Name:	Register Number:	Class:

BEDOK GREEN SECONDARY SCHOOL

4E **4E**

Preliminary Examination 2024

CHEMISTRY **6092/01**

Paper 1 Multiple Choice 27 August 2024

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, register number and class on the multiple choice answer sheet provided.
Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

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

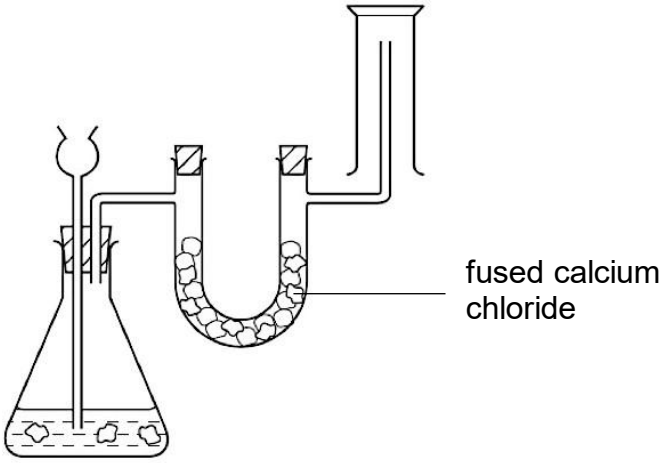
Choose the **one** you consider to be correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read very carefully the instructions on the Answer Sheet very carefully.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 15.
The use of an approved scientific calculator is expected, where appropriate.

1 The diagram shows an experimental setup for the preparation and collection of a dry gas.



Which gas can be collected in this way?

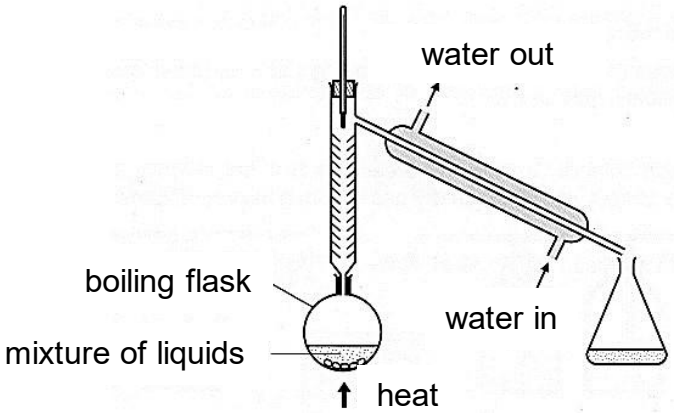
A oxygen
B carbon dioxide
C chlorine
D sulfur dioxide

2 An organic solvent, hexane and aqueous sodium chloride are accidentally mixed together.

Which of the following shows the most efficient methods of separation to obtain pure samples of hexane and solid sodium chloride?

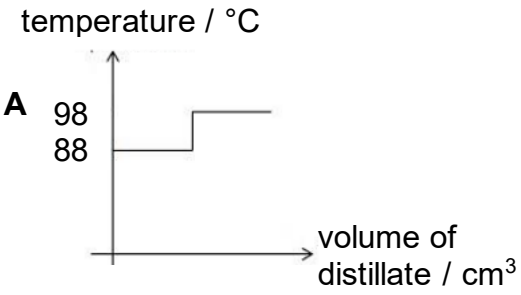
A filtration followed by crystallisation
B fractional distillation followed by evaporation to dryness
C simple distillation followed by crystallisation
D using a separating funnel followed by evaporation to dryness

3 The diagram shows a setup to distil a mixture of propanol (boiling point 88 °C) and heptane (boiling point 98 °C).



Which graph correctly shows the changes in volume of distillate in the conical flask as the distillation proceeds?

A



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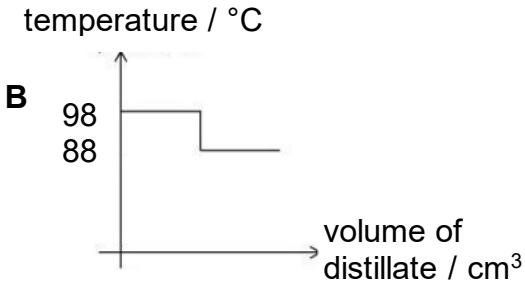

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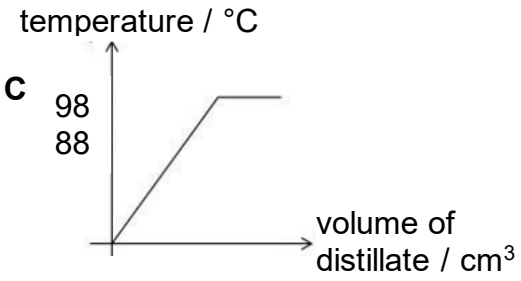

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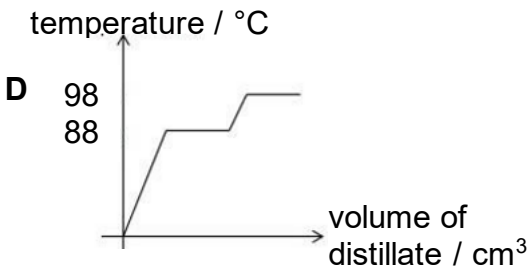
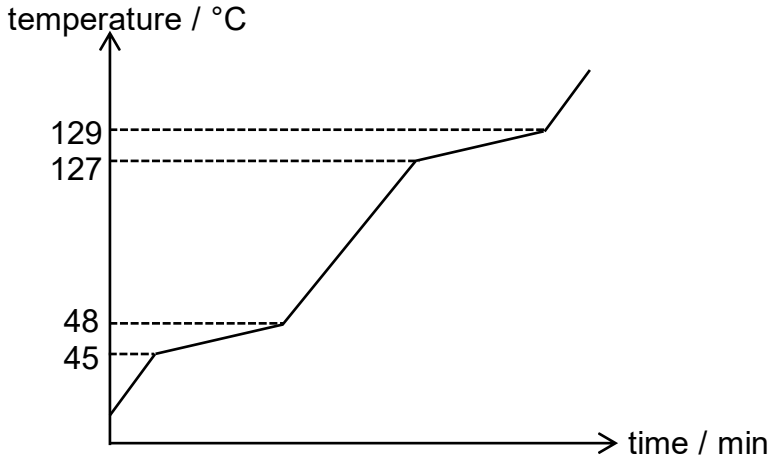


4 When 50 cm^3 of pure ethanol is mixed with 50 cm^3 of pure water in a measuring cylinder, the total volume of mixture is found to be 97 cm^3.

What is the best explanation for this observation?

A A small volume of the ethanol has evaporated.
B The ethanol and water molecules react to form another compound.
C The ethanol molecules have a random arrangement in water.
D The ethanol molecules move into empty spaces between the water molecules.

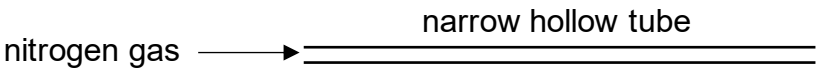
5 The heating curve of an impure sample of substance **X** is shown below.



What are the melting point and boiling point of pure substance **X**?

	melting point / °C	boiling point / °C
A	45	129
B	47	128
C	48	127
D	49	130

6 Nitrogen gas is allowed to diffuse across a narrow hollow tube as shown below.



Which of the following changes will increase the rate of diffusion of the gas through the tube?

I increasing the temperature of the gas from 25 °C to 45 °C

II lowering the pressure from 1 atm to 0.5 atm

III replacing the nitrogen gas with carbon monoxide gas

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

7 The equation illustrates the ion-molecule interaction in gas clouds involving $^{1}_{1}H$.

$$H_2^+ (g) + H_2 (g) \rightarrow H (g) + H_3^+ (g)$$

What are the number of subatomic particles present in a H_3^+ ion?

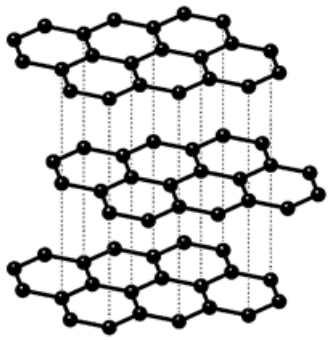
	number of neutrons	number of protons	number of electrons
A	0	3	1
B	0	3	2
C	3	2	1
D	3	3	2

8 Which statement(s) correctly describe(s) properties of a compound, copper(II) sulfide and a mixture of copper and sulfur?

	copper(II) sulfide compound	mixture of copper and sulfur
1	copper and sulfur react when heated to form copper(II) sulfide	copper and sulfur mix together without any heat involved
2	the ratio of copper to sulfur is always 1:1	the ratio of copper to sulfur in the mixture can vary
3	copper(II) sulfide has the properties of copper and sulfur	the mixture does not have the properties of copper and sulfur

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

9 The diagram shows the structure of graphite.



A sample of graphite was completely combusted in oxygen to form a gaseous oxide.

