Pasir Ris Secondary School

Name	Class	Register Number

SECONDARY 4 EXPRESS
PRELIMINARY EXAMINATION 2023

CHEMISTRY **6092/01**

Paper 1 Multiple Choice **25 Aug 2023**

Friday 1105 – 1205 **1 hour**

Additional Material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

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

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

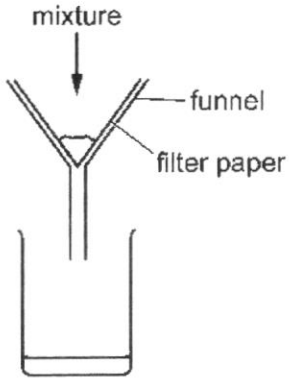
Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 14.
The use of an approved scientific calculator is expected, where appropriate.

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

Setter: Ms Chua Wei Tian **[Turn over**

1 A mixture is separated using the apparatus shown.

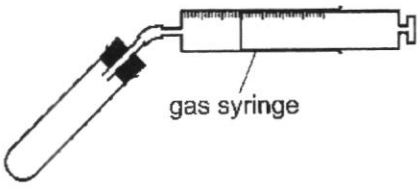


What is the likely identity of the mixture?

A aqueous copper(II) sulfate and aqueous sodium chloride
B aqueous copper(II) sulfate and calcium carbonate
C copper and sulfur
D ethanol and ethanoic acid

2 The formula of zinc oxide can be investigated by using the fact that when zinc is heated, it reacts with oxygen to form zinc oxide. Which apparatus is used for this investigation?

1



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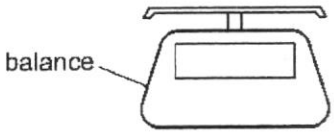

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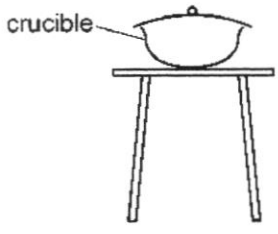


A 1 and 2 only
B 1 and 3 only
C 2 and 3 only
D 1, 2 and 3

3 Which statement about states of matter is correct?

A When a gas cools, the particles cannot vibrate about its fixed positions.
B When a liquid freezes, it becomes a solid and energy is released to the surroundings.
C When a solid is heated, the size of particles increases.
D When a solid melts, the particles get further apart and have less energy.

4 The melting points and boiling points of some gases in air are shown.

gas	melting point / °C	boiling point / °C
argon	–190	–187
nitrogen	–210	–197
oxygen	–220	–183

At which temperature will oxygen be the **only** liquid present?

A –180°C
B –185°C
C –188°C
D –200°C

5 Deuterium, D, is an isotope of hydrogen with a nucleon number of 2. Heavy water, D_2O, is water in which both the hydrogen atoms have been replaced with deuterium. It is commonly used in nuclear reactors. Some properties of ordinary water and heavy water are as shown.

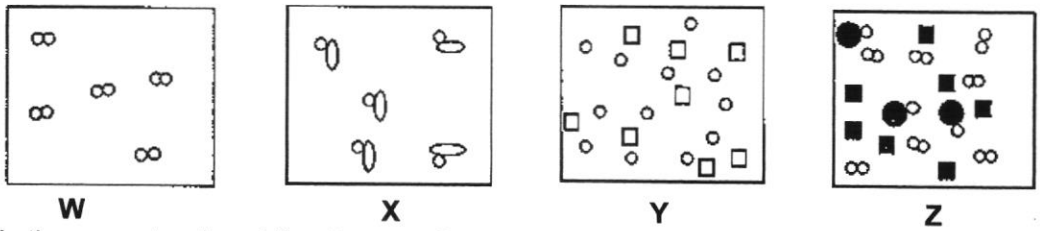
	ordinary water, H_2O	heavy water, D_2O
relative molecular mass	18	20
melting point / °C	0	3.8
boiling point / °C	100.0	101.4
density / g/cm^3	0.997	1.104

Which process can be used to recover heavy water from ordinary water?

A cracking
B fractional distillation
C separating funnel
D simple distillation

6 The diagrams below can be used to illustrate the following.

1 pure element
2 a mixture of elements
3 pure compound
4 a mixture of elements and a compound



W **X** **Y** **Z**

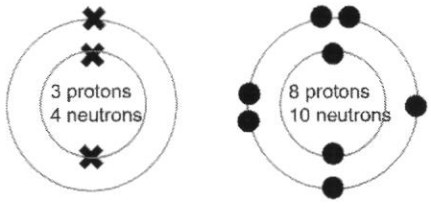
What is the correct order of the diagrams?

	1	2	3	4
A	**W**	**X**	**Y**	**Z**
B	**Z**	**W**	**X**	**Y**
C	**W**	**Y**	**X**	**Z**
D	**X**	**Z**	**W**	**Y**

7 An element, **M**, has p protons and n neutrons in its nucleus. Which row gives the correct number of protons, neutrons and electrons in a positive ion of an isotope of **M**?

	protons	neutrons	electrons
A	p	n	p + 1
B	p	n – 1	p – 1
C	p + 1	n	p + 1
D	p + 1	n + 1	p – 1

8 The atomic structures of two elements, **Q** and **R**, are shown.



atom **Q** atom **R**

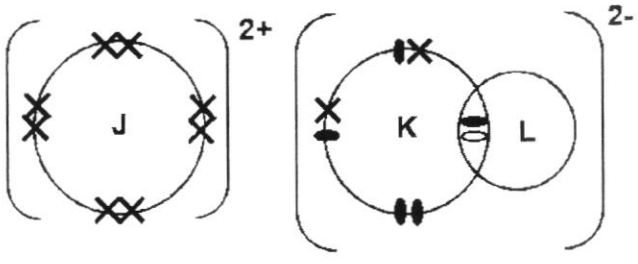
What is the mass of one mole of the compound formed between **Q** and **R**?

A 18 g **B** 25 g
C 32 g **D** 43 g

9 In which molecule are all the valence electrons of the atoms involved in bonding?

A CH_4 **B** HF
C H_2O **D** NH_3

10 **J**, **K** and **L** are three different elements in the Periodic Table. The electronic structure of the compound formed between **J**, **K** and **L**, with only the valence electrons, is shown.



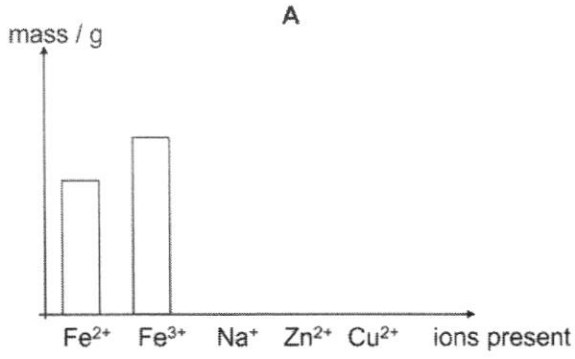
Which statement is **incorrect**?

A Element **J** belongs to Group II of the Periodic Table.
B Element **K** could be nitrogen.
C Element **K** and element **L** are bonded together by a covalent bond.
D Element **L** is a metal.

11 Five solutions were prepared so that each solution contained 1 mol/dm^3 of one of the following ions: Fe^{2+}, Fe^{3+}, Na^+, Zn^{2+} and Cu^{2+}. To each solution, excess aqueous ammonia was added and the precipitate, if any, was filtered and weighed. The masses were obtained and plotted on a bar graph.

Which of the following shows the correct graph?

A



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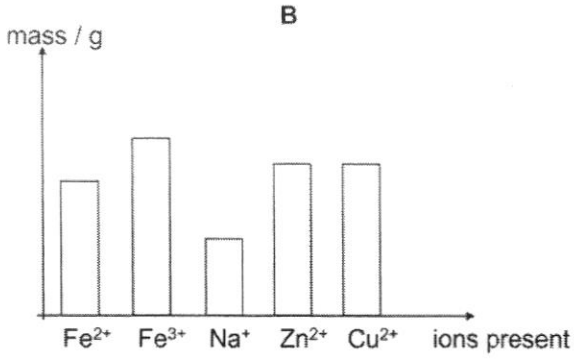

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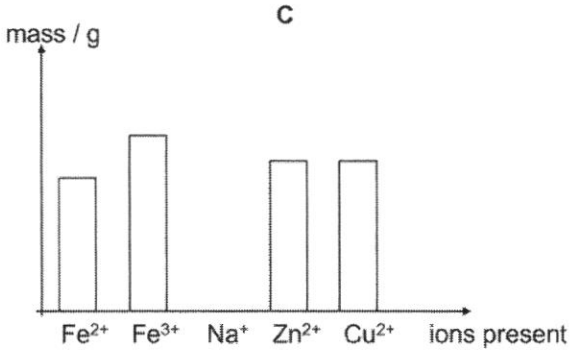
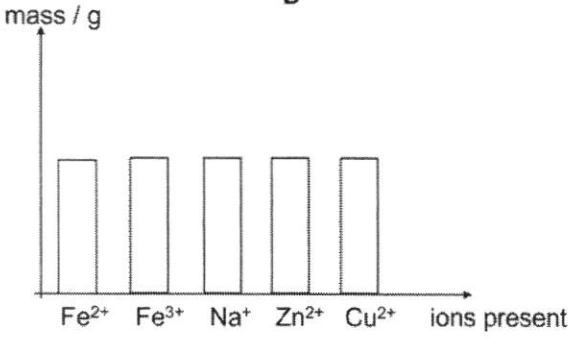


D



12 A **concentrated** aqueous solution of a strong acid, HX, contains molecules of water and the ions H^+ and X^-. Which statement is correct?

