SMILE Tutor

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2022
SECONDARY 4 PURE CHEMISTRY TEST PAPERS

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BROADRICK SECONDARY SCHOOL PRELIM PAPER

1 In a titration, 25.0 cm^3 of aqueous sodium hydroxide is transferred into a conical flask. A few drops of indicator are added. Dilute hydrochloric acid is then added to the flask until the end-point is reached.

Which pieces of apparatus are used to measure volume in this experiment?

	to measure dilute hydrochloric acid	to measure aqueous sodium hydroxide
A	burette	beaker
B	burette	pipette
C	pipette	pipette
D	pipette	beaker

2 Which gas is **not** obtained industrially by fractional distillation?

A ammonia
B argon
C nitrogen
D oxygen

3 An impure sample of compound X has a melting point of 120 °C.

X is purified and its melting point is measured again.

Which row is correct?

	method of purifying X	melting point of pure X / °C
A	crystallisation	115
B	distillation	115
C	crystallisation	125
D	distillation	125

4 When dilute hydrochloric acid is added to a white powder, a gas is produced.

The solution remaining is tested separately with small volumes of both aqueous ammonia and aqueous sodium hydroxide.

A white precipitate is produced in both tests.

What is the white powder?

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

5 Which statement explains why isotopes of the same element have the same chemical properties?

- **A** They have the same electronic structure.
- **B** They have the same relative mass.
- **C** They have the same nucleon number.
- **D** They have the same proton number.

6 An aqueous solution of a sulfate is made from a solid hydroxide, of a metal *M*, by the reaction:

$$M(OH)_2(s) + H_2SO_4(aq) \rightarrow MSO_4(aq) + 2H_2O(l)$$

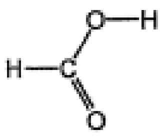
For which hydroxide would the method **not** work?

- **A** barium hydroxide
- **B** copper(II) hydroxide
- **C** iron(II) hydroxide
- **D** magnesium hydroxide

7 A covalent compound P has the empirical formula CH_2O.

Which structure represents P?

A



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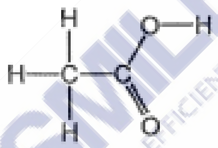

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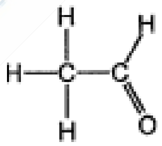

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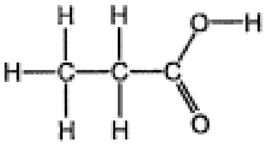


8 Which row explains why copper is a good conductor of electricity at room temperature?

	copper ions move freely	electrons move freely
A	no	no
B	no	yes
C	yes	no
D	yes	yes

9 What is the structure of sand?

- **A** an ionic lattice
- **B** a macromolecule
- **C** a polymer
- **D** a simple molecule

10 Pentane, C_5H_{12}, has a higher boiling point than propane, C_3H_8.

Which statement explains the difference in boiling point?

A Carbon-carbon single bonds are stronger than carbon-hydrogen bonds.

B Pentane has more covalent bonds to break.

C Pentane does not burn as easily as propane.

D The forces of attraction between pentane molecules are stronger than those between propane molecules.

11 Sodium nitride contains the nitride ion, N^{3-}.

Sodium nitride is unstable and decomposes into its elements.

What is the equation for the decomposition of sodium nitride?

A $2NaN_3 \rightarrow 2Na + 3N$

B $2Na_3N \rightarrow 6Na + N_2$

C $2NaN_3 \rightarrow Na_2 + 3N_2$

D $2Na_3N \rightarrow 6Na + 2N$

12 What is the mass of one mole of carbon-13?

A 0.013 g

B 0.026 g

C 1 g

D 13 g

13 The Haber process is a reversible reaction.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The reaction has a 30% yield of ammonia.

Which volume of ammonia gas, NH_3, measured at room temperature and pressure, is obtained by reacting 0.75 moles of hydrogen with excess nitrogen?

A 3600 cm^3

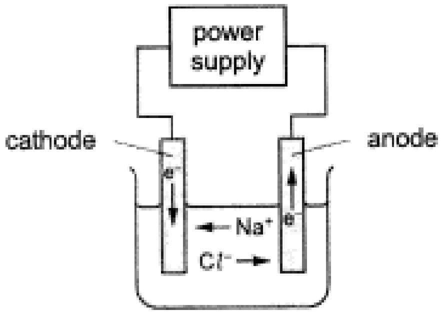
B 5400 cm^3

C 12000 cm^3

D 18000 cm^3

14 Which diagram shows the direction of movement of ions and electrons during the electrolysis of molten sodium chloride?

A



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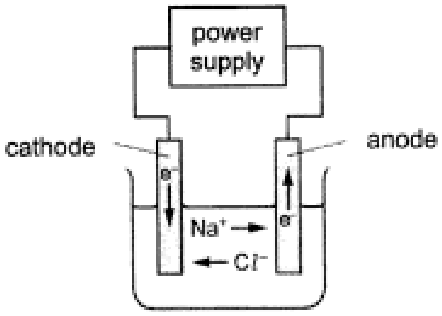

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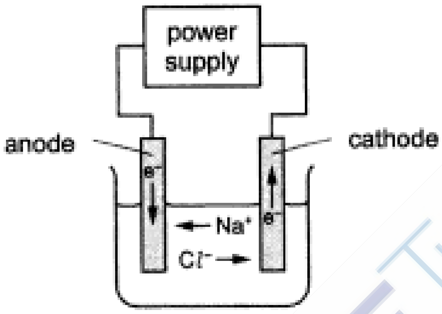

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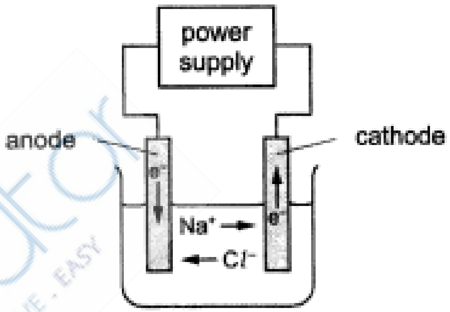
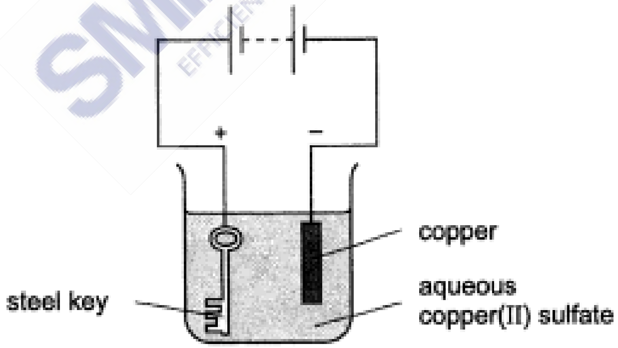


15 The apparatus shown is set up to plate a steel key with copper.



The key does **not** get coated with copper.

Which change needs to be made to plate the key?

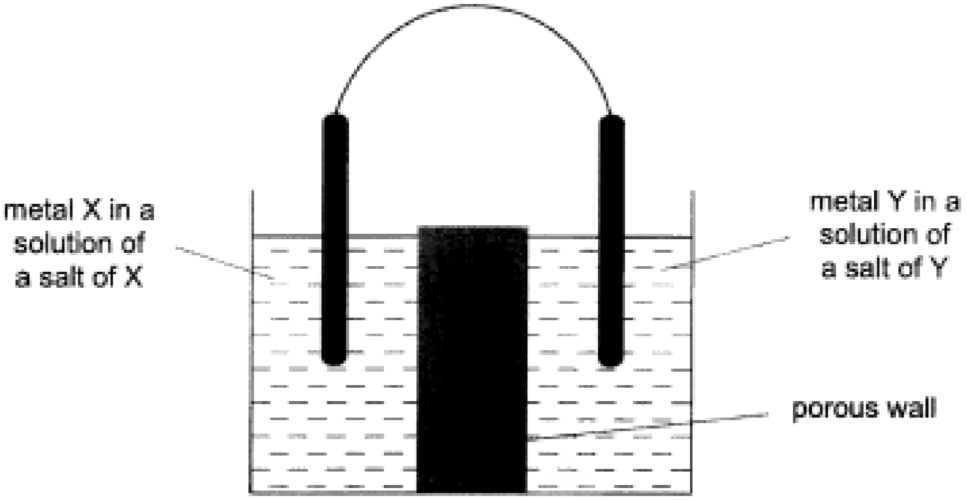
A increase the concentration of the aqueous copper(II) sulfate

B increase the voltage

C replace the solution with dilute sulfuric acid

D reverse the electrical connections

16 Which pair of metals X and Y will produce the highest voltage when used as electrodes in a simple cell?



	metal X	metal Y
A	copper	silver
B	magnesium	silver
C	magnesium	zinc
D	zinc	copper

17 Which row describes the changes that occur in an endothermic reaction?

	energy change	temperature
A	energy given out to the surroundings	decreases
B	energy given out to the surroundings	increases
C	energy taken in from the surroundings	decreases
D	energy taken in from the surroundings	increases

18 Which statement about fuels is correct?

A Heat energy is only produced by burning fuels.

B Hydrogen is used as a fuel although it is difficult to store.

C Methane is a good fuel because it produces only water when burned.

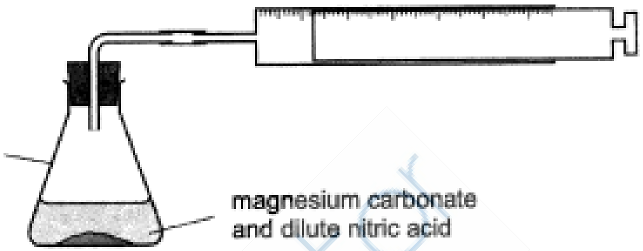
D Uranium is burned in air to produce energy.

19 Which statement about endothermic and exothermic reactions is correct?

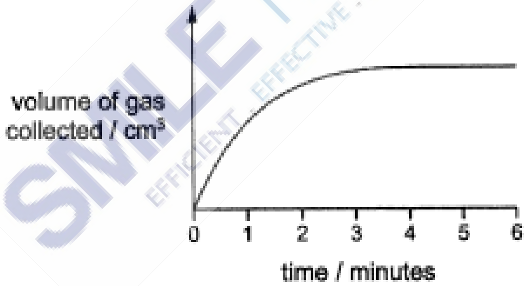
A In an endothermic reaction, less energy is absorbed in bond breaking than is released in bond forming.
B In an endothermic reaction, the activation energy is always higher than in an exothermic reaction.
C In an exothermic reaction, more energy is absorbed in bond breaking than is released in bond forming.
D In an exothermic reaction, the reactants are higher energy level than the products on an energy level diagram.

20 The apparatus shows a method of following the rate of the reaction between magnesium carbonate, $MgCO_3$, and dilute nitric acid, HNO_3.

$$MgCO_3(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$



The graph shows the volume of gas collected against time.



Three statements are made about the experiment.

1 The mass of the flask and its contents decreases as time increases.
2 The rate of the reaction decreases as time increases.
3 The reaction has finished after four minutes.

Which statements are correct?

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

21 How does increasing the concentration affect the reacting particles in a chemical reaction?

	increases the collision rate	increases the proportion of particles with the activation energy
A	✓	✗
B	✓	✓
C	✗	✗
D	✗	✓

22 Zinc oxide is an amphoteric oxide.

Which of the following substances will react with zinc oxide?

A acids and bases
B acids only
C bases only
D neither acids nor bases

23 When aqueous iron(III) chloride is added to aqueous potassium iodide, a chemical reaction occurs and iodine is formed.

Which statement is correct?

A Iodide ions are oxidised, they gain electrons in this reaction.
B Iodide ions are oxidised, they lose electrons in this reaction.
C Iron(III) chloride is oxidised in this reaction.
D Neither iodide ions nor iron(III) chloride is oxidised in this reaction.

24 In which reaction is the underlined substance behaving as an oxidising agent?

A $\underline{BaCl_2} + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$
B $3CuO + \underline{2NH_3} \rightarrow 3Cu + N_2 + 3H_2O$
C $2FeCl_2 + \underline{Cl_2} \rightarrow 2FeCl_3$
D $O_2 + \underline{2SO_2} \rightarrow 2SO_3$

25 The oxide of an element X increases the rate of decomposition of hydrogen peroxide. At the end of the reaction the oxide of X is unchanged.

Which details are those of X?

	proton number	mass number
A	18	40
B	20	40
C	25	55
D	82	207

26 The proton number of indium, In, is 49.

What is the most likely formula for the oxide of indium?

A In_2O
B In_2O_3
C InO
D InO_2

27 Which statement(s) is/are true about all the noble gases?

1 The number of protons in their atoms equals the number of neutrons.
2 The number of protons in their atoms does not equal the number of electrons.
3 They all have eight electrons in their outer shell.
4 They do not react to form ionic compounds.

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

28 Many metal carbonates decompose when they are heated.

Which row describes what happens when potassium carbonate, calcium carbonate and copper(II) carbonate are heated using a Bunsen burner?

	decomposes easily	decomposes with difficulty	does not decompose at Bunsen temperatures
A	calcium carbonate	copper(II) carbonate	potassium carbonate
B	copper(II) carbonate	calcium carbonate	potassium carbonate
C	copper(II) carbonate	potassium carbonate	calcium carbonate
D	potassium carbonate	calcium carbonate	copper(II) carbonate

29 Three correct statements about aluminium are listed.

1 Aluminium is the most common metal in the Earth's crust.
2 It is costly to extract aluminium from its ore, bauxite.
3 The world's supply of bauxite is limited.

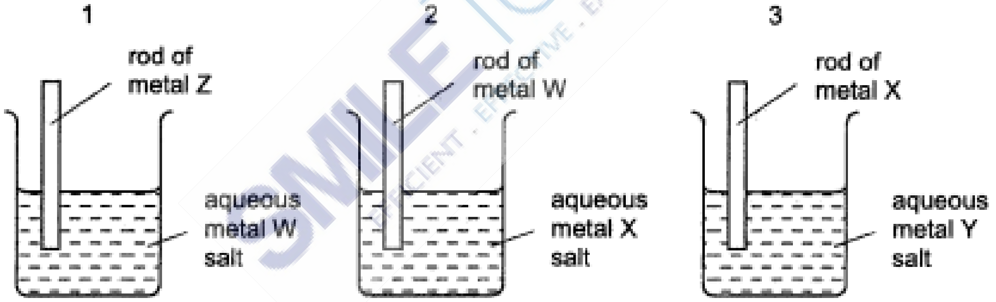
Which statement(s) explain why aluminium should be recycled?

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

30 Which process, used to prevent iron from rusting, involves sacrificial protection?

A alloying
B electroplating
C galvanising
D painting

31 Three different beakers are set up as shown.



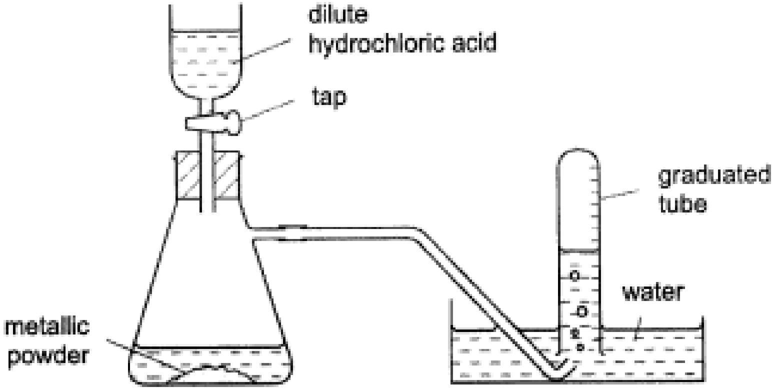
In beaker 1, metal W is displaced from solution.
In beaker 2, metal X is displaced from solution.
In beaker 3, metal Y is displaced from solution.

What is the order of decreasing reactivity of the four metals?

	most reactive		→	least reactive
A	W	X	Y	Z
B	Y	X	W	Z
C	Z	W	X	Y
D	Z	X	W	Y

32 The diagram shows the experimental setup for measuring the volume of hydrogen given off when an excess of 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 the same mass of powder each time but with different powders:

- pure magnesium
- pure zinc
- a mixture of magnesium and zinc

Which powder gives the greatest volume of hydrogen and which the least volume in 5 minutes?

	greatest volume of H_2	least volume of H_2
A	magnesium	zinc
B	magnesium	the mixture
C	zinc	magnesium
D	zinc	the mixture

33 Ammonia is produced using the Haber process.

Which row shows the source of the raw materials and the optimum reaction conditions?

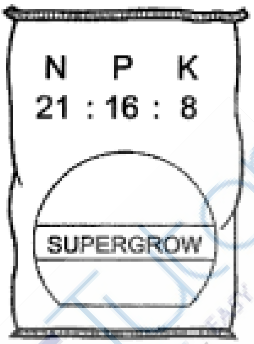
	source of nitrogen	source of hydrogen	temperature / °C	pressure / atm
A	air	hydrocarbons	200	450
B	hydrocarbons	air	450	200
C	air	hydrocarbons	450	200
D	air	hydrocarbons	450	450

34 The processes photosynthesis, respiration and fermentation all change the amount of carbon dioxide in the atmosphere.

Which process(es) increase(s) the amount of carbon dioxide in the atmosphere?

A photosynthesis and fermentation
B photosynthesis only
C respiration and fermentation
D respiration only

35 Which combination of chemical compounds can be used to produce the fertiliser shown?



A $(NH_4)_3PO_4$, KCl
B NH_4NO_3, $Ca_3(PO_4)_2$
C NH_4NO_3, $CO(NH_2)_2$
D NH_4NO_3, K_2SO_4, $(NH_4)_2SO_4$

36 The two statements are about the fractional distillation of crude oil. The statements may or may **not** be correct. They may or may **not** be linked.

statement 1 Fractional distillation is used to separate crude oil into useful fractions.

statement 2 The fractions with lower boiling points are found at the top of the fractionating column.

What is correct about these two statements?

A Both statements are correct and statement 2 explains statement 1.
B Both statements are correct but statement 2 does not explain statement 1.
C Statement 1 is correct but statement 2 is incorrect.
D Statement 1 is incorrect but statement 2 is correct.

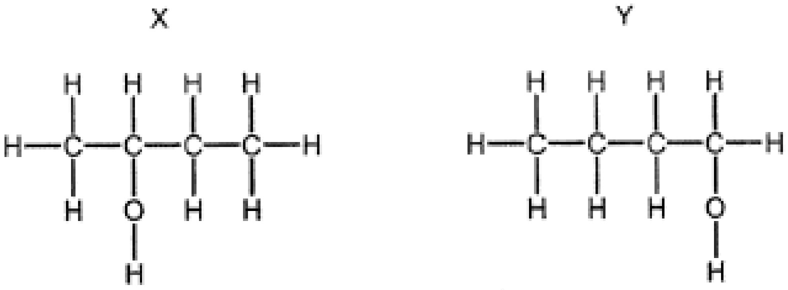
37 Which statements about alcohols are correct?

1 All alcohols contain the hydroxide ion, OH^-.

2 Ethanol can be formed from ethene using a reaction catalysed by yeast.

3 Methanol can be oxidised to methanoic acid.

4 The alcohols X and Y shown are isomers.



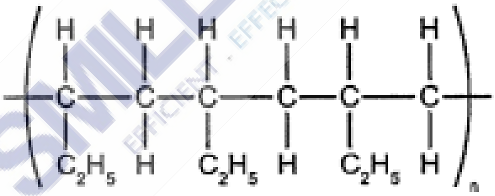
A 1, 2 and 3

B 3 only

C 2 and 4 only

D 3 and 4 only

38 The section of a polymer chain is shown.



Which molecule would produce this polymer and by which type of polymerisation?

	molecule	type of polymerisation
A	$CH_3–CH=CH–CH_3$	condensation
B	$CH_3–CH_2–CH=CH_2$	addition
C	$CH_3–CH_2–CH_2–CH=CH_2$	condensation
D	$CH_3–CH=CH–CH_3$	addition

39 The formula of an ester is $CH_3CH_2CH_2COOCH_2CH_2CH_3$.

Which acid and alcohol react together to make the ester?

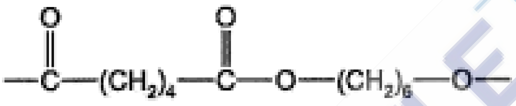
	acid	alcohol
A	butanoic acid	butanol
B	butanoic acid	propanol
C	propanoic acid	butanol
D	propanoic acid	propanol

40 P is a polymer that:

- has six carbon atoms in each of the monomers from which it is formed,
- is not a polyester,
- is formed using condensation polymerisation.

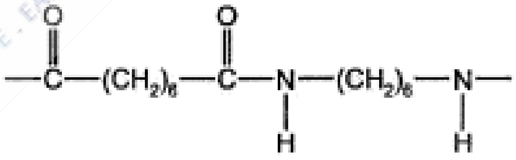
What is the partial structure of P?

A



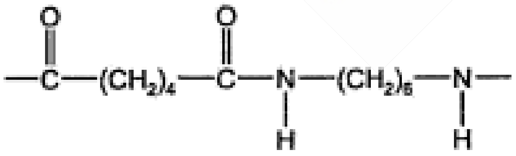
$-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-O-(CH_2)_6-O-$

B



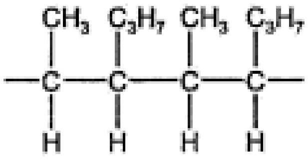
$-\overset{O}{\overset{\|}{C}}-(CH_2)_6-\overset{O}{\overset{\|}{C}}-\underset{H}{\underset{|}{N}}-(CH_2)_6-\underset{H}{\underset{|}{N}}-$

C



$-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-\underset{H}{\underset{|}{N}}-(CH_2)_6-\underset{H}{\underset{|}{N}}-$

D



$-\underset{H}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-\underset{H}{\underset{|}{\overset{C_3H_7}{\overset{|}{C}}}}-\underset{H}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-\underset{H}{\underset{|}{\overset{C_3H_7}{\overset{|}{C}}}}-$

Section A [50 marks]

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

A1 Iron is extracted from iron ore in the Blast Furnace.

The equations A, B, C, D and E show some reactions that happen in the Blast Furnace.

A $CaCO_3 \rightarrow CaO + CO_2$

B $SiO_2 + CaO \rightarrow CaSiO_3$

C $C + O_2 \rightarrow CO_2$

D $CO_2 + C \rightarrow 2CO$

E $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Use the letters, A, B, C, D and E to answer the following questions.

(a) Which equation shows thermal decomposition?

.... [1]

(b) Which equation shows combustion?

.... [1]

(c) Which equation shows a reaction between an acidic compound and a base?

.... [1]

(d) Which equation shows the formation of a toxic gas?

.... [1]

(e) Two equations show different elements in compounds being reduced.

Give the letters for these **two** equations.

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

(f) Iron from the Blast Furnace is further processed to make steel. Some types of steel contain more carbon than others.

How are the properties of high carbon steel different from those of low carbon steel?

....

.... [2]

[Total: 7]

A2 Fluorine forms numerous compounds of varied properties.

The chemical formulae and melting points of two of the compounds formed are shown below.

compound	chemical formula	melting point / °C
aluminium fluoride	AlF_3	1291
phosphorus trifluoride	PF_3	-151

(a) Draw a 'dot and cross' diagram to show the bonding formed in aluminium fluoride and phosphorus trifluoride.

Show only the outer shell electrons.

aluminium fluoride

phosphorus trifluoride

[4]

(b) Explain in term of bonding and structure, why aluminium fluoride has a high melting point while phosphorus trifluoride has a low melting point.

....

....

....

.... [3]

[Total: 7]

A3 The table shows the names and structures of some hydrocarbons.

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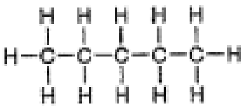
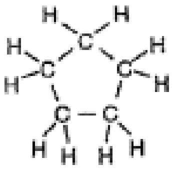
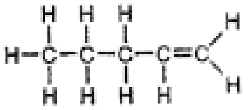
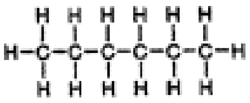
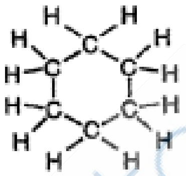
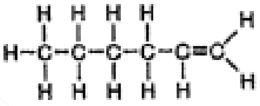
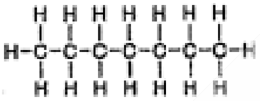
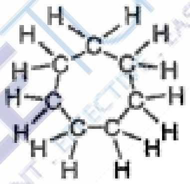
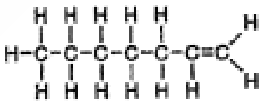
number of carbon atoms	**alkanes**	**cycloalkane**	**alkene**
5	pentane 	cyclopentane 	pentene 
6	hexane 	cyclohexane 	hexene 
7	heptane 	cycloheptane 	heptene 

(a) Cycloalkanes are an example of a homologous series.

(i) Explain how the formulae of cycloalkanes in the table show this.

.... [1]

(ii) Suggest **two** differences in physical properties between cyclopentane and cycloheptane.

....

.... [2]

(iii) The molecular formula of hexadecane is $C_{16}H_{34}$.

Give the molecular formula for cyclohexadecane

.... [1]

For Examiner's Use

(b) **(i)** Are cycloalkanes isomers of alkanes? Explain your reasoning.

....

.... [1]

(ii) Draw the structure of a branched chain isomer of hexane which is a straight chain alkane with the formula C_6H_{14}.

[1]

(c) The percentage of carbon and hydrogen in some molecules are shown in the table.

name of molecule	percentage of carbon by mass	percentage of hydrogen by mass
hexane	84	16
hexene	86	14
cycloheptane	86	14

Explain why the percentages of carbon and hydrogen are the same for hexene and cycloheptane, but different for hexane.

....

....

.... [2]

(d) Bromine water can be used in a test to distinguish between cycloalkanes and alkenes.

Describe the results that would be obtained if this test is carried out on separate samples of cyclooctane and octene.

....

....

.... [2]

[Total: 10]

A4 Aqueous thiosulfate, $S_2O_3^{2-}(aq)$, reacts with aqueous iodine according to the equation.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

In a titration, 40.0 cm³ of 0.1 mol/dm³ aqueous thiosulfate was added to 30 cm³ of 0.1 mol/dm³ aqueous iodine.

(a) Determine the limiting reagent. Show your working.

[3]

(b) If only 0.001 mol of I^- was produced, calculate the percentage yield.

percentage yield ....% [2]

(c) Explain why aqueous thiosulfate acts as a reducing agent in this reaction in terms of changes in oxidation states.

....

....

.... [2]

(d) Name another suitable reagent that can be used to confirm that aqueous thiosulfate is a reducing agent. Include the observation in your answer, if any.

....

....

.... [2]

[Total: 9]

A5 Iron(II) sulfate crystals decompose when heated to give three gases U, V and W and an orange-brown solid T.

- Gas U was tested with filter paper soaked with acidified potassium manganate(VII). The filter paper changed colour from purple to colourless.
- Analysis of gas V showed it contained 40.0% sulfur and 60.0% oxygen by mass.
- When gas W was condensed it formed a colourless liquid that turned anhydrous copper(II) sulfate from white to blue.
- Solid T was dissolved in dilute nitric acid. Aqueous ammonia was added drop by drop and a red-brown precipitate was obtained.

(a) **(i)** What is the formula for gas U?

.... [1]

(ii) Determine the empirical formula of gas V.

empirical formula of gas V .... [2]

(iii) Name gas W.

.... [1]

(iv) Give the name or the formula of the metal ion present in solid T.

.... [1]

(b) Iron(II) sulfate dissolves in water to give a green solution X. Aqueous sodium hydroxide was added drop by drop to solution X.

A green precipitate, Y, was formed.

(i) Name precipitate Y.

.... [1]

(ii) Construct the ionic equation, with state symbols, to show the formation of the precipitate Y.

.... [1]

(c) Use the following information to suggest the steps needed to prepare by precipitation pure barium sulfate, using aqueous iron(II) sulfate and powdered barium carbonate in a laboratory.

- barium sulfate is insoluble in water
- barium carbonate is insoluble in water
- barium nitrate is soluble in water

....

....

....

....

.... [3]

[Total: 10]

A6 Group I and Group VII elements show different trends in their properties.

Group I
Li
Na
K
Rb

Group VII
F
C*l*
Br
I

(a) Explain why the reactivity of metals in Group I increases on going down the group.

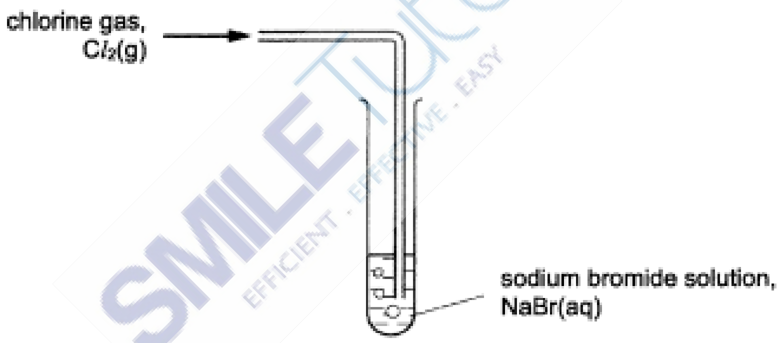
....

....

....

.... [2]

(b) When chlorine gas is bubbled into sodium bromide solution, a reaction occurs.



This reaction is commonly known as a 'displacement reaction'.

(i) Write an ionic equation for the displacement reaction.

.... [2]

(ii) Explain your observations in **(i)**.

....

.... [1]

(c) The radii of atoms and ions can be measured.

The table below shows some information about the atomic and ionic radii of Group I and Group VII elements.

element	number of shells of electrons in atom	atomic radius / pm	number of shells of electrons in ion	ionic radius / pm
Group I				
lithium (Li)	2	152	1	68
sodium (Na)	3	185	2	98
Group VII				
fluorine (F)	2	71	2	133
chlorine (C*l*)	3	99	3	181

[1 pm = 10^{-12} m]

(i) Suggest a reason for the difference in radius of a fluorine atom when it forms a fluorine ion.

....

.... [1]

(ii) Lithium and fluorine are found in the same period.

Suggest why the atomic radius decreases across a period.

....

.... [1]

[Total: 7]

Section B [30 marks]

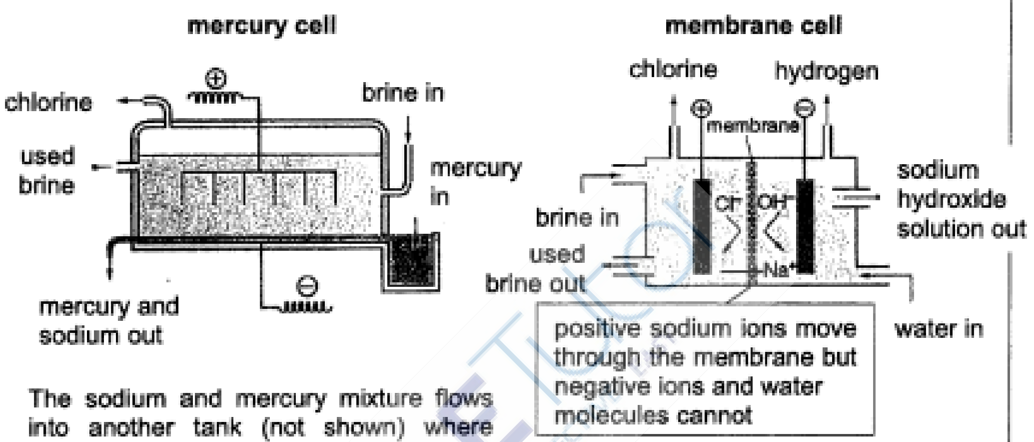
Answer all **three** questions in this section.

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 electrolysis of brine.

Industrial Electrolysis of Brine
Brine is a concentrated solution of sodium chloride, containing about 25% by mass of sodium chloride. Electrolysis of brine produces chlorine, hydrogen and sodium hydroxide.

Industrial electrolysis of brine used to be carried out in mercury cells but is now mostly carried out in membrane cells. The diagrams below show how these cells work.



positive sodium ions move through the membrane but negative ions and water molecules cannot

The sodium and mercury mixture flows into another tank (not shown) where sodium reacts with water to make sodium hydroxide and hydrogen.

The membrane cell allows sodium hydroxide and chlorine to be produced in the same cell. Without the membrane, the sodium hydroxide would not be pure because it would contain chloride ions.

One other problem that the membrane cell solves is that it keeps the chlorine gas and hydroxide ions separate. Chlorine and hydroxide ions react together which would reduce the amount of chlorine gas made and create more impurities in the sodium hydroxide.

The table below shows some information of the two types of cell.

	mercury	membrane
overall energy consumption (kWh per tonne of chlorine) 1 tonne = 1,000,000 g	3360	2650
purity of sodium hydroxide produced	high purity	high purity
concentration of sodium hydroxide produced	50% concentration	30% concentration
other points	mercury is toxic and must be removed from used brine	low maintenance costs

For Examiner's Use

(a) **(i)** In the membrane cell, it is important that negative ions do not pass through the membrane.

Explain why.

....

....

....

.... [3]

(ii) It is an advantage that negative ions do not pass through the membrane. Describe other advantages of using membrane cell instead of mercury cell.

....

....

.... [2]

(iii) Give a disadvantage of using membrane cell over mercury cell.

....

.... [1]

(b) Calculate the energy consumption of the membrane cell per mole of chlorine gas produced.

Give your answer to 3 significant figures.

[2]

(c) **(i)** Write the overall equation for the reaction in the membrane cell.

.... [1]

(ii) Calculate the maximum mass of sodium hydroxide that can be produced from 1 tonne of concentrated brine.

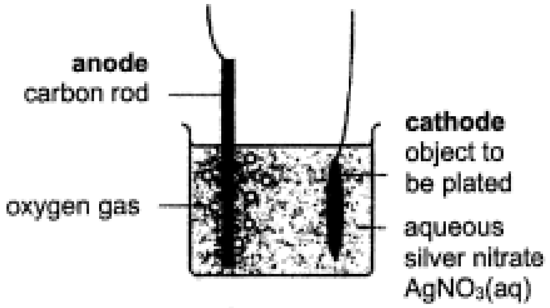
Give your answer to 3 significant figures.

[3]

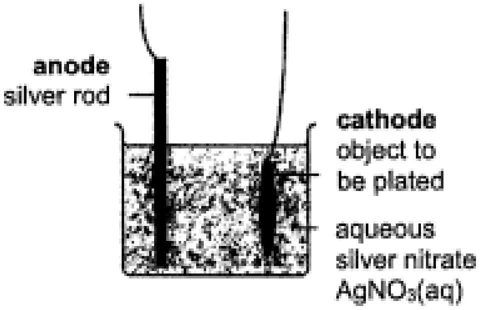
[Total: 12]

For Examiner's Use

B8 A student sets up two different experiments for electroplating an object with silver.



Experiment 1



Experiment 2

(a) Write equations, with state symbols, to show the reactions that happen at the anode and cathode during each experiment.

experiment 1

anode: ....

cathode: ....

experiment 2

anode: ....

cathode: .... [3]

(b) At the beginning of each experiment the student removes a sample of the electrolyte, aqueous silver nitrate, and puts it in a test-tube.

The student then adds a few drops of aqueous sodium chloride to the sample.

(i) Describe and explain what the student sees.

Include an ionic equation in your answer.

....

.... [2]

(ii) After some time, the student observes that no more silver is being deposited on the object in experiment 1 but more silver is still being deposited on the object in experiment 2.

Suggest a reason for this observation and describe how he could use aqueous sodium chloride to find out if his reasoning is correct.

....

.... [2]

(c) If an iron object is placed in a beaker of aqueous silver nitrate, a silver coating forms on the iron.

If a gold object is placed in aqueous silver nitrate, no reaction happens.

Explain why.

....

.... [1]

[Total: 8]

EITHER

B9 Poly(propene) and nylon are both used to make strong, waterproof ropes.

Poly(propene) is an addition polymer. Nylon is a condensation polymer.

(a) Describe the differences between addition polymers and condensation polymers.

....

....

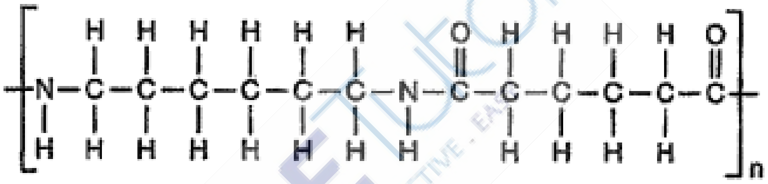
....

....

.... [3]

(b) There are several different types of nylon. One type of nylon is nylon-6,6.

This is the repeating unit of nylon-6,6.



(i) Draw the structures of the two monomers that react to form nylon-6,6.

monomer 1

monomer 2

[2]

(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 in the range of 14 000 to 22 000.

What is the range of the average number of repeating units in the nylon-6,6 molecules?

Show your working.

[2]

(c) Nylon-5,10 is made by reacting these two monomers together.

$$H_2N-(CH_2)_5-NH_2 \quad + \quad HO-\overset{O}{\overset{\|}{C}}-(CH_2)_8-\overset{O}{\overset{\|}{C}}-OH$$

(i) Draw the repeating unit of nylon-5,10.

[1]

(ii) Give one similarity and one difference between the structures of the repeating units of nylon-6,6 and nylon-5,10.

similarity ....

....

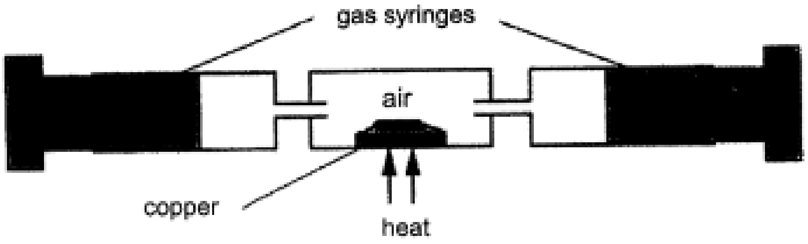
difference ....

.... [2]

[Total: 10]

OR

B10 An experiment (Experiment 1) was set up to heat copper in air.



At the start of Experiment 1, the apparatus contained a total of 200 cm^3 of air.

During heating, the copper reacted with oxygen in the air to form black copper(II) oxide.

The copper was heated until the volume of gas, measured at room temperature and pressure, remained constant.

(a) **(i)** Explain why it was important to continue heating until the volume remained constant.

....

.... [1]

(ii) The table shows some data about the mass change during the experiment.

mass of copper at the start of the experiment	**mass of solid left at the end of the experiment**
1.00 g	1.07 g

Use the data in the table to show that the solid left at the end of the experiment contains unreacted copper.

Show your working.

....

.... [3]

(b) **(i)** Name the gas that is left in the gas syringes at the end of the experiment.

.... [1]

(ii) Estimate the total volume of gas left in the gas syringes at the end of the experiment.

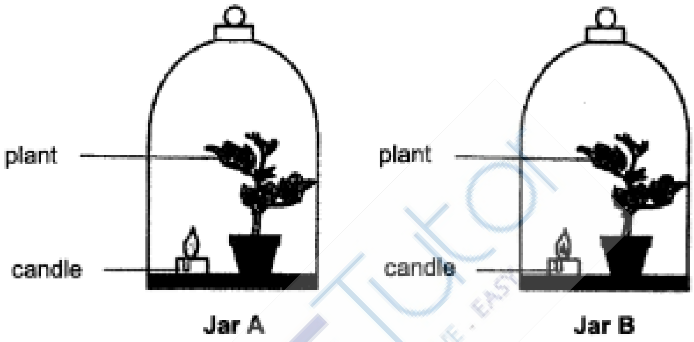
Explain your reasoning.

....

.... [2]

(c) A burning candle and a plant were placed in two jars of air.

Both jars were left in sunlight.



A 200 cm^3 sample of air from Jar A was tested immediately after the candle burned out using the same procedure as in Experiment 1.

A 200 cm^3 sample of air from Jar B was tested a few days after the candle burned out using the same procedure as in Experiment 1.

Describe and explain how the results of the tests would differ for each jar.

....

....

....

....

....

.... [3]

[Total: 10]

ANSWER SHEET

Paper 1: MULTIPLE-CHOICE QUESTIONS (40 MARKS)

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

Section A [50 marks]

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

For Examiner's Use

A1 Iron is extracted from iron ore in the Blast Furnace.

The equations A, B, C, D and E show some reactions that happen in the Blast Furnace.

A $CaCO_3 \rightarrow CaO + CO_2$

B $SiO_2 + CaO \rightarrow CaSiO_3$

C $C + O_2 \rightarrow CO_2$

D $CO_2 + C \rightarrow 2CO$

E $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Use the letters, A, B, C, D and E to answer the following questions.

(a) Which equation shows thermal decomposition?

A [1]

(b) Which equation shows combustion?

C [1]

(c) Which equation shows a reaction between an acidic compound and a base?

B [1]

(d) which equation shows the formation of a toxic gas?

D [1]

(e) Two equations show different elements in compounds being reduced.

Give the letters for these two equations.

D and E [1]

(f) Iron from the Blast Furnace is further processed to make steel. Some types of steel contain more carbon than others.

How are the properties of high carbon steel different from those of low carbon steel?

Harder and stronger [1]
Less malleable / more brittle [1] [2]

[Total: 7]

For Examiner's Use

A2 Fluorine forms numerous compounds of varied properties.

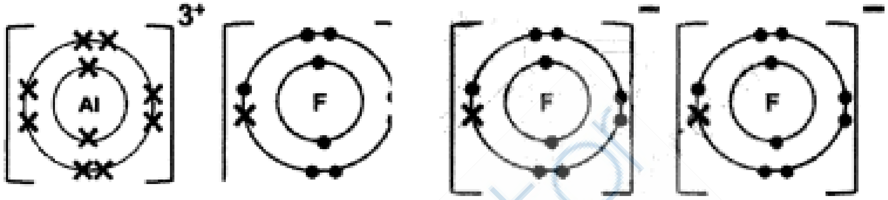
The chemical formulae and melting points of two of the compounds formed are shown below.

compound	chemical formula	melting point / °C
aluminium fluoride	AlF_3	1291
phosphorus trifluoride	PF_3	-151

(a) Draw a 'dot and cross' diagram to show the bonding formed in aluminium fluoride and phosphorus trifluoride.

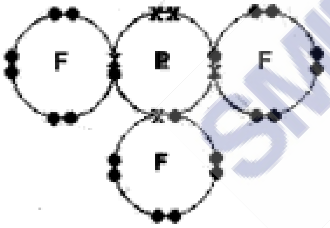
Show only the outer shell electrons.

aluminium fluoride



[1] correct 'dot and cross' diagram of Al^{3+} ion and F^- ion
[1] ratio of Al^{3+} : F^- is 1 : 3

phosphorus trifluoride



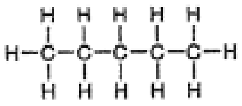
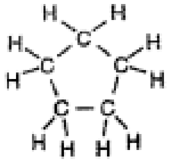
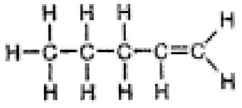
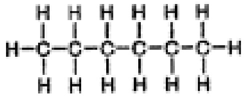
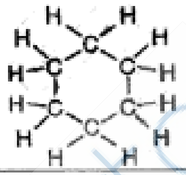
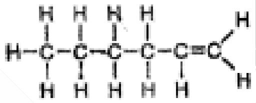
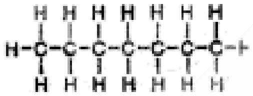
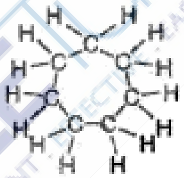
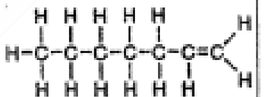
[1] correct no. of shared electrons (3 pairs)
[1] correct 'dot and cross' diagram of PF_3 [4]

(b) Explain in term of bonding and structure, why aluminium fluoride has a high melting point while phosphorus trifluoride has a low melting point.

- **Aluminium fluoride has a giant ionic lattice structure [1]**
- **Phosphorus trifluoride has a simple molecular structure [1]**
- **More heat energy is required to overcome the strong electrostatic forces of attraction between the ions in aluminium fluoride as compared to the weak intermolecular forces of attraction between phosphorus trifluoride molecules [1]** [3]

[Total: 7]

A3 The table shows the names and structures of some hydrocarbons.

number of carbon atoms	**alkanes**	**cycloalkane**	**alkene**
5	pentane 	cyclopentane 	pentene 
6	hexane 	cyclohexane 	hexene 
7	heptane 	cycloheptane 	heptene 

(a) Cycloalkanes are an example of a homologous series.

(i) Explain how the formulae of cycloalkanes in the table show this.

It has a general formula of C_nH_{2n} [1]

(ii) Suggest **two** differences in physical properties between cyclopentane and cycloheptane.

viscosity / melting and boiling point / flammability / density
[any for 2 m]

[2]

(iii) The molecular formula of hexadecane is $C_{16}H_{34}$.

Give the molecular formula for cyclohexadecane

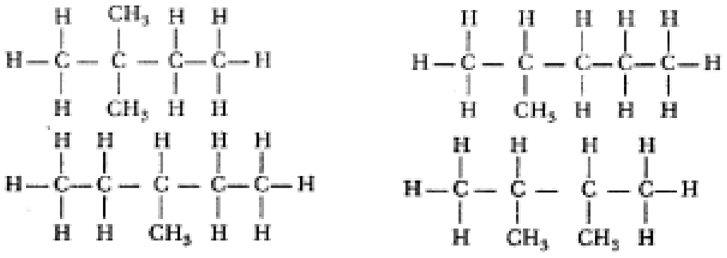
$C_{16}H_{32}$ [1]

For Examiner's Use

(b) (i) Are cycloalkanes isomers of alkanes? Explain your reasoning.

No, cycloalkanes have a <u>different chemical formula</u> from alkanes <u>for the same number of carbons</u> [1]

(ii) Draw the structure of a branched chain isomer of hexane which is a straight chain alkane with the formula C_6H_{14}.



[any plausible isomer for 1 m] [1]

(c) The percentage of carbon and hydrogen in some molecules are shown in the table.

name of molecule	percentage of carbon by mass	percentage of hydrogen by mass
hexane	84	16
hexene	86	14
cycloheptane	86	14

Explain why the percentages of carbon and hydrogen are the same for hexene and cycloheptane, but different for hexane.

Hexene and cycloheptane have the <u>same carbon : hydrogen ratio of 1 : 2</u> thus the percentages of carbon and hydrogen by mass are the same [1]

Hexane has a carbon : hydrogen ratio of 3 : 7 thus the percentages of carbon and hydrogen by mass are different from hexene and cycloheptane [1] [2]

(d) Bromine water can be used in a test to distinguish between cycloalkanes and alkenes.

Describe the results that would be obtained if this test is carried out on separate samples of cyclooctane and octene.

The test-tube containing the sample of <u>cyclooctane turns/remains reddish-brown/red-brown/brown</u> [1]

The test-tube containing the sample of octene <u>decolourises</u> bromine water from <u>reddish-brown/red-brown/brown to colourless</u> [1] [2]

[Total: 10]

A4 Aqueous thiosulfate, $S_2O_3^{2-}$(aq), reacts with aqueous iodine according to the equation.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

In a titration, 40.0 cm³ of 0.1 mol/dm³ aqueous thiosulfate was added to 30 cm³ of 0.1 mol/dm³ aqueous iodine.

(a) Determine the limiting reagent. Show your working.

No. of moles of $S_2O_3^{2-}$ = $\frac{40}{1000}$ x 0.1 = 0.004 mol [0.5]

No of moles of I_2 = $\frac{30}{1000}$ x 0.1 = 0.003 mol [0.5]

Mole ratio of $S_2O_3^{2-}$: I_2 → 2 : 1

0.004 mol of $S_2O_3^{2-}$ requires 0.002 mol of I_2 to react [1]

Thus, the limiting reactant is $S_2O_3^{2-}$ [1] [3]

(b) If only 0.001 mol of I^- was produced, calculate the percentage yield.

Mole ratio of $S_2O_3^{2-}$: I^- → 2 : 2 → 1 : 1

No. of moles of I^- = 0.004 mol [1]

% yield = $\frac{0.001}{0.004}$ x 100 % = 25% [1]

percentage yield **25%** [2]

(c) Explain why aqueous thiosulfate acts as a reducing agent in this reaction in terms of changes in oxidation states.

The oxidation state of iodine decreases [1] from 0 in I_2 to −1 in I^- [1] [2]

(d) Name another suitable reagent that can be used to confirm that aqueous thiosulfate is a reducing agent. Include the observation in your answer, if any.

Acidified potassium manganate(VII) / Acidified potassium permanganate [1]

It will decolourise from purple to colourless [1] [2]

[Total: 9]

For Examiner's Use

A5 Iron(II) sulfate crystals decompose when heated to give three gases U, V and W and an orange-brown solid T.

- Gas U was tested with filter paper soaked with acidified potassium manganate(VII). The filter paper changed colour from purple to colourless.
- Analysis of gas V showed it contained 40.0% sulfur and 60.0% oxygen by mass.
- When gas W was condensed it formed a colourless liquid that turned anhydrous copper(II) sulfate from white to blue.
- Solid T was dissolved in dilute nitric acid. Aqueous ammonia was added drop by drop and a red-brown precipitate was obtained.

(a) (i) What is the formula for gas U?

SO_2 [1]

(ii) Determine the empirical formula of gas V.

	S	**O**
% mass	**40**	**60**
***A*_r**	**32**	**16**
no. of moles	$\frac{40}{32}$ **= 1.25**	$\frac{60}{16}$ **= 3.75**
mole ratio	$\frac{1.25}{1.25} = \underline{1}$	$\frac{3.75}{1.25} = \underline{3}$

[1] correct working presented in a tabular form
[1] correct empirical formula

empirical formula of gas V **$\underline{SO_3}$** [2]

(iii) Name gas W.

water (vapour)/ steam [1]

(iv) Give the name or the formula of the metal ion present in solid T.

Iron(III) / Fe^{3+} [1]

(b) Iron(II) sulfate dissolves in water to give a green solution X. Aqueous sodium hydroxide was added drop by drop to solution X.

A green precipitate, Y, was formed.

(i) Name precipitate Y.

Iron(II) hydroxide [1]

(ii) Construct the ionic equation, with state symbols, to show the formation of the precipitate Y.

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

[1] correct formulae and balanced equation
[1] correct state symbols [2]

(c) Use the following information to suggest the steps needed to prepare by precipitation pure barium sulfate, using aqueous iron(II) sulfate and powdered barium carbonate in a laboratory.

- barium sulfate is insoluble in water
- barium carbonate is insoluble in water
- barium nitrate is soluble in water

- **Add excess barium carbonate to dilute nitric acid, filter to obtain barium nitrate as the filtrate [1]**
- **Mix solutions of barium nitrate and iron(II) sulfate and filter the mixture to obtain barium sulfate as the residue [1]**
- **Wash the residue with distilled water and dry between two pieces of filter paper [1]**

[3]

[Total: 10]

A6 Group I and Group VII elements show different trends in their properties.

Group I
Li
Na
K
Rb

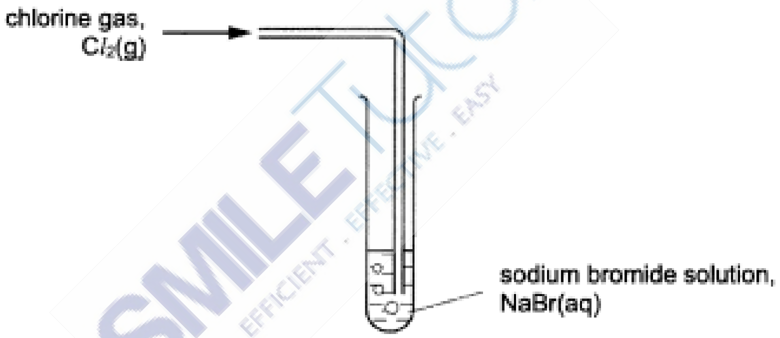
Group VII
F
C*l*
Br
I

(a) Explain why the reactivity of metals in Group I increases on going down the group.

As the atomic radius increases/number of electron shells increases down the group, the effective nuclear charge/forces decreases as the valence electrons are further away from the nucleus [1]

There is a greater tendency of losing its valence electron to form the positively charged ions results in increased reactivity [1] [2]

(b) When chlorine gas is bubbled into sodium bromide solution, a reaction occurs.



This reaction is commonly known as a 'displacement reaction'.

(i) Write an ionic equation for the displacement reaction.

$$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$$

[1] – correct chemical formulae
[1] – correct balancing and state symbols [2]

(ii) Explain your observations in **(i)**.

As chlorine is more reactive than bromine, it can displace bromine from sodium bromide [1] [1]

(c) The radii of atoms and ions can be measured.

The table below shows some information about the atomic and ionic radii of Group I and Group VII elements.

element	number of shells of electrons in atom	atomic radius / *pm*	number of shells of electrons in ion	ionic radius / *pm*
Group I				
lithium (Li)	2	152	1	68
sodium (Na)	3	185	2	98
Group VII				
fluorine (F)	2	71	2	133
chlorine (C*l*)	3	99	3	181

[1 pm = 10^{-12} m]

(i) Suggest a reason for the difference in radius of a fluorine atom when it forms a fluorine ion.

As F forms F^-, an electron is added to the valence shell, the effective nuclear charge/forces decreases, resulting in the ionic radius is larger than its atomic radius [1]

(ii) Lithium and fluorine are found in the same period.

Suggest why the atomic radius decreases across a period.

As the number of protons and electrons increases across the period the effective nuclear charge/forces increases, thus the atomic radius decreases. [1] [1]

[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.

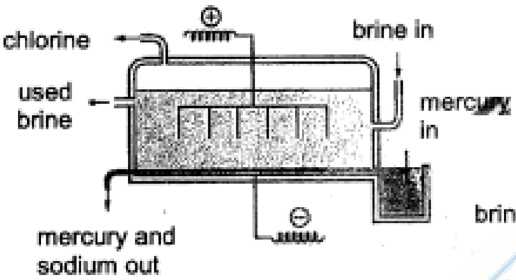
For Examiner's Use

B7 Read the information about the industrial electrolysis of brine.

Industrial Electrolysis of Brine
Brine is a concentrated solution of sodium chloride, containing about 25% by mass of sodium chloride. Electrolysis of brine produces chlorine, hydrogen and sodium hydroxide.

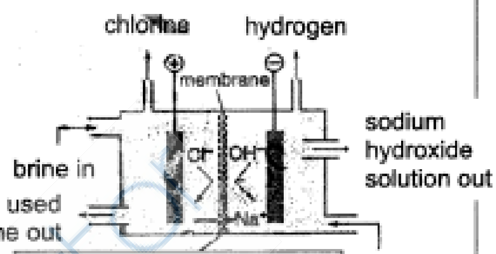
Industrial electrolysis of brine used to be carried out in mercury cells but is now mostly carried out in membrane cells. The diagrams below show how these cells work.

mercury cell



The sodium and mercury mixture flows into another tank (not shown) where sodium reacts with water to make sodium hydroxide and hydrogen.

membrane cell



positive sodium ions move through the membrane but negative ions and water molecules cannot

The membrane cell allows sodium hydroxide and chlorine to be produced in the same cell. Without the membrane, the sodium hydroxide would not be pure because it would contain chloride ions.

One other problem that the membrane cell solves is that it keeps the chlorine gas and hydroxide ions separate. Chlorine and hydroxide ions react together which would reduce the amount of chlorine gas made and create more impurities in the sodium hydroxide.

The table below shows some information of the two types of cell.

	mercury	membrane
overall energy consumption (kWh per tonne of chlorine) 1 tonne = 1 000 000 g	3360	2650
purity of sodium hydroxide produced	high purity	high purity
concentration of sodium hydroxide produced	50% concentration	30% concentration
other points	mercury is toxic and must be removed from used brine	low maintenance costs

(a) (i) In the membrane cell, it is important that negative ions do not pass through the membrane.

Explain why.

- **As the OH^- moves to the anode, the discharge of OH^- ions forms oxygen gas and contaminates the chlorine gas collected [1]**
- **As the Cl^- ions move to the cathode, it acts an impurity, resulting in the formation of sodium chloride decreasing the purity of sodium hydroxide produced [1]**
- **Thus, purification is needed to obtain pure chlorine and pure sodium hydroxide [1]**

[3]

[Note: Importance of obtaining pure chlorine and sodium hydroxide. Avoid fully lifting from passage]

(ii) It is an advantage that negative ions do not pass through the membrane. Describe other advantages of using membrane cell instead of mercury cell.

- **For the same mass (1 tonne) of chlorine gas produced, overall energy consumption of the membrane cell is 710 kWh energy lesser than that of the mercury cell [1]**
- **Does not contain toxic substances such as mercury that must be removed from used brine [1]**
- **Has a lower maintenance cost [1]**

[2]

[Any for 2 m]
[Reject: It uses lesser energy and has low maintenance costs. Comparison must be made]

(iii) Describe the disadvantage of using membrane cell over mercury cell.

The concentration of sodium hydroxide produced is more diluted, giving rise to only 30% concentration as compared to the 50% concentration in mercury cell

[1]

(b) Calculate the energy consumption of the membrane cell per mole of chlorine gas produced.

Give your answer to 3 significant figures.

No. of moles of Cl_2 = $\frac{100000}{2(35.5)}$ = 1.41×10^4 mol (3 s.f) [1]

Energy consumed per mole = $\frac{2650}{1.41 \times 10^4}$ ≈ 0.188 kWh (3 s.f) [1]

[2]

(c) (i) Write the overall equation for the reaction in the membrane cell.

$2NaCl + 2H_2O \rightarrow 2NaOH + Cl_2 + H_2$ [1]

(ii) Calculate the maximum mass of sodium hydroxide that can be produced from 1 tonne of concentrated brine.

Give your answer to 3 significant figures.

Mass of NaC*l* = $\frac{25}{100}$ x 1 000 000 = 0.25 x 10^6 g [1]

No. of moles of NaC*l* = $\frac{0.25 \times 10^6}{58.5}$ ≈ 4.27 x 10^3 mol (3 s.f)

Mole ratio of NaC*l* : NaOH → 2 : 2 → 1 : 1

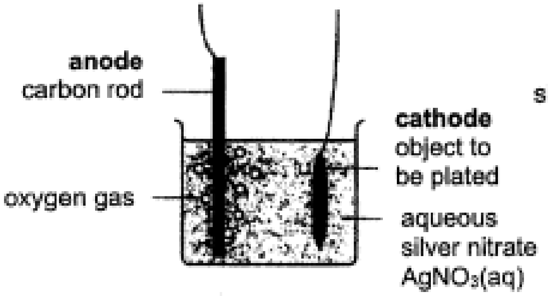
No. of moles of NaOH ≈ 4.27 x 10^3 mol (3 s.f) [1]

Maximum mass of NaOH produced = 4.27 x 10^3 x (23 + 16 + 1)
≈ 171 000 g (3 s.f) [1] [3]

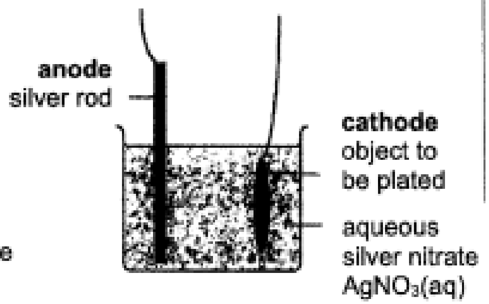
[Total: 12]

B8 A student sets up two different experiments for electroplating an object with silver.

For Examiner's Use



Experiment 1



Experiment 2

(a) Write equations, with state symbols, to show the reactions that happen at the anode and cathode during each experiment.

experiment 1

anode: **$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$ [1]**

cathode: **$Ag^+(aq) + e^- \rightarrow Ag(s)$ [0.5]**

experiment 2

anode: **$Ag(s) \rightarrow Ag^+(aq) + e^-$ [1]**

cathode: **$Ag^+(aq) + e^- \rightarrow Ag(s)$ [0.5]**

[3]

(b) At the beginning of each experiment the student removes a sample of the electrolyte, aqueous silver nitrate, and puts it in a test-tube.

The student then adds a few drops of aqueous sodium chloride to the sample.

(i) Describe and explain what the student sees.

Include an ionic equation in your answer.

A white precipitate is observed as silver chloride is insoluble in water [1]

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ [1]

[2]

(ii) After some time, the student observes that no more silver is being deposited on the object in experiment 1 but more silver is still being deposited on the object in experiment 2.

Suggest a reason for this observation and describe how he could use aqueous sodium chloride to find out if his reasoning is correct.

In experiment 2, for every 1 mole of silver ion discharged at the cathode, 1 mole of silver ion is formed at the anode [1]

A white precipitate of silver chloride would be observed in experiment 2 only when sodium chloride is added to test for silver ions [1] [2]

(c) If an iron object is placed in a beaker of aqueous silver nitrate, a silver coating forms on the iron.

If a gold object is placed in aqueous silver nitrate, no reaction happens.

Explain why.

<u>Iron is more reactive than silver</u> in the reactivity series of metals, thus it is <u>able to displace silver from aqueous silver nitrate/</u>

<u>Gold is less reactive than silver</u> in the reactivity series of metals, thus is it <u>unable to displace silver from aqueous silver nitrate</u> [1]

[Any for 1m]

[Total: 8]

EITHER

B9 Poly(propene) and nylon are both used to make strong, waterproof ropes.

Poly(propene) is an addition polymer. Nylon is a condensation polymer.

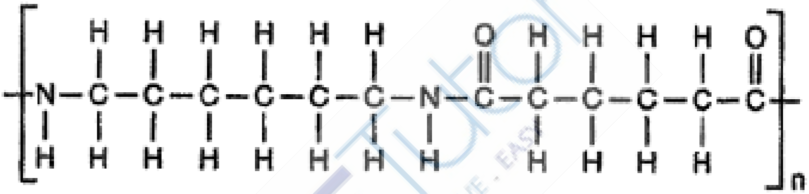
(a) Describe the differences between addition polymers and condensation polymers.

- **Addition polymers are formed from the joining of monomers without the loss of any small molecules [1]**
- **Condensation polymers form through the joining of monomers with the loss of a small molecule in the form of water [1]**
- **Monomers of addition polymers must have a $C=C$ double bond while monomers of condensation polymers must have two functional groups [1]**

[3]

(b) There are several different types of nylon. One type of nylon is nylon-6,6.

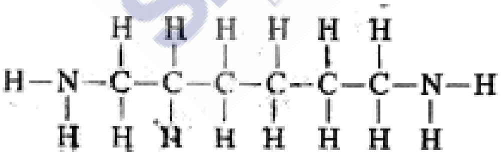
This is the repeating unit of nylon-6,6.



$$\left[-\begin{array}{ccccccccccccccccccccccccccc} & & H & & H & & H & & H & & H & & H & & & & O & & H & & H & & H & & H & & O \\ & & | & & | & & | & & | & & | & & | & & & & \| & & | & & | & & | & & | & & \| \\ N & - & C & - & C & - & C & - & C & - & C & - & C & - & N & - & C & - & C & - & C & - & C & - & C & - & C \\ | & & | & & | & & | & & | & & | & & | & & | & & & & | & & | & & | & & | & & \\ H & & H & & H & & H & & H & & H & & H & & H & & & & H & & H & & H & & H & & \end{array}-\right]_n$$

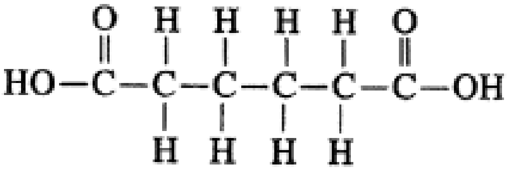
(i) Draw the structures of the two monomers that react to form nylon-6,6.

monomer 1



$$\begin{array}{ccccccccccccccccccc} & & & & H & & H & & H & & H & & H & & H & & & & \\ & & & & | & & | & & | & & | & & | & & | & & & & \\ H & - & N & - & C & - & C & - & C & - & C & - & C & - & C & - & N & - & H \\ & & | & & | & & | & & | & & | & & | & & | & & | & & \\ & & H & & H & & H & & H & & H & & H & & H & & H & & \end{array}$$

monomer 2



$$\begin{array}{ccccccccccccccc} & & O & & H & & H & & H & & H & & O & & \\ & & \| & & | & & | & & | & & | & & \| & & \\ HO & - & C & - & C & - & C & - & C & - & C & - & C & - & OH \\ & & & & | & & | & & | & & | & & & & \\ & & & & H & & H & & H & & H & & & & \end{array}$$

[2]

For Examiner's Use

(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 in the range of 14 000 to 22 000.

