dilute hydrochloric acid not behaving as an acid?

A. \( \text{HCl (aq)} + \text{NaOH (aq)} \rightarrow \text{NaCl (aq)} + \text{H}_2\text{O (l)} \)  
B. \( \text{HCl (aq)} + \text{AgNO}_3 (aq) \rightarrow \text{AgCl (s)} + \text{HNO}_3 (aq) \)  
C. \( 2\text{HCl (aq)} + \text{CuO (s)} \rightarrow \text{CuCl}_2 (aq) + \text{H}_2\text{O (l)} \)  
D. \( 2\text{HCl (aq)} + \text{Mg (s)} \rightarrow \text{MgCl}_2 (aq) + \text{H}_2 (g) \)
22 Manganese dioxide acts as a catalyst in the following reaction:

\[ \text{Hydrogen peroxide (H}_2\text{O}_2) \rightarrow \text{water + oxygen} \]

Several experiments were carried out using the same mass of manganese dioxide and the same volume of hydrogen peroxide solution.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Concentration of ( \text{H}_2\text{O}_2 ) (mol/dm(^3))</th>
<th>Temperature / °C</th>
<th>Form of catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td>20</td>
<td>powder</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>30</td>
<td>lump</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>20</td>
<td>lump</td>
</tr>
<tr>
<td>4</td>
<td>1.5</td>
<td>30</td>
<td>powder</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
<td>20</td>
<td>lump</td>
</tr>
<tr>
<td>6</td>
<td>2.0</td>
<td>20</td>
<td>powder</td>
</tr>
</tbody>
</table>

Which two experiments should be compared to show the effect of particle size on the speed of reaction?

- A Experiments 1 and 3
- B Experiments 1 and 5
- C Experiments 2 and 4
- D Experiments 3 and 6

23 Which pair of gases do **not** damage limestone buildings?

- A nitrogen and carbon monoxide
- B nitrogen dioxide and carbon monoxide
- C nitrogen dioxide and carbon dioxide
- D sulfur dioxide and carbon dioxide

24 In the Haber process, the yield of ammonia can be increased by _____.

- A increasing the pressure to 300 atmospheres
- B increasing the temperature to 1500 °C
- C using a mixture containing three parts of nitrogen to one part of hydrogen
- D using platinum as a catalyst
25 Which of the following statements correctly describes a trend in the properties of the elements, going from left to right of Period 2 of the Periodic Table?

A. The ability of the elements to conduct electricity increases.
B. The melting point of the elements increases.
C. The number of neutrons in the atoms decreases.
D. The ability to form positive ions decreases.

26 Excess bromine was shaken with a mixture of potassium chloride and potassium iodide solution. The final solution will contain ____________

A. potassium chloride, potassium bromide, bromine and iodine
B. potassium bromide, bromine and iodine
C. potassium iodide, potassium bromide, bromine and chlorine
D. potassium bromide, iodine, bromine and chlorine

27 The diagram below shows the structure of a catalytic converter.

Which part of the Periodic Table is element X most likely to be found?

A. The period lithium to neon
B. Group I
C. The transition metals
D. Group VII

28 The following data refer to copper as a typical transition element and to sodium, a Group I element. For which property are they under the correct element?

<table>
<thead>
<tr>
<th>Property</th>
<th>Copper</th>
<th>Sodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Density / g cm⁻³</td>
<td>8.92</td>
<td>0.97</td>
</tr>
<tr>
<td>B. Colour</td>
<td>blue</td>
<td>white</td>
</tr>
<tr>
<td>C. Melting point / °C</td>
<td>810</td>
<td>1083</td>
</tr>
<tr>
<td>D. Nature of oxide</td>
<td>amphoteric</td>
<td>basic</td>
</tr>
</tbody>
</table>
29 Metal M is placed between zinc and iron in the reactivity series. Which of the following statement is a correct assumption of the metal M?

A Metal M has to be extracted by electrolysis.
B Metal M reacts with water at room temperature to produce hydrogen.
C Metal M forms an oxide that can be reduced by coke.
D Its oxide decomposes to give the metal on heating.

30 Which pair of substances act as reducing agents in the blast furnace?

A carbon and oxygen
B carbon monoxide and carbon dioxide
C carbon and carbon monoxide
D carbon dioxide and oxygen

31 Scrap iron is often recycled. Which reason for recycling is not correct?

A It reduces the amount of pollution at the site of the ore extraction.
B It reduces the amount of waste taken to landfill sites.
C It reduces the need to collect the scrap iron...
D It saves natural resources.

32 Which of the following best describes the properties of the three types of steel?

<table>
<thead>
<tr>
<th>High carbon steel</th>
<th>Mild steel</th>
<th>Stainless steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>corrosion resistant</td>
<td>soft and easily shaped</td>
<td>strong and brittle</td>
</tr>
<tr>
<td>strong and brittle</td>
<td>soft and easily shaped</td>
<td>corrosion resistant</td>
</tr>
<tr>
<td>corrosion resistant</td>
<td>strong and brittle</td>
<td>soft and easily shaped</td>
</tr>
<tr>
<td>soft and easily shaped</td>
<td>strong and brittle</td>
<td>corrosion resistant</td>
</tr>
</tbody>
</table>

33 Which of the following statements about homologous series is not true?

A The members have similar chemical properties.
B The boiling points increase with increasing relative molecular mass.
C The relative molecular masses of consecutive members differ by 14.
D They can be represented by the same empirical formula.
34 Which of the following compounds could be formed by the action of bromine on an alkene of formula C₄H₉?

A
\[ \text{CH}_2=\text{CHCH}_2\text{CH}_2\text{Br} \]

B
\[ \text{CH}_2=\text{CHCH}_2\text{Br} \]

C
\[ \text{CH}_2=\text{CHCH}_2\text{Br} \]

D
\[ \text{CH}_2=\text{CHCH}_2\text{Br} \]

35 What happens when one mole of methane is mixed in the dark at room temperature with four moles of chlorine (Cl₂)?

A 1 mole of CCl₄ and 4 moles of HCl are formed.
B 4 moles of CH₃Cl and HCl are formed.
C 1 mole of CH₃Cl and HCl are formed.
D There is no reaction.

36 Which of the following has not been prepared by reacting a carboxylic acid with an alcohol?

A
\[ \text{HOOC-CH}_{2}-\text{CH}_{2}-\text{O-CH}_{3} \]

B
\[ \text{HOOC-CH}_{2}-\text{CH}_{2}-\text{OH} \]

C
\[ \text{H-C-C-CH} \]

D
\[ \text{H-C-C-O-C-H} \]
37 The structure of pentan-2-ol is shown.

Which structure(s) is/are isomer(s) of pentan-2-ol?