A The pH value of the acid is above 7.
B The solution also contains a high concentration of water molecules.
C The solution also contains OH^- ions.
D The solution contains less H^+ ions than water molecules.

13 Two reagent bottles contain solutions of ammonium nitrate and ammonium carbonate respectively. The labels have fallen off the bottles. Which substance could be added to each bottle to identify the reagents correctly?

A aqueous ammonia
B aqueous nitric acid
C aqueous potassium nitrate
D aqueous sodium hydroxide

14 **Z** is a solid which conducts electricity and has a high melting point. On warming, **Z** partly dissolves in excess dilute nitric acid, leaving behind a residue. What is the likely identity of **Z**?

A brass
B graphite
C sodium chloride
D zinc

15 Which three salts are all prepared by precipitation?

A barium sulfate, calcium nitrate, lead(II) sulfate
B barium sulfate, calcium nitrate, silver chloride
C calcium carbonate, barium sulfate, lead(II) chloride
D calcium chloride, barium sulfate, silver sulfate

16 In an experiment, 2.0 cm^3 of 1.0 mol/dm^3 aqueous copper(II) nitrate and 4.0 cm^3 of 1.0 mol/dm^3 aqueous potassium carbonate are mixed. What does the reaction vessel contain once the reaction is complete?

A a colourless solution only
B a green precipitate and a blue solution
C a green precipitate and a colourless solution
D a white precipitate and a colourless solution

17 Ammonia is used to make nitric acid, HNO_3 by the Ostwald Process. Three reactions occur in the following stages.

1 $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$
2 $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$
3 $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$

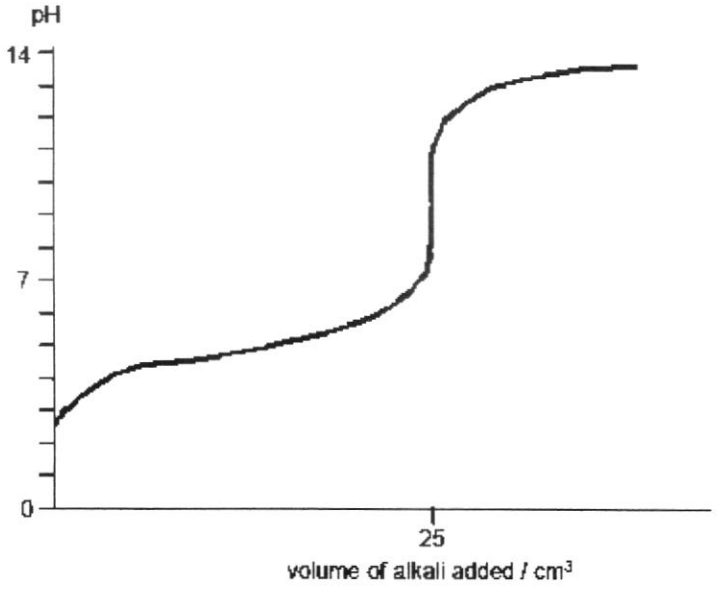
What is the number of moles of nitric acid produced from the reaction between 50.0 dm^3 of oxygen gas and excess ammonia gas in stage 1?

A 1.11
B 1.25
C 1.39
D 1.74

18 Hydrazine, N_2H_4, is a powerful reducing agent. When reacted with an aqueous solution containing silver ions, nitrogen is one of the products formed. Which ionic equation best represents this reaction?

A $N_2H_4 + 2Ag^+ \longrightarrow N_2 + 2AgH_2$
B $N_2H_4 + Ag^+ \longrightarrow N_2 + 2H_2 + Ag$
C $N_2H_4 + Ag^+ \longrightarrow N_2 + 4H^+ + Ag$
D $N_2H_4 + 4Ag^+ \longrightarrow N_2 + 4H^+ + 4Ag$

19 Dilute ethanoic acid was titrated with aqueous sodium hydroxide. The pH changes were recorded using a pH meter. The graph of pH against volume of alkali added was plotted as shown.



The diagram shows the pH ranges of three indicators.

pH	1	2	3	4	5	6	7	8	9
methyl orange	red			yellow					
phenolphthalein	colourless							pink	
bromothymol blue	yellow					blue			

Which indicator(s) can be used to determine the end-point of the titration?

A methyl orange only
B phenolphthalein only
C bromothymol blue and phenolphthalein only
D bromothymol blue, methyl orange and phenolpthalein

20 Some properties of metal **H** are listed.

- **H** does not react with cold water.
- **H** reacts with dilute hydrochloric acid.
- No reaction occurs when the oxide of **H** is heated with carbon.

What is a possible identity of metal **H**?

A copper
B iron
C magnesium
D potassium

21 10 cm^3 of propane is burned in 70 cm^3 of oxygen in a closed container.

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

What is the total volume of gas present after the reaction at room temperature and pressure?

A 30 cm^3 **B** 50 cm^3
C 70 cm^3 **D** 90 cm^3

22 When a mixture of sodium chloride and sodium hydrogencarbonate is heated, the following reaction takes place.

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Sodium chloride is unchanged on heating. When 6.0 g of the mixture is heated, the loss in mass is 1.5 g. What is the percentage by mass of sodium hydrogencarbonate in the mixture?

[relative molecular mass, M_r: $NaHCO_3$, 84; Na_2CO_3, 106; CO_2, 44; H_2O, 18]

A 34% **B** 48%
C 68% **D** 95%

23 These statements refer to hydrogen and its use as a fuel.

1 Both water and hydrocarbons can be used as a source of hydrogen.
2 In a fuel cell, hydrogen reacts with oxygen to generate electricity.
3 The reaction taking place in a fuel cell is a redox reaction.

Which statements are correct?

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

24 Metals **P**, **Q**, **R** and **S** are found to have the following properties.

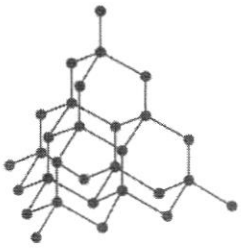
1 Only oxides of **P** and **R** can be reduced by heating with hydrogen.
2 **P** and **Q** react with acid but not with cold water.
3 **R** does not react with both acid and water.
4 Carbonate of **S** does not decompose under heat.

What is the order of reactivity of the metals?

	most reactive ⟶			least reactive
A	**Q**	**S**	**P**	**R**
B	**R**	**P**	**Q**	**S**
C	**S**	**Q**	**P**	**R**
D	**S**	**R**	**Q**	**P**

25 Which diagram shows the structure of an alloy?

A



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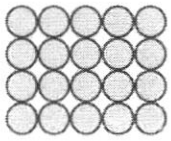

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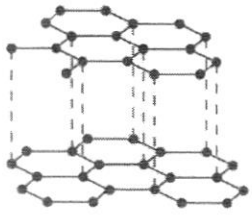

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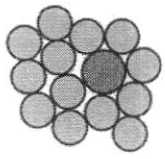
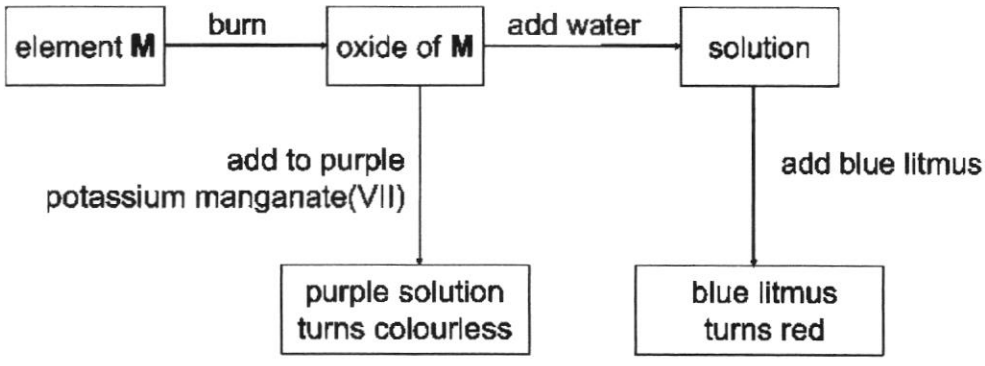


26 Some reactions of element **M** are shown.



What is the likely identity of element **M**?

A carbon
B iron
C magnesium
D sulfur

27 Disproportionation is a reaction in which the same element is oxidised and reduced simultaneously. Which reaction is an example of disproportionation?