What is the range of the average number of repeating units in the nylon-6,6 molecules?

Show your working.

M_r of 1 repeat unit = 12(12) + 22 + 2(16) + 2(14) = 226 [1]

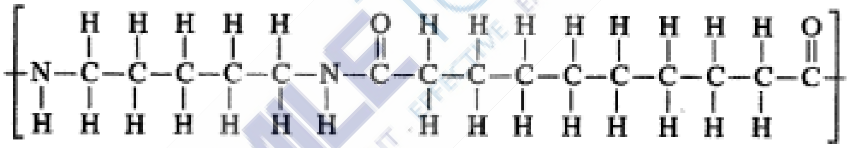
No. of repeat units in polymer of M_r (14 000) = $\frac{14\,000}{226} \approx 62$

No. of repeat units in polymer of M_r (22 000) = $\frac{22\,000}{226} \approx 97$

Range: <u>between 62 to 97 [1]</u> [2]

(c) Nylon-5,10 is made by reacting these two monomers together.

(i) Draw the repeating unit of nylon-5,10.



$$\left[-\underset{H}{N}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\underset{H}{N}-\overset{O}{\overset{\|}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{O}{\overset{\|}{C}}-\right]$$

[1]

(ii) Give one similarity and one difference between the structures of the repeating units of nylon-6,6 and nylon-5,10.

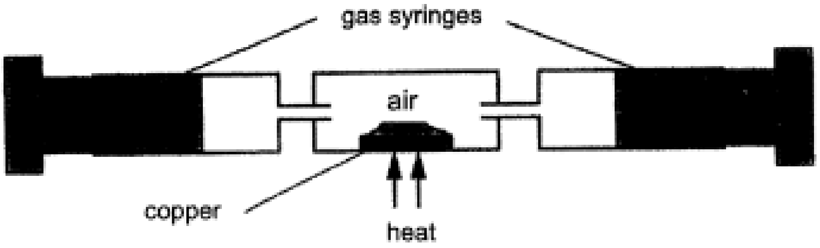
similarity **monomers are joined by amide linkages (-CONH-) [1]**

difference **the repeat unit of nylon-5,10 has a longer carbon chain than in nylon-6,6, thus it will have a larger relative molecular mass [1]** [2]

[Total: 10]

OR

B10 An experiment (Experiment 1) was set up to heat copper in air.



At the start of Experiment 1, the apparatus contained a total of 200 cm^3 of air.

During heating, the copper reacted with oxygen in the air to form black copper(II) oxide.

The copper was heated until the volume of gas, measured at room temperature and pressure, remained constant.

(a) **(i)** Explain why it was important to continue heating until the volume remained constant.

To ensure that all the oxygen in the air sample has been used up/has reacted. [1]

(ii) The table shows some data about the mass change during the experiment.

mass of copper at the start of the experiment	mass of solid left at the end of the experiment
1.00 g	1.07 g

Use the data in the table to show that the solid left at the end of the experiment contains unreacted copper.

Show your working.

No. of moles of Cu = $\frac{1}{64}$ = 0.0156 mol [1]

$2Cu + O_2 \rightarrow 2CuO$

Mole ratio of Cu : CuO → 2 : 2 → 1 : 1

No. of moles of CuO = 0.0156 mol

Theoretical mass of CuO = 0.0156 x (64 + 16) = 1.248 g [1]

Since the <u>actual mass obtained (1.07 g) is lower than the theoretical mass (1.248 g)</u>, there is some unreacted copper present [1] [3]

(b) (i) Name the gas that is left in the gas syringes at the end of the experiment.

Nitrogen [1]

(ii) Estimate the total volume of gas left in the gas syringes at the end of the experiment.

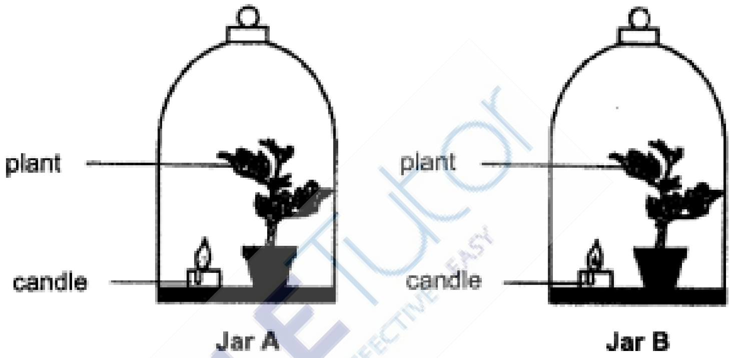
Explain your reasoning.

158 cm^3 is left [1] as

21% of air is made up of oxygen (42 cm^3) that reacts with copper [1] [2]

(c) A burning candle and a plant were placed in two jars of air.

Both jars were left in sunlight.



A 200 cm^3 sample of air from Jar A was tested immediately after the candle burned out using the same procedure as in Experiment 1.

A 200 cm^3 sample of air from Jar B was tested a few days after the candle burned out using the same procedure as in Experiment 1.

Describe and explain how the results of the tests would differ for each jar.

- **The air in Jar A contains lesser oxygen than Jar B as it is used (up) by the candle to support burning/combustion [1]**
- **The air in Jar B contains more oxygen than Jar A as photosynthesis occurred during those few days after the candle burned out [1]**
- **Thus, the mass of solid left at the end of the experiment would be greater in Jar B than Jar A [1]** [3]

[Total: 10]

-End of Marking Scheme-

CHRIST CHURCH SECONDARY SCHOOL PRELIM PAPER

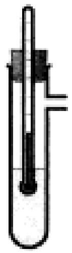
1 Which one of the following correctly describes the particles in a dilute sugar solution at room temperature?

	sugar molecules	water molecules
A	widely separated, moving at random	close together, moving at random
B	widely separated, moving at random	close together, not moving
C	widely separated, not moving	widely separated, moving at random
D	close together, moving at random	widely separated, vibrating slightly

2 The tubes shown in the diagram all contain a dilute solution of a solid X dissolved in a liquid Y.

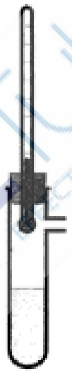
Which apparatus is most suitable for finding the boiling point of liquid Y?

A

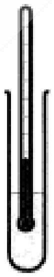


B

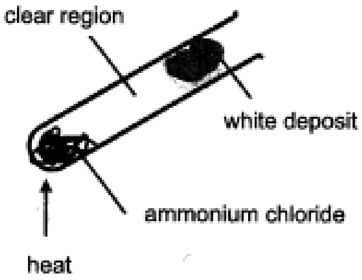
C



D



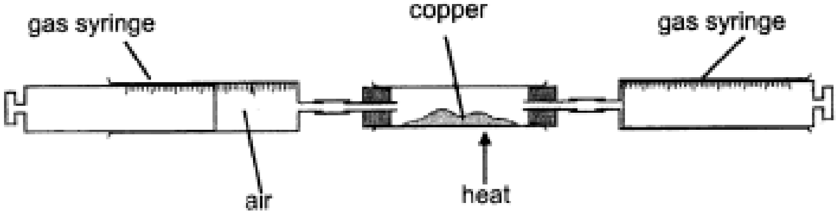
3 The diagram shows some ammonium chloride being heated.



What does the clear region between the ammonium chloride and the white deposit contain?

- **A** ammonia and chlorine
- **B** ammonia and hydrogen chloride
- **C** ammonia and water vapour
- **D** ammonium chloride vapour

4 The percentage of oxygen in the air is found by using the apparatus shown below. The air is passed over heated copper until there is no further decrease in volume.



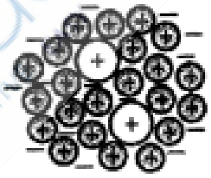
What precaution should be taken before the initial volume of air and final volume of gases remaining in the apparatus are found?

A The tube containing the copper should be removed.
B Both syringes should contain the same volume of air.
C All the copper should have reacted.
D The apparatus should be at room temperature.

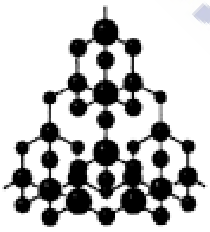
5 Which of the following shows the structure of bronze?

A

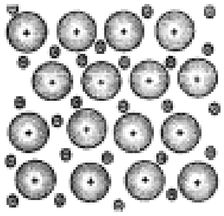
B



C



D



6 Naturally-occurring bromine has a relative atomic mass of 80 and consists entirely of two isotopes of relative atomic masses 79 and 81.

What can be deduced about naturally-occurring bromine from this information only?

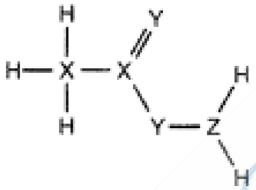
A Bromine is radioactive.
B Bromine has different oxidation states.
C Bromine isotopes have different number of protons.
D Bromine contains the two isotopes in equal proportions.

7 Silicon carbide is a shiny, hard, chemically inert material with a very high melting point. It can be used to sharpen knives and make crucibles.

Which type of structure explains these properties?

A a giant structure with covalent bonds between carbon and silicon atoms
B a giant structure containing metallic bonds
C a giant structure with covalent bonds between atoms and weak forces of attraction between the layers of atoms
D a simple molecular structure with covalent bonds between the carbon and silicon atoms

8 The diagram shows the structure of a covalent compound containing the element hydrogen, H, and the unknown elements X, Y and Z.



To which groups of the Periodic Table do these three elements, X, Y and Z, belong?

	X	Y	Z
A	1	5	6
B	4	5	1
C	4	6	5
D	5	1	4

9 What does a solution of hydrogen chloride and methylbenzene contain?

A methylbenzene ions, hydrogen ions and chloride ions
B methylbenzene ions and hydrogen chloride molecules
C methylbenzene molecules, hydrogen molecules and chlorine molecules
D methylbenzene molecules and hydrogen chloride molecules

10 Which one of the following substances

(i) is an element
(ii) also forms crystals composed of small molecules?

A carbon dioxide
B ice
C iodine
D graphite

11 The table below shows the results of experiments to measure the volume of sulfuric acid (column 1) needed to neutralise the mass of sodium hydroxide (column 2) dissolved in the volume of water (column 3).

experiment	column 1 volume of sulfuric acid required / cm^3	column 2 mass of sodium hydroxide / g	column 3 volume of water required / cm^3
1	20	1	20
2	40	2	40
3	40	2	20
4	?	1	40

From the results, what volume of sulfuric acid is needed to neutralise the sodium hydroxide in experiment 4?

A 10 cm^3 **B** 20 cm^3
C 40 cm^3 **D** 80 cm^3

12 Dinitrogen tetroxide, N_2O_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.

$$N_2O_4(g) + 2NaOH(aq) \rightarrow NaNO_3(aq) + NaNO_2(aq) + H_2O(l)$$

What is the least volume of aqueous sodium hydroxide required to dispose of 300 cm^3 of N_2O_4 at room temperature and pressure?

A 10 cm^3 **B** 20 cm^3
C 120 cm^3 **D** 240 cm^3

13 An element X in found in Group VII of the Periodic Table.

Which of the following is a likely behaviour of element X?

A reacts vigorously with water
B forms a hydride of formula XH_7
C reduces hydrogen sulfide
D oxidises SO_3^{2-} to SO_4^{2-}

14 250 cm^3 of 3.00 mol/dm^3 dilute hydrochloric acid is added to 350 cm^3 of 2.00 mol/dm^3 dilute hydrochloric acid.

What is the concentration of the resulting solution?

A 1.45 mol/dm^3
B 2.42 mol/dm^3
C 2.50 mol/dm^3
D 8.33 mol/dm^3

15 The table below shows the results of heating the carbonates and nitrates of three metals to the same temperature.

metal	products of decomposition	
	metal carbonate	metal nitrate
W	no change	metal nitrite and oxygen
X	oxide and carbon dioxide	metal oxide, nitrogen dioxide and oxygen
Y	no change	metal oxide, nitrogen dioxide and oxygen

What is the order of these metals in the reactivity series likely to be?

	most reactive	→	least reactive
A	W	X	Y
B	W	Y	X
C	X	Y	W
D	Y	W	X

16 Nickel is between iron and lead in the reactivity series.

Which of the following can be deduced from this?

A Nickel can be obtained by moderate heating of nickel hydroxide.
B Nickel can displace hydrogen rapidly from hot water.
C Nickel can be displaced from an aqueous solution containing nickel ions.
D Nickel loses electrons more readily than iron

17 Which one of the following reactions could be represented by the ionic equation.
M is the symbol for a metallic element.

$$M(s) + 2H^+(aq) \longrightarrow M^{2+}(aq) + H_2(g)$$

A iron + dilute hydrochloric acid
B lead + dilute sulfuric acid
C iron + steam
D sodium + water

18 A sample of air was shaken with an alkaline solution of a compound called pyrogallol. The gases remaining did not support combustion.

Which one of the following pairs of gases was removed by pyrogallol?

A carbon dioxide and nitrogen
B oxygen and carbon dioxide
C oxygen and nitrogen
D water vapour and hydrogen

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C oxygen and nitrogen
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22 When sulfur dioxide is bubbled into aqueous bromine, the reddish brown colour fades.

Which of the following describes the role of sulfur dioxide in the above reaction?

A an acid
B an oxidising agent
C a reducing agent
D a catalyst

23 Which one of the following processes does **not** involve either oxidation or reduction?

A manufacture of iron from haematite
B manufacture of ammonium sulfate from ammonia and sulfuric acid
C manufacture of ammonia from nitrogen and hydrogen
D manufacture of zinc from zinc blende (ZnS)

24 Which one of the following statements is always true for all examples of combustion?

A One product is always carbon dioxide.
B It is an exothermic reaction.
C The combustion products have more energy than the original fuel and oxygen.
D No bonds are broken in the reaction.

25 When powdered metal M was placed in aqueous lead(II) nitrate, a grey precipitate was obtained. The temperature rose and some M remained unchanged.

Which of the following conclusions cannot be deduced from this information?

A The reaction is exothermic.
B M is more reactive than lead.
C M was in excess.
D M has the same valency as lead.

26 Hydrogen peroxide decomposes to form water and oxygen gas. In two separate experiments, manganese(VI) oxide was added to 50 cm^3 of aqueous hydrogen peroxide.

The measurements taken are shown in the table below.

experiment	mass of MnO_2 / g	tempertaure rise / °C	Total volume of O_2 produced / cm^3
1	0.1	5	50
2	0.2	x	y

What were the values of x and y?

	x	y
A	2.5	50
B	5.0	50
C	5.0	100
D	10.0	100

27 Sulfur dioxide is reacted with oxygen to produce sulfur trioxide. This reaction is catalysed by a metal oxide catalyst.

$$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$$

What will become larger if the experiment is repeated using a better catalyst?

A The total volume of gas produced at the end of the reaction.
B The amount of hydrogen peroxide left over at the end of the reaction.
C The initial gradient of a graph of total volume of gas produced against time.
D The time needed to produce a particular volume of gas.

28 Four oxides are added separately to aqueous sodium hydroxide.

1. aluminium oxide
2. carbon dioxide
3. copper(II) oxide
4. magnesium oxide

Which oxides react with aqueous sodium hydroxide?

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

29 The results of some tests on solid X are listed below.

1. Solid X produced water when it is gently heated alone.
2. When dissolved completely in water and added to aqueous ammonia, it gave a dirty-green precipitate.
3. When dissolved completely in water and added to silver nitrate solution, it gave a white precipitate.

From the above results, what is solid X?

A hydrated copper(II) sulfate
B anhydrous copper(II) chloride
C hydrated iron(II) chloride
D anhydrous iron(II) sulfate

30 Which of the following mixtures below will result in the ionic equation shown?

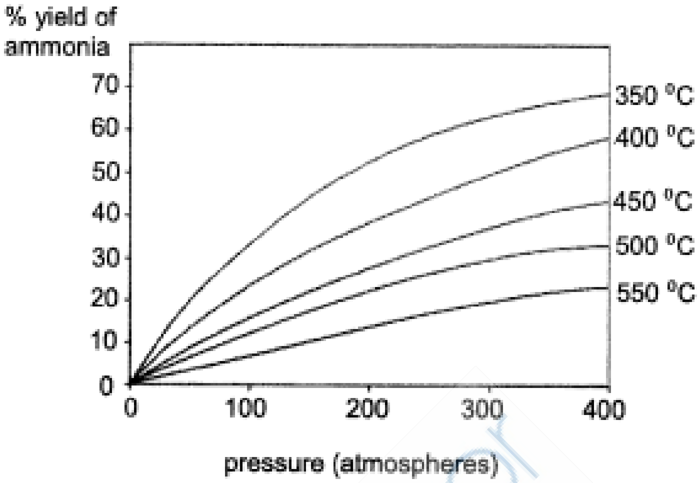
$$Pb^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow PbSO_4(s)$$

A aqueous lead(II) nitrate is added to dilute sulfuric acid
B lead(II) chloride is added to aqueous sodium sulfate
C lead(II) oxide is added to dilute sulfuric acid
D lead(II) sulfate is added to water

31 Nitrogen and hydrogen can react upon heating, according to the chemical equation.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The graph below shows the percentage yield of ammonia produced from 1 mole of nitrogen at different temperatures and pressures.



Which of the following statement(s) can be deduced from the information given above?

1. At 200 atmospheres, the number of moles of ammonia produced is greater at 450 °C than at 500 °C.
2. An increase in pressure increases the number of moles of ammonia produced at both 400 °C and at 350 °C.
3. The percentage yield of ammonia will most likely to be 33% at 500 °C and at 400 atmospheres.

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

32 The following ionic equation shows a redox reaction.

$$BrO_3^- + 5\,Br^- + 6H^+ \longrightarrow 3Br_2 + 3H_2O$$

Which one of the following substances is the oxidising agent?

A BrO_3^-
B Br^-
C H^+
D H_2O

33 Which one of the following reagents can be used to distinguish between butane and butanol?

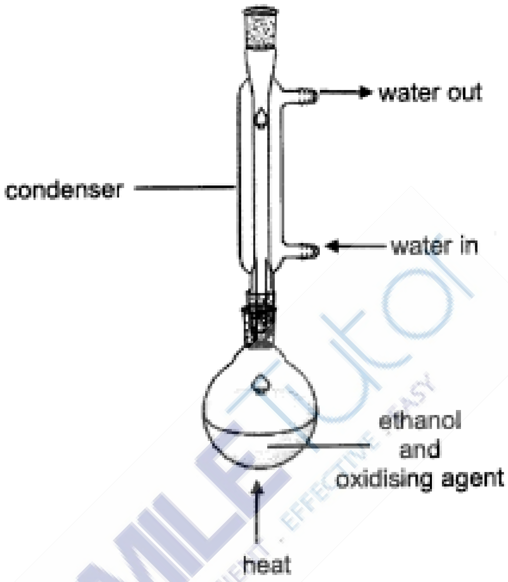
A concentrated sulfuric acid
B aqueous bromine
C phosphoric acid
D acidified potassium manganate(VII)

34 Ethanol is used in some after-shave lotions and deodorants.

Which pair of properties makes it suitable for these uses?

A It is flammable and mixes easily with water.
B It is flammable and vapourises easily.
C It is a good solvent and vapourises easily.
D It is colourless and mixes easily with water.

35 Ethanol was oxidised to ethanoic acid using the apparatus shown below.



What is the purpose of the condenser in the above set-up?

A prevent the conversion of the ethanol to ethene
B prevent the escape of any unchanged ethanol
C prevent the reforming of ethanol from ethanoic acid
D prevent the reaction of ethanoic acid with ethanol

36 Under suitable conditions, concentrated sulfuric acid dehydrates methanoic acid, H_2CO_2, to give carbon monoxide according to the equation below.

$$H_2CO_2 \rightarrow CO + H_2O$$

Concentrated sulfuric acid also dehydrates $H_2C_2O_4$. In this case, what product(s), other than water, would you expect to be formed?

A carbon monoxide only
B carbon dioxide only
C carbon monoxide and hydrogen
D carbon dioxide and carbon monoxide

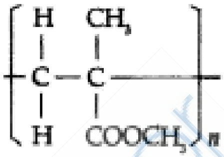
37 Which one of the following correctly describes both ethene and ethane?

- **A** They are both unsaturated hydrocarbons.
- **B** They both readily decolourise bromine water.
- **C** They can both burn to produce carbon dioxide and water.
- **D** They are both readily polymerised.

38 In which process do large molecules become smaller molecules?

- **A** fermentation of sugars
- **B** catalytic reaction between ethene and steam
- **C** reaction between ethene and bromine
- **D** polymerisation of ethene

39 The polymer, perspex, has the structural formula.



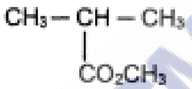
$$\left[-\overset{H}{\underset{H}{C}} - \overset{CH_3}{\underset{COOCH_3}{C}} - \right]_n$$

Which of the following structures is the monomer for the polymer?

A $CH_2=C(CH_3)CO_2CH_3$

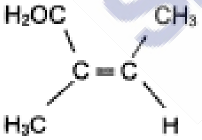
B $CH_2=CH-CO_2CH_3$

C

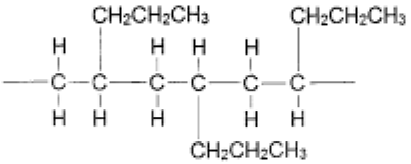


$CH_3-\underset{CO_2CH_3}{CH}-CH_3$

D



40 Engine oil is used to lubricate the car engine. Certain polymers are added to engine oil to improve its viscosity. A portion of the chain of one such polymer is shown below.



$$-\overset{H}{\underset{H}{C}}-\overset{CH_2CH_2CH_3}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{CH_2CH_2CH_3}{C}}-\overset{H}{\underset{H}{C}}-\overset{CH_2CH_2CH_3}{\underset{H}{C}}-$$

A molecule of this polymer contains 40 carbon atoms.
How many molecules of monomer are required to form one molecule of this polymer?

- **A** 4
- **B** 5
- **C** 8
- **D** 10

Section A

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

A1 Fig. 1.1 shows part of the Periodic Table. Only some of the elements are shown.

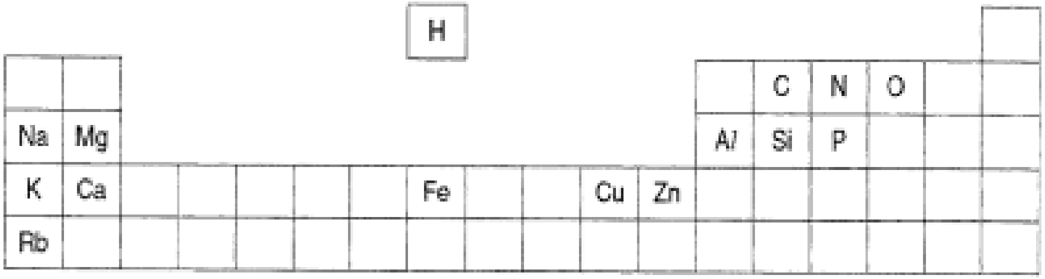


Fig. 1.1

(a) Each element may be used once, more than once or not at all.
Use the symbols used in the diagram.

Give **one** element which

(i) has a giant molecular structure,

.... [1]

(ii) combines with oxygen to form a gas which contributes to acid rain,

.... [1]

(iii) forms an ion of type X^+ which has only three completely filled shells of electrons,

.... [1]

(iv) forms a chloride with the formula XCl_3 and forms white precipitate insoluble in excess sodium hydroxide solution.

.... [1]

(b) Arsenic reacts with oxygen to form arsenic(III) oxide, As_2O_3.
Construct a balanced chemical equation for this reaction.

.... [1]

(c) Arsenic(III) oxide is slightly soluble in water. Arsenous acid, $\mathbf{H_3AsO_3}$, a weak acid is formed.

100 cm^3 of 0.05 mol/dm^3 of both arsenous acid and hydrochloric acid are added separately to excess magnesium.

(i) Suggest whether arsenous acid will produce more, less or the same volume of hydrogen compared to hydrochloric acid?

.... [1]

(ii) Will the **pH** of arsenous acid solution be higher, lower or the same as hydrochloric acid?

.... [1]

[Total: 7]

A2 Niobium, Nb, is a transition element. Sodium is an element in Group I of the Periodic Table.

(a) Describe two properties of niobium which are different from sodium.

....

....

....

....[2]

(b) Niobium chloride is a covalent molecule. Fig. 2.1 shows the structure of niobium chloride.

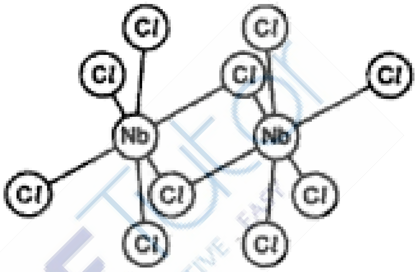


Fig. 2.1

(i) What is unusual about the structure of niobium chloride?

....

....

....[1]

(ii) State the molecular formula of niobium chloride.

....[1]

(c) Sodium chloride has a much higher melting point than niobium chloride.

(i) Draw a 'dot-and-cross' diagram to show the electronic structure of sodium chloride. You only need to show the outer shell electrons.

(ii) Use your knowledge of bonding in sodium chloride and niobium chloride to explain the difference in their melting points.

....

....

....

....

....[3]

(d) Describe a simple experiment which you could carry out to determine whether an aqueous solution contained an ionic or covalent compound.

Your answer should clearly state all the equipment required and how the observations made would lead to the conclusion.

....

....

....

....

....

....

....

....[3]

[Total: 12]

A3 **(a)** Polybutadiene is a synthetic rubber which is used in the manufacture of car tyres. It is non-biodegradable. More than 2 million tonnes of polybutadiene are produced annually as shown by the reaction in Fig. 3.1.

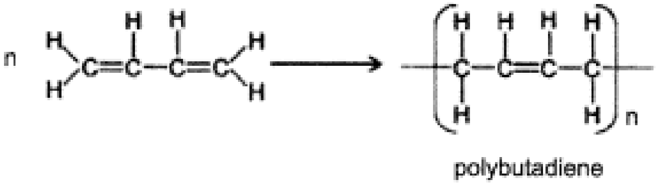
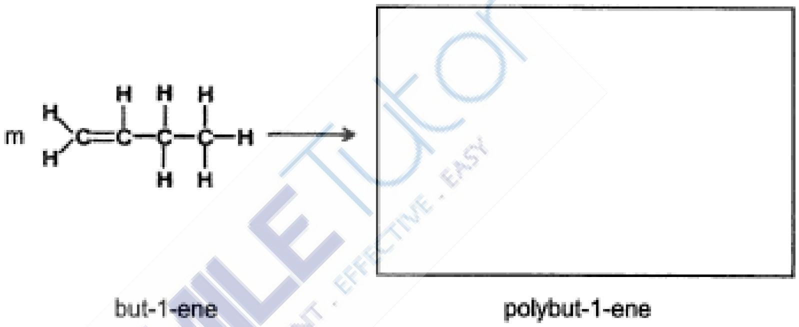


Fig. 3.1

Polybut-1-ene is a non-toxic, colourless and odourless material which is used in the manufacture of plastics, cosmetics and adhesives. It is made by polymerising but-1-ene.

(i) Complete the equation in Fig. 3.2 by drawing in the box provided the structure of the polybut-1-ene formed.



[1]

Fig. 3.2

(ii) Describe one difference in the structure between polybutadiene and polybut-1-ene.

....

....

....[1]

(iii) Give one chemical test and observations that can be used to distinguish between polybutadiene and polybut-1-ene.

....

....

....

....

....[2]

(iv) Suggest one property of polybutadiene which makes it a suitable material to make car tyres.

....

....[1]

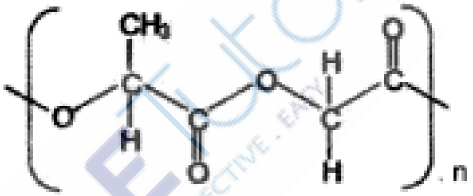
(v) Equal masses of polybutadiene and polybut-1-ene are burnt in air.

Which substance is more likely to burn with a more smoky flame?
Explain your answer.

....

....[1]

(b) Some biopolymer stitches are made of materials that the human body produces naturally. These stitches need not be removed as the body can absorb them when the wound is healed. The structure for one of these biopolymers is shown below.



This biopolymer is made from the polymerisation of two different monomers.

Draw the structural formulae of the two monomers in the boxes below.

monomer 1

monomer 2

[2]

[Total: 8]

A4 Hydrazine, N_2H_4, is used as a rocket fuel. The equation for the combustion of hydrazine given below.

$$N_2H_4(g) + O_2(g) \rightarrow 2H_2O(g) + N_2(g) \qquad \Delta H = -622\text{ kJ/mol}$$

(a) Explain, in terms of bond breaking and bond forming, why the above reaction is an exothermic reaction.

....

....

....

....

....

....[2]

(b) Draw the energy profile diagram for the reaction between hydrazine and oxygen. On your diagram, label clearly the following.

- axes
- ΔH of reaction,
- activation energy, E_a,
- reactants and products

(c) Hydrazine also undergoes another reaction with fluorine

$$N_2H_4(g) + 2F_2(g) \longrightarrow 4HF(g) + N_2(g)$$

Table 4.1 gives information about the bond energy of some bonds.

Table 4.1

Bond	bond energy (Kj/mol)
N – N	163
N – H	390
F – F	158
H – F	565
$N \equiv N$	945

Calculate the ΔH for the reaction between hydrazine and fluorine.

[2]

A5 Ammonia gas can be decomposed to nitrogen gas and hydrogen gas.

$$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$$

(a) Other than the reaction above, name one **other** source of hydrogen gas for the aerospace industry.

....[1]

(b) One of the uses of ammonia is in the manufacture of nitric acid. This is done by a two-stage process.

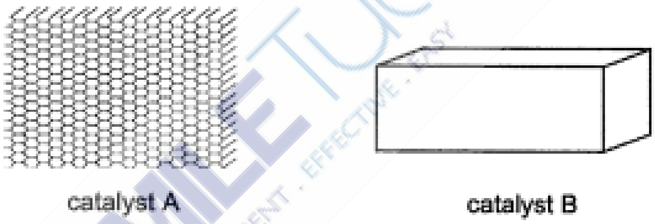
Stage 1: ammonia is converted to nitrogen(II) oxide.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

Stage 2: nitrogen(II) oxide is converted to nitric acid.

$$4NO(g) + 2H_2O(l) + 3O_2(g) \rightarrow 4HNO_3(aq)$$

(i) In **stage 1**, ammonia and oxygen are passed through a porous honeycomb-shaped catalyst A and a non-porous block-shaped catalyst B, of the same mass.



Explain, in terms of collision theory, which catalyst, A or B, is more efficient.

....

....

....

....

....

....[2]

(ii) Explain, in terms of oxidation states, why **stage 2** is a redox reaction.

....

....

....

....[2]

(iii) Calculate the maximum mass of nitric acid which can be produced from 720 dm^3 of ammonia measured at room temperature and pressure.

[2]

(iv) Use the two equations from **stage 1** and **stage 2** to construct an overall equation for the conversion of ammonia to nitric acid.

....[1]

[Total: 8]

A6 Fig. 6.1 gives the set-up used to investigate the relative reactivity of various metals, A, B, C and D. The metal strips and copper were first cleaned with sandpaper. Various metal strips were connected in turn with the copper sheet and the voltage recorded.

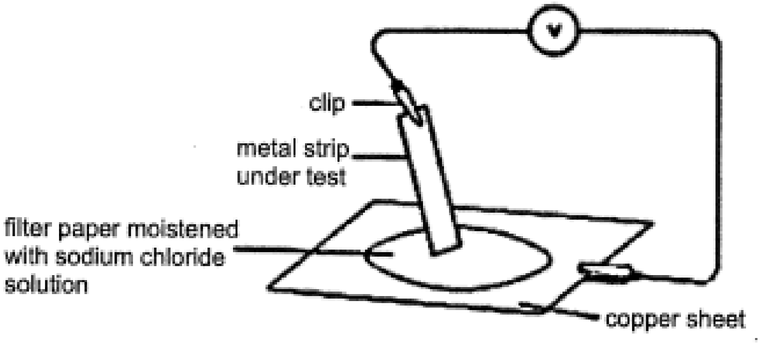


Fig. 6.1

Table 6.1 gives the results of the investigation.

Table 6.1

metal under test	direction of electron flow in the external circuit	voltage recorded (volts)
A	A to Cu	+ 1.40
B	Cu to B	- 2.22
C	A to C	+ 0.77
D	A to D	+ 0.28

(a) Explain why the metal strips and copper sheet were first cleaned with sandpaper.

....

....[1]

(b) Which of these metal(s) is/are less reactive than copper?
Explain your answer in terms of electron flow and the results shown in Table 6.1

....

....

....

....[2]

(c) Using the results in Table 6.1, arrange the four metals A, B, C and D in decreasing order of reactivity.

....[1]

[Total: 4]

A7 **(a)** Table 7.1 shows data about the melting point and boiling point of three halogens, chlorine, bromine and iodine.

Complete Table 7.1 by filling in the names of the halogens.

Table 7.1

name of halogen	melting point / °C	boiling point / °C
	- 7.2	58.8
	-100.9	-34.7
	113.8	184.5

[1]

(b) Sea water contains potassium bromide.

Bromine can be produced from sea water by displacement.

Name an element that can displace bromine from sea water. Give a reason for your choice.

....

....[1]

(c) Table 7.2 shows the colours of some silver halide precipitates and the observations made when the precipitates are left to stand.

Table 7.2

silver halide	colour of precipitate	observations on standing
silver chloride	white	rapid formation of grey solid
silver bromide	cream	slow formation of grey solid
silver iodide		no visible change after several minutes

[1]

(i) Complete Table 7.2 to show the colour of silver iodide precipitate.

(ii) What conclusion can you make about the relationship between the reactivity of halogen and the rate of breakdown of silver halide.

....

....[1]

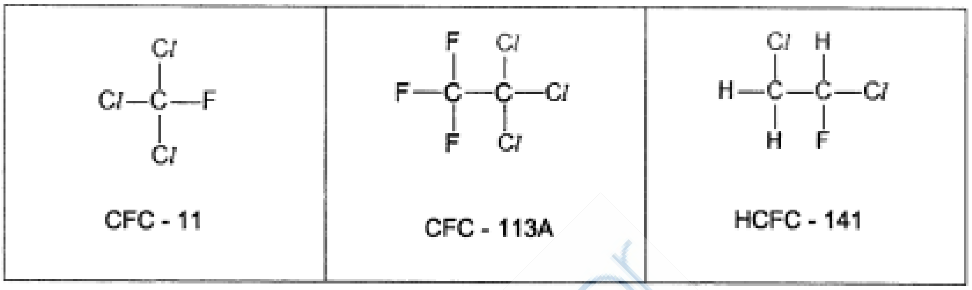
[Total:4]

Section B

Answer all **three** questions from this section.
The last question is in the form **EITHER / OR** and only **one** of the alternatives should be attempted.

B8 Chlorofluorocarbons (CFCs) are inert on the Earth's surface. However in the stratosphere, they are very reactive. CFCs are part of a group of compounds which can be classfied as ozone depleting compounds. Other than CFCs, there are also hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs) and perfluorocarbons (PFCs).

Some common examples of CFC and HCFC molecules are shown in Fig. 8.1 below with their names.



CFC - 11

CFC - 113A

HCFC - 141

Fig. 8.1

A naming system for these substances was devised several decades ago. The prefixes to the name tell us the elements present in the compound as shown in Table 8.1 below.

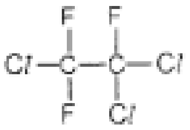
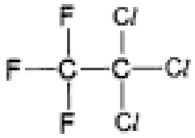
Table 8.1

prefix	elements present
PFC	carbon, fluorine
CFC	carbon, fluorine, chlorine
HFC	hydrogen, carbon, fluorine
HCFC	hydrogen, carbon, fluorine, chlorine

The numbers suffixed to the names of the compounds give us the number of each type of atom present in one molecule of the compound. The key to decoding the number is simply to add 90 to the number suffixed to the name.

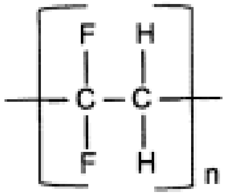
For example, to decode the number of atoms in CFC - 113A, we add 113 to 90 to obtain 203. The first number, 2, tells us the number of carbon atoms, the second number, 0, tells us the number of hydrogen atoms and the third number, 3, tells us the number of fluorine atoms. Chlorine atoms make up the remaining bonds since all these compounds are saturated.

The letter 'a' in CFC - 113a tells us about the structural formula of the compound. The arrangement of the type of atoms in the compound that most evenly distributes atomic masses has no letter. The second most even distribution is given the letter 'a', the third most even distribution is given the letter 'b', so on and so forth.

molecule	atomic mass of left carbon	atomic mass of right carbon
 CFC - 113	73.5	90
 CFC - 113a	57	106.5

Although most of these substances are harmful to the ozone layer, they can also be used to make polymers by first converting them to alkenes. For example, HCFCs react with potassium hydroxide which is dissolved in ethanol (solvent) to give an alkene, potassium chloride and water. An example of the reaction is shown below.

The alkene produced from the above reaction can be used to make useful polymers such as the one shown below.



(b) In the table given below, draw the **other** two isomers of HCFC -141 in the correct respective boxes.

HCFC -141a	HCFC - 141b

[2]

(c) A student comments that HFCs are safer alternatives to CFCs as HFCs do not harm the environment like CFCs do.

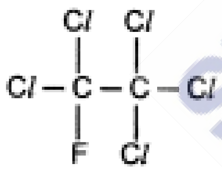
Explain why the student is correct.

....

....[1]

(d) Use the naming system discussed in the passage, write down the names of the following molecules.

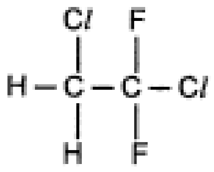
(i)



$$\begin{array}{ccccccc} & & Cl & & Cl & & \\ & & | & & | & & \\ Cl & - & C & - & C & - & Cl \\ & & | & & | & & \\ & & F & & Cl & & \end{array}$$

....[1]

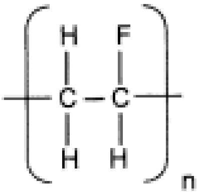
(ii)



$$\begin{array}{ccccccc} & & Cl & & F & & \\ & & | & & | & & \\ H & - & C & - & C & - & Cl \\ & & | & & | & & \\ & & H & & F & & \end{array}$$

....[2]

(e) **(i)** A scientist wants to produce the polymer, polyvinyl fluoride, using HCFCs.



Using a suitable HCFC, write down **two** equations showing the reactions he has to carry out to produce polyvinyl fluoride.

Show the structures of all the organic compounds in your equations.

[3]

(ii) Samples of the polyvinyl fluoride polymer produced were analysed and found to have a maximum relative molecular mass of 12000.

Calculate the maximum number of repeating units for this polymer?

[2]

[Total: 12]

B9 **(a)** Six samples of carbonates are heated strongly until there is no further change in mass.

Table 9.1 shows the mass of solid remaining at the end of the heating.

Table 9.1

carbonate	mass before heating / g	mass after heating / g
calcium carbonate	2.00	1.12
copper(II) carbonate	2.00	1.29
iron(II) carbonate	2.00	1.24
magnesium carbonate	2.00	0.95
sodium carbonate	2.00	2.00
zinc carbonate	2.00	1.30

(i) Explain why there is a decrease in mass for most carbonates except sodium carbonate.

....

....

....

....[2]

(ii) Which of the above carbonates is the **least** thermally stable? Explain your answer.

....

....

....

....[2]

(iii) For each carbonate, a 2.00 g sample was heated.

Explain why the mass of solid obtained after heating is different for each carbonate.

....

....

....

....[2]

(b) A student carried out an experiment to investigate the rusting of iron nails. He joined small pieces of different metals to identical iron nails and placed the nails in open test-tubes which contained a little water.

The observations that he made some days later are as shown in Fig. 9.1.

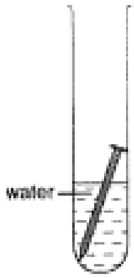
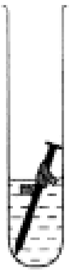
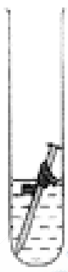
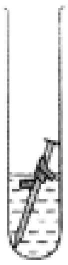
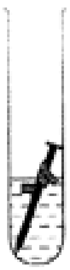
metal joined to nail	none (control)	tin	magnesium	zinc	copper
diagram of set-up					
observation	slight rusting	heavy rusting	no rusting	no rusting	heavy rusting

Fig. 9.1

What conclusions could the student draw from these observations?

....

....

....

....[2]

[Total: 8]

Either

B10 The speed of reaction between three compounds, hydrogen peroxide, hydrochloric acid and potassium iodide, was studied in a series of experiments.

$$H_2O_2(aq) + 2KI(aq) + 2HCl(aq) \longrightarrow 2H_2O(l) + I_2(aq) + 2KCl(aq)$$

The speed of reaction was measured using the rate of production of iodine as shown below.

$$\text{rate of production of iodine} = \frac{\text{change in concentration of iodine}}{\text{change in time}}$$

Table 10.1 shows the results obtained.

Table 10.1

experiment	concentration of H_2O_2 (mol/dm^3)	concentration of HCl (mol/dm^3)	concentration of KI (mol/dm^3)	rate of production of I_2 (mol/dm^3/s)
1	0.1	0.1	0.1	0.0001
2	0.2	0.1	0.1	0.0002
3	0.4	0.1	0.1	0.0004
4	0.1	0.2	0.1	0.0001
5	0.2	0.1	0.2	0.0004

(a) **(i)** Using the information given in Table 10.1, state how the concentration of potassium iodide affects the speed of reaction.

....

....

....[2]

(ii) Besides potassium iodide, identify another reactant whose concentration affects the speed of reaction and suggest how the speed is affected.

Explain your answer using the data provided in Table 10.1.

....

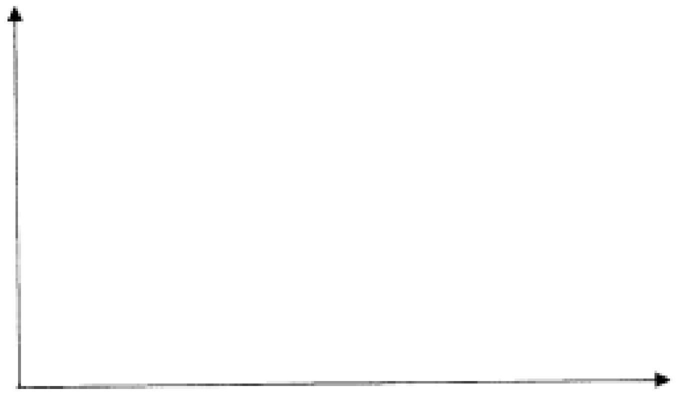
....

....

....

....[2]

(b) Sketch the graph of the concentration of hydrogen peroxide against the speed of reaction using the axes provided below.



[2]

(c) Besides concentration, state and explain using collision theory one **other** factor that increases the speed of reaction.

....

....

....

....

....[2]

(d) From experiment 1, assuming that hydrogen peroxide is the limiting reagent, calculate the mass of iodine formed in the reaction when the volume of hydrogen peroxide used is 100 cm^3.

Or

B10 A student electrolysed 2 dm³ aqueous copper(II) sulfate using platinum electrodes. A current of 1 ampere was passed. The graph of gain in mass of the cathode against time is given in Fig 10.1.

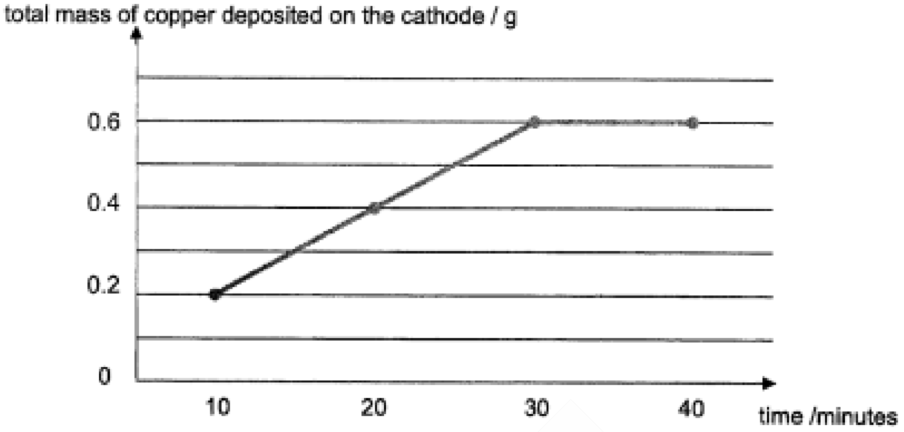


Fig 10.1

(a) Write ionic equations, including state symbols, to represent the formation of

(i) copper at the cathode,

....[1]

(ii) oxygen at the anode.

....[1]

(b) The solution initially contained 2.50 g of copper(II) sulfate crystals ($CuSO_4 . 5H_2O$).

(i) Calculate the initial concentration of the copper(II) sulfate solution in mol/dm³.

[1]

(ii) From the graph, what mass of copper was deposited after 10 minutes? How many moles of copper is this?

[1]

(iii) What is the concentration of the copper(II) sulfate, in mol/dm^3, after 10 minutes?

[2]

(c) Describe and explain the change in the appearance of aqueous copper(II) sulfate over time.

....

....

....

....

....[2]

(d) Why does the mass of copper deposited at the cathode not increase after 30 minutes, although the volume of oxygen given off at the anode continues to increase after this time?

....

....

....

....

....

....[2]

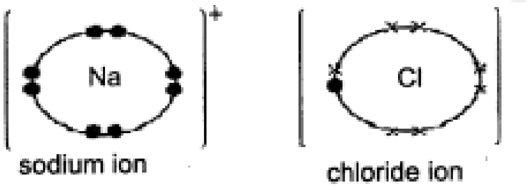
[Total 10]

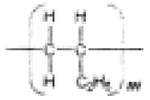
ANSWER SHEET

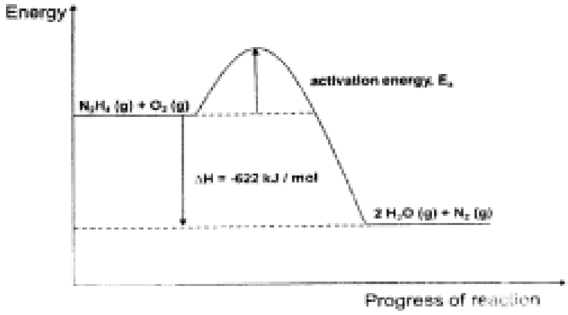
Paper 1 6092/01

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

Paper 2 6092/02
Section A

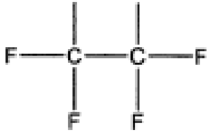
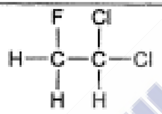
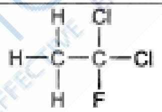
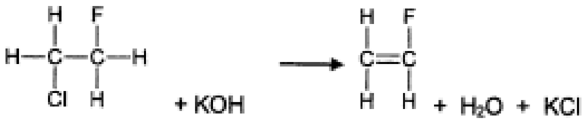
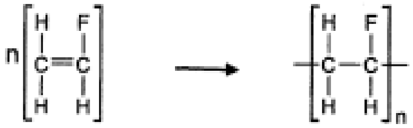
Qn	Answer		Marks/ Remarks
A1	**(a)(i)**	C	1
	(a)(ii)	N	1
	(a)(iii)	K	1
	(a)(iv)	Ca	1
	(b)	$4As + 3O_2 \rightarrow 2As_2O_3$	1
	(c)(i) **(c)(ii)**	more higher	1 1
			[Total: 7]
A2	**(a)**	any 2 from: • high melting point /high boiling point • high density • catalytic activity • form ions with different oxidation state/has several oxidation states in the compounds • forms coloured compounds	2
	(b)(i)	Niobium is a metal and is expected to form ionic compounds but forms covalent compound instead here.	1
	(b)(ii)	Nb_2Cl_{10}	1
	(c)(i)	1 mark per correct ion  	2
	(ii)	Strong electrostatic forces between Na^+ and Cl^- ions [1] Weak intermolecular forces of attraction between niobium chloride molecules. [1] **More** heat energy is required to overcome the bonds in sodium chloride than niobium chloride. [1]	3

Qn	Answer		Marks/ Remarks
	(d)	Ionic compounds conduct electricity in aqueous state but covalent compounds do not A circuit is set up using 2 carbon electrode (or any other inert electrode) dipped in the solutions. The electrodes are then connected to a battery and a light bulb/ and or ammeter. [1] In an ionic compound, the mobile ions help to conduct electricity and the bulb will light up. [1] In a covalent compound, there are no mobile electrons or ions to help conduct electricity and the bulb will not light up. [1]	3
			[Total: 12]
A3	(a)(i)	 Polybut-1-ene	1
	(a)(ii)	Polymer formed by butadiene contains carbon-carbon double bond/(C=C) bonds while polymer formed by but-1-ene does not contain carbon-carbon double bonds/(C=C) bonds	1
	(a)(iii)	React both polymers with aqueous bromine. Polybutadiene will decolourise aqueous bromine [1] but with polybut-1-ene, aqueous bromine remains reddish brown. [1]	2
	(a)(iv)	Strong/durable / resistance to wear/ resistant to heat (heat caused by friction/flexible)	1
	(a)(v)	**Percentage of carbon** in polybutadiene **is greater** than in polybut-1-ene thus combustion of polybutadiene produces a more smoky flame.	1
	(b)	$HOCH(CH_3)COOH$ [1] $HOCH_2COOH$ [1]	2
			Total : 8
A4	(a)	The total **energy absorbed to break/overcome the bonds of 2 mol N_2H_4 and 1 mol O_2 is lesser** [1] than the **energy released to form the bonds in 2 mol H_2O and 1 mol N_2** [1]. Zero marks if simply state that the energy absorbed for bond breaking is lesser than energy released for bond forming.	2

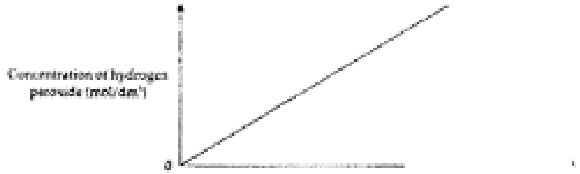
Qn		Answer	Marks/ Remarks
	(b)		1 m – correct shape of graph 1 m – for correct labelling of enthalpy change, activation energy, products &reactants If direction of any arrow is wrong [0] 1m – correct axes 3
	(c)	Energy absorbed = 163 + 390 (4) + 158 (2) = 2039 kJ Energy released = 565 (4) + 945 = 3205 kJ [1] ΔH = 2039 – 3205 = -1166 kJ / mol [1]	2
			[Total: 8]
A5	(a)	Any one of the following: • Cracking of petroleum • Electrolysis of water	1
	(b)(i)	A because A has larger surface area of contact than B. This allows higher frequency of effective collisions and higher rate of reaction than B.	1[no mark if explanation is wrong] 1
	(b)(ii)	Oxidation state of N increases from +2 in NO to +5 in HNO_3, as N is oxidised. Oxidation state of O decreases from 0 in O_2 to -2 in HNO_3, as O is reduced.	1 1
	(b)(iii)	720 dm^3 NH_3 = 30 mol NH_3 NH_3:NO:HNO_3 = 4:4:4 = 1:1:1 Mr of HNO_3 = 1+14+3(16) = 63 30 mol HNO_3 = 30x63 = 1890g [1]	1 1
	(b)(iv)	$NH_3 + 2O_2 \rightarrow H_2O + HNO_3$	1
			[Total: 8]
A6	(a)	Sandpaper removes the **surface layer of metal oxide** that may prevent the metal sheet from conducting electricity.	1
	(b)	Metal B. Electrons flow from Cu to B/ copper has a greater tendency/potential to lose electrons than B/Since reactive metals have a greater tendency to lose electrons, B is less reactive than copper.	1 1
	(c)	A, D, C, B	1

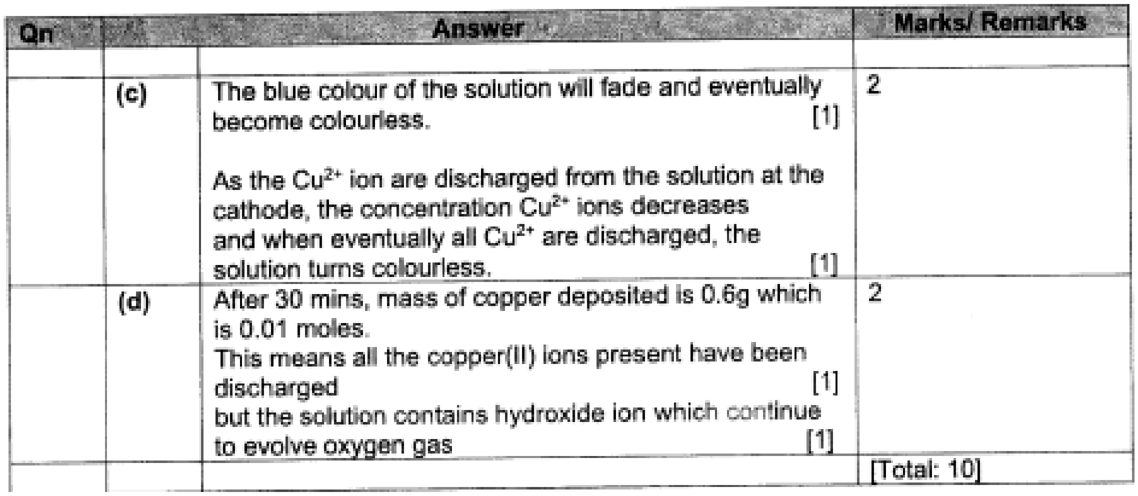
<table>
<tr><th>Qn</th><th colspan="2">Answer</th><th>Marks/ Remarks</th></tr>
<tr><td></td><td></td><td></td><td>[Total: 4]</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>A7</td><td>(a)</td><td><table><tr><th>name of halogen</th><th>melting point/°C</th><th>boiling point/°C</th></tr><tr><td>bromine</td><td>-7.2</td><td>58.8</td></tr><tr><td>chlorine</td><td>-100.9</td><td>-34.7</td></tr><tr><td>iodine</td><td>113.8</td><td>184.5</td></tr></table></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>Chlorine or fluorine – more reactive than bromine and can displace bromine from its compound.</td><td>1</td></tr>
<tr><td></td><td>(c)(i)</td><td>pale yellow</td><td>1</td></tr>
<tr><td></td><td>c)(ii)</td><td>The less reactive the halogen, the slower the breakdown of silver halide.</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td>[Total:4]</td></tr>
</table>

Section B

<table>
<tr><th>Qn</th><th colspan="2">Answer</th><th>Marks/ Remarks</th></tr>
<tr><td>B8</td><td>(a)</td><td></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td><table><tr><th>HCFC-141a</th><th>HCFC-141b</th></tr><tr><td></td><td></td></tr></table></td><td>1 mark per correct structure
2</td></tr>
<tr><td></td><td>(c)</td><td>HFCs do not contain chlorine atoms which will deplete the ozone layer.</td><td>1</td></tr>
<tr><td></td><td>(d)(i)</td><td>CFC-111</td><td>1</td></tr>
<tr><td></td><td>(d)(ii)</td><td>HCFC-132a Note: 1 mark for HCFC-132, 1 mark for a</td><td>2</td></tr>
<tr><td></td><td>(e)(i)</td><td>Reaction I

1 mark for correct HCFC used; 1 mark for equation.
Reaction 2

[1]</td><td>3</td></tr>
</table>

Qn		Answer	Marks/ Remarks
	(e)(ii)	M_r of repeating unit: 12 x 2 + 19 + 1 x 3 = 46 [1] No. of repeating units: 12000/46 = 260 (round down) [1]	2
			[Total: 12]
B9	(a)(i)	Except for sodium carbonate which is thermally stable;all other carbonates decompose (on heating) to form corresponding oxide and carbon dioxide; [1] carbon dioxide gas goes into the air so its mass is not captured. [1]	2
	(a)(ii)	Copper(II) carbonate; [1] Copper is the least reactive metal (hence its compound is the least stable) [1]	2
	(a)(iii)	The relative molecular mass / molar mass of each carbonate differs; [1] Hence the number of moles of each carbonate in a 2g sample differs (so number of moles of oxide left also differs) [1]	2
	(b)	Rusting is prevented if the metal attached is more reactive than iron; Iron rusts if attached metal is less reactive than iron; Rusting is worse than control if less reactive metal is attached (any 2)	2
			[Total: 8]
Either			
B10	(a)(i)	Using Expt 2 and 5, when the concentration of potassium iodide doubles from 0.1 to 0.2 mol/dm^3 and with the concentrations of hydrogen peroxide and HCl kept constant at 0.2 mol/dm^3 and 0.1 mol/dm^3 respectively, [1] the speed of reaction doubles from 0.0002 to 0.0004 mol/dm^3 /s. [1] (quotation of data in order to get the full 1m.)	2
	(a)(ii)	The other reactant is hydrogen peroxide. [1] Using Expt 1 and 2, when the concentration of hydrochloric acid and potassium iodide kept constant at 0.1 mol/dm^3, doubling the concentration of hydrogen peroxide from 0.1 to 0.2 mol/dm^3 doubles the speed of reaction from 0.0001 to 0.0002 mol/dm3 /s. [1] OR Using Expt 2 and 3, when the concentration of hydrochloric acid and potassium iodide are kept constant at 0.1 mol/dm^3, doubling the concentration of hydrogen peroxide from 0.2 to 0.4 mol/dm^3 doubles the speed of reaction from 0.0002 to 0.0004 mol/dm3 /s.	2

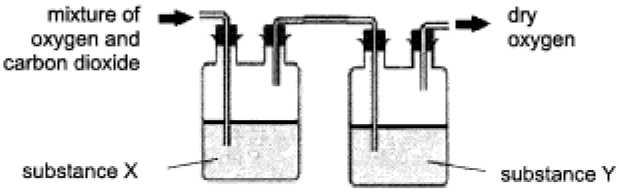
Qn		Answer	Marks/ Remarks
		OR Using Expt 1 and 3, when the concentration of hydrochloric acid and potassium iodide are kept constant at 0.1 mol/dm^3, increasing the concentration of hydrogen peroxide from 0.1 to 0.4 mol/dm^3 ,the speed of reaction increases four times from 0.0001 to 0.0004 mol/dm3 /s.	
	(b)	 Positive straight line from origin [1] Correct axes labelled when graph is correct. [1]	2
	(c)	With an increase in temperature, particles gain kinetic energy and move faster. More particles possess energy levels equivalent to or greater than the activation energy. This leads to an increase in the frequency of effective collisions between particles.	2
	(d)	No. of mole of H_2O_2 = 0.1 x 0.1 = 0.01 mol [1] Since $H_2O_2 : I_2$ is 1:1, therefore the number of moles of I_2 is also 0.01 mol Mass of I_2 formed = 0.01 x (127x2) = 2.54g [1]	2
			[Total : 10]
Or			
B10	(a)(i)	$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$	1
	(a)(ii)	$4OH^{-}(aq) \rightarrow 2H_2O\ (l) + O_2\ (g) + 4e^{-}$	1
	(b)(i)	2 dm^3 contains 2.5 g of copper (II) sulfate. Mass in 1 dm^3 = 2.5/2 = 1.25 g No of moles = 1.25 / 250 = 0.005 Hence, concentration is 0.005 mol/dm^3 [1]	1 (no working shown – no marks awarde)
	(b)(ii)	Mass of copper deposited = 0.2 g Number of moles = 0.2/64 = 0.003125 = 0.00313 mol (3sf)	1
	(b)(iii)	Initial number of moles of copper(II) sulfate in 2 dm^3 of solution = 0.005 x 2 = 0.01 mol No of mol of copper deposited = 0.00313 No of mol left in 2 dm^3 of solution = 0.01 – 0.00313 = 0.00687mol No of mol in 1 dm^3 of solution = 0.00687/2 = 0.00345 [1] Concentration after 10 mins = 0.00345 mol/dm^3 [1]	2



Qn		Answer	Marks/ Remarks
	(c)	The blue colour of the solution will fade and eventually become colourless. [1] As the Cu^{2+} ion are discharged from the solution at the cathode, the concentration Cu^{2+} ions decreases and when eventually all Cu^{2+} are discharged, the solution turns colourless. [1]	2
	(d)	After 30 mins, mass of copper deposited is 0.6g which is 0.01 moles. This means all the copper(II) ions present have been discharged [1] but the solution contains hydroxide ion which continue to evolve oxygen gas [1]	2
			[Total: 10]

CHUA CHU KANG SECONDARY SCHOOL PRELIM PAPER

1 A gaseous mixture of oxygen and carbon dioxide was passed through substance X and substance Y. Dry oxygen was obtained at the end of the setup.



Which of the following shows the correct identities of substances X and Y?

	substance X	substance Y
A	water	concentrated sulfuric acid
B	limewater	aqueous sodium hydroxide
C	water	aqueous sodium hydroxide
D	limewater	concentrated sulfuric acid

2 The table shows some information about the solubilities of three solids.

solid	solubility in water	solubility in ethanol
K	soluble	insoluble
L	insoluble	soluble
M	insoluble	insoluble

The following steps could be carried out to obtain pure K from a mixture K, L and M.

1 filter
2 evaporate filtrate to dryness
3 add water
4 add ethanol

What is the correct order of steps to be carried out?

A 4, 1, 2

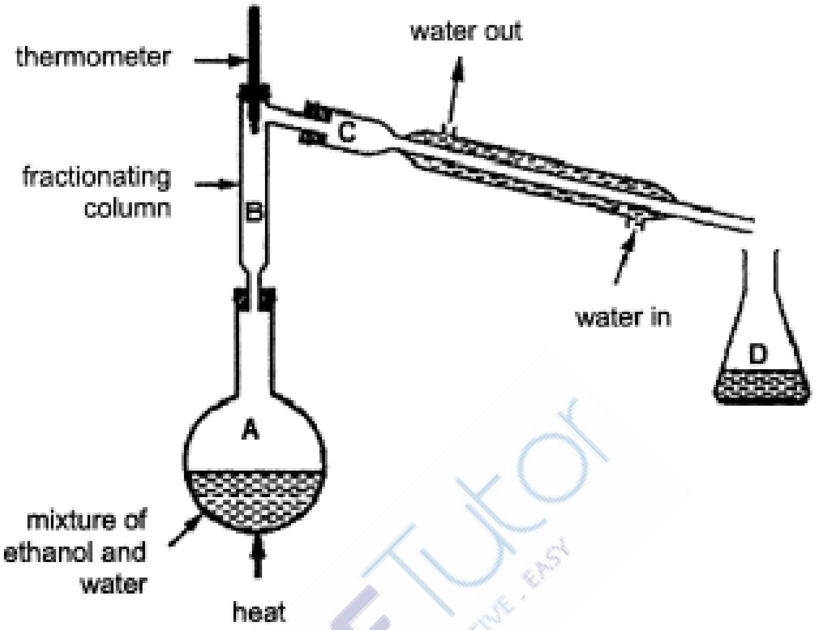
B 3, 1, 2

C 3, 2, 4, 1

D 4, 1, 3, 2

3 A mixture containing equal volumes of two miscible liquids is placed in the apparatus shown in the diagram and heated until the thermometer first shows a steady reading.

At which point, **A**, **B**, **C** or **D** will there be the highest proportion of the liquid with the higher boiling point?