A None of the above
B II and III only
C I and IV only
D All of the above

38 Which of these polymers is a nylon?

A \((\text{C}_2\text{H}_5\text{C})_n\)  B \((\text{C}_8\text{H}_8\text{O}_2)_n\)
C \((\text{C}_6\text{H}_{10}\text{O}_5)_n\)  D \((\text{C}_2\text{H}_5\text{NO})_n\)
39 Which organic compound(s) can react with sodium carbonate to form a compound?

![Images of organic compounds I, II, III, IV]

A  I and II only
B  I and III only.
C  I, II and III only.
D  All of the above.

40 Which formula shows the polymer made from but-2-ene?

![Images of polymer structures A, B, C, D]
### Sec 4 Express Chemistry Prelim Examination 2017 – Marking Scheme

**Paper 1 (40 marks)**

<table>
<thead>
<tr>
<th>No.</th>
<th>Ans</th>
<th>Explanation</th>
<th>Key concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D</td>
<td>An atom has equal number of protons and electrons. Since there are 2 more electrons, particle would have gained two extra negative charge since electrons have a charge of -1. Mass number would be 128 since it is the total sum of number of protons (52) and neutrons (76). Proton number would be 52.</td>
<td>Atomic Structure</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Draw out full structural formula to see clearly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A – Contains 9 covalent bonds</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B – Contains 8 covalent bonds</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C – Contains 9 covalent bonds</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D – Contains 9 covalent bonds</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Covalent Bonding</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>A – Ammonium chloride can sublime but not potassium iodide which will remain behind.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B – Both cannot sublime.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C – Both can sublime.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D – Both cannot sublime.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Separation Techniques</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Metals form solid oxides at room temperature and can conduct electricity in solid and liquid state.</td>
<td>Metallic Bonding</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>X is a noble gas found in Group 0. Y must be in Group II. Since Y is Y^{2+} and phosphide is P^3, the formula is Y_3P_2.</td>
<td>Periodic Table</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>Silver iodide is an ionic compound and is insoluble in water (hence, will not conduct electricity when placed in water since the ions cannot dissociate to move and carry charge). It will conduct only when molten as there are mobile oppositely charged ions that can move and carry charge.</td>
<td>QA</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>Hydrocarbon: CO_2H_2O.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5:30:15</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1:6:3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equation will be 1C_4H_10 + ( \frac{15}{2} )O_2 \rightarrow 8CO_2 + 3H_2O</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stoichiometry</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>A</td>
<td>No. of moles of HNO_3 = (10/1000) x 1 = 0.01 mol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Since hydrated sodium carbonate nitric acid = 1:2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of moles of hydrated sodium carbonate = 0.01 / 2 = 0.005 mol</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass = moles x Mr</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.8 = 0.005 x Mr</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mr = 160</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mr of hydrated sodium carbonate = 2 x 23 + 12 + 3 x 16 + n (2 + 16)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stoichiometry</td>
<td></td>
</tr>
</tbody>
</table>
Anode: Hydroxide ions will be preferentially discharged at anode as sulfate ions are not discharged. Since hydroxide ions are discharged to give oxygen gas, colourless gas is observed.

Cathode: Copper(II) ions will be preferentially discharged at cathode instead of hydrogen ion as copper is below hydrogen in the metal reactivity series. Electrolyte: Since copper(II) ions are being discharged and leaving the electrolyte, the blue colour will fade.

10 B Sodium hydroxide (Alkali) will react with sulfur dioxide (acidic oxide). Bromine will react with ethane. This leaves behind oxygen which will relight a glowing splint.

11 B \[ R_{f} = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}} \]

\[ 0.4 = \frac{2.4}{x} \]

\[ x = 6 \text{ cm} \]

\[ R_{f} \text{ of } Q = \frac{3.6}{6} = 0.6 \]

12 D Anode: Hydroxide ions will be preferentially discharged at anode as sulfate ions are not discharged. Since hydroxide ions are discharged to give oxygen gas, colourless gas is observed.

Cathode: Copper(II) ions will be preferentially discharged at cathode instead of hydrogen ion as copper is below hydrogen in the metal reactivity series.

Electrolyte: Since copper(II) ions are being discharged and leaving the electrolyte, the blue colour will fade.

13 D A – The more reactive metal is the anode, which the negative electrode. Terminal for simple cell is opposite of electrolytic cell.

B – X is more reactive then copper and will be above it.

C – Copper is not dissolving. Metal X is dissolving as it is the more reactive metal and is the anode.

D – Electrons flow from the more reactive metal to the less reactive metal since more reactive metals have a higher tendency to lose electrons.

\[ X \rightarrow X^+ + e^- \]

Since electrons are lost, metal X is being oxidised and will decrease in mass.

14 B Number of moles of ethanol and ethoxyethane are calculated to be 0.1 mol. Since more energy was taken in to overcome the attractive forces in
ethanol, answer must be B.

A – The strong covalent bonds are not overcome in the process of boiling, only the weak intermolecular forces of attraction are overcome.