Which of the following are the structures of graphite and the gaseous oxide?

	graphite	gaseous oxide
A	crystal lattice structure	crystal lattice structure
B	giant covalent structure	giant covalent structure
C	giant covalent structure	simple molecular structure
D	simple molecular structure	simple molecular structure

10 The equation shows the reaction between element **Y** and dilute sulfuric acid.

$$2\mathbf{Y}\ (s) + H_2SO_4\ (aq) \rightarrow \mathbf{X}_2SO_4\ (aq) + H_2\ (g)$$

What types of bonding are present in element **Y** and in compound $\mathbf{Y}_2SO_4$?

	element **Y**	compound $\mathbf{Y}_2SO_4$
A	covalent	covalent
B	covalent	ionic and covalent
C	metallic	covalent
D	metallic	ionic and covalent

11 When hydrogen peroxide is used as a bleaching agent, it decomposes to form water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

When 68 g of hydrogen peroxide decomposes, the volume of oxygen gas collected under room temperature and pressure is 1200 cm^3.

What is the percentage purity of hydrogen peroxide?

A 2.5 % **B** 5.0 % **C** 10.0 % **D** 50.0 %

12 0.2 mol/dm^3 of dilute sulfuric acid is titrated with 0.5 mol/dm^3 aqueous potassium hydroxide.

What is the volume of aqueous potassium hydroxide required to react completely with V dm^3 of dilute sulfuric acid?

A 0.1 V dm^3 **B** 0.4 V dm^3 **C** 0.8 V dm^3 **D** 1.6 V dm^3

13 The main compound in glass is silicon dioxide.

Which of the following chemicals can be added into sewage pipes to dissolve glass fragments trapped in them?

A sodium hydroxide
B dilute sulfuric acid
C ethanol
D tetrachloromethane

14 Which ionic equation describes the reaction between solutions of ammonium carbonate and sodium hydroxide?

A $H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$
B $2H^+ (aq) + CO_3^{2-} (aq) \rightarrow CO_2 + H_2O (l)$
C $2Na^+ (aq) + CO_3^{2-} (aq) \rightarrow Na_2CO_3$
D $NH_4^+ (aq) + OH^- (aq) \rightarrow NH_3 (g) + H_2O (l)$

15 The table contains data about two acids.

acid	concentration (mol/dm^3)	pH
hydrochloric acid	0.1	1.0
ethanoic acid	0.1	3.7

Why of the following statements best explains the difference in pH values?

A Ethanoic acid contains carbon, hydrogen and oxygen.
B Ethanoic acid has larger molecules.
C Hydrochloric acid partially ionises.
D Hydrochloric acid releases more H^+ ions in water.

16 A mixture of the oxides of two elements from Period 3 of the Periodic Table is dissolved in water. This solution is approximately neutral.

What could be the constituents of the mixture?

A Al_2O_3 and MgO
B Na_2O and MgO
C SO_3 and P_4O_{10}
D Na_2O and P_4O_{10}

17 Which sequence of steps is used to collect a pure, dry sample of magnesium sulfate crystals?

	step 1	step 2	step 3	step 4
A	add acid in excess to magnesium carbonate	filter	evaporate to dryness	leave to cool
B	add acid in excess to magnesium carbonate	filter	evaporate filtrate to saturation point	leave to cool
C	add magnesium carbonate in excess to acid	evaporate to saturation point	-	-
D	add magnesium carbonate in excess to acid	filter	evaporate filtrate to saturation point	leave to cool

18 Given a supply of lead(II) carbonate, copper(II) oxide, dilute nitric acid and aqueous sodium hydroxide, how many different salt(s) could be prepared?

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

19 An aqueous solution contains $Al^{3+}(aq)$ and $Cu^{2+}(aq)$. Aqueous ammonia is added until in excess. After shaking, the mixture is filtered.

What would be left on the filter paper?

A a blue solid
B a blue solid and a white solid
C a white solid
D no solid residue

20 The Haber Process may be represented by the equation below. 92 kJ is released for every mole of nitrogen reacted.

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g) \qquad \Delta H = -92\ kJ/mol$$

Which of the following statements about the Haber Process is **false**?

A 46 kJ of heat is given out for every mole of ammonia formed.
B The speed of reaction can be increased by a higher pressure.
C The activation energy of the forward and backward reaction is equal.
D Nitrogen is obtained from fractional distillation of liquefied air.

21 Which of the following chemical reactions is the underlined substance acting as an oxidising agent?

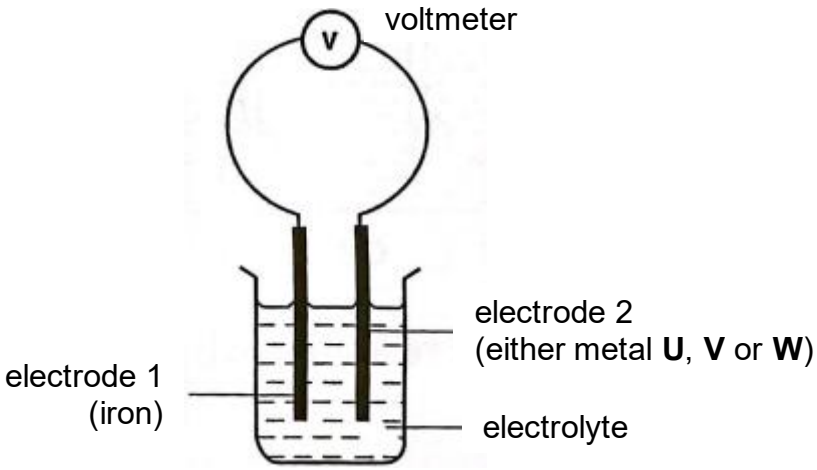
A $\underline{S} + O_2 \rightarrow SO_2$
B $\underline{S} + Fe \rightarrow FeS$
C $\underline{SO_3} + H_2O \rightarrow H_2SO_4$
D $\underline{SO_2} + Cl_2 + 2H_2O \rightarrow 4H^+ + SO_4^{2-} + 2Cl^-$

22 In an electrolysis experiment, the same amount of charge deposited 32 g of zinc and 8.5 g of chromium. [A_r: Zn, 65; Cr, 52]

What is the charge on the chromium ion?

A 2+ **B** 3+ **C** 5+ **D** 6+

23 Three simple cells are set up using iron metal as electrode 1 and three other unknown metals, **U**, **V** and **W**, separately as electrode 2.



The results of the experiments are shown in the table.

electrode 1	metal used as electrode 2	voltmeter reading/ V
Fe	metal **U**	-1.93
	metal **V**	+0.78
	metal **W**	+1.09

Which row shows the correct metal for **U**, **V** and **W**?

	metal **U**	metal **V**	metal **W**
A	copper	lead	magnesium
B	lead	magnesium	copper
C	magnesium	copper	lead
D	magnesium	lead	copper

24 An iron key is to be electroplated with silver using aqueous silver nitrate as the electrolyte.

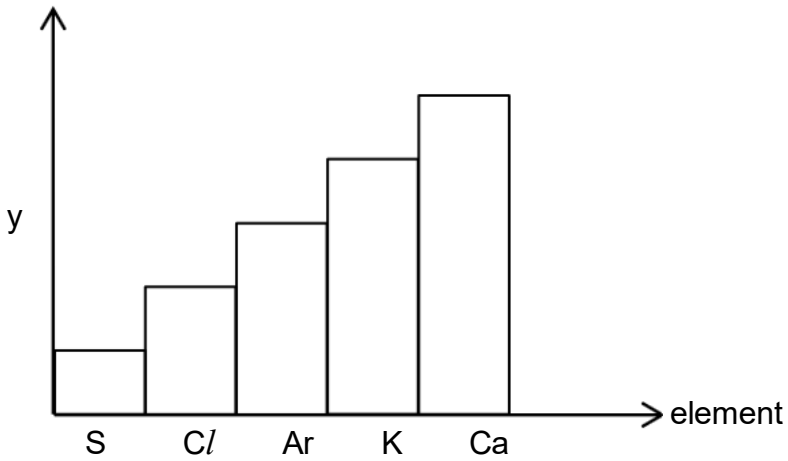
Which row correctly shows the materials used for the electrodes and the reaction at the negative electrode?

	positive electrode	negative electrode	reaction at negative electrode
A	iron key	silver	$Ag^+ (aq) + e^- \rightarrow Ag (s)$
B	iron key	silver	$Fe^{2+} (aq) + 2e^- \rightarrow Fe (s)$
C	silver	iron key	$Ag^+ (aq) + e^- \rightarrow Ag (s)$
D	silver	iron key	$Fe^{2+} (aq) + 2e^- \rightarrow Fe (s)$

25 Which statement about hydrogen-oxygen fuel cell is correct?

A Electricity is required to generate hydrogen and oxygen.
B Hydrogen reacts with oxygen to produce electricity.
C Oxygen is oxidised and hydrogen is reduced in the reaction.
D Pure water is used as the electrolyte in the fuel cell.

26 The graph below shows how a property changes for the elements from sulfur to calcium.



What is the unknown property y on the y-axis?

A the charge of the ion formed by the element
B the number of electrons in an atom
C the number of valence electron in an atom
D the sum of protons and neutrons in an atom

27 Which statement about transition elements is correct?

A A transition element can conduct electricity as it has free moving ions to carry electrical charges.
B All coloured compounds contain transition elements.
C The highest oxidation state that a transition element can show is +6.
D Transition elements have high melting points due to the strong attraction between positive ions and 'sea of electrons'.

28 Which pair of elements, when reacted together, would give the most violent reaction?

A caesium and fluorine
B lithium and iodine
C potassium and bromine
D sodium and chlorine

29 In each of three experiments, a halogen was added to separate solutions containing ions of one of the other two halogens.