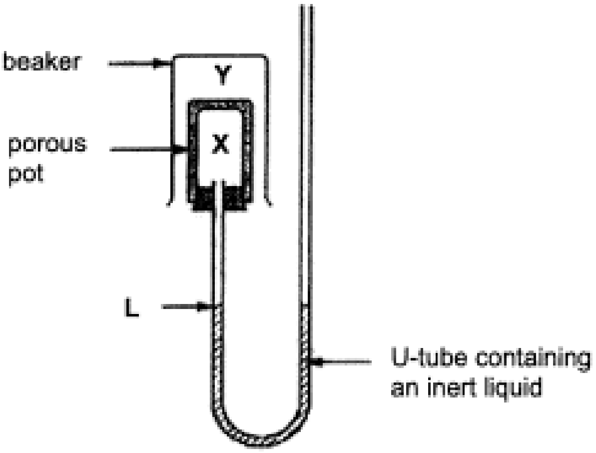
4 When pink cobalt(II) chloride crystals are heated, they form steam and a blue solid.

When water is added to the blue solid, it turns pink and becomes hot.

Which terms describe the pink cobalt(II) chloride crystals and the reactions?

	pink cobalt(II) chloride	reactions
A	anhydrous	reversible
B	anhydrous	irreversible
C	hydrated	irreversible
D	hydrated	reversible

5 The apparatus consists of a porous pot containing a gas X which is then surrounded by a gas Y in a beaker.



Which of the following pairs of gases would cause an upward movement of the liquid in the U-tube at the point labelled L?

	gas X	gas Y
A	H_2	NH_3
B	CO_2	N_2
C	O_2	H_2
D	NH_3	Ne

6 The atmosphere of Venus contains mainly oxygen, argon and nitrogen. The melting and boiling points of these gases are shown in the table.

gas	melting point / °C	boiling point/ °C
oxygen	-219	-183
argon	-189	-186
nitrogen	-210	-196

What temperature should the sample of air be in order to obtain two of the gases as liquids?

A -180 °C

B -184 °C

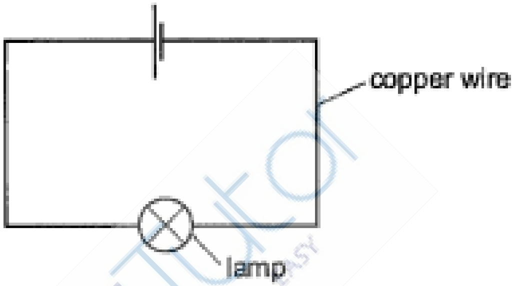
C -190 °C

D -198 °C

7 Which row gives a possible correct number of neutrons and electrons in an ion of chlorine-35?

	neutrons	electrons
A	18	17
B	17	17
C	18	18
D	17	18

8 An electrical circuit is set up using copper wire.



Which process takes place in the copper wire?

A Cations stay in position and electrons move to the positive terminal of the battery.

B Cations and electrons move to the negative terminal of the battery.

C Anions move to the positive terminal and cations move to the negative terminal of the battery.

D Cations stay in position and anions move to the positive terminal of the battery.

9 How many covalent bonds are there in the molecule with the formula CH_2CHCH_3?

A 7

B 8

C 9

D 10

10 Which of the following aqueous solutions contains the highest number of ions?

A 1 dm^3 of 0.1 mol/dm^3 $Al(NO_3)_3$

B 1 dm^3 of 0.2 mol/dm^3 H_2SO_4

C 1 dm^3 of 0.3 mol/dm^3 $MgCl_2$

D 1 dm^3 of 0.4 mol/dm^3 HNO_3

11 The formula of an oxide of element Y is Y_2O. 9.4 g of Y_2O contains 7.8 g of Y.

How many moles of Y does 7.8 g of the element contain?

A $\frac{1.6}{16}$ x 2

B $\frac{1.6}{16}$ x $\frac{1}{2}$

C $\frac{9.4}{16}$ x 2

D $\frac{9.4}{16}$ x $\frac{1}{2}$

12 Hydrogen reacts with oxygen according to the following equation.

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l)$$

What is the total volume of gas left in the mixture when 30 cm^3 of hydrogen reacts with 30 cm^3 of oxygen? (All volumes measured at room temperature and pressure)

A 15 cm^3

B 30 cm^3

C 45 cm^3

D 60 cm^3

13 Tin is extracted from its ore, SnO_2, by reducing it with coal in a blast furnace.

$$SnO_2 + 2C \rightarrow Sn + 2CO$$

What is the percentage purity of the tin ore if 900 g of SnO_2 produces 102 g of tin?

A $\frac{119}{102}$ X $\frac{900}{151}$ x 100%

B $\frac{119}{102}$ X $\frac{900}{151}$ x 100%

C $\frac{102}{119}$ X $\frac{151}{900}$ x 100%

D $\frac{102}{119}$ X $\frac{900}{151}$ x 100%

14 50.0 cm^3 of 0.10 mol/dm^3 of silver nitrate, $AgNO_3$, is added to 150.0 cm^3 of 0.05 mol/dm^3 sodium iodide, NaI, in a beaker. After the reaction, solid silver iodide settles to the bottom of the beaker.

What are the ions are present in solution?

A sodium ions and iodide ions

B sodium ions and nitrate ions

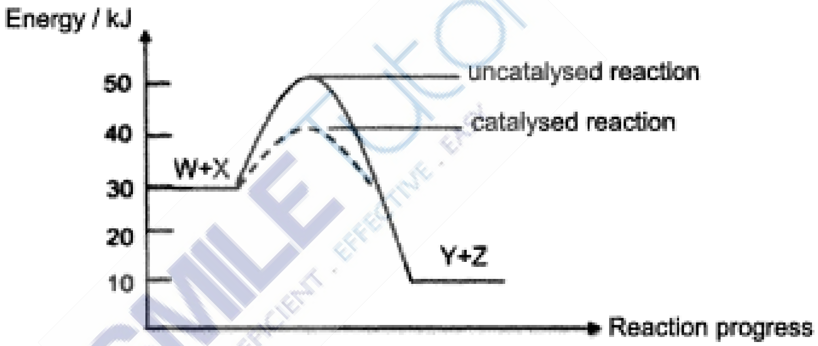
C sodium ions, nitrate ions and iodide ions

D sodium ions, silver ions and nitrate ions

15 A reversible reaction is represented by the equation shown.

$$W + X \leftrightarrow Y + Z$$

The energy profiles for the reversible reaction under catalysed and uncatalysed conditions are shown.



What is the activation energy of the reverse catalysed reaction?

A -40 kJ

B -10 kJ

C +30 kJ

D +40 kJ

16 The table shows the chemical formula of some carbon-containing compounds.

chemical name	chemical formula
sodium carbide	Na_2C_2
carbon dioxide	CO_2
iron(II) carbide	Fe_2C
carbonate ion	CO_3^{2-}

Which two compounds contain carbon with the same oxidation state?

A carbon dioxide and carbonate ion

B sodium carbide and carbonate ion

C carbon dioxide and iron(II) carbide

D sodium carbide and iron(II) carbide

17 Which reaction does **not** involve oxidation or reduction?

A $Fe^{2+} \rightarrow Fe^{3+} + e^-$

B $2H_2 + O_2 \rightarrow 2H_2O$

C $CuO + H_2 \rightarrow Cu + H_2O$

D $2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$

18 Solid calcium carbonate reacts with dilute hydrochloric acid to produce calcium chloride salt, carbon dioxide gas and water.

Which row shows the correct effect on the rate of the reaction when a factor is changed?

	factor changed	effect on rate of reaction
A	particle size of calcium carbonate increased	decrease
B	concentration of hydrochloric acid increased	decrease
C	pressure of surrounding increased	increase
D	temperature increased	decrease

19 A white solid reacted with both hydrochloric acid and aqueous sodium hydroxide solution separately.

What could be the identity of the solid?

A lithium oxide

B calcium oxide

C phosphorus oxide

D zinc oxide

20 Which method(s) is/are suitable to distinguish between 1.00 mol/dm^3 of hydrochloric acid and 1.00 mol/dm^3 of ethanoic acid?

1 using a pH meter
2 determining the volume of 1.00 mol/dm^3 of sodium hydroxide solution used to neutralise 25.0 cm^3 of the acids separately
3 measuring the total volume of hydrogen gas formed when excess magnesium is added to the acids separately

A 1 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

21 A salt is prepared by titrating a carbonate with an acid.

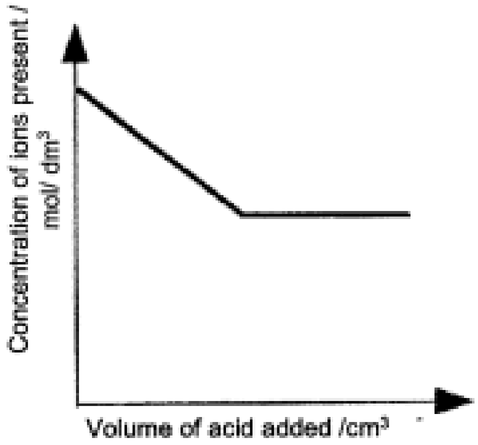
What are the solubilities of the carbonate and the salt?

	carbonate	salt
A	soluble	insoluble
B	insoluble	soluble
C	soluble	soluble
D	insoluble	insoluble

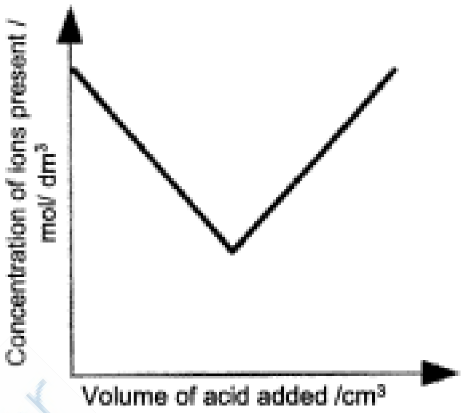
22 Dilute sulfuric acid was added to aqueous barium hydroxide until the acid was in excess.

Which graph best represents the variation in the concentration of ions in the solution?

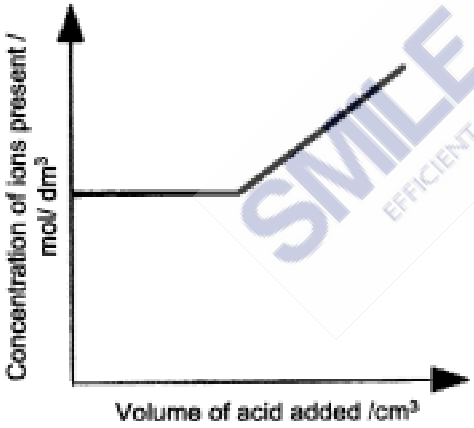
A



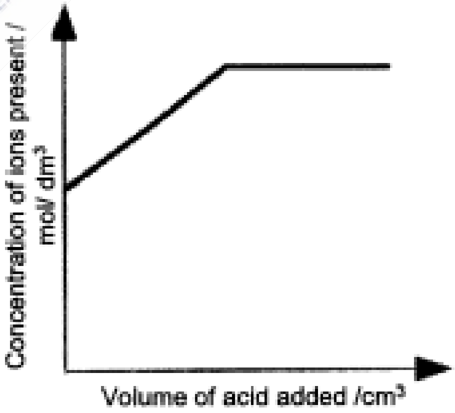
B



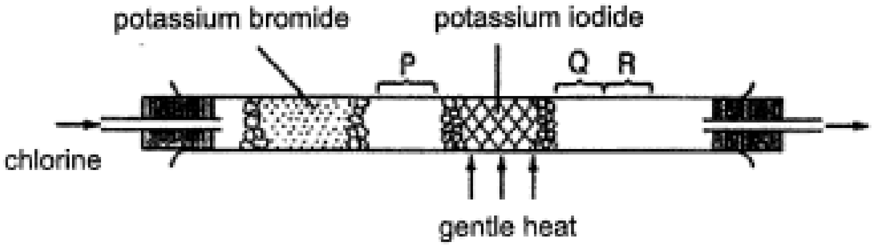
C



D



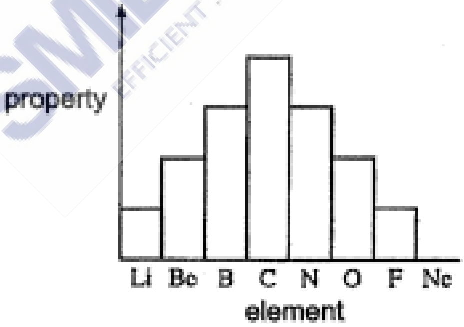
23 Using the apparatus shown, chlorine was passed through the tube. After a short time, coloured substances were at P, Q and R.



Identify the colours expected at P, Q and R.

	P	Q	R
A	yellow-green gas	reddish brown vapour	violet vapour
B	reddish brown vapour	violet vapour	black solid
C	yellow-green gas	violet vapour	black solid
D	reddish brown vapour	black vapour	violet vapour

24 The chart shows a property of elements from lithium to neon.



Which property of these elements is shown on the chart?

A number of electrons used in bonding

B relative atomic mass of the element

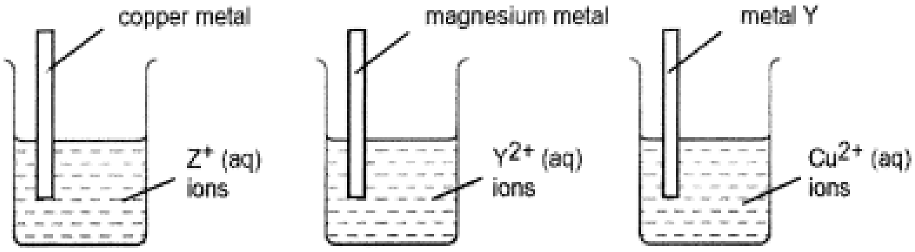
C number of electrons shells in an atom

D number of valence electrons

Refer to the information below for questions **25** and **26**.

Three experiments were conducted 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.



25 How many metals that were investigated will be able to react with aqueous hydrochloric acid?

A 1

B 2

C 3

D 4

26 If a simple cell was set up between two of the metals above, which pair of electrodes will give the largest voltmeter reading?

A magnesium and Z

B copper and Y

C magnesium and copper

D Z and Y

27 A large volume of copper(II) sulfate solution is left in an iron container overnight.

Which statement describes the effect observed in the morning?

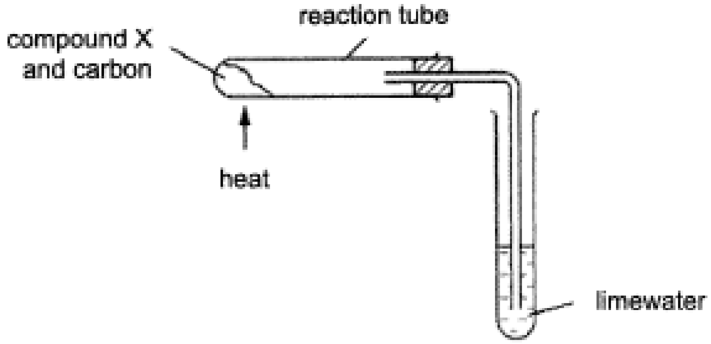
A Atmospheric oxygen reacts with the copper(II) sulfate and crystals are left behind.

B The part of the container in contact with the solution is coated with copper.

C The solution evaporates completely and some copper(II) sulfate crystals are left behind.

D Some fine iron particles are formed in the solution.

28 Compound X is heated with carbon using the apparatus shown.



A brown solid is formed in the reaction tube and a white precipitate forms in limewater.

What is compound X?

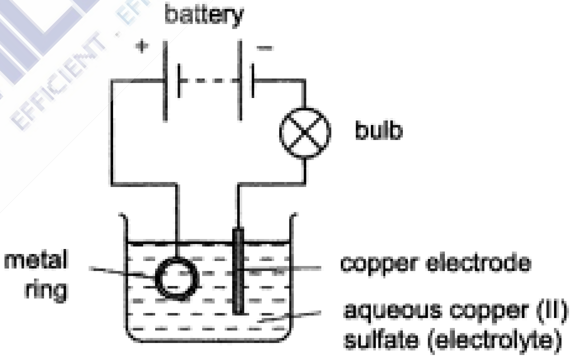
A calcium oxide

B copper(II) oxide

C magnesium oxide

D sodium oxide

29 The diagram shows apparatus used in an attempt to electroplate a metal ring with copper.



The experiment did not work.

Which change is needed to make the experiment work?

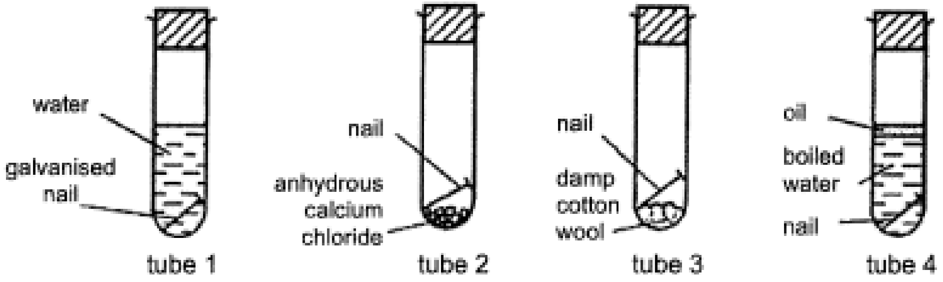
A add solid copper(II) sulfate to the electrolyte

B increase the temperature of the electrolyte

C replace the copper electrode with a carbon electrode.

D reverse the connections to the battery

30 A student set up four test tubes to investigate rusting in iron nails.



After leaving the tubes for a week, which tube(s) would show evidence of rusting?

A 2 only

B 3 only

C 1 and 2 only

D 3 and 4 only

31 Which molecule present in car exhaust fumes is not a pollutant?

A nitrogen monoxide

B sulfur dioxide

C carbon dioxide

D carbon monoxide

32 A catalytic converter is a device used to reduce the emissions from an internal combustion engine used in most modern day vehicles. However, they may also have negative impacts on the environment.

Which of the following describes the negative impact that catalytic convertors cause?

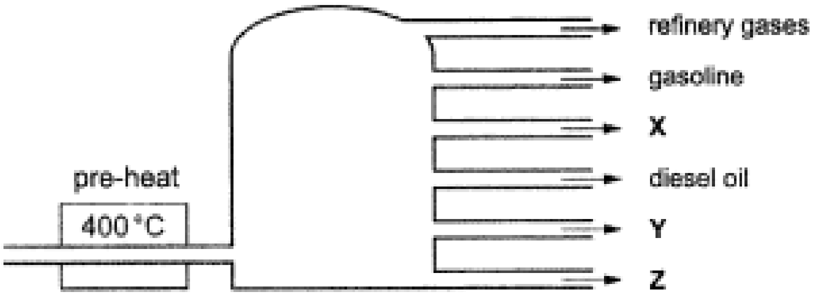
A They contribute to poisonous gases in air that cause breathing difficulties.

B They emit by-products which lead to the depletion of the ozone.

C They increase the amount of carbon particles in the air which leads to smog.

D They contribute the greenhouse gases which leads to global warming.

33 The diagram shows a fractionating column used in the separation of petroleum.



Which row about X, Y and Z are correct?

A Y has higher viscosity than X.

B Y has higher density compared to Z.

C Y has higher average molecular mass compared Z.

D Z has higher flammability compared to X.

34 Which of the following mixtures could not be produced when heptane, C_7H_{16} is cracked?

A propene + butane

B propane + butene

C propane + butane + hydrogen

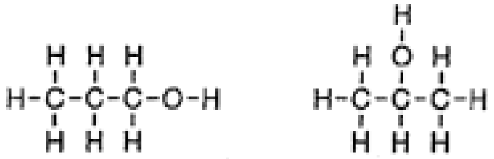
D butene + propene + hydrogen

35 Which pair of compounds are isomers of each other?

A

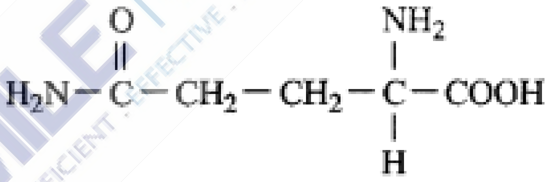
B

C



D

36 The structural formula of the amino acid, glutamine, is shown.



$$\mathrm{H_2N-\overset{\overset{O}{\|}}{C}-CH_2-CH_2-\overset{\overset{NH_2}{|}}{\underset{\underset{H}{|}}{C}}-COOH}$$

Which of the following statements about the amino acid are correct?

1 It undergoes addition polymerisation.
2 It reacts with magnesium to produce hydrogen gas.
3 It forms a polymer with the same linkage as nylon.
4 It decolourises acidified potassium manganate(VII) solution readily.

A 1 and 3

B 1 and 4

C 2 and 3

D 3 and 4

37 The number of C=C bonds in a vegetable oil can be found by reacting the oil with aqueous bromine.

0.02 moles of vegetable oil was found to react completely with 19.2 g of aqueous bromine.

How many C=C bonds are there in one molecule of vegetable oil?

A 2

B 6

C 8

D 12

38 An organic compound M is known to have the following properties.

1 It does not decolourise bromine solution.
2 It does not react with aqueous sodium hydroxide.
3 It does not produce a sweet-smelling substance when warmed with a mixture of ethanoic acid and concentrated sulfuric acid.

What could be the chemical formula of compound M?

A CH=CHCOOH

B $CH_3CH_2CH_2OH$

C CH_2=$CHCOOCH_3$

D $CH_3CH_2CH_2Cl$

39 Which property does **not** change when ethene undergoes polymerisation to form poly(ethene)?

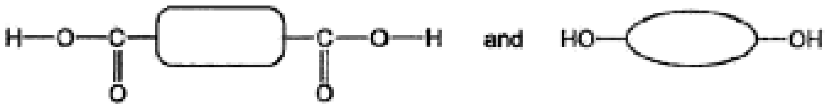
A boiling point

B empirical formula

C molecular mass

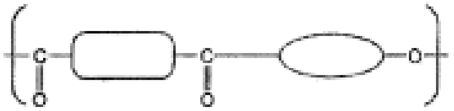
D molecular formula

40 A condensation polymer is made from the two monomers shown.

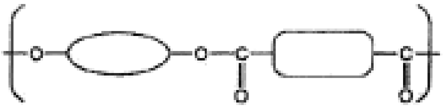


What is the repeat unit of the polymer?

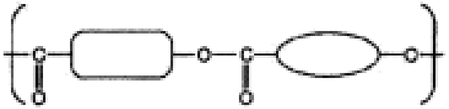
A



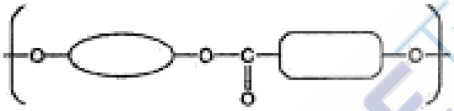
B



C



D



END OF PAPER 1

Section A

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

A1 Fig. 1.1 shows how the outer shell electrons are arranged in a compound.

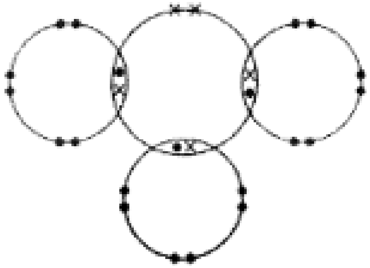


Fig. 1.1

(a) Put a tick (√) in **one** box in each row to show which statement(s) about the compound is/are **true** and which is/are **false**.

	true	**false**
It is a saturated hydrocarbon.		
It could be ammonia.		
It is a halogen compound.		
It is an ionic compound.		

[2]

(b) Draw a similar diagram to show the arrangement of electrons in a molecule of carbon dioxide, CO_2.

You only need to show outer shell electrons.

[2]

[Total: 4]

A2 A small piece of sodium metal is heated until it melts. It is then placed into chlorine gas where sodium burns quickly with a bright intense flame to form solid sodium chloride.

$$2\,Na \quad + \quad Cl_2 \quad \rightarrow \quad 2\,NaCl$$

(a) Explain, in terms of electron transfer, why the reaction is a redox reaction.

....

....

....

....

.... [3]

(b) Predict how sodium would react with fluorine. State all the observations and explain your answer.

....

....

....

.... [2]

(c) Calculate the percentage yield of sodium chloride, if 40 g of sodium produces 65 g of sodium chloride.

percentage yield = ... % [2]

[Total: 7]

A3 Ammonia is produced in the Haber process. The volume of gases in the reaction chamber is monitored throughout the reaction and the results are plotted in the graph shown in Fig. 3.1.

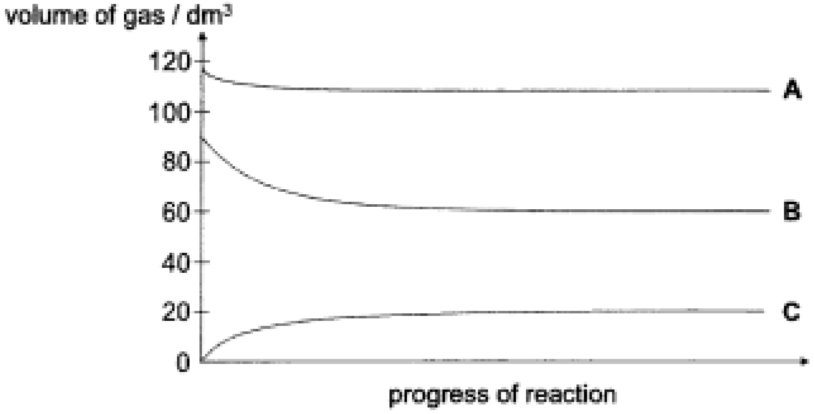


Fig. 3.1

(a) Complete the table below to show the source and method used to obtain hydrogen and nitrogen for Haber process.

	source	method
hydrogen gas		
nitrogen gas		

[2]

(b) Identify the graph (**A**, **B** or **C**) in Fig. 3.1 that represents the following gases in the Haber process.

nitrogen : ....

hydrogen : ....

ammonia: .... [1]

(c) Suggest a reason why Fig. 3.1 shows that the production of ammonia in the Haber process is a reversible reaction.

....

.... [1]

[Total: 4]

A4 Graphene is a 2-dimensional single sheet of carbon atoms arranged in a hexagonal network. Due to graphene's physical and chemical properties, it is a promising new advanced material that has been used in several key applications such as batteries, energy storage, and as catalyst.

Fig. 4.1 shows the structure of a single sheet of graphene.

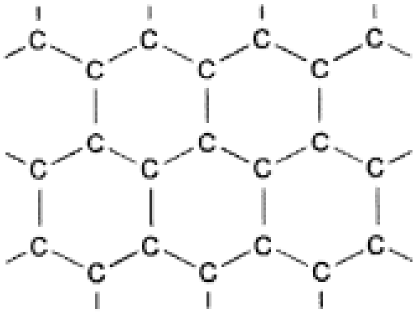


Fig 4.1

(a) Graphene and graphite have similar physical properties.

Give **two** physical properties of graphene that are similar to graphite. Explain, in terms of bonding and structure, why these physical properties are similar.

Property 1 ....

....

....

Property 2 ....

....

.... [3]

(b) Diamond and graphite have very different physical properties.

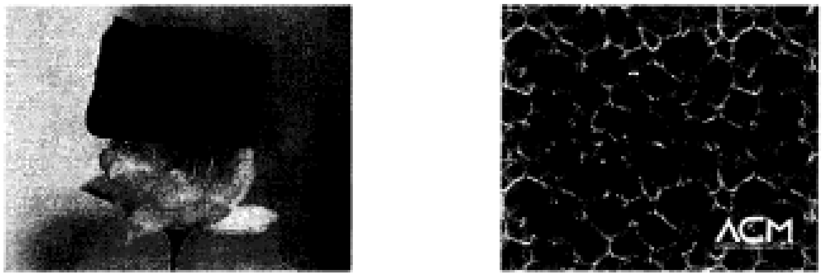
State **one** such physical property and explain why.

....

....

.... [2]

(c) A recent development in graphene chemistry is the creation of graphene sponges. Graphene sponges (shown in Fig. 4.2) are three dimensional foam-like structures that has high surface area at extremely low density.



A piece of graphene sponge placed on a flower.

Microscopic view of the graphene sponge

Fig. 4.2

Because of its foam-like structure, graphene foam is able to capture gases. One possible use of graphene sponges is in flue gas desulfurisation in fossil fuel powerplants. Traditionally, calcium carbonate is used in the process of flue gas desulfurisation.

(i) Explain why calcium carbonate can be used in flue gas desulfurisation.

....

.... [1]

(ii) Describe the environmental impact if flue gas is not desulfurised.

....

.... [1]

[Total: 7]

A5 Group I and Group VII elements show trends in their melting points and boiling points.

	element	melting point / °C	boiling point / °C
Group I	lithium	180	1330
	sodium	97.8	890
	potassium	64	774
Group VII	chlorine	–101	–35
	bromine	–7	59
	iodine	114	184

(a) **(i)** The trends in melting points and boiling points for elements in Group I differ from those of Group VII.

Describe the trends down each group.

....

....

.... [2]

(ii) The melting point and boiling point of sodium is higher than that of chlorine. Use ideas about bonding to explain why.

....

....

....

....

....

.... [3]

(b) The table shows the densities of chlorine and bromine at room temperature and pressure.

element	density / g/cm^3
chlorine	0.03
bromine	3.12

A student makes a comment about the densities.
"The difference in molecular mass of chlorine and bromine is not enough to account for the difference in densities."

(i) Explain why the student is correct.

....

....

.... [2]

(ii) What is the main reason that the densities of chlorine and bromine are so different?

....

.... [1]

(c) All the elements in Group VII are diatomic.

Explain the meaning of the term *diatomic*.

....

.... [1]

[Total: 9]

A6 Some information about four elements, **P**, **Q**, **R** and **S** are shown in Table 6.1.

Table 6.1

Element	**P**	**Q**	**R**	**S**
Density in g/dm³	2.22	8.9	0.9	7.9
Melting point /°C	3720	1083	64	1538
Atomic radius /pm	77	135	203	126
Charge on the ion(s)	Usually 4– and 4+	Usually 1+ and 2+	1+	Usually 2+ and 3+
Colour of the element	Black	Reddish Brown	Silvery	Silver Grey
Formulae and appearance of the chlorides at room temperature	$\mathbf{P}Cl_4$ is a colourless liquid	$\mathbf{Q}Cl$ is a white solid $\mathbf{Q}Cl_2$ is a blue-green solid	$\mathbf{R}Cl$ is a white solid	$\mathbf{S}Cl_2$ is a greenish white solid $\mathbf{S}Cl_3$ is an orange solid

The four elements can be arranged in decreasing order in the reactivity series as such:

R > **P** > **S** > hydrogen > **Q**

(a) Which of the following, **P**, **Q**, **R** and **S** are transition elements?

Using information from Table 6.1, give **two** pieces of evidence to support your answer.

1. ....

....

2. ....

.... [2]

(b) A small piece of element **R** is placed in cold water that had a few drops of Universal Indicator added.

Describe what would be observed and write the balanced chemical equation for the reaction that occurred.

....

....

....

....

.... [3]

(c) Which of the following, **P**, **Q**, **R** or **S** is **not** a metal?

Use evidence from Table 6.1 to support your answer.

....

....

.... [2]

(d) In the construction industry, elements **P** and **S** are found in alloys that are used to make the support pillars for buildings.

(i) Give the meaning of the term *alloy*.

.... [1]

(ii) Draw a labelled diagram showing the arrangement of atoms in an alloy containing **P** and **S**.

[1]

(iii) With reference to the arrangement of atoms drawn in **(d)(ii)**, explain why alloys are used in the construction industry rather than the elements.

....

....

.... [1]

[Total: 10]

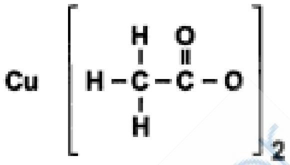
A7 Ethanoic acid is a colourless liquid and organic compound. The global demand for ethanoic acid is about 6.5 million tons per year. While the common use of ethanoic acid at home is as the main component of vinegar, 90% of ethanoic acid produced globally is used as a chemical feedstock to produce ethanoate esters and metal ethanoate salts.

(a) Describe why ethanoic acid is considered a weak acid.

....

.... [1]

All metal ethanoate salts are soluble in water. Copper(II) ethanoate is a dark green crystalline solid and has been used as fungicides and coloured pigments. Fig. 7.1 shows the chemical formula of copper(II) ethanoate.



$$Cu\left[CH_3COO\right]_2$$

Fig. 7.1

Copper(II) ethanoate is commonly prepared industrially using the steps below.

Step 1 – Add an excess of **substance X** to ethanoic acid in a reaction chamber. Heat reaction gently. Open the cover of the reaction chamber to ensure that the pressure within the reaction chamber does not increase due to gas production during the reaction.

Step 2 – When effervescence stops, the reaction mixture is filtered and the filtrate is collected in another container.

(b) Draw a 'dot-and-cross' diagram for the **ethanoate ion** found in copper(II) ethanoate.

Show outer electrons only.

[2]

(c) **(i)** Identify substance X.

.... [1]

(ii) Either evaporation to dryness or crystallisation will produce pure and dry copper(II) ethanoate from the solution obtained in Step 2.

Describe an advantage and a disadvantage evaporation to dryness have over crystallisation.

advantage ....

....

disadvantage ....

.... [2]

Methyl ethanoate is a ethanoate ester with a pleasant smell that is similar to nail polish remover. Commonly used as a solvent, it is highly volatile and flammable.

(d) **(i)** Deduce and draw the structural formula for methyl ethanoate.

[1]

(ii) Explain, in terms of bonding, why copper(II) ethanoate exists as crystals while methyl ethanoate exists as a volatile liquid at room temperature.

....

....

....

.... [2]

[Total: 9]

Section B

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

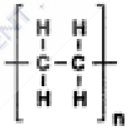
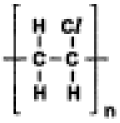
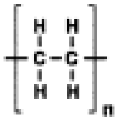
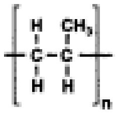
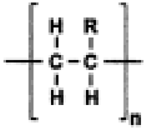
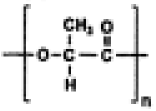
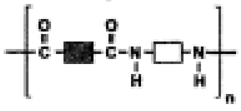
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Plastic Recycling

Plastic recycling is the processing of plastic waste into new and useful products. Although plastic recycling is essential to prevent further harm on our environment, Singapore's recycling rate of plastics in 2021 was only 6%. Each plastic polymer has its own unique chemical structure and properties. In order to ensure the quality and value of the recycled plastic, plastics of different polymer types have to be sorted out before they can be recycled. The Resin Identification Code (RIC) was introduced so that plastic item can be labelled for easier sorting.

Table 8.1 shows the names of the polymers that fall under the 7 different RIC as well as their proportion in global plastic waste. Plastics usually consist of polymer chains of varying lengths. Table 8.1 shows the general range of molar masses of the different plastics.

Table 8.1

RIC	polymer name	chemical structure	molar mass / g/mol	% of all plastic waste
1 PETE	poly(ethylene terephthalate)		8 000 – 31 000	18.8
2 HDPE	high density poly(ethene)		100 000 – 250 000	19.8
3 V	poly(vinyl chloride)		50 000 – 120 000	5.3
4 LDPE	low density poly(ethene)		100 000 – 250 000	13.9
5 PP	poly(propene)		75 000 – 700 000	19.1
6 PS	poly(styrene)	 where **R** represents a hydrocarbon branch	100 000 – 400 000	5.9
7 OTHER	Other plastics (such as polycarbonates, polyamides.	poly(lactic acid)  nylon 	–	17.2

(a) (i) Deduce and draw the structural formula of the monomer(s) of poly(propene).

monomer(s) of poly(propene) [1]

(ii) Explain, in terms of bonding and structure, why the melting point of a polymer is always higher than its monomer(s).

....

....

....

.... [2]

(b) The shortest chain of poly(styrene) consists of 962 repeating units. Elemental analysis of poly(styrene) found that the polymer contains 92.3% of carbon and 7.7% of hydrogen by mass.

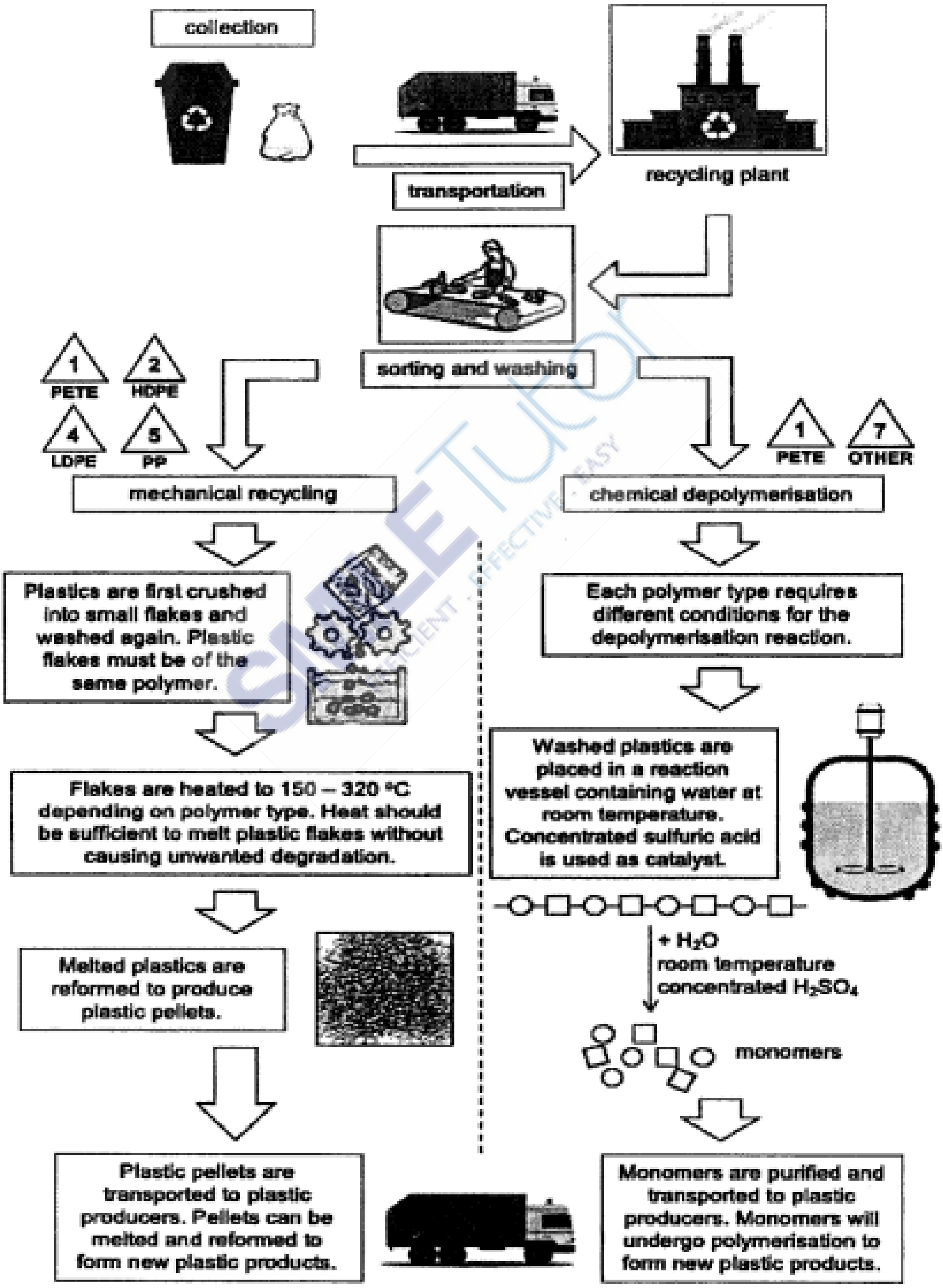
Calculate and deduce the formula of **R** in poly(styrene).

formula of **R**= .... [3]

Mechanical recycling and depolymerisation

There are two methods that are commonly used to recycle plastics. Mechanical recycling is a physical method that melts plastics of the same polymer before making them into small pellets to be used again. Depolymerisation is a chemical method that uses either heat or chemical reactions to convert the polymers back into its monomers. Since each polymer has its own unique chemical properties, machinery and methods are specific to one particular plastic.

Fig. 8.1 shows the journey of plastic trash from recycling bin to becoming a new plastic product.



Plastics are first crushed into small flakes and washed again. Plastic flakes must be of the same polymer.

Flakes are heated to 150 – 320 °C depending on polymer type. Heat should be sufficient to melt plastic flakes without causing unwanted degradation.

Melted plastics are reformed to produce plastic pellets.

Plastic pellets are transported to plastic producers. Pellets can be melted and reformed to form new plastic products.

Each polymer type requires different conditions for the depolymerisation reaction.

Washed plastics are placed in a reaction vessel containing water at room temperature. Concentrated sulfuric acid is used as catalyst.

Monomers are purified and transported to plastic producers. Monomers will undergo polymerisation to form new plastic products.

Fig. 8.1

(c) A student looks at the data in Table 8.1 and Fig. 8.1 and suggests that mechanical recycling can only recycle addition polymers while depolymerisation only recycles condensation polymers.

Do you agree with the student? Use the data to support your answer.

....

.... [1]

(d) Most recycling companies find that it is more cost-effective to develop mechanical recycling methods as compared to depolymerisation recycling methods.

By referring to Table 8.1 and/or Fig. 8.1, suggest a reason why this is so.

....

.... [1]

(e) Based on Fig. 8.1, give **two** reasons why recycling plastic is **not** entirely environmentally friendly.

1. ....

....

2. ....

.... [2]

(f) Fig. 8.2 shows how poly(lactic acid) is depolymerised to form its monomer.

Fig. 8.2

Is poly(lactic acid) a condensation polymer or addition polymer? Give **two** evidence from Fig. 8.2 that supports your answer.

....

....

.... [2]

[Total: 12]

B9 An experiment is carried out to electrolyse dilute aqueous sodium chloride.

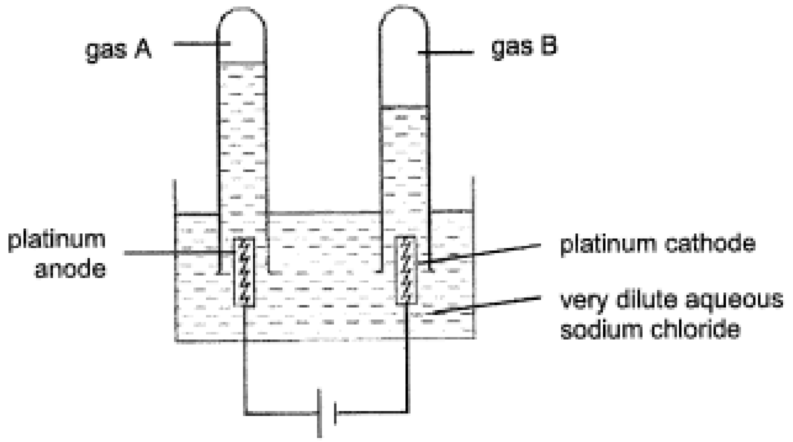


Fig. 9.1

(a) **(i)** Identify all the ions present in the solution.

.... [1]

(ii) Write an ionic equation for each reaction that happens at the anode and cathode.

anode: ....

cathode: .... [2]

(iii) Describe a simple test and its result that would identify the gas given off at the anode.

....

....

.... [2]

(b) After the electrolysis has been running for some time, the solution becomes more concentrated.

What are the products of the electrolysis when the solution becomes concentrated? Give your reasoning.

....

....

....

....

.... [3]

[Total: 8]

EITHER

B10 Fig. 10.1 shows the volume of gas produced with time for four experiments **1 to 4** where a metal carbonate, **MCO_3** is reacted with different concentrations and volumes of hydrochloric acid.

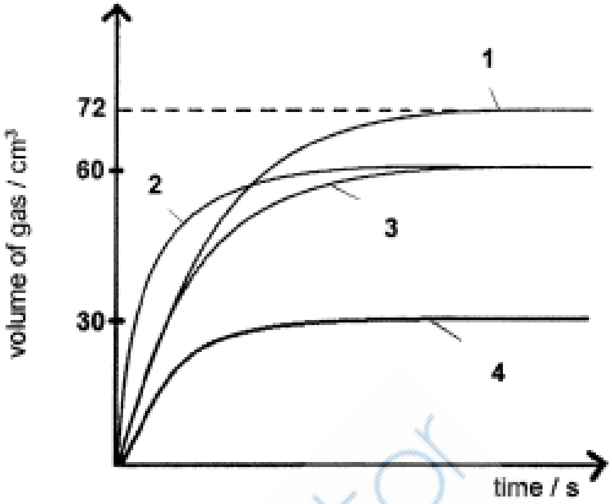


Fig. 10.1

(a) Give the identity of the gas produced in the experiments.

.... [1]

(b) With reference to Fig. 10.1, complete the table below.

experiment number	**concentration of acid in mol/dm³**	**volume of acid /cm³**
	0.125	20
	0.200	30
	0.250	
3	0.200	

[3]

(c) **M** forms an ion with a 2+ charge in the reaction between the metal carbonate and hydrochloric acid. The mass of $\mathbf{MCO_3}$ used in each experiment is 0.375 g.
The chemical equation of the reaction is as shown below.

$$MCO_3 + 2\,HCl \rightarrow MCl_2 + CO_2 + H_2O$$

(i) Only experiment **1** has no excess of either reactants at the end of the reaction, while the rest of the experiments (**2**, **3**, **4**) have an excess of metal carbonate $\mathbf{MCO_3}$.

Calculate the number of moles of hydrochloric acid used in experiment **1**.

number of moles = ………………………………… mol [1]

(ii) Hence or otherwise, calculate the relative molecular mass of **M** and identify metal **M**.

identity of metal **M** is ………………………………… [3]

(d) Using ideas on collisions between particles, explain why the speed of reaction in experiment **2** is faster than experiment **3**.

……

……

………………………………………………………………………………………………… [2]

[Total: 10]

OR

B10 Displacement reactions can be used for the extraction of metals.

In the 19th century, Frederich Wohler obtained aluminium metal by reacting potassium with aluminium chloride at a high temperature to form potassium chloride and aluminium. Wohler also observed that the temperature increased during the reaction.

$$AlCl_3 \quad + \quad 3\,K \quad \rightarrow \quad Al \quad + \quad 3\,KCl$$

(a) **(i)** Write an ionic equation for the reaction.

.... [1]

(ii) Explain, using oxidation states, which substance is reduced.

....

....

....

.... [2]

(iii) Determine the mass of aluminium chloride needed to produce 0.81 kg of aluminium metal.

mass of aluminium chloride .... g [2]

(b) **(i)** Is the reaction between potassium and aluminium chloride exothermic or endothermic? Give a reason to support your answer.

....

.... [1]

(ii) Draw the energy profile diagram for this reaction.

Your diagram should include

- labels for the reaction enthalpy change,
- activation energy, and
- formulae of reactants and products.

[3]

(c) Beryllium is less reactive than potassium and more reactive than aluminium.

Deduce whether Wohler's technique can be used to obtain beryllium from beryllium chloride. Suggest one reason why.

....

.... [1]

[Total: 10]

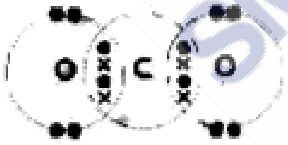
ANSWER SHEET

Paper 1 (40 marks)

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

A – 11, B – 10, C – 11, D – 8

Paper 2
Section A (50 marks)

<table>
<tr><td>A1(a)</td><td>
<table>
<tr><th></th><th>true</th><th>false</th></tr>
<tr><td>It is a saturated hydrocarbon.</td><td></td><td>√</td></tr>
<tr><td>It could be ammonia.</td><td></td><td>√</td></tr>
<tr><td>It is a halogen compound.</td><td>√</td><td></td></tr>
<tr><td>It is an ionic compound.</td><td></td><td>√</td></tr>
</table>
4 pt → 2m, 3 - 2 pt → 1 m, 1 – 0 → 0m
</td><td>2</td></tr>
<tr><td>(b)</td><td>


carbon dioxide, CO_2
correct number of sharing electrons in carbon;
correct number of sharing electrons in oxygen;
</td><td>2</td></tr>
<tr><td></td><td></td><td>[Total: 4]</td></tr>
<tr><td>A2(a)</td><td>Sodium is <u>oxidized</u> as it <u>loses an electron</u> to form sodium ion, Na^+
Chlorine is <u>reduced</u> as it <u>gains an electron</u> to form chloride ion, Cl^-
Since oxidation and reduction occurs <u>concurrently/simultaneously/at the same time</u>,
Hence it is a redox reaction</td><td>1
1
1</td></tr>
<tr><td>(b)</td><td>Sodium will explode into flames/When placed into fluorine gas to form a white solid of sodium fluoride (observation should be more vigorous than what is given in question stem, reject bubble form)
Fluorine is above chlorine in Group VII and hence <u>more reactive</u>;</td><td>1
1</td></tr>
</table>

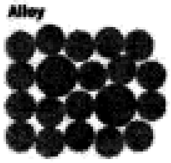
(c)	Mole of sodium = 40/23 = 1.7391 mol Mole ratio of Na: NaCl = 1: 1 Mass of sodium chloride produced = 1.7391 X 58.5 = 101.74 g %yield = 65/101.74 x 100 = 63.9%	 1 1
		[Total: 7]
A3(a)	(table below)	2

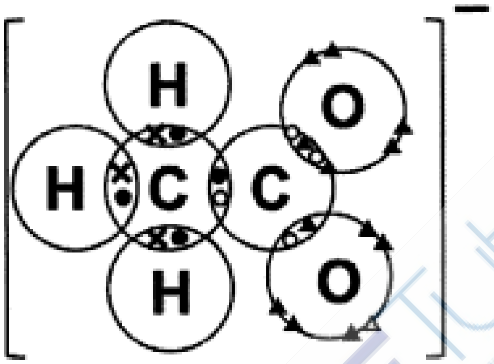
	source	method
hydrogen gas	Crude oil	cracking
nitrogen gas	liquid air	Fractional distillation

(b)	nitrogen: A hydrogen: B ammonia: C	1
(c)	reactants are not fully reacted even when reaction has stopped. (reject: reaction does not complete)	1
		[Total: 4]
A4(a)	high melting point or strong (reject. hard, strength and hardness is different) - 1 strong covalent bonds between carbon atoms -2 require a lot of energy to break -3 electrical conductor -4 one carbon atom bonded to three other carbon atoms/ 3 valence electrons in carbon used in bonding 1 valence electron in each carbon not involved in bonding/delocalised -5 mobile electron present -6 6 – 5 points → 3 m, 4 – 3 pt → 2m, 2 pt → 1 m, 1 – 0 pt → 0m (reject: soft / slippery, there is only one layer in graphene)	3
(b)	(table below)	1

hard	cannot conduct electricity
strong covalent bonds between carbon atoms require a lot of energy to break	all valence electrons used in bonding no mobile electrons/charged particles present (if part (a) did not mention)

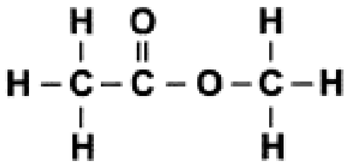
	as compared to the weak intermolecular forces of attraction between graphite layers. 1 valence electron in each carbon not involved in bonding/delocalised mobile electron present	1
(c) (i)	sulfur dioxide is an acidic oxide and will react with the calcium carbonate. (not a marking point but students are reminded that this is not a neutralisation reaction and calcium carbonate is not a base)	1
(c) (ii)	sulfur dioxide causes • respiratory problems OR • lead to the formation of 'acid rain' which harms aquatic life and corrodes metal and stone structures ecf if (c)(i) mentions a different pollutant	1
		[Total: 7]
A5 (a)(i)	In group I, melting point and boiling point decreases down the group. In group VII, melting point and boiling point increases down the group.	1 1
(a)(ii)	Students need to be clearer with the different bonding present in different substances. Common mistakes include 1) not knowing the particles found in each structures (e.g. mistaking atoms with molecules, atoms with ions). 2) Students must also remember that forces are overcome and bonds are broken. Sodium is a metal with strong electrostatic force of attraction/metallic bond between the cations and the sea of electrons. Whereas, chlorine exists as diatomic molecules with weak intermolecular forces of attraction between the molecules. Hence, lots of energy required to overcome the strong electrostatic forces of attraction in sodium. Hence higher melting point. Little energy needed to overcome weak intermolecular forces of attraction in chlorine gas. Hence low melting point.	1 1 1
(b)(i)	Students answered this question badly. Many students did not answer the question which should involve students explaining why the difference in molecular mass does not account for the difference in density. Many students instead explain what should account for density without accounting for the molecular mass. The molecular mass of chlorine is 71 and the molecular mass of bromine is 160. Even though bromine is slightly more than twice the mass of chlorine, but the density of bromine is at least a 100 times that of chlorine. (show the difference in density is much larger than the difference in molecular mass)	1 1

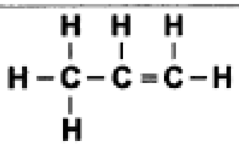
	Accept: volume needs to be considered as well (1 m)	
(ii)	Chlorine is a <u>gas</u> and bromine is a <u>liquid</u> at room temperature. Reject: students mention states without specifying	1
(c)	Question is badly done. While we accepted a range of answers, the definition of diatomic should be as follows. Diatomic means molecules with <u>two atoms covalently bonded</u> together. Accept: students answer must include both concept of two atoms and being bonded.	1
		[Total: 9]
A6(a)	Students must remember that evidence from the data provided should be given clearly. Transition elements are Q (1) and S(2) - variable oxidation states (3) - formed coloured compounds (4) 4 pt → 2m, 3 - 2 pt → 1 m	2
(b)	Bubbles of gas produced/gas extinguishes burning splint with pop sound Colour of water changes from green to dark blue/purple. Remind students that Group I alkali should turn universal indicator purple $2R + 2H_2O \longrightarrow 2ROH + H_2$	1 1 1
(c)	P because it forms a chloride that is a liquid at room temperature/low melting point The chloride is a covalent compound/simple molecule hence P is a non-metal **OR** **P** is from Group IV Q,R,S are from Group I and II which are all metals Reject: if students explain that P is a non-metal because the rest are metals. **OR** **P** is black in colour Metals are usually grey/shiny	1 1
(d)	This question was surprisingly badly done. disappointing Alloy is a mixture of a metal with another element.	1
(ii)	 must be labelled, P must be smaller than S,	1

<table>
<tr><td></td><td>Can only have two sizes of particles
Quantity does not matter.</td><td></td></tr>
<tr><td>(iii)</td><td>disruption of the regular arrangement of layers of atoms makes it hard for the layers to slide hence making alloys harder and stronger</td><td>1</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>[TOTAL:10]</td></tr>
<tr><td>A7(a)</td><td>dissociates/ionises (reject: dissolves) partially in water forming hydrogen ions and ethanoate ions</td><td>1</td></tr>
<tr><td>(b)</td><td>Students either forget that atoms form bonds to form a complete valence shell of electrons or they forget that they are drawing an ion and forget to include the charge

1m for charge, 1m for dot and cross (accept even if symbols for electrons are the same)</td><td>2</td></tr>
<tr><td>(c)(i)</td><td>copper carbonate/copper(II) carbonate (reject: copper oxide as gas is produced)

Students did not read the passage carefully to realise that substance X has to react with an acid to produce a gas. There are also many students who wrote names of salts showing their lack of understanding of acid reactions.</td><td>1</td></tr>
<tr><td>(ii)</td><td>Many students are unfamiliar with the evaporation to dryness procedure. Many students think that evaporation to dryness does not need heat.

Some students did not understand the phrasing of the question and described the advantages of crystallisation over evaporation to dryness.
<table>
<tr><th>advantage</th><th>disadvantage</th></tr>
<tr><td>- higher yield of solute / crystallisation does not crystallise all solute
- faster
- with heat, will be dryer</td><td>- heat sensitive compounds will decompose/solute might decompose
- impurities in the solution will also be obtained
- solute obtained is less pure</td></tr>
</table></td><td>2</td></tr>
</table>

(d)(i)	 Students need to learn the condensation reaction to form esters better.	1
(ii)	copper(II) ethanoate has strong electrostatic forces of attraction (a) methyl ethanoate has weak intermolecular forces of attraction (b) more energy required to overcome All – 2m, (a) or (b) – 1m	2
		[Total: 9]

<table>
<tr><td colspan="2">Section B (30 marks)</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>B8(a)</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>Macromolecule (polymer) has a higher molar mass/relative molecular mass than the monomer
stronger intermolecular forces between polymer molecules
more energy required to overcome the forces between polymer molecules</td><td>1
1</td></tr>
<tr><td>(b)</td><td>Mr of repeating unit - 100 000 / 962 = 103.95
<table>
<tr><td>element</td><td>C</td><td>H</td></tr>
<tr><td>%composition</td><td>92.3</td><td>7.7</td></tr>
<tr><td>Ar</td><td>12</td><td>1</td></tr>
<tr><td>mole</td><td>92.3/12 = 7.691</td><td>7.7 / 1 = 7.7</td></tr>
<tr><td>ratio</td><td>1</td><td>1</td></tr>
</table>
Empirical formula CH
Molecular formula of repeating unit
103.95 / 13 = 8 (C_8H_8)
R – C_6H_5</td><td>1
1
1</td></tr>
<tr><td>(c)</td><td>Disagree, PETE is a condensation polymer so mechanical recycling can recycle condensation polymers.
OR</td><td>1</td></tr>
</table>

	Agree, PETE and polymers under others are condensation polymers can be recycled using chemical depolymerisation	
(d)	mechanical recycling recycles more types of plastics as compared to chemical depolymerisation OR mechanical recycling recycles a higher percentage of plastic waste as compared to chemical depolymerisation	1
(e)	- transportation requires fossil fuels to be burnt - mechanical recycling requires plastic to be heated and that requires fossil fuels to be burnt to provide the energy - Chemical depolymerisation requires concentrated sulfuric acid which will harm the environment when released. - Washing of the plastic requires water to be used which will deplete the world's water supply	2
(f)	condensation polymerisation - Monomer has a higher molar mass than the repeating unit - monomers are joined together by an ester linkage - when monomers combine to form the polymer, a small molecule of water is released. - when polymer is broken down to the monomer, a small molecule of water is added. ANY TWO	2
		[Total: 12]
B9 (a)(i)	Hydrogen, hydroxide, sodium and chloride ion OR H^+, OH- , Na^+, Cl^-	1
(ii)	Anode: 4OH- $\rightarrow O_2 + 2H_2O$ + 4e- Cathode: $2H^+ + 2e^- \rightarrow H_2$	1 1
(iii)	Place a glowing splint at the gas; Splint relights	1 1
(b)	At cathode, hydrogen gas is produced, as sodium ion (reject: sodium) cannot be discharged. At anode, chlorine gas is produced. When solution is concentrated sodium chloride, chloride ions are preferentially discharged over hydroxide ions.	1 1 1
		[Total: 8]
Either		
B10 (a)	carbon dioxide	1

<table>
<tr><td>(b)</td><td>
<table>
<tr><th>experiment</th><th>concentration of acid in mol/dm³</th><th>volume of acid /cm³</th></tr>
<tr><td>4</td><td>0.125</td><td>20</td></tr>
<tr><td>1</td><td>0.200</td><td>30</td></tr>
<tr><td>2</td><td>0.250</td><td>20</td></tr>
<tr><td>3</td><td>0.200</td><td>25</td></tr>
</table>
5 points → 3 m, 4 pt → 2m, 3 - 2 pt → 1 m, 1 pt → 0 m</td><td>3</td></tr>
<tr><td>(c)</td><td>(i) No. of moles of HCl = 0.200 x 0.03 = 0.006 mol

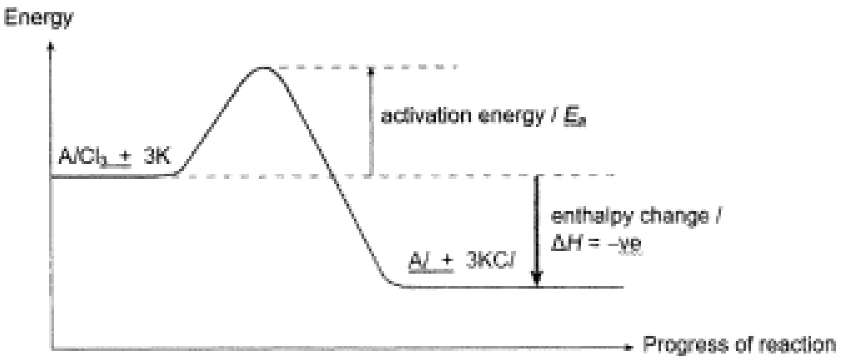
(ii)
Mole ratio HCl:MCO₃ is 2:1
No. of moles of MCO₃ = 0.003
Molar mass of MCO₃ = 0.375/0.003 = 125 g/mol
Atomic mass of M = 125 – M_r CO₃ = 125 – 60 = 65

OR
Mole ratio CO₂:MCO₃ is 1:1
No. of moles of MCO₃ = 0.003
Molar mass of MCO₃ = 0.375/0.003 = 125 g/mol
Atomic mass of M = 125 – M_r CO₃ = 125 – 60 = 65

Hence M is Zinc</td><td>1

1
1
1</td></tr>
<tr><td>(d)</td><td>When there is an increase of concentration of acid,
There is <u>greater number of reacting particles per unit volume.</u>
<u>Hence higher frequency of effective collisions</u> and higher speed of reaction.</td><td>
1
1</td></tr>
<tr><td></td><td colspan="2">[Total: 10]</td></tr>
</table>

Or		
B10 (a)(i)	3K(s) + $Al^{3+}(l)$ → 3K⁺(l) + Al(s)	1
(ii)	Aluminium is reduced as its oxidation state of +3 in Al^{3+} ions decreased to 0 in Al atoms 1m – decrease 1m – oxidation states	2
(iii)	M_r of $AlCl_3$ = 27 + 3(35.5) = 133.5 From equation, no of moles of $AlCl_3$ = no. of moles of Al = 810/27 = <u>30 mol</u> Mass of aluminium chloride = 30 x 133.5 = <u>4000 g</u> Award 1 m if never convert kg to grams.	 1 1
(b)(i)	(i) reaction is exothermic as temperature increased during the reaction.	1

(b)(ii)	 ecf from (c)(i) 1 m – correct labels for Ea and enthalpy change 1 m – exothermic graph 1 m – correct labels from reactant and products	**3**
(c)	Yes. Since beryllium is less reactive than potassium, potassium can displace beryllium out beryllium chloride. Reject: 'IT' can displace beryllium	**1**
		[Total: 10]

GREENDALE SECONDARY SCHOOL PRELIM PAPER

1 A student put exactly 25.0 cm^3 of dilute hydrochloric acid into a conical flask.

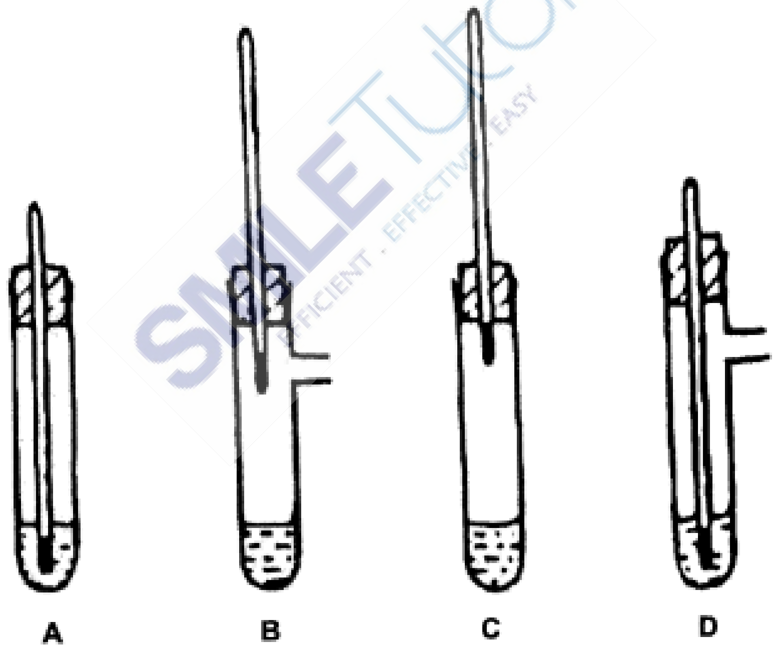
The student added 2.5 g of solid sodium carbonate and measured the change in temperature of the mixture.

Which apparatus does the student need to use?

A balance, measuring cylinder, thermometer
B balance, pipette, stopwatch
C balance, pipette, thermometer
D burette, pipette, thermometer

2 The tubes shown all contain a dilute solution of a solid X dissolved into a liquid Y.

Which apparatus is most suitable for finding the boiling point of liquid Y?