D – Since covalent bonds are not overcome, student cannot discuss the presence of more carbon atoms which will have covalent bonds within the molecule.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>D</td>
<td>No. of moles of methane = mass / Mr = 1 / 16 = 0.0625 mol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0625 mol → 55 kJ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 mol → 896 kJ/mol</td>
</tr>
<tr>
<td>16</td>
<td>A</td>
<td>Total volume of hydrogen = 70 cm³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Half of hydrogen volume = 35 cm³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At 35 cm³, the time taken is 1 min.</td>
</tr>
<tr>
<td>17</td>
<td>D</td>
<td>A – Oxidation state (O.S.) of Cr = +6, O.S. of Cl = +5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B – O.S. of Cu = +2, O.S. of Na = +1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C – O.S. of Mn = +7, O.S. of Cr = +6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D – O.S. of Mn = +2, O.S. of Fe = +2</td>
</tr>
<tr>
<td>18</td>
<td>C</td>
<td>A – Z will have a less steep gradient only.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B – Z may be steeper or less steep as there are 2 factors that are varied here that affects gradient.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C – Using half the mass will give half the yield as per curve Z. Using higher temperature will give steeper gradient as per curve Z.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D – Using half the mass will give half the yield. Using lower temperature will give less steep gradient.</td>
</tr>
<tr>
<td>19</td>
<td>D</td>
<td>Potassium dichromate (VI) is an oxidising agent so ethanol must be a reducing agent. Ethanol will be oxidised to be ethanoic acid while potassium dichromate (VI) will be reduced to Cr³⁺ ions.</td>
</tr>
<tr>
<td>20</td>
<td>A</td>
<td>Zinc carbonate is an insoluble substance which must be prepared by precipitation which is the mixing of 2 aqueous substances. Only option A is viable.</td>
</tr>
<tr>
<td>21</td>
<td>B</td>
<td>A – Acid + alkali → Salt + water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B – Precipitation reaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C – Acid + Base → Salt + water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D – Acid + metal → Salt + hydrogen</td>
</tr>
<tr>
<td>22</td>
<td>B</td>
<td>A – Concentration and particle size were varied.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B – Only particle size was varied while concentration and temperature were kept constant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C – Concentration and temperature were varied.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D – Concentration and particle size were varied.</td>
</tr>
<tr>
<td>23</td>
<td>A</td>
<td>Limestone contains calcium carbonate. Find substances that are neutral.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
| 24 | A | A – Increase pressure will increase yield.  
B – Increase temperature will decrease yield.  
C – Since \(3\text{H}_2 + \text{N}_2 \rightarrow 2\text{NH}_3\), the reacting ratio should be three parts hydrogen to one part nitrogen, not vice versa.  
D – The catalyst is finely divided iron, not platinum. |   |
|   | D |   |   |
| 25 | D | A – From left to right, elements change from metal to non-metal, so ability to conduct electricity decreases.  
B – Metals will have a higher melting point than non-metals so melting point should decrease as elements change from metal to non-metal.  
C – Number of neutrons may sometimes remain the same for two different elements from left to right.  
D – From left to right, elements change from metal to non-metal. Only metals have a tendency to form positive ions while non metals have a tendency to form negative ions. This statement is true. | Periodic Table |
|   |   |   |   |
| 26 | A | There will be leftover bromine since excess bromine was used.  
Bromine cannot displace chlorine from KCl so KCl will also remain.  
Bromine can displace iodine from KI so there will be iodine and KBr.  
Hence, there will be bromine, KCl, iodine and KBr. | Periodic Table (Group VII) |
|   | C | There are catalysts in a catalytic converter, namely palladium, rhodium, platinum. These are transition metals. Transition metals make good catalysts. | Air and Atmosphere |
| 27 |   |   |   |
| 28 | A | A – Transition metals will have high density while Group I metals have low density.  
B – Copper is reddish brown/pink in colour while sodium is silvery grey.  
C – Transition metals have high melting point while Group I metals have low melting point.  
D – Copper forms \(\text{CuO}\) (basic oxide). Sodium forms \(\text{NaO}\) (basic oxide). Only zinc oxide, aluminium oxide and lead (II) oxide are amphoteric. | Periodic Table (Group I and Transition) |
|   |   |   |   |
| 29 | C | A – Only ores of Potassium, sodium, calcium, Magnesium and aluminium are extracted via electrolysis.  
B – Metal M cannot react with water, only steam since magnesium, zinc and iron react with steam. Only potassium, sodium, calcium and magnesium react with water.  
C – Since zinc ore and iron ore can undergo reduction with carbon or... | Metals (Extraction) |
| C | A:  

\[ C + O_2 \rightarrow CO_2 \]  

In this reaction, carbon has reduced oxygen to CO$_2$ so carbon is a reducing agent. Oxidation state (O.S.) of oxygen decreased from 0 to -2.  

However, oxygen has oxidised carbon to CO so oxygen is an oxidising agent. O.S. of carbon increased from 0 to +4.  

B:  

\[ Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2 \]  

CO is a reducing agent as it reduced iron from Fe$_2$O$_3$ to Fe. O.S. of Fe decreased from +3 to 0.  

\[ CO_2 + C \rightarrow 2CO \]  

However, CO$_2$ is an oxidising agent as it oxidised carbon into CO.  

C:  

\[ C + O_2 \rightarrow CO_2 \]  

In this reaction, carbon has reduced oxygen to CO$_2$ so carbon is a reducing agent. Oxidation state (O.S.) of oxygen decreased from 0 to -2.  

\[ Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2 \]  

CO is a reducing agent as it reduced iron from Fe$_2$O$_3$ to Fe. O.S. of Fe decreased from +3 to 0.  

D:  

\[ CO_2 + C \rightarrow 2CO \]  

CO$_2$ is an oxidising agent as it oxidised carbon into CO.  

\[ C + O_2 \rightarrow CO_2 \]  

Oxygen has oxidised carbon to CO so oxygen is an oxidising agent. O.S. of carbon increased from 0 to +4.  

| C | A - True. Mining and extraction by heating with carbon need not be carried out which will reduce emission of gases which are released during burning of fossil fuels to supply heat energy in extraction in blast furnaces. There will also be reduced air pollution as gases like CO$_2$ (greenhouse gas) will also not be released when there is less extraction of iron being carried out.  

B - True. Less scrap metal will be disposed off to occupy space in landfill as the metal is being recycled instead.  

C - False. It increases the need to collect scrap iron if they are recycled.  

D - True. We conserve fossil fuels as they do not need to be burnt to supply energy for extraction of iron in blast furnace.  

| B | High carbon steel will be hard and strong as there are more carbon atoms.
| 33 | D | A – True. They will behave the same way in chemical reactions to give similar products.  
   B – True. The larger the molecule, the more and stronger the intermolecular forces of attraction which require more heat energy to overcome, thus increasing the boiling points.  
   C – True. They each differ by a -CH₂ - unit which has an Mr of 14.  
   D – False. Take methane and ethane (2 members of the same homologous series) for example. Empirical formula of Methane is CH₄ while empirical formula of ethane is CH₃ (simplify C₂H₆ to CH₃).  

| 34 | B | A – Can only obtain this from substitution reaction under UV light of an alkane where the formula is C₆H₁₄.  
   B – The Br atoms will add across 2 different carbon atoms which are right next to each other as the original carbon-carbon double bond will be between two adjacent carbon atoms.  
   C – Cannot obtain this as this does not show the carbon-carbon double bond was between two carbon atoms that are right next to each other.  
   D – This would imply there were two double bonds. However, C₆H₁₄ only has one double bond.  

| 35 | D | Without UV light, substitution reaction cannot even begin.  

| 36 | | All of the above have the circled ester functional group (-COO-) except option C.  

| 37 | D | All have different structures where there are 6 carbon atoms, 12 hydrogen atoms and 1 oxygen atom.  

| 38 | D | Look out for -CONH - group. Only option D has it, as given away by the nitrogen atom.  