A $3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

B $2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$

C $2NO_2 + H_2O \longrightarrow HNO_3 + HNO_2$

D $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$

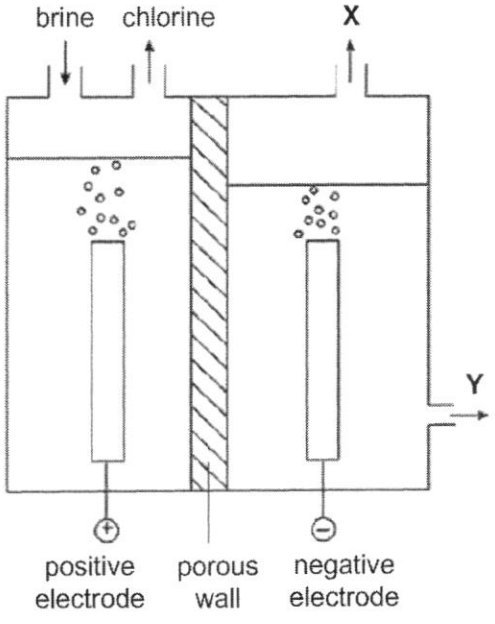
28 A student wrote four statements about the following reaction.

$$TiCl_4(l) + O_2(g) \longrightarrow TiO_2(s) + 2Cl_2(g) \qquad \Delta H = \text{negative}$$

Which statement is **incorrect**?

A Complete combustion is involved in this process.
B Energy is absorbed when the bonds are broken in titanium(IV) chloride and oxygen gas.
C The reaction releases energy and is an exothermic reaction.
D The volume of gas produced after reaction is twice the original volume.

29 The electrolysis of brine, concentrated sodium chloride solution, is shown in the diagram.



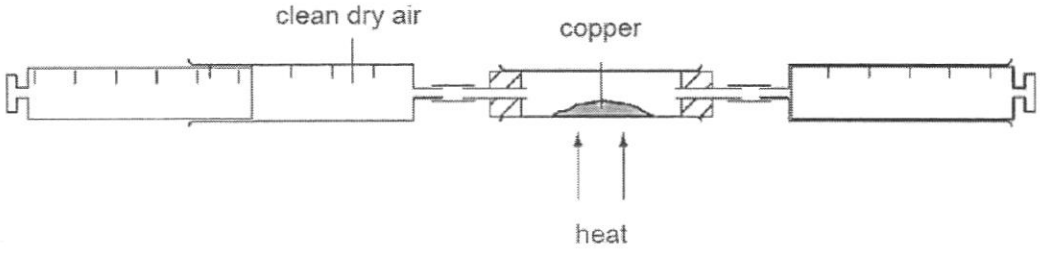
What are products **X** and **Y**?

	X	Y
A	hydrogen	dilute hydrochloric acid
B	hydrogen	dilute sodium hydroxide
C	oxygen	dilute hydrochloric acid
D	oxygen	dilute sodium hydroxide

30 In an electrolysis experiment, the same amount of charge deposited 38.4 g of copper and 14.4 g of titanium. The charge on the copper ion is 2+ and titanium has a relative atomic mass of 48. What was the charge on the titanium ion?

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

31 A sample of clean, dry air is passed over hot copper until all the oxygen in the air reacts with the copper. The volume of air decreases by 31.5 cm^3.



What was the starting volume of the sample of air?

A 63 cm^3
B 105 cm^3
C 150 cm^3
D 315 cm^3

32 Which statement about gases in the atmosphere is correct?

A Carbon monoxide is a pollutant which causes acid rain.
B Catalytic converters reduce carbon monoxide to carbon dioxide.
C Methane in the atmosphere depletes the ozone layer.
D Photosynthesis adds oxygen to the atmosphere.

33 Which noble gas has the highest concentration in dry air?

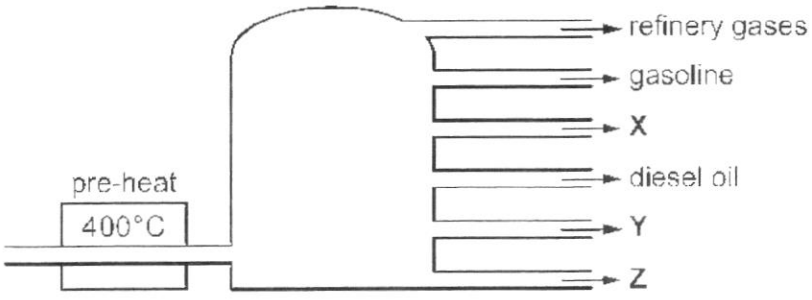
A argon
B helium
C krypton
D neon

34 How many of the following statements correctly describe(s) the petroleum gas fraction obtained after fractional distillation of crude oil?

1 Its molecules are hydrocarbons.
2 Its molecules have one to four carbon atoms.
3 The fraction has a fixed boiling point.
4 The fraction is the same as natural gas.

A 1
B 2
C 3
D 4

35 In an oil refinery, petroleum is separated into useful fractions. The diagram shows some of these fractions.



What are fractions **X**, **Y** and **Z**?

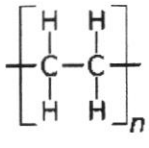
	X	Y	Z
A	kerosene	bitumen	lubricating oil
B	kerosene	lubricating oil	bitumen
C	lubricating oil	bitumen	kerosene
D	lubricating oil	kerosene	bitumen

36 Which statements are true about alkanes?

1 Their general formula is C_nH_{2n}.
2 They are flammable.
3 They can undergo combustion reaction.
4 They react with chlorine only.

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

37 The diagram shows a sample of poly(ethene).



Poly(ethene) contains molecules with an average relative molecular mass of 2800. How many carbon atoms are there in an average molecule of the polymer?

A 100
B 150
C 200
D 250

38 Two compounds, **Q** and **R**, react together to form a polymer.

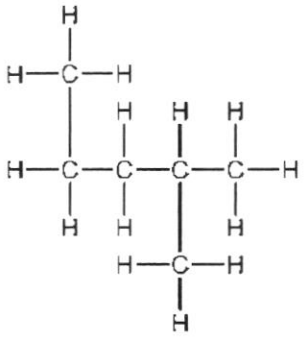
Q	**R**
$H_2N–(CH_2)_{10}–NH_2$	$HOOC–(CH_2)_6–COOH$

What is the formula of the repeating unit within the polymer?

A $C_{16}H_{34}N_2O_2$ **B** $C_{18}H_{34}N_2O_2$
C $C_{18}H_{36}N_2O_3$ **D** $C_{20}H_{38}N_2O_3$

39 Alkanes are saturated compounds containing carbon and hydrogen only. Structures 1, 2, 3 and 4 are saturated hydrocarbons.

1



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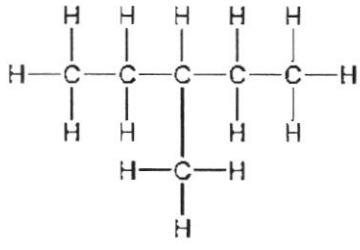

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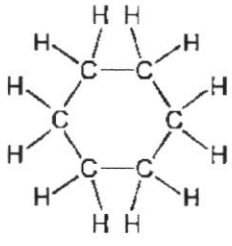

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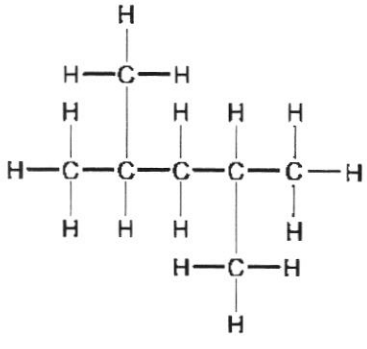


Which pair of structures are isomers?

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

40 A polyunsaturated compound has a molecular mass of 400. 100 g of the polyunsaturated compound reacts with 127 g of iodine.

How many double bonds are there in each molecule of the fat?

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

Pasir Ris Secondary School

Name	Class	Register No.

SECONDARY 4 EXPRESS
PRELIMINARY EXAMINATION 2023

CHEMISTRY **6092/02**

Paper 2 **18 Aug 2023**

1 h 45 min

Friday 1035 – 1220

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions in the spaces provided.

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

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 22.

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

For Examiner's Use	
Section A	
B9	
B10	
B11	
Total	

This document consists of **22** printed pages, including the cover page.

Setter: Ms Chua Wei Tian

[Turn over

Section A

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

A1 Fig. 1.1 shows the electronic configurations of five elements, **A**, **B**, **C**, **D** and **E**.

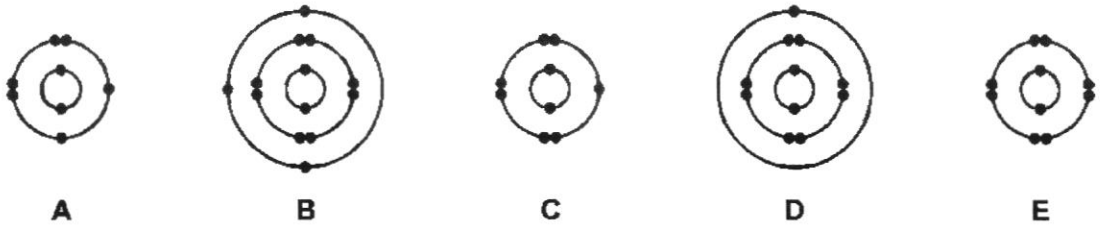


Fig. 1.1

(a) Use the letters **A**, **B**, **C**, **D** and **E** to answer the following questions.

Each letter may be used once, more than once or not at all.

(i) Which element is most likely to be a metal with low melting point?

..... [1]

(ii) Which element can be oxidised by oxygen to form an amphoteric oxide?

..... [1]

(iii) Which element can form a molecule with a double covalent bond?

..... [1]

(b) Element **E** exists as a single atom only. Explain why.

.....

..... [1]

[Total: 4]

A2 Table 2.1 shows the formulae of oxides of elements across Period 2 and Period 3 in the Periodic Table.