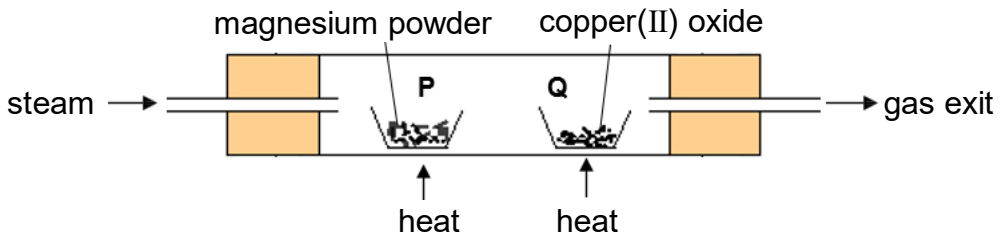
The results are shown in the table.

experiment	halogen added	solution of halide		
		X^-	Y^-	Z^-
1	X_2		no reaction	reaction occurs
2	Y_2	reaction occurs		reaction occurs
3	Z_2	no reaction	no reaction	

What are the identities of **X**, **Y** and **Z**?

	X	Y	Z
A	Br_2	Cl_2	I_2
B	Br_2	I_2	Cl_2
C	Cl_2	Br_2	I_2
D	I_2	Cl_2	Br_2

30 In an experiment, steam is passed into the set-up below for some time.

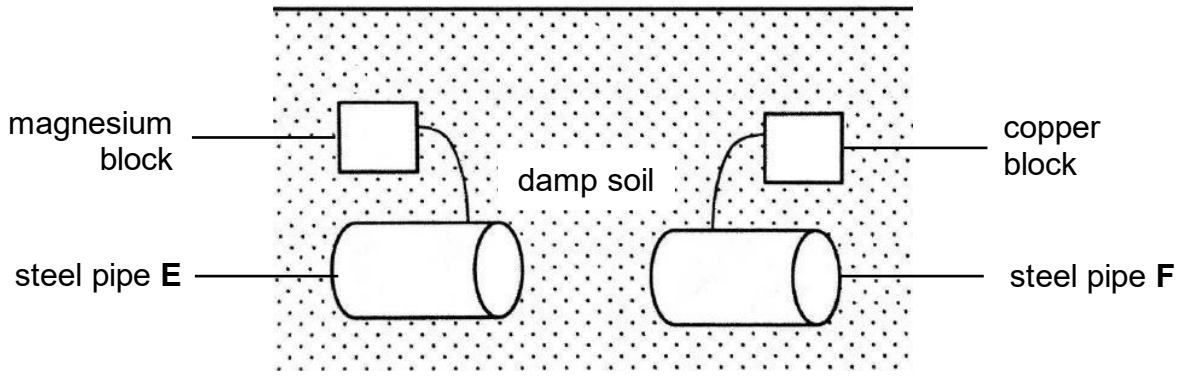


What are the products formed at **P** and **Q**?

	P	Q
A	magnesium oxide	copper
B	magnesium hydroxide	copper
C	magnesium oxide	copper(II) hydroxide
D	magnesium hydroxide	copper(II) hydroxide

31 A block of magnesium is attached to steel pipe **E**.

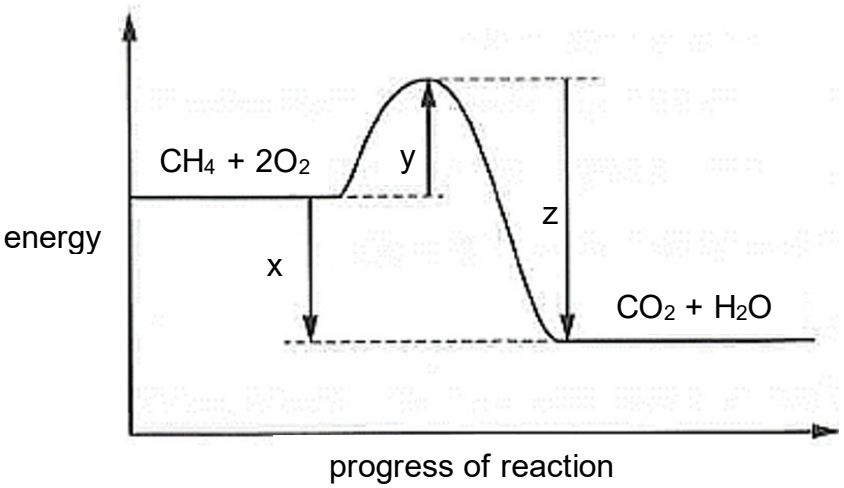
A block of copper is attached to steel pipe **F**.



What are the reactions occurring at pipe **E** and **F**?

	steel pipe **E**	steel pipe **F**
A	$Fe \rightarrow Fe^{2+} + 2e^-$	$Fe \rightarrow Fe^{2+} + 2e^-$
B	$Fe \rightarrow Fe^{2+} + 2e^-$	$Cu \rightarrow Cu^{2+} + 2e^-$
C	$Mg \rightarrow Mg^{2+} + 2e^-$	$Cu \rightarrow Cu^{2+} + 2e^-$
D	$Mg \rightarrow Mg^{2+} + 2e^-$	$Fe \rightarrow Fe^{2+} + 2e^-$

32 The energy profile diagram of combustion of methane is shown below.



Which statement about bond-breaking and bond-forming is correct?

A The enthalpy change of the reaction is equal to y.
B The energy released in forming bonds is equal to x.
C The energy released in breaking bonds is equal to z.
D The energy released in forming bonds is more than the energy absorbed in breaking bonds.

33 Which process is endothermic?

A $C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$
B $H_2O\ (g) \rightarrow H_2O\ (l)$
C $H_2\ (g) \rightarrow 2H\ (g)$
D $HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$

34 Which statements about exothermic reactions are correct?

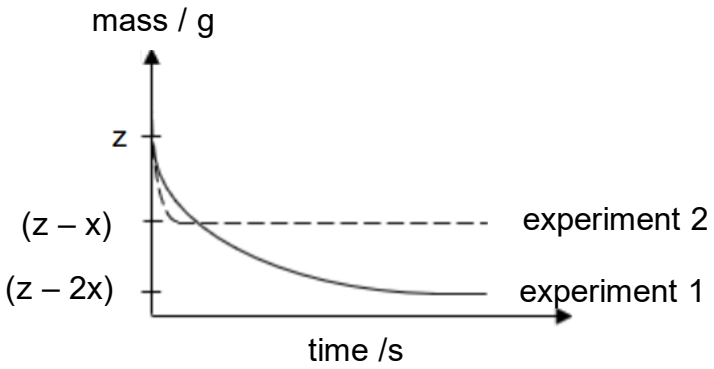
1 Energy is released to the surroundings.
2 Energy is absorbed from the surroundings.
3 The temperature of the reactants rises.
4 The temperature of the reactants falls

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

35 How does the activation energy and enthalpy change for a reaction between two gases change when it is carried out in the presence of a catalyst?

	change in	
	activation energy	enthalpy change
A	decrease	decrease
B	decrease	no change
C	increase	no change
D	no change	decrease

36 In experiments 1 and 2, excess calcium carbonate was added to dilute hydrochloric acid. The graphs show how the masses of both reaction mixtures varied with time.



In experiment 1, 100 g of calcium carbonate lumps was added to 100 cm^3 of 1.0 mol/dm^3 dilute hydrochloric acid.

Which change to the experimental conditions will give the graph for experiment 2?

A using 50 g of calcium carbonate powder
B using 12.5 cm^3 of 2.0 mol/dm^3 dilute sulfuric acid
C using 25 cm^3 of 2.0 mol/dm^3 dilute hydrochloric acid
D using 100 cm^3 of 0.5 mol/dm^3 dilute hydrochloric acid

37 The cracking of the hydrocarbon $C_{12}H_{26}$ is represented by the equation below.

$$C_{12}H_{26} \rightarrow \mathbf{X} + \mathbf{Y}$$

Which statement is correct?

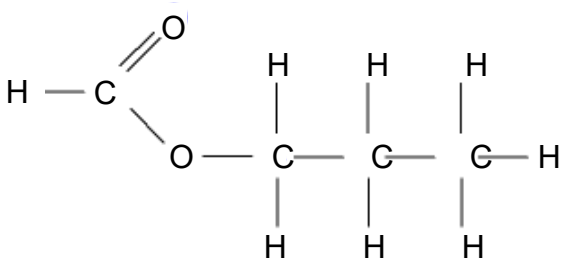
A If **X** is C_6H_{12}, **Y** can react with aqueous bromine in the absence of light.
B If **X** is $C_{10}H_{22}$, **Y** can be polymerised and used to manufacture clingfilm.
C If **X** is hydrogen gas, **Y** is a saturated molecule.
D **X** and **Y** can be structural isomers.

38 An unsaturated acid has a formula $C_{13}H_{21}COOH$.

What is the maximum number of carbon-carbon double bonds present in one molecule of the acid?

A 2 **B** 3 **C** 4 **D** 6

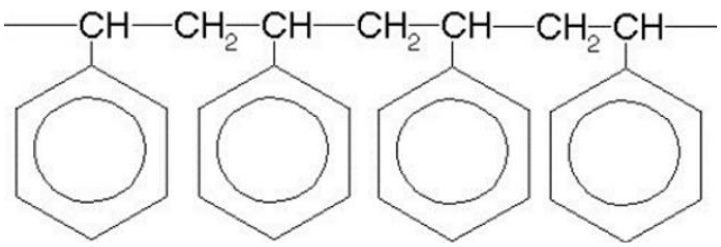
39 The diagram below shows the structural formula of a sweet-smelling compound.