3 Which description of brass are correct?

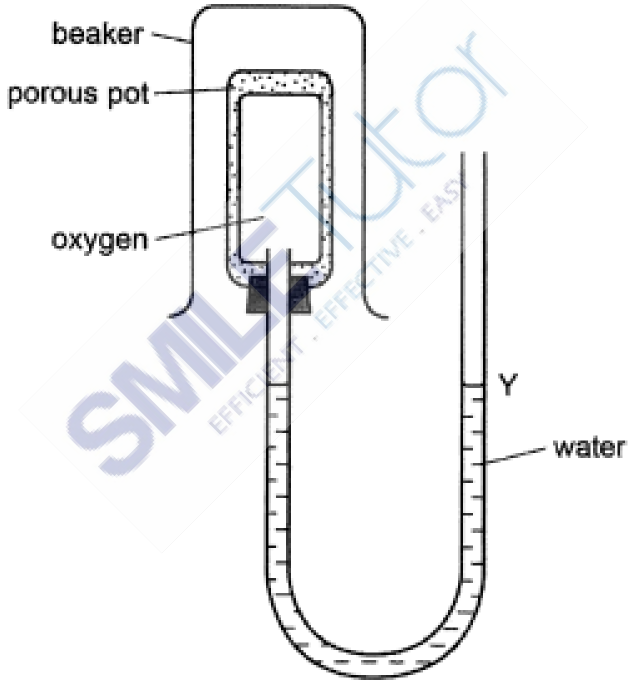
1 It is an alloy.
2 It is a mixture.
3 It is a non-metal.

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

4 Which one of the following correctly describes the particles in a dilute sugar solution at room temperature?

	sugar molecules	water molecules
A	widely separated, moving at random	close together, moving at random
B	widely separated, moving at random	close together, not moving
C	close together, moving at random	widely separated, moving at random
D	close together, vibrating slightly	close together, moving at random

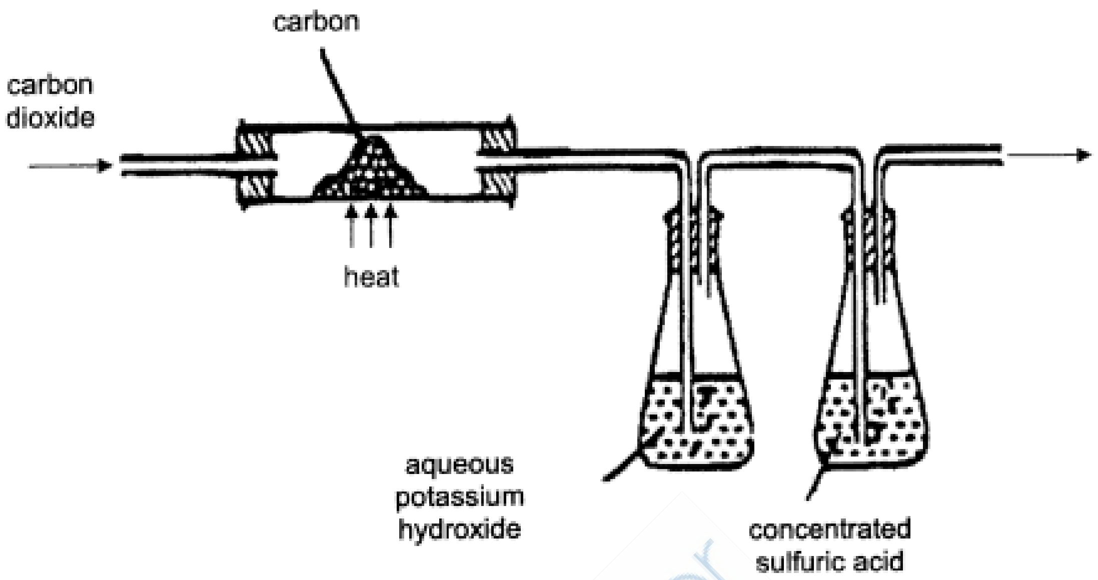
5 The diagram shows a diffusion experiment.



Which gas, when present in the beaker over the porous pot, will cause water level at Y to initially rise?

A CO_2 **B** Cl_2
C CH_4 **D** NO_2

6 The apparatus shown is used to prepare carbon monoxide.



What is the purpose of the aqueous potassium hydroxide?

A to absorb any oxygen formed
B to cool the carbon monoxide
C to dry carbon monoxide
D to remove traces of carbon dioxide

7 A bottle of copper(II) oxide has been contaminated with some solid sodium chloride.

How can the sodium chloride be removed from the copper(II) oxide?

A Place the mixture in a separating funnel.
B Heat the mixture and allow it to cool.
C Add aqueous silver nitrate to the mixture and filter.
D Add water to the mixture and filter.

8 A particle consists of three electrons, four protons and five neutrons.

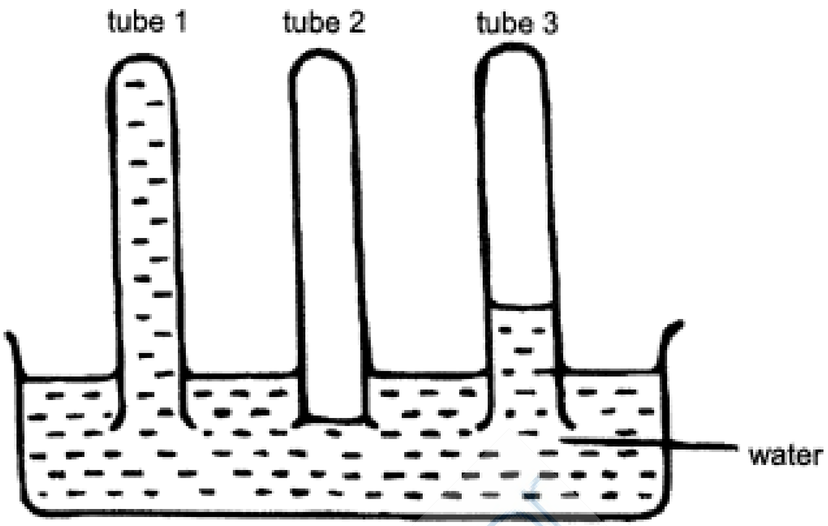
Which of the statement about the particle are correct?

1 The particle has an atomic number of 3.
2 The particle has a mass number of 7.
3 The particle has a charge of 1+.

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

9 Three dry test-tubes were filled with different gases and placed in a trough of water.

After a short time, the water had risen in two of the tubes as shown.



Which gases could the tubes have contained?

	tube 1	tube 2	tube 3
A	ammonia	carbon dioxide	hydrogen
B	ammonia	hydrogen	carbon dioxide
C	carbon dioxide	ammonia	oxygen
D	oxygen	ammonia	carbon dioxide

10 The elements T, X and Y have consecutive, increasing atomic numbers.

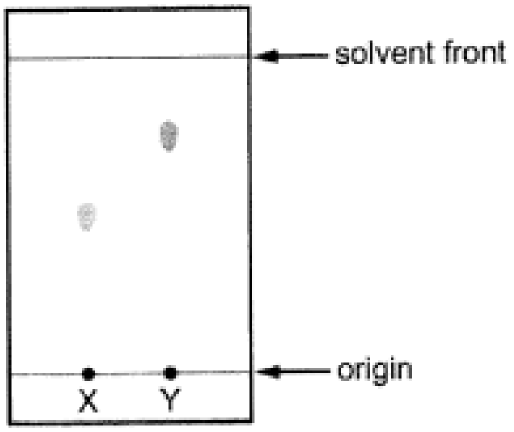
If element T is a noble gas, what will be the symbol for the ion of element Y in its compounds?

A Y^+ **B** Y^{2+} **C** Y^{2-} **D** Y^-

11 What are the different forms for the same element in the same physical state called?

A allotropes **B** isomers **C** isotopes **D** polymers

12 The results of a paper chromatography experiment are shown.



X is an aqueous solution of a salt of a Group I element.

Y is an aqueous solution of a salt of a transition element.

Which row is correct?

	larger R_f value	requires a locating agent
A	X	X
B	X	Y
C	Y	X
D	Y	Y

13 Hydrogen gas is produced when sodium is added to water.

What is the volume of hydrogen gas, measured at r.t.p., produced when 18.4 g of sodium reacts with excess water?

A 9.6 dm^3 **B** 15.0 dm^3 **C** 19.2 dm^3 **D** 30.0 dm^3

14 Iron can be electroplated with zinc to make it resistant to corrosion.

Which row about electroplating iron with zinc is correct?

	positive electrode	negative electrode	electrolyte
A	iron	zinc	iron(II) nitrate
B	iron	zinc	zinc nitrate
C	zinc	iron	iron(II) nitrate
D	zinc	iron	zinc nitrate

15 Element P has an electronic configuration of 2.8.6.

Element R has an electronic configuration of 2.8.8.1.

What is likely to form if P and R combine?

A a covalent compound RP
B a covalent compound R_2P
C an ionic compound RP
D an ionic compound R_2P

16 One mole of compound Q gives three moles of ions in aqueous solution. Q reacts with ammonium carbonate to give an acidic gas.

What is compound Q?

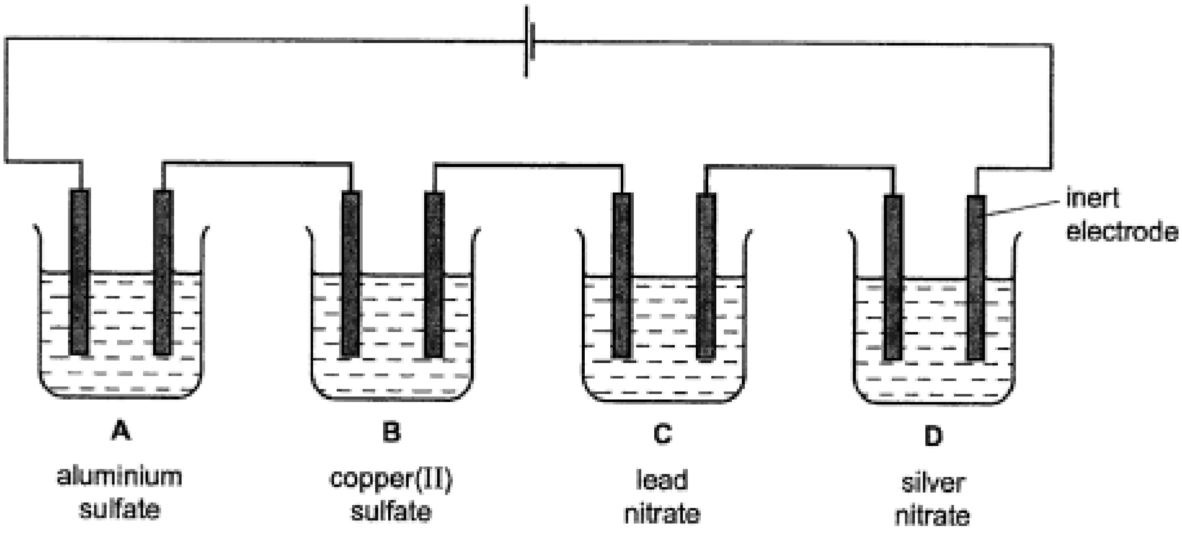
A calcium hydroxide
B nitric acid
C sodium hydroxide
D sulfuric acid

17 124 g of phosphorus vapour has the same volume as 71 g of chlorine gas at the same temperature and pressure.

What is the formula of a molecule of phosphorus?

A P_8 **B** P_4 **C** P_2 **D** P

18 When electrolysed using inert electrodes, which dilute solution would produce the greatest increase in mass of the negative electrode?
[A_r: Al, 27; Cu, 64; Pb, 207; Ag, 108]



19 Which of the following involves the largest number of electrons for complete discharge during electrolysis?

A 5 moles of OH^- ions
B 6 moles of Cu^{2+} ions
C 7 moles of O^{2-} ions
D 12 moles of Na^+ ions

20 High carbon steel is used in manufacturing processes.

Which properties does high carbon steel have?

1 It is brittle.
2 It is malleable.
3 It is soft.
4 It is strong.

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

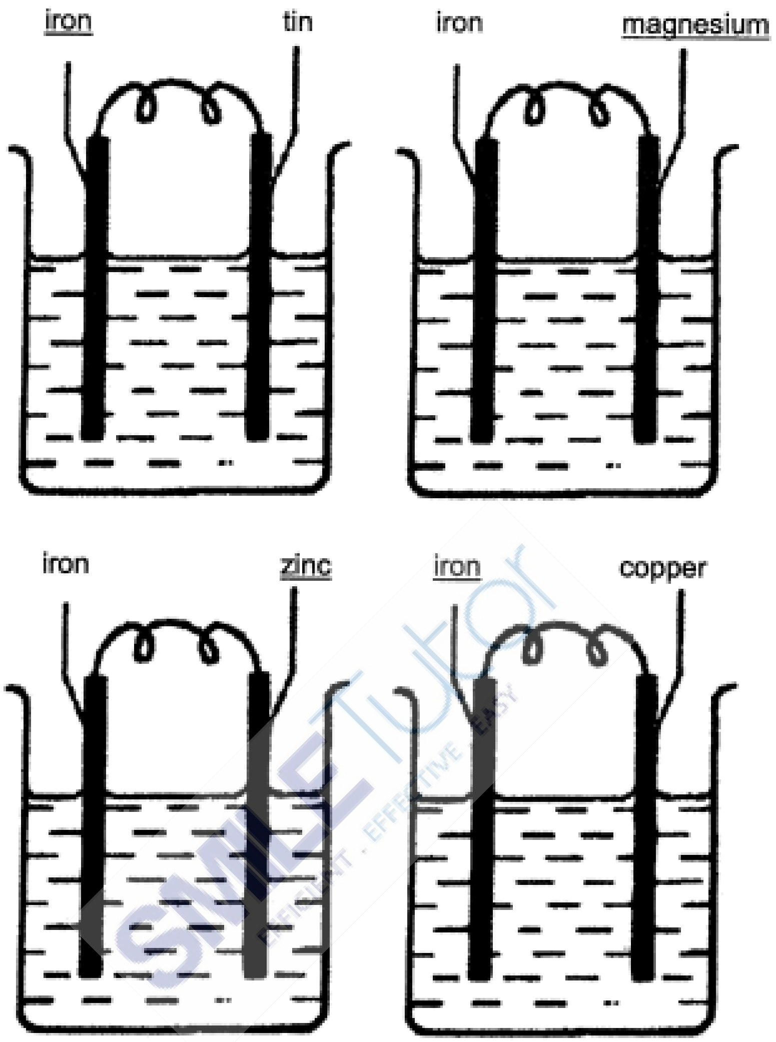
21 The table shows the energy released by the complete combustion of some compounds used as fuel.

compound	M_r	ΔH in kJ/mol
methane	16	– 880
ethanol	46	– 1380
propane	44	– 2200
heptane	100	– 4800

Which fuel produces the most energy when 1 g of the compound is completely burned?

A ethanol
B heptane
C methane
D propane

22 Four cells were set up using aqueous sodium chloride as the electrolyte.



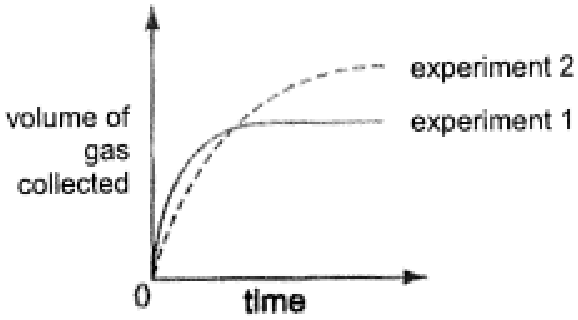
In each cell, only the underlined electrode dissolved. To establish the order of reactivity of the metals, it is necessary to set up two or more cells.

Which of the following pairs of cells are needed in addition to the four cells above?

	first cell electrodes	second cell electrodes
A	tin/copper	magnesium/zinc
B	tin/magnesium	zinc/copper
C	tin/zinc	magnesium/copper
D	tin/zinc	zinc/copper

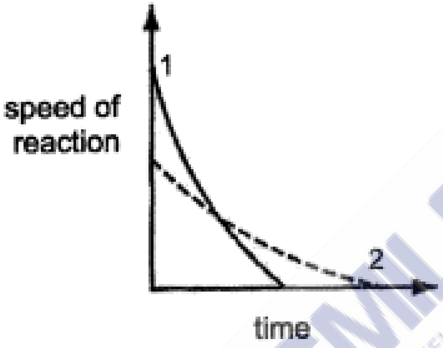
23 In two separate experiments, a substance was decomposed and the gas evolved was collected.

The graph shows the total volume of gas collected against time for each experiment.

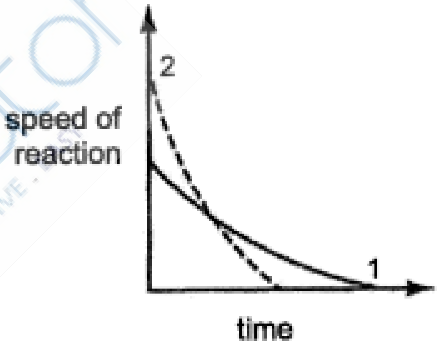


Which graph shows how the speed of reaction varied with time in each experiment?

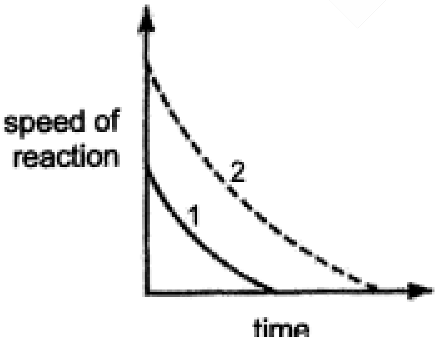
A



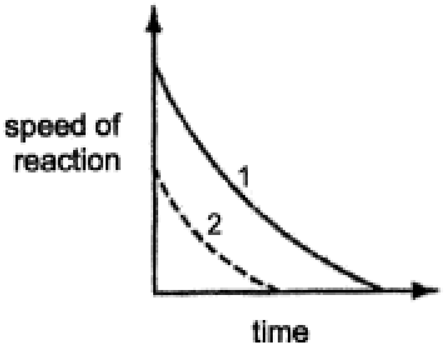
B



C



D



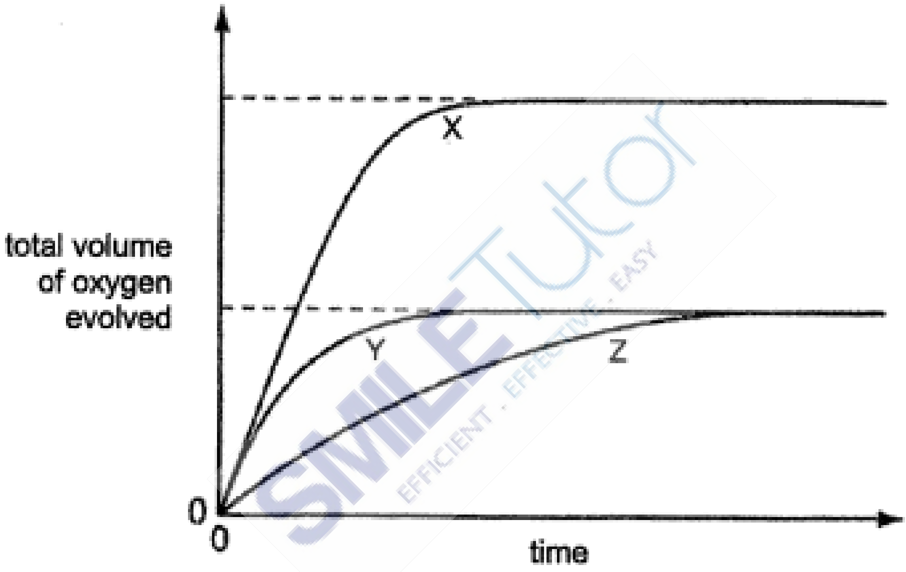
24 The hydrogen peroxide solution is catalytically decomposed by manganese(IV) oxide.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

To study the effect of the concentration of the solutions on the rate of reaction, the total volume of oxygen evolved was recorded against time.

Three experiments were performed using a fixed mass of catalyst but with

(i) 50 cm^3 of 2.0 mol/ dm^3 hydrogen peroxide.
(ii) 100 cm^3 of 1.0 mol/ dm^3 of hydrogen peroxide.
(iii) 100 cm^3 of 2.0 mol/dm^3 of hydrogen peroxide.



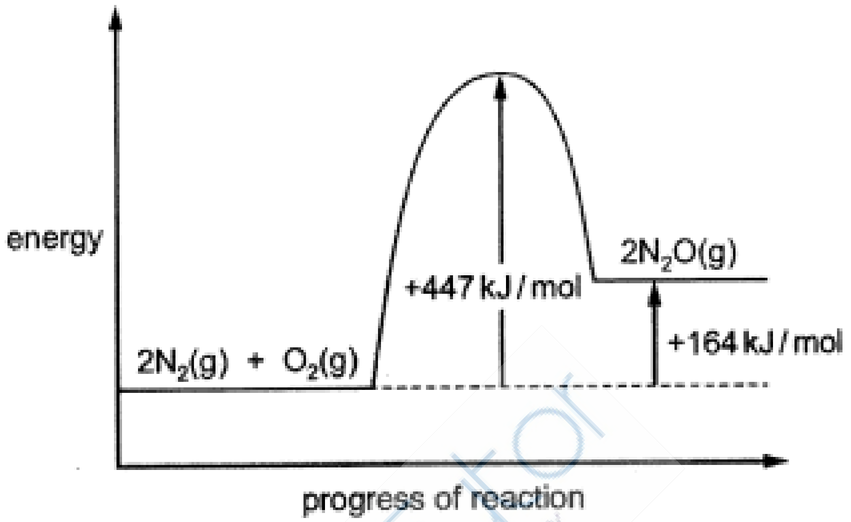
On the graph above, which of the curves, X, Y and Z relate to the solutions (i), (ii) and (iii)?

	(i)	(ii)	(iii)
A	X	Y	Z
B	X	Z	Y
C	Z	X	Y
D	Y	Z	X

25 Under certain conditions nitrogen reacts with oxygen to form dinitrogen monoxide.

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$$

The energy profile diagram for the reaction is shown.



What is the activation energy for the reverse reaction?

A – 447 kJ/mol
B – 283 kJ/mol
C + 141.5 kJ/mol
D + 283 kJ/mol

26 The formation of liquid water from hydrogen and oxygen is thought to occur in three stages.

1 $2H_2(g) + O_2(g) \rightarrow 4H(g) + 2O(g)$
2 $4H(g) + 2O(g) \rightarrow 2H_2O(g)$
3 $2H_2O(g) \rightarrow 2H_2O(l)$

Which stages would be exothermic?

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

27 Iron is extracted from iron ore in a blast furnace.

Which substances are fed into the top of the blast furnace?

1 coke
2 limestone
3 hot air

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

28 Which noble gas is present in the largest percentage by volume in air?

A argon
B helium
C krypton
D neon

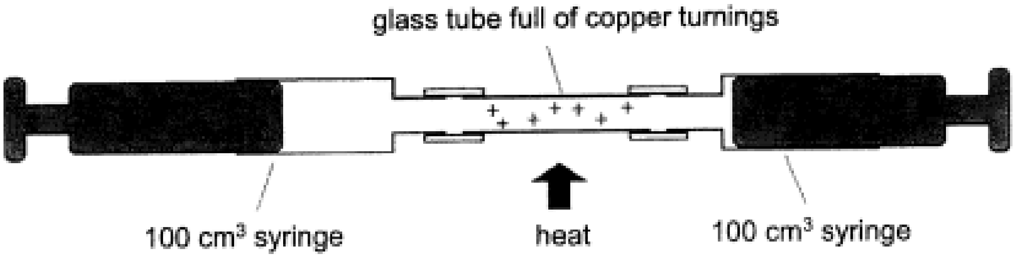
29 Which gas can be removed from the exhaust gases of a petrol-powered car by its catalytic converter?

A carbon monoxide
B carbon dioxide
C nitrogen
D steam

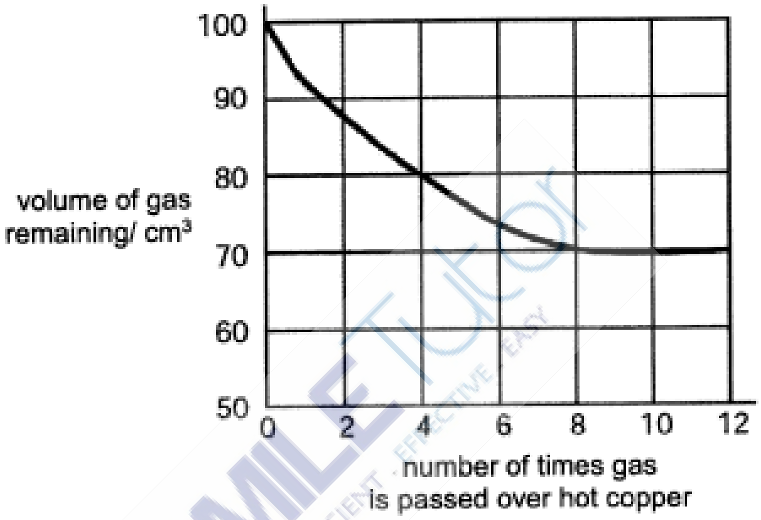
30 Which gas will react with ozone in the upper atmosphere of the Earth?

A CF_2Cl_2 **B** CH_4 **C** CO_2 **D** CF_4

31 A 100 cm^3 sample of bottled gas used for diving was placed in a gas syringe in the apparatus shown.



The gas was passed backward and forward over heated copper turnings. The results obtained were used to plot the graph.



What is the percentage of oxygen in the bottled gas?

A 20% **B** 30% **C** 70% **D** 80%

32 Which physical properties of the alkanes does **not** increase as relative molecular mass increases?

A boiling point **B** flammability
C melting point **D** viscosity

33 When 20 cm^3 of a gaseous alkene burns in an excess of oxygen, 60 cm^3 of carbon dioxide are formed. Both volumes are measured at r.t.p.

What is the formula of the alkene?

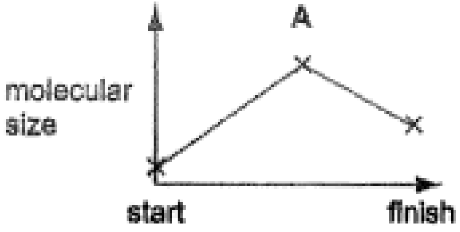
A C_3H_6 **B** C_3H_8 **C** C_6H_{12} **D** C_6H_{14}

34 Poly(ethene) can be manufactured by the process below.

$$\boxed{\text{decane}} \xrightarrow[\text{cracking}]{} \boxed{\text{ethene}} \xrightarrow[\text{polymerisation}]{} \boxed{\text{poly(ethene)}}$$

Which diagram shows the change in molecular size during this process?

A



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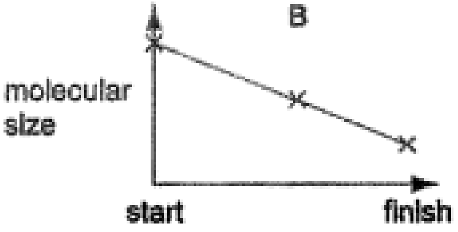
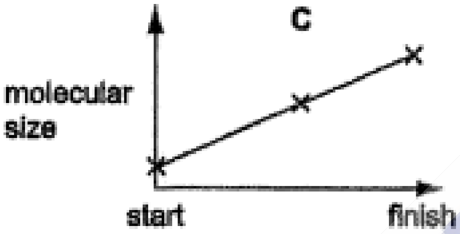
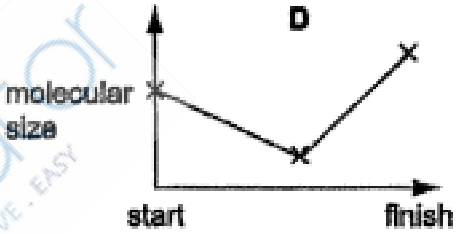


C



D



35 Which bond in a molecule of ethanoic acid is broken when it reacts with magnesium?

A the C — H bond
B the C — C bond
C the O — H bond
D the C ═ O bond

36 An alcohol contains 60% carbon by mass.

What is its formula?

A CH_3OH **B** C_2H_5OH
C C_3H_7OH **D** C_4H_9OH

37 Some synthetic products are said to be non-biodegradable.

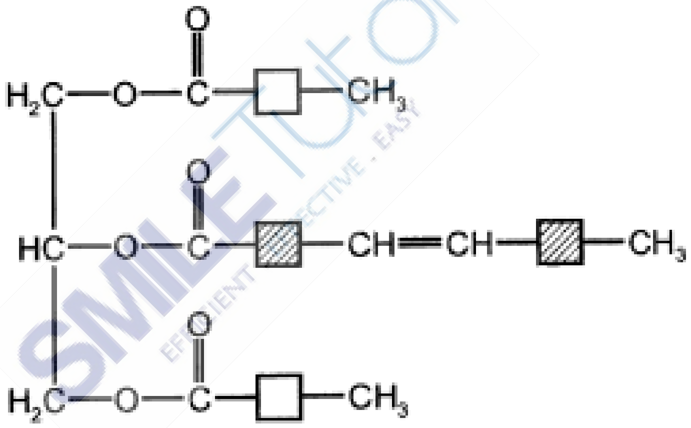
What does this term mean?

A cannot act as catalysts for biological process
B not harmful to living organisms
C not decomposed by strong heat
D not broken down by bacteria

38 What is the catalyst used in the preparation of ethyl ethanoate from ethanol and ethanoic acid?

A concentrated sulfuric acid
B nickel
C phosphoric acid
D yeast

39 The diagram shows a simplified structure of a fat.

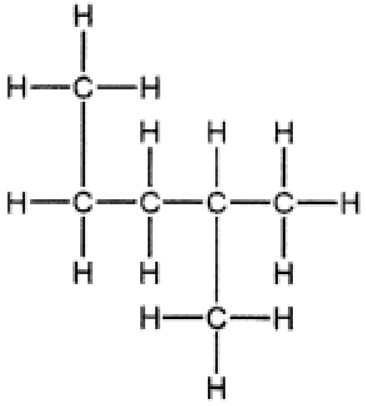


Which compounds in the table have functional groups that can be found in this fat?

	ethene	nylon	ethanoic acid
A	✓	✓	✓
B	✓	✓	✗
C	✓	✗	✗
D	✗	✗	✗

40 Structures 1, 2, 3 and 4 are hydrocarbons.

1



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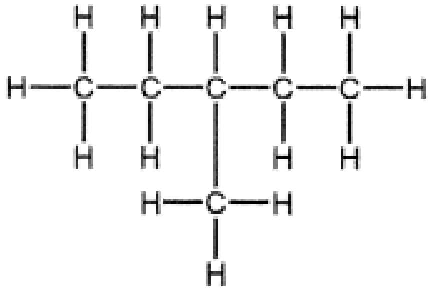

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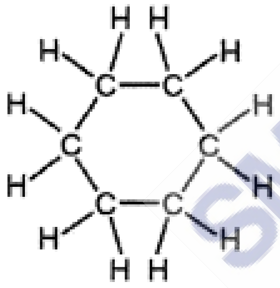

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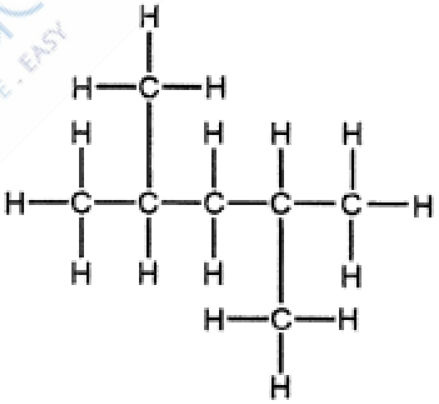


Which pair of structures are isomers?

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

END OF PAPER

Section A

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

A1 Use the list of the substances to answer the questions.

potassium lead(II) bromide oxygen

zinc oxide hydrogen carbon

Each substance can be used once, more than once, or not at all.

Name a substance from the list above which

(a) reacts violently with water,

.... [1]

(b) conducts electricity when molten but not when solid,

.... [1]

(c) is amphoteric,

.... [1]

(d) has a formula of the type XY_2,

.... [1]

(e) has the lowest boiling point,

.... [1]

(f) is produced at the negative electrode during electrolysis of dilute sulfuric acid.

.... [1]

[Total: 6]

A2 **(a)** Table 2.1 shows information about the preparation of pure samples of solid salts.

Complete the table by filling in the missing information. Include state symbols with any formula.

Table 2.1

formula of salt	formulae of reagents used	method used
$CuCl_2(s)$	…………………. $HCl(aq)$	addition of excess solid to acid filtration evaporation and crystallisation
…………………….	$KOH(aq)$ $HNO_3(aq)$	…………………………………………………… evaporation and crystallisation
$PbSO_4(s)$	…………………. ………………….	…………………………………………………… ……………………………………………………

[5]

(b) Explain why

(i) excess solid is added to acid to prepare the salt, $CuCl_2$,

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(ii) crystals are formed in the process of crystallisation.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

[Total: 7]

A3 Fig. 3.1 shows giant molecular structures of diamond and graphite.

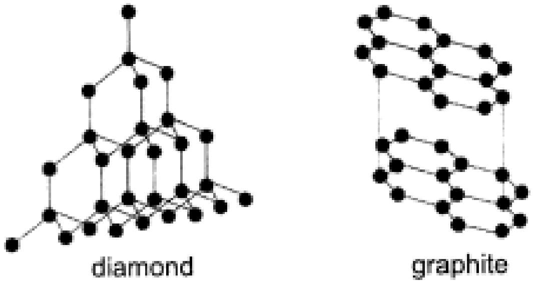


Fig. 3.1

(a) Describe how a simple molecular structure differs from a giant molecular structure.

....

....

.... [2]

(b) Diamonds are used as drill tips because they are very hard.

Explain why diamond is very hard. Refer to the structure of diamond in your answer.

....

....

....

.... [2]

(c) Graphite is used as lubricant for engines.

Explain why graphite acts as a lubricant. Refer to the structure of graphite in your answer.

....

....

....

.... [2]

[Total: 6]

A4 Lithium metal and its compounds have many uses, ranging from nuclear chemistry, rechargeable batteries and pharmaceuticals.

(a) Naturally occurring lithium contains the isotopes ^{6}Li and ^{7}Li.

(i) Describe the similarities and differences between the structure of the nuclei of the two isotopes of lithium.

....

....

.... [2]

(ii) A nuclear reaction is a reaction in which there is a change to an atomic nucleus.

An experimental nuclear reactor uses ^{6}Li and deuterium, ^{2}H, as fuel. Three nuclear reactions between these two atoms are described below.
(p^+ is a proton; n is a neutron).

$$^{6}Li + {}^{2}H \rightarrow 2{}^{4}He$$

$$^{6}Li + {}^{2}H \rightarrow {}^{4}He + \mathbf{X} + n$$

$$^{6}Li + {}^{2}H \rightarrow \mathbf{Y} + p^{+}$$

Given that the number of nucleons is conserved in these nuclear reactions, suggest the identities of **X** and **Y**.

X ....   **Y** ....   [2]

(b) Lithium-ion batteries are light in weight and can hold a large amount of charge.

One type of lithium-ion battery consists of

- an electrolyte of $LiBF_4$ dissolved in an organic solvent,
- a cathode made from cobalt oxide, CoO_2,
- and an anode made from graphite with lithium atoms inserted between layers.

During discharge, Li atoms at the anode give up electrons to become Li^+ ions. The electrons travel round the external circuit and are picked up by the cathode. A Li^+ ion from the electrolyte also moves to the cathode.

This is illustrated in Fig 4.1 in which C–C–C–C–C is also a simplified representation of a layer of carbon atoms in graphite.

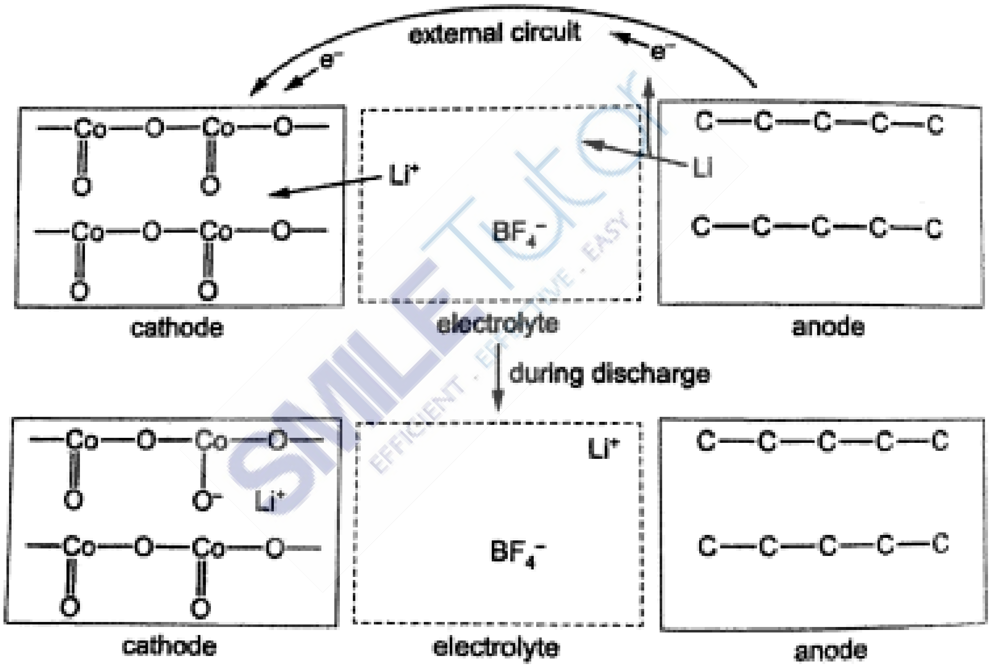


Fig. 4.1

(i) Suggest the type of bonding between lithium atoms and the layers of carbon atoms in graphite.

Give your reasoning.

....

....

....

.... [2]

(ii) State the oxidation state of cobalt in the cobalt oxide cathode before discharge and after the cell is totally discharged.

before discharge ....

after cell is totally discharged .... [2]

[Total: 8]

A5 Ethanol belongs to the homologous series called alcohols.

(a) Write the general formula of alcohols.

.... [1]

(b) Explain why ethanol **cannot** be described as a hydrocarbon.

....

.... [1]

(c) Ethanol can be manufactured from different substances by reaction with steam or by fermentation. Give the formulae of these substances.

substance which reacts with steam to form ethanol ....

substance which will undergo fermentation to form ethanol .... [2]

(d) Fig. 5.1 shows ethane-1,2-diol has two alcohol functional groups.

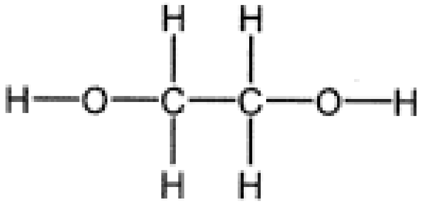


Fig. 5.1

One molecule of ethane-1,2-diol will react with two molecules of ethanoic acid to form molecule **X**.

X has two ester functional groups and a molecular formula of $C_6H_{10}O_4$.

(i) State the empirical formula of **X**.

....[1]

(ii) Draw the structure of **X**.

Show all of the atoms and all of the bonds.

[1]

(iii) Name the other substance formed in this reaction.

....[1]

(e) Each alcohol functional group in ethane-1,2-diol reacts with acidified potassium manganate(VII) to form a different organic compound, **Y**.

(i) Name the functional group formed in **Y**.

....[1]

(ii) Draw the structure of **Y**.

Show all of the atoms and all of the bonds.

[1]

[Total: 9]

A6 **(a)** Hydrogen peroxide can behave as an oxidising agent or a reducing agent depending on the reactant added to it. When solid silver(I) oxide is added to aqueous hydrogen peroxide, the reaction shown in equation 1 takes place.

equation 1 $Ag_2O(s) + H_2O_2(aq) \rightarrow 2Ag(s) + O_2(g) + H_2O(l)$

(i) State, with reasoning, whether hydrogen peroxide is behaving as an oxidising agent or a reducing agent in this reaction.

....

....

.... [1]

(ii) Describe a simple test and its result that would identify the gas given off in the reaction.

....

....

.... [1]

(b) **(i)** 1.0 cm^3 of '20-volume' hydrogen peroxide produces 20.0 cm^3 of oxygen gas at room temperature and pressure, as shown in equation 2.

equation 2 $2H_2O_2 \rightarrow 2H_2O + O_2$

Use this information to calculate the concentration, in mol/dm^3, of '20-volume' hydrogen peroxide.

[2]

(ii) Use the value obtained in **(b)(i)** to calculate the minimum mass of silver(I) oxide which must be used to ensure that 10.0 cm^3 of '20-volume' hydrogen peroxide reacts completely at room temperature and pressure, according to equation 1.

[1]

[Total: 5]

A7 Methane, methanol and hydrogen have all been investigated as possible alternative fuels for motor vehicles that currently used petrol. Table 7.1 shows some information of these fuels.

Table 7.1

fuel	density at r.t.p (g/dm^3)	enthalpy change of combustion (kJ/mol)	energy released per gram (kJ/g)	energy released per dm^3 at r.t.p (kJ/dm^3)
petrol	710 – 770	–	47.3	33 600 – 36 400
methane	0.645	– 891	55.7	35.8
methanol	792	– 726	22.7	18 000
hydrogen	0.0833	– 286	143	12.6

(a) Explain why no value is quoted for the enthalpy change of combustion of petrol in Table 7.1.

....

.... [1]

(b) Both petrol and methanol have a much higher density than methane and hydrogen. Suggest why.

....

.... [1]

(c) **(i)** Write down the chemical equation for the complete combustion of methane.

.... [2]

(ii) Use ideas of about breaking and forming bonds to explain why the value of enthalpy change of combustion for methane is negative.

....

....

....

....

....

.... [3]

(d) Although hydrogen releases less than half the energy per dm^3 than methane, many people believe that hydrogen is a better alternative fuel compared to methane. Explain why.

....

....

....

....[2]

[Total: 9]

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 Dynamics equilibrium

Many reversible reactions are incomplete. We can understand what is happening by examining what happens when a solution of iodine in potassium iodide solution is shaken with the solvent trichloroethane. Water and trichloroethane do not mix.

$$I_2 \text{ in aqueous potassium iodide } \rightleftharpoons I_2 \text{ in trichloroethane}$$

Fig. 8.1 shows the movement of iodine molecules during the shaking.

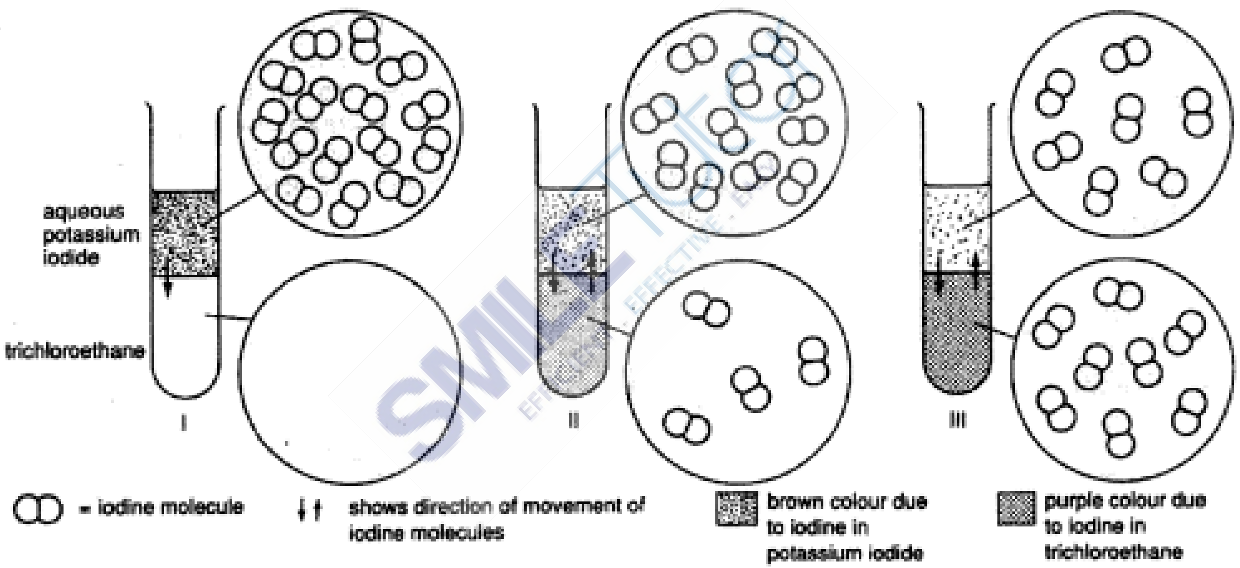


Fig. 8.1

Iodine dissolves in aqueous potassium iodide to form a brown solution, but dissolves in trichloroethane to form a purple solution.

What has happened is the iodine molecules first started going from the aqueous layer into the trichloroethane. As the concentration of iodine in the trichloroethane increased, the molecules started going back into the aqueous layer. As the concentration of iodine in the aqueous layer decreased, the forward reaction slowed down. As the concentration of iodine in the trichloroethane increased, the backward reaction became faster. Eventually *the speed of the forward reaction and backward reaction become equal.*

When the reactants reach equilibrium in a reversible reaction, the concentration of reactants and products become constant and reaction appears to have stopped.

This situation is called *dynamic equilibrium*.

Fig 8.2 shows the concentration of iodine in the two solvents against time.

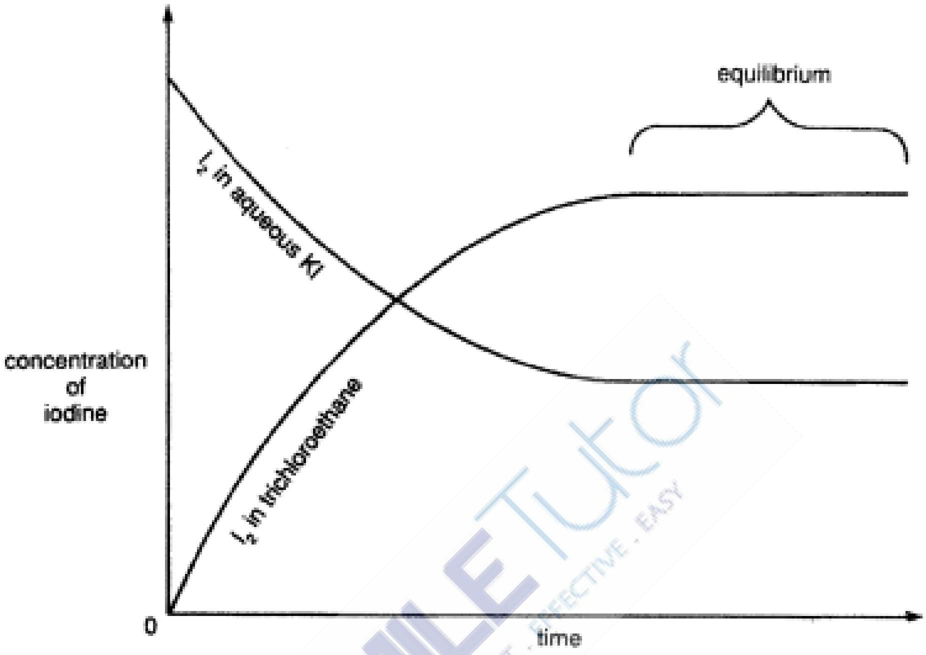


Fig. 8.2

When the graph becomes horizontal, equilibrium is reached. This is when concentration of iodine in two solvents become constant.

Factors affecting equilibrium

The composition of an equilibrium mixture in a reversible reaction can be affected by changes in concentration, temperature and pressure.

The best way to predict the effect of a change in conditions is to use *Le Chaterlier's Principle*.

Le Chaterlier's Principle state that:

If an equilibrium mixture is disturbed by changing the conditions, then the composition of the equilibrium mixture will try to remove the disturbance.

Changing concentration

An example is the formation of a white precipitate of bismuth oxychloride, $BiOCl$, when colourless bismuth(III) chloride, $BiCl_3$, is added to water.

$$BiCl_3(aq) + H_2O(l) \rightleftharpoons BiOCl(s) + 2HCl(aq)$$

At equilibrium, there is a mixture of all four substances. If extra $HCl(aq)$ is added to this mixture, the extra $HCl(aq)$ increases the concentration of $H^+(aq)$ and $Cl^-(aq)$. This is a 'disturbance'. The mixture will try to remove this extra $HCl(aq)$. It removes by increasing the backward reaction to produce more $BiCl_3(aq)$ and $H_2O(l)$ and decreasing the amounts $BiOCl(s)$ and $HCl(aq)$. This removes much of the $HCl(aq)$ 'disturbance'. A new equilibrium is obtained, where there are more $BiCl_3(aq)$ and $H_2O(l)$ and less $BiOCl(s)$.

Changing temperature

An example is the removal of carbon dioxide using hydrogen.

$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g); \quad \Delta H = -165 \text{ kJ}$$

A negative ΔH means that the forward reaction at equilibrium releases heat and the backward reaction absorbs heat. If temperature is raised, the reaction mixture absorbs heat. By Le Chatelier's Principle, the reaction mixture will try to get rid of the extra heat by absorbing it. It removes the heat 'disturbance' by increasing the backward reaction to produce more CO_2 and H_2.

Changing pressure

An example is the industrial manufacture of ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

If the pressure of the equilibrium mixture is increased, the reaction mixture will try to remove the pressure 'disturbance' by decreasing the number of moles of gas present. The forward reaction will increase as 4 moles of gas (1 mole of N_2 and 3 moles of H_2) produces only 2 mole of gas (2 moles of NH_3) – a net loss of 2 moles of gas in a fixed volume.

Adapted from Chemistry for 'O' Level – JGR Briggs

(a) Dinitrogen tetroxide, N_2O_4, decomposes into nitrogen dioxide, NO_2. The reaction is reversible.

$$\underset{\text{colourless gas}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown gas}}{2NO_2(g)}$$

Fig. 8.3 shows a gas syringe containing a mixture of dinitrogen tetroxide and nitrogen dioxide gases was sealed and heated. After reaching equilibrium, the mixture was a pale brown colour.

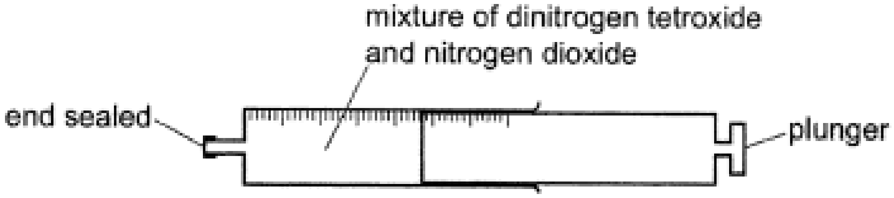


Fig. 8.3

The forward reaction is endothermic.

(i) Using Le Chaterlier's Principle, describe and explain what you would observe when the temperature of the mixture is increased.

....

....

....

.... [2]

(ii) Explain, using the ideas of particles, what happens to the speed of the forward reaction when the temperature of the mixture is increased.

....

....

....

....

....

.... [3]

(b) The plunger of the gas syringe is pushed in as shown in Fig. 8.4. The temperature does not change. The mixture initially turns darker brown. After a few seconds, the mixture turns lighter brown.

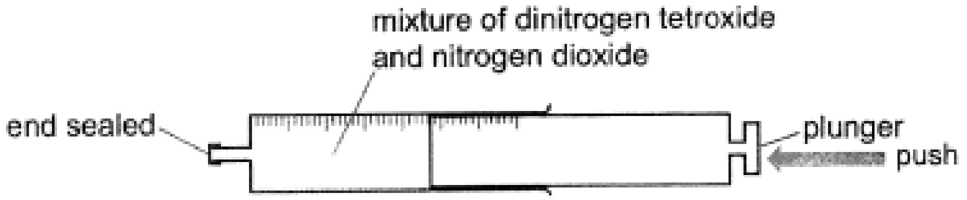


Fig. 8.4

(i) Explain why the mixture initially turns darker brown.

....

.... [1]

(ii) Using Le Chaterlier's Principle, explain why the mixture turns lighter brown after a few seconds.

....

....

....

....

.... [2]

(c) When hydrogen ions are added to methyl orange (Meor), a red coloured complex (H-Meor) is formed.

An equilibrium mixture between the two forms of methyl orange will be established.

$$\text{H-Meor} \rightleftharpoons H^+(aq) + \text{Meor}^-(aq)$$

Meor $^-$ is yellow in colour.

Using Le Chaterlier's Principle, suggest what you would observe when hydroxide ions are added to this equilibrium mixture.

Explain your reasoning.

....

....

....

....

....

.... [2]

[Total: 10]

B9 The structure of styrene and butadiene are shown in Fig. 9.1. Styrene-butadiene rubber is a synthetic rubber. It is made by polymerising a mixture of the monomers butadiene and styrene.

styrene butadiene

Fig. 9.1

(a) What type of polymerisation will take place when the monomers polymerise? Explain your reasoning.

....

....

.... [2]

One possible structure for the polymer is shown in Fig. 9.2.

Fig. 9.2

(b) Give the **full structural formula** for the repeating unit in this polymer structure.

[2]

(c) When the mixture of styrene and butadiene polymerises, the polymer is unlikely to contain only this regular, repeating pattern. Explain why.

....

....

.... [1]

Butadiene can be made by cracking butane in a cracking tower.

(d) (i) Butane cracks to form butadiene, C_4H_6, and one other product.

Write an equation to show this reaction.

....[1]

(ii) Describe a test to confirm the identity of the other product.

....

....[1]

(e) 2.90 kg of butane entered the cracking tower. After the reaction, 2.16 kg of butadiene had been made.

Calculate the percentage yield of butadiene.

[3]

[Total: 10]

EITHER

B10 A student carried out some experiments to place four metals, **W**, **X**, **Y** and **Z** in order of reactivity.

Table 10.1 shows the results.

key ✓ shows a reaction happened
✗ Shows no reaction happened
– Shows the experiment was not performed

Table 10.1

	metal **W**	metal **X**	metal **Y**	metal **Z**
solution of **W** nitrate	–	✗	✗	✗
solution of **X** nitrate	✓	–	✓	✓
solution of **Y** nitrate	✓	✗	–	✓
solution of **Z** nitrate	✓	✗	✗	–

(a) Place the metals in order of reactivity, starting with the most reactive.

.... [2]

(b) Metal **Z** reacts with hydrochloric acid.

What would you see when metal **Z** reacts with hydrochloric acid?

Explain your reasoning.

....

....

.... [2]

(c) The student carried out further experiments to place metal **M** in the list.

She used dilute hydrochloric acid and samples of the metals.

She found out that metal **M** is the fourth most reactive metal.

Describe the experiments that the student carried out. Your answer should include

- the experiments that she carried out using dilute hydrochloric acid and samples of the metals,
- the measurements that she made,
- how the results showed that metal **M** is the fourth most reactive metal.

....

....

....

....

....

....

.... [3]

(d) The five metals, **W**, **X**, **Y**, **Z** and **M** are extracted from their ores in three different ways.

Two of the metals are extracted from their ores by electrolysis.
Metal **M** and one other metal are extracted by heating their ores with carbon.
One of the metals occurs uncombined.

(i) Suggest which other metal, **W**, **X**, **Y** and **Z** is extracted by heating its ore with carbon. Explain your reasoning.

....

....

....

....[2]

(ii) Suggest the name of metal **M**.

....[1]

[Total: 10]

OR

B10 Sodium metal is extracted from sodium chloride by electrolysis.

Fig. 10.1 shows how the process works.

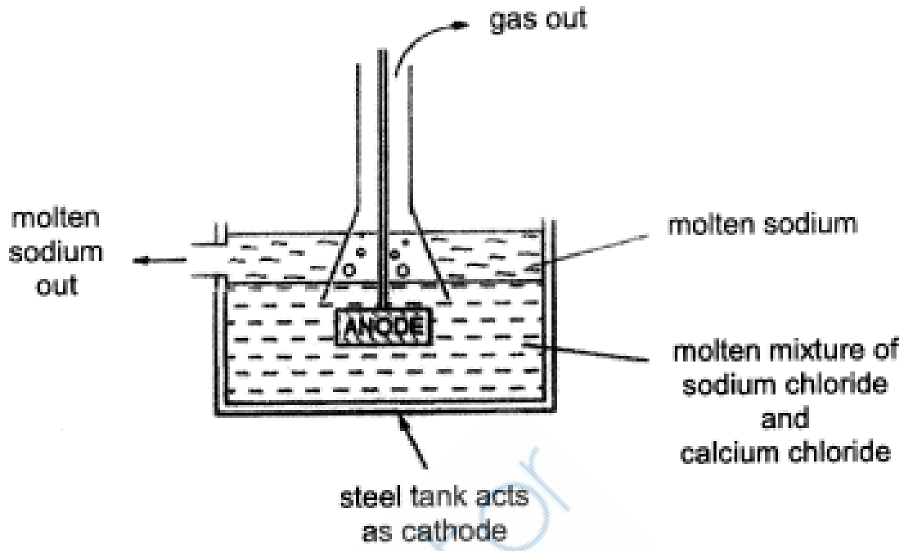


Fig. 10.1

(a) **(i)** Write an ionic half equation, with state symbols, to show the reaction that happens at the anode.

....[2]

(ii) Describe a simple test and its result that would identify the gas given off at the anode.

....

....

....[2]

(b) Calcium chloride is added to the sodium chloride to lower the melting point of the mixture.

(i) Explain why lowering the melting point makes the process cheaper to run.

....

....

....

....[2]

(ii) The molten sodium contains metallic impurities.

Name the main metal impurity you would expect to find and explain how it forms.

....

....

....

....[2]

(c) Sodium chloride can be electrolysed in aqueous solution.

Describe the differences in the products of the electrolysis of concentrated aqueous sodium chloride compared to molten sodium chloride.

....

....

....

.... [2]

[Total: 10]

ANSWER SHEET

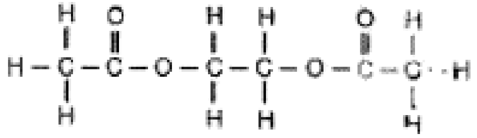
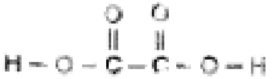
Paper 1

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

Paper 2 Section A

Qn	Answer	Mark
1(a)	Potassium	[1]
1(b)	lead(II) bromide OR zinc oxide	[1]
1(c)	zinc oxide	[1]
1(d)	lead(II) bromide	[1]
1(e)	Hydrogen	[1]
1(f)	Hydrogen	[1]
	TOTAL	[6]
2(a)	$CuCO_3(s)$ OR $Cu(OH)_2(s)$ OR $CuO(s)$;	[1]
	$KNO_3(s)$;	[1]
	titration;	[1]
	any solution containing Pb^{2+} ions AND any solution containing SO_4^{2-} ions	[1]
	mixing OR precipitation AND filtration	[1]
2(b)(i)	to ensure all acid is reacted	[1]
2(b)(ii)	solubility of salt decreases when temperature decreases	[1]

Qn	Answer	Mark
	TOTAL	[7]
3(a)	A giant network of atoms that are covalently bonded.	[1]
	Discrete molecules held together by weak intermolecular forces.	[1]
3(b)	Three dimensional network; Strong covalent bonds between atoms.	[1] [1]
3(c)	layers of carbon atoms held loosely by weak intermolecular forces; COND layers of carbon atoms can slide over each other when a force is applied	[1] [1]
	TOTAL	[6]
4(a)(i)	3 protons; lithium-6 has 3 neutrons, lithium-7 has 4 neutrons	[1] [1]
4(a)(ii)	^{3}He; ^{7}Li	[1] [1]
4(b)(i)	ionic AND idea of formation of positive ions and negative ions OR metallic AND idea of interaction of lithium cation with delocalised electrons in graphite	[1] [1]
4(b)(ii)	+4; +3	[1] [1]
	TOTAL	[8]
5(a)	$C_nH_{2n+1}OH$	[1]
5(b)	contain oxygen not only hydrogen and carbon	[1]
5(c)	C_2H_4; $C_6H_{12}O_6$	[1] [1]
5(d)(i)	$C_3H_5O_2$	[1]

Qn	Answer	Mark
5(d)(ii)	 $CH_3-CO-O-CH_2-CH_2-O-CO-CH_3$	[1]
5(d)(iii)	Water	[1]
5(e)(i)	carboxyl	[1]
5(e)(ii)	 $H-O-CO-CO-O-H$	[1]
	TOTAL	**[9]**
6(a)(i)	reducing agent AND removes oxygen from Ag_2O / decreases oxidation state of silver from +1 in Ag_2O to 0 in Ag / donates electron to Ag^+ to form Ag	[1]
6(a)(ii)	place glowing splint near the gas AND relighted / rekindled	[1]
6(b)(i)	$n_{hydrogen\ peroxide}$ $= 2 \times \frac{20.0}{24000}$ = 0.000833 mol	[1]
	$C_{hydrogen\ peroxide}$ $= (2 \times \frac{20.0}{24000}) \div (\frac{1.0}{1000})$ = <u>1.67 mol/dm³ (3.s.f)</u>	[1]
6(b)(ii)	$m_{silver(I)\ oxide}$ $= (1.67 \times \frac{10}{1000}) \times 232$ = <u>3.87 g (3.s.f)</u>	[1]
	TOTAL	**[5]**
7(a)	Petrol is a mixture / enthalpy change of combustion has no fixed value.	[1]
7(b)	Petrol and methanol exist as liquids and methane and hydrogen as gas (at r.t.p)	[1]
7(c)(i)	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ Correct formulae of products; balanced equation	[1] [1]

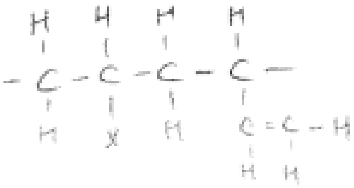
Qn	Answer	Mark

7(c)(ii)	break 4 mol of C-H bonds, 2 mol of O=O bonds;
	form 2 mol of C=O bonds, 4 mol of O-H bonds;
	more energy is given out in bond formation than energy taken in to break bond
		[1]
		[1]
		[1]

7(d)	idea of water being produced **AND** water is non-polluting / harmless; idea of carbon dioxide being produced **AND** CO_2 is a greenhouse gas / causes global warming	[1] [1]
	TOTAL	[9]

Paper 2 Section B

Qn	Answer	Mark
8(a)(i)	darker brown; the reaction mixture will try to get rid of the extra heat **AND** by increasing forward reaction / producing more NO_2	[1] [1]
8(a)(ii)	particles have more energy / gain energy **AND** move faster; more proportion of particles having energy equal or greater than E_a frequency of effective collision/ chances of effective collision increases **AND** faster speed of reaction	[1] [1] [1]
8(b)(i)	more NO_2 particles in a unit volume / concentration of NO_2 increases / NO_2 particles are closer together	[1]
8(b)(ii)	get rid of the increase in pressure;	[1]
	idea of less number of mole of gaseous particle / net loss of moles of gas in the backward reaction	[1]
8(c)	turned yellow/ orange	[1]
	idea of hydroxide ions reacting with hydrogen ions **AND** increase forward reaction/ more Meor $^-$ is present in equilibrium	[1]
		[10]
9(a)	addition polymerisation;	[1]

Qn	Answer	Mark
	C=C / unsaturated	[1]
9(b)		[2]
9(c)	idea of self-polymerisation	[1]
9(d)(i)	$C_4H_{10} \rightarrow C_4H_6 + 2H_2$	[1]
9(d)(ii)	place a lighted splint near the gas **AND** lighted splint was extinguished with a pop sound	[1]
9(e)	amount of butane $= \frac{2.9 \times 1000}{58} = 50$ mol	[1]
	Mole ratio butane: butadiene = 1:1 Theoretical mass of butadiene = 50 x 54 = 2700 g	[1]
	percentage yield $= \frac{2160}{2700} \times 100\%$ = 80%	[1]
	Alternative:	
	amount of butane $= \frac{2.9 \times 1000}{58} = 50$ mol [1]	[1]
	amount of butadiene $= \frac{2.16 \times 1000}{54} = 40$ mol [1]	[1]
	Mole ratio butane: butadiene = 1:1 percentage yield $= \frac{40}{50} \times 100\%$	

Qn	Answer	Mark
	= 80% [1]	
	TOTAL	**[10]**
EITHER		
10(a)	W, Z, Y, X	[2]
10(b)	effervescence; hydrogen gas is produced	[1] [1]
10(c)	Measurement that she made: using collection of volume gas over time	[1]
	control variables: such as fixed concentration and volume of acid used **AND** fixed mass of metal	[1]
	Link result to why M is the fourth most reactive metal: gradient of the graph - volume of gas produced against time	[1]
10(d)(i)	Y; W and Z are extracted using electrolysis as they are the two most reactive metals **AND** X is the least reactive metal and will be uncombined	[1] [1]
10(d)(ii)	zinc/ iron/ lead **REJECT**: copper, silver, (metal has to be able to react with acid to differentiate X and M in part c)	[1]
	TOTAL	**[10]**
OR		
10(a)(i)	$2Cl^- (l) \rightarrow Cl_2(g) + 2e^-$	[2]
10(a)(ii)	place a damp litmus paper near the gas; gas bleached damp litmus paper	[1] [1]
10(b)(i)	lower temperature / energy to keep mixture in molten state; Idea that less energy / electricity **OR** less fuel to burn lead to cheaper cost.	[1] [1]
10(b)(ii)	calcium; calcium ions gain electrons to form calcium metal	[1] [1]

Qn	Answer	Mark
10(c)	negative electrode / cathode: hydrogen gas produced for concentrated aqueous sodium chloride **AND** sodium produced for molten sodium chloride; electrolyte: sodium hydroxide will be produced for concentrated aqueous sodium chloride **AND** calcium chloride for molten sodium chloride	[1] [1]
	TOTAL	**[10]**

GUANGYANG SECONDARY SCHOOL

PAPER 1 (40 MARKS)

This paper consists of 40 multiple-choice questions. For each question, there are four possible answers. Choose the best answer you consider correct and record your answer on the Answer Sheet provided.