Table 2.1

Period	Group						
	I	II	III	IV	V	VI	VII
2	Li_2O	BeO	B_2O_3	CO_2	NO_2	-	F_2O
3	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_2	Cl_2O

(a) Carbon and silicon are elements in Group IV of the Periodic Table. They form oxides with very different melting points.

Explain, in terms of structure and bonding, why the melting points of carbon dioxide and silicon dioxide are different.

.....

.....

.....

.....

..... [3]

(b) **(i)** Draw a 'dot-and-cross' diagram to show the bonding in Na_2O. Show only the valence electrons.

[2]

(ii) Discuss the differences in the type of bonding and the way bonds formed in Na_2O and Cl_2O.

.....

.....

.....

..... [2]

[Total: 7]

A3 Mixture **S** contains one cation and two anions. A series of tests was performed on mixture **S** as shown in Fig. 3.1.

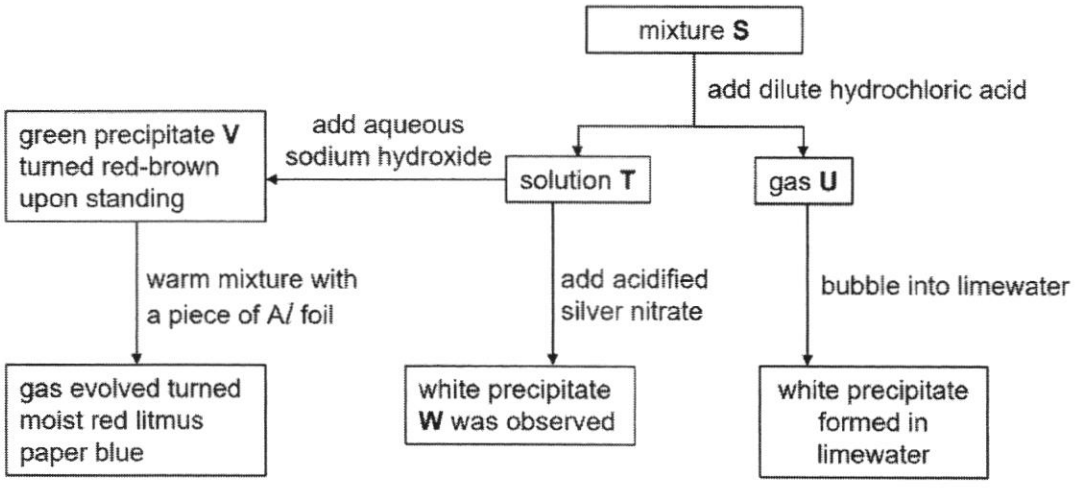


Fig. 3.1

(a) Identify the following unknown substances:

(i) **T**, ... [1]

(ii) **U**, ... [1]

(iii) **V**, ... [1]

(iv) **W**. ..... [1]

(b) Suggest the likely identities of the ions present in mixture **S**.

..... [1]

(c) Write a balanced chemical equation to represent **one** of the reactions in Fig. 3.1.

..... [1]

[Total: 6]

A4 All Group I metals form metal hydroxides that are soluble in water. Most other metal hydroxides are insoluble in water.

Crystals of lithium chloride can be prepared using titration between aqueous hydrochloric acid and aqueous lithium hydroxide. Fig. 4.1. represents the experimental set-up.

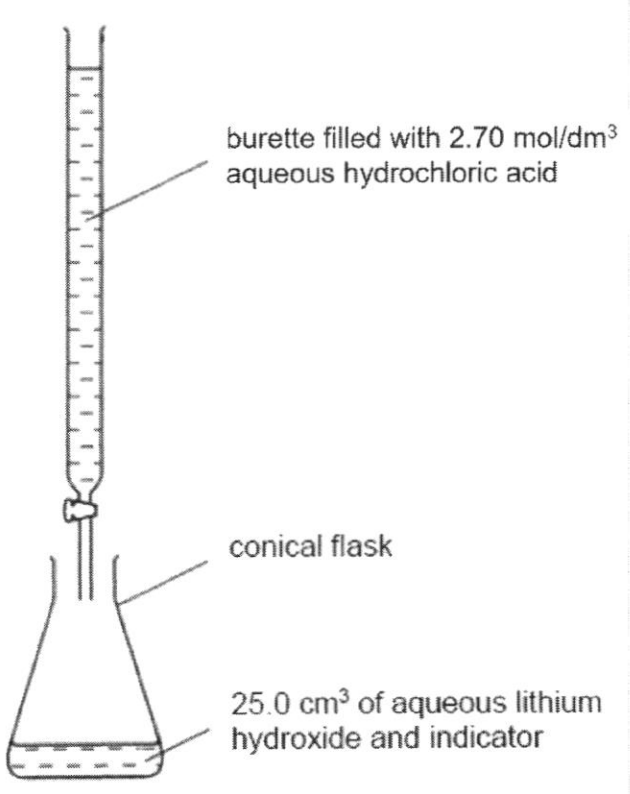


Fig. 4.1

25.0 cm^3 of aqueous lithium hydroxide is pipetted into the conical flask. A few drops of an indicator are added. Aqueous hydrochloric acid is added until the indicator just changes colour. The volume of acid required to completely neutralise lithium hydroxide is recorded.

(a) A neutral solution of lithium chloride containing the indicator is left at the end of titration. It is known that lithium chloride is unstable to heat and melts at 617°C. Describe how you could obtain a **pure** dry sample of lithium chloride crystals.

.....

.....

.....

..... [2]

(b) Suggest why magnesium chloride could **not** be prepared using the same method as lithium chloride.

.....

..... [1]

(c) The concentration of aqueous hydrochloric acid is 2.70 mol/dm^3. 22.50 cm^3 of aqueous hydrochloric acid is required to neutralise 25.0 cm^3 of aqueous lithium hydroxide.

Calculate the concentration of aqueous lithium hydroxide.

[2]

[Total: 5]

A5 Table 5.1 shows the melting points and boiling points of Group VII elements.

Table 5.1

Group	element	melting point / °C	boiling point / °C
VII	chlorine	–101	–35
	bromine	–7	59
	iodine	114	184

(a) Describe the trend of melting points and boiling points of elements down Group VII. Use ideas about bonding to explain why.

.....

.....

.....

..... [2]

(b) Sea water contains potassium bromide. Bromine can be produced from sea water by displacement.

(i) Name an element that can displace bromine. Explain your answer.

.....

..... [2]

(ii) Write an ionic equation to represent the equation.

..... [1]

[Total: 5]

A6 Copper is a transition element. It can act as a catalyst in the form of an element or a compound.

(a) State **two** other chemical properties of transition elements which make them different from Group I elements.

1 .....

2 ..... [2]

(b) Copper can exist in the form of copper(II) oxide. When copper(II) oxide is heated at 800°C, it decomposes to form two products as shown in the following chemical equation.

$$4CuO \longrightarrow 2Cu_2O + O_2$$

(i) Explain, in terms of electron transfer, why CuO is described as an oxidising agent.

.....

..... [1]

(ii) Explain, in terms of oxidation states, why CuO is described as a reducing agent.

.....

..... [1]

(c) Copper metal is obtained when scrap iron is added to aqueous copper(II) sulfate.

(i) Describe **two** observations and explain why this is possible. Include a chemical equation to support your answer.

.....

.....

.....

..... [3]

(ii) Identify **another** method for obtaining copper metal from aqueous copper(II) sulfate.

..... [1]

[Total: 8]

A7 Electrolysis and simple chemical cells both involve chemical reactions and electricity. Some students investigated the electrolysis of copper(II) nitrate solution using inert electrodes. Fig. 7.1 shows the experimental set-up.

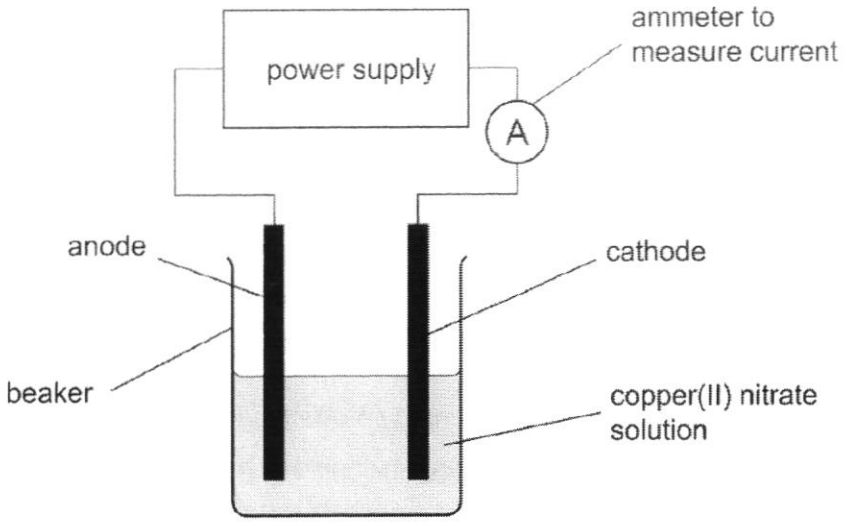


Fig. 7.1

(a) Explain the differences between an electrolytic cell and a simple chemical cell.

.....

.....

..... [2]

(b) Write ionic equations for the reactions at the cathode and anode.