---

Need a home tutor? Visit smiletutor.sg
| Page 667
<table>
<thead>
<tr>
<th>39</th>
<th>A</th>
<th>Look out for carboxylic acid functional groups that can react with the sodium carbonate. Only I and II have them.</th>
<th>Carboxylic Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td><img src="image1.png" alt="Chemical Structure I" /></td>
<td></td>
</tr>
<tr>
<td></td>
<td>II</td>
<td><img src="image2.png" alt="Chemical Structure II" /></td>
<td></td>
</tr>
<tr>
<td></td>
<td>III</td>
<td><img src="image3.png" alt="Chemical Structure III" /></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td><img src="image4.png" alt="Chemical Structure IV" /></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>B</td>
<td>But-2-ene:</td>
<td>Addition Polymer</td>
</tr>
<tr>
<td></td>
<td><img src="image5.png" alt="Chemical Structure But-2-ene" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hence after converting the double bond into single bonds, the polymer looks like option B:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><img src="image6.png" alt="Chemical Structure Polymer" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHRIST CHURCH SECONDARY SCHOOL
2017 PRELIMINARY EXAMINATION
FOUR EXPRESS

CANDIDATE NAME

CLASS

CENTRE NUMBER $ INDEX NUMBER

CHEMISTRY
Paper 1

5073/01

23 August 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number, name and class on all the work you hand in.
Write in soft pencil on the Multiple Choice Answer Sheet.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are forty questions on this paper. Answer all questions. For each question there are four possible answers A, B, C and D.
Choose the one you consider correct and record your choice in soft pencil on the separate Multiple Choice Answer Sheet.

Read the instructions on the answer sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 15.
The use of an approved scientific calculator is expected, where appropriate.
1. Which of the following gases diffuses the fastest?

It is given that the relative molecular mass of gas A and gas B is 14 and 32 respectively.

- A gas A at 10°C
- B gas B at 10°C
- C gas A at 15°C
- D gas B at 15°C

2. The set up below shows one way to collect a dry sample of the gas produced from the reaction of calcium hydroxide and ammonium chloride.

Which of the following best suggest the possible identity of the gas and the drying agent?

<table>
<thead>
<tr>
<th>gas</th>
<th>drying agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ammonia</td>
<td>calcium oxide</td>
</tr>
<tr>
<td>ammonia</td>
<td>concentrated sulfuric acid</td>
</tr>
<tr>
<td>hydrogen chloride</td>
<td>calcium oxide</td>
</tr>
<tr>
<td>hydrogen chloride</td>
<td>concentrated sulfuric acid</td>
</tr>
</tbody>
</table>

3. Solid samples of three chlorides, ammonium chloride, lead(II) chloride and sodium chloride, were accidentally mixed together.

Which of the following outlines the best method to obtain the pure and dry sample for each substance?

- A sublimation, dissolving, filtration, evaporation
- B dissolving, filtration, sublimation, crystallisation
- C sublimation, filtration, evaporation, crystallisation
- D dissolving, fractional distillation, filtration, evaporation
Sterling silver is an alloy that is commonly used in jewellery and ornaments. It consists 90% silver and 10% copper.

Which of the following statements is likely to be true about the properties of sterling silver as compared to pure silver?

A. Sterling silver does not react with acids.
B. Sterling silver is more malleable than pure silver.
C. Sterling silver is stronger but more brittle than pure silver.
D. Sterling silver has a higher melting point as compared to pure silver.

The atmosphere of a newly discovered planet contains mainly oxygen, argon and nitrogen. The melting and boiling points of these gases are shown in the table below.

<table>
<thead>
<tr>
<th>gas</th>
<th>melting point/ °C</th>
<th>boiling point/ °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>oxygen</td>
<td>-219</td>
<td>-183</td>
</tr>
<tr>
<td>argon</td>
<td>-189</td>
<td>-186</td>
</tr>
<tr>
<td>nitrogen</td>
<td>-210</td>
<td>-196</td>
</tr>
</tbody>
</table>

Out of the three gases, only oxygen exists in the liquid state on the planet. What is most likely the temperature at the surface of the planet?

A. -182°C
B. -184°C
C. -187°C
D. -198°C

75% of chlorine exists naturally as chlorine-35 and 25% of chlorine exists naturally as chlorine-37. Which of the following properties describes the two forms of chlorine correctly?

I. Chlorine-35 contains less neutrons as compared to chlorine-37
II. Chlorine-37 has a stronger odour than chlorine-35.
III. They can both react with ethane in the presence of UV light.

A. I only
B. I and III
C. II and III
D. All of the above
7. What is the atomic structure of $X^2-$ given that $X$ has an atomic number of 8 and a mass number of 18?

<table>
<thead>
<tr>
<th></th>
<th>electrons</th>
<th>protons</th>
<th>neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

8. Lead(IV) chloride, $\text{PbCl}_4$, is a yellow, oily liquid and has a melting point of $-15{^\circ}\text{C}$ and boiling point of $50{^\circ}\text{C}$.

Which of the following statements is incorrect?

A. It is formed by reacting lead with chlorine.
B. It does not conduct electricity under any conditions.
C. It is formed by the transfer of electrons from lead to chlorine atoms.
D. It is a simple covalent molecule with strong covalent bonds between the atoms.

9. The following structures show four different allotropes of carbon.

```
graphite

C_{60} fullerene

diamond

fullerene nanotube
```

Which allotrope(s) conducts electricity?

A. graphite
B. $C_{60}$ fullerene, graphite
C. $C_{60}$ fullerene, graphite, fullerene nanotube
D. All of the above
10. Which one of the following represents the structural formula of disulfur dichloride, S₂Cl₂?
   A. Cl-S-S-Cl
   B. S-Cl-Cl-S
   C. S-Cl-S-Cl
   D. Cl=SS=Cl

11. If the formula of sodium thiosulfate is Na₂S₂O₃ and the formula of niobium oxide is NbO, then the formula of niobium thiosulfate is
   A. NbS₂O₃
   B. Nb₂S₂O₃
   C. Nb(S₂O₃)₂
   D. Nb₂(S₂O₃)₂

12. Element X exists as gaseous molecules with the molecular formula X₂ at room temperature and pressure.
    50 cm³ of element X combines with 100 cm³ of hydrogen gas to form 100 cm³ of the gaseous hydride of X. What is the molecular formula of the hydride of X formed?
   A. HX
   B. HX₂
   C. H₂X
   D. H₂X₂

13. When a sample of unknown green solid was added to a beaker of dilute hydrochloric acid, effervescence was observed. Which of the following is most likely this unknown solid?
   A. iron(III) oxide
   B. copper(II) oxide
   C. iron(III) carbonate
   D. copper(II) carbonate

14. Element Y is a good conductor of electricity and forms a halide which dissolves readily in water. In addition, Y hydroxide reacts with both acids and alkalis. Hence, the identity of Y is most likely
   A. lead
   B. sodium
   C. magnesium
   D. aluminium
15 Which of the following method(s) is/are suitable to differentiate between two monobasic acids of the same concentration but of different strength?

I Using a pH meter.
II Titration using aqueous sodium hydroxide of known concentration.
III Measuring the total amount of hydrogen gas produced when excess magnesium metal is added to the acids respectively.