What are the names of the reagents that react to form the compound?

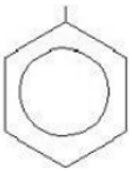
A methanol and propanoic acid
B propanol and methanoic acid
C propanol and propanoic acid
D methanol and methanoic acid

40 The diagram shows the partial structure of polystyrene.

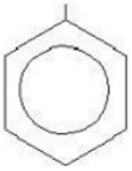


What is the structural formula of the monomer of polystyrene?

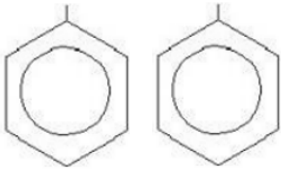
A CH_2CH_3



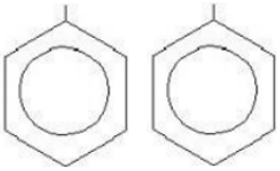
B $CH{=}CH_2$



C $CH{=}CH_2{-}CH$



D $CH{=}CH_2{-}CHCH_2$



END OF PAPER

Name: ……( )

Section A

Answer **all** questions.

1 Use the list of substances to answer the questions. Each substance may be used once, more than once or not at all.

ammonia	diamond	graphite	methane
silicon dioxide	sodium carbonate	sulfur dioxide	zinc oxide

State a substance that

(a) has giant covalent structure, ……...

(b) conducts electricity in solid state, ……...

(c) reacts with dilute acids to produce bubbles of gas, ……...

(d) is formed from bacterial decay of vegetable matter, ……...

(e) reacts with both an acid and alkali, ……... [5]

[Total: 5]

2 Aqueous sodium thiosulfate reacts with dilute hydrochloric acid in a conical flask as illustrated in Fig. 2.1. The chemical equation is shown below.

$$Na_2S_2O_3\ (aq) + 2HCl\ (aq) \rightarrow 2NaCl\ (aq) + S\ (s) + SO_2\ (g) + H_2O\ (l)$$

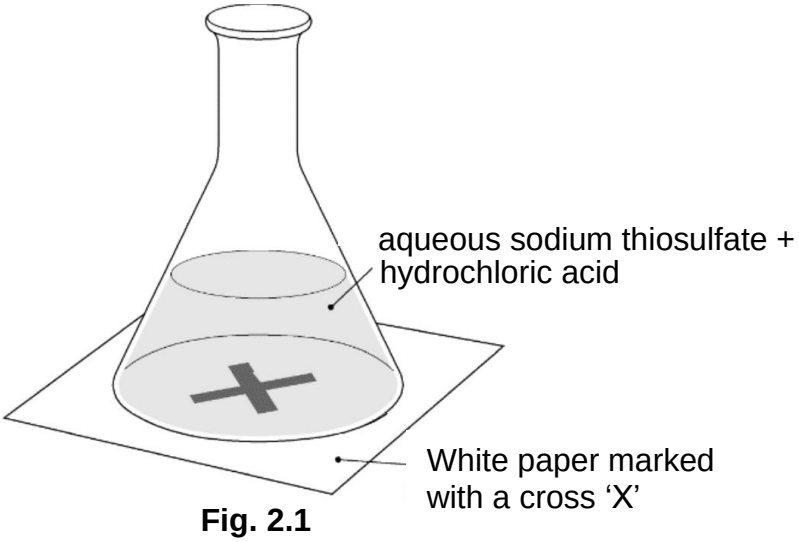


Fig. 2.1

(a) Suggest why the cross on the paper disappeared after some time.

……

…… [1]

(b) **(i)** Complete Table 2.2 to show the oxidation state of sulfur in different substances.

Table 2.2

substance	oxidation state of sulfur
$Na_2S_2O_3$ (aq)	
S (s)	
SO_2 (g)	

[2]

(ii) Hence, or otherwise, explain why the above reaction is a redox reaction.

……...

……...

……... [2]

(c) Describe a positive test that can be used to detect that sulfur dioxide is produced from the reaction.

…….....

……..... [2]

[Total: 7]

3 A student investigates how the particle size would affect the rate of reaction. For each experiment, he added 2 g of magnesium metal to 30 cm^3 of 0.5 mol/dm^3 dilute sulfuric acid.

The chemical reaction is presented by the chemical equation below.

$$Mg\ (s) + H_2SO_4\ (aq) \rightarrow MgSO_4\ (aq) + H_2\ (g)$$

Experiment 1: Magnesium strips were used
Experiment 2: Magnesium powder was used.

The student measured and recorded the volume of gas produced in each experiment every 15 seconds. Fig. 3.1 shows the results of his experiments.

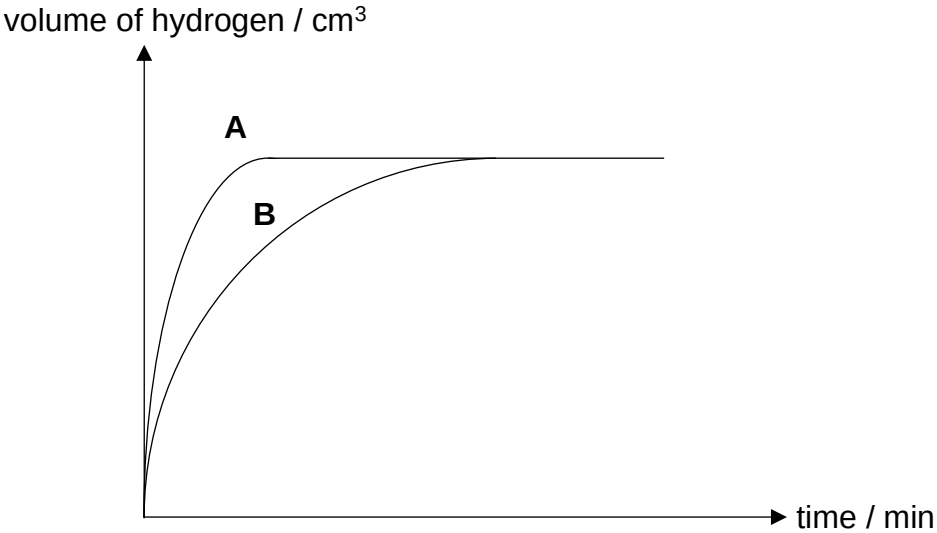


Fig. 3.1

(a) (i) Identify the limiting reagent in both experiments.

[2]

(ii) Hence, calculate the maximum mass of magnesium sulfate that could be produced in each experiment.

[1]

(b) State which graphs, **A** or **B**, shows the results for experiments 1 and 2 respectively.

Explain, in terms of collisions between particles, how the change in particle size affects the graph.

experiment 1 ……

experiment 2 ……

explanation ……

……

…… [3]

(c) A third experiment was conducted, with the same mass of zinc strips.

(i) Explain how the rate of reaction will change as compared to experiment 1.

……

…… [2]

(ii) Predict whether the volume of hydrogen collected will be **less**, **more** or the **same**.

Explain your answer.

……

…… [2]

(iii) Sketch on Fig. 3.1 a graph to show how the volume of hydrogen changes with time. Label the graph as **C**. [1]

[Total: 11]

4 Liquified natural gas (LNG) and liquified petroleum gas (LPG) are two types of fuels that are mainly used for cooking and heating in households. The information on the compositions of LNG and LPG is given in Table 4.1.

Table 4.1

Liquified Natural Gas (LNG)		Liquified Petroleum Gas (LPG)	
component	percentage composition / %	component	percentage composition / %
methane, CH_4	94.0	dimethyl propene, C_5H_{10}	0.3
ethane, C_2H_6	4.2	ethane, C_2H_6	1.5
propane, C_3H_8	1.5	propane, C_3H_8	31.1
butane, C_4H_{10}	0.3	butane, C_4H_{10}	67.1

(a) Explain why the gases are stored in the liquefied form before transportation.

……

…… [1]

(b) Predict which fuel, LNG or LPG, has a lower density.

…… [1]

(c) Flammability is how readily a substance burns. Hydrocarbons are considered to be more flammable when they have a lower percentage of carbon by mass.

Predict, using **suitable** calculations, whether LNG or LPG is more flammable.

[2]

(d) Dimethyl propene is added as an additive to give LPG its distinct petroleum-like odour as the other components are odourless.

Suggest why it is important to add this addictive before use in households.

……

…… [1]

(e) Explain, using the carbon cycle, why biofuels are more environmentally sustainable than fossil fuels.

……

……

……

…… [2]

[Total: 7]

5 A student conducted an experiment with the set-up shown in Fig. 5.1 to collect the gaseous products when concentrated aqueous potassium chloride is electrolysed. Litmus solution is added into the electrolyte during the electrolysis process. Litmus solution is purple in neutral solution.