1 Copper (II) nitrate is soluble in water. Copper (II) carbonate is insoluble in water.
A mixture of solid copper (II) nitrate and copper(II) carbonate is added to a beaker of water.
It is stirred until no more solid dissolves.
How can separate samples of copper (II) nitrate and copper (II) carbonate be obtained from the resulting mixture?

A crystallisation followed by distillation
B evaporation followed by distillation
C evaporation followed by filtration
D filtration followed by crystallisation

2 A mixture of three liquids is separated by fractional distillation.
Which statements are **correct**?

1 The mixture boils at constant temperature throughout the separation.
2 The temperature at which the mixture boils increases during the separation.
3 The liquid with the highest boiling point is collected first.
4 The liquid with the lowest boiling point is collected first.

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

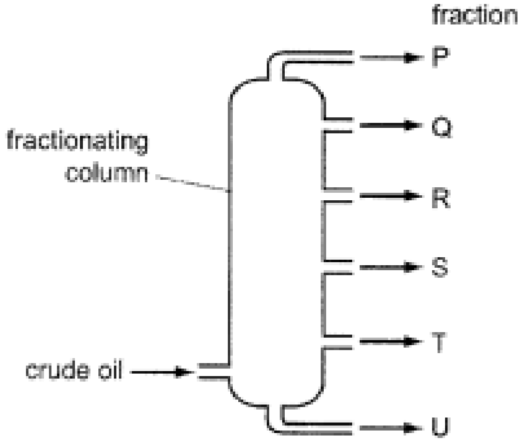
3 It is possible to produce Ar^{2+} ions from argon atoms in a laboratory.
Which statement is **correct**?

A Each argon atom gains two electrons and loses the electronic configuration of an inert gas.
B Each argon atom gains two electrons and obtains the electronic configuration of an inert gas.
C Each argon atom loses two electrons and loses the electronic configuration of an inert gas.
D Each argon atom loses two electrons and obtains the electronic configuration of an inert gas.

4 Two isotopes of chlorine are ^{35}Cl and ^{37}Cl.
Using these isotopes, how many different relative molecular masses are possible for the compound with molecular formula $C_2H_3Cl_3$?

A 2
B 3
C 4
D 5

5 The diagram below shows a fractionating column used in the separation of petroleum.



Which row explains why fraction R is collected above fraction S?

	boiling point of R	average molecular mass of R
A	greater than S	greater than S
B	greater than S	smaller than S
C	smaller than S	greater than S
D	smaller than S	smaller than S

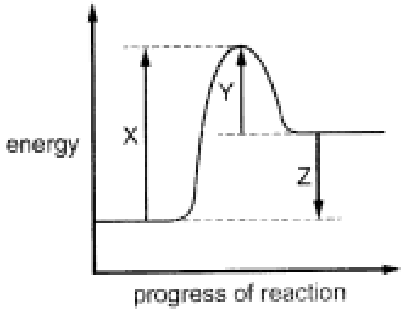
6 The table shows data for some particles. There are gaps represented by W, X, Y and Z.

particle	proton number	nucleon number	number of neutrons	number of electrons
Ar	18	40	W	18
K^+	19	39	20	X
Sc	21	Y	24	21
S^{2-}	16	32	16	Z

Which row shows the correct values for W, X, Y and Z?

	W	X	Y	Z
A	20	20	42	14
B	20	20	42	16
C	22	18	45	14
D	22	18	45	18

7 The energy profile diagram of a chemical reaction is shown below.



Which statement is **correct**?

A The reaction is exothermic.
B Y represents ΔH for the reaction.
C X represents the activation energy for the reaction.
D Z represents the energy given out as the reaction proceeds.

8 Three statements about the elements carbon, nitrogen and sulfur are shown below.

1 They are in groups next to each other in the Periodic Table.
2 Their neutron to proton ratios are all two to one.
3 They each form an acidic oxide.

Which statements are **correct**?

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

9 When K_2MnO_4 is dissolved in water, the following reaction occurs.

$$a\text{MnO}_4^{2-}(aq) + b\text{H}_2\text{O}(l) \rightarrow c\text{MnO}_4^-(aq) + d\,\text{MnO}_2(s) + e\text{OH}^-(aq)$$

What could be the values of *a* and *c* in the balanced chemical equation?

	a	*c*
A	2	1
B	3	1
C	3	2
D	4	3

10 Many elements and compounds contain covalent bonds.
Which statement about covalently bonded elements and compounds is **correct**?

- **A** Aqueous solutions of covalent compounds always conduct electricity.
- **B** Bonding in the nitrogen molecule involves three shared pairs of electrons.
- **C** Double covalent bonds are present in ethene and in water.
- **D** The formation of covalent bonds always produces atoms with eight electrons in their outer shells.

11 J is an aqueous solution.
On addition of aqueous sodium hydroxide to J a green precipitate is formed.
The resulting mixture is heated and no gas is formed.
Aluminium foil is added to the warmed mixture. A gas is formed that turns damp red litmus paper blue.
Which ions could be present in J?

- **A** Fe^{3+} and NH_4^+
- **B** Fe^{3+} and NO_3^-
- **C** Fe^{2+} and NH_4^+
- **D** Fe^{2+} and NO_3^-

12 An aqueous solution of zinc chloride is tested by adding reagents.
Which observation is **correct**?

	reagent added to zinc chloride (aq)	observations
A	acidified aqueous barium nitrate	forms a white precipitate
B	aqueous ammonia	forms a white precipitate, soluble in excess of the reagent
C	aqueous sodium hydroxide	forms a white precipitate, insoluble in excess of the reagent
D	powdered copper	forms a grey precipitate

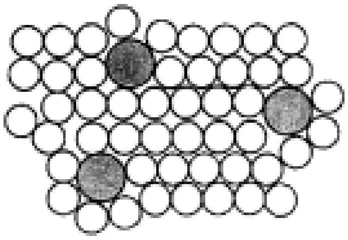
13 Which reaction is a redox reaction?

- **A** $Mg + 2HCl \rightarrow MgCl_2 + H_2$
- **B** $MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$
- **C** $MgO + 2HCl \rightarrow MgCl_2 + H_2O$
- **D** $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

14 One mole of an organic compound, **Q**, is completely burnt in oxygen and produces exactly three moles of water. Which compound is **Q**?

- **A** butane, C_4H_{10}
- **B** ethanol, C_2H_5OH
- **C** propane, C_3H_8
- **D** propanol, C_3H_7OH

15 The diagram below shows the structure of an alloy.



Which statement about alloys is **correct**?

A The alloy brass has a chemical formula.
B High carbon steel alloys are soft and easily shaped.
C Alloys can only be formed by mixing copper or iron with other metals.
D In an alloy there is attraction between positive ions and a 'sea of electrons'.

16 Calcium carbonate, $CaCO_3$, reacts with an acid, HA as shown below.

$$CaCO_3(s) + 2HA(aq) \rightarrow CaA_2(aq) + H_2O(l) + CO_2(g)$$

What is the minimum mass of acid required to react completely with 10 g of calcium carbonate?
[M_r: HA, 46; $CaCO_3$, 100]

A 4.6 g
B 9.2 g
C 10 g
D 20 g

17 When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.
Which statement is **correct**?

A Hydrogen sulfide is the product of a reduction reaction.
B Iodide ions are stronger oxidising agents than sulfate ions.
C Sulfur atoms from the sulfuric acid are both oxidised and reduced.
D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

18 Attaching pieces of magnesium to underground iron pipes can protect the iron from corrosion.
Which reaction protects the iron from corrosion?

A Fe^{2+} (aq) + $2e^-$ →□ Fe (s)
B Fe (s) →□ Fe^{2+} (aq) + $2e^-$
C Mg^{2+} (aq) + $2e^-$ →□ Mg (s)
D Mg (s) → Mg^{2+} (aq) + $2e^-$

19 The names and formulae of three nitrogen compounds are shown below.

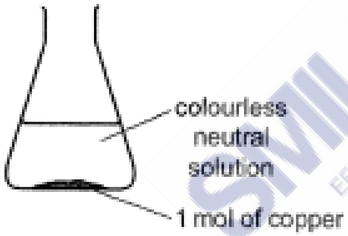
ammonia	hydrazine	hydroxylamine
NH_3	N_2H_4	NH_2OH

Which compound has the highest relative molecular mass, M_r, and in which compound is the percentage by mass of hydrogen the **greatest**?

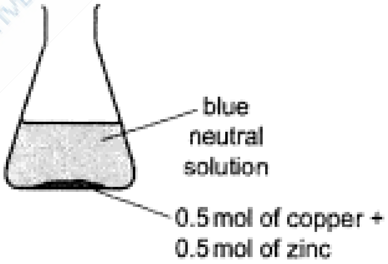
	highest M_r	greatest percentage by mass of hydrogen
A	N_2H_4	NH_3
B	N_2H_4	N_2H_4
C	NH_2OH	NH_3
D	NH_2OH	N_2H_4

20 In an experiment, 1 mol of powdered copper and 1 mol of powdered zinc are placed in a flask. Dilute acid, containing 1 mol of acid, is added to the flask.
The flask is left until all the reactions, if any, are complete.
Which diagram shows the result of the experiment?

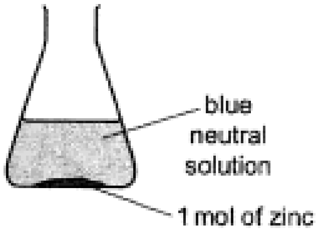
A



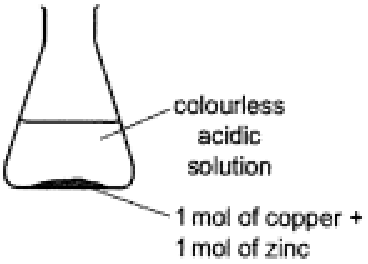
B



C



D



21 The diagram below shows the positions of elements L, M, Q, R and T in the Periodic Table. These letters are not the chemical symbols of the elements.

Which statement about the properties of these elements is **correct**?

A L reacts more vigorously with water than does M.
B L, M and Q are all metals.
C T exists as diatomic molecules.
D T is more reactive than R.

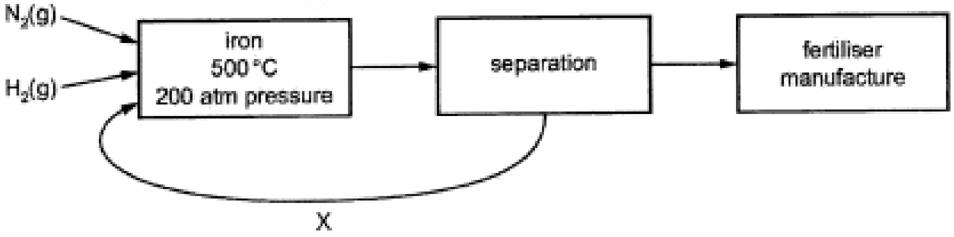
22 The section of the reactivity series shown includes a newly discovered metal, symbol X.

Ca
Mg
Fe
X
H
Cu

The only oxide of X has the formula XO. Which equation shows a reaction which occurs?

A $Cu (s) + X^{2+} (aq) \rightarrow Cu^{2+} (aq) + X (s)$
B $2X (s) + Cu^{2+} (aq) \rightarrow 2X^{+} (aq) + Cu (s)$
C $X (s) + Fe_2O_3 (s) \rightarrow 2Fe (s) + 3XO (s)$
D $X (s) + 2HCl (aq) \rightarrow XCl_2 (aq) + H_2 (g)$

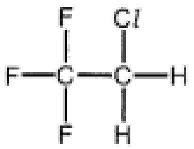
23 The diagram below shows the main stages in the manufacture of an ammonia-based fertiliser.



What is happening in the process labelled X?

A Unreacted hydrogen only is recycled.
B Unreacted hydrogen and nitrogen are recycled.
C The gases are cooled to cause ammonia to form a liquid.
D Ammonia is returned to the start of the process to shift the equilibrium towards the product.

24 CFC compounds were used as aerosol propellants. The structure of one CFC compound is shown.



Which element in this compound causes a depletion of ozone in the atmosphere?

A carbon
B chlorine
C fluorine
D hydrogen

25 Pollutant gases are released by the bacterial decay of vegetable matter.
The bacterial decay of vegetable matter is the main source of which gas?

A carbon monoxide
B methane
C nitrogen dioxide
D sulfur dioxide

26 The rate of a chemical reaction decreases as the temperature decreases because at a lower temperature:

1 a lower proportion of molecules have energy that exceeds the activation energy
2 the molecules are further apart
3 the frequency of successful collision is less.

Which reasons **correctly** explain this decrease?

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

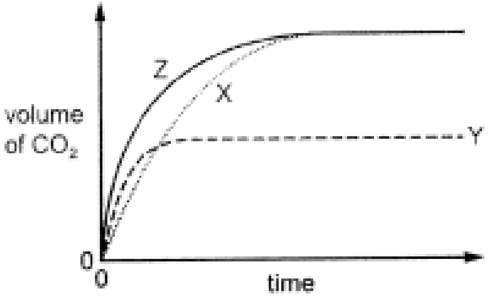
27 If a sample of ammonia is passed over heated iron, two gases, X and Y, are formed.
Gas X reacts with oxygen. Gas Y is unreactive.
Which statement is **correct**?

A Gas X reacts with oxygen to form water.
B Gas Y is a compound.
C The formation of the two gases from ammonia cannot be reversed.
D There is a triple covalent bond in one molecule of gas X.

28 The rate of the reaction between a metal carbonate and a dilute acid is followed by measuring the volume of carbon dioxide produced and plotting this against time.

The line labelled X shows the results of an experiment using 50 cm³ of 1.0 mol / dm³ hydrochloric acid and excess metal carbonate.

The experiment is repeated using different conditions and lines Y and Z are drawn to show the volumes of carbon dioxide produced against time.



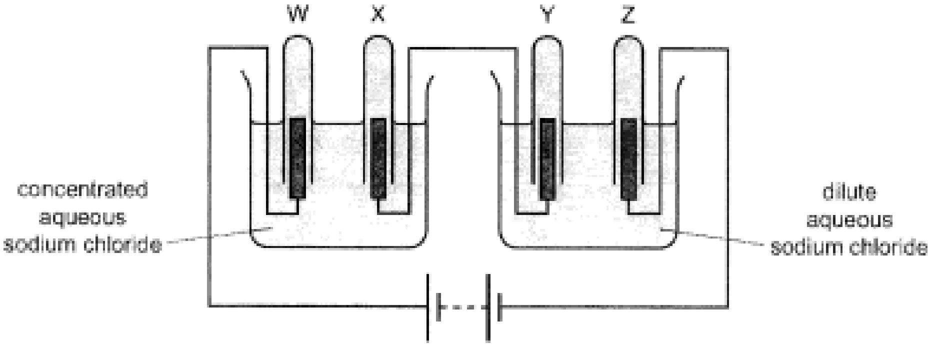
Which row shows the conditions that could give lines Y and Z?

	conditions for Y	conditions for Z
A	50 cm³ of 0.5 mol / dm³ hydrochloric acid at same temperature.	25 cm³ of 2.0 mol / dm³ hydrochloric acid at same temperature
B	50 cm³ of 0.5 mol / dm³ hydrochloric acid at same temperature with a catalyst.	12.5 cm³ of 4.0 mol / dm³ hydrochloric acid at same temperature.
C	50 cm³ of 1.0 mol / dm³ hydrochloric acid at a lower temperature.	50 cm³ of 1.0 mol / dm³ hydrochloric acid at a higher temperature.
D	50 cm³ of 0.5 mol / dm³ hydrochloric acid at a higher temperature.	50 cm³ of 1.0 mol / dm³ sulfuric acid at same temperature.

29 Magnesium can be produced by electrolysis of molten magnesium chloride, $MgCl_2$.
What are the equations for the reactions that occur at the positive electrode and at the negative electrode?

	positive electrode	negative electrode
A	$2Cl^- \rightarrow Cl_2 + 2e^-$	$2H^+ + 2e^- \rightarrow H_2$
B	$Cl_2 + 2e^- \rightarrow 2Cl^-$	$Mg^{2+} + 2e^- \rightarrow Mg$
C	$2Cl^- \rightarrow Cl_2 + 2e^-$	$Mg^{2+} + 2e^- \rightarrow Mg$
D	$2Cl^- \rightarrow Cl_2 + 2e^-$	$Mg^{2+} + 2e^- \rightarrow 2Mg$

30 The diagram below shows the electrolysis of concentrated and dilute aqueous sodium chloride using inert electrodes. Gases are produced and collected in each of the test-tubes W, X, Y and Z.

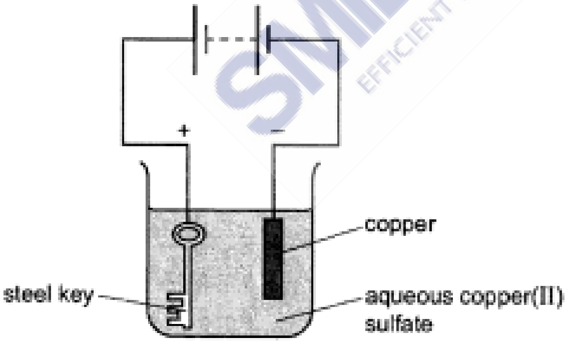


Which statements are **correct**?

1 Approximately equal volumes of gas are produced and collected in test-tubes W and X.
2 Approximately equal volumes of gas are produced and collected in test-tubes Y and Z.
3 Three different gases are produced in the experiment.

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

31 The apparatus shown below is set up to plate a steel key with copper.



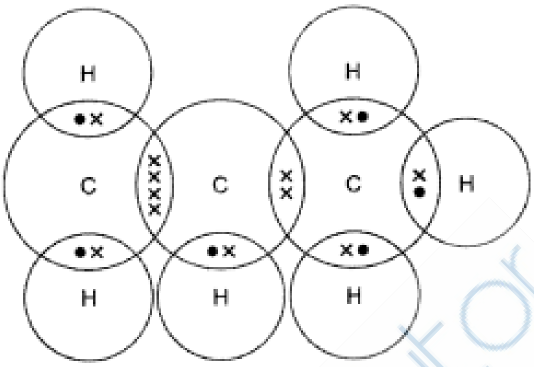
The key does not get coated with copper.
Which change needs to be made to plate the key?

A Increase the voltage.
B Reverse the electrical connections.
C Replace the solution with dilute sulfuric acid.
D Increase the concentration of the aqueous copper (II) sulfate.

32 A hydrocarbon, C_xH_y, undergoes an addition reaction with chlorine.
A second hydrocarbon, C_pH_q, undergoes a substitution reaction with chlorine.
If x = 4 and p = 6, what are the values of y and q?

	y	q
A	8	16
B	8	14
C	10	12
D	10	14

33 Compound X is shown in the dot-and-cross diagram below.



Which statement about compound X is correct?

A It is a saturated hydrocarbon.
B It is an isomer of butene.
C It will decolourise bromine water.
D Its chemical name is propane.

34 A solution of sodium hydroxide reacts with 3 mol of chlorine under certain conditions. The reaction produces 5 mol of sodium chloride and 1 mol of X, the only other chlorine-containing product.
What is the formula of compound X?

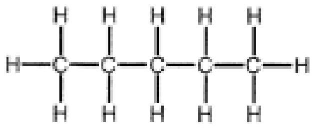
A $NaClO$
B $NaClO_2$
C $NaClO_3$
D $NaClO_4$

35 An ester is formed from a carboxylic acid and an alcohol.
How does the number of carbon, hydrogen and oxygen atoms in an ester differ from the total number of these atoms in the carboxylic acid and alcohol from which the ester is formed?

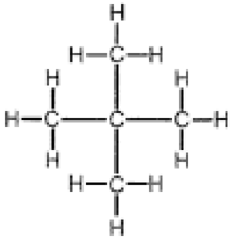
	carbon atoms	hydrogen atoms	oxygen atoms
A	fewer	fewer	fewer
B	fewer	same	fewer
C	same	fewer	fewer
D	same	same	same

36 The diagrams below show the structures of five hydrocarbons.

1



2



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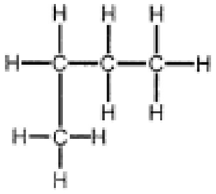

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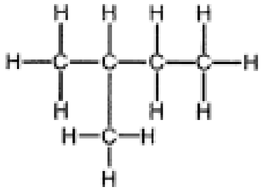

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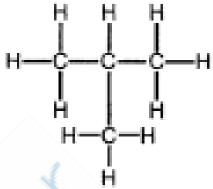


Which three hydrocarbons are isomers of each other?

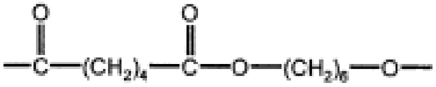
A 1, 2 and 4
B 2, 3 and 5
C 2, 3 and 4
D 3, 4 and 5

37 P is a polymer that:

- has six carbon atoms in each of the monomers from which it is formed
- is **not** a polyester
- is formed using condensation polymerisation.

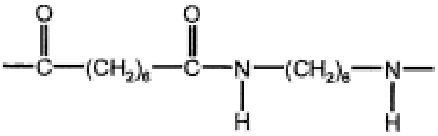
What is the partial structure of P?

A



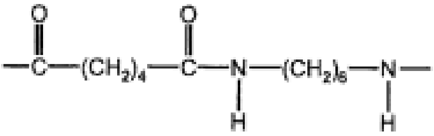
$$-\overset{\overset{\displaystyle O}{\|}}{C}-(CH_2)_4-\overset{\overset{\displaystyle O}{\|}}{C}-O-(CH_2)_6-O-$$

B



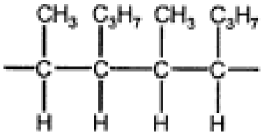
$$-\overset{\overset{\displaystyle O}{\|}}{C}-(CH_2)_6-\overset{\overset{\displaystyle O}{\|}}{C}-\underset{\underset{\displaystyle H}{|}}{N}-(CH_2)_6-\underset{\underset{\displaystyle H}{|}}{N}-$$

C



$$-\overset{\overset{\displaystyle O}{\|}}{C}-(CH_2)_4-\overset{\overset{\displaystyle O}{\|}}{C}-\underset{\underset{\displaystyle H}{|}}{N}-(CH_2)_6-\underset{\underset{\displaystyle H}{|}}{N}-$$

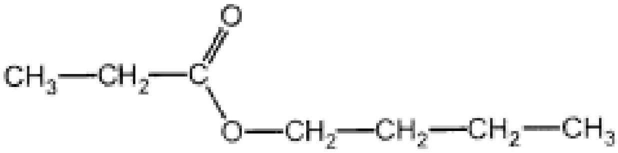
D



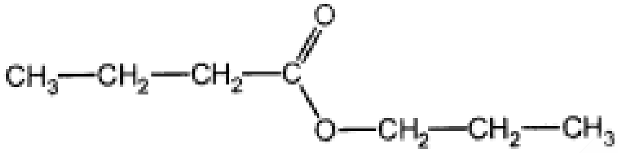
$$-\underset{\underset{\displaystyle H}{|}}{\overset{\overset{\displaystyle CH_3}{|}}{C}}-\underset{\underset{\displaystyle H}{|}}{\overset{\overset{\displaystyle C_3H_7}{|}}{C}}-\underset{\underset{\displaystyle H}{|}}{\overset{\overset{\displaystyle CH_3}{|}}{C}}-\underset{\underset{\displaystyle H}{|}}{\overset{\overset{\displaystyle C_3H_7}{|}}{C}}-$$

38 A carboxylic acid with molecular formula $C_4H_8O_2$ reacts with an alcohol with molecular formula C_3H_8O to form an ester. What is the formula of the ester formed?

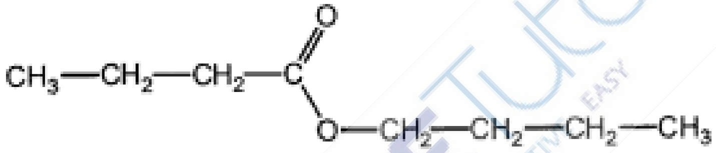
A



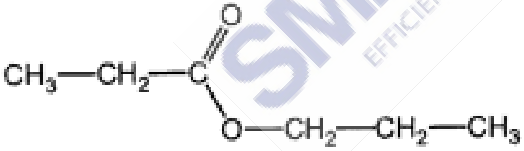
B



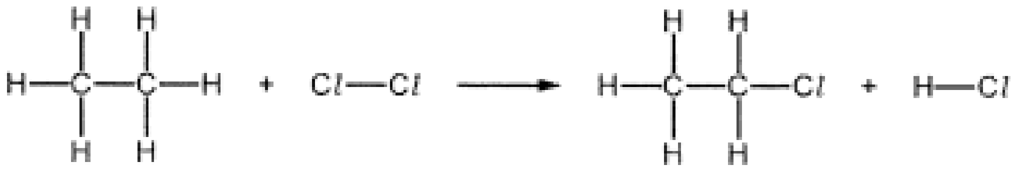
C



D



39 Chlorine reacts with ethane to produce chloroethane and hydrogen chloride. The reaction is exothermic.



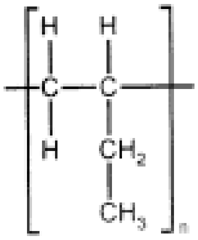
The bond energies are shown in the table.

bond	bond energy in kJ / mol
C–Cl	+340
C–C	+350
C–H	+410
Cl–Cl	+240
H–Cl	+430

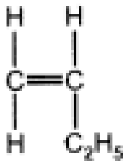
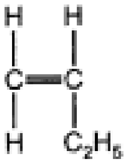
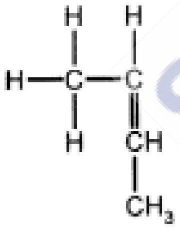
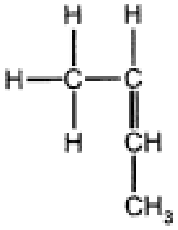
What is the energy change for the reaction?

A –1420 kJ / mol
B –120 kJ / mol
C +120 kJ / mol
D +1420 kJ / mol

40 The diagram below shows the repeat unit of a polymer.



Which row **correctly** identifies the monomer and type of polymerisation involved in making this polymer?

	monomer	type of polymerisation
A		addition
B		condensation
C		addition
D		condensation

End of Paper

A1 (a) The following table gives information about six substances.

substance	melting point / °C	boiling point / °C	electrical conductivity as a solid	electrical conductivity as a liquid
A	839	1484	good	good
B	–188	–42	poor	poor
C	776	1497	poor	good
D	–117	78	poor	poor
E	1607	2227	poor	poor
F	–5	102	poor	good

(i) Which substance could be a metal?

.... [1]

(ii) State all the substances that are liquid at room temperature.

.... [1]

(iii) Which substance could have a macromolecular structure similar to that of silicon (IV) oxide?

.... [1]

(iv) Which substance could be sodium chloride?

.... [1]

(b) The symbol equation for the production of sodium hydride is shown below.

$2Na + H_2 \rightarrow 2NaH$

(i) Suggest why the hydrogen must be dry.

.... [1]

(ii) Sodium hydride reacts with iron (III) oxide to form iron and sodium hydroxide. Write a balanced chemical equation for the reaction.

.... [1]

(iii) Explain, in terms of electron transfer, how this equation shows that it is a redox reaction.

....

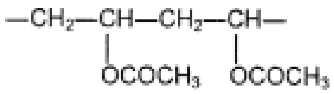
....

....

.... [3]

[Total: 9]

A2 The polymer known as PVA is used in paints and adhesives. Its structural formula is shown below.



$$-CH_2-\underset{\displaystyle OCOCH_3}{\underset{|}{CH}}-CH_2-\underset{\displaystyle OCOCH_3}{\underset{|}{CH}}-$$

(a) Deduce the structural formula of its monomer. [1]

(b) A condensation polymer can be made from the following monomers.

$HOOC(CH_2)_4COOH$ and $H_2N(CH_2)_6NH_2$

Draw the structural formula of this polymer, showing two repeating units. [2]

(c) Besides fractional distillation of petroleum, some fractions can be obtained through cracking. More petrol can be made by cracking less useful petroleum fractions.
Write a chemical equation for the cracking of dodecane, $C_{12}H_{26}$, to form ethene and one other hydrocarbon.

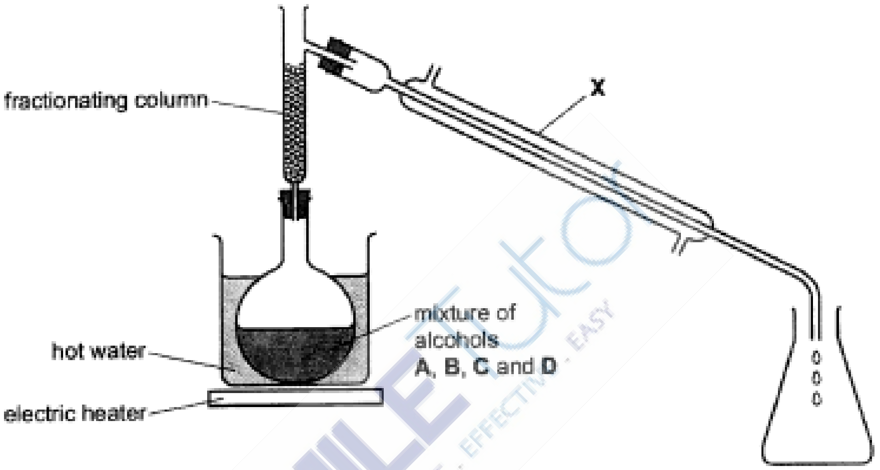
.... [1]

[Total: 4]

A3 Mixtures can be separated by physical processes.
The boiling points of four different alcohols, **A**, **B**, **C** and **D**, are shown below.

alcohol	**A**	**B**	**C**	**D**
boiling point / °C	56	78	122	160

A student suggested that the apparatus shown below could be used to separate the mixture of alcohols.



(a) Apparatus **X** needs to have cold water flowing through it.

- Draw an arrow on the diagram to show where the cold water enters apparatus X. [1]
- Name apparatus X.

.... [1]

(b) Part of the fractionating column is missing. This means that the experiment will not work.

- Draw on the diagram the part of the fractionating column which is missing. [1]
- Explain why the experiment will not work with this part of the fractionating column missing.

....

.... [1]

(c) Suggest why a Bunsen burner is **not** used to heat the flask.

.... [1]

(d) A hot water bath cannot be used to separate alcohols **C** and **D**. Explain why.

....

....

.... [1]

[Total: 6]

A4 (a) The alcohols form a homologous series.
The following two alcohols are members of a homologous series and they are isomers.

$CH_3 — CH_2 — CH_2 — CH_2 — OH$ and $(CH_3)_2CH — CH_2 — OH$

(i) Explain why they are isomers.

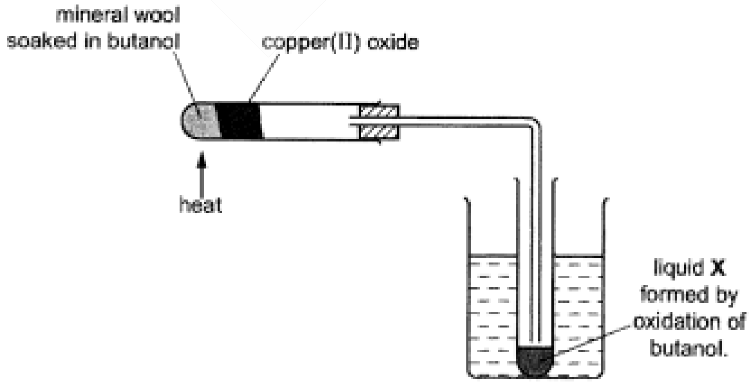
....

....

.... [2]

(ii) Deduce the structural formula of another alcohol which is also an isomer of these alcohols. [1]

(b) Copper (II) oxide can oxidise butanol to liquid **X**, whose pH is 4.



(i) Give the name of another reagent which can oxidise butanol.

.... [1]

(ii) Which homologous series does liquid **X** belong to?

.... [1]

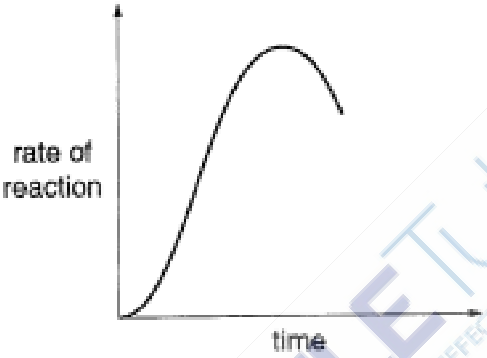
(iii) State the formula of liquid **X**.

.... [1]

(c) The alcohol ethanol can be made by fermentation. Yeast is added to aqueous glucose.

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

Carbon dioxide is given off and the mixture becomes warm, as the reaction is exothermic.
The graph shows how the rate of reaction varies over several days.



(i) Suggest a method of measuring the rate of this reaction.

....

.... [1]

(ii) Why does the rate initially increase?

....

.... [1]

(iii) Suggest one reason why the rate eventually decreases.

.... [1]

[Total: 9]

A5 Hydrogen reacts with oxygen as shown in the equation.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

A sample containing 1.00 mol of hydrogen, H_2, is completely burnt.
This sample releases 286 kJ of heat energy.

(a) Calculate the heat energy released when 25.0 g of hydrogen is completely burnt. [2]

(b) Use ideas about bond breaking and bond forming to explain why this reaction is exothermic.

....

....

....

.... [2]

(c) The reaction shown also represents the overall process that occurs within a hydrogen-oxygen fuel cell.

(i) Describe one advantage of using a hydrogen-oxygen fuel cell to power a motor vehicle rather than burning petrol.

....

.... [1]

(ii) Complete the equations for the two electrode reactions that happen in a hydrogen-oxygen fuel cell.

$H_2 \rightarrow$ .... + $2e^-$

$O_2 + 4H^+ + 4e^- \rightarrow$ .... [2]

[Total: 7]

A6 Sulfur dioxide is a colourless gas which can be found in air.

(a) State one environmental problem caused by the presence of sulfur dioxide in air.

....

.... [1]

(b) When heated in air, iron pyrite, FeS_2, reacts with oxygen.
Sulfur dioxide and iron (III) oxide, Fe_2O_3, are the products of this reaction.
Write the equation for this reaction.

.... [1]

(c) Explain, in terms of oxidation state, if the reaction in (b) is a redox reaction.

....

....

.... [3]

(d) Liquid sulfur dioxide is stored in cylinders.
When the cylinder is opened the liquid quickly changes into a gas.
Use the kinetic particle theory to describe the changes in **movement** and **arrangement** of the particles when liquid sulfur dioxide becomes a gas.

....

....

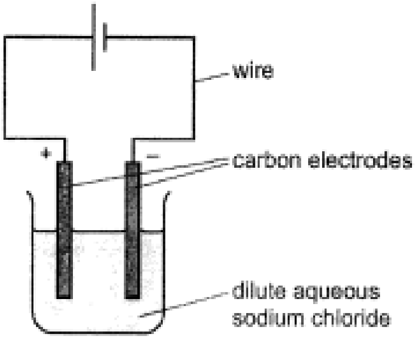
....

....

.... [2]

[Total: 7]

A7 A student carries out an electrolysis experiment using the apparatus shown below.



The student uses dilute aqueous sodium chloride.

(a) State the name given to any solution which undergoes electrolysis.

.... [1]

(b) (i) Hydroxide ions are discharged at the anode. Write the ionic half-equation for the anode.

.... [1]

(ii) Explain how the ionic half-equation shows the hydroxide ions are being oxidised.

....

.... [1]

(c) (i) Describe what the student observes at the cathode.

.... [1]

(ii) Write the ionic half-equation for the reaction at the cathode.

.... [1]

(d) The student repeats the experiment using concentrated aqueous sodium chloride. Describe what the student observes at:

- the cathode .... [1]
- the anode .... [1]

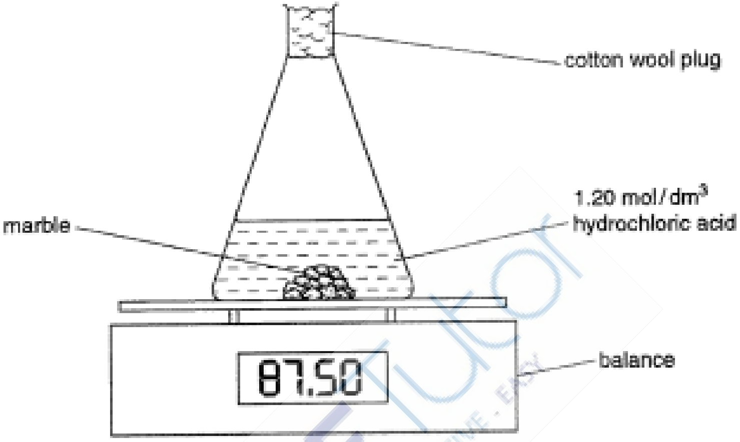
(e) Write the overall chemical equation for (d).

.... [1]

[Total: 8]

SECTION B (30 marks)
Answer all three questions in the spaces provided. The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 A student uses the apparatus shown to investigate the reaction between marble ($CaCO_3$) and hydrochloric acid.
10.0 g of marble lumps (an excess) are added to 30.0 cm^3 of 1.20 mol / dm^3 hydrochloric acid contained in a flask.
The mass of the flask and contents is recorded every 30 seconds. This is experiment **1**.
The experiment is repeated using the same mass of marble but finely powdered instead of lumps.
The volume and concentration of the hydrochloric acid used is unchanged. This is experiment **2**.



(a) The results of the two experiments are recorded in the table.
Complete the table by calculating the total change in mass at each time for both experiments. [2]

time / s	experiment 1 (lumps)		experiment 2 (powder)	
	mass of flask and contents / g	total change in mass / g	mass of flask and contents / g	total change in mass / g
0	87.50	0.00	87.50	0.00
30	87.22	0.28	87.02	0.48
60	87.02	0.48	86.83	0.67
90	86.87		86.74	
120	86.77		86.69	
150	86.69		86.69	
180	86.69		86.69	

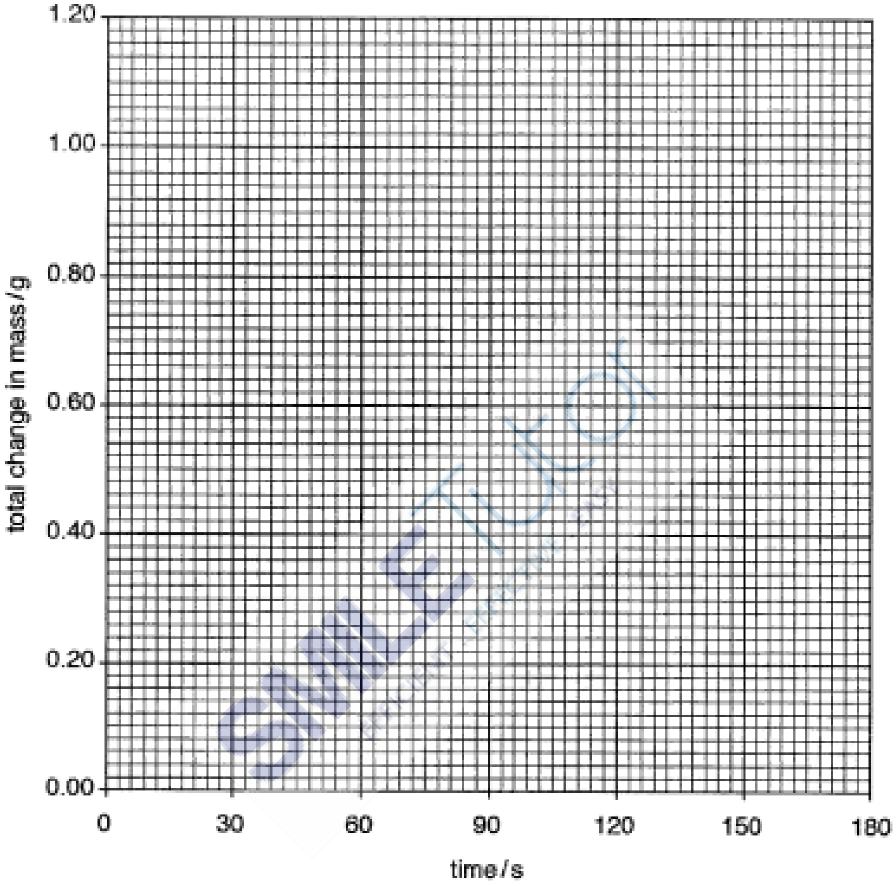
(b) Construct the equation for the reaction between calcium carbonate and hydrochloric acid. [1]

....

(c) Suggest why the mass of the flask and contents decreases as the reaction progresses.

.... [1]

(d) Plot the points for each experiment on the grid.
Draw a smooth curve through each set of points.
Label the curves 'experiment **1**' and 'experiment **2**'. [3]



Using your graph,

(i) what is the total change in mass in experiment **1** after 75 seconds,

.... [1]

(ii) what is the mass of the flask and contents in experiment **2** after 45 seconds?

.... [1]

(f) Using your equation in **(b)**, calculate the mass of marble that remains after reaction with 30 cm^3 of 1.20 mol / dm^3 hydrochloric acid. [3]

[Total: 12]

B9 (a) Steel may be coated with another metal, e.g. zinc or chromium, or with a polymer, e.g. poly(chloroethene), to prevent rusting.

(i) Suggest a property of poly(chloroethene) that makes it suitable for this purpose.

.... [1]

(ii) Explain why the steel will rust when the protective coating of chromium or polymer is broken.

....

.... [1]

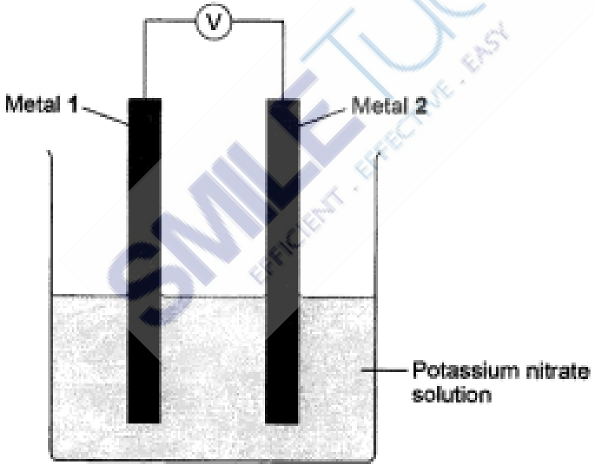
(iii) When the protective layer of zinc is broken, the steel does not rust. Suggest an explanation.

....

....

.... [2]

(b) A student investigated simple cells using the apparatus shown below.



- If metal **2** is more reactive than metal **1** then the voltage measured is positive.
- If metal **1** is more reactive than metal **2** then the voltage measured is negative.
- The bigger the difference in reactivity of the two metals, the larger the voltage produced.

The student's results are shown in the table below.

Metal 2 / Metal 1	Chromium	Copper	Iron	Tin	Zinc
Chromium	0.0 V				
Copper	1.2 V	0.0 V			
Iron	0.5 V	not measured	0.0 V		
Tin	0.8 V	-0.4 V	0.3 V	0.0 V	
Zinc	0.2 V	-1.0 V	-0.3 V	-0.6 V	0.0 V

(i) The ionic equation for the reaction occurring at the zinc electrode in the simple cell made using copper and zinc electrodes is:

$$Zn\ (s) \rightarrow Zn^{2+}\ (aq)\ + 2e^-$$

Zinc is oxidised in this reaction.
Give a reason why this is oxidation.

.... [1]

(ii) Which one of the metals used was the least reactive?
Give a reason for your answer.

....

.... [1]

(iii) Predict the voltage that would be obtained for a simple cell that has iron as metal **1** and copper as metal **2**.
Explain your answer.

....

....

....

....

.... [2]

[Total: 8]

Either

B10 (a) Nitrogen reacts with fluorine to form nitrogen trifluoride, NF_3.

(i) The chemical equation can be represented as shown below.

$$N{\equiv}N + 3\,F{-}F \rightarrow 2\,F{-}\underset{\displaystyle F}{\underset{|}{N}}{-}F$$

Some bond energies are shown in the table.

bond	bond energy in kJ / mol
N≡N	945
F–F	160
N–F	300

Calculate the energy change for the reaction between nitrogen and fluorine. [3]

(ii) Use your answer to (i) to deduce whether this reaction is endothermic or exothermic. Explain your answer.

....

.... [1]

(b) Draw a dot-and-cross diagram to show the arrangement of all the electrons in one molecule of nitrogen trifluoride. [2]

(c) (i) Silver nitrate can be prepared by reacting silver oxide with dilute nitric acid as shown below.

$$Ag_2O + 2HNO_3 \rightarrow 2AgNO_3 + H_2O$$

Excess silver oxide is reacted with 30.0 cm³ of 0.150 mol/dm³ nitric acid.
After purification the percentage yield of silver nitrate is 80.0 %.
Calculate the mass of silver nitrate prepared. [3]

(ii) Explain why excess silver oxide is used in the preparation of silver nitrate in (i).

.... [1]

[Total: 10]

Or

B10 (a) Silicon shows the same type of bonding and structure as diamond.
Silicon reacts with magnesium to form Mg_2Si.
Solid Mg_2Si reacts with dilute hydrochloric acid to form gaseous SiH_4 and a solution of magnesium chloride.

(i) Construct an equation for this reaction. Include state symbols.

.... [2]

(ii) Predict the shape of the SiH_4 molecule.

.... [1]

(b) Calcium chlorate (I), $Ca(ClO)_2$, is used as an alternative to sodium chlorate (I), NaClO, in some household products.

(i) The chlorate (I) ion is formed when cold aqueous sodium hydroxide reacts with chlorine. Write an ionic equation for this reaction.

.... [1]

(ii) The chlorate(I) ion is unstable and decomposes when heated as shown.

$$3ClO^- \rightarrow 2Cl^- + ClO_3^-$$

This reaction can be described as a disproportionation reaction.
Describe what is meant by disproportionation reaction.

....

.... [1]

(iii) Explain, in terms of oxidation state, if the disproportion reaction is a redox reaction.

....

....

....

.... [2]

(c) Phosphorus is a non-metal in Group V of the Periodic Table.
Phosphorus can be manufactured from calcium phosphate, $Ca_3(PO_4)_2$ as shown below.

$$2Ca_3(PO_4)_2 + 6SiO_2 + 10C \rightarrow 6CaSiO_3 + 10CO + P_4$$

What is the maximum mass of phosphorus that can be made using 300 g of silicon dioxide, SiO_2? [3]

[Total: 10]

ANSWER SHEET

Paper 1

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

Paper 2

SECTION A

A1 (a)

(i) A [1]

(ii) D / F [1]

(iii) E [1]

(iv) C [1]

(b)

(i) If moist, hydrogen will react explosively with sodium. [1]

(ii) $Fe_2O_3 + 3NaH \rightarrow 2Fe + 3NaOH$ [1]

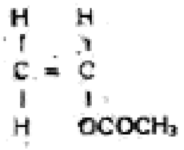
(iii) Fe_2O_3 is reduced to Fe because Fe^{3+} (in Fe_2O_3) gained electrons to form Fe. [3]
NaH is oxidised to NaOH because H^- (in NaH) lost electrons to form H^+ (in NaOH).

[Total: 9]

A2

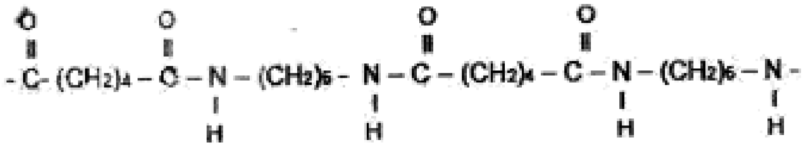
(a) [1]

$CH_2 = CHOCOCH_3$ or



$$\begin{array}{ccc} H & & H \\ | & & | \\ C & = & C \\ | & & | \\ H & & OCOCH_3 \end{array}$$

(b)



$$-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}-\underset{\underset{H}{|}}{N}-(CH_2)_6-\underset{\underset{H}{|}}{N}-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}-\underset{\underset{H}{|}}{N}-(CH_2)_6-\underset{\underset{H}{|}}{N}-$$

[2]

(c)

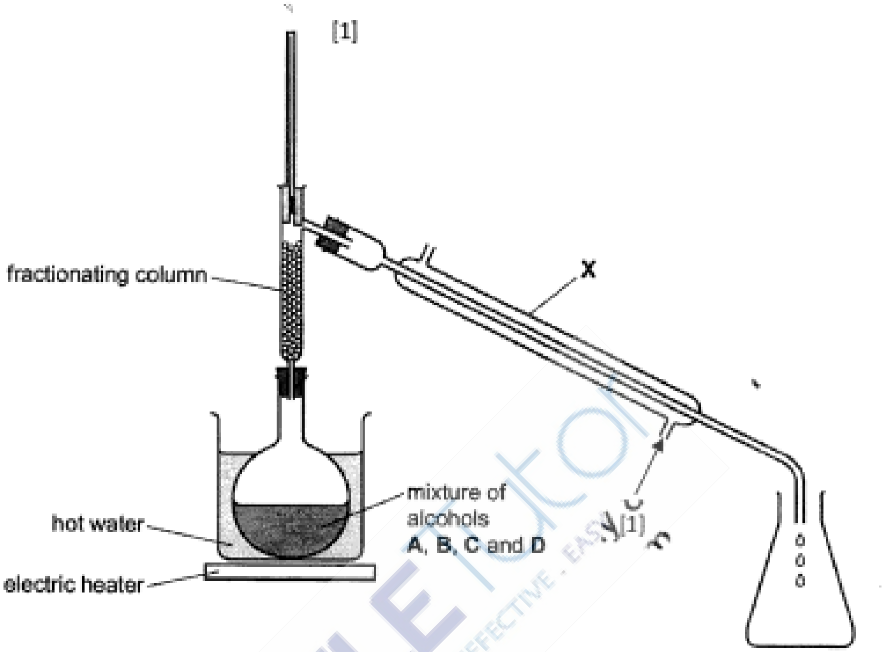
$C_{12}H_{26} \rightarrow C_2H_4 + C_{10}H_{22}$

OR

$C_{12}H_{26} \rightarrow 5C_2H_4 + C_2H_6$ [1]

[Total: 4]

A3



(a) Liebig condenser [1]

(b) Alcohols will evaporate through and will not distil off at any specific temperatures. [1]

(c) Alcohols are flammable. [1]

(d) Water will boil first before the alcohols can boil because they have higher boiling points and the alcohols will not be separated out. [1]

[Total: 6]

A4 (a) (i) They have the same molecular formula but different structural formula. [2]

(ii)

$$\begin{array}{c} OH \\ | \\ CH_3 - CH_2 - CH - CH_3 \end{array}$$ [1]

(b) (i) Acidified potassium manganate (VII) [1]
oxygen

(ii) carboxylic acid [1]

(iii) C_3H_7COOH [1]

(c) (i) Measure the volume of gas produced over regular time intervals [1]

(ii) There was an increase in temperature. [1]

(iii) Glucose was used up. [1]

[Total: 9]

A5 (a) 1 mol of H_2 = 2(1) = 2g [2]

No. of mol of H_2 = $\frac{25}{2}$ = 12.5

Heat Energy released = 12.5 x 286 = 3575 kJ

(b) The amount of energy given out to make bonds in 2 mols of water is greater than the amount of energy taken in to make bonds in 2 mol of hydrogen and one mol of oxygen. [2]

(c) (i) Advantage of using hydrogen-oxygen fuel is that it does not produce any pollutants (produces water) but petrol may produce carbon monoxide or carbon. [1]

(ii) $H_2 \rightarrow$ ....$2H^+$............... + $2e^-$

$O_2 + 4H^+ + 4e^- \rightarrow$ ....$2H_2O$.................... [2]

[Total: 7]

A6 (a) Sulfur dioxide reacts with the rain to form acid rain that destroys crops and buildings. [1]

(b) $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$ [1]

(c) FeS_2 is oxidized to Fe_2O_3 because oxidation state of iron increase from +2 to +3. O_2 is reduced to Fe_2O_3 and SO_2 because the oxidation state of oxygen decrease from 0 to -2 in Fe_2O_3 and SO_2. FeS_2 is also oxidised to SO_2 because the oxidation state of sulfur increase from -1 to +4. [3]

(d) Liquid sulfur dioxide molecules are arranged closely packed together in a disorderly arrangement sliding over each other under high pressure in the cylinders. When the pressure in the cylinders is reduced when the cylinders are opened, liquid molecules move further apart in all directions with a lot of empty space between them when they are in the gaseous state. [2]

[Total: 7]

A7 (a) electrolyte

(b) (i) $4OH^-(aq) \rightarrow 2H_2O\ (l) + O_2\ (g) + 4e^-$

(ii) OH^- ions loses electrons to form water and oxygen.

(c) (i) Effervescence of a colourless gas seen. [1]

(ii) $2H^+ (aq) + 2e^- \rightarrow H_2 (g)$ [1]

(d)

- the cathode : effervescence of a colorless gas seen [1]
- the anode : effervescence of a yellow green gas produced [1]

(e) $2NaCl (aq) + H_2O (l) \rightarrow 2NaOH (aq) + Cl_2 (g) + H_2 (g)$ [1]

[Total: 8]

End of Section A

SECTION B (30 marks)

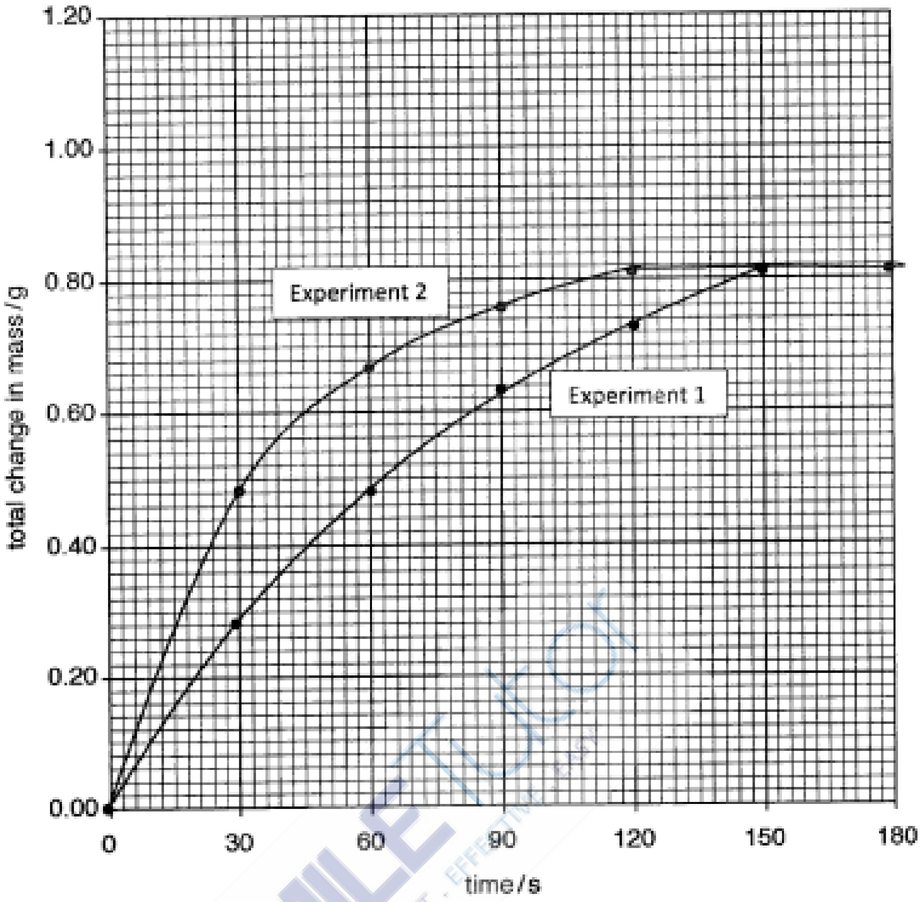
B8 (a) [2]

time / s	experiment 1 (lumps)		experiment 2 (powder)	
	mass of flask and contents / g	total change in mass / g	mass of flask and contents / g	total change in mass / g
0	87.50	0.00	87.50	0.00
30	87.22	0.28	87.02	0.48
60	87.02	0.48	86.83	0.67
90	86.87	0.63	86.74	0.76
120	86.77	0.73	86.69	0.81
150	86.69	0.81	86.69	0.81
180	86.69	0.81	86.69	0.81

(b) $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$ [1]

(c) The production of carbon dioxide gas which escapes into the air. [1]

(d)



[3]

(i) 0.56 g [1]

(ii) 87.50 – 0.58 = 86.92 g [1]

(f) No. of mol of HCl = 0.0300 x 1.20 = 0.0360 [3]

$\frac{\text{No. of mol. of } CaCO_3}{\text{No. of mol. of HCl}} = \frac{1}{2}$

No. of mol of $CaCO_3$ = $\frac{1}{2}$ x 0.0360 = 0.0180

Mass of $CaCO_3$ used = 0.0180 x (40 + 12 + 3(16)) = 1.80 g

Mass of $CaCO_3$ remains = 10.0 - 1.80 = 8.2 g

[Total: 12]

B9 (a) (i) Poly(chloroethene) is inert and corrosion resistant. [1]

(ii) Iron in steel will be exposed to the air and water and hence, will rust. [1]

(iii) Zinc is more reactive than iron and will undergo sacrificial protection and will corrode in place of iron; hence, preventing from rusting. [2]

(b) (i) Zinc lost electrons to form Zn^{2+} [1]

(ii) Copper. It sets up a voltage of +1.2 V (the largest) with chromium. [1]

(iii) The voltage will be -0.7V. Since iron is more reactive than copper and as metal 1, the voltage will be negative. Since the voltage between zinc and copper is 1 V; the voltage between zinc and iron is 0.3 V; hence, the voltage between iron and copper is 0.7 V. [2]

[Total: 8]

Either

B10 (a) (i) Amount of energy taken in to break bonds in one mole of N_2 and 3 moles of F_2

$= 945 + 3(160) = 1425$ kJ

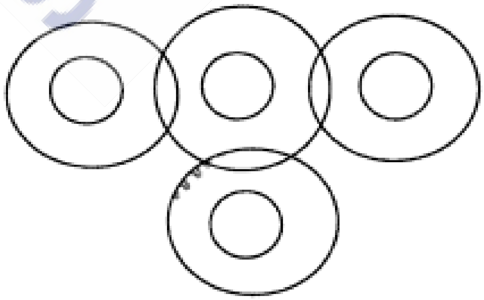
Amount of energy given out to make bonds in 2 mols of NF_3

$= 2(3)(300) = 1800$ kJ

Hence, $\Delta H = 1425 - 1800 = -375$ kJ [3]

(ii) The reaction is exothermic because ΔH is negative. [1]

(b) Draw a dot-and-cross diagram to show the arrangement of all the electrons in one molecule of nitrogen trifluoride. [2]



(c) (i) No. of mol of $HNO_3 = 0.030 \times 0.150 = 0.00450$

$$\frac{\text{No. of mol of AgNO}_3}{\text{No. of mol of HNO}_3} = \frac{2}{2} = 1$$ [3]

No. of mol of $AgNO_3 = 0.00450$

Mass of $AgNO_3 = 0.00450 \times (108 + 14 + 3(16))$
$= 0.765$ g

Mass of $AgNO_3$ produced $= \frac{80}{100} \times 0.765 = 0.612$ g

(ii) To ensure that all the nitric acid is used up. [1]

[Total: 10]

Or

B10 (a) (i) $Mg_2Si\ (s) + 4HCl\ (aq) \rightarrow SiH_4\ (g) + 2MgCl_2\ (aq)$ [2]

(ii) It is tetrahedral in shape. [1]

(b) (i) $4OH^-\ (aq) + Cl_2\ (g) \rightarrow 2ClO^-\ (aq) + 2H_2O\ (l)$ [1]

(ii) A reaction where a substance undergoes oxidation and reduction at the same time. [1]

(iii) It is a redox reaction because ClO^- is reduced to Cl^- and ClO^- is also oxidized to ClO_3^-.
ClO^- is reduced to Cl^- because the oxidation state of chlorine decreased from +1 to -1. ClO^- is oxidized to ClO_3^- because the oxidation state of chlorine is increased from +1 to +5. [2]

(c) No. of mol of $SiO_2 = \frac{300}{28 + 2(16)} = 5$ [3]

$\frac{\text{No. of mol of } P_4}{\text{No. of mol of } SiO_2} = \frac{1}{6}$

Therefore, no, of mol of $P_4 = \frac{1}{6} \times 5 = 0.833$

Mass of P_4 produced $= 0.833 \times 4(31) = 103.3$ g
$= 103$ g (3 sf)

[total: 10]

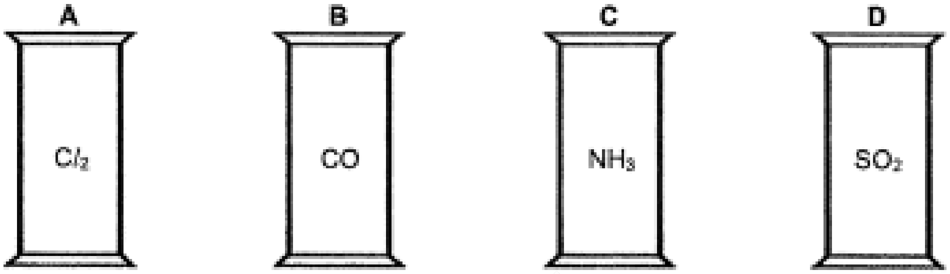
End of Paper

JURONGVILLE SECONDARY SCHOOL PRELIM PAPER

1 Four identical gas jars are filled with different gases.

The lids are taken off the gas jars and they are left open to the air for a few hours.

Which gas jar will first contain the most air in it?



2 A pale green solution X gives a green precipitate with excess aqueous sodium hydroxide.

An alkaline gas is only given off when the mixture is warmed with powdered aluminium.

Which ions does X contain?

A ammonium and copper(II) ions

B ammonium and iron(II) ions

C copper(II) and nitrate ions

D iron(II) and nitrate ions

3 Which apparatus **cannot** be used to measure the rate of neutralisation between solid sodium carbonate and aqueous hydrochloric acid?

A	electronic balance	**B**	gas syringe
C	stopwatch	**D**	thermometer

4 An analysis is carried out on a plant extract containing some coloured pigments.

In Fig. 4.1, a small amount of plant extract is dotted on a chromatography paper and separated using solvent A.