(i) cathode: ..... [1]

(ii) anode: ..... [1]

(c) Describe and explain **two** observations that could be made during the experiment.

.....

.....

..... [2]

(d) When the anode was replaced with a piece of zinc electrode, some gas bubbles were observed around the zinc electrode. Suggest a reason for this observation.

.....

..... [1]

[Total: 7]

A8 The reaction between hydrogen sulfide and oxygen is exothermic. It can be represented by the following equation.

$$2H_2S(g) + 3O_2(g) \longrightarrow 2H_2O(g) + 2SO_2(g)$$

(a) (i) Fig. 8.1 shows part of the energy profile diagram for the reaction.

Complete Fig. 8.1. Your diagram should include:

- the reactants and products of the reaction,
- labels to show the enthalpy change of reaction and the activation energy.

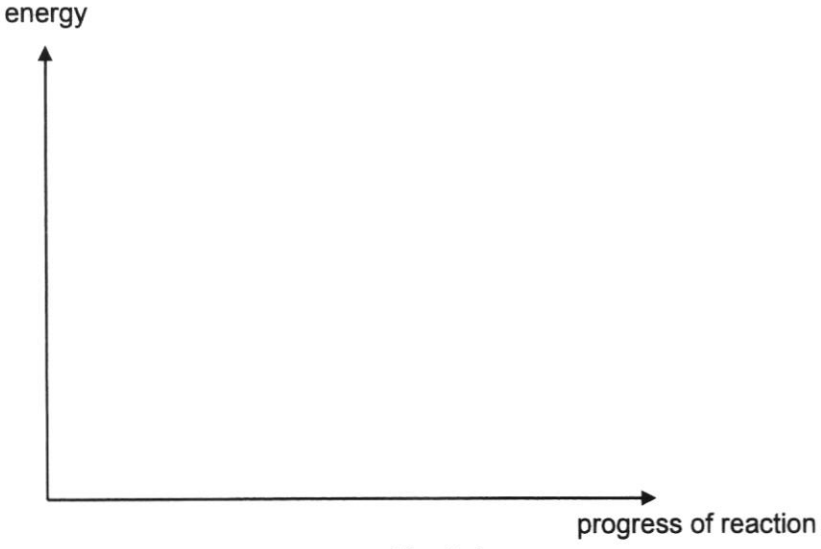


Fig. 8.1

[3]

(ii) Use ideas about breaking and forming bonds to explain why the overall reaction is exothermic.

.....

..... [2]

(b) Table 8.2 shows some of the bond energies.

Table 8.2

bond	bond energy / kJ/mol
H–S	364
O=O	498
H–O	464
S=O	**X**

Given that the enthalpy change of the reaction is –1034 kJ/mol, calculate the bond energy **X** for the S=O bond.

[3]

[Total: 8]

Section B

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

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

The total mark for this section is 30.

B9 Depletion of fossil fuels

Fossil fuels are formed naturally from the remains of dead plants and animals. When fossil fuels are burnt, they produce large amounts of energy which can be used to produce electricity in power stations, or to power engines in vehicles. Fossil fuels take millions of years to form, and the global high demand for fossil fuels has accelerated its depletion. As such, there is a need to source for alternative energy sources that are renewable and more sustainable.

Biofuels as alternative fuels

Biofuels are derived from biomass, which is material originally from living organisms. This could either be animal or plant derived. Some common examples of biofuels include ethanol and biodiesel. While the production and combustion of biofuel produces carbon dioxide, the use of biofuel is described as *carbon neutral*.

Ethanol as biofuel

Ethanol can be created by fermenting biomass that contains carbohydrates such as sucrose, glucose, and starch. Fermentation of glucose solution, in the presence of yeast, produces ethanol and can be represented by the following chemical equation.

$$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

Biodiesel as biofuel

Researchers discovered a method to transform waste vegetable oils to biodiesel for use as an alternative fuel. In fact, waste vegetable oil is the main raw material used for biodiesel production in the United States. As compared to fossil fuels, biodiesel produces less soot, carbon monoxide and unburnt hydrocarbons. Fig. 9.1 summarises some of the key processes involved in the production of biodiesel.

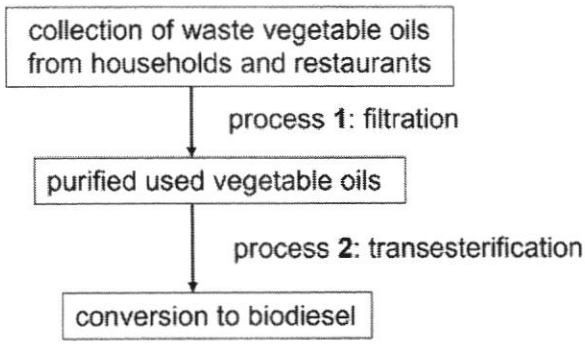
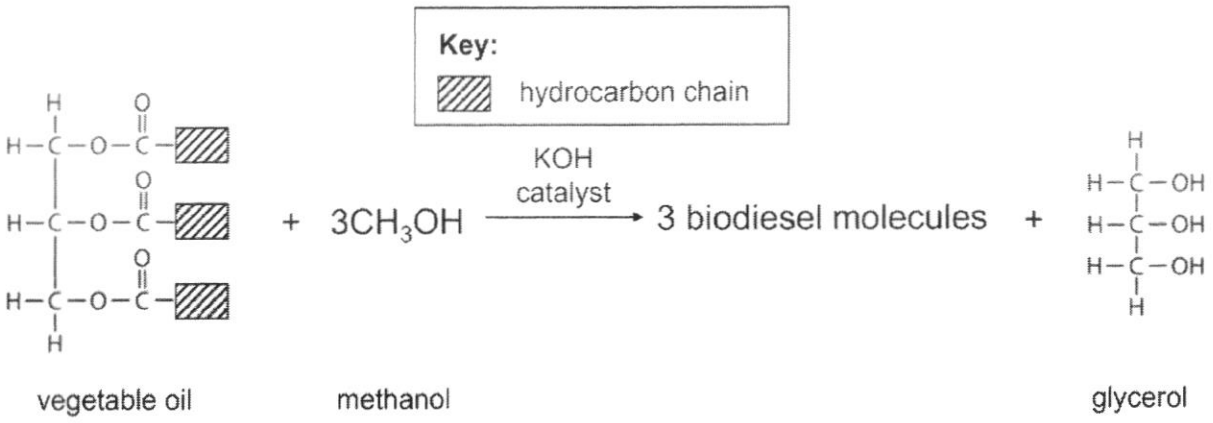


Fig. 9.1

Transesterification

Vegetable oils are tri-esters with long hydrocarbon chains. It can react with methanol, in the presence of potassium hydroxide as catalyst, to form biodiesel and glycerol. Fig. 9.2 shows the structures of some of the molecules involved in the reaction. **Biodiesel is an ester.**



vegetable oil methanol glycerol

Fig. 9.2

Waste vegetable oils, that were previously exposed to high temperatures during cooking, usually contain acids. The presence of acid in the waste vegetable oils makes it challenging to convert them into biodiesel, taking a longer time than waste vegetable oil without acid.

Comparison between fossil fuel and biofuel

Table 9.3 compares some of the properties between fossil fuel and biofuel.

Table 9.3

type of fuel	fossil fuel (e.g. petrol obtained after refining petroleum)	biofuel	
		ethanol	biodiesel
energy produced/ kJ per g	approx. 46.0	26.8	37.8
biodegradability	non-biodegradable	biodegradable	biodegradable
production process	• takes millions of years to form • requires fossil fuel to be refined before it is useful	• takes a few hours, slow rate of reaction • requires crops (e.g. corn) to be grown for fuel	• presence of acid decreases the rate of reaction • requires crops (e.g. corn) to be grown for fuel
incomplete combustion	more likely	less likely	less likely

Reference: Topi, D. Transforming waste vegetable oils to biodiesel, establishing of a waste oil management system in Albania. SN Appl. Sci. 2, 513 (2020).

(a) **(i)** Explain why the use of biofuel is described as *carbon neutral.*

.....

.....

..... [2]

(ii) With reference to Fig. 9.1, suggest **one** improvement that could be included in process **1** to produce a greater yield of biodiesel.

.....

..... [1]

(b) **(i)** Describe, in general, the meaning of transesterification. Include the functional group(s) involved.

.....

..... [1]

(ii) Suggest why vegetable oils are called *tri-esters.*

.....

..... [1]

(iii) One molecule of vegetable oil reacts to form three molecules of biodiesel. Suggest the structure of one molecule of biodiesel.

Use  to represent the hydrocarbon chain.

[2]

(c) Explain how and why the presence of acid in the waste vegetable oils will take a longer time for its conversion into biodiesel.

.....

.....

..... [2]

(d) Explain why the production of ethanol is a slow process.

.....

..... [1]

(e) *"Biofuel is a better source of fuel than fossil fuel."*

With reference to Table 9.3, justify if you agree with the statement.

.....

.....

.....

..... [2]

[Total: 12]

B10 Alkynes and alkenes are homologous series of unsaturated hydrocarbons. All alkynes contain C≡C triple bond. Table 10.1 shows information about the first three alkynes.

Table 10.1

formula	C_2H_2	C_3H_4	C_4H_6
structure	H–C≡C–H	H–C≡C–CH_3	H–C≡CH_2–CH_3
names	ethyne	propyne	butyne

(a) Compounds in the same homologous series have the same general formula.