A I only
B I and II only
C II and III only
D All of the above

16 A student performed four tests on an aqueous solution of potassium carbonate and recorded the results as shown below.

Which one of the tests should be repeated as the observation made is inaccurate?

<table>
<thead>
<tr>
<th>test conducted</th>
<th>observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A addition of hydrochloric acid</td>
<td>effervescence observed</td>
</tr>
<tr>
<td>B addition of barium nitrate</td>
<td>no visible reaction</td>
</tr>
<tr>
<td>C addition of sodium hydroxide solution</td>
<td>no visible reaction</td>
</tr>
<tr>
<td>D addition of zinc chloride solution</td>
<td>white precipitate</td>
</tr>
</tbody>
</table>

17 The flow chart below shows the reactions of a salt solution Y with three reagents:

What is a possible identity of salt solution Y?

A sodium nitrate
B sodium sulfate
C ammonium nitrate
D ammonium sulfate
18 Which of the following gases has the lowest density at r.t.p.?

A neon
B nitrogen
C sulfur dioxide
D carbon monoxide

19 What is the concentration of sulfate ions in 0.01 mol/dm³ sulfuric acid?

A 0.01 g/dm³
B 0.02 g/dm³
C 0.96 g/dm³
D 1.92 g/dm³

20 A solution containing one mole of aqueous ammonia is added to a solution containing one mole of aluminium sulfate.

The equation for this reaction is shown below.

$$\text{Al}_2\text{(SO}_4\text{)}_3 + 6\text{NH}_3\text{OH} \rightarrow 2\text{Al(OH)}_3 + 3\text{(NH}_4\text{)}_2\text{SO}_4$$

What is the number of moles of aluminium hydroxide formed?

A 0.333
B 0.500
C 1.000
D 2.000

21 Aspirin, C₉H₈O₄, is commonly used to treat mild to moderate pain and also to reduce fever or inflammation.

Aspirin is made from salicylic acid, C₇H₆O₃, as shown by the equation given below.

$$\text{C}_7\text{H}_6\text{O}_3 + \text{C}_4\text{H}_6\text{O}_3 \rightarrow \text{C}_9\text{H}_8\text{O}_4 + \text{CH}_3\text{COOH}$$

Assuming that aspirin is always produced with a percentage yield of 70%, calculate the mass of salicylic acid required to make an aspirin tablet of 325 mg.

A 174 mg
B 249 mg
C 356 mg
D 424 mg

22 What is the oxidation state of nitrogen in NO₂ and NH₄⁺?
23 Which of the following is not a redox reaction?

A  \( \text{Mg} + 2\text{HF} \rightarrow \text{MgF}_2 + \text{H}_2 \)
B  \( \text{LiOH} + \text{HNO}_3 \rightarrow \text{LiNO}_3 + \text{H}_2\text{O} \)
C  \( \text{Cu} + 4\text{HNO}_3 \rightarrow \text{Cu(NO}_3)_2 + 2\text{H}_2\text{O} + 2\text{NO}_2 \)
D  \( \text{Cu} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + 2\text{H}_2\text{O} + \text{SO}_2 \)

24 Which of the following statements about the properties of a catalyst is inaccurate?

A  A catalyst increases the average kinetic energy of the reactants.
B  A catalyst increases the rate of both the forward and reverse reaction.
C  A catalyst has no effect on the enthalpy change of the reaction.
D  A catalyst is more effective in the powdered than granular form.

25 The table compares the strengths of the bonds for reaction of the type below.

\[ \text{X}_2 + \text{Y}_2 \rightarrow 2\text{XY} \]

Which reaction is most likely to be exothermic?

<table>
<thead>
<tr>
<th>X-X bond</th>
<th>Y-Y bond</th>
<th>X-Y bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Strong</td>
<td>Strong</td>
</tr>
<tr>
<td>B</td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td>C</td>
<td>Weak</td>
<td>Strong</td>
</tr>
<tr>
<td>D</td>
<td>Weak</td>
<td>Weak</td>
</tr>
</tbody>
</table>
\[
N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)
\]
\[\Delta H = +92 \text{ kJ}\]

Which of the following may be deduced from the energy level diagram?

I. The reaction is exothermic.
II. A catalyst was used to speed up the reaction.
III. 92 kJ of heat energy has to be absorbed to decompose one mole of ammonia.

A. I and II
B. II and III
C. All of the above
D. None of the above

27 Which property is displayed by all metals?

A. They are extracted from their ores by heating with carbon.
B. They conduct electricity in all states.
C. They either form acidic oxides or basic oxides.
D. They react with hydrochloric acid to form hydrogen.

28 An experiment was conducted to test the reactivity of some metals. Different metals were placed into different metal salt solutions and the observations were recorded in the table given below.
Based on the observation, arrange the reactivity of the metals in order of decreasing reactivity.

A  Ni, Cr, Cu, Pt
B  Cr, Ni, Cu, Pt
C  Ni, Cu, Pt, Cr
D  Cr, Ni, Pt, Cu

29 In which of the following process is the presence of water not essential?

A  the rusting of iron
B  the electrolytic purification of copper
C  the production of ethanol from ethene
D  the extraction of iron in the Blast Furnace

30 Which statement about the extraction of iron in the blast furnace is correct?

A  Iron(III) oxide is reduced by carbon monoxide.
B  Coke is added to the furnace to remove acidic impurities.
C  Limestone reacts with silicon dioxide to form calcium silicate.
D  Pure molten iron floats on top of molten slag at the bottom of the furnace.

31 The graph below shows the variation of a physical property with the proton number for the elements from sodium to chlorine in the Periodic Table.
Which of the following is a possible physical property as described above?

A atomic radius  
B electrical conductivity  
C valency  
D melting point

32 A catalytic converter in a car exhaust system changes pollutants into less harmful products. Which of the following changes does not occur in a catalytic converter?

A carbon dioxide → carbon  
B nitrogen oxides → nitrogen  
C carbon monoxide → carbon dioxide  
D unburnt hydrocarbons → carbon dioxide and water

33 Polyvinyl chloride, commonly known as PVC, is the world’s third most widely produced synthetic plastic polymer. PVC products are often burnt in incinerators for disposal purpose.

Which gases produced would contribute to the formation of acid rain?
I hydrogen chloride
II carbon dioxide
III carbon monoxide

A I only
B I and II only
C II and III only
D All of the above

34 A metal can be extracted by the electrolysis of its molten chloride. The table shows properties of the metal and its chloride.

<table>
<thead>
<tr>
<th>substance</th>
<th>melting point/°C</th>
<th>boiling point/°C</th>
<th>density/ g cm⁻³ (at temperature of electrolysis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>metal</td>
<td>328</td>
<td>1750</td>
<td>11</td>
</tr>
<tr>
<td>metal chloride</td>
<td>534</td>
<td>950</td>
<td>4.5</td>
</tr>
</tbody>
</table>

In what state will the metal be formed in the electrolysis?