After drying the chromatography paper, the chromatography paper is subjected to another separation using solvent B, as shown in Fig. 4.2.

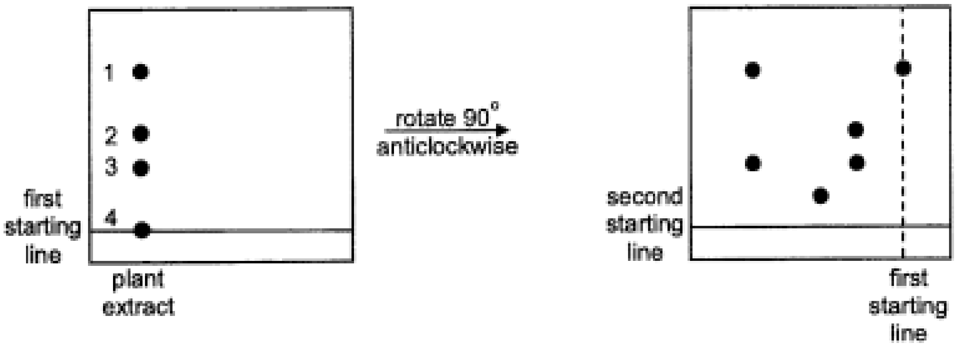


Fig. 4.1 **Fig. 4.2**

Which statement is **not** true?

A Pigment 2 is less soluble in solvent A than in solvent B.

B Pigment 4 is most likely a pure substance.

C Pigments 1 and 3 have a same substance.

D The components in pigment 1 have different solubilities in solvent B.

5 An ion X^+ contains 23 nucleons and 10 electrons.

What does the nucleus of the ion X^+ contain?

	protons	neutrons
A	9	14
B	10	13
C	11	11
D	11	12

6 A covalent compound has the following structural formula.

$$X - Y \equiv Z$$

Which row shows the possible electronic structures of the atoms X, Y and Z?

	X	Y	Z
A	1	2,2	2,5
B	1	2,4	2,3
C	2,8,7	2,2	2,3
D	2,8,7	2,4	2,5

7 Peeling onions often cause tearing of the eyes due to the release of a sulfide compound.

Peeling them under running water reduces the problem.

Which statements are true of the sulfide compound?

1 It has a low boiling point.
2 It has small and light ions with weak bonding.
3 It is a covalent compound with weak covalent bonds.
4 It is soluble in water.

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

8 The strongest ionic crystal lattices are generally observed to consist of highly charged ions combined in a 1 : 1 ratio.

Which two elements are likely to form crystals with the highest melting point?

A aluminium and oxygen
B calcium and fluorine
C lithium and fluorine
D magnesium and oxygen

9 Sulfur vapour with a mass of 128 g has the same volume as 16 g of oxygen at the same temperature and pressure.

What is the formula of a molecule of sulfur vapour?

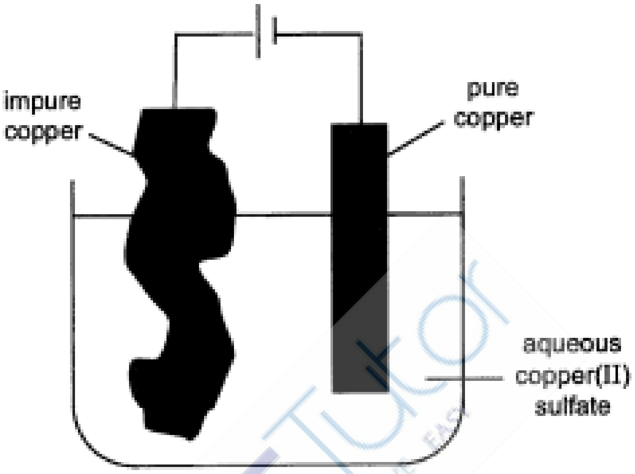
A S_2
B S_4
C S_6
D S_8

10 75 cm^3 of 0.200 mol / dm^3 of sodium hydroxide is added to 25 cm^3 of 0.200 mol / dm^3 sulfuric acid.

What is the concentration of the excess sodium hydroxide in the resultant solution?

A	0.005 mol / dm^3	**B**	0.010 mol / dm^3
C	0.030 mol / dm^3	**D**	0.050 mol / dm^3

11 A student carried out an electrolytic purification of copper as shown.



The table shows the information about this electrolytic purification.

mass of	before electrolytic purification / g	after electrolytic purification / g
anode	100	10
cathode	10	80

What was the percentage impurity of the impure copper anode?

A	10.0 %	**B**	20.0 %
C	30.0 %	**D**	90.0 %

12 When gold plating an orchid, a coating containing fine metal or carbon particles is first painted onto the orchid.

Why is this coating applied?

A It allows the gold to form a tough alloy on the orchid's surface.

B It gives the orchid a conductive surface so that it can act as the anode.

C It gives the orchid a conductive surface so that it can act as the cathode.

D It gives the orchid a sticky surface so that the gold plating will not fall off.

13 Which observation will be made when dilute sulfuric acid is electrolysed using graphite electrodes?

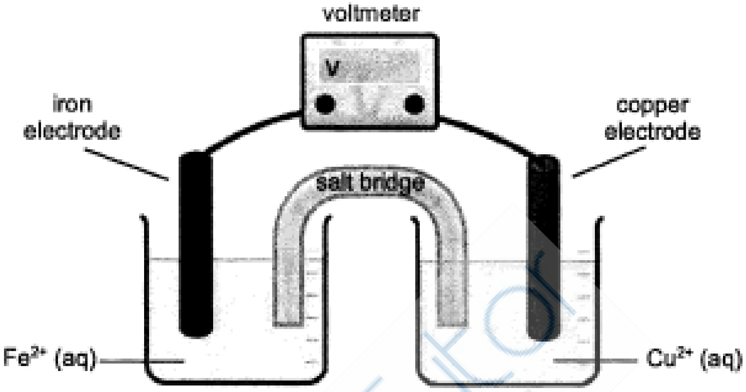
A No gas is evolved at both the cathode and anode.

B The gas evolved at the anode extinguishes a lighted splint with a 'pop' sound.

C The gas evolved at the cathode is less dense than air.

D The gas evolved at the cathode relights a glowing splint.

14 The figure shows the set-up of a simple cell involving iron and copper electrodes immersed in their respective electrolytes.



Which statement is **not** true for the experiment?

A The colour intensity of copper(II) solution decreases over time.

B The electrons flow from left to right through the salt bridge.

C There is a decrease in the mass of iron electrode.

D There is an increase in the mass of copper electrode.

15 The table shows the energy released by the complete combustion of some compounds used as fuels.

compound	formula	M_r	ΔH / kJ / mol
methane	CH_4	16	–880
ethanol	C_2H_5OH	46	–1380
propane	C_3H_8	44	–220
heptane	C_7H_{16}	100	–4800

Which fuel produces the most energy when 1 g of the compound is completely burnt?

A methane **B** ethanol

C propane **D** heptane

16 The equations for three reactions are given.

reaction 1 $H_2 \rightarrow 2H$

reaction 2 $2H + O \rightarrow H_2O$

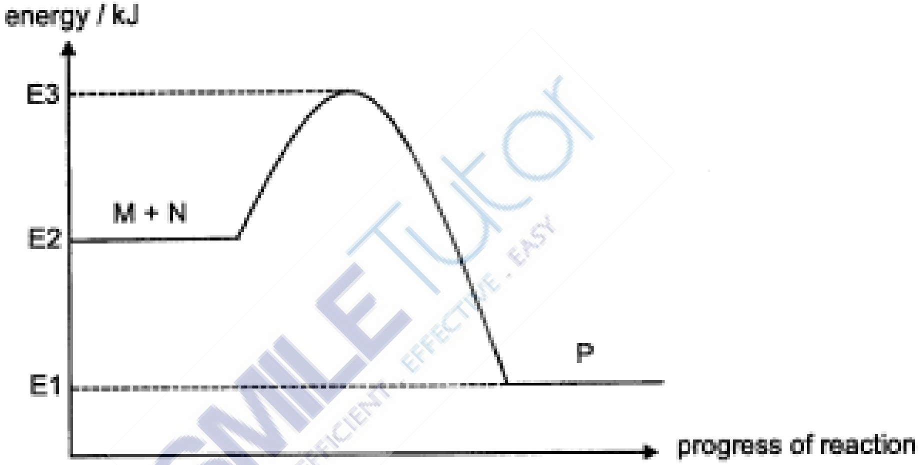
reaction 3 $HCl \rightarrow H + Cl$

Which of these reactions are endothermic?

A	reaction 1 only	**B**	reactions 1 and 2 only
C	reactions 1 and 3 only	**D**	reactions 2 and 3 only

17 The energy profile diagram for the following reaction is shown.

$M + N \rightleftharpoons P$ $\Delta H = -108$ kJ / mol

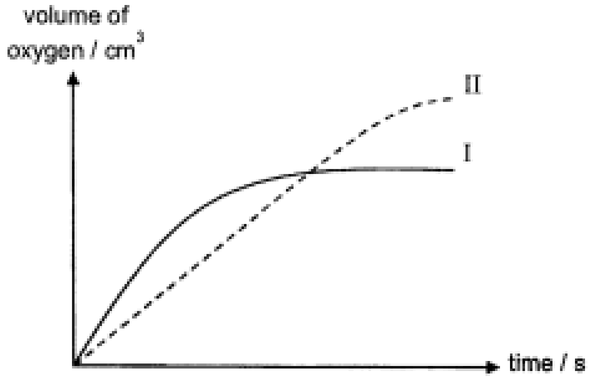


Which equation represents the activation energy of the forward reaction?

A	E1 + E2	**B**	E2 – E1
C	E3 – E1	**D**	E3 – E2

18 Curve I is obtained by the decomposition of 50 cm^3 of 1 mol / dm^3 aqueous hydrogen peroxide, catalysed by manganese(IV) oxide.

$$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$$



Which change will produce curve II?

A adding 60 cm^3 of 1 mol / dm^3 aqueous hydrogen peroxide

B adding 100 cm^3 of 0.1 mol / dm^3 aqueous hydrogen peroxide

C lowering the temperature

D using 75 cm^3 of 0.5 mol / dm^3 aqueous hydrogen peroxide instead

19 Which observation is that of a redox reaction?

A Aqueous potassium iodide turns brown when chlorine gas is bubbled into it.

B Blue precipitate is formed when aqueous ammonia is added to copper(II) nitrate solution.

C Bubbles of gas are observed when an acid reacted with solid magnesium carbonate.

D Solution turned blue when copper(II) sulfate crystals are added to hydrochloric acid.

20 When acidified aqueous hydrogen peroxide is added to aqueous potassium manganate(VII), the reaction takes place:

$$2MnO_4^-(aq) + 5H_2O_2(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5O_2(g) + 8H_2O(l)$$

Which statement about the reaction is correct?

A Hydrogen peroxide acts as an oxidising agent.

B The oxidation number of manganese changes from +7 to +2.

C The potassium manganate(VII) is oxidised.

D The potassium manganate(VII) solution turns green.

21 Which salt can only be prepared by titration method?

A aluminium sulfate

B ammonium sulfate

C copper(II) sulfate

D iron(II) sulfate

22 Freshly distilled water has a pH of 7.0.

After it was left standing for a short time, the pH was observed to have dropped below 7.0.

Which of the equations best explains the phenomenon?

A $HCl(aq) \rightleftharpoons H^+(aq) + Cl^-(aq)$

B $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$

C $H_2O(l) + CO_2(g) \rightleftharpoons 2H^+(aq) + CO_3^{2-}(aq)$

D $H_2O(l) + NH_3(g) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

23 Three flasks containing different solutions are labelled incorrectly.

In order to identify the solutions, a student mixes two of the solutions at one time and recording the change in temperature.

Which row shows an **incorrect** explanation to the student's observation?

	observation	explanation
A	There is no change in temperature when two solutions are mixed.	The solutions could be hydrochloric acid and sodium hydroxide respectively.
B	There is no change in temperature when two solutions are mixed.	The solutions could be hydrochloric acid and sulfuric acid respectively.
C	There is temperature rise when two solutions are mixed.	The solutions could be hydrochloric acid and sodium hydroxide respectively.
D	There is temperature rise when two solutions are mixed.	The solutions could be sulfuric acid and sodium hydroxide respectively.

24 Germanium, Ge, is in the same group of the Periodic Table as carbon.

Which formula would **not** belong to a compound of germanium?

A	$NaGeO_3$	**B**	Na_4Ge
C	GeH_4	**D**	GeO_2

25 Which statement is **false** about the Periodic Table?

A Group VII elements are coloured.

B The atomic radii of elements increases down the group.

C The density of alkali metals decreases down the group.

D The metallic nature of the elements increases down the group.

26 Which element is most likely to be a transition metal?

	density / g / cm^3	melting point / °C	number of chlorides
A	0.07	–259	1
B	3.10	–7	2
C	2.07	113	1
D	8.92	1083	2

27 Metal P can reduce steam to hydrogen, but metal Q cannot reduce steam.

Based on this information, which action will cause a reaction to occur?

A heating a mixture of metal Q and oxide of metal P

B heating carbonate of Q strongly

C passing hydrogen over the heated oxide of metal P

D passing steam over the heated oxide of metal P

28 Alloys are usually harder than the metals that they are made of.

Which difference would explain the hardness of alloys?

A	atomic sizes	**B**	densities
C	electrical conductivities	**D**	relative atomic masses

29 The position of metal X in the reactivity series is shown.

decrease in reactivity →

K Na Al X Fe Pb Cu Ag

What method **cannot** be used to extract X from its ore?

A electrolysis of its aqueous sulfate
B electrolysis of its molten oxide
C reduction of its oxide by heating with coke
D reduction of its sulfide by heating with coke

30 The metal chromium liberates hydrogen from dilute hydrochloric acid, but does not react with cold water.

When a piece of chromium is placed in lead(II) nitrate solution, grey solid is formed.

Which row shows the reactivity of calcium, chromium, lead and platinum in decreasing order?

A calcium, chromium, lead, platinum
B calcium, lead, chromium, platinum
C chromium, calcium, lead, platinum
D platinum, lead, chromium, calcium

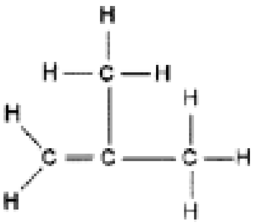
31 Why is a tin-plated iron sheet less resistant to rusting than a galvanised iron sheet?

A Iron is less reactive than zinc but more reactive than tin.
B Tin does not adhere to iron as well as zinc.
C Zinc forms a layer that protects the iron surface but tin does not.
D Zinc is more scratch-resistant as compared to tin.

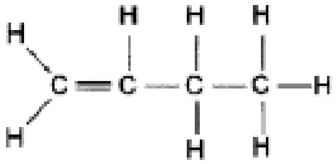
32 Which gas can be removed from the exhaust gases of a petrol-powered car by its catalytic convertor?

A carbon dioxide
B carbon monoxide
C nitrogen
D steam

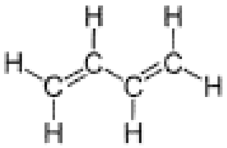
33 Structures of three hydrocarbons are shown.



hydrocarbon 1



hydrocarbon 2



hydrocarbon 3

Which statements about these hydrocarbons are correct?

1 On complete combustion of one mole of each hydrocarbon, they give the same volume of carbon dioxide.

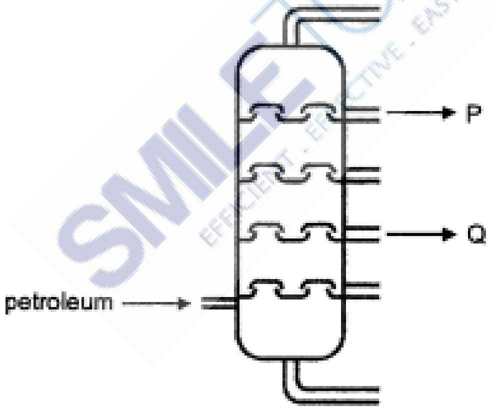
2 They all form addition compounds with bromine.

3 They are all isomers of the same hydrocarbon.

A 1 and 2 only **B** 1 and 3 only

C 2 and 3 only **D** 1, 2 and 3

34 The diagram shows the separation of crude oil into fractions.



Which statement about fractions P and Q is correct?

A P and Q are mainly alkenes.

B P and Q boil at a fixed temperature.

C P can be cracked to meet the higher demands of Q.

D P has a lower boiling point and a higher flammability than Q.

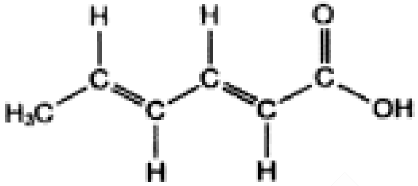
35 A food chemist wants to create the odour of pineapples in a product.

An ester with this odour has the formula $C_3H_7COOC_2H_5$.

Which pair of reactants would produce this ester?

A CH_3COOH and C_3H_7OH
B C_2H_5COOH and C_2H_5OH
C C_2H_5COOH and C_3H_7OH
D C_3H_7COOH and C_2H_5OH

36 Sorbic acid is used as a food preservative as it kills fungi and moulds that would possibly grow on food.



Sorbic acid will react with

- bromine in an organic solvent.
- Hydrogen at 200 °C in the presence of nickel catalyst.

How many moles of bromine and hydrogen will be incorporated into one mole of sorbic acid in these reactions?

	moles of bromine	moles of hydrogen
A	2	2
B	2	3
C	2.5	2
D	2.5	3

37 Which property does **not** change when ethene is polymerised to form poly(ethene)?

A boiling point
B melting point
C molecular formula
D percentage composition of carbon

38 Propene reacts with steam at 300 °C in the presence of phosphoric acid as a catalyst to produce a colourless liquid P.

On warming, liquid P with acidified potassium manganate(VII) solution, a colourless liquid Q is produced.

Identify liquids P and Q.

	P	Q
A	propane	butanol
B	propanol	butanoic acid
C	propanol	propanoic acid
D	propyl ethanoate	water

39 Polyunsaturated fats are considered healthy fats as they may reduce your risk of heart disease, especially when substituted for saturated fats.

An example of a polyunsaturated fat is C_6H_9COOH.

How many double covalent bonds are present in one molecule of the acid?

A 1 **B** 2

C 3 **D** 4

40 In which reaction is water produced?

A manufacture of ethanol from ethene

B manufacture of margarine from vegetable oils

C manufacture of poly(ethene) from ethene

D manufacture of Terylene from an alcohol and a carboxylic acid

Section A

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

A1 Table 1.1 shows some properties of four oxides.

Table 1.1

oxide	melting point / °C	electrical conductivity when molten	reaction with water	resulting pH of solution
W	17	poor	exothermic	1
X	1280	good	exothermic	14
Y	1720	poor	none	7
Z	2850	good	very little	8

(a) Use the letters W, X, Y and Z to answer the questions.

Each letter may be used once, more than once or not at all.

(i) Which of the oxides are non-metallic oxides?

.... [1]

(ii) Which of the oxides have a giant lattice structure?

.... [1]

(iii) Which of the oxide has a giant molecular structure?

.... [1]

(b) Oxide W is an atmospheric pollutant which changes the colour of potassium manganate(VII), and forms acid rain.

(i) Suggest an identity for oxide W.

.... [1]

(ii) Write an equation to show how oxide W identified in **(b)(i)** forms acid rain.

.... [1]

(iii) State two negative impacts of acid rain on the environment.

....

....

....

.... [2]

[Total: 7]

A2 Magnesium is best known for burning with a characteristic brilliant white light.

The metal was first produced by Sir Humphry Davy in 1808 by the electrolysis of a molten mixture of magnesia, MgO with mercury oxide. Mercury oxide was added as an impurity and inert electrodes were used during the electrolysis.

(a) Construct ionic half-equation with state symbols to show how the product is formed at the cathode.

.... [1]

(b) Suggest a reason why the product obtained at the cathode was a mixture.

.... [1]

(c) A gas was obtained at the anode.

Describe a positive test to identify the gas formed at the anode.

....

.... [2]

(d) Give a reason for adding mercury oxide as an impurity.

.... [1]

[Total: 5]

A3 A student tried to prepare magnesium sulfate by reacting sulfuric acid with magnesium oxide.

(a) Explain why this method **cannot** be used to prepare barium sulfate from sulfuric acid and barium oxide.

....

.... [2]

(b) Describe a suitable method of preparing a pure and dry sample of barium sulfate. Suggest the reagents required.

....

....

....

....

....

.... [4]

[Total: 6]

[Turn over

A4 Table 4.1 lists some physical properties of the metals found in Period 4 of the Periodic Table.

Table 4.1

	proton number	atomic radius / nm	ionic radius / nm	melting point / °C	density / g / cm^3	electrical conductivity / S / m
calcium	20	0.197	0.114	842	1.54	29.8 x 10^6
iron	26	0.126	0.075	1538	7.86	9.93 x 10^6
copper	29	0.128	0.087	1084	8.92	59.6 x 10^6

(a) Explain why the ionic radius of the metal ion is always smaller than its atomic radius.

....

....

.... [2]

(b) The high electrical conductivity of copper makes it a very useful element for making electrical components.

Using the data from Table 4.1,, suggest why copper is not usually used as overhead electrical cables.

.... [1]

(c) Using the data from Table 4.1, explain why the other metals are unsuitable for making electrical wires.

calcium: ....

.... [1]

iron: ....

.... [1]

[Total: 5]

A5 Chlorofluorocarbons, CFCs, are sometimes used as propellants in aerosols.

Ozone hole are caused by reactions involving CFCs.

(a) Explain why ozone hole can cause harm to humans.

....

.... [2]

(b) Difluoromethane, CH_2F_2, is a hydrofluorocarbon. It can be used instead of CFCs in aerosols.

Draw a dot and cross diagram to show the bonding in CH_2F_2, showing only the valence electrons.

[2]

(c) Difluoromethane can be synthesised by reacting methane with fluorine.

$$CH_4 + F_2 \rightarrow CH_3F + \text{substance X}$$

$$CH_3F + F_2 \rightarrow CH_2F_2 + \text{substance X}$$

(i) Name substance X.

.... [1]

(ii) What is the name for this type of reaction?

.... [1]

(iii) State the condition required for the reaction to occur.

.... [1]

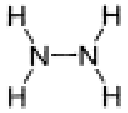
(iv) Gaseous bromine will also react with methane. Suggest whether the reaction is faster or slower than fluorine. Explain your answer.

....

.... [1]

[Total: 8]

A6 **(a)** One of the early alternative rocket fuels was hydrazine, N_2H_4. The structure of hydrazine is shown.



Liquid hydrazine combined with liquid oxygen in the combustion chamber in the rocket engine to produce thrust for the rocket. The equation of the combustion reaction is shown.

$$N_2H_4(l) + O_2(l) \rightarrow N_2(g) + 2H_2O(l) \qquad \Delta H = -585 \text{ kJ / mol}$$

Table 6.1 shows the bond energies of some covalent bonds.

Table 6.1

bond	N – H	N ≡ N	O = O	O – H	N – N
bond energy / kJ / mol	388	944	496	463	

(i) Calculate the bond energy of N – N bond.

bond energy of N – N bond = ... kJ / mol [2]

(ii) Explain, using bond energies, why the above reaction is exothermic, in terms of bond breaking and bond forming.

....

.... [1]

(iii) Draw an energy profile diagram for the reaction, showing the activation energy, enthalpy change, reactants and products.

[3]

(b) Butane is a fuel used in portable heaters.

For complete combustion of one mole of butane, the enthalpy change is –2880 kJ.

Calculate the quantity of heat evolved from the combustion of 16 dm^3 of butane, at room temperature and pressure.

heat evolved = ... kJ [2]

[Total: 8]

A7 Ammonia is manufactured in the Haber process.

(a) Explain, with the help of an equation, why nitrogen and hydrogen are mixed in a ratio of 1 : 3 by volume.

....

.... [2]

(b) State the essential conditions required in the Haber process.

.... [1]

(c) Ammonia is used to manufacture nitric acid by first converting ammonia to nitrogen monoxide.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$$

(i) In terms of the collision between reacting particles, state and explain how the rate changes when the pressure is increased.

....

.... [1]

(ii) During the reaction, ammonia and oxygen are passed through a powdered catalyst. Explain how the catalyst increases the speed of reaction.

....

.... [1]

(iii) The formation of nitrogen monoxide can be determined by pH changes. Explain how this is possible.

....

.... [1]

[Total: 6]

A8 Fig. 8.1 shows the stages involved in the extraction of zinc from zinc blende, which contains mainly zinc sulfide, ZnS.

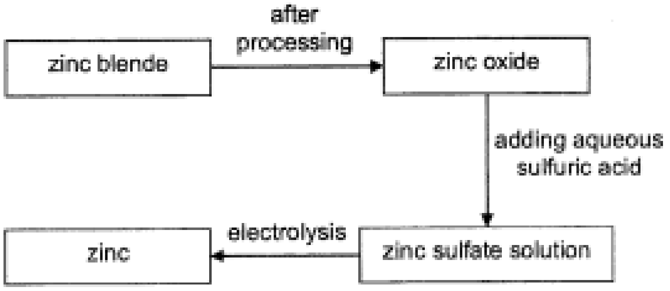


Fig. 8.1

Zinc sulfate solution obtained contained ions of other metals, which are present as impurities in zinc oxide.

(a) It is necessary to remove ions of metals which are less reactive than zinc from zinc sulfate solution before electrolysis.

However, it is not necessary to remove ions of metals which are more reactive than zinc.

Explain why.

....

....

....

.... [2]

(b) Suggest how to remove the metal ions that are less reactive than zinc from zinc sulfate solution before electrolysis.

....

....

.... [2]

(c) Suggest a more economical method to reduce zinc oxide to zinc metal.

....

.... [1]

[Total: 5]

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.

B9 Transition metals occupy the middle portions of the long periods of the Periodic Table, between the groups on the left-hand side and the groups on the right-hand side.

Each transition metal may have several oxidation states, which shows the number of electrons that the transition metal would lose if it were to bond with other atoms. Table 9.1 shows the range of oxidation states of the first row of transition metals in their compounds. Some of the oxidation states are uncommon and unstable. The important ones are underlined.

Table 9.1

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
								+1	
	+2	+2	+2	+2	+2	+2	+2	+2	+2
+3	+3	+3	+3	+3	+3	+3	+3	+3	
	+4	+4	+4	+4	+4	+4	+4		
		+5	+5	+5					
			+6	+6	+6				
				+7					

Chromium is a hard bluish-white metal, whose name refers to its many colourful compounds. Chromium, like other transition metals, forms a few oxides. Table 9.2 gives some information of the common oxides of chromium.

Table 9.2

formula of oxide	melting point / °C	nature of oxide	colour of oxide
CrO	decomposes at 300 °C	basic	black
Cr_2O_3	2450	amphoteric	dark green
CrO_3	190	acidic	deep red

Transition metals are not as reactive as alkali metals, but they are hard and strong metals. Hence, transition metals are often used for making objects and machineries. An example is titanium which has high strength, is strong as steel but 45% lighter, and is resistant to corrosion. Hence, titanium is used in aircrafts, ships and hip replacement joints. However, titanium is more expensive than iron, and five times more expensive than stainless steel.

[Turn over

Most titanium is extracted from its ore, rutile, which contains titanium dioxide. Titanium cannot be extracted by using carbon as a reducing agent, as titanium forms a carbide, TiC. The presence of carbide makes the metal brittle and thus, titanium is extracted from its ore in two stages as shown in Fig. 9.1

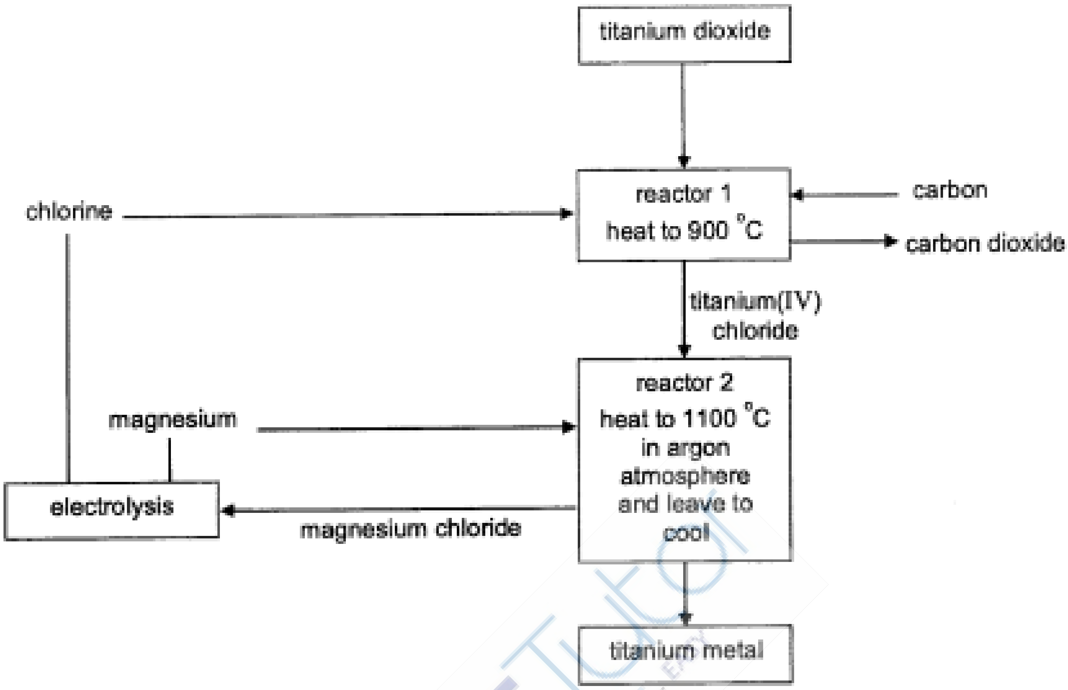


Fig. 9.1

Fig. 9.2 shows the mass of titanium metal produced from pure rutile ore and impure rutile ore. The difference between the two lines represents the amount of waste rock in the impure ore.

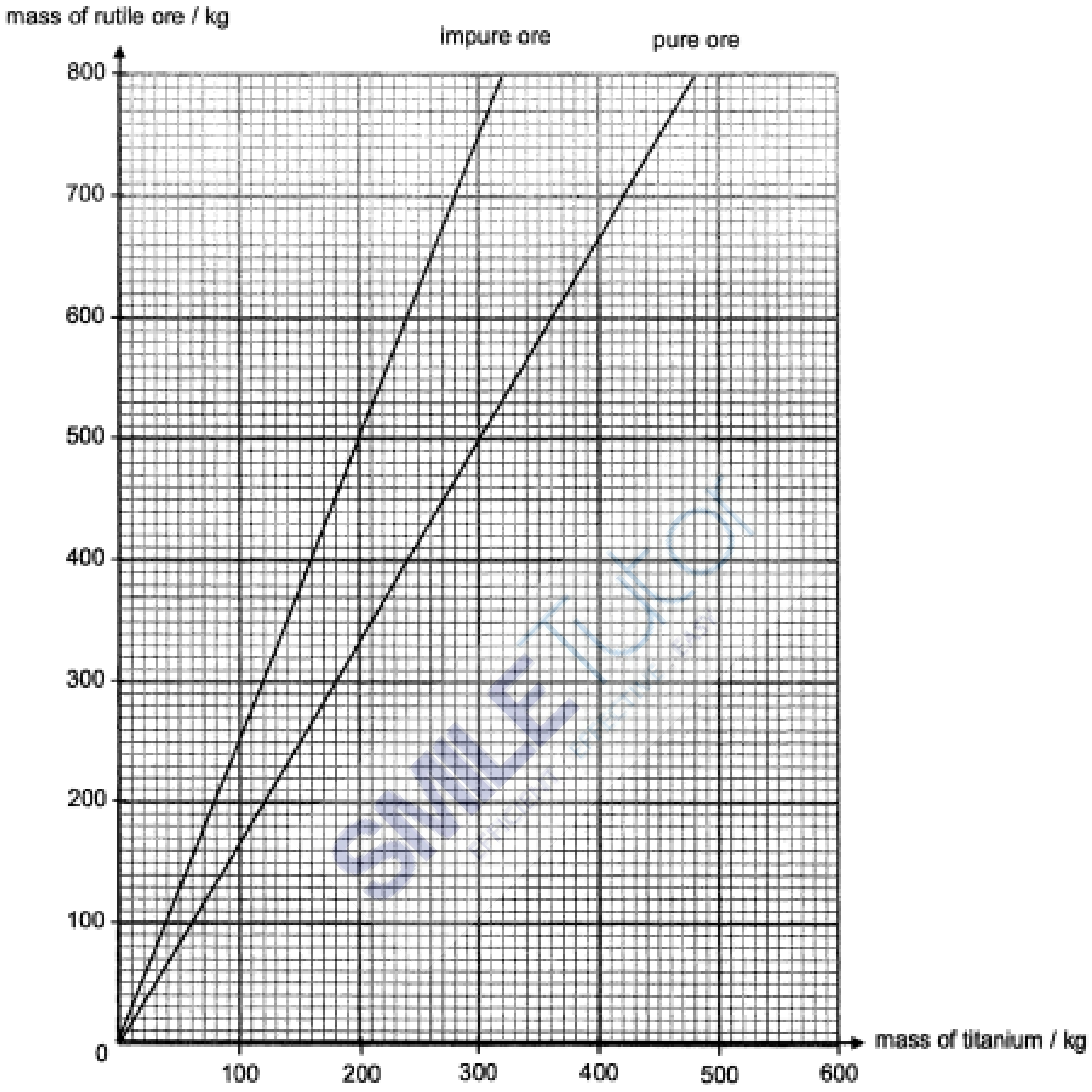


Fig. 9.2

(a) Explain why +2 oxidation state is the most common amongst the transition metals.

....

.... [1]

[Turn over

(b) State the relationship between the oxidation state of chromium oxides and the nature of the oxides.

....

.... [1]

(c) Similar to chromium, manganese also forms a few oxides. The chemistry of manganese resembles that of chromium. Predict the nature of the oxides.

name of oxide	nature of oxide
manganese(VII) oxide	
manganese(IV) oxide	
manganese(II) oxide	

[1]

(d) Describe how magnesium chloride was recycled in Fig. 9.1.

....

.... [2]

(e) **(i)** From Fig. 9.1, construct the equation to show the reaction which produces titanium metal.

.... [1]

(ii) Besides high temperature, state one other condition for the reaction and explain why this condition is required.

....

.... [2]

(f) From the impure ore, 300 kg of pure titanium was produced. Calculate the mass of waste rock in the impure ore.

mass .... kg [1]

(g) **(i)** State the reducing agents in the extraction of iron and titanium respectively.

....

.... [1]

(ii) Give two reasons why titanium is more costly than iron even through it is the ninth most abundant element in the Earth's crust.

....

....

.... [2]

[Total: 12]

B10 A toilet detergent contains the acid salt sodium dihydrogen phosphate, NaH_2PO_4.

(a) Explain why sodium dihydrogen phosphate is both an acid and a salt.

....

....

.... [2]

(b) Sodium dihydrogen phosphate can be made by reacting sodium hydroxide solution with dilute phosphoric acid, H_3PO_4.

(i) Write the balanced chemical equation for the formation of sodium dihydrogen phosphate, including state symbols.

.... [1]

(ii) Suggest the chemical formula of another possible salt formed from sodium hydroxide solution and dilute phosphoric acid.

.... [1]

(c) Table 11.1 shows information about other acids.

Table 11.1

acid	pH
sodium dihydrogen phosphate	4.5
ethanoic acid	3.8
sulfuric acid	1.0

(i) Explain how sulfuric acid behaves as a strong acid, but ethanoic acid behaves like as a weak acid.

....

....

....

.... [2]

(ii) Describe an experiment, other than measuring pH and using indicators, how you would carry out an experiment to show that sulfuric acid is a strong acid and ethanoic acid is a weak acid.

State the measurements you would make and expected results.

....

....

....

....

....

....

....

.... [2]

[Total: 8]

EITHER

B11 1,1-dichloroethene, $C_2H_2Cl_2$, undergoes polymerisation to form polyvinylidene chloride, PVDC.

The most well-known use of PVDC is as plastic food wraps. PVDC is non-biodegradable and the only way to dispose PVDC is to incinerate. But incinerating PVDC causes serious environmental issues.

(a) Describe one similarity and one difference in structure between 1,1-dichloroethene and polyvinylidene chloride.

....

....

.... [2]

(b) Draw the structure of PVDC polymer, showing three repeating units.

[2]

(c) Calculate the number of repeating units in a PVDC polymer if it has a relative molecular mass of 82 450.

number of repeating units .... [2]

(d) Describe a chemical test to distinguish between 1,1-dichloroethene and PVDC.

....

....

.... [2]

(e) Explain why being non-biodegradable is both an advantage and a disadvantage.

....

....

.... [2]

[Total: 10]

OR

B11 Ethers are a group of compounds containing carbon, hydrogen and oxygen as shown in Table 12.1.

Table 12.1

name	molecular formula	boiling point / °C
methoxyethane	$CH_3 - O - CH_2CH_3$	7
ethoxyethane	$CH_3CH_2 - O - CH_2CH_3$	35
Z	$CH_3 - O - CH_2CH_2CH_3$	39
Propoxybutane	$CH_3CH_2CH_2 - O - CH_2CH_2CH_2CH_3$	117

(a) Name ether Z.

.... [1]

(b) With reference to Table 12.1, state and explain the trend observed in the boiling points of ether.

....

....

....

.... [2]

(c) Simple ethers are prepared commercially by the dehydration of alcohols using concentrated sulfuric acid.

Alcohol Y is used to prepare ethoxyethane, $C_2H_5 - O - C_2H_5$, as shown in the equation.

$$2Y \rightarrow C_2H_5 - O - C_2H_5 + H_2O$$

(i) Give the formula of alcohol Y used in the dehydration reaction.

.... [1]

(ii) Alcohol Y reacted with an organic compound W, CH_2O_2, to form a sweet smelling liquid X.

Give the name and full structural formula of the sweet smelling liquid X.

name: .... [1]

structure:

[1]

(d) Epoxides also known as oxiranes, are three-membered ring structures in which one of the vertices is an oxygen and the other two are carbons.

The full structural formula for the first member, C_2H_4O, is shown in Fig. 12.1.

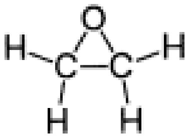


Fig. 12.1

(i) Epoxides can be produced by reacting an alkene with oxygen.

Name the alkene which could be used to produce the first member, C_2H_4O.

.... [1]

(ii) The second member of epoxides has a chemical formula, C_3H_6O, with three atoms in a ring, one of which is oxygen.

Draw the full structural formula of the epoxide, C_3H_6O.

[1]

(e) Epoxides are more reactive than simple ethers due to ring strain. Opening the ring relieves the ring strain and the products are 2 substituted alcohols.

Suggest a way to produce ethanol in the laboratory.

....

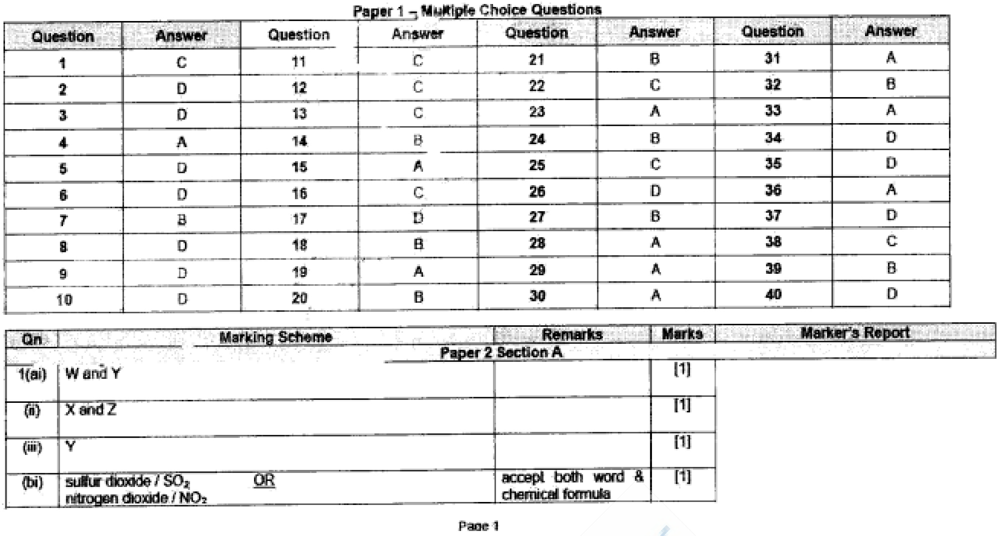
....

.... [2]

[Total: 10]

End of Paper

ANSWER SHEET

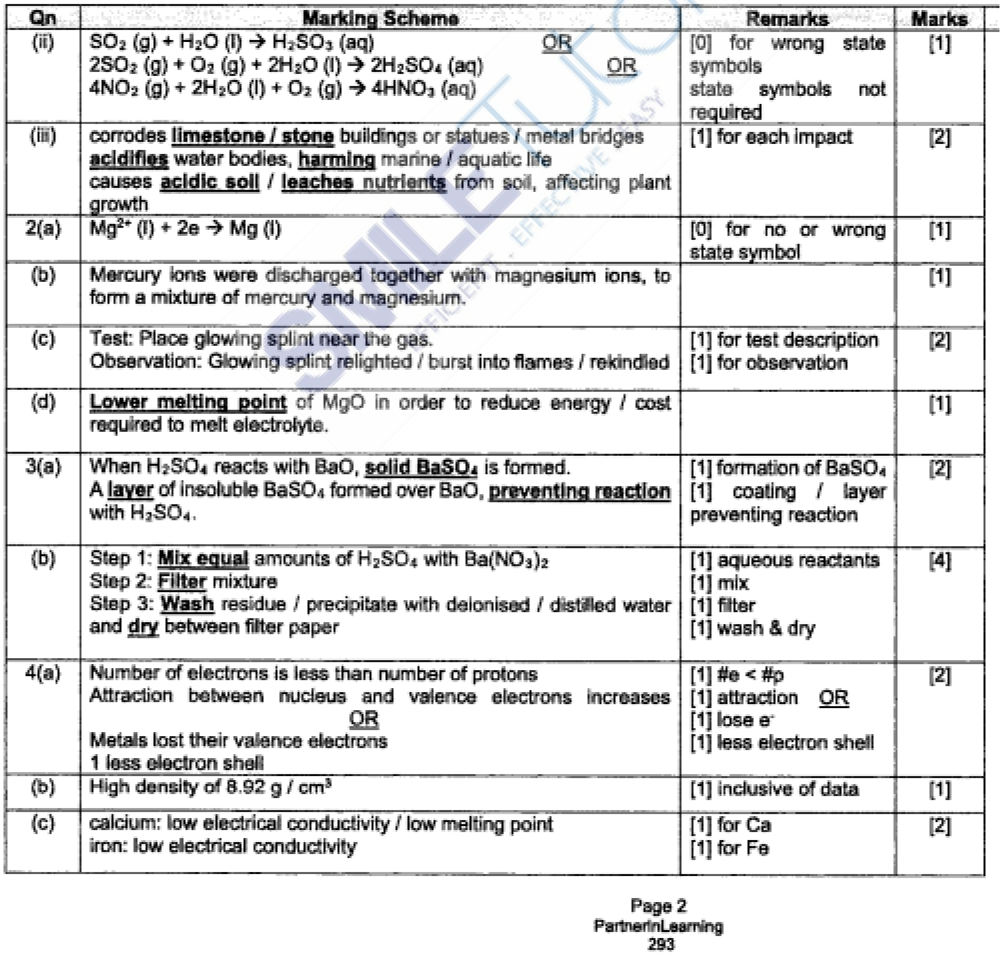


Paper 1 – Multiple Choice Questions

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

Qn	Marking Scheme	Remarks	Marks	Marker's Report
Paper 2 Section A				
1(ai)	W and Y		[1]	
(ii)	X and Z		[1]	
(iii)	Y		[1]	
(bi)	sulfur dioxide / SO_2 OR nitrogen dioxide / NO_2	accept both word & chemical formula	[1]	

Page 1



Qn	Marking Scheme	Remarks	Marks
(ii)	SO_2 (g) + H_2O (l) → H_2SO_3 (aq) OR $2SO_2$ (g) + O_2 (g) + $2H_2O$ (l) → $2H_2SO_4$ (aq) OR $4NO_2$ (g) + $2H_2O$ (l) + O_2 (g) → $4HNO_3$ (aq)	[0] for wrong state symbols state symbols not required	[1]
(iii)	corrodes **limestone / stone** buildings or statues / metal bridges **acidifies** water bodies, **harming** marine / aquatic life causes **acidic soil** / **leaches nutrients** from soil, affecting plant growth	[1] for each impact	[2]
2(a)	Mg^{2+} (l) + 2e → Mg (l)	[0] for no or wrong state symbol	[1]
(b)	Mercury ions were discharged together with magnesium ions, to form a mixture of mercury and magnesium.		[1]
(c)	Test: Place glowing splint near the gas. Observation: Glowing splint relighted / burst into flames / rekindled	[1] for test description [1] for observation	[2]
(d)	**Lower melting point** of MgO in order to reduce energy / cost required to melt electrolyte.		[1]
3(a)	When H_2SO_4 reacts with BaO, **solid $BaSO_4$** is formed. A **layer** of insoluble $BaSO_4$ formed over BaO, **preventing reaction** with H_2SO_4.	[1] formation of $BaSO_4$ [1] coating / layer preventing reaction	[2]
(b)	Step 1: **Mix equal** amounts of H_2SO_4 with $Ba(NO_3)_2$ Step 2: **Filter** mixture Step 3: **Wash** residue / precipitate with deionised / distilled water and **dry** between filter paper	[1] aqueous reactants [1] mix [1] filter [1] wash & dry	[4]
4(a)	Number of electrons is less than number of protons Attraction between nucleus and valence electrons increases OR Metals lost their valence electrons 1 less electron shell	[1] #e < #p [1] attraction OR [1] lose e^- [1] less electron shell	[2]
(b)	High density of 8.92 g / cm^3	[1] inclusive of data	[1]
(c)	calcium: low electrical conductivity / low melting point iron: low electrical conductivity	[1] for Ca [1] for Fe	[2]

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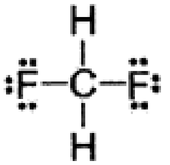
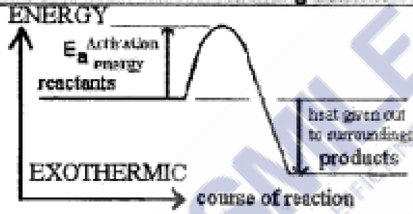
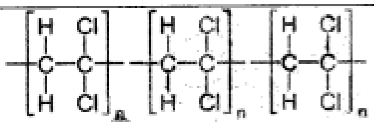
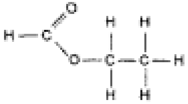
Qn	Marking Scheme	Remarks	Marks
5(a)	Excessive ultraviolet radiation passes through the ozone hole Too much UV causes skin cancer / immune system damage / eye cataract / genetic mutations	[1] ultraviolet radiation [1] harmful effect	[2]
(b)		[1] bond pair [1] lone pair [-1] full structure or wrong differentiation of electrons	[2]
(ci)	Hydrogen fluoride	[0] for formula HF	[1]
(ii)	Substitution / Halogenation	CAO	[1]
(iii)	Ultraviolet light		[1]
(iv)	Slower reaction Harder to break Br–Br bond than F–F bond OR H–Br bond is less stable than H–F bond OR Br is less reactive than F	[0] for slower [1] slower & lower reactivity	[1]
6(ai)	ΔH = (N–N) + 4(N–H) + (O=O) – (N≡N) – 4(O–H) -585 = (N–N) + (4 x 388) + (496) – (944) – (4 x 463) -585 = (N–N) – 748 N–N = **163 kJ / mol**	[1] working [1] answer	[2]
(ii)	**Total energy** given out for **bond forming** is **greater** than the **total energy** absorbed for **bond breaking**.		[1]
(iii)		[1] activation energy [1] enthalpy change [1] formulae of reactants + products [-1] for endothermic profile diagram [-1] for double headed arrow	[3]
(b)	No. of mol of 16 dm^3 butane = 16 / 24 = 2 / 3 mol Heat evolved = 2880 x 2/3 = **1920 kJ**	[1] for mol [1] for heat Allow fraction or decimal for mol	[2]
7(a)	$N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$ From the equation, 1 mole / volume of N_2 reacts with 3 moles / volumes of H_2.	[1] balanced equation with ⇌ [1] for mole ratio	[2]
(b)	Temperature: between **450 ºC** Pressure: between **250 atm** Catalyst: finely divided **iron**	[1] for all 3 conditions	[1]
(ci)	When pressure increases, particles come **closer together**. **Frequency / Rate of effective collisions** increases. Rate of reaction increases.		[1]
(ii)	Catalyst provides **alternate reaction pathway** with a **lower activation energy**		[1]
(iii)	As NO forms, **pH decreases** / pH becomes **neutral**.		[1]
8(a)	**Less reactive** metal ions are **preferentially discharged** instead of zinc ions With more reactive metal ions, **zinc ions are preferentially discharged** instead	[1] less reactive metal ions [1] more reactive metal ions	[2]

<table>
<tr><th>Qn</th><th>Marking Scheme</th><th>Remarks</th><th>Marks</th></tr>
<tr><td>(b)</td><td>Adding a more reactive metal to displace the less reactive metals in the solution.
Once the less reactive metals are displaced, filter the mixture to remove the less reactive metals as residue.</td><td>[1] add more reactive metal
[1] filtration</td><td>[2]</td></tr>
<tr><td>(c)</td><td>Heating zinc oxide with carbon
OR
Reducing zinc oxide by heating with coke</td><td></td><td>[1]</td></tr>
<tr><td>9(a)</td><td>Oxidation state of +2 forms most stable ion.</td><td>[1]</td><td>[1]</td></tr>
<tr><td>(b)</td><td>As oxidation state increases, oxide becomes more acidic
OR
As oxidation state increases, oxide changes from basic to amphoteric to acidic.</td><td></td><td>[1]</td></tr>
<tr><td>(c)</td><td><table>
<tr><td>name of oxide</td><td>nature of oxide</td></tr>
<tr><td>manganese(VII) oxide</td><td>acidic</td></tr>
<tr><td>manganese(IV) oxide</td><td>amphoteric</td></tr>
<tr><td>manganese(II) oxide</td><td>basic</td></tr>
</table></td><td>[1] all correct</td><td>[1]</td></tr>
<tr><td>(d)</td><td>Molten $MgCl_2$ was electrolysed
Magnesium metal and chlorine gas produced and recycled</td><td>[1] electrolysis of molten $MgCl_2$
[1] products</td><td>[2]</td></tr>
<tr><td>(e)(i)</td><td>$TiCl_4$ (l) + 2Mg (s) → $2MgCl_2$ (s) + Ti (s)</td><td>[1] equation</td><td>[1]</td></tr>
</table>

Qn	Marking Scheme	Remarks	Marks
	Atmosphere of argon To prevent Mg reaction with oxygen which makes metal brittle.	[1] condition [1] explanation	[2]
(f)	750 – 300 = **450 kg**	[0] no working	[1]
(g)(i)	Fe extraction involves CO as reducing agent while Ti extraction uses Mg.	[1] stating both R.A.	[1]
(ii)	More costly as Mg is extracted via electrolysis Requires atmosphere of argon	[1] electrolysis of Mg [1] inert atmosphere R: high temperature as Fe extraction also requires high temp R: 2 stages	[2]
10(a)	Acid – produces H^+ ions when dissolved in water Salt – ionic compound formed when metal ion replaces one or more hydrogen ions of an acid.	[1] for acid [1] for salt	[2]
(bi)	NaOH (aq) + H_3PO_4 (aq) → NaH_2PO_4 (aq) + H_2O (l)		[1]
(ii)	Na_2HPO4 / Na_3PO_4		[1]
(ci)	H_2SO_4 – dissociates **fully** in water to produce **high concentration / a lot of** of H^+ ions CH_3COOH – dissociates **partially** in water to produce **low concentration / a few** of H^+ ions	[1] full / partial dissociation in water [1] concentration of H^+	[2]
(ii)	Method 1 Add 2 cm strip of magnesium ribbon to 25 cm^3 of 1 mol / dm^3 of sulfuric acid. Measure the time taken for all the magnesium ribbon to finish reacting. Repeat the experiment with same length of magnesium ribbon, same volume and concentration of ethanoic acid. H_2SO_4 will require less time for the magnesium ribbon to react.	[1] logical steps + repeat experiment with same variables [1] measurements + results	[2]

Qn	Marking Scheme	Remarks	Marks
	Method 2 Add 2 g of $CaCO_3$ into a conical flask with 25 cm^3 of 1 mol / dm^3 of sulfuric acid. Measure the gas evolved in 1 minute Repeat the experiment with the same mass of $CaCO_3$, same volume and concentration of ethanoic acid. H_2SO_4 will produce a greater volume of gas in 1 minute.	Accept both gas collection & mass loss	
11(a)	Similarity: covalent bond / contains C, H and Cl / same empipircal formual Difference: PVDC has large M_r / more C, H and Cl atoms than CH_2Cl_2 / PVDC has no C = C / different molecular formula / giant molecular vs simple molecular	[1] similarity [1] difference	[2]
(b)	 without brackets & 'n'	[1] Cl on same carbon [1] three repeating units [-1] Cl on different carbon [-1] no repeating	[2]
(c)	M_r of $C_2H_2Cl_2$ = **<u>97</u>** Number of repeating units = 82450 / 97 = **<u>850</u>**	[1] M_r of CH_2Cl_2 [1] ans	[2]
(d)	Test: add aqueous bromine / bromine water Observations: Aqueous bromine decolourises in CH_2Cl_2 but remains reddish-brown in PVDC	[1] test [1] observation of the 2 compounds	[2]
(e)	Advantage: long lasting / durable / resistant to corrosion Disdavantage: does not decompose naturally / contributes to waste / difficult to dispose / causes problems or environmental issues during disposal	[1] advantage [1] disadvantage	[2]

Qn	Marking Scheme	Remarks	Marks
OR 11(a)	methoxypropane		[1]
(b)	As molecule becomes bigger, boiling point increases. **<u>Intermolecular</u>** / **<u>van der waals</u>** **<u>forces of attraction</u>** becomes stronger **<u>More energy</u>** required to overcome the stronger forces of attraction	[1] trend [1] strength of force + energy	[2]
(ci)	CH_3CH_2OH / C_2H_6O / C_2H_5OH		[1]
(ii)	ethyl methanoate 	[1] name [1] full structure	[2]
(di)	ethene	[0] formula	[1]
(ii)			[1]
(e)	**<u>Glucose solution</u>** mixed with **<u>yeast</u>**. Temperature kept at **<u>37 ºC</u>** with the **<u>absence</u>** of oxygen / air Ethanol obtained by **<u>fractional distillation</u>**	[1] glucose with yeast [1] 37 °C + no O_2 + fractional distillation	[2]

SERANGOON SECONDARY SCHOOL PRELIM PAPER

1 25 cm^3 of aqueous sodium hydroxide is pipetted into a conical flask and titrated with dilute hydrochloric acid from a burette. How can the accuracy of the titration be improved?

I. Rinse the interior of the pipette with aqueous sodium hydroxide.
II. Rinse the interior of the pipette with aqueous hydrochloric acid.
III. Rinse the interior of the conical flask with aqueous sodium hydroxide.
IV. Rinse the interior of the burette with dilute hydrochloric acid.

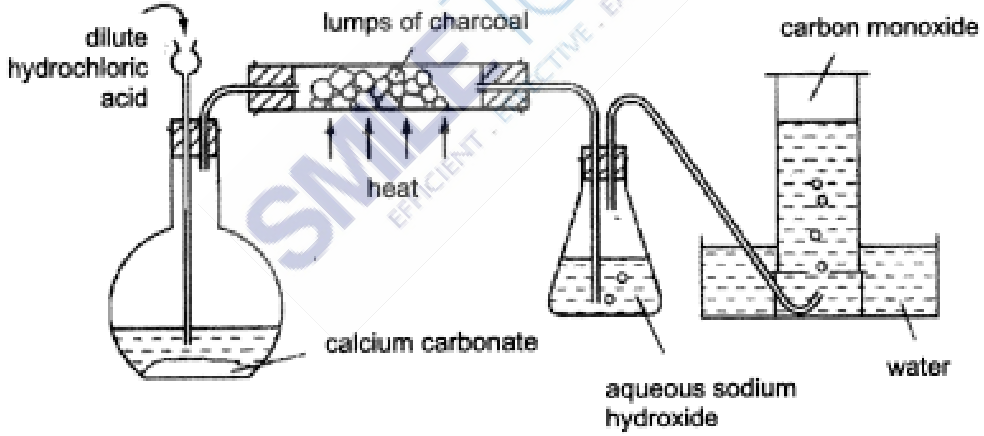
A I and III only

B I and IV only

C II and III only

D I, III and IV

2 The diagram below is a set-up used to obtain carbon monoxide.



What is the main purpose of the aqueous sodium hydroxide?

A Dry the carbon monoxide.

B Remove the carbon dioxide.

C Remove the excess acid.

D Remove the oxygen present.

3 Esters can be prepared by reactions of alcohols and carboxylic acids. The yield of these reactions is often low. One way of improving the yield is to remove the ester formed as the reaction proceeds and this can be done by carrying out fractional distillation.

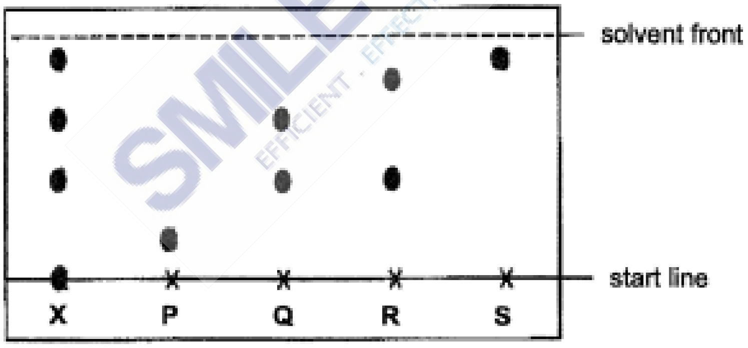
Which of the following mixtures will yield an ester as the distillate using this method?

A	ethanol (B.P: 78°C)	ethanoic acid (B.P: 118°C)	ethyl ethanoate (B.P: 77°C)
B	butanol (B.P: 117°C)	ethanoic acid (B.P: 118°C)	butyl ethanoate (B.P: 128°C)
C	ethanol (B.P: 78°C)	butanoic acid (B.P: 164°C)	ethyl butanoate (B.P: 121°C)
D	methanol (B.P: 65°C)	butanoic acid (B.P: 164°C)	methyl butanoate (B.P: 102°C)

B.P. : Boiling Point

4 Vitamins are essential nutrients needed in small amounts for various roles in the human body. They are either water-soluble or fat-soluble.

A sample of herbal tea, **X**, was analysed using chromatography with four water-soluble vitamins, P, Q, R and S, using water as the solvent. When the solvent front reached the position indicated, the chromatogram was placed under ultra-violet light. The following diagram shows the chromatogram obtained.



What can be deduced from the results?

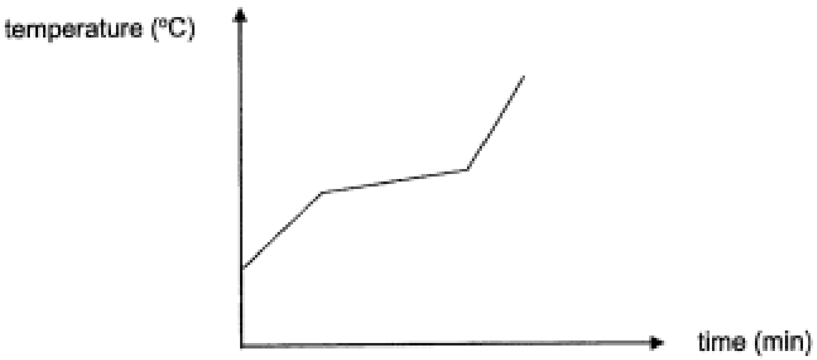
A All vitamins in **X** are soluble in water.

B One of the vitamins in **X** is not soluble in water.

C Vitamin **X** consists of vitamin Q, R and S.

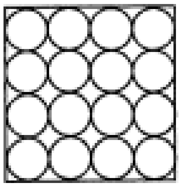
D Vitamin **X** contains three different components.

5 The diagram below shows the heating curve of substance X.

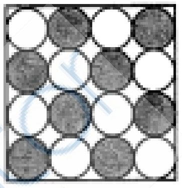


Which of the following represents the arrangement of the particles in substance X?

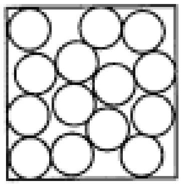
A



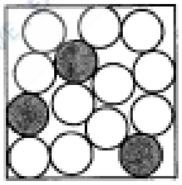
B



C



D



6 The chemical symbol of an element is shown below.

$$^{197}_{79}X$$

Which of the following describes how this element achieves a stable electronic configuration?

A gain electrons to form positive ion

B lose electrons to form negative ions

C lose electrons to form positive ions

D share electrons to form diatomic molecules

7 The proton number and electron number of some particles are shown below. The symbols used here do not represent the actual chemical symbol of the elements.

particle	P	Q	R	S
proton number	4	15	19	30
electron number	4	18	19	28

Which two particles are found in an ionic compound?

A P and R

B P and Q

C Q and S

D R and S

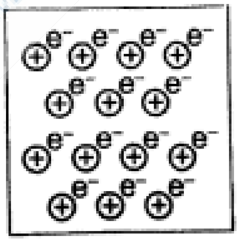
8 The properties of an unknown substance are given below.

- low melting and boiling point
- low density
- good conductor of electricity in solid state

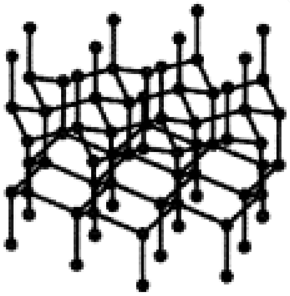
Which of the following is the substance?

A

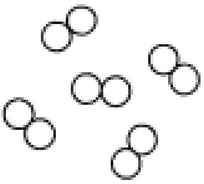
B



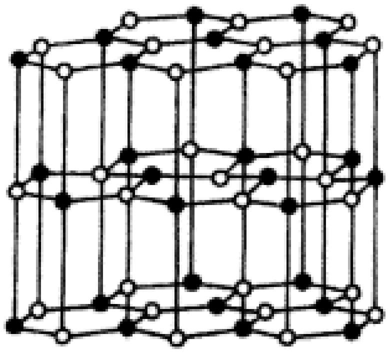
C



D



9 Which of the following best explains the reason why the substance with the structure shown below would be a good lubricant?



A strong covalent bonds between the layers of atoms

B weak forces of attraction between the layers of atoms

C weak covalent bonds between the layers of atoms

D weak electrostatic forces of attraction between the layers of atoms

10 Which statement about groups in the Periodic Table is correct?

A All groups contain both metals and non-metals.

B Atoms of the elements in the same group have the same number of total electrons.

C Atomic radius decreases down the group.

D Ionisation energy decreases down the group.

11 $X_2 + 2KY \rightarrow 2KX + Y_2$

Based on the equation shown above, ______________________________.

A the reaction is a redox reaction

B the reaction is a metal displacement reaction

C X is less reactive than Y

D X_2 is the reducing agent

12 The setup below was used to collect the gas produced when an excess magnesium was added to 50 cm^3 of 1 mol/dm^3 of hydrochloric acid.
The time taken for the reaction to be completed was also recorded.
The table below shows the results obtained.

volume of gas (cm^3)	600
time taken for reaction to complete (s)	60

Which of the following would likely be the results obtained when same concentration of propanoic acid is used instead?

	volume of gas (cm^3)	time taken for reaction to complete (s)
A	300	30
B	300	60
C	600	60
D	600	180

13 In an experiment, 5 cm^3 of 1.0 mol/dm^3 of sodium hydroxide is gradually added to 10 cm^3 of 1.0 mol/dm^3 of hydrochloric acid, containing methyl orange indicator.