(i) Give **two** other characteristics of members of a homologous series.

1 .....

2 ..... [2]

(ii) Alkynes are unsaturated. Describe a test for unsaturation.

test .....

result ..... [2]

(b) Explain why methyne and methene do **not** exist.

..... [1]

(c) Ethene can be converted to ethanoic acid by a two-stage process in the laboratory. In stage one, ethene is converted to ethanol by catalytic addition.

(i) Identify the catalyst used in stage one.

..... [1]

(ii) Deduce the type of reaction involved in stage two to produce ethanoic acid. Include the necessary chemical reagent.

.....

..... [2]

[Total: 8]

EITHER

B11 Hydrogen is used to produce ammonia in the Haber process. The hydrogen is made in two stages. In each process, hydrogen is the useful product.

Stage 1 involves the reaction between methane and steam to produce carbon monoxide and hydrogen. This reaction can be represented by the following equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

Stage 2 uses the carbon monoxide produced in **stage 1**.

The carbon monoxide is reacted with more steam to produce carbon dioxide and more hydrogen. This reaction can be represented by the following equation.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

The atom economy of a process is a measure of the percentage by mass of the products that are useful.

$$\text{atom economy} = [(\text{total } M_r \text{ of useful product}) \div (\text{total } M_r \text{ of products})] \times 100\%$$

(a) Calculate the atom economy for the formation of hydrogen in **stage 1**.

[2]

(b) What is the effect of increasing the pressure on the equilibrium yield and the rate of formation of hydrogen in **stage 2**? Use ideas about energy and collisions to explain why.

.....

.....

.....

..... [3]

(c) Fig. 11.1 shows the percentage yield of ammonia produced at different temperatures and pressures in the Haber process. A temperature of 450°C and a pressure of 200 atm are commonly used in the Haber process.

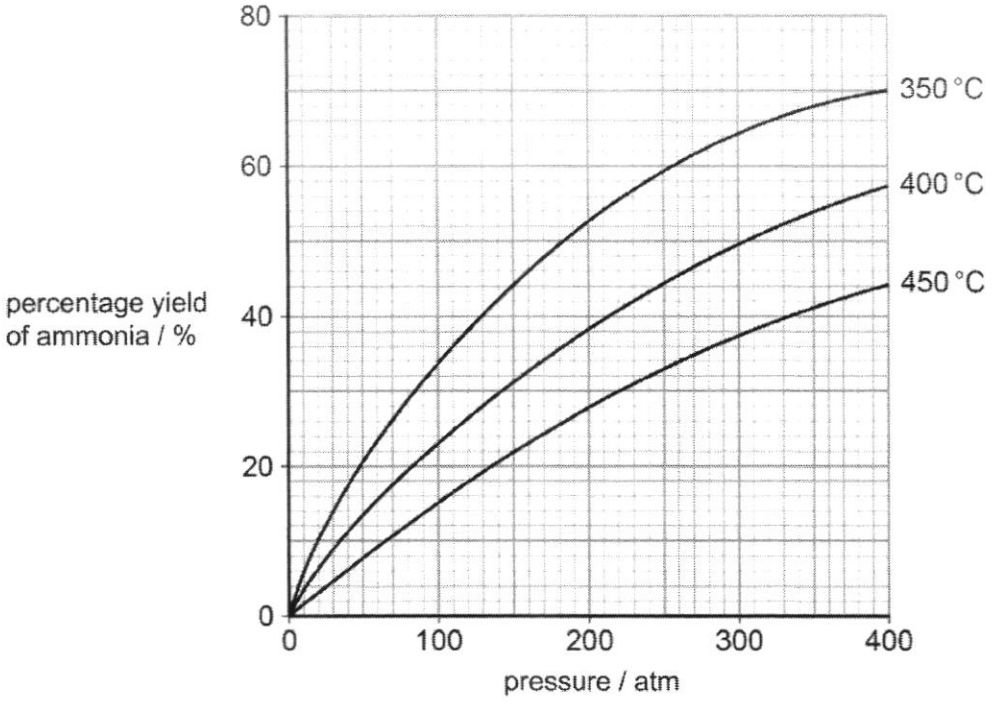


Fig. 11.1

(i) A student proposed that a temperature of 350°C and a pressure of 285 atm could be used instead of those used in the Haber process.

Determine how many times greater the percentage yield of ammonia obtained would be.

..... [1]

(ii) Suggest why the proposed conditions by the students are **not** ideal for industrial purpose.

.....

.....

..... [2]

(d) World production of ammonia is now about 50 times greater than it was in the 1940s. Suggest why the demand for ammonia has increased.

.....

.....

..... [2]

[Total: 10]

OR

B11 Some students investigated the rate of decomposition of hydrogen peroxide, H_2O_2.

The reaction can be represented by the following chemical equation. However, the equation is unbalanced with a missing state symbol.

$$\ldots\ldots\ H_2O_2\ (\ldots\ldots) \longrightarrow \ldots\ldots\ H_2O\ (l) + \ldots\ldots\ O_2\ (g)$$

The catalyst for the reaction is manganese(IV) oxide.

(a) Balance the above chemical equation. Include the missing state symbol. [1]

(b) Student **X** investigated the effect of the particle size of manganese dioxide on the rate of the reaction. The following method is used.

1. Measure 25 cm^3 of 0.30 mol/dm^3 hydrogen peroxide solution into a conical flask.
2. Add a spatula of fine manganese(IV) oxide powder to the conical flask.
3. Measure the volume of gas produced every minute for 10 minutes.
4. Repeat steps 1 to 3 with some coarse manganese(IV) oxide lumps.

The method student **X** used did **not** give valid results.

Suggest **two** improvements that student **X** could make to the method to give valid results.

.....

.....

..... [2]

(c) Student **Y** used a method which gave valid results.

Student **Y** performed the experiment using 25 cm^3 of 0.30 mol/dm^3 hydrogen peroxide solution with fine manganese(IV) oxide powder.

Student **Y** repeated the experiment with coarse manganese(IV) oxide powder.

Fig. 11.2 shows student **Y**'s results.

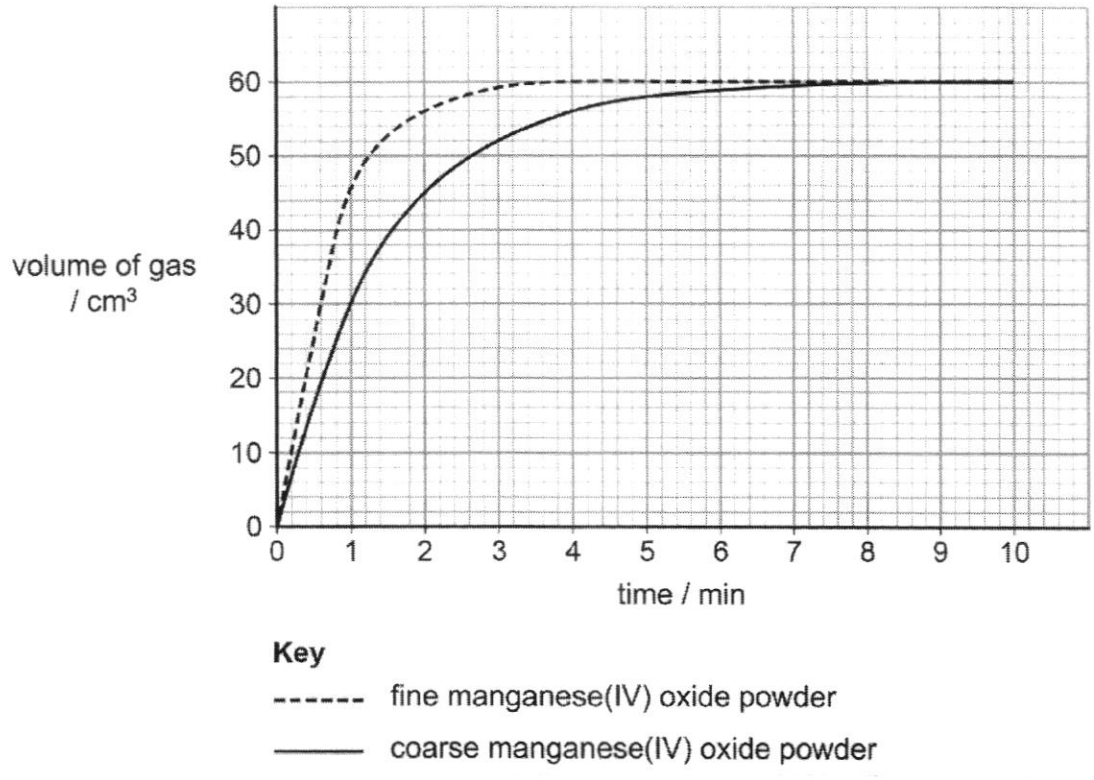


Fig. 11.2

(i) Describe the change in the rate of reaction when the experiment was repeated with coarse manganese(IV) oxide powder.

Use ideas about energy and collisions to explain why.

.....

.....

.....

..... [3]

(ii) Student **Y** repeated the experiment with coarse lumps of manganese(IV) oxide.

Student **Y** used the same volume of 0.15 mol/dm^3 hydrogen peroxide instead of 0.30 mol/dm^3 hydrogen peroxide.