A As a solid below the molten chloride.
B As a liquid below the molten chloride.
C As a solid on the surface of the molten chloride.
D As a liquid on the surface of the molten chloride.

35 The following electrolysis circuit is set up, using inert electrodes P, Q, R and S.
At which electrodes is a Group VII element produced?

A  P only
B  P and R
C  Q only
D  Q and S

36 Which of the following is most likely the product when ethene is bubbled into bromine water?

\[
\begin{align*}
A & : \text{H}_2\text{C} = \text{C}-\text{Br} \\
B & : \text{H}_2\text{C} = \text{C}-\text{Br} \quad \text{H} \\
C & : \text{H}_2\text{C} = \text{C}-\text{Br} \quad \text{H} \quad \text{OH} \\
D & : \text{H}_2\text{C} = \text{C}-\text{Br} \quad \text{H} \\
\end{align*}
\]

37 A food chemist wants to create the smell of pineapples using an organic compound with the chemical formula, \( \text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \).

Which of the following pair of reactants, with a suitable catalyst, would produce this compound?

A  \( \text{CH}_3\text{CH}_2\text{OH} \) and \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \)
B  \( \text{CH}_3\text{CH}_2\text{OH} \) and \( \text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} \)
C  \( \text{CH}_3\text{COOH} \) and \( \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \)
D  \( \text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} \) and \( \text{CH}_3\text{COOH} \)

38 Two unlabelled bottles containing benzoic acid and nonanol respectively were mixed up. The best method to distinguish between the two organic compounds is by using
A aqueous bromine  
B sodium carbonate  
C dilute sulfuric acid  
D sodium hydroxide solution

39 Oleic acid is an unsaturated acid found commonly in olive oil which has a molecular formula of $C_{17}H_{31}COOH$. How many carbon-carbon double bond(s) is/are present in one molecule of oleic acid?

A 1  
B 2  
C 3  
D 4

40 Which of the following statements about the fractional distillation of petroleum is correct?

A The molecules collected at the bottom of the column are the most flammable.  
B The molecules reaching the top of the column have the lowest viscosity.  
C The molecules reaching the bottom of the column are usually the least intensely coloured.  
D The molecules collected at the top of the column possess the highest boiling point.

End of Paper
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>2</td>
<td>A</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>7</td>
<td>D</td>
<td>8</td>
<td>C</td>
</tr>
<tr>
<td>11</td>
<td>A</td>
<td>12</td>
<td>C</td>
<td>13</td>
<td>D</td>
</tr>
<tr>
<td>16</td>
<td>B</td>
<td>17</td>
<td>A</td>
<td>18</td>
<td>A</td>
</tr>
<tr>
<td>21</td>
<td>C</td>
<td>22</td>
<td>C</td>
<td>23</td>
<td>B</td>
</tr>
<tr>
<td>26</td>
<td>D</td>
<td>27</td>
<td>B</td>
<td>28</td>
<td>B</td>
</tr>
<tr>
<td>31</td>
<td>D</td>
<td>32</td>
<td>A</td>
<td>33</td>
<td>B</td>
</tr>
<tr>
<td>36</td>
<td>D</td>
<td>37</td>
<td>C</td>
<td>38</td>
<td>B</td>
</tr>
</tbody>
</table>
SECONDARY 4 PRELIMINARY EXAMINATION

CHEMISTRY

Paper 1

3 August 2017

1 h

Additional Materials: Optical Answer Sheet (OAS)

Instructions to Candidates

Write your name, register number and class at the top of this page.

Write in dark blue or black pen.

You may use pencil for any diagrams, graphs, tables or rough working.

There are forty questions on this paper. Answer all questions. For each question there are four possible answers A, B, C and D.

Choose the one you consider correct and record your choice in soft pencil on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

A copy of the Periodic Table is printed on page 2.

The use of an approved scientific calculator is expected, where appropriate.

Checked by student: ________________ Date: __________
1 Methylbenzene is an organic compound which is insoluble in water and it is found to boil at 111 °C.

Given a mixture of methylbenzene and dilute aqueous copper(II) sulfate, which two methods would need to be carried out in order to obtain samples of methylbenzene and copper(II) sulfate crystals?

<table>
<thead>
<tr>
<th>method 1</th>
<th>method 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A fractional distillation</td>
<td>crystallisation</td>
</tr>
<tr>
<td>B simple distillation</td>
<td>evaporation</td>
</tr>
<tr>
<td>C using of a separating funnel</td>
<td>crystallisation</td>
</tr>
<tr>
<td>D using of a separating funnel</td>
<td>evaporation</td>
</tr>
</tbody>
</table>

2 A piece of zinc metal does not react when placed in a solution of hydrogen chloride which is dissolved in toluene. Which of the following changes will cause a reaction?

A Add water and stir well.
B Bubble more hydrogen chloride gas into the solution to increase its concentration.
C Remove the layer of oxide on the zinc metal before placing it in the solution.
D Use zinc powder instead of zinc metal as rate of reaction will increase.

3 Which of the following salts is best prepared using precipitation?

A barium nitrate
B potassium carbonate
C silver chloride
D zinc sulfate

4 Which of the following reagents, when mixed and heated with ammonium sulfate, liberates a gas that turns a moist red litmus paper blue?

A acidified potassium dichromate(VI)
B aqueous bromine
C dilute hydrochloric acid
D limewater

5 When testing for a sulfate ion using barium nitrate, the solution must be acidified with nitric acid.

What is the purpose of the nitric acid?

A to act as a catalyst
B to adjust the pH such that it is suitable for the reaction to occur
C to prevent precipitation of barium carbonate
D to reduce the sulfate ion
6. An aqueous solution, of a salt was placed in a test tube and aqueous sodium hydroxide was gradually added from the burette. The mass of the precipitate was obtained when various volumes of aqueous sodium hydroxide was added and a graph was obtained as shown.

Which of the following is likely to be the aqueous solution?

A. aluminium phosphate
B. copper(II) chloride
C. lead(II) nitrate
D. zinc sulfate

7. An organic molecule has the structural shown:

\[ \text{H} - \text{C} = \text{C} - \text{C} - \text{H} \]

How many of the electrons is/are not involved in bonding?

A. 3
B. 4
C. 6
D. 8

8. Which of the compounds does not contain covalent bonds?

A. calcium carbonate
B. magnesium oxide
C. potassium phosphate
D. sodium hydroxide

9. The element X has three electrons in its outer shell.

What is the formula of the oxide of element X?