Which change occurs in the mixture?

A A white precipitate is formed.

B Methyl orange changes in colour.

C The concentration of OH^- increases.

D The concentration of H^+ decreases by half.

14 X, Y and Z elements are found in Period 3 of the Periodic Table.
X forms an acidic oxide when burnt in oxygen.
Y forms a basic oxide when burnt in oxygen.
Z forms an amphoteric oxide when burnt in oxygen.

What is the order of the three elements across the Periodic Table?

A X, Y, Z

B X, Z, Y

C Y, X, Z

D Y, Z, X

15 Which of the following reactions is **unlikely** to take place?

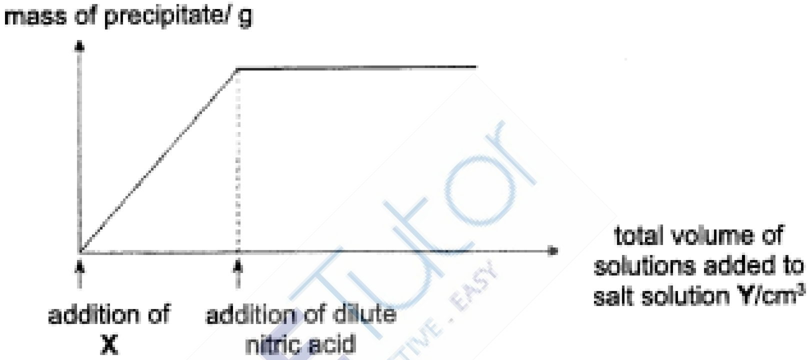
A Pb^{2+} (aq) + $2Cl^-$ (aq) → $PbCl_2$ (s)

B Fe^{2+} (aq) + Mg (s) → Mg^{2+} (aq) + Fe (s)

C $2H^+$ (aq) + Cu (s) → H_2 (g) + Cu^{2+} (aq)

D $2H^+$ (aq) + $CO_3{}^{2-}$(aq) → CO_2 (g) + H_2O (*l*)

16 In a chemistry experiment, solution **X** is gradually added to a salt solution **Y**, followed by the addition of a dilute nitric acid solution. The graph shows how the mass of precipitate formed changes with the addition of the different solutions.



Which of the following would produce the graph as shown above?

	solution **X**	ions present in salt solution **Y**
A	aqueous silver nitrate	chloride ion and carbonate ion
B	aqueous silver nitrate	nitrate ion and sulfate ion
C	aqueous barium nitrate	sulfate ion and carbonate ion
D	aqueous barium nitrate	sulfate ion and nitrate ion

17 The table shows the observations made when an aqueous solution X was tested.

reagent added	observation
acidified silver nitrate	solution remained colourless.
aqueous sodium hydroxide	pungent gas turns moist red litmus paper blue.

Which of the following could X possibly be?

A ammonium nitrate **B** ammonium chloride

C zinc nitrate **D** zinc chloride

18 A gas was produced during a reaction. The descriptions below show some of the properties of the gas produced.

- turns moist blue litmus paper red
- pungent smell
- no visible change with limewater

What is the identity of the gas produced?

A ammonia **B** carbon dioxide

C nitrogen monoxide **D** sulfur dioxide

19 Which element contains the greatest number of atoms in 1 g?

A aluminium **B** carbon

C iodine **D** nitrogen

20 An impure sample of 1 g of silver oxide reacts with excess of nitric acid to form silver nitrate and water. The reaction produces, 0.86 g of silver nitrate.

$$Ag_2O + 2HNO_3 \rightarrow AgNO_3 + H_2O$$

What is the percentage purity of the sample?

A 31.3 % **B** 58.7 %

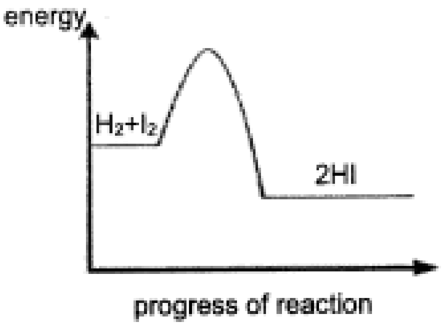
C 85.5 % **D** 86.0 %

21 Hydrogen and iodine react according to the equation shown below.

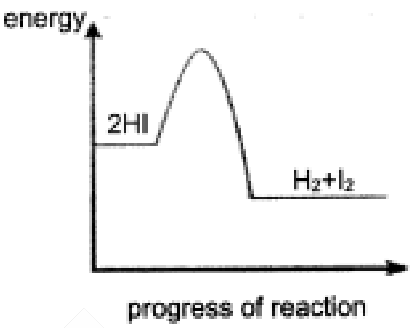
$$H_2 + I_2 \rightleftharpoons 2HI \qquad \Delta H = +52.96\ kJ$$

Which of the following energy profile diagrams shows the backward reaction?

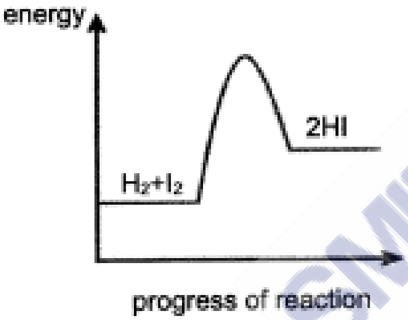
A



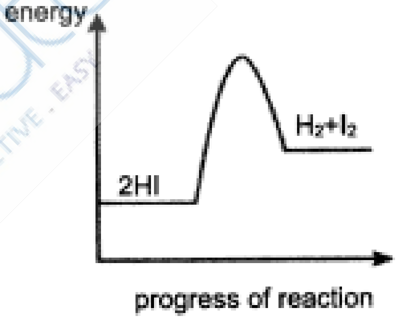
B



C



D



22 The scheme shows four stages I to IV in the conversion of solid candlewax, $C_{30}H_{62}$, into carbon dioxide and water.

$$C_{30}H_{62}(s) \xrightarrow{\text{I}} C_{30}H_{62}(l) \xrightarrow{\text{II}} C_{30}H_{62}(g) \xrightarrow{\text{III}} \begin{array}{c} 30CO_2(g) \\ + \\ 31H_2O(g) \end{array} \xrightarrow{\text{IV}} \begin{array}{c} 30CO_2(g) \\ + \\ 31H_2O(l) \end{array}$$

Which stage(s) is/are exothermic?

A III only

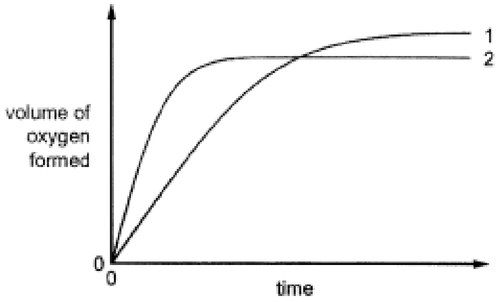
B III and IV only

C I, II and III only

D I, II and IV only

23 In the graph, curve 1 was obtained by observing the decomposition of 100 cm³ of 1.0 mol/dm³ hydrogen peroxide solution, catalysed by manganese(IV) oxide.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$



Which alteration to the original experimental conditions would produce curve 2?

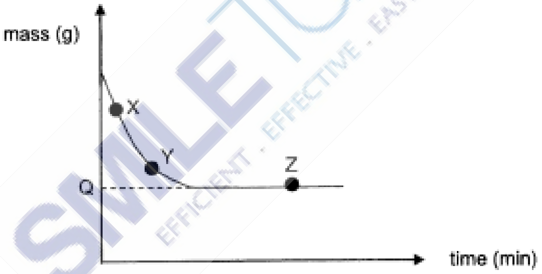
A increase the pressure

B lower the temperature

C using 100 cm³ of 1.2 mol/dm³ hydrogen peroxide solution

D using 50 cm³ of 1.2 mol/dm³ hydrogen peroxide solution

24 The graph shows the mass of hydrogen gas evolved, plotted against time, when excess hydrochloric acid reacts with 2 g of magnesium ribbon.



Which statement is correct?

A The reaction is faster at point X than at point Y.

B The reaction first reaches completion at point Z.

C The mass of hydrogen gas evolved will be higher if magnesium powder is used instead.

D Mass of hydrogen gas evolved is Q g.

25 The statements below describe the reactions of metals P, Q and R.

- Metal P does not react with cold water but reacts quickly with an acid.
- Metal Q reacts slowly with an acid but has no reaction with steam.
- Metal R reacts fast with cold water.

Which of the following statements is correct?

A Metal P can only be extracted by electrolysis from its ore.

B Metal Q exists naturally uncombined.

C Metal R cannot be reduced by coke.

D Metals P and Q are positioned below hydrogen in the metal reactivity series.

26 Which of the following equations show the protection of iron from rusting?

A $3Ca^{2+} + 2Fe \rightarrow 2Fe^{3+} + 3Ca$

B $Zn^{2+} + Fe \rightarrow Fe^{2+} + Zn$

C $Mg + Fe^{2+} \rightarrow Fe + Mg^{2+}$

D $Sn + Fe^{2+} \rightarrow Fe + Sn^{2+}$

27 Which of the following is true about steel?

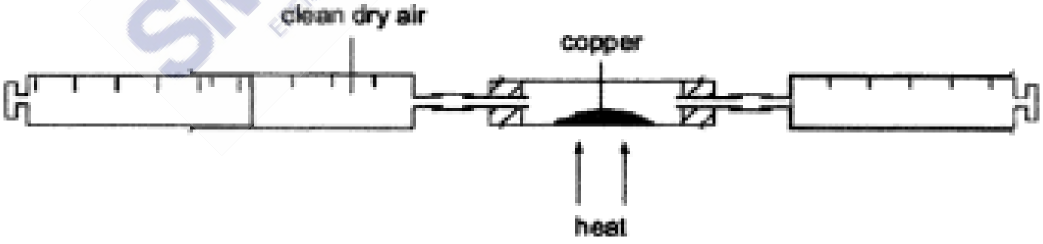
A It is resistant to corrosion.

B It is softer than pure metal.

C It is a poor conductor of electricity.

D It reacts with acid to form hydrogen gas.

28 A 150 cm^3 sample of clean, dry air is passed over hot excess copper at room temperature and pressure until there is no further change in volume. The pink copper metal turns black at the end of the reaction.



What is the minimum mass of copper metal that is needed for this reaction?

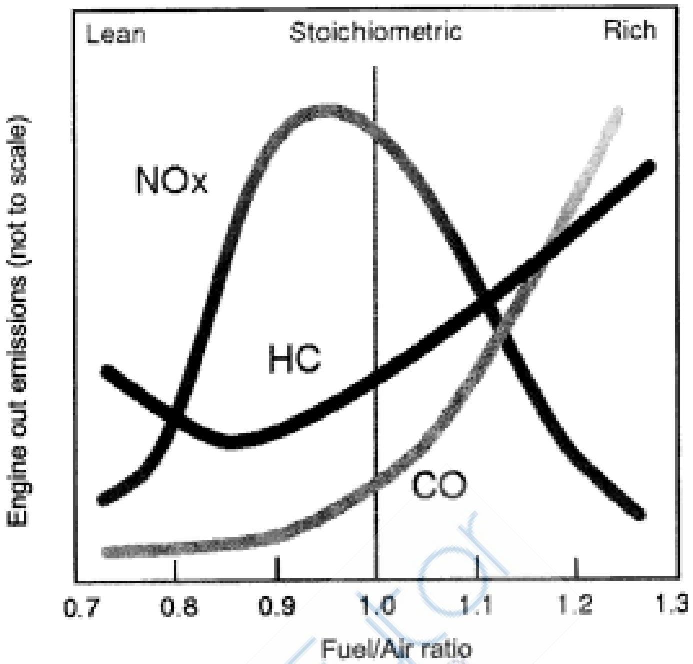
A 0.084 g

B 0.168 g

C 0.316 g

D 0.632 g

29 The diagram below shows the changes to the emission of different gases from a car engine at different fuel/air ratio.



Why is there an increase in the emission of CO when the fuel/air ratio increases from 0.8 to 1.0?

A There is a decrease in the volume of air in the engine, leading to internal combustion.

B There is an increase in the volume of air in the engine, leading to internal combustion.

C There is a decrease in the volume of air in the engine, leading to incomplete combustion.

D There is an increase in the volume of air in the engine, leading to incomplete combustion.

30 Which two processes in the carbon cycle help to regulate the carbon level in the atmosphere?

A combustion and respiration

B decomposition and respiration

C deforestation and photosynthesis

D photosynthesis and combustion

31 Why is iron metal added to Haber Process?

A To lower the pressure needed for the reaction.

B To lower the temperature needed for the reaction.

C To lower the activation energy level of the process.

D To react with hydrogen and nitrogen to form ammonia.

32 Given the following reaction

$$2MnO_4^- + 5SO_3^{2-} + 6H^+ \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$$

Which statement about the reaction above is true?

A MnO_4^- is acting as the reducing agent.

B SO_3^{2-} is oxidised to form SO_4^{2-} .

C H^+ is oxidised.

D SO_3^{2-} is neither oxidised nor reduced.

33 During electroplating process, an object is coated with silver metal. The mass of the was measured before and after the process.

mass of object before process (g)	4.78
mass of object after process (g)	6.15

The difference in the mass recorded is due to ______________________________.

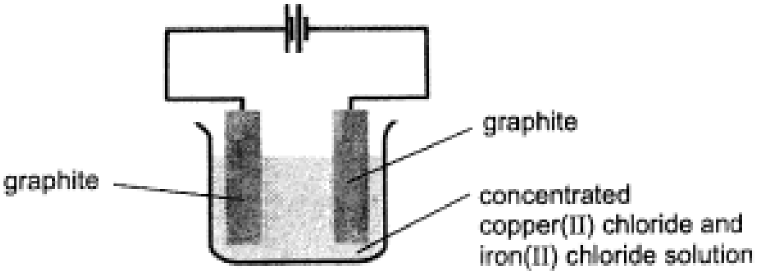
A a gas being produced at the object

B a salt being produced on the object

C oxidation of silver metal

D reduction of silver ions

34



Which of the following statements correctly describes the observations made in the setup a few hours later?

A Green fumes observed at the cathode.

B The electrolyte would be blue in colour.

C The electrolyte would be green in colour.

D The anode will increase in size.

35 In the electrolysis of an aqueous solution of cerium nitrate, 70 g of cerium, Ce, (A_r = 140) is deposited at the cathode by 2 moles of electrons. What is the charge on the cerium ion?

A 1+ **B** 2+

C 4+ **D** 6+

36 The table below shows the uses of two fractions obtained from fractional distillation of crude oil.

fraction	uses
X	fuel for lorries and trucks
Y	feedstock for petrol chemical industry

What is fraction X and Y based on the uses given?

	fraction X	fraction Y
A	diesel	lubricating oil
B	diesel	naphtha
C	petrol	lubricating oil
D	petrol	naphtha

37 One of the compounds found in bitumen has a molecular formula of $C_{20}H_{42}$. It undergoes cracking to form smaller molecules as shown in the equation below.

$$C_{20}H_{42} \rightarrow C_{12}H_{26} + 2\ \_\_\_\_\_\_$$

What is the chemical formula of the other compound formed?

A C_4H_8

B C_4H_{10}

C C_8H_{16}

D C_8H_{18}

38 400 cm³ of 5 mol/dm³ of aqueous bromine was found to react with 1 mole of an unsaturated hydrocarbon.

What is the number of bromine atoms that would be found in the product formed?

A	2	**B**	3
C	4	**D**	6

39 Below shows a list of reactions.

I combustion of ethanol
II fermentation of glucose
III oxidation of ethanol by air in the presence of bacteria
IV reaction of sodium carbonate with ethanoic acid

In which reaction is carbon dioxide a product?

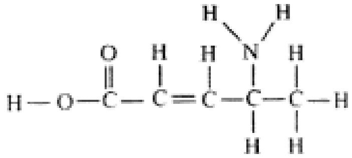
A I and II only

B I and IV only

C I, II and III only

D I, II and IV only

40 Which of the following reactions will **not** take place with the molecule shown below?



A bromination

B condensation polymerisation

C oxidation

D reaction with magnesium

END-OF-PAPER

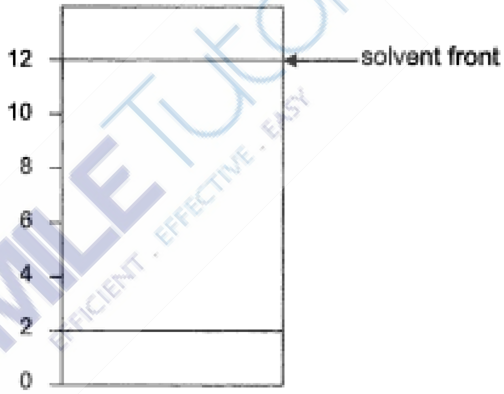
Section A [50 marks]
Answer **all** questions.

A1 The table below gives some information of an unknown substance **Y**.

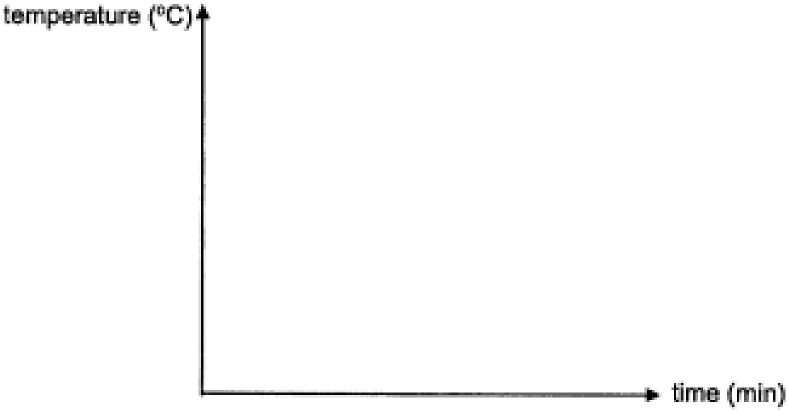
property of substance Y	
colour	black
melting point	1326 °C
boiling point	2000 °C
solubility in water	insoluble
chromatogram	$R_f = 0.7$

(a) Based on the information given above,

(i) Draw in the chromatogram the spot for **Y** that would be obtained below. Show your workings clearly on how the answer is derived. [2]



(ii) Sketch in the axes below, the **freezing curve** of substance **Y**. [1]



(b)(i) Based on the information given, substance **Y** can be classified as either an element or a compound. Explain why this is so. [1]

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(ii) Describe and explain what can be done to determine whether substance **Y** is an element or a compound. [2]

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A2 Electronegativity is a measure of an atom's ability to attract shared electrons to itself.

The bond dissociation energy is the energy required to break a bond and form two atomic or molecular fragments, each with one electron of the original shared pair.

The table below shows the electronegativity and bond dissociation energy of halogens.

halogen	**electronegativity**	**bond dissociation energy kJ/mol**
fluorine	4	156
chlorine	3	243
bromine	2.8	193
iodine	2.5	151

(a)(i) Excluding fluorine, describe the relationship between electronegativity and bond dissociation energy of halogens. [1]

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(ii) Suggest a plausible reason for the relationship observed in **(a)(i)**. [3]

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(b) Suggest a plausible reason for fluorine for **not** following the relationship describe in **(a)(i)**. [1]

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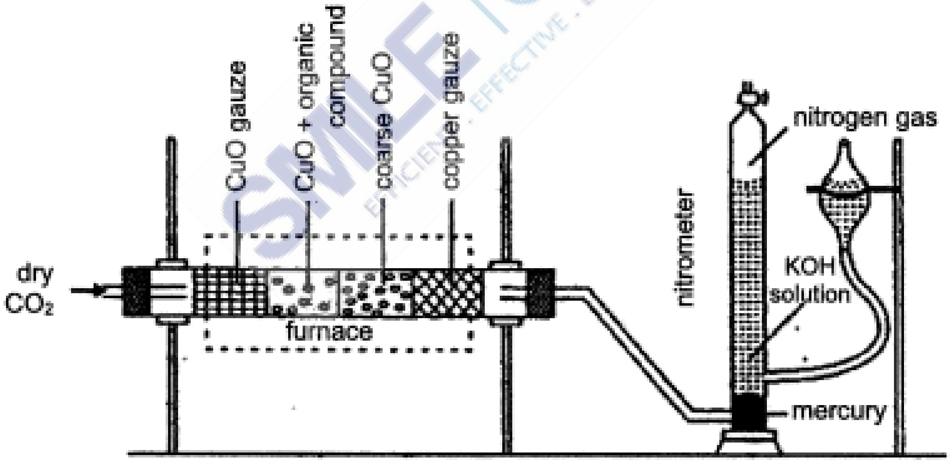
A3 Dumas method is a quantitative method used to determine nitrogen content in a given organic compound. The diagram below shows the setup used to determine nitrogen content in the Dumas method.



In the Dumas method, the organic compound containing nitrogen would be heated with excess copper(II) oxide in an atmosphere of carbon dioxide. During the reaction, nitrogen gas, carbon dioxide gas and water would be obtained.

Oxides of nitrogen is a by-product that would be also formed during the reaction. It would be converted to nitrogen when they are passed over heated copper gauze. Copper(II) oxide would also be formed during the reaction.

(a)(i) Write the chemical equation between nitrogen dioxide and copper gauze. [1]

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(ii) State and explain, in terms of oxidation state, whether nitrogen dioxide is oxidised or reduced by the copper gauze. [2]

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(b) Suggest a possible reason for the potassium hydroxide in the setup. [1]

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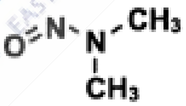
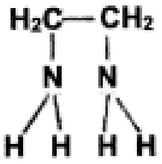
(c) From the analysis of an unknown organic compound, it was found that the percentage of nitrogen is 37.8%.

The table below shows a list of possible organic compound and their structural formula.

name of organic compound	**structural formula**
acetonitrile	$N{\equiv}C{-}CH_3$
N, N-dimethylnitrous amide	
ethylenediamine	

Determine the identity of the unknown organic compound. Explain how you derive your answer. You may show your workings to aid in your explanation. [2]

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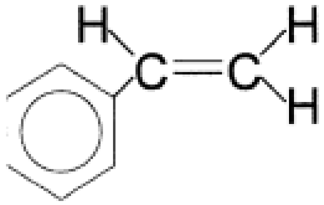
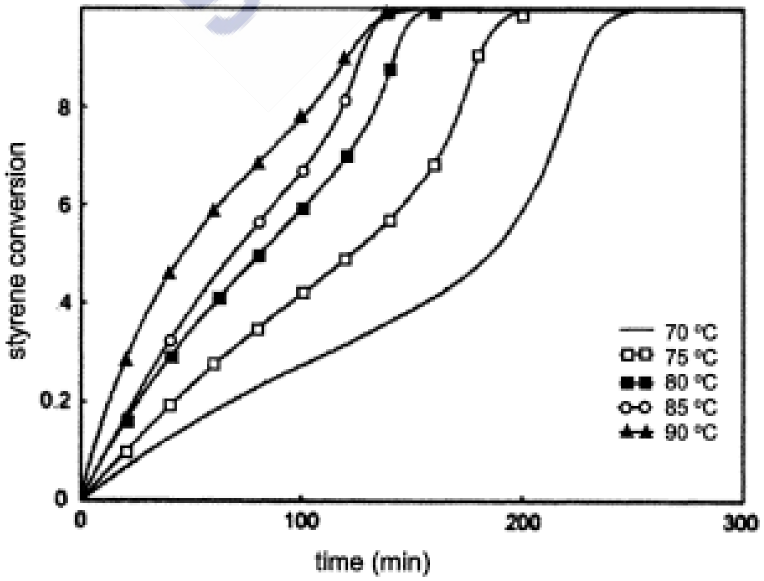
A4 The diagram below shows the structural formula of styrene. It can undergo polymerisations in the presence of a catalyst.



(a) Draw the structural formula of the polymer formed by styrene and give the name of the polymer formed. [2]

name of polymer: ....

(b) Experiments were carried out to determine the optimum temperature to carry out the polymerisation of styrene. The diagram below shows the results obtained.



Based on the results obtained, at which temperature should the polymerisation of styrene be carried out? Explain your answer in terms of collision theory. [3]

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(c) What would happen to the rate of polymerisation of styrene if the catalyst is not used? Explain. [1]

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A5 A student measured the temperature change when 5.0 g of potassium chloride was dissolved in excess water. The table below shows the results obtained.

temperature / °C	24.5
highest /lowest recorded temperature / °C	22.0
calculated energy change / J	1160

https://socratic.org/questions/5709d5887c014947fcb6e231

(a) State and explain if the change is exothermic or endothermic. [1]

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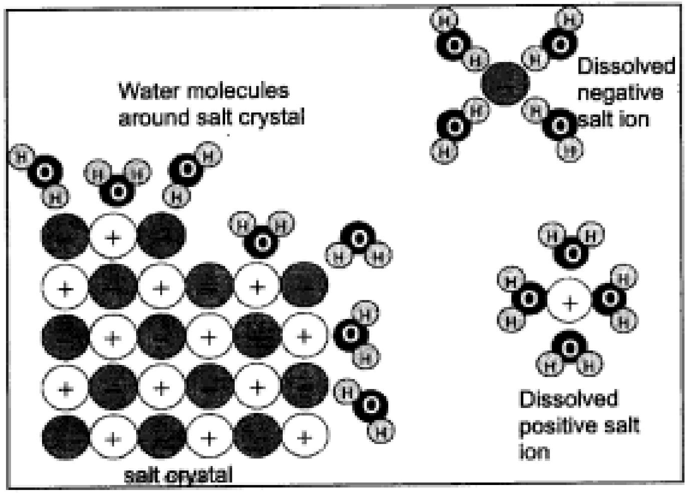
(b) The process of dissolving involves both bond-forming and bond-breaking. The process and description are given below.



When water dissolves a substance, the water molecules attract and "bond" to the particles (molecules or ions) of the substance causing the particles to separate from each other. The "bond" that a water molecule makes is not a covalent or ionic bond. It is a strong force of attraction.

Using information given and your knowledge of bond-breaking and bond-forming, explain why the calculated energy change for dissolving potassium chloride is positive. [2]

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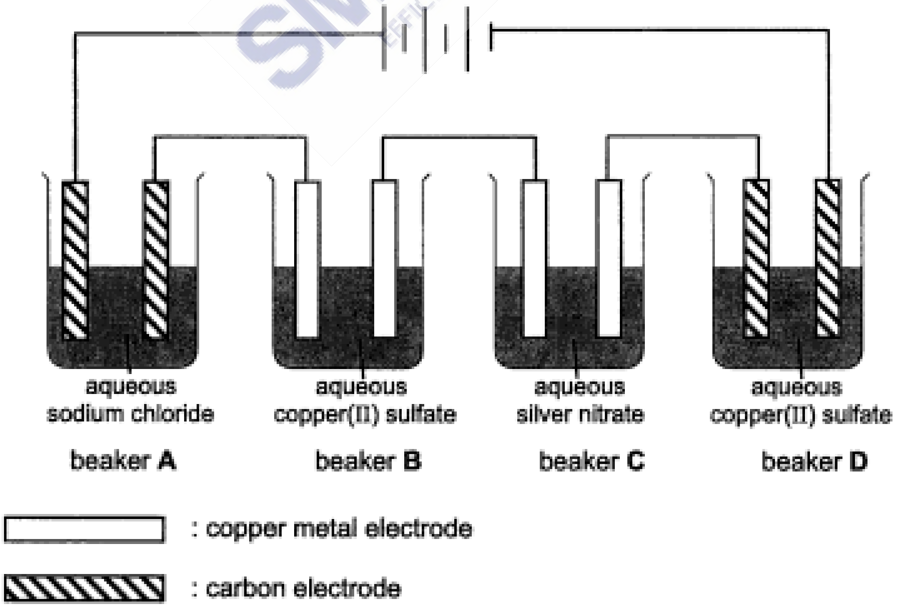
(c) Use the student's results to calculate the enthalpy change when one mole of potassium chloride dissolves in excess water.
Give your answer in kJ/mol, to three significant figures. [3]

A6 The diagram below shows an electrolysis setup.



(a) In the table below, fill in the missing observations of the anode, cathode and electrolyte. [3]

beaker	anode	cathode	electrolyte
A			no visible change
B	decrease in size	increase in size	no visible change
C	decrease in size		
D		increase in size	

(b) After the setup has been running for some time, explain for the observation made on the electrolyte found in

(i) beaker **A**, [1]

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(ii) beaker **B** and [1]

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(iii) beaker **C**? [2]

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(c) Write the half equations, for the reactions at the anode and cathode in beaker **D**. [2]

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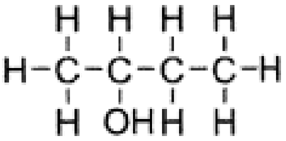
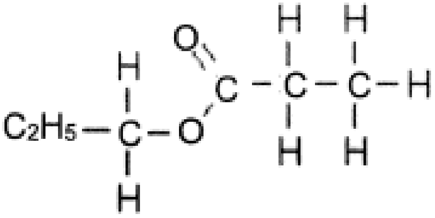
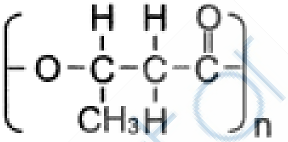
A7 The diagram below shows three different organic compounds, **P**, **Q** and **R**.

compound	
P	
Q	
R	

(a)(i) State whether each statement below is true or false. [2]

statement	True / False
Compound **P** can be made by fermentation.	
Compound **Q** can be made by reacting compound **P** with an organic acid.	
Water is also produced during the formation of compound **Q** and **R**.	

(ii) State and explain one condition used when carrying out fermentation. [1]

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(b)(i) What is the name of compound **Q**? [1]

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(ii) State a possible use for compound **Q**. [1]

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(c) Draw the reactant(s) that is/are used to form compound **R**. [1]

A8 A composite material is a mixture of two different substances. Reinforcing fibres are often used in a plastic to give the plastic extra strength. The table below gives some information about four different fibres that are used to make composite plastics.

fibre	density (kg/m^3)	force needed to break the fibre (N/m^2)
carbon	174	3.1
glass	257	3.7
kevlar	145	3.6
polyester	138	1

(a) Kevlar and carbon fibre composites are used in the building of spacecraft. Suggest reasons why,

(i) polyester fibre composites and [1]

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(ii) glass fibre composites, are not suitable for this purpose. [1]

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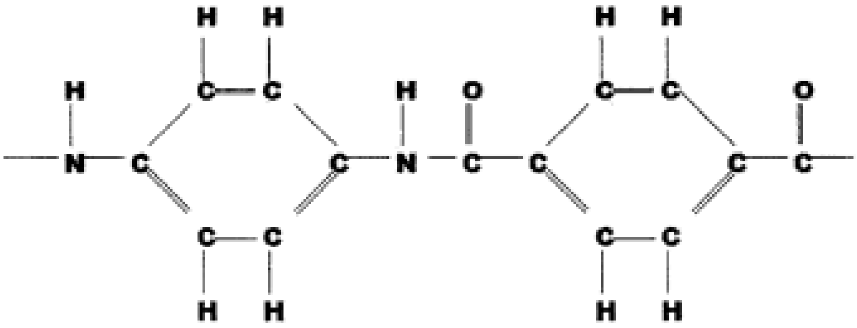
(b) Kevlar has a structure shown below.



Describe two differences between kevlar and polyester. [2]

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(c) Glass is mainly made up of silicon dioxide. Describe another property of glass and explain in terms of bonding and structure for the property described. [2]

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Section B [30 marks]

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.

B9 Hard water is water that has high mineral content. These minerals may enter the water sources when rain, containing dissolved carbon dioxide, reacts with calcium carbonate and carry calcium ions away with it. Hardness refers to the total concentration of alkaline earth (Group II) ions in water. Due to the much higher concentrations of Ca^{2+} and Mg^{2+} than other alkaline earth ions, hardness can be equated to the concentration of Ca^{2+} and Mg^{2+}. Hardness is commonly expressed as the equivalent number of milligrams of calcium carbonate per dm^3. Thus, if concentration of Ca^{2+} and Mg^{2+} = 1 mmol/dm^3, we would say that hardness is 100 mg calcium carbonate per dm^3 of water as 100 mg of calcium carbonate is equivalent to 1 mmol of calcium carbonate. Water whose hardness is less than 60 mg calcium per dm^3 of water is considered to be "soft". If the hardness is above 270 mg/dm^3, the water is considered to be "hard".

To measure the total hardness, a sample of water is treated with ascorbic acid to reduce Fe^{3+} to Fe^{2+}. Titration with EDTA, a chemical substance, at pH 10 in ammonia solution, would then give the total concentration of Ca^{2+} and Mg^{2+}. The concentration of Ca^{2+} can be determined separately if the titration is carried out at pH 13 without ammonia.

Insoluble carbonates are converted to soluble bicarbonates by excess carbon dioxide:

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$$

Heating converts bicarbonate to carbonate by driving off carbon dioxide and causes calcium carbonate to precipitate.

Hard water reacts with soap ($C_{17}H_{35}CO_2Na$) to form insoluble curds:

$$Ca^{2+} + 2C_{17}H_{35}CO_2^- \rightarrow Ca(C_{17}H_{35}CO_2)_2$$

Enough soap is needed before the soap will lather and be useful for cleaning.

Hard water may be treated by using washing soda (Na_2CO_3) method where sodium carbonate is added into the hard water that contains chlorides and sulfates of calcium and magnesium.

(a) Explain why rain containing dissolved carbon dioxide can react with calcium carbonate. [2]

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(b) Suggest a chemical that can be added to carry out the titration at pH 13. [1]

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(c)(i) It is mentioned above that "enough soap is needed before the soap will lather and be useful for cleaning". Explain why this is so [1]

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(ii) A 500 cm^3 sample of water has a hardness reading of 275 mg/dm^3. Determine the minimum mass of soap that must be added into the sample of water before the soap will lather and be useful for cleaning. [3]

(d) Explain, with appropriate equation, how the addition of sodium carbonate will help to reduce the hardness of water. Describe how the treated water can be obtained after the treatment. [3]

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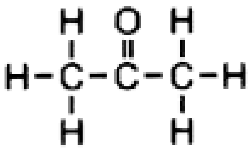
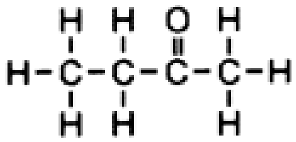
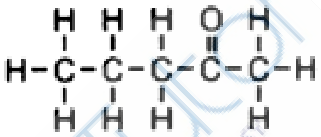
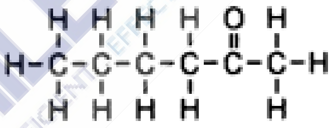
B10 In the table below shows a list of members found in the ketones homologous series.

name	molecular formula	structural formula	boiling point (°C)
propanone	C_3H_6O	 $H-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\Vert}{C}}-\underset{H}{\overset{H}{C}}-H$	56.2
butanone	C_4H_8O	 $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\Vert}{C}}-\underset{H}{\overset{H}{C}}-H$	79.6
pentanone	$C_5H_{10}O$	 $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\Vert}{C}}-\underset{H}{\overset{H}{C}}-H$	102
hexanone	$C_6H_{12}O$	 $H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\Vert}{C}}-\underset{H}{\overset{H}{C}}-H$	

(a) Draw the structural formula and write the name of the next member after hexanone. [2]

Name: ....

(b) What is the general formula of the ketones homologous series? [1]

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(c) Draw an isomer of butanone. [1]

(d) Suggest the boiling point of hexanone. [3]
Explain your answer in terms of bonding and structure.

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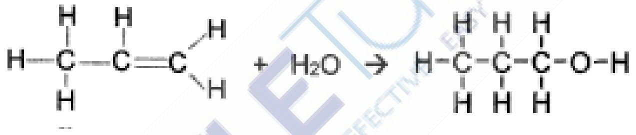
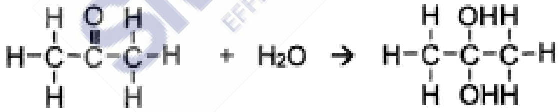
(e) Ketones and alkenes both undergo addition reactions as shown by the structural equations shown below.

Alkene: Propene reaction with water



Ketone: Propanone reaction with water



(i) Describe **two** differences between the two addition reactions shown above. [2]

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(ii) State and explain what would be observed when a few drops of Universal indicator are added into propanone. [1]

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Either

B11 Some metal carbonates, when heated, decompose to produce carbon dioxide.

Fig. 11.1 shows the results from an investigation on the rate of decomposition of four metal carbonates.

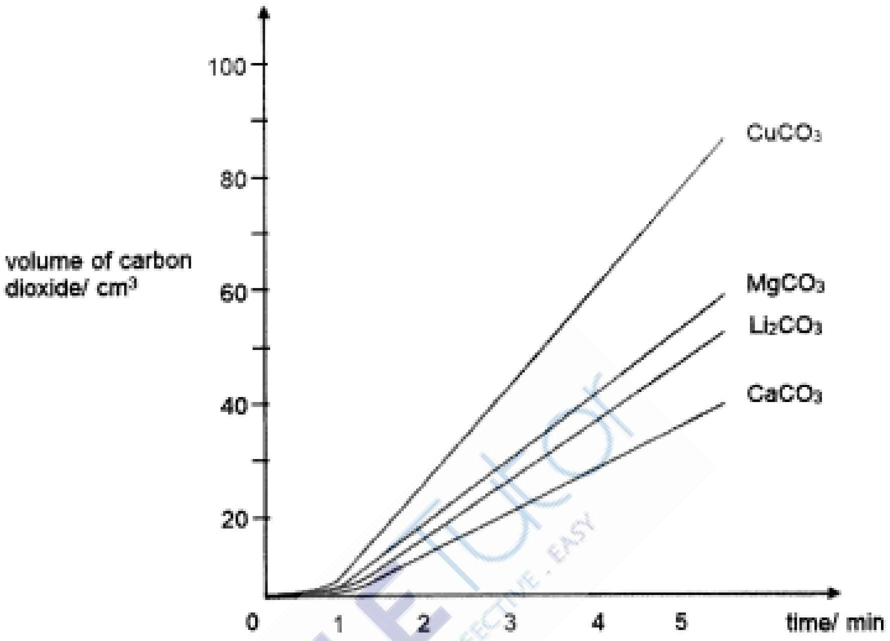

Fig. 11.1

In each experiment, 1.00 g of metal carbonate was heated to the same temperature using flame of the same intensity. The volume of carbon dioxide produced was measured at every minute interval.

(a) Suggest why very little carbon dioxide was collected at the start of each experiment. [1]

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(b) Using the information in **Fig. 11.1**, explain why the decomposition of metal carbonates were **not** completed at the end of the investigation. [1]

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(c)(i) Ignoring the volume of carbon dioxide recorded at time one minute, determine the speed of the decomposition lithium carbonate. [1]

(ii) Hence, determine the time it would take for 1 g of lithium carbonate to be completely decomposed. [3]

(d)(i) Using **only** the information in **Fig.** 11.1, state and explain which metal carbonate decomposed at the fastest rate. [2]

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(ii) Describe and explain how the volume of carbon dioxide will change with time if potassium carbonate was used for the experiment. [2]

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Or

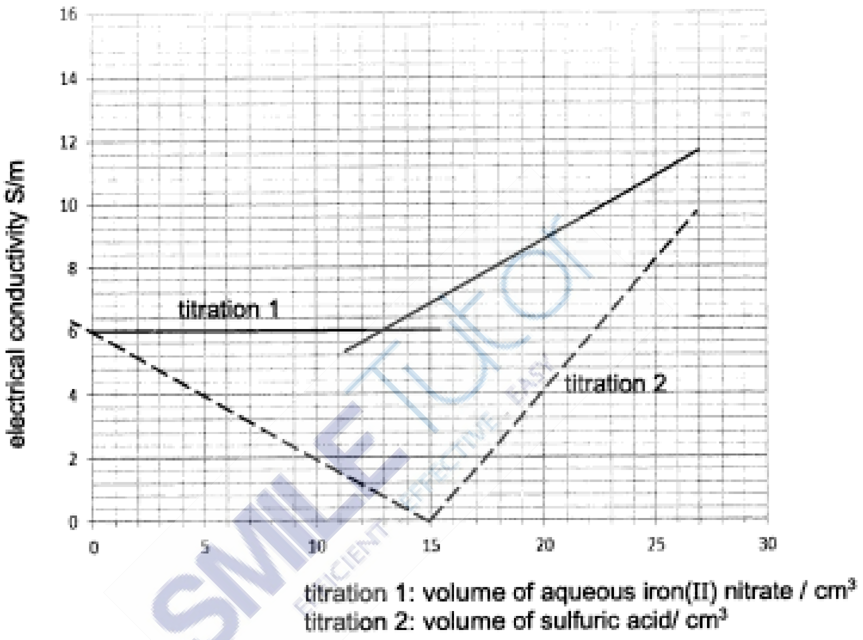
B11 Two titrations were carried with two different sets of solutions.
Titration 1 involved 20.0 cm^3 of sodium hydroxide and iron(II) nitrate solution.

$$2NaOH + Fe(NO_3)_2 \rightarrow Fe(OH)_2 + 2NaNO_3$$

Titration 2 involved 20.0 cm^3 barium hydroxide and sulfuric acid.

$$Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$$

To determine the end-point of a titration, the electrical conductivity of the solution was monitored. With the data collected, graphs were plotted and shown below.



(a)(i) One difference between the graphs obtained from titration 1 and titration 2 is that the electrical conductivity decreases to 0 S/m for titration 2 but not for titration 1. Explain why this is so. [4]

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(ii) State another difference in the graphs obtained for titration 1 and titration 2. [1]

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(iii) Suggest a reason for the difference in **(a)(ii)**. [2]

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....

(b) Determine the concentration of sodium hydroxide used in titration 1 given that the concentration of iron(II) nitrate used was 0.563 mol/dm^3. [3]

ANSWER SHEET

Paper 1

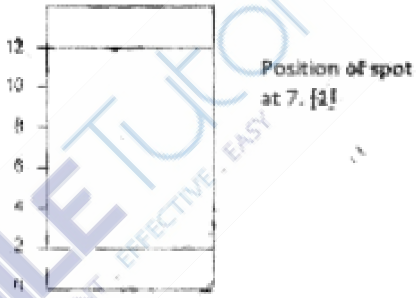
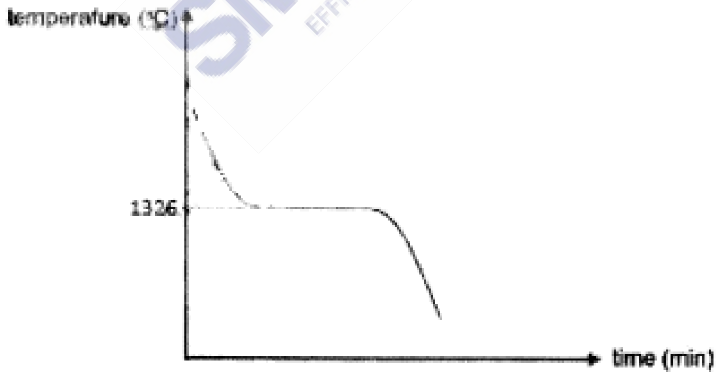
1	2	3	4	5	6	7	8	9	10
B	B	A	B	D	C	C	B	B	D

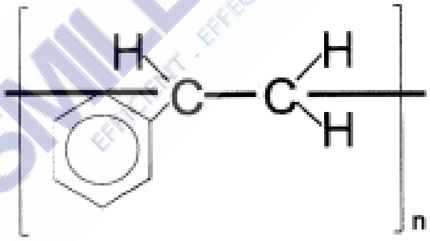
11	12	13	14	15	16	17	18	19	20
A	D	D	D	C	D	A	D	B	B

21	22	23	24	25	26	27	28	29	30
B	B	D	A	C	C	D	B	C	D

31	32	33	34	35	36	37	38	39	40
C	B	D	C	C	B	A	C	D	C

Paper 2

Section A		
A1		
ai	$\frac{\text{Distance travelled}}{10} = 0.7$ Distance travelled=7 [1]  Position of spot at 7. [1]	2
ii		1
bi	Based on the information provided, they only informed us that substance Y is a pure substance. A pure substance can be an element or a compound.	1
ii	Heat substance Y. If only one product is formed, substance Y is an element and if more than one product is formed, substance Y is a compound. Or	1 1

	Carry out thermal decomposition If substance Y did not break down into simpler substance, it is an element but if it breaks down to simpler substances, it is a compound.	
A2		
ai	Down the group from chlorine to iodine, as the electronegativity decreases, the bond dissociation energy decreases.	1
ii	Down the group, the atomic radius increases and the attraction between the nucleus between the shared electrons decreases. Hence, the electronegativity decreases. Thus, the amount of energy required to break the bond would be lower.	1 1 1
b	Fluorine has a small atomic radius and this cause the electrons in the atoms to repel each other. Hence, the bond dissociation energy is lower than expected.	1
A3		
a	$4Cu + 2NO_2 \rightarrow 4CuO + N_2$	1
ii	Nitrogen dioxide is reduced. The oxidation state of nitrogen decreases from +4 to 0 in nitrogen gas.	1 1
b	To remove the carbon dioxide gas/ unreacted oxides of nitrogen so that the nitrogen gas collected is pure.	1
c	Acetonitrile: % of nitrogen =34.15% N, N-dimethylnitrous amide: % of nitrogen = 37.8% Ethylenediamine: % of nitrogen = 46.7% The identity of the unknown organic compound is N, N-dimethylnitrous amide. The percentage of nitrogen in N, N-dimethylnitrous amide is the same as the unknown organic compound.	1 1
A4		
a	 Name of polymer: poly(styrene)	1 1
b	It should be carried out at 90 °C. At a 90 °C, the styrene monomers have a higher kinetic energy. This leads to a higher frequency effective collision and hence the rate of polymerisation is higher.	1 1 1
c	In the absence of catalyst, the rate of polymerisation of styrene decreases. The activation energy of the reaction is higher and lesser number of reacting particles would have the minimum energy.	1
A5		
a	The change is endothermic as the temperature of the mixture decreases after KC*l* is added into the water.	1
b	Energy taken in to break the bond in the KC*l* is more than the energy given out when the water molecules form bonds with the ions.	1 1
c	5 g of KC*l* takes in 1160 J of energy 0.067114 mols of KC*l* takes in 1160 J of energy 1 mol of KC*l* takes in 1160/0.067114 = 17284 J/mol = 17.3 kJ/mol	1 1 1

A6		
a	see table below	

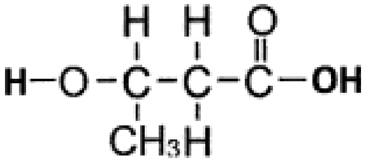
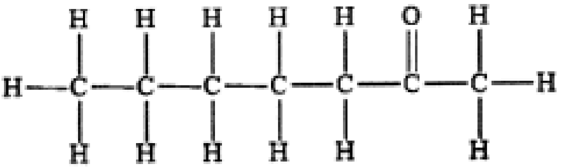
beaker	anode	cathode	electrolyte	
A	Bubbles are formed	Bubbles are formed	no visible change	1
B	decrease in size	increase in size	no visible change	
C	decrease in size	*increase in size*	*Solution turns blue*	1
D	Bubbles are formed	increase in size	*Blue solution turns colourless*	1

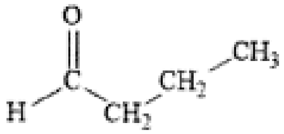
bi	For beaker A, there is no visible change to the electrolyte as the H+ and OH- ions preferentially discharged at the electrodes to form hydrogen and oxygen gas respectively. Water is being removed from the electrolyte	1
ii	For beaker B, the electrolyte will remain unchanged as the rate of oxidation of the copper anode is the same as the reduction of copper(II) ions at the cathode	1
iii	The copper anode will be oxidised to form copper(II) ions. However, the silver ions will be preferentially discharged at the cathode. With the presence of copper(II) ions in the electrolyte, the solution will gradually turn blue.	1 1
c	Anode: $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ Cathode: $Cu^{2+} + 2e- \rightarrow Cu$	1 1
A7		
ai	see table below	2

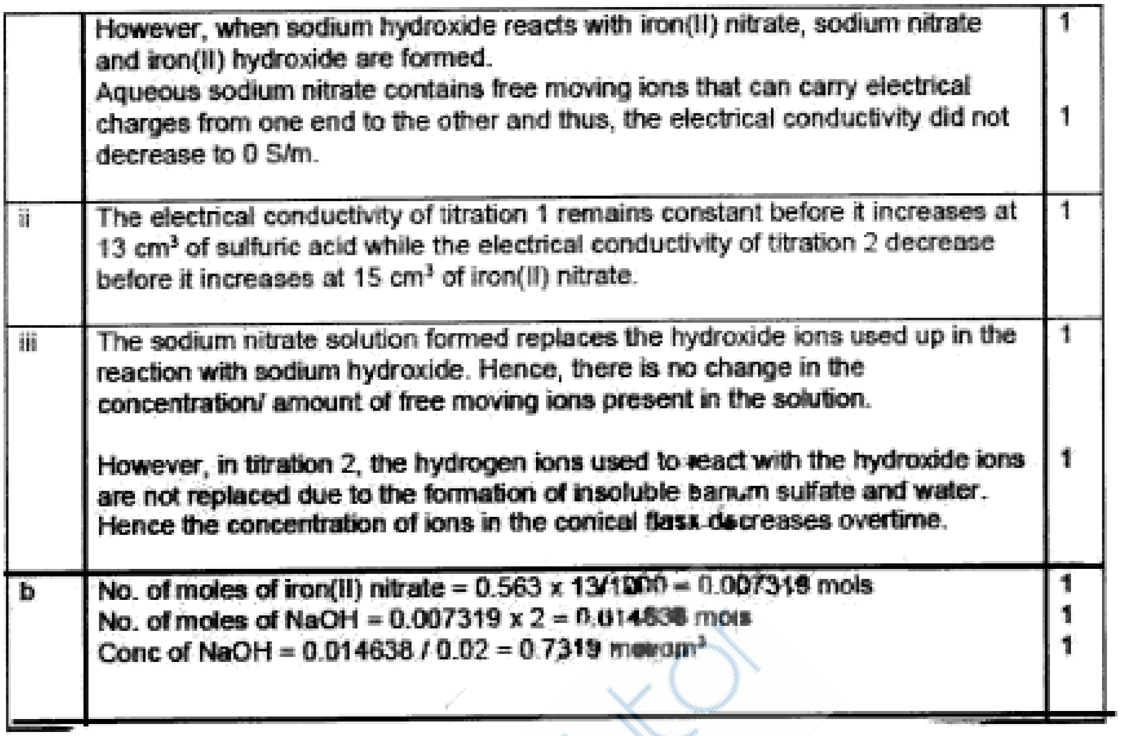
statement	True / False
Compound P can be made by fermentation.	False
Compound Q can be made by reacting compound P with an organic acid.	False
Water is also produced during the formation of compound Q and R.	true

All correct – 2M
2 correct – 1 M
1 or 0 correct – 0 M

ii	Temperature of about 37 °C Any temperature that is too high, the yeast will be denatured and too low, the yeast will be inactive. OR Absence of oxygen To prevent the oxidation of the alcohol produced.	1
bi	Propyl propanoate	1
ii	As a solvent; for perfume; for food flavouring	1

		1
A8		
ai	Polyester composites are too brittle/ break easily.	1
ii	Glass fibre has too high a density.	1
b	Kevlar has amide linkages but polyester has ester linkages. Kevlar is formed from reacting an amine with an organic acid while polyester is formed by reacting an alcohol with an organic acid.	1 1
c	Silicon dioxide has a high MP It has a giant molecular structure with strong covalent bonds between the silicon and oxygen atoms. Thus, a large amount of energy is needed to overcome these bonds. Or Silicon dioxide is a poor conductor of electricity. There are no free moving electrons or ions to Carry electrical charges from one end to the other.	1 1 1 1
Section B		
B9		
a	Carbon dioxide is an acidic oxide that can dissolve in rain to form a weak carbonic acid. The acidic solution can then react with calcium carbonate to form salt, water and carbon dioxide gas.	1 1
bi	Sodium hydroxide	1
ci	The soap needs to first react with the calcium ions found in hard water to form the insoluble curds before it can be used for cleaning purposes.	1
ii	Mass of $CaCO_3$ = 275 x 0.5 = 137.5 mg No. of moles of $CaCO_3$ = 137.5/100 = 1.375 mmoles (0.001375 mols) No. of moles of soap = 1.375 x 2 = 2.75 mmoles Mass of soap = 2.75 x (12 x 18 + 35 + 32 + 23) = 841.5 mg or 0.8415 g	1 1 1
d	Sodium carbonate will undergo precipitation with chlorides and sulfates of calcium and magnesium to form insoluble $CaCO_3$ or $MgCO_3$. The insoluble salts can be then removed by filtration. Equation	1 1 1
B10		
a		1

	Name: heptanone	1
b	$C_nH_{2n}O$	1
c		1
d	122 °C It has a larger molecular size than pentanone. Hence, it has a stronger attraction forces between its molecules. Thus, it needs more energy to overcome these forces leading to a higher temperature.	1 1 1
ei	When propene reacts with water, it forms propanol. However, when propanone reacts with water, it forms propanediol. The addition reaction between propene with water is the breaking of C=C while the addition reaction between propanone with water is the breaking of C=O.	1 1
ii	The Universal indicator would appear green. The propanone would not ionise in water to form any H^+ ions or OH^- ions. Thus, it will be neutral.	1
E11		
a	Energy was still being absorbed to overcome the activation energy Or most reactant particles have insufficient activation energy to undergo decomposition.	1
b	The volume of carbon dioxide gas collected did not remain constant.	1
ci	48/5 = 9.6 cm^3/min	1
ii	$Li_2CO_3 \rightarrow Li_2O + CO_2$ No. of moles of Li_2CO_3 = 1/ (14+12+16x3) = 0.013514 mols Vol of CO_2 = 0.013514 x 24 = 0.324336 = 324.336 cm^3 Time taken = 324.336 / 9.6 = 33.785 min	1 1 1
di	Copper(II) carbonate decomposes at the fastest rate. It produces the highest volume of carbon dioxide gas at time 5 min or It has the steepest gradient.	1 1
ii	The volume of carbon dioxide gas will remain at 0 or close to 0 cm^3. The more reactive the metal, the more thermally stable its carbonate. Hence, potassium carbonate is not able to decompose readily to form carbon dioxide gas.	1 1
O11		
ai	When barium hydroxide reacts with sulfuric acid, barium sulfate salt and water are formed. Barium sulfate is insoluble in water. Hence, when all the barium hydroxide has reacted, solid barium sulfate and water are poor conductors of electricity, and the electrical conductivity decreases to 0 S/m.	1 1



	However, when sodium hydroxide reacts with iron(II) nitrate, sodium nitrate and iron(II) hydroxide are formed. Aqueous sodium nitrate contains free moving ions that can carry electrical charges from one end to the other and thus, the electrical conductivity did not decrease to 0 S/m.	1 1
ii	The electrical conductivity of titration 1 remains constant before it increases at 13 cm^3 of sulfuric acid while the electrical conductivity of titration 2 decrease before it increases at 15 cm^3 of iron(II) nitrate.	1
iii	The sodium nitrate solution formed replaces the hydroxide ions used up in the reaction with sodium hydroxide. Hence, there is no change in the concentration/ amount of free moving ions present in the solution. However, in titration 2, the hydrogen ions used to react with the hydroxide ions are not replaced due to the formation of insoluble barium sulfate and water. Hence the concentration of ions in the conical flask decreases overtime.	1 1
b	No. of moles of iron(II) nitrate = 0.563 x 13/1000 = 0.007319 mols No. of moles of NaOH = 0.007319 x 2 = 0.014638 mols Conc of NaOH = 0.014638 / 0.02 = 0.7319 mol/dm^3	1 1 1

YISHUN SECONDARY SCHOOL PRELIM PAPER

1 Magnesium sulfate is prepared by reacting excess magnesium carbonate with dilute sulfuric acid.

$$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + CO_2(g) + H_2O(l)$$

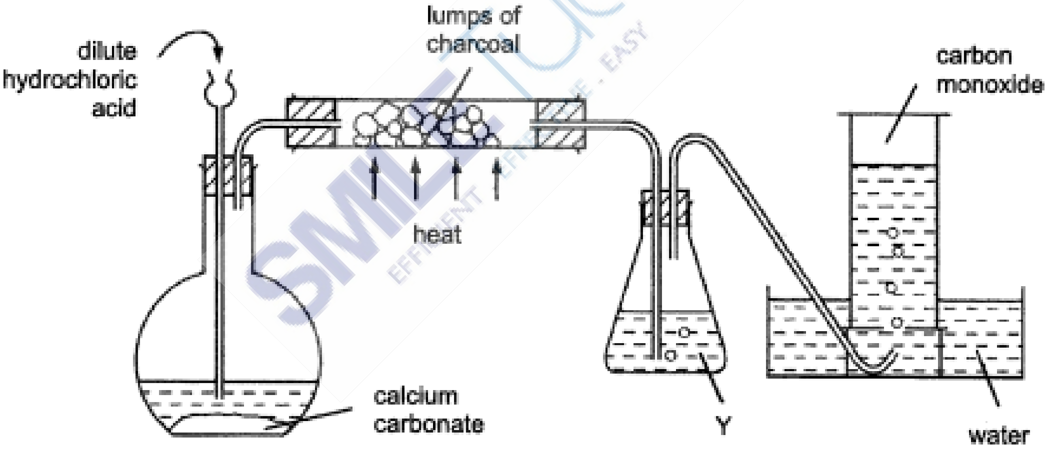
In addition to measuring cylinder, the following pieces of apparatus are available.

1 thermometer
2 evaporating dish
3 filter funnel
4 gas syringe

Which two pieces of apparatus are needed to obtain magnesium sulfate crystals?

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

2 The diagram shows apparatus used to obtain carbon monoxide.



What is the main purpose of Y?

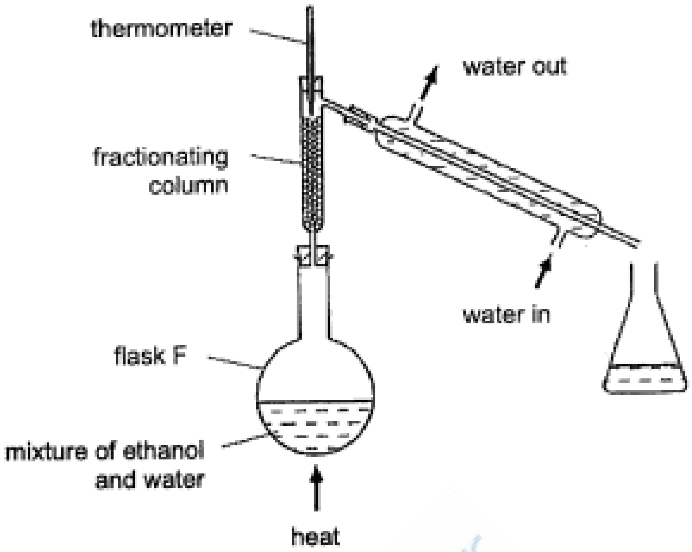
A to dry the gas

B to prevent water from being sucked back on to the hot charcoal

C to remove carbon dioxide from the gas

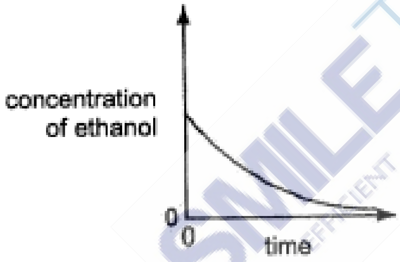
D to remove hydrogen chloride from the gas

3 The apparatus shown is used to distil ethanol from a mixture of ethanol and water.

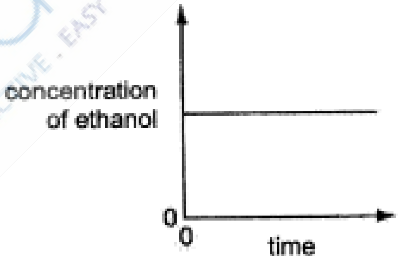


Which graph shows the change in concentration of ethanol in flask F over time?

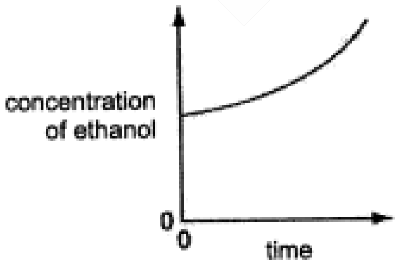
A



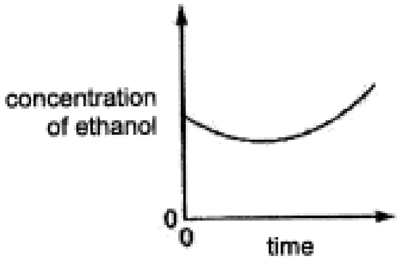
B



C



D



4 Aqueous sodium hydroxide was added to a mixture of an aqueous solution of Z. On warming, ammonia gas evolved. When aluminium foil is added to the reaction mixture and warmed, more ammonia gas was given off.

What could chemical Z be?

A aluminium nitrate

B aluminium sulfate

C ammonium nitrate

D ammonium sulfate

5 Some students are asked to describe differences between liquids and gases.

Four of their descriptions are:

1 Particles in liquid and gas are disorderly arranged.
2 Particles in gas are smaller than in liquid.
3 Particles in liquid vibrate about fixed positions.
4 When a force is applied, particles in gas are able to move closer together.

Which descriptions are correct?

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

6 Which particle contains the same number of both neutrons and electrons?

A $^{40}_{20}Ca^{2+}$ **B** $^{24}_{12}Mg^{2+}$ **C** $^{19}_{9}F^{-}$ **D** $^{32}_{16}S^{2-}$

7 Solid copper metal, aqueous copper(II) sulfate, solid graphite and molten sodium chloride will all conduct electricity.

Which pair will conduct electricity because they both contain mobile ions?

A aqueous copper(II) sulfate and molten sodium chloride

B solid copper metal and aqueous copper(II) sulfate

C solid copper metal and solid graphite

D solid graphite and molten sodium chloride

8 Which salt contains covalent bond?

- **A** ammonium chloride
- **B** magnesium bromide
- **C** potassium iodide
- **D** sodium fluoride

9 Which statement explains why potassium chloride, KC*l*, has a lower melting point than calcium oxide, CaO?

- **A** Potassium is more reactive than calcium.
- **B** Potassium chloride has covalent bonds and calcium oxide has ionic bonds.
- **C** The melting point of potassium is lower than that of calcium.
- **D** The attraction between K^+ and Cl^- is weaker than Ca^{2+} and O^{2-}.

10 Bromoethane reacts with sodium hydroxide.

The equation for the reaction is shown.

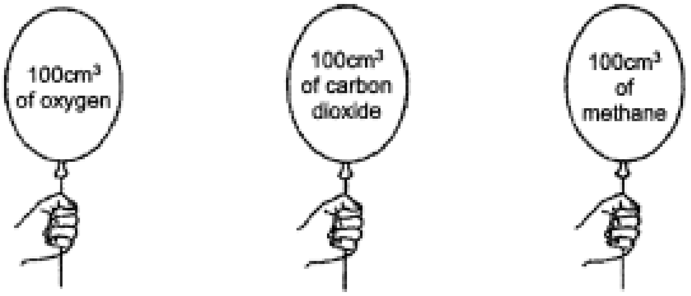
$$C_2H_5Br + NaOH \rightarrow C_2H_5OH + NaBr$$

In an experiment, 10.90g of bromoethane is converted into 3.45g of ethanol.

What is the percentage yield of ethanol?

- **A** 32 %
- **B** 42 %
- **C** 75 %
- **D** 100 %

11 The diagram shows three balloons filled with different gases held by students. All gas volumes were measured at room temperature pressure.



The students made the following statements.

1 The number of moles of gases in the 3 balloons is different.
2 The number of molecules in the 3 balloons is the same.
3 The mass of gases in the 3 balloons is different.

Which statements are correct?

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

12 A piece of chalk has a mass of 23.0 g. Chalk is impure calcium carbonate.
When analysed, the chalk is found to contain 0.226 moles of pure calcium carbonate, $CaCO_3$.