Sketch on Fig. 11.2 the curve you would expect to see. Assume that the reaction is complete after 9 minutes. [2]

(iii) Determine the volume of distilled water required to prepare 0.15 mol/dm^3 hydrogen peroxide from 1 dm^3 of 0.30 mol/dm^3 hydrogen peroxide. Show all your workings clearly.

[2]

[Total: 10]

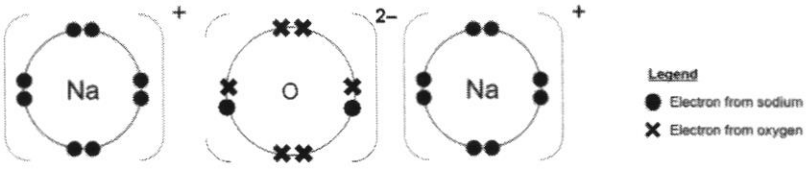
End of Paper

SEC 4 EXPRESS – CHEMISTRY 6092 PRELIM EXAM 2023 – ANSWERS

Paper 1 – MCQ

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

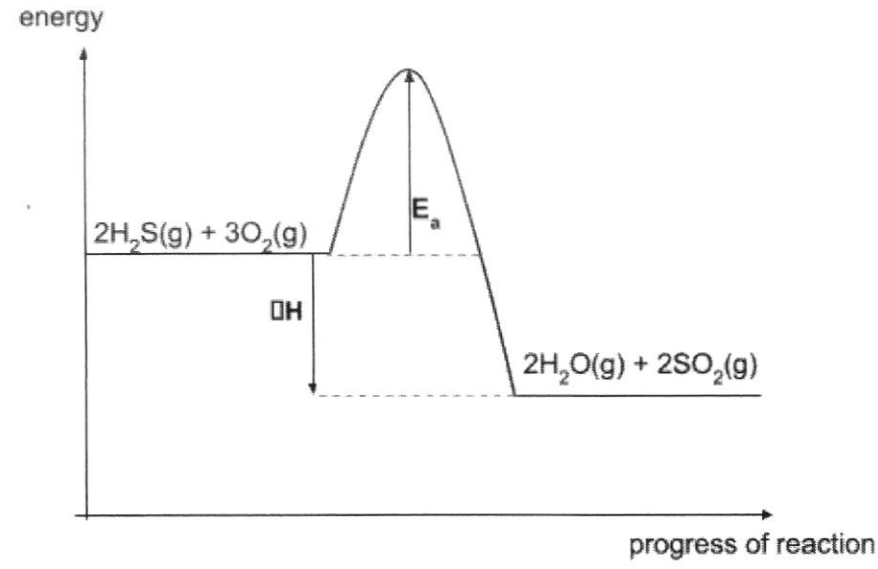
Paper 2 – Section A – Structured Questions

No	Suggested Answers	Marks
A1(a)	(i) D (ii) B (iii) A *In general, part (i) and (iii) are not done well. Most students did not relate metal with low melting point as group I element.*	[3]
A1(b)	**E** has **achieved stable noble gas configuration / full valence shell of electrons**. [1/2] Hence, **E does not have to gain, lose or share electrons**. [1/2] *Most students find it challenging to relate why atom reacts as "gain/lose or share" electrons.*	[1]
A2(a)	Carbon dioxide has a **simple molecular structure** [1/2] where **discrete molecules are held together by weak intermolecular forces of attraction** [1/2]. **Little amount of energy** is required to **overcome** these **forces** [1/2]. Silicon dioxide has a **giant molecular structure** [1/2] where **atoms are held together by strong covalent bonds** [1/2]. **Large amount of energy** is required to **break** these **bonds** [1/2]. Hence, **carbon dioxide has a lower melting point than silicon dioxide**. *(Minus ½ if this point is missing)*	[3]
A2(b)	(i)  Correct number of charges for each ion – [1] Correct valence electrons drawn for each ion – [1] (ii) Na_2O **contains ionic bonds / involves transfer of electrons from Na to O** [1/2] where **oppositely charged ions are held together by strong electrostatic forces of attraction** [1/2]. Common error: atoms instead of ions are mentioned for Na_2O. CI_2O **involves sharing of valence electrons** [1/2] where **atoms are held together by strong covalent bonds** [1/2]. Accept: **contains covalent bonds** (alternative for marking point on "sharing of valence", if students did not mention "atoms are held together by strong covalent bonds"	[4]

	Most students compare differences in structure which is not required in the question.	
A3(a)	(i) T: **iron(II) chloride** (ii) U: **carbon dioxide** (iii) V: **iron(II) hydroxide** (iv) W: **silver chloride** *Also accept chemical formulae*	[4]
A3(b)	Mixture **S** likely contains **iron(II)**, **carbonate** and **nitrate** ions. *All three ions must be correct.* *Also accept formulae of ions: Fe^{2+}, CO_3^{2-}, NO_3^-* *Reject: chloride (could have come from hydrochloric acid)*	[1]
A3(c)	$CO_2 + Ca(OH)_2 \longrightarrow CaCO_3 + H_2O$ $Fe^{2+}(aq) + 2OH^-(aq) \longrightarrow Fe(OH)_2(s)$ $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$ $CO_3^{2-}(aq) + 2H^+(aq) \longrightarrow CO_2(g) + H_2O(l)$ *Accept any of the above or any other possible reactions.* Common error: incorrect formulae of silver chloride, iron(II) nitrate etc	[1]
A4(a)	**Repeat the experiment with known titre value without adding indicator** [1/2] *Also accept answer if students wrote the procedures with values indicated (e.g. 25.0 cm^3 of LiOH added to…)* **Heat the mixture until a saturated solution is formed**. [1/2] **Cool** the **solution for crystals to form**. [1/2] **Filter** the mixture to obtain the crystals. **Dry** the crystals between sheets of filter paper. [1/2]	[2]
A4(b)	Magnesium hydroxide is **sparingly soluble / insoluble in water**. / It is **difficult to determine the end-point of the neutralisation** (when magnesium hydroxide exists as a solid). OR **Mixture that is formed may contain excess acid**. [1] Reject: reaction between magnesium hydroxide and acid is reactive/unsafe.	[1]
A4(c)	Moles of hydrochloric acid = 2.70 x (22.50/1000) = **0.06075 mol** ---------- [1] Since hydrochloric acid and lithium hydroxide reacts in 1:1 ratio, moles of lithium hydroxide = 0.06075 mol Concentration of lithium hydroxide = 0.06075 ÷ (25/1000) = **2.43 mol/dm^3** ---------- [1]	[2]

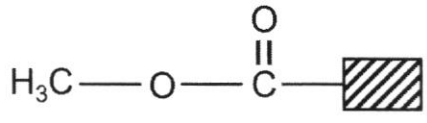
A5(a)	Both melting points and boiling points of elements **increase** [1/2] down Group VII. Down Group VII, the **intermolecular forces of attraction increases** [1/2] as the **molecular size of halogen increases** [1/2]. Hence, a **larger amount of energy** is required to **overcome** these forces of attraction. [1/2] misconception: students relate the increase in mp/bp to within the atom itself, where a larger amount of energy is required to overcome electrostatic forces of attraction between nucleus and valence electron (down the group)	**[2]**
A5(b)	(i) **Fluorine / chlorine** [1], as **they are more reactive than bromine** [1/2], and **can displace bromine from its aqueous solution** [1/2]. (ii) **$F_2(aq) + 2Br^-(aq) \longrightarrow Br_2(aq) + 2F^-(aq)$** OR **$Cl_2(aq) + 2Br^-(aq) \longrightarrow Br_2(aq) + 2Cl^-(aq)$** [1] *not penalised for missing /incorrect state symbols in this exam*	**[3]**
A6(a)	1. transition elements exhibit **variable oxidation states in their compounds / form compounds that have variable oxidation states** [1] 2. transition elements can **form coloured compounds** [1]	**[2]**
A6(b)	(i) **CuO gained electrons and reduced to form Cu_2O** OR **Cu^{2+}** in CuO **gained electrons and reduced to form Cu^+** in Cu_2O. [1] (ii) The **oxidation state of oxygen in CuO increases from -2 in CuO to 0 in O_2**. [1]	**[2]**
A6(c)	**(i) Blue solution turned green / pale green** [1/2] *(not colourless)* **Reddish-brown / pink deposits can be observed**. [1/2] **Iron is more reactive than copper**, [1/2] hence **iron will displace copper from its aqueous solutions**. [1/2] **$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$** [1] (ii) **Electrolysis / using electricity**. [1]	**[4]**

A7(a)	An **electrolytic cell** converts **electrical energy to chemical energy**, [1/2] while a **simple chemical cell** converts **chemical energy to electrical energy**. [1/2] An **electrolytic cell requires batteries / electric cells**, [1/2] while a **simple chemical cell requires a continuous supply of reactants**. [1/2] Reject: simple cell does not require batteries	**[2]**
A7(b)	**(i)** cathode: **$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$** [1] no state symbol minus ½ **(ii)** anode: **$4OH^-(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e^-$** [1]no state symbol minus ½	**[2]**
A7(c)	Accept any two observations below [1/2 mark each]: - **Effervescence** could be observed at the **anode** - **Reddish-brown/pink deposits** could be observed at the **cathode / cathode increases in size** - **Blue electrolyte turns colourless** Accept any two matching explanation [1/2 mark each]: - **hydroxide ions are discharged at the anode to form oxygen gas** - **copper(II) ions are discharged at the cathode to form copper metal** - **concentration of copper(II) ions decreases** **Common error: students did not EXPLAIN the observations as stated in the question**	**[2]**
A7(d)	**Zinc could have reacted with water** in the aqueous copper(II) nitrate to **form hydrogen gas**. This question is poorly attempted. Candidates are not sensitise to the occurrence of side reaction (e.g. between metal and water to produce hydrogen gas as one of the products) Common error: - zinc is above hydrogen and hence hydrogen is preferentially discharged. note that this is not possible when zinc is the ANODE, which will be oxidised. - hydroxide ions are discharged at anode (not possible as anode is ZINC/reactive electrode)	**[1]**