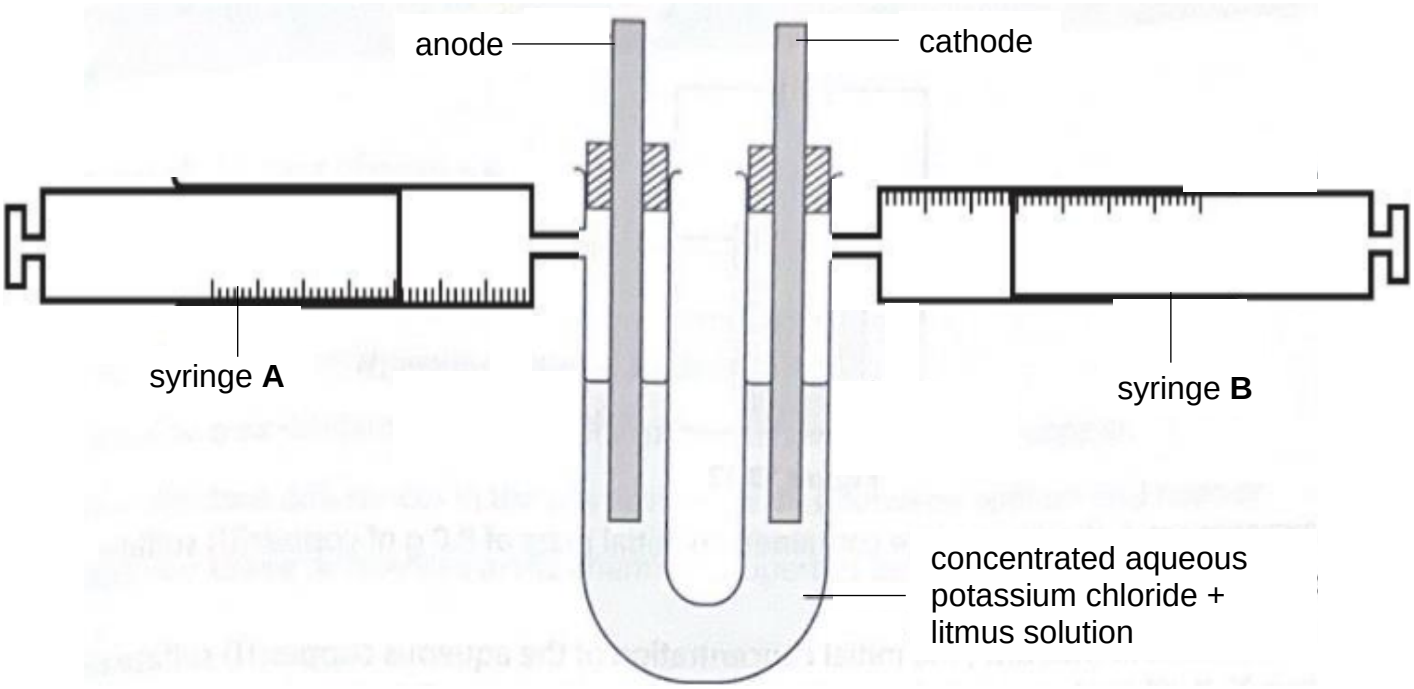


Fig. 5.1

(a) Identify the gases collected in syringes **A** and **B.**

A: ……... **B**: ……... [2]

(b) It was predicted that the volume of gases produced at both electrodes would be the same.

(i) Explain, using suitable equations, to verify if the prediction is true.

……

……

…… [2]

(ii) At the end of the experiment, 100 cm^3 of gas was collected in syringe **B** and 10 cm^3 of was collected in syringe **A**.

Explain what could have resulted in this observation.

……

…… [1]

(c) Describe and explain the colour changes of the

(i) solution at the anode during electrolysis,

……

…… [2]

(ii) electrolyte at the end of the experiment.

……

…… [2]

[Total: 9]

6 Nicotine, the substance that causes addiction in smoking and vaping, has a chemical formula of $C_{10}H_{14}N_2$. The structural formula of nicotine is shown in Fig. 6.1.

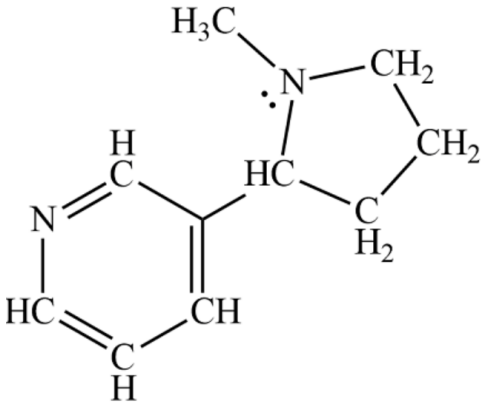


Fig. 6.1

(a) Explain if nicotine is a hydrocarbon.

……

…… [1]

(b) Nicotine is considered an unsaturated compound.

Describe a test to verify that nicotine is unsaturated.

……

……

…… [2]

(c) In the presence of excess oxygen, nicotine can undergo complete combustion to form nitrogen dioxide, carbon dioxide and water.

$$2C_{10}H_{14}N_2 + 31O_2 \rightarrow 4NO_2 + 20CO_2 + 14H_2O$$

(i) A cigarette stick typically contains about 15 mg of nicotine.

Calculate the volume of nitrogen dioxide produced in a week by a typical smoker who smokes an average of 5 cigarettes a day.

[3]

(ii) Describe the harmful effect of nitrogen dioxide on the environment.

……...

……... [1]

(iii) State one other source of nitrogen dioxide produced due to human activity.

……... [1]

(iv) Suggest how the nitrogen dioxide produced in **(iii)** can be removed.

……...

……... [1]

(d) A smokerlyzer is used to detect if someone has been smoking or vaping by checking the level of carbon monoxide in the body by blowing into the mouthpiece of the smokerlyzer. Fig. 6.2 shows a typical smokerlyzer device.

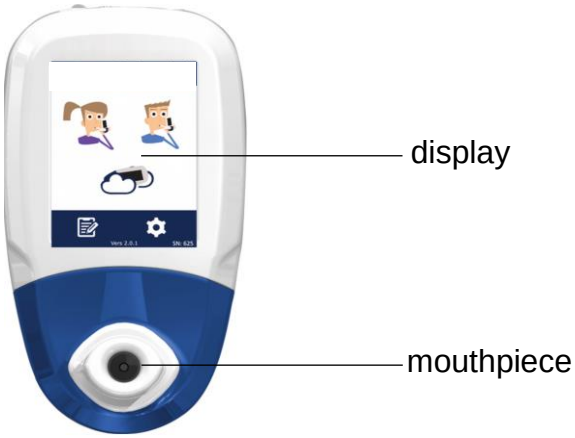


Fig. 6.2

(i) Describe the harmful effect of carbon monoxide on human health.

……...

……... [1]

(ii) Carbon monoxide is often described as a silent killer.

Suggest why based on your knowledge of its properties.

……...

……... [1]

[Total: 11]

7 Study the reaction scheme in Fig 7.1.

Solid **P** is a mixture of 2 compounds, which can be separated by adding water, followed by filtration. A white solid **Q** is collected as the residue and colourless solution **R** collected as the filtrate.

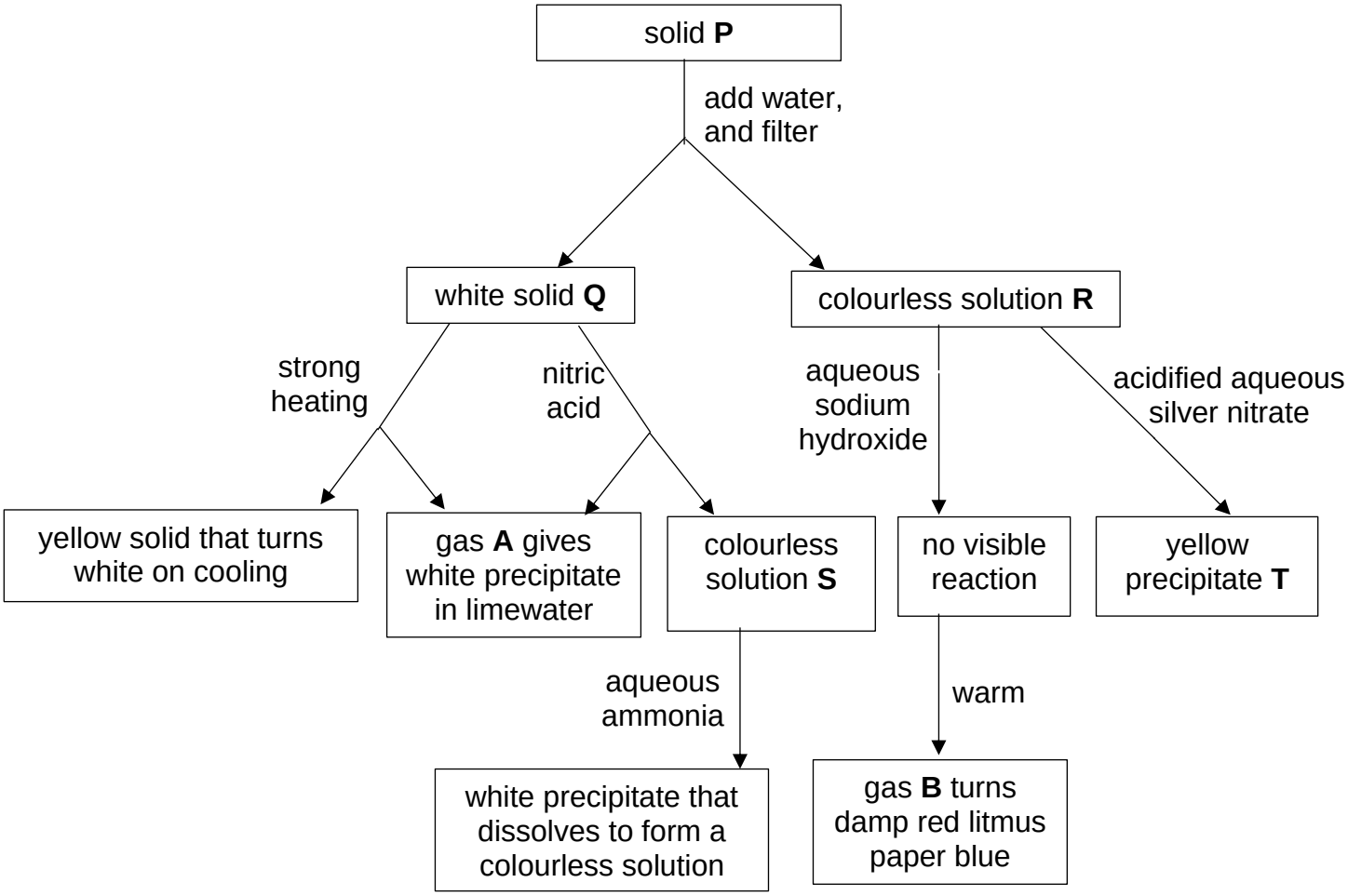


Fig. 7.1

(a) Identify the unknown substances below.

gas **A**: ……

gas **B**: ……

solid **P**: ……

solution **S**: ……

precipitate **T** …… [5]

(b) Write the ionic equation for the formation of precipitate **T**.