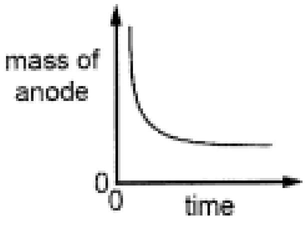
What is percentage purity of the piece of chalk?
[M_r: $CaCO_3$, 100]

A 0.983 % **B** 1.02 % **C** 77.0 % **D** 98.3 %

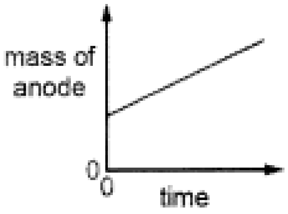
13 Aqueous copper(II) sulfate is electrolysed using copper electrodes. The current is constant and the anode is weighed at regular time intervals.

Which graph is obtained when the mass of the anode is plotted against time?

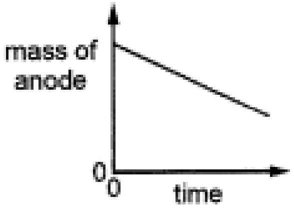
A



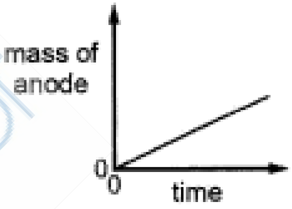
B



C



D



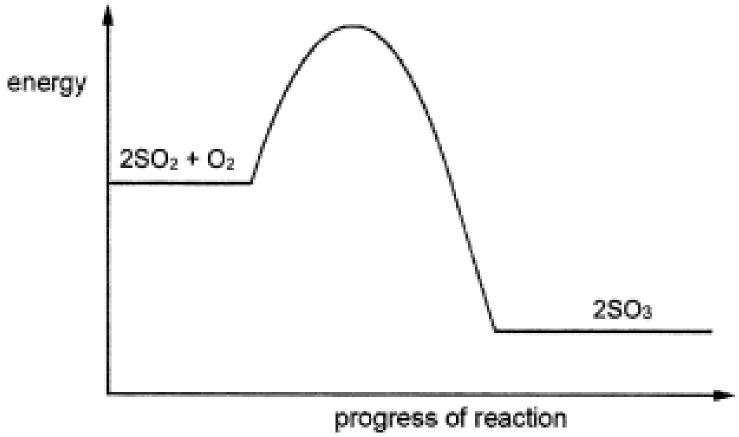
14 Three different processes using electrolysis with inert electrodes are listed.

1 electrolysis of concentrated aqueous sodium chloride
2 electrolysis of dilute sulfuric acid
3 electrolysis of dilute copper(II) chloride

Which processes form a gas at the cathode?

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

15 The energy profile diagram for the reversible reaction $2SO_2 + O_2 \rightleftharpoons 2SO_3$ is shown.



Which statements about this reaction are both correct?

	statement 1	statement 2
A	The reverse reaction is endothermic.	The activation energy is different for the forward and reverse reactions.
B	The reverse reaction is endothermic.	The activation energy is the same for the forward and reverse reactions.
C	The reverse reaction is exothermic.	The activation energy is different for the forward and reverse reactions.
D	The reverse reaction is exothermic.	The activation energy is the same for the forward and reverse reactions.

16 The table compares the strengths of bonds present in substances, P_2, Q_2 and PQ_3 that are involved in the reaction shown.

$$P_2 + 3Q_2 \rightarrow 2PQ_3$$

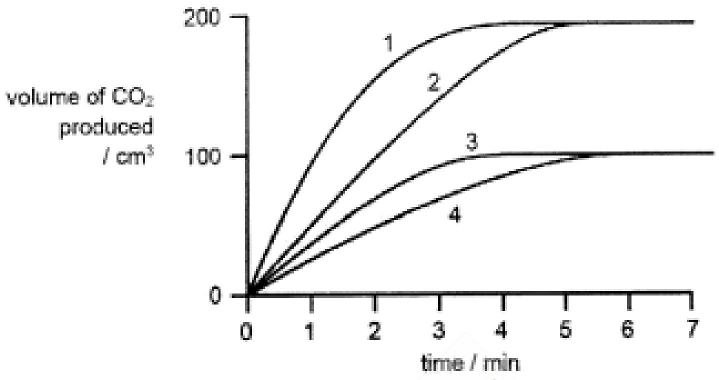
Which comparison of the strengths of the bonds will result in the most endothermic reaction?

	bonds in P_2	bonds in Q_2	bonds in PQ_3
A	strong	strong	weak
B	strong	weak	weak
C	weak	strong	strong
D	weak	weak	strong

17 In four separate experiments, 1, 2, 3 and 4, dilute nitric acid was added to excess marble chips and the volume of carbon dioxide formed was measured.

In all four experiments, the same volume of dilute nitric acid was used. Its concentration, or temperature, or both concentration and temperature, were changed.

The results of the experiments are shown on the graph.



Which statement is correct?

A A lower concentration of acid was used in experiment 1 than in experiment 3.

B Experiment 4 was faster than experiment 3.

C The acid used in experiment 2 was of a lower temperature than in experiment 1.

D The temperature of the acid was the same in experiments 1 and 2.

18 Separate samples of a solution H is added to aqueous potassium iodide and to acidified potassium manganate(VII). The iodide ions remain unchanged and the manganate(VII) ions are reduced in the reaction.

What are the observations?

	aqueous potassium iodide	acidified potassium manganate(VII)
A	brown solution turns colourless	colourless solution turns purple
B	colourless solution turns brown	purple solution turns colourless
C	solution remains brown	solution remains colourless
D	solution remains colourless	purple solution turns colourless

19 Three elements X, Y and Z belong to the same period in the Periodic Table.

The properties of their oxides are given in the table.

oxide of X:	soluble in both nitric acid and aqueous sodium hydroxide
oxide of Y:	insoluble in water and aqueous sodium hydroxide but dissolves readily in nitric acid
oxide of Z:	changes acidified potassium manganate(VII) from purple to colourless

Based on the statements above, arrange X, Y and Z in order of **decreasing** atomic numbers in the Periodic Table.

A Y, X, Z
B X, Y, Z
C Z, Y, X
D Z, X, Y

20 Four statements about acids were made.

1 Their pH value is less than 7.
2 They are completely ionised when dissolved in water.
3 They react with any metal to give hydrogen gas.
4 Dibasic acids are stronger than monobasic acids.

Which statements must be true for all acidic solutions?

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

21 Which reactants could be used safely to prepare sodium nitrate?

A aqueous sodium hydroxide and dilute nitric acid
B aqueous sodium sulfate and aqueous potassium nitrate
C sodium and dilute nitric acid
D sodium and aqueous potassium nitrate

22 Which statement about the manufacture of ammonia by the Haber Process is correct?

A Nickel is used as a catalyst in this process.
B The reactants and product are compounds.
C The reactants are both obtained from the air.
D A high yield is favoured by conditions of high pressure and low temperature.

23 Elements from Group IV of the Periodic Table are shown.

carbon
silicon
germanium
tin
lead
flerovium

Which does **not** occur down Group IV?

A The elements become more metallic.
B The elements have more electron shells.
C The number of outer shell electrons increases.
D The proton number of the elements increases.

24 A new element, Gr, was discovered with the following properties.

solubility	electrical conductivity	formula of element	bonding in a molecule of the element
insoluble	does not conduct	Gr_2	$Gr \equiv Gr$

Which group is Gr from?

A Group III
B Group V
C Group VII
D Group 0

25 Which pair of compounds shows that transition elements have variable oxidation states?

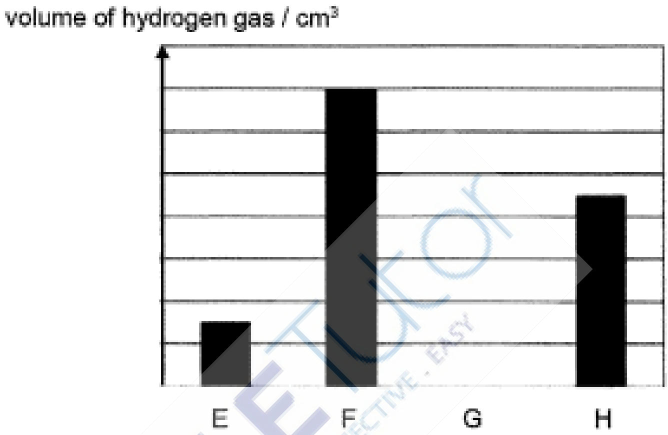
A Cr_2O_3 and $CrBr_3$

B $CuSO_4$ and $CuCl_2$

C Fe_2O_3 and $FeCl_2$

D NiO and $NiCl_2$

26 The bar chart shows the volume of hydrogen gas collected in 1.0 min when equal masses of metals E, F, G and H were added to excess dilute nitric acid



The carbonates of these metals were then heated.

Which row correctly shows the temperature required to decompose the carbonates in increasing order?

	increasing temperature →			
A	F	E	H	G
B	F	H	E	G
C	G	E	F	H
D	G	E	H	F

27 Which process removes carbon dioxide from the atmosphere?

A combustion of fuels
B photosynthesis
C respiration
D volcanic activity

28 The list shows the position of metal Q in the reactivity series of metals.

Na Al Fe Q Cu Ag

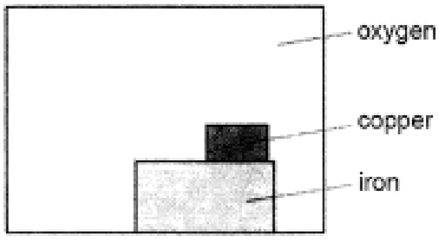
Which method(s) could be used to extract metal Q?

1 electrolysis of the solid metal oxide
2 heating the metal oxide with copper
3 heating the metal oxide with carbon

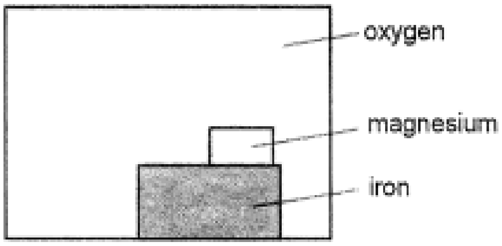
A 1, 2 and 3
B 1 and 3
C 2 and 3
D 3 only

29 Which diagram correctly shows the conditions required for rusting to take place and the metal used as sacrificial protection?

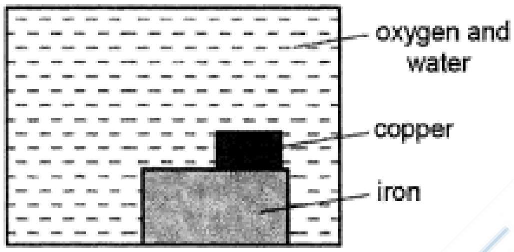
A



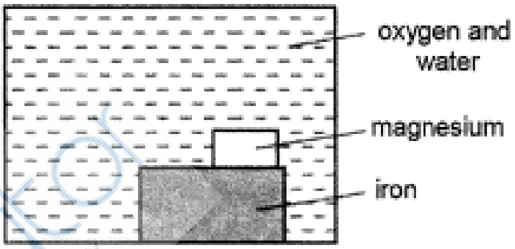
B



C



D



30 Petrol and diesel are two common fuels used by cars and buses respectively. The combustion of these fuels produces air pollutants.

The table shows the mass of pollutants found in the exhaust fumes when 1 kg of each fuel is burnt.

fuel	mass of pollutants/ g			
	carbon monoxide	oxides of nitrogen	sulfur dioxide	unburnt hydrocarbons
petrol	240	20	1	25
diesel	10	60	4	20

Which statement can be inferred from the table?

A Petrol contributes more towards the formation of acid rain.

B Carbon monoxide is produced by complete combustion of the fuels.

C All the pollutants listed can be removed by installing a catalytic converter.

D The temperature in the petrol engine is lower than that in the diesel engine.

31 Which method is the **least** effective method in reducing the amount of pollutant gases that cause acid rain?

- **A** Burning fuel with low sulfur content.
- **B** Reduce usage of air−conditioners.
- **C** Pass waste gases through catalytic converters in motor vehicles.
- **D** Use limestone to absorb pollutant gases from factories.

32 The table shows the boiling points of four fractions obtained when crude oil is distilled.

fraction	W	X	Y	Z
boiling point/ °C	35 – 75	80 – 145	150 – 250	greater than 250

Which statement describing the fractions is true?

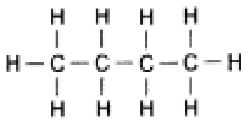
- **A** Fraction W is more flammable than fraction Y.
- **B** Fraction W is more viscous than fraction Z.
- **C** The density of fraction X is greater than that of fraction Z.
- **D** The molecules in X have a longer chain length than those in fraction Z.

33 Several observations of an organic compound were made:

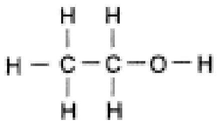
- liquid Br_2 remained brown when added to it in the dark
- there was no observable change when it was heated with acidified $KMnO_4$
- there was no observable change when it was added to Mg metal

Which is the organic compound?

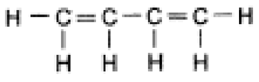
A



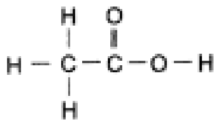
B



C



D



34 The table shows the reactions between chlorine and methane.

Which row shows the correct equation and condition of the reaction?

	equation	condition
A	$Cl_2 + CH_4 \rightarrow CH_2Cl_2 + H_2$	gases are mixed in the presence of UV light
B	$Cl_2 + CH_4 \rightarrow CH_2Cl_2 + H_2$	methane is bubbled into aqueous chlorine
C	$Cl_2 + CH_4 \rightarrow CH_3Cl + HCl$	gases are mixed in the presence of UV light
D	$Cl_2 + CH_4 \rightarrow CH_3Cl + HCl$	methane is bubbled into aqueous chlorine

35 When decane, $C_{10}H_{22}$, is cracked, only three compounds are formed.

The compounds are ethane, ethene and propene.

What is the ratio of the compounds formed?

	ethane	ethene	propene
A	1	1	1
B	1	1	2
C	1	2	1
D	2	1	1

36 One mole of hydrocarbon, J reacts with three moles of bromine to form a saturated organic compound.

What could be the molecular formula of J?

A C_3H_6
B C_4H_6
C C_5H_8
D C_6H_8

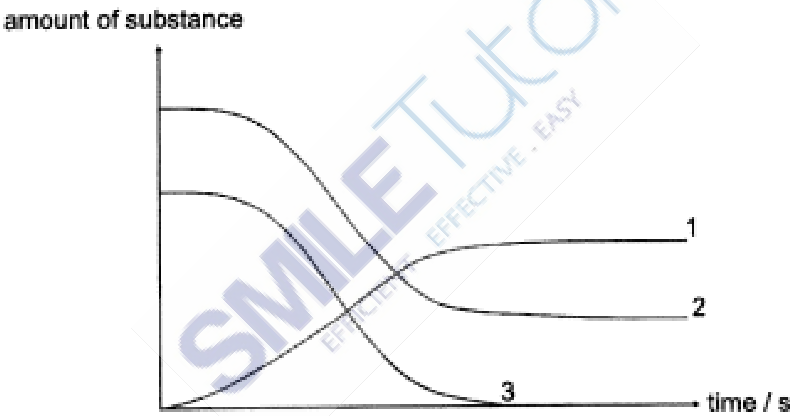
37 The properties of three substances are given:

1 an ester from an alcohol and a carboxylic acid
2 ethanol from ethene
3 margarine from vegetable oil

In which preparations are one or more double bonds converted to single bonds?

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

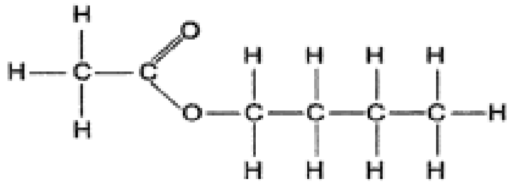
38 The graphs show the amount of various substances present in a mixture during the process of fermentation.



Which row shows the correct substance for each graph?

	graph 1	graph 2	graph 3
A	ethanol	yeast	glucose
B	glucose	yeast	ethanol
C	glucose	ethanol	yeast
D	ethanol	glucose	yeast

39 A food chemist wants to create the odour of pineapples using the organic compound,



Which row correctly shows the pair of reactants that would react to form this compound and the name of the compound?

	reactant 1	reactant 2	name of the compound
A	CH_3CH_2OH	$CH_3CH_2CH_2CH_2OH$	ethyl butanoate
B	CH_3CH_2OH	$CH_3CH_2CH_2COOH$	ethyl butanoate
C	CH_3COOH	$CH_3CH_2CH_2CH_2OH$	butyl ethanoate
D	$CH_3CH_2CH_2COOH$	CH_3COOH	butyl ethanoate

40 The table refers to the polymers nylon and poly(ethene).

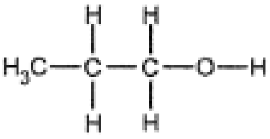
Which row is correct?

	polymer	type	use
A	nylon	addition	cling film
B	nylon	condensation	parachutes
C	poly(ethene)	addition	parachutes
D	poly(ethene)	condensation	cling film

Section A

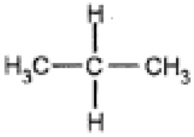
Answer **all** questions in this section in the space provided.
The total mark for this section is 50.

A1 The diagrams can be used to represent the structures of some organic compounds.



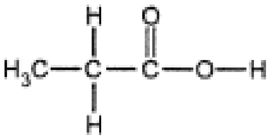
$H_3C-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-O-H$

A



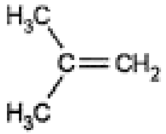
$H_3C-\overset{H}{\underset{H}{C}}-CH_3$

B

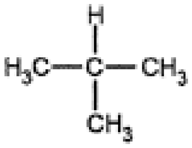


$H_3C-\overset{H}{\underset{H}{C}}-\overset{O}{\overset{\|}{C}}-O-H$

C

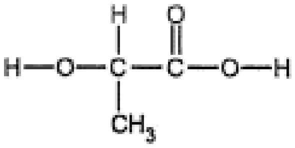


D



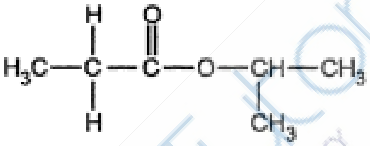
$H_3C-\overset{H}{\underset{CH_3}{C}}-CH_3$

E



$H-O-\overset{H}{\underset{CH_3}{C}}-\overset{O}{\overset{\|}{C}}-O-H$

F



$H_3C-\overset{H}{\underset{H}{C}}-\overset{O}{\overset{\|}{C}}-O-\underset{CH_3}{CH}-CH_3$

G

Each compound may be used once, more than once or not at all.

(a) State which compound:

(i) has a molecule with only 14 atoms

....[1]

(ii) can be oxidised to form propanoic acid

....[1]

(iii) is an isomer of butane

....[1]

(iv) reacts with steam to make an alcohol

....[1]

(b) State which **two** compounds in aqueous solution turn blue litmus red.

....[1]

[total: 5]

A2 This question is about ammonia.

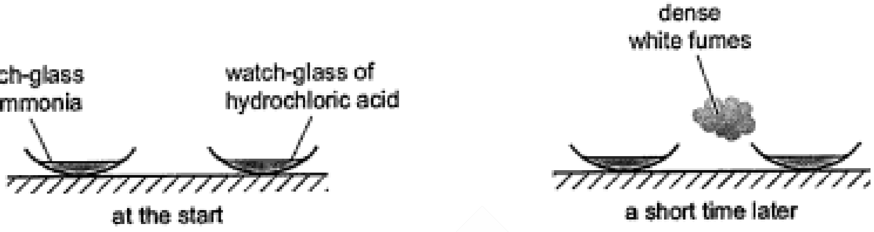
(a) When ammonia gas reacts with hydrogen chloride gas, white fumes of ammonium chloride are formed.

$$NH_3 + HCl \rightleftharpoons NH_4Cl$$

Watch-glasses of aqueous ammonia and concentrated hydrochloric acid were placed near each other on a table.

At first no white fumes were seen.

After a short time, white fumes were seen between the watch-glasses.



Explain these observations using kinetic particle theory.

....

....

....

....

....

....[3]

(b) Ammonia is produced by reacting nitrogen gas and hydrogen gas during the Haber process.

(i) State the conditions required for the Haber process.

....[1]

(ii) Since nitrogen is the most abundant gas in air, explain why air is **not** used as a raw material during the Haber process.

....

....

....

....[2]

(c) Concentrated aqueous ammonia is used to make fertilisers such as ammonium sulfate, $(NH_4)_2SO_4$.

Aqueous ammonia reacts with dilute sulfuric acid.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_2(aq)$$

A student titrates 20.0 cm^3 of aqueous ammonia with 0.150 mol/dm^3 sulfuric acid.

10.5 cm^3 of sulfuric acid is required to neutralise the aqueous ammonia.

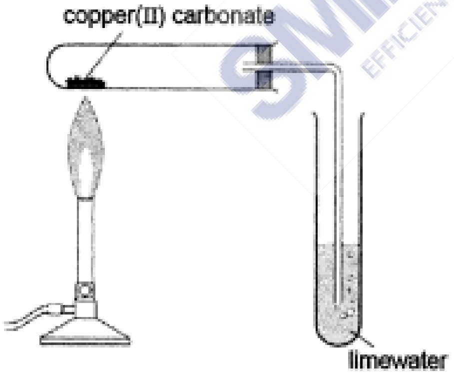
Calculate the concentration, in mol/dm^3, of the aqueous ammonia.

[3]

[total: 9]

A3 A student investigated the rate of a reaction using the apparatus and materials as shown.

He also noted observations at regular time interval during heating.



time interval / min	observations
0 – 1	A slow release of bubbles. No change observed in limewater. The solid in the test tube was green.
1 – 2	A fast release of bubbles. A change was observed in limewater at 1 minute 10 seconds. The solid turned black.
2 – 3	No release of bubbles. The solid in the test tube remained black after cooled.

(a) Explain the student's observation between

(i) zero and first minute

....

....[1]

(ii) first and second minute

....

....

....[2]

(iii) second and third minute

....

....

....[2]

(b) Explain how the observations would differ from the decomposition of copper(II) carbonate if the same number of moles of calcium carbonate is heated.

....

....

....

....

....[3]

[total: 8]

A4 Table 4.1 shows some properties of *oxyacids* of chlorine.

Table 4.1

name of acid	chemical formula	reaction with magnesium (all acids have the same concentration)	oxidation state of chlorine
hypochlorous acid	$HClO$	only a few bubbles seen	
chlorous acid	$HClO_2$	reacts readily	
chloric acid	$HClO_3$	vigorous	
perchloric acid	$HClO_4$	very vigorous	

(a) Suggest why these acids are known as *oxyacids*.

....

....[2]

(b) Complete the table by filling in the oxidation states of chlorine. [2]

(c) State the relationship between the oxidation state of chlorine in the formula and the strength of the acid. Justify your answers with reference to Table 4.1

....

....

....

....[2]

(d) Suggest a method, beside observations, the student could use to follow the rate of the reaction.

....

....[2]

[total: 8]

A5 Oxides of nitrogen are atmospheric pollutants. Nitrogen monoxide, NO, is formed in combustion engines when nitrogen and oxygen react together.

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

Fig. 5.1 shows the energy profile for this reaction.

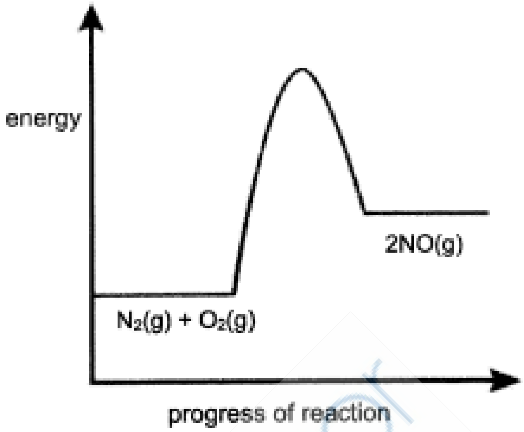


Fig. 5.1

(a) Label clearly on Fig. 5.1 the reaction enthalpy change and the activation energy on the energy profile diagram. [2]

(b) The reaction between nitrogen and oxygen is endothermic.

(i) Explain how you can tell from the diagram that the reaction is endothermic.

....[1]

(ii) The year 2019 proved to be one of the hottest years on record in Singapore, with the annual mean temperature hitting 28.4 °C.
Describe and explain how a hotter day affects the activation energy of the formation of nitrogen monoxide in combustion engines.

....

....

....

....[2]

(c) Cars have catalytic converters fitted to reduce pollution problems caused by some of the exhaust gases.

Write an equation to show one exhaust gas is converted to a harmless substance within the catalytic converter.

....[1]

[total: 6]

A6 Two metal electrodes and an electrolyte can be used to produce electrical energy.

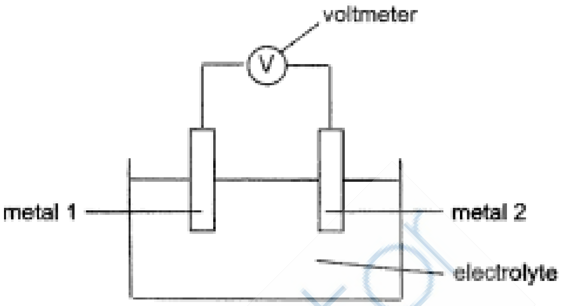


Table 6.1 shows the voltage produced by some cells when different metals are used.

Table 6.1

cell	metal 1	metal 2	voltage / V
1	copper	zinc	1.10
2	copper	magnesium	2.72
3	silver	zinc	1.56
4	silver	iron	1.25

(a) In which direction does the electrons flow in the external wire of cell 3?

....[1]

(b) In terms of the reactions that take place in the cells, explain why the voltage of cell 2 is higher than cell 1.

....

....

....

....[2]

(c) Suggest the voltages that will be produced when the following metals are used.

metal 1	metal 2	predicted voltage / V
copper	iron	
silver	magnesium	

[2]

(d) In cell 1, the student observed that the mass of zinc electrode decreases while the mass of copper remains when the electrolyte used is sodium chloride. However, when the electrolyte is changed to copper(II) chloride, the mass of copper electrode increases. Explain these observations.

....

....

....

....

....

....[3]

[total: 8]

A7 Table 7.1 shows the R_f values of pure substances, **A**, **B**, **C**, **D** and **E**. where chromatography was carried out in separate experiments using two different solvents, **X** and **Y**.

Table 7.1

	Substance				
Solvent	**A**	**B**	**C**	**D**	**E**
X	0.50	0.78	0.15	0.50	0.32
Y	0.98	0.00	0.50	0.65	0.32

(a) State which of the substances is insoluble in solvent **Y**. Explain your answer.

....

....[2]

(b) Using chromatography, a mixture was found to contain substances **A**, **D** and **E**. Suggest which solvent was used to obtain the results. Explain your answer.

....

....[1]

(c) A chromatography of five substances was carried on the same chromatogram with both solvents **X** and **Y**.

The chromatogram was first run using solvent **X**. It was then turned 90° on its side where a second chromatogram using solvent **Y** was run.

On the chromatogram on Fig. 7.1,

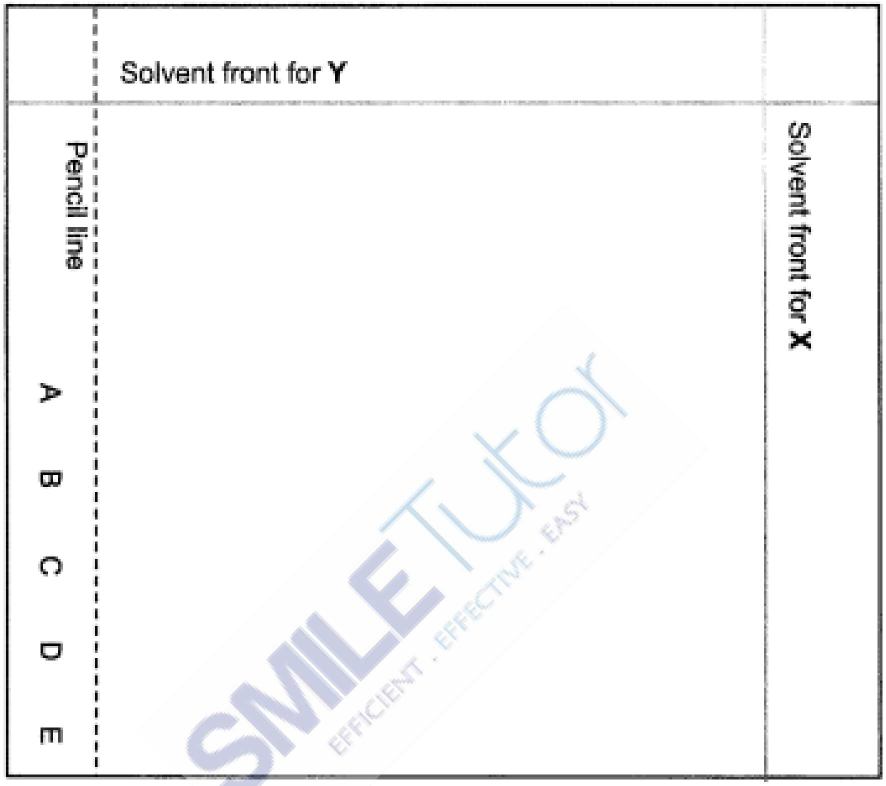


Fig. 7.1

(i) Mark with a "**B**" where you would find the final spot formed by substance **B**. [1]

(ii) Mark "**E**' where you would find the final spot formed by substance **E**. [1]

(d) The use of a locating agent was required in the chromatography experiments.

Explain why a locating agent is used.

....

....[1]

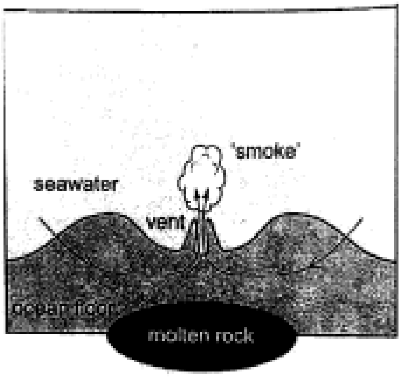
[total: 6]

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 This question is about the chemistry of reactions occurring in hydrothermal vents that are found on the ocean floor.



The diagram shows a hydrothermal vent. Seawater flows through the rocks in the ocean floor and is heated by molten rock below the surface. It then flows back out into the ocean through the hydrothermal vent, producing a cloud of 'smoke' consisting of precipitated solids.

The chemical composition of the water coming out of the vents is different from normal seawater.

Table 8.1 shows a typical composition of both types of water.

Table 8.1

	normal seawater	hydrothermal vent water
temperature / °C	2	350
pH	7.8	4.3
concentration of ions / x 10^{-3} mol/dm^3		
Cl^-	531	539
Na^+	450	419
Mg^{2+}	51.2	0.0
SO_4^{2-}	27.1	0.0
HCO_3^-	2.3	5.7
Ca^{2+}	9.9	15.1
K^+	9.5	22.5
Fe^{2+}	0.0	1.62
Mn^{2+}	0.0	0.93
Cu^{2+}	0.0	0.03
NH_4^+	0.0	0.03
concentration of gases / x 10^{-3} mol/dm^3		
O_2	0.1	0.0
HCl	0.0	7.1
H_2S	0.0	1.7
CH_4	0.0	0.1
He	0.0	2 x 10^{-6}

(a) **(i)** State which ions are removed from the seawater by the hydrothermal vent.

....[1]

(ii) State which transition metal ions have been added to the water by the process.

....[1]

(b) An environmentalist made the following statement: "The decrease in the concentration of the hydrogen ions is only due to the increase in the temperature of the water."

Using relevant data from Table 8.1, explain why the statement made by the environmentalist is incorrect.

....

....

....

....

....

....[3]

(c) The 'smoke' contains a variety of metal sulfides, which are precipitated when the hot hydrothermal vent water meets the cold seawater.

In one reaction, iron(II) disulfide, FeS_2, is formed in a redox reaction from iron(II) ions and hydrogen sulfide.

$$Fe^{2+}(aq) + 2H_2S(aq) \rightarrow FeS_2(s) + H_2(g) + 2H^+(aq)$$

(i) Deduce which element is oxidised and which is reduced in this reaction.

oxidised .... reduced .... [1]

(ii) Draw a 'dot-and-cross' diagram of hydrogen sulfide, showing the outer shell electrons only.

(d) Normal seawater contains the salt sodium hydrogen carbonate which can be prepared in the science laboratory as shown below.

In the first experiment, 25.00 cm³ of 2.00 mol/dm³ dilute hydrochloric acid solution is added to completely react with 25.0 of 1.00 mol/dm³ aqueous sodium carbonate in a conical flask to produce sodium chloride, water and carbon dioxide gas as shown in the reaction.

$$2\ HCl(aq)\ +\ Na_2CO_3(aq)\ \rightarrow\ 2NaCl(aq)\ +\ H_2O(g)\ +\ CO_2(g)$$

The above reaction is said to proceed via these two steps:

step 1	$HCl(aq)\ +\ Na_2CO_3(aq)\ \rightarrow\ NaHCO_3(aq)\ +\ NaCl(aq)$
step 2	$HCl(aq)\ +\ NaHCO_3(aq)\ \rightarrow\ NaCl(aq)\ +\ H_2O(g)\ +\ CO_2(g)$

In a second experiment, 25.0 cm³ of the same dilute hydrochloric acid solution is placed inside a conical flask.

You are given the same aqueous sodium carbonate that was used in the first experiment.

State the minimum volume of aqueous sodium carbonate to be added in order to produce maximum number of moles of sodium hydrogen carbonate.

....[1]

(e) The gas from a hydrothermal vent contains helium with a slightly lower relative atomic mass than is normally found in the Earth's atmosphere.

(i) Define the term *relative atomic mass*.

....

....[1]

(ii) The relative atomic mass of the helium from a particular vent is exactly 4.0025959.

The two naturally occurring isotopes of helium have the precise relative isotopic masses as shown in Table 8.2.

Table 8.2

isotope	relative isotopic mass
^3He	3.0160293
^4He	4.0026033

Calculate the percentage of ^3He in the mixture.

[2]

[total: 12]

B9 A precipitation reaction refers to the formation of an insoluble salt when two soluble salt solutions react. The insoluble salt that is produced is known as the precipitate. Barium hydroxide is an alkali solution which can be used in precipitation reaction. It has the following structure:

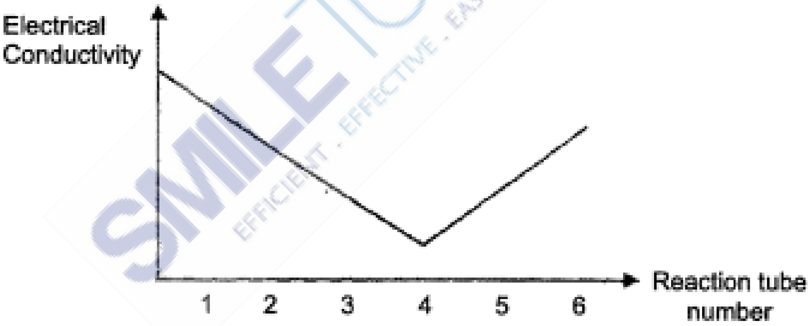
$$Ba^{2+}\ [H{-}O]^{-}\ [H{-}O]^{-}$$

A study of a precipitation reaction between barium hydroxide and dilute sulfuric acid was conducted. The reaction tubes containing different volumes of barium hydroxide and dilute sulfuric acid. Precipitation occurs in all the reaction tubes and after 20 minutes, the height of the precipitate in each tube is measured and recorded in Table 9.1.

Table 9.1

reaction tube	1	2	3	4	5	6
volume of 0.25 mol/dm^3 barium hydroxide used / cm^3	5.0	5.0	5.0	5.0	5.0	5.0
volume of 0.50 mol/dm^3 dilute sulfuric acid used / cm^3	1.0	1.5	2.0	2.5	3.0	3.5
height of precipitate / cm	2.5	3.0	3.5	4.0	4.0	?

The electrical conductivity of each reaction tube is recorded and shown in the graph.



(a) Write an ionic equation to represent the precipitation reaction.

....[1]

(b) Draw a 'dot-and-cross' diagram to show the bonding in a hydroxide ion, showing the outer shell electrons only.

[2]

(c) Predict, with reason, the height of the precipitate and the colour of the Universal Indicator when added to reaction tube 6 after 20 minutes.

height of the precipitate ....

colour of Universal Indicator ....

reason ....

....[2]

(d) Describe and explain the shape of the electrical conductivity graph.

....

....

....

....

....

....[3]

[total: 8]

B10 **Either**

Table 10.1 shows some information on different types of plastics that are commonly used.

Table 10.1

	tensile strength (MPa)	density (g/cm^3)	number of years to break down the plastic
biopolymers	36	1.24	0.5
clear polystyrene	25	1.04	approximately 100
polycarbonates	55 – 75	1.20	1

Note: Tensile strength measures the resistance of a material to breaking under tension.

(a) **(i)** Explain why biopolymers and polycarbonate have been used to replace polystyrene as plastics.

....

....

....

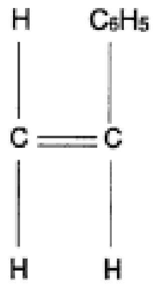
....[2]

(ii) Give one disadvantage of using biopolymers as a plastic container to store food.

....

....[1]

(b) Polystyrene is manufactured from phenylethene. The structure of phenylethene is shown.



(i) Explain how polystyrene could be obtained from phenylethene.

....

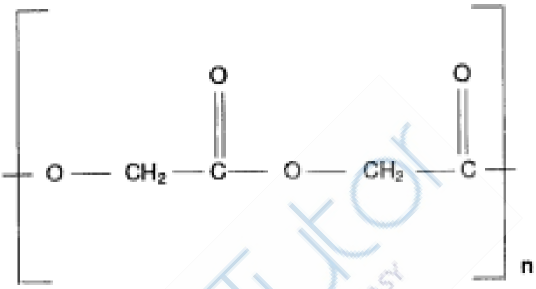
....

....[3]

(ii) Draw the structural formula of polystyrene, showing two repeat units.

[1]

(c) Biopolymers are renewable plastic materials manufactured from biomass such as corn, wheat, sugar cane and potatoes. An example of the structure of a type of biopolymer is shown below:



$$\left[-O-CH_2-\overset{\overset{\displaystyle O}{\|}}{C}-O-CH_2-\overset{\overset{\displaystyle O}{\|}}{C}- \right]_n$$

(i) With reference to the linkage, what type of polymer is this biopolymer?

....[1]

(ii) Name one synthetic polymer that has a similar structure as this biopolymer.

....[1]

(iii) The biopolymer in **(c)** can be broken down easily to its monomer.
Draw the structural formula of the monomer after the biopolymer is broken down.

[1]

[total: 10]

B10 Or

Both copper and magnesium are metals.

(a) Explain why magnesium reacts with hydrochloric acid but copper does not.

....

....[1]

(b) Brass is an alloy of copper and zinc. Table 10.2 shows how the composition of brass influences its relative strength.

Table 10.2

composition of brass		relative strength
% copper	% zinc	
90	10	2.6
80	20	3.0
70	30	3.3
60	40	3.6

How does the composition of brass affect its strength?

....

....[1]

(c) Use your knowledge of the structure of metals to explain why brass is stronger than pure copper. You may include a labelled diagram in your answer.

....

....

....

....[3]

(d) A 11.09 g sample of an oxide of copper contains 9,86 g of copper.

Deduce the empirical formula of this oxide of copper.

empirical formula ....[2]

(e) Water draining from the waste heaps around a copper mine is often blue due to the presence of hydrated copper(II) ions.

Describe and explain what would be observed if an iron bar is placed into a container filled with water containing hydrated copper(II) ions.

....

....

....

....

....

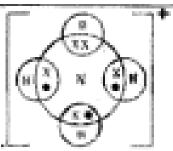
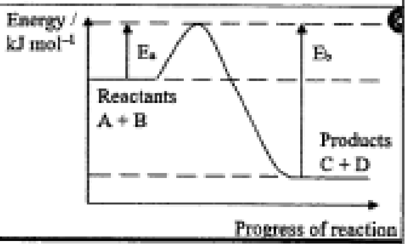
....[3]

[total: 10]

ANSWER SHEET

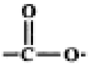
Answers to Paper 1

<table>
<tr><th>Qn</th><th>Answer</th><th>Explanation</th></tr>
<tr><td>1</td><td>C</td><td>Magnesium sulfate is a soluble salt and the preparation of magnesium sulfate involves reaction of excess magnesium carbonate with dilute sulfuric acid. Excess, unreacted magnesium carbonate need to be removed by filtration using filter funnel lined with filter paper. Followed by crystallization which require evaporating dish and tripod stand.</td></tr>
<tr><td>2</td><td>C</td><td>Reaction between hydrochloric acid and calcium carbonate produces carbon dioxide. The carbon dioxide produced is reacted with charcoal (carbon) to produce carbon monoxide. The purpose of Y is to neutralize the unreacted carbon dioxide with an alkali.</td></tr>
<tr><td>3</td><td>A</td><td>Ethanol (b.p 78 °C) has lower bpt than water, hence distilled first. As time progresses, more ethanol is distilled and collected as distillate. The concentration of ethanol at flask F decreases over time as more ethanol is distilled and water remained in flask F.</td></tr>
<tr><td>4</td><td>C</td><td>The first test is a cation test, when aq sodium hydroxide is added and warmed, ammonia gas is produced which shows the presence of ammonium ions. The second test is an anion test for nitrate ions. More ammonia gas is produced when aluminium metal is added showed the presence of nitrate ions. Z is ammonium nitrate.</td></tr>
<tr><td>5</td><td>B</td><td>
<table>
<tr><td>1</td><td>Both liquid and gas particles are disorderly arranged.</td><td>✓</td></tr>
<tr><td>2</td><td>Gas particles are smaller than liquid particles.
Size of a particles depends on the number of atoms of the gas and liquid particles. Gas particles can be bigger or smaller than liquid particles.</td><td>×</td></tr>
<tr><td>3</td><td>Liquid particles vibrate about fixed positions.
Liquid particles slide over other liquid particles.</td><td>×</td></tr>
<tr><td>4</td><td>When a force is applied, gas particles are able to move closer together.</td><td>✓</td></tr>
</table>
</td></tr>
<tr><td>6</td><td>C</td><td>
<table>
<tr><th></th><th>No of electrons</th><th>No of neutrons</th><th>Ans</th></tr>
<tr><td></td><td>18</td><td>20</td><td></td></tr>
<tr><td></td><td>10</td><td>12</td><td></td></tr>
<tr><td></td><td>10</td><td>10</td><td>✓</td></tr>
<tr><td>$^{32}_{16}S^{2-}$</td><td>18</td><td>16</td><td></td></tr>
</table>
</td></tr>
<tr><td>7</td><td>A</td><td>
<table>
<tr><th></th><th>solid copper metal</th><th>aqueous copper(II) sulfate</th><th>solid graphite</th><th>molten sodium chloride</th></tr>
<tr><td>conducts electricity</td><td>mobile electrons</td><td>mobile ions</td><td>mobile electrons</td><td>mobile ions</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>8</td><td>A</td><td>Ammonium ion has covalent bonding. </td></tr>
<tr><td>9</td><td>D</td><td>• The attraction between K^+ and Cl^- is weaker than Ca^{2+} and O^{2-}.
• the electrostatic force in CaO is stronger than KCl because the number of charges in CaO is greater than in KCl
• A larger amount of energy is needed to overcome the electrostatic force in CaO than in KCl</td></tr>
<tr><td>10</td><td>C</td><td><table>
<tr><td></td><td colspan="2">$C_2H_6Br + NaOH \rightarrow C_2H_5OH + NaBr$</td></tr>
<tr><td>Mol ratio</td><td>0.1 mol</td><td>0.1 mol</td></tr>
<tr><td>Theoretical yield</td><td></td><td>0.1 x 46 = 4.6g</td></tr>
<tr><td>% yield</td><td colspan="2">$\frac{3.45}{4.6}$ x 100%= 75%</td></tr>
</table></td></tr>
<tr><td>11</td><td>D</td><td><table>
<tr><td>1</td><td>The number of moles of gases in the 3 balloons is different.</td><td>× same vol of gas = same no of mol</td></tr>
<tr><td>2</td><td>The number of molecules in the 3 balloons is the same.</td><td>✓ same no of mol = same no of molecules</td></tr>
<tr><td>3</td><td>The mass of gases in the 3 balloons is different.</td><td>✓ different Mr for each gas</td></tr>
</table></td></tr>
<tr><td>12</td><td>D</td><td>Mass of $CaCO_3$ = 0.226 moles
Mass of CaCO3 = 0.226 x 100 = 22.6 g
% purity = $\frac{22.6}{23.0}$ × 100% = 98.3 %</td></tr>
<tr><td>13</td><td>C</td><td>Copper atoms in the copper anode oxidises to form Cu^{2+} ions in the electrolyte and the anode decreases in size, hence loses mass</td></tr>
<tr><td>14</td><td>A</td><td><table>
<tr><td></td><td>Cathode</td><td>anode</td></tr>
<tr><td>electrolysis of concentrated aqueous sodium chloride</td><td>Hydrogen</td><td>chlorine</td></tr>
<tr><td>electrolysis of dilute sulfuric acid</td><td>Hydrogen</td><td>water</td></tr>
<tr><td>electrolysis of dilute copper(II) chloride</td><td>Copper</td><td>water</td></tr>
</table></td></tr>
<tr><td>15</td><td>A</td><td>The reverse reaction is endothermic and the activation energy is Eb as shown in the graph. </td></tr>
<tr><td>16</td><td>A</td><td>In endothermic reactions, more energy is absorbed to break bond of the reactants than energy released making bonds.</td></tr>
<tr><td>17</td><td>C</td><td>Gradient in experiment 2 is gentler than 1 which indicates lower concentration</td></tr>
<tr><td>18</td><td>D</td><td>Potassium iodide solution is colourless and a reducing agent. If the colour remain unchanged means no oxidising agent is present. Acidified potassium manganate(VII) is purple in colour and an oxidising agent. As it is reduced, the colour will change from purple to colourless.</td></tr>
</table>

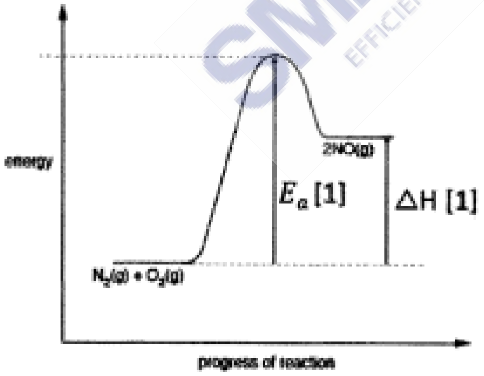
<table>
<tr><td>19</td><td>D</td><td>
<table>
<tr><td>oxide of X:</td><td>soluble in both nitric acid and aqueous sodium hydroxide</td><td>Amphoteric oxide</td><td>Zinc oxide, lead(II) oxide, aluminium oxide</td></tr>
<tr><td>oxide of Y:</td><td>insoluble in water and aqueous sodium hydroxide but dissolves readily in nitric acid</td><td>Basic oxide</td><td>metals other than amphoteric oxide</td></tr>
<tr><td>oxide of Z:</td><td>changes acidified potassium manganate(VII) from purple to colourless</td><td>Reducing agent</td><td>Acidic oxide → non-metal oxides</td></tr>
</table>
</td></tr>
<tr><td>20</td><td>A</td><td>
<table>
<tr><td>1</td><td>Their pH value is less than 7.</td><td>True</td></tr>
<tr><td>2</td><td>They are completely ionised when dissolved in water.</td><td>Some acids partially ionised acids in water such as ethanoic acid</td></tr>
<tr><td>3</td><td>They react with any metal to give hydrogen gas.</td><td>Some metals such as copper do not react with acids</td></tr>
<tr><td>4</td><td>Dibasic acids are stronger than monobasic acids.</td><td>Not all dibasic acids are stronger than mono basic acids</td></tr>
</table>
</td></tr>
<tr><td>21</td><td>A</td><td>Sodium nitrate is a SPA salt and method of preparation is titration. Titration involves the reaction between acids with alkali or metal carbonate</td></tr>
<tr><td>22</td><td>D</td><td>Conditions for Haber process:
• high temperature, 450°C, high pressure - about 200 atmospheres, and iron catalyst.</td></tr>
<tr><td>23</td><td>C</td><td>As the elements are in Group IV, all the elements will have the same number of valence electrons, ie, 4 electrons</td></tr>
<tr><td>24</td><td>B</td><td>Element has similar properties of nitrogen element, which has 5 valence electrons, and placed in Group V.
<table>
<tr><td>electrical conductivity</td><td>formula of element</td><td>bonding in a molecule of the element</td></tr>
<tr><td>does not conduct</td><td>Gr_2</td><td>$Gr \equiv Gr$</td></tr>
<tr><td>Non-metal</td><td></td><td>Similar to N_2 which has 5 valence electrons</td></tr>
</table>
</td></tr>
<tr><td>25</td><td>C</td><td>
<table>
<tr><td></td><td>O.S</td><td></td><td>O.S</td></tr>
<tr><td>Cr_2O_3</td><td>Cr: +3</td><td>$CrBr_3$</td><td>Cr: +3</td></tr>
<tr><td>$CuSO_4$</td><td>Cu: +2</td><td>$CuCl_2$</td><td>Cu: +2</td></tr>
<tr><td>Fe_2O_3</td><td>Fe: +3</td><td>$FeCl_2$</td><td>Fe: +2</td></tr>
<tr><td>NiO</td><td>Ni: +2</td><td>$NiCl_2$</td><td>Ni: +2</td></tr>
</table>
</td></tr>
<tr><td>26</td><td>D</td><td>The higher volume of hydrogen gas collected means the more reactive the metal is.
Order of reactivity from least reactive to most reactive:
F , H , E , G

Metals higher in the reactivity series form metal carbonate which are more heat stable and requires very high temperature to thermally decompose.
Metals lower in the reactivity series form carbonates which are less heat stable and require low temperature to thermally decompose.</td></tr>
<tr><td>27</td><td>B</td><td>In the carbon cycle, carbon dioxide in the atmosphere is removed by photosynthesis.</td></tr>
<tr><td>28</td><td>D</td><td>As metal X is between Fe and Cu, X can be extracted using the reducing metal oxide using carbon</td></tr>
</table>

29	D	For rusting to take place, oxygen (air) and water is required For sacrificial corrosion, the metal attached must be more reactive than iron
30	D	As the mass of oxides of nitrogen produced by petrol is 1/3 of diesel, that shows that the petrol engine is running on a lower temperature than diesel.
31	B	Reduce usage of air–conditioners will mean using using less electricity. However, this activity does not tell the type of the source of electricity.
32	A	As fraction W has the lowest boiling point range, this means that it is most flammable.
33	A	• liquid Br2 remained brown when added to it in the dark >> absence of C=C • there was no observable change when it was heated with acidified $KMnO_4$ >> not an alcohol • there was no observable change when it was added to Mg metal >> not carboxylic acid
34	C	One of the products of substitution reaction is HCl. The reactants are in gaseous state in the presence of UV light.
35	B	Cracking of decane $C_{10}H_{22} \rightarrow C_2H_6 + C_2H_4 + 2C_3H_6$ Mole ratio is 1 1 1 2
36	D	J : Br_2 1 : 3, this shows that there are 3 pairs of C=C. Using all the options available, C_6H_8 fits the mol ratio
37	C	Carboxylic acid has a double bond in . Esters has a double bond in  $-\overset{\overset{O}{\parallel}}{C}-O-$. Ethene has C=C. Ethanol does not have double bond Vegetable contains C=C bonds. Margarine is saturated and contains C-C bonds.
38	A	During fermentation, all the glucose will react and converted to ethanol. The amount of yeast will reduce and remain the same after some time.
39	C	From the diagram, the acid is ethanoic acid and the alcohol is butanol.
40	B	Correct method of production and the correct use of the plastics

Answers to Paper 2

Qn no.	Key Answers	Remarks
1ai	E	1
ii	A	1
iii	E	1
iv	D	1
b	C and F	1
2a	**Evaporation occurs** and the molecules escapes from the surface of the liquids. [1] **Ammonia has a lower relative molecular mass of 17 compared to hydrochloric acid, which has a relative molecular mass of 36.5.** [1] Ammonia **diffuses faster** than hydrogen chloride, the white fumes is **formed closer to hydrochloric acid.** [1]	3
bi	250 atm and 450 °C, iron as catalyst [1]	1 reject iron(II)
ii	Air is made up of a mixture of **many gases, like oxygen** and **nitrogen**. [1] **Oxygen can react with hydrogen to form water** if air is used during Haber process. / **Carbon dioxide in air** can react with **ammonia** ./ **Nitrogen reacts with oxygen** to form oxides of nitrogen / Air contains **oxygen which oxidises iron catalyst** to iron(II) oxide/iron(III) oxide **Iron react with oxygen and** water and rusting occurs. [1] (hence lower the yield of ammonia)	2
c	No of mole of H_2SO_4 = 10.5/1000 ×0.150= 0.001575 mol [1] H_2SO_4 : NH_3 1 : 2 0.001575 : 0.00315 mole ratio [1] Concentration of NH_3 = 0.00315/0.020= 0.1575 mol/dm^3 [1]	3 allow ECF
3ai	(beginning of thermal decomposition) particles absorbing energy to reach activation energy / low rate of reaction / not enough CO_2 produced to form white precipitate in limewater (OTTW)	1 reject oxygen
ii	thermal decomposition at the fastest rate; [1] carbon dioxide given off and copper(II) oxide (black solid) formed; [1] carbon dioxide forms white precipitate with limewater; [1]	reject cloudy/milky max 2m
iii	thermal decomposition stopped; [1] copper(II) carbonate completely decomposed; [1] copper(II) oxide left behind; [1]	max 2m reject reaction is completed

<table>
<tr><td></td><td>the term "thermal decomposition" must appear at least once in (i) – (iii) to get total 5m</td><td></td></tr>
<tr><td>b</td><td>rate of reaction would be slower / time taken is longer; [1]
as calcium carbonate is more heat-stable; [1]
solid remains white upon thermal decomposition; [1]</td><td>3</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>4a</td><td>contains oxygen [1]
can dissociate in water to form H^+ ions [1]</td><td></td></tr>
<tr><td>b</td><td>
<table>
<tr><th>name of acid</th><th>chemical formula</th><th>reaction with magnesium (all acids have the same concentration)</th><th>oxidation state of chlorine</th></tr>
<tr><td>hypochlorous acid</td><td>$HClO$</td><td>only a few bubbles seen</td><td>+1</td></tr>
<tr><td>chlorous acid</td><td>$HClO_2$</td><td>reacts readily</td><td>+3</td></tr>
<tr><td>chloric acid</td><td>$HClO_3$</td><td>vigorous</td><td>+5</td></tr>
<tr><td>perchloric acid</td><td>$HClO_4$</td><td>very vigorous</td><td>+7</td></tr>
</table>
</td><td>2m for all correct
1m for 2-3 correct
0m for 1 correct</td></tr>
<tr><td>c</td><td>Strength of acid increases as OS of Cl increases [1]
When OS of Cl increases from +1 to +7, the reaction between the acid and Mg become more vigorous. [1]</td><td>2
reject direct relationship</td></tr>
<tr><td>d</td><td>measure the volume of H_2 produced /loss in mass at a regular interval [1]
plot volume of gas vs time on a graph [1]</td><td>2</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>5a</td><td>

spell out activation energy and enthalpy change</td><td>2
reject Ea and/or ΔH</td></tr>
<tr><td>bi</td><td>the energy level of the reactants is lower than that of product / energy absorbed is more than energy released</td><td>1</td></tr>
<tr><td>ii</td><td>no effect [1]

only the use of a catalyst can lower activation energy (of a reaction);
OR
activation energy is not affected by energy levels of particles; [1]</td><td>2</td></tr>
<tr><td>c</td><td>$2CO + O_2 \rightarrow 2CO_2$
OR</td><td>1</td></tr>
</table>

<table>
<tr><td></td><td>$2NO + 2CO \rightarrow N_2 + 2CO_2$
OR
$2NO_2 + 4CO \rightarrow N_2 + 4CO_2$</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>6a</td><td>electrons flow from zinc metal to silver metal</td><td>1
reject clockwise and anticlockwise</td></tr>
<tr><td>b</td><td>increasing order of reactivity: Cu, Zn, Mg
the larger the difference in reactivity between the metal electrodes, the larger the voltage form [1]

in both cells, reduction occurs at the copper electrode. Extend of oxidation/ionisation is higher at the magnesium electrode in cell 2 than at the zinc electrode in cell 1 [1]
<i>voltage = electromotive force</i></td><td>2</td></tr>
<tr><td>c</td><td>
<table>
<tr><th>metal 1</th><th>metal 2</th><th>predicted voltage / V</th></tr>
<tr><td>copper</td><td>iron</td><td>0.79</td></tr>
<tr><td>silver</td><td>magnesium</td><td>3.18</td></tr>
</table>

voltage between silver and copper = 1.56 – 1.10 = 0.46V

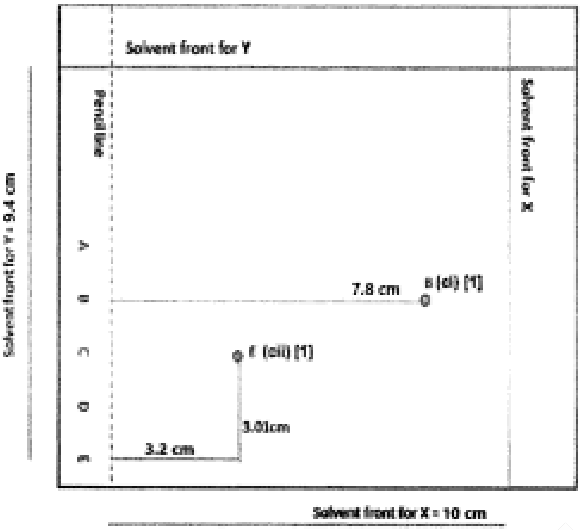
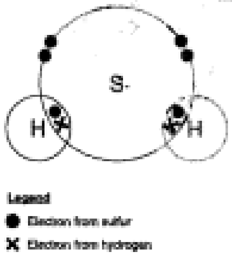
hence voltage between copper and iron = 1.25 (silver to iron) – 0.46 = 0.79V

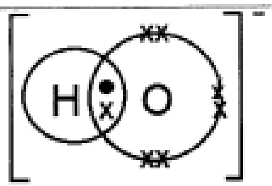
hence voltage between silver and magnesium = 2.72 (copper to magnesium) + 0.46 = 3.18V</td><td>1m each</td></tr>
<tr><td>d</td><td>in sodium chloride solution, the zinc electrode oxidised to form Zn^{2+} ions, causing a decrease in the mass [1],
while hydrogen ions (H^+) are preferentially discharged at copper electrode, hence causing no change in the mass [1]

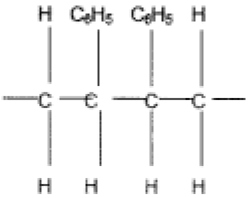
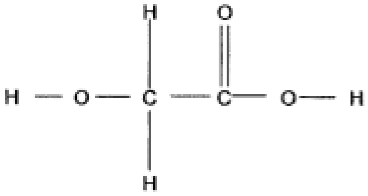
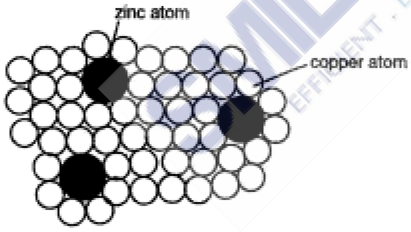
in copper(II) chloride solution, Cu^{2+} is preferentially discharged, as it is lower in the electrochemical series than H^+, forming copper metal which is deposited on the copper electrode [1]</td><td>max 3 m</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>7a</td><td>Substance B is insoluble in solvent Y. [1]

With a R_f value of 0.00, substance B did not move along the chromatogram and hence it is insoluble in solvent Y. [1]</td><td>2</td></tr>
<tr><td>b</td><td>Solvent Y was used.

Substances A and D have the same R_f values in solvent X and therefore will not form distinct spots on a chromatogram.
To separate substance A and D, solvent Y would have to be used. [1]</td><td>1</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

c		
d	The locating agent forms coloured product with colourless substance tested for and could be highlighted/seen/visible in a chromatogram.	1
8ai	Mg^{2+} and SO_4^{2-} ions	1
ii	Fe^{2+}, Mn^{2+} and Cu^{2+}	1
b	as temperature increases from 2 °C to 350 °C, the pH decreases from 7.8 to 4.3 [1] indicating that the concentration of hydrogen ions increases [1] however the concentration of hydrogen ions also increase due to the presence of hydrogen chloride, which dissolves in hydrothermal vent water to form hydrogen ions (and hydrogen sulfide) [1] hence, temperature is not the only factor	3
ci	oxidised: sulfur reduced: hydrogen	1
ii	 1 m for correct number of shared electrons 1 m for correct number of valence electrons on each atom	2
d	add 50.0 cm^3 of aqueous sodium carbonate (since the vol of acid remains unchanged)	
ei	average mass of 1 isotope/atom of an element compared to $\frac{1}{12}$ of the mass of a ^{12}C atom	1
ii	let % of ^3He be x	2

	$\frac{x}{100}(3.0160293) + \frac{100-x}{100}(4.0026033) = 4.0025959$ [1] $\frac{3.0160293x+400.26033-4.0026033x}{100} = 4.0025959$ 0.986574x = 0.00074 x = 0.0750 % [1]	
9a	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$	1
b	 1 m for number of electrons shared 1 m for correct number of valence electrons + charge	2
c	height of precipitate: 4.0 cm; } [1] colour of indicator: red Barium hydroxide is used up and **dilute sulfuric acid is in** excess. [1] Hence, the height of precipitate remains at 4.0 cm and the pH of solution is approximately 2.0.	2
d	• The electrical conductivity decreases from tube 1 to 4 and • increase from tube 5 to 6. [1] • As more dilute sulfuric acid is used, more barium sulfate precipitate, which does not conduct electricity is formed. • Hence, the number of free-moving ions decreases. Formation of water molecules also reduces electrical conductivity as water does not conduct electricity well. [1] • The conductivity increases from tube 5 to 6 as excess acid is present which dissociates to form free-moving ions. [1]	3
10	**either**	
ai	They have **higher tensile strength/ stronger** and will **not break easily [1]** (when compared to polystyrene) Take a **shorter time to be broken down** hence it takes up **less space in landfills/cut down the need to build more landfills/ less land pollution;** (when compared to polystyrene) [1]	2
ii	Biopolymers will break down in 0.5 years, this limits the use of biopolymers as it breaks down it will affect the quality of the food;	1
bi	Phenylethene undergoes **addition polymerization [1]** The carbon-carbon double bonds present in the phenylethene is being broken [1]	3

	and many phenylethene molecules joined together to become one giant macromolecule (of polystyrene) [1]	
ii	 $-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{C_6H_5}{C}}-\underset{H}{\overset{C_6H_5}{C}}-\underset{H}{\overset{H}{C}}-$	1
ci	polyester	1
ii	Terylene	1
iii	 $H-O-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\Vert}{C}}-O-H$ *all bonds must be shown*	1
10	**or**	
a	magnesium loses (outer shell) electrons more easily than copper / copper cannot give (outer shell) electrons to hydrogen ions but magnesium can / magnesium more reactive than hydrogen while copper less reactive than hydrogen ;	**1** **A** magnesium more reactive than copper
b	the higher % Zn, the greater the strength / the lower % Cu, the lower the strength ;	1
c	 layers (of atoms) in copper can slide (when a force is applied) [1] atoms/ions of zinc are different size to those of copper/atoms of zinc disrupt the copper lattice [1] layers (of atoms) in alloy cannot slide (as easily) [1]	max 3m diagram must show disruption to orderly structure
d	Cu_2O ; 1m for working (calculate number of moles) 1m for mole ratio;	2

e	Solution turns from blue to pale green/lighter in colour [1] Pink/brown/reddish brown solid is formed on the iron bar [1] Iron is more reactive than copper and will displace copper from copper(II) salt solution [1]	3