A. a covalent compound \( X_3O \)
B. an ionic compound \( X_3O \)
C. a covalent compound \( X_2O_3 \)
D. an ionic compound \( X_2O_3 \)
10 A solid, \( R \), has a melting point of 734 °C. It can only conduct electricity when molten or in aqueous solution. It is soluble in water but not in organic solvent.

Which of the following is likely to be \( R \)?

A diamond  
B graphite  
C potassium bromide  
D zinc

11 Aqueous solution \( S \) is added to aqueous solution \( R \). The changes pH is shown in the graph.

\[ \text{Volume of } S/ \text{cm}^3 \]

Which of the following solutions best represents \( R \) and \( S \)?

A aqueous ammonia  
B aqueous ammonia  
C aqueous sodium hydroxide  
D aqueous sodium hydroxide

12 Which row correctly shows the order of rates of diffusion of the gases carbon dioxide, nitrogen and oxygen?

<table>
<thead>
<tr>
<th>slowest</th>
<th>( \rightarrow )</th>
<th>fastest</th>
</tr>
</thead>
<tbody>
<tr>
<td>A CO(_2)</td>
<td>N(_2)</td>
<td>O(_2)</td>
</tr>
<tr>
<td>B CO(_2)</td>
<td>O(_2)</td>
<td>N(_2)</td>
</tr>
<tr>
<td>C O(_2)</td>
<td>CO(_2)</td>
<td>N(_2)</td>
</tr>
<tr>
<td>D N(_2)</td>
<td>O(_2)</td>
<td>CO(_2)</td>
</tr>
</tbody>
</table>

Need a home tutor? Visit smiletutor.sg
13 The table shows details of the particles present in the following 4 atoms or ions.

<table>
<thead>
<tr>
<th>atoms/ions</th>
<th>number of neutrons</th>
<th>number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>W⁻</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>X</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Y²⁺</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Z</td>
<td>20</td>
<td>17</td>
</tr>
</tbody>
</table>

Which of the following atoms is an isotope of W?

A X  
B Y  
C Z  
D None of the above

14 The graph represents the results of two experiments, X and Y, demonstrating the catalytic decomposition of hydrogen peroxide to form water and oxygen. Assuming that all other conditions are kept constant, which one of the following is a correct explanation of the different results?

![Graph showing total volume of oxygen vs time]

A The catalyst was in lumps.  
B 1.0 g of manganese(IV) oxide was used  
C The reaction was carried out at 60 °C.  
D 50 cm³ of 1.0 mol/dm³ hydrogen peroxide were used

X  
Y  

The catalyst was finely divided.  
0.50 g of manganese(IV) oxide was used  
The reaction was carried out at 30 °C.  
12.5 cm³ of 2.0 mol/dm³ hydrogen peroxide were used
15 Copper(II) oxide reacts with ammonia at high temperature to form a solid and two gases.

A mixture of ammonium chloride and calcium hydroxide

\[
\text{Copper(II) oxide} \quad \text{Gas X}
\]

Gentle heat

Heat

Water

The gas X

A relights a glowing splint.
B has no effect on the colour of moist litmus paper.
C turns a moist blue litmus paper red then bleaches.
D turns anhydrous copper(II) sulfate blue.

16 Which statement describes the changes in the elements from left to right across a period of the Periodic Table?

A The ability to conduct electricity increases.
B The element changes from metals to non-metals.
C The melting and boiling point increases.
D The number of neutrons in an atom decreases.

17 What volume of air is required to ensure the complete combustion of 24 cm³ of propane at room temperature and pressure?

A 24 cm³
B 120 cm³
C 114 cm³
D 571 cm³

18 Tin is extracted from SnO₂ (\(M_r = 151\)) by reducing it with coal in a furnace according to the chemical equation:

\[
\text{SnO}_2 + 2\text{C} \rightarrow \text{Sn} + 2\text{CO}
\]

What is the percentage purity of tin ore if 600 g of SnO₂ on reduction produces 82 g of tin?

A 17.3%
B 34.6%
C 41.3%
D 82.6%
19 Which of the following has $7.2 \times 10^{23}$ atoms?
   A  0.2 mol of magnesium metal
   B  0.3 mol of ammonia gas
   C  3.0 mol of carbon dioxide gas
   D  4.0 mol of hydrogen chloride

20 Copper reacts with hot concentrated sulfuric acid in a redox reaction.
   \[
   Cu + H_2SO_4 \rightarrow CuSO_4 + SO_2 + H_2O
   \]
   Which statement about this reaction is correct?
   During the reaction
   A  copper changes from oxidation state 0 to oxidation state +2.
   B  hydrogen changes from oxidation state +1 to −1.
   C  sulfuric acid is acting as a reducing agent.
   D  sulfur remains in oxidation state +4.

21 Photochemical smog appears as a brownish haze over many industrialized cities. Which of the following is not responsible for its formation?
   A  nitrogen dioxide
   B  ozone
   C  propane
   D  sulfur dioxide

22 A sample of air along the Tampines Expressway (TPE) is collected and its composition is examined.
   Which of the following is least likely to be one of the components in the sample of air?
   A  carbon monoxide
   B  nitrogen dioxide
   C  nitrogen monoxide
   D  sulfur dioxide

23 The following observations were made when nickel, Ni, and iron, Fe, were put separately into salt solutions of three metals P, Q and R.

<table>
<thead>
<tr>
<th>metals</th>
<th>salt solution, P</th>
<th>salt solution, Q</th>
<th>salt solution, R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni</td>
<td>not displaced</td>
<td>yes, displaced</td>
<td>not displaced</td>
</tr>
<tr>
<td>Fe</td>
<td>yes, displaced</td>
<td>yes, displaced</td>
<td>not displaced</td>
</tr>
<tr>
<td>R</td>
<td>yes, displaced</td>
<td>yes, displaced</td>
<td>-</td>
</tr>
</tbody>
</table>

What is the correct order in increasing reactivity of the five metals?
   A  P, R, Fe, Ni, Q
   B  P, Fe, R, Q, Ni
   C  Q, Ni, Fe, R, P
   D  Q, Ni, P, Fe, R
24. A metal X is placed between zinc and tin in the reactivity series. Which method can be used to extract X?

A. electrolysis of an aqueous solution of a chloride of X
B. heating of a carbonate of X
C. reduction of an oxide of X by hydrogen
D. reduction of an oxide of X by carbon

25. Element X
- density is 19.25 g/cm³.
- forms XO₂ and XO₃.
- has the ability to conduct electricity in solid state.

What is the possible identity of element X?

A. lithium
B. sulfur
C. tungsten
D. zinc

26. Which statement describes what happens when hydrogen and oxygen are used in a fuel cell?

A. Electricity is generated directly.
B. Electricity is used to produce water.
C. Hydrogen is burned to form steam.
D. Hydrogen reacts to form a hydrocarbon fuel.