……... [1]

(c) Describe the procedure to prepare pure dry solid **Q**.

Include the reagents that can be used to form solid **Q**.

……...

……...

……...

……...

……...

……... [3]

[Total: 9]

8 Properties of Covalent Molecules

Valence Shell Electron Pair Repulsion (VSEPR) Theory

The Valence Shell Electron Pair Repulsion (VSEPR) Theory can be used to predict the shapes of molecules based on the number of electron pairs around the central atom.

A central atom refers to an atom which is bonded to two or more other atoms, while a terminal atom is bonded to only one other atom. For example in a water molecule (H–O–H), the oxygen atom is the central atom while the hydrogen atom is a terminal atom as shown in Fig. 8.1.

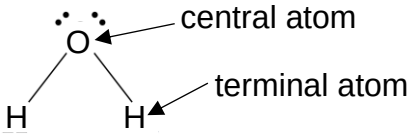


Fig. 8.1

Electron pair repulsion

As electron pairs are negatively charged and will repel each other, the electron pairs around the central atom will adopt a shape that will minimise repulsion between them.

Electron pairs can be categorised as bond pair electrons and lone pair electrons. Lone pair electrons refer to a pair of valence electrons not involved in bonding on the central atom while bond pair electrons refer to a pair of electrons involved in bonding on the central atom.

The repulsion between a lone pair and bond pair is stronger compared to the repulsion between two bond pairs, resulting in different bond angles.

Bond Angle

Bond angle is defined as the angle between two bonds. Using water as an example, the bond angle between each O–H bond is 105° as shown in Fig. 8.2.

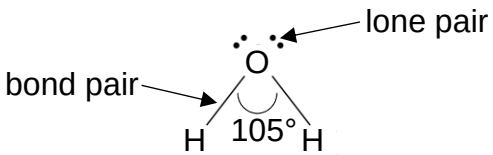


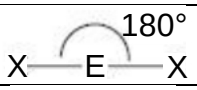
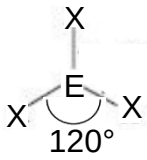
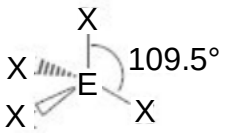
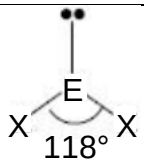
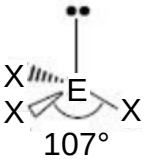
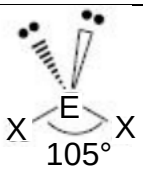
Fig. 8.2

From Fig. 8.2, oxygen in water has 2 bond pairs from the two O–H bonds and 2 lone pairs. Thus, shape of water molecule is bent.

Shape of Molecules

Based on the total number of electron pairs, chemists have predicted the shape of the molecules and its associated bond angle as shown in Table 8.3.

Table 8.3

number of electron pairs		shape	bond angle / °	model representation
number of bond pairs	number of lone pairs			E: central atom X: terminal atom
2	0	linear	180	
3	0	trigonal planar	120	
4	0	tetrahedral	109.5	
2	1	bent	118	
3	1	trigonal pyramidal	107	
2	2	bent	105	

Electronegativity

Electronegativity is the tendency of an atom to attract electrons in a molecule. The higher the electronegativity value, the higher the tendency of an atom to attract electrons. Table 8.4 shows the electronegativity of some elements.

Table 8.4

element	electronegativity value
hydrogen, H	2.1
nitrogen, N	3.0
oxygen, O	3.5

Hydrogen Bonding

Hydrogen bonding is a type of intermolecular force of attraction in covalent substances that arises due to the difference in electronegativity between atoms.

The hydrogen atom bears a large partial positive charge (δ+) while the more electronegative atoms such as nitrogen and oxygen bear a large partial negative charge (δ-).

$$^{\delta-}N-H^{\delta+} \qquad ^{\delta-}O-H^{\delta+}$$

A model representation of hydrogen bonding in water is shown in Fig. 8.5.

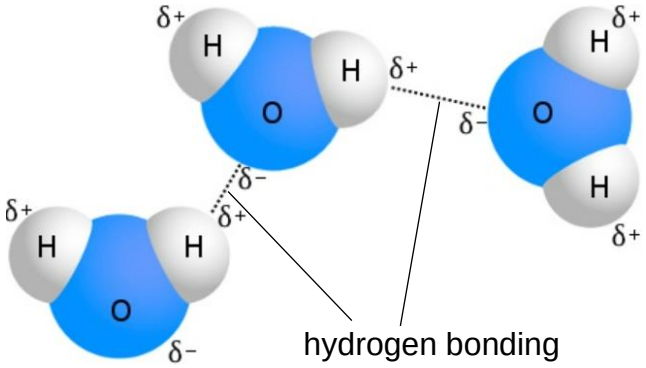


Fig. 8.5

The boiling points of some compounds with hydrogen bonding are shown in Table 8.6.

Table 8.6

compound	boiling point / °C
ammonia, NH_3	−33.3
water, H_2O	100.0

(a) Using information in Table 8.3, describe the relationship between the

(i) number of bond pair electrons and bond angle;

……

…… [1]

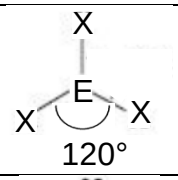
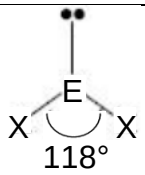
(ii) number of lone pair electrons and bond angle.

……

…… [1]

(b) A section of Table 8.3 is extracted in Table 8.7.

Table 8.7

number of electron pairs		shape	bond angle / °	model representation
number of bond pairs	number of lone pairs			E: central atom X: terminal atom
3	0	trigonal planar	120	
2	1	bent	118	

With reference to the **electron pair repulsion**, comment on the difference in bond angles between the two molecules in Table 8.7.

……

…… [2]

(c) **(i)** Draw the 'dot-and-cross' diagram of ammonia, showing only the valence electrons.

[1]

(ii) Predict the shape and bond angle of ammonia using Table 8.3.

shape: …… bond angle: …… [1]

(iii) Explain your answer.

…… [1]

(d) **(i)** Explain, with reference to Table 8.4 and Fig. 8.5, why H_2O has a higher boiling point than NH_3.

……

……

……

…… [3]

(ii) Predict the electronegativity value of fluorine, which is in the same period as nitrogen and oxygen.

…… [1]

[Total: 11]

Section B

Answer **one** question from this section.

9 1.00 g samples of different metal carbonates are heated strongly for 5 minutes.

Table 9.1 shows the mass of solid remaining after heating.

Table 9.1

carbonate	mass after heating/ g
copper(II) carbonate	0.56
magnesium carbonate	0.83
potassium carbonate	
zinc carbonate	0.72

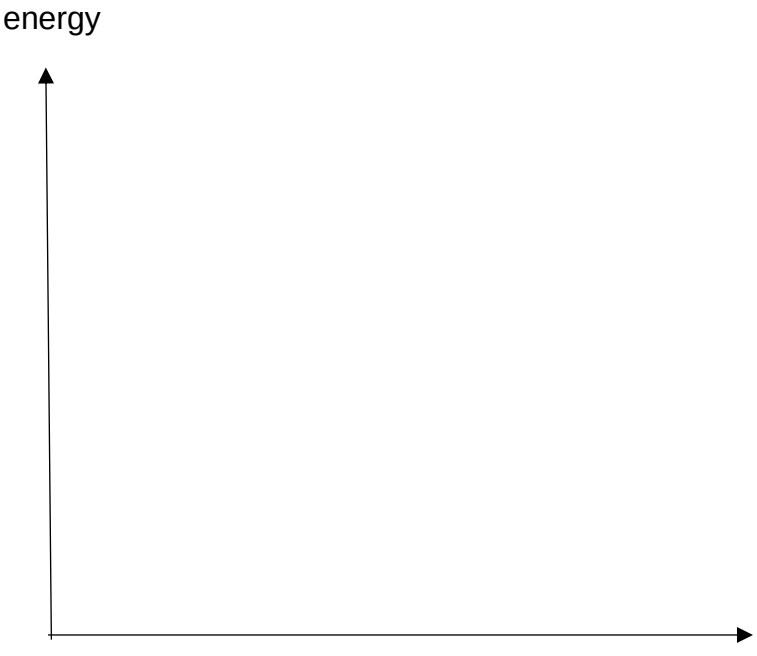
(a) **(i)** Write a balanced chemical equation, with state symbols, for the thermal decomposition of copper(II) carbonate.

…… [2]

(ii) Draw the energy profile diagram for the above chemical reaction.

Your diagram should include:

- the reactants and products;
- the activation energy;
- the enthalpy change of the reaction.



[2]

(iii) Although the initial mass of each carbonate is the same, the mass of solid remaining after heating is different.

Explain the difference in the loss in mass between copper(II) carbonate and magnesium carbonate.

……

……

……

…… [2]

(b) Predict the mass of the solid obtained after heating potassium carbonate. Explain your reasoning.

mass of solid after heating = …….. g

……...

……... [2]

(c) A pure metal can be extracted by further heating the solids remaining at the end of the reaction in Table 9.1 with carbon.

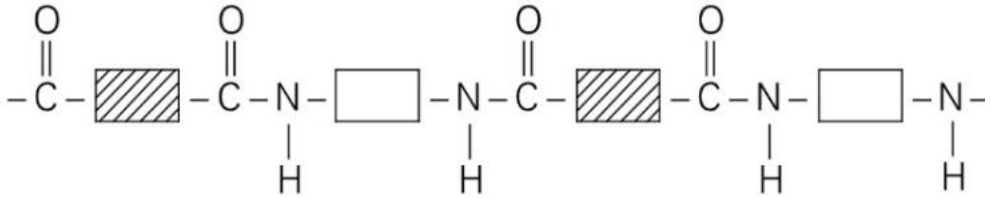
State the metal(s) that can be extracted. Explain your answer.

……...

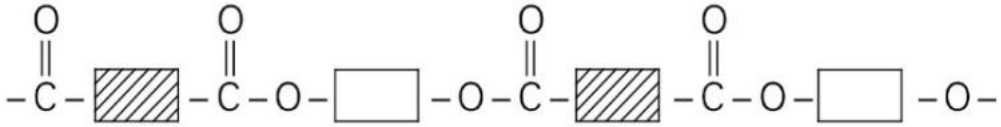
……... [2]

[Total: 10]

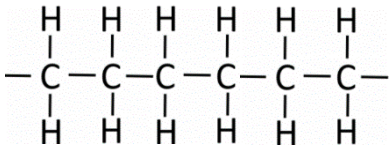
10 The partial structure of the three polymers are shown in Fig. 10.1.



Polymer **A**



Polymer **B**



Polymer **C**

Fig. 10.1

(a) Polymers **A** and **B** are synthesised by condensation polymerisation while polymer **C** is synthesised by addition polymerisation.

Describe **two** differences between addition polymerisation and condensation polymerisation.

……...

……...

……... [2]

(b) **(i)** Identify the polymer that represents the structure of nylon. Explain your answer.

……

……

[2]

(ii) Hence, draw the structural formula of the monomer(s) used to form nylon.

[2]

(iii) State a use for nylon.

…… [1]

(c) Even though there are various methods available to recycle polymers like plastics, only 4 % plastic waste generated in Singapore are recycled.

Suggest **one** social, economic and environmental issue with recycling plastics.

social: ……...

……...

economic ……...

……...

environmental ……...

……... [3]

[Total: 10]

End of Paper

Secondary 4
Chemistry (6092)
Preliminary Examination 2024

Mark Scheme

Date: 27 August 2024

Paper 1

Question	Answer
1	**A**
2	**D**
3	**A**
4	**D**
5	**C**
6	**A**
7	**B**
8	**B**
9	**C**
10	**D**
11	**B**
12	**C**
13	**A**
14	**D**
15	**D**
16	**A & D**
17	**D**
18	**C**
19	**C**
20	**C**

Question	Answer
21	**B**
22	**D**
23	**D**
24	**C**
25	**B**
26	**B**
27	**D**
28	**A**
29	**A**
30	**A**
31	**D**
32	**D**
33	**C**
34	**A**
35	**B**
36	**C**
37	**B**
38	**B**
39	**B**
40	**B**

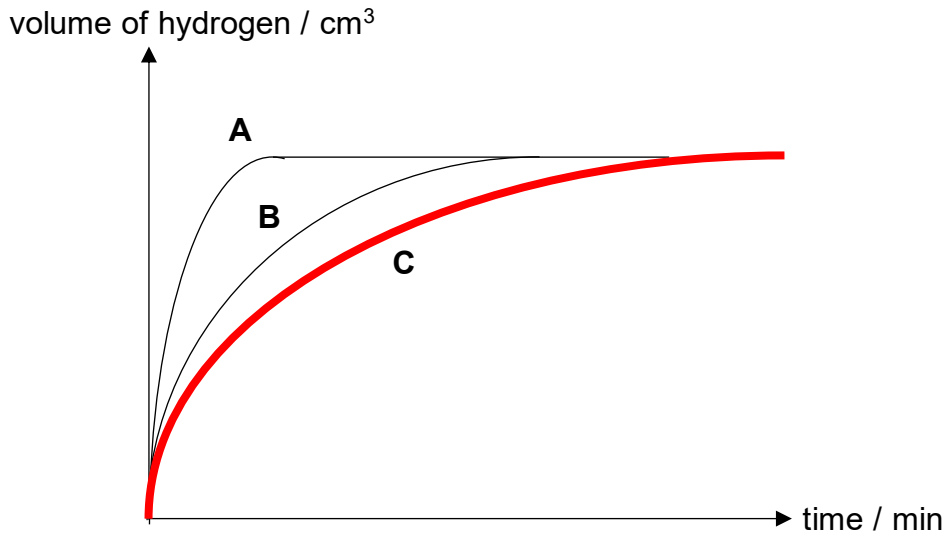
Paper 2

Qn	Suggested answer	Marks
1(a)	silicon dioxide / graphite / diamond	1
1(b)	graphite	1
1(c)	sodium carbonate	1
1(d)	methane	1
1(e)	zinc oxide	1
	Subtotal	5

2(a)	The formation of (sulfur) solid / precipitate from the reaction will cover the cross.	1
2(b)i	S in $Na_2S_2O_3$: +2 S: 0 (rule 0) S in SO_2: +4 [reject] 2+, 4+ *all correct – 2, 2 correct – 1*	2

Qn	Suggested answer	Marks
2(b)ii	Oxidation state of S decreased from +2 in $Na_2S_2O_3$ to 0 in S, thus reduction has occurred. Oxidation state of S increased from +2 in $Na_2S_2O_3$ to +4 in SO_2, thus oxidation has occurred. Since oxidation and reduction has occurred, it is a redox reaction. *Award 1m only if only change in oxidation states are mentioned without linking to the process (oxidation and reduction)*	1 1
2(c)	Test: Place a piece of filter paper soaked with <u>acidified</u> potassium manganate (VII) at opening of test tube Observation: purple $KMnO_4$ turns colourless [accept: purple $KMnO_4$ decolourises]	1 1
	Subtotal	7

3(a)i	no. of mol. of Mg = 2 ÷ 24 = 0.083333 mol no. of mol. of H_2SO_4 = 30 ÷ 1000 × 0.5 = 0.015 mol *calculation of mol for both reagent correctly* Based on mol ratio, Mg : H_2SO_4 = 1:1 = 0.083333 : 0.083333 (> 0.015) Thus H_2SO_4 is the limiting reagent.	 1 1
3(a)ii	no. of mol. of $MgSO_4$ = 0.015 mol mass of $MgSO_4$ = 0.015 × (24 + 32 + 4 x 16) = 1.8 g [allow] ecf from (a)i	 1
3(b)	Experiment 1 is graph **B** and Experiment 2 is graph **A**. Powdered magnesium has a <u>larger surface</u> area for reaction, increasing the <u>frequency of effective collision</u>, increasing the rate of reaction, as observed in graph **A** which has a steeper gradient. [accept] Magnesium strips has a smaller surface area for reaction, with a lower frequency of effective collision, decreasing the rate of reaction, as observed in graph **B** which has a more gentle gradient.	1 1 1
3(c)i	Experiment 3 will be the slowest as compared to experiments 1 and 2. Zinc, being less reactive than magnesium, will react with sulfuric acid less readily	1 1
3(c)ii	The volume of hydrogen will be **the <u>same</u>** as the <u>limiting reagent is sulfuric acid / zinc metal is in excess</u>, thus the reaction will stop when <u>all the acid has reacted</u>.	1 1

Qn	Suggested answer	Marks
3(c)iii	 **Fig. 3.1** less steep gradient than graph B, same height	1
	Subtotal	11

4(a)	In liquid state, the fuels occupy a smaller volume thus more can be transported in a tank.	1
4(b)	LNG has a lower density as it mainly made of methane and ethane which has a smaller Mr as compared to LPG which is mainly made of propane and butane.	1
4(c)	% mass of C in LNG = $(0.94 \times 12 \div 16 + 0.042 \times 24 \div 30) \times 100\ \% = 73.86\ \%$ % mass of C in LPG = $(0.311 \times 36 \div 44 + 0.671 \times 48 \div 58) \times 100\ \% = 81.0\ \%$ LNG is more flammable [accept estimation of % mass C using methane for LNG and % mass C averaging between propane and butane]	1 1
4(d)	It is added as a safety precaution to detect a gas leak.	1