27. The energy profile diagram for the reaction between carbon monoxide and chlorine gases to form carbonyl dichloride is shown below.

From the diagram, which statement about this reaction is correct?

A. The energy change when breaking the bonds in carbon monoxide and chlorine is greater than the energy change when forming the bonds in carbonyl dichloride.
B. The presence of catalyst lowers the activation energy of the reaction.
C. The reaction is exothermic as heat energy is given out.
D. The volume of the reactants is equal to the volume of products.
28 Two cells were set up as shown in the diagram. The arrow indicates the direction of the electron flow in the circuit.

Which set of metals would give the electron flow in the direction shown above?

<table>
<thead>
<tr>
<th>metal X</th>
<th>metal Y</th>
<th>metal Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Ag</td>
<td>Zn</td>
</tr>
<tr>
<td>B</td>
<td>Mg</td>
<td>Ag</td>
</tr>
<tr>
<td>C</td>
<td>Mg</td>
<td>Zn</td>
</tr>
<tr>
<td>D</td>
<td>Zn</td>
<td>Ag</td>
</tr>
</tbody>
</table>

29 Carbon electrodes are used in the electrolysis of an aqueous solution containing both copper(II) nitrate and sodium sulfate.

What will be produced at the positive electrode?

A copper  
B hydrogen  
C nitrogen  
D oxygen

30 During electrolysis, an electrolyte contains two different anions each present at the same concentration.

Which of the statements is correct?

A Both are discharged at the anode at the same time.  
B Both are discharged at the cathode at the same time.  
C The stronger reducing agent is discharged at the anode.  
D The stronger reducing agent is discharged at the cathode.
31 Ammonia is produced by the Haber process.

Which of the statements is true?

1. Each hydrogen molecule reacts with three nitrogen molecules to form two molecules of ammonia.
2. Hydrogen can be obtained by the cracking of long chain hydrocarbons.
3. The formation of ammonia is a reversible process.

A 1 and 2 only  
B 1 and 3 only  
C 2 and 3 only  
D 1, 2 and 3

32 Which of the following does not take place in the catalytic converter?

A carbon monoxide is oxidised to carbon dioxide  
B oxides of nitrogen are reduced to nitrogen  
C unburnt hydrocarbons are oxidised to carbon dioxide and water  
D water vapour is reduced to hydrogen

33 Which two compounds are commonly used as fuels for cooking?

A diesel and naphtha  
B kerosene and petroleum gas  
C kerosene and diesel  
D petroleum gas and naphtha

34 Which of the following statements is true about butane and butene?

1. They can react with chlorine in the dark.  
2. Butene burns with a smokier flame than butane.  
3. Butene is more reactive than butane.

A 1 only  
B 1 and 2 only  
C 2 and 3 only  
D 1, 2 and 3
35 The structural formulae of three compounds, X, Y and Z are as shown.

\[ \text{X} \quad \text{Y} \quad \text{Z} \]

\[
\begin{array}{c}
\text{H} \\
\text{C} - \text{C} - \text{C} - \text{O} - \text{H} \\
\text{H} \quad \text{H} \quad \text{H} \\
\end{array}
\quad
\begin{array}{c}
\text{H} \\
\text{C} - \text{C} - \text{C} - \text{H} \\
\text{H} \quad \text{H} \quad \text{O} - \text{H} \\
\text{H} \\
\end{array}
\quad
\begin{array}{c}
\text{H} \\
\text{C} - \text{C} - \text{C} - \text{O} - \text{H} \\
\text{H} \quad \text{H} \quad \text{H} \\
\end{array}
\]

Which compounds are isomers?

A X and Y only
B X and Z only
C Y and Z only
D X, Y and Z

36 The structural formulae of two compounds are as shown.

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} - \text{C} - \text{C} - \text{O} - \text{H} \\
\text{H} \\
\end{array}
\quad
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} - \text{C} - \text{C} - \text{O} - \text{H} \\
\text{H} \\
\end{array}
\]

Which of the following is the best method to distinguish between these two compounds?

A using bromine water
B using dilute hydrochloric acid
C using sodium carbonate
D using sodium hydroxide

37 Which compound is obtained by hydration of propene?

A \( \text{C}_3\text{H}_6 \)  
B \( \text{C}_3\text{H}_7\text{OH} \)  
C \( \text{C}_3\text{H}_5\text{COOH} \)  
D \( \text{C}_4\text{H}_9\text{OH} \)
38. Limonene is found in orange oil. The structure of limonene is as shown.

![Limonene structure](image)

Which statements are true about limonene?

1. It reacts with chlorine.
2. It is flammable.
3. It can react with hydrogen gas to form a saturated hydrocarbon.

A 1 and 2 only  
B 1 and 3 only  
C 2 and 3 only  
D 1, 2 and 3

39. An alcohol \( X \) can react with acid \( Y \) to form an ester with the formula \( C_8H_{16}O_2 \).

Alcohol \( X \) can be oxidised to acid \( Y \) by heating with acidified aqueous potassium manganate(VII).

What is the structural formula of the ester?

A \( C_3H_7COOC_8H_{11} \)  
B \( C_3H_7COOC_4H_6 \)  
C \( C_4H_9COOC_4H_6 \)  
D \( C_8H_{15}COOC_2H_6 \)

40. The structure of a polymer is shown below.

\[
\begin{align*}
\text{CH} & \quad \text{CH}_2 \quad \text{CH} & \quad \text{CH}_2 \quad \text{CH} & \quad \text{CH}_2 \quad \text{CH} \\
\text{CH}_2 \quad \text{CH}_3 & \quad \text{CH}_2 \quad \text{CH}_3 & \quad \text{CH}_2 \quad \text{CH}_3
\end{align*}
\]

What is the molecular formula of the monomer?

A \( C_2H_4 \)  
B \( C_3H_8 \)  
C \( C_4H_6 \)  
D \( C_4H_{10} \)

--- End of Paper ---
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td></td>
<td>B</td>
<td>21</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>12</td>
<td>B</td>
<td>22</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>13</td>
<td>C</td>
<td>23</td>
<td>D</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>14</td>
<td>D</td>
<td>24</td>
<td>D</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>15</td>
<td>B</td>
<td>25</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>16</td>
<td>B</td>
<td>26</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>C</td>
<td>17</td>
<td>D</td>
<td>27</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>B</td>
<td>18</td>
<td>A</td>
<td>28</td>
<td>B</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>19</td>
<td>B</td>
<td>29</td>
<td>D</td>
</tr>
<tr>
<td>10</td>
<td>C</td>
<td>20</td>
<td>A</td>
<td>30</td>
<td>C</td>
</tr>
</tbody>
</table>