4(e)	Carbon dioxide is absorbed by the crops from which biofuels are produced via photosynthesis. Carbon dioxide is released when biofuels are burnt. Since it is carbon neutral, it is more environmentally sustainable than fossil fuels.	1 1
	Subtotal	7

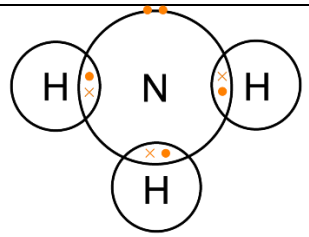
5(a)	A: chlorine B: hydrogen [accept] chemical formula	1 1
5(b)i	$2H^+ + 2e^- \rightarrow H_2$ $2Cl^- \rightarrow Cl_2 + 2e^-$ Comparing the equations, for every 2 mole of electrons, one mole of gas is discharged. *award 1 when both equations are correct* [accept] For the same amount of charge, equal volumes of gas is discharged.	1 1

Qn	Suggested answer	Marks
5(b)ii	Chlorine gas that is produced is soluble in water, while hydrogen is not, thus a smaller volume of chlorine is collected.	1
5(c)i	The chlorine discharged at anode <u>bleaches</u> the litmus solution. [accept] litmus solutions turns colourless.	1 1
5(c)ii	As hydrogen and chlorine are being discharged during electrolysis, the solution becomes more alkaline as the remaining solution contains potassium and hydroxide ions, hence the litmus solutions appears as blue.	1 1
	Subtotal	9

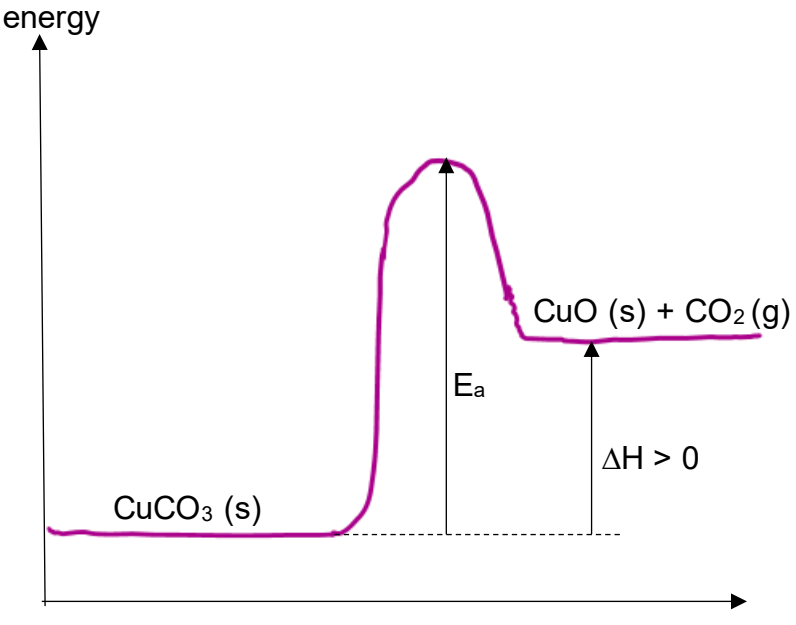
6(a)	Nicotine is not a hydrocarbon as it contains carbon bonded to not only hydrogen but nitrogen as well.	1
6(b)	Add <u>aqueous</u> bromine/ bromine solution / water to nicotine. Reddish brown bromine will turn colourless [accept] reddish brown bromine decolourises	1 1
6(c)i	mass of nicotine taken in a year = $15 \div 1000 \times 5 \times 7 = 0.525$ g no. of mol. of nicotine = $0.525 \div (12 \times 10 + 14 + 14 \times 2) = 0.0032407$ mol volume of NO_2 = $0.0032407 \times 2 \times 24 = 0.156$ dm^3 (3 s.f.) *award 1 for correct conversion to g and calculating mass of nicotine for 5 cigarettes a day, 7 days a week.* *award 1 for calculating mole by dividing mass over correct M_r* *award 1 for accounting for mole ratio and volume of gas*	
6(c)ii	Nitrogen dioxide reacts with water vapour in the air to form acid rain.	1
6(c)iii	Formed <u>in</u> vehicle combustion engine.	1
6(c)iv	It can be reduced by passing through a catalytic converter to form nitrogen gas.	1
6(d)i	Carbon monoxide binds with haemoglobin in blood irreversibly to reduce the ability of blood to transport oxygen around the body.	1
6(d)ii	Carbon monoxide is odourless and colourless so it is difficult to detect its presence.	1
	Subtotal	11

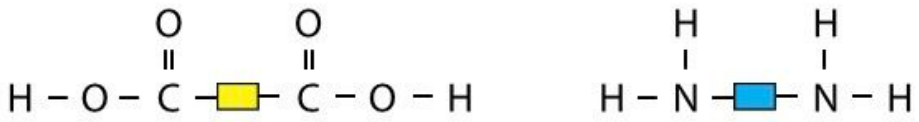
7(a)	gas **A**: carbon dioxide gas **B**: ammonia solid **P**: mixture of zinc carbonate and ammonium iodide solution **S**: zinc nitrate precipitate **T**: silver iodide [accept] chemical formula	1 1 1 1 1
7(b)	$Ag^+(aq) + I^-(aq) \rightarrow AgI\ (s)$ [accept] no state symbols	1

Qn	Suggested answer	Marks
7(c)	Method of preparation: Precipitation Add equal volumes of (aqueous) zinc nitrate and (aqueous) sodium carbonate into a conical flask mix well. Filter the mixture and collect the residue. Wash the residue with distilled water and dry between filter paper [Accept] any soluble zinc compound and carbonate, chemical formula	1 1 1
	Subtotal	9

8(a)i	As the number of bond pair electrons increase, bond angle decreases.	1
8(a)ii	As the number of lone pair electrons increase, bond angle decreases.	1
8(b)	As the repulsion between lone pair electron is greater than the bond pair electron, the repulsion due the presence of lone pair for molecule in Table 8.7 forces the bond pairs to come closer together, reducing the bond angle. *Students need to express the idea that one of the molecules in Table 8.7 has lone pair resulting in greater repulsion reducing the bond angle.*	1 1
8(c)i		1
8(c)ii	shape: trigonal pyramidal, bond angle: 107 ° *both correct – 1*	1
8(c)iii	Ammonia has 3 bond pairs and 1 lone pair of electrons, and the associated shape and bond angle is retrieved from table 8.3.	1
8(d)i	From table 8.4, oxygen has a higher electronegativity value of 3.5 as compared to nitrogen with value 3.0. Due to this difference in electronegativity, this will translate to the hydrogen bonding between oxygen and hydrogen in H_2O is stronger than that of nitrogen and hydrogen in NH_3. Thus, more energy is required to overcome this force of attraction leading to a higher boiling point. *Students need to show evidence by retrieving data from table 8.4 for comparison before arriving at conclusion.* [Accept] electronegativity difference between O and H in H_2O is 1.4 which is greater than that between N and H which gives 0.9.	1 1 1
8(d)ii	any value above 3.5. (electronegativity of oxygen)	1
	Subtotal	11
	Total	70

Section B

Qn	Suggested answer	Marks
9(a)i	$CuCO_3$ (s) → CuO (s) + CO_2 (g) *correct chemical formulae – 1* *correct state symbols – 1*	1 1
9(a)ii	 *Reactants and products clearly labelled – 1* *activation energy and enthalpy change correctly drawn – 1*	2
9(a)iii	Copper is lower in the reactivity series than magnesium. Thus, its carbonate is thermally less stable than that of magnesium, resulting in a greater rate of decomposition for the same time period. [accept] the ionic bonding between magnesium and carbonate is much stronger than that of copper and carbonate thus it decomposes less.	1 1
9(b)	1.00 g (no decrease in mass) Potassium carbonate is <u>thermally stable</u> and hence <u>does not decompose</u> upon heating.	1
9(c)	copper and zinc Both metals are below carbon in the reactivity series thus its oxide can be reduced by carbon.	1 1
	Subtotal	10

Qn	Suggested answer	Marks
10(a)	*Any 2* • Addition polymerisation will require only one monomer while condensation polymerisation will require two monomers. • Addition polymerisation will require only require one functional group (C=C) while condensation polymerisation will require at least two functional groups • Water molecules are formed as side products from condensation polymerisation while no other side products are formed from addition polymerisation.	1 1
10(b)i	Polymer **A** represents nylon. Nylon contains amide linkages as illustrated in Polymer **A**. [accept] structural formula for amide linkage	1 1
10(b)ii	 *award 1 for each correct structure of monomer.*	2
10(b)iii	*any 1* clothing, curtains, parachutes, fishing lines, sleeping bags	1
10(c)	*select any 1 from each domain* social issue • People find it more convenient to throw plastics than recycling • Many are not aware of the proper way to recycle plastics (e.g. contamination with leftover food, non-recyclable plastics thrown in recycling bins) • It takes time and effort for communities to adopt recycling as a lifestyle. economic issue 1. Recycling plastics can be more expensive than disposal in landfill or incineration • Cost for transporting waste to processing plant • Costs for sorting and cleaning waste before physical / chemical recycling • Costs for manpower, machines and energy 2. Not economically viable as cost of recycling waste higher than value of recycled plastics • Recycled plastics have lower market value than virgin plastics • High cost of recycling plastics environmental issue • Wastewater is generated from recycling plastics and may cause water pollution if not treated properly before discharge [accept any other logical reasoning in each domain]	3
	Subtotal	10
	Total	20