A8(a)	**(i) Marker to note: to mark strictly for the ARROW. Students are advised to use a ruler to draw their lines. Some students did not draw vertical straight line and/or horizontal line that should be parallel to both y-axis and x-axis respectively.**  correct profile of diagram – [1] label reactants and products – [1] label enthalpy change and activation energy correctly – [½ x 2] (ii) The **amount of energy required to break bonds in hydrogen sulfide and oxygen** is **less than** the **amount of energy released to form bonds in water and sulfur dioxide**. correct comparison in terms of amount of energy – [1] correct identification of the bonds to break / bonds to form – [1]	**[5]**

A8(b)	Total energy required for bond breaking = (2 x 2 x 364) + (3 x 498) = **<u>2950 kJ</u>** ---------- [1] Total energy released during bond forming = (2 x 2 x 464) + (2 x 2 x **X**) = **<u>(1856 + 4X) kJ</u>** ---------- [1] Enthalpy change of the reaction = –1034 kJ +2950 – 1856 – 4**X** = –1034 kJ +1094 – 4**X** = -1034 kJ **X** = **<u>532 kJ</u>** ---------- [1] *Also accept X = 532 kJ/mol* *Allow e.c.f. for total energy calculated for bond breaking and bond forming.* *Some candidates find it challenging to count the number of bonds to break/form, and should have made reference to the balanced chemical equation given. Some students mixed up the signs (+/-) required during calculation for enthalpy change for bond breaking (+) and enthalpy change for bond forming (-).*	**[3]**

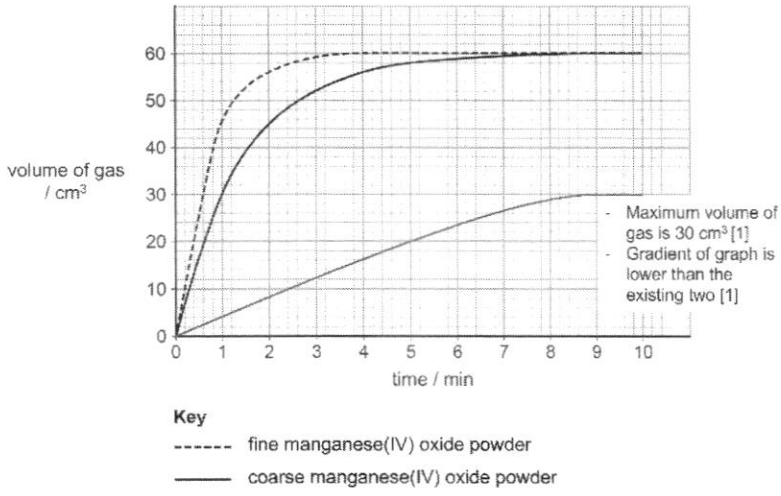
Paper 2 – Section B

No	Suggested Answers	Marks
B9(a)	(i) Biofuel is carbon neutral as there is **no net gain/loss in the amount of carbon** released to the environment [1] Biofuel **contains carbon that comes from biomass of animals/ the uptake of carbon dioxide by plants** [½] during photosynthesis, and **releases carbon in the form of carbon dioxide during the combustion of biofuel**. [½] *Most candidates have no concept of the carbon cycle. A large number relates 'neutral' to 'neither acidic nor alkaline' instead of 'no net gain/loss in carbon'* (ii) Process **1** should include processes to **remove any acid impurities** before transesterification process. [1]	**[3]**
B9(b)	(i) Transesterification is the **reaction between fats/ oils/ esters** (NOT carboxylic acid) **and alcohols** [1/2] **to form esters/ biodiesel and glycerol/alcohol**, [1/2] in the presence of catalyst. *(not insisted)* *reject: when students copy directly from the question info* (ii) Vegetable oils are called tri-esters as there are **three ester linkages** (accept: 3 ester 'functional groups') [1/2] present **per molecule**. [1/2] *Also accept: three fatty acids linked to one glycerol per molecule* *reject: one molecule of vegetable oil can form 3 ester molecules* (iii) Structure of one molecule of biodiesel:  *Also accept if full displayed structural formula is shown* Correctly drawn one ester linkage – [1] All other atoms – [1]	**[4]**
B9(c)	Presence of acid in the waste vegetable oil will **inactivate / make the catalyst ineffective / neutralise / remove KOH**. [1]	**[2]**

	This **slows down / reduces the speed of reaction**. [1] Therefore, longer time is required for its conversion. Also accept: acid reacts with the alcohol (i.e. methanol), hence there is less methanol presence to react with vegetable oils to form biodiesel.	
B9(d)	**Fermentation is a slow process**, [1] requiring specific conditions (i.e. yeast, glucose solution, temperature of 37°C, absence of oxygen)	**[1]**
B9(e)	Yes, biofuel is a better source of fuel than fossil fuel. *(no mark is awarded without justification)* This is because **biofuel is biodegradable** [1/2] when released into the environment (e.g. oil spill) and **produces less air pollutants** [1/2] as it is less likely to be involved in incomplete combustion compared to fossil fuel. *Also accept: renewable compared to fossil fuel [max ½]* However, **biofuel produces less amount of energy per mass of fuel** [1/2] compared to fossil fuel and requires crops to be grown for fuel implying that **more energy is involved in the production process**. [1/2] *To also justify on why biofuel is not a better source of fuel than fossil fuel* *To reject: "more crops to be grown for fuel" as students should unpack the implication.* *To reject: "take a shorter time to form"; time factor does not make a fuel good or bad.*	**[2]**
B10(a)	(i) - **differ from the next member by a $-CH_2$ group** - contain the **same functional group** - show **trend in physical properties** (down the series) (reject: different physical properties) - **similar chemical properties** (within the series) *(accept any two) – [2]* (ii) Test: To a portion of the sample, **add aqueous bromine / bromine water**. [1] (minus ½ if aqueous is not stated) *note: students need to describe the test* *(reject: bromination)* Result: **Reddish-brown** aqueous bromine/ bromine water [1/2] **decolourises/turns colourless** [1/2]	**[4]**
B10(b)	Both methyne and methene contains carbon-carbon triple bond and carbon-carbon double bond respectively. **At least two carbon atoms are required** [1] to form its respective triple/double bond.	**[1]**
B10(c)	**(i) phosphoric(V) acid** [1]	**[3]**

	(ii) **oxidation** is involved. [1] **acidified potassium manganate(VII) / acidified potassium dichromate** [1] (minus ½ if acidified is not stated) *reject: oxygen gas from the atmosphere*	
Either		
B11(a)	Atom economy = (3 x 2) ÷ (28 + 6) x 100% = 17.647 = **17.6 % (3 sig.fig)** ---------- [1] Correct M_r of useful product determined – [1/2] Correct M_r of products determined – [1/2]	**[2]**
B11(b)	Increasing the pressure **will not increase the equilibrium yield of hydrogen** [1/2] but **increase the rate of formation of hydrogen**. [1/2] Only the **number of particles per unit volume will increase**, [1/2] leading to a **higher frequency of collisions and higher frequency of effective collisions**. [1/2] The **total number of particles present in the reaction remains the same**. [1] (Many missed this point)	**[3]**
B11(c)	(i) 63 / 28 = **2.25 times greater** [1] (Many gave an integer value) (ii) A lower temperature implies that the **rate of reaction will be slower**, [1] and a higher pressure is **more costly/ more difficult to maintain** [1].	**[3]**
B11(d)	The demand for ammonia has increased as **more fertilisers are required for agriculture**, [1] and **for various industrial applications like making of plastics, explosives, and synthetic fibres**. [1] *(at least two reasons)* (rej: lab requires aqueous ammonia)	**[2]**

Or		
B11(a)	**2**H_2O_2 (**aq**) $\longrightarrow$ **2**H_2O (*l*) + **1**O_2 (g) *Also accept if coefficient for oxygen gas is left empty*	**[1]**
B11(b)	**Use a fixed mass of catalyst** at each time (e.g. 1 g) – [1] **Place the conical flask in a water bath** to maintain at constant temperature. – [1] *Note that temperature will affect rate of reaction* *Also accept any other reasonable answer*	**[2]**
B11(c)	(i) The **rate of reaction will decrease** [1]. Coarse manganese(V) oxide power has a **smaller surface area** [1] compared to fine manganese(V) oxide power for particles to react with. Hence, particles will have a **lower frequency of collisions** [½], **leading to a lower frequency of effective collisions**. [½] (ii) Expected curve should end after 9 min:	**[7]**



(iii) *Note that moles of hydrogen peroxide will remain constant.*

$$\frac{0.30 \text{ mol}}{1 \text{ dm}^3 + \text{volume of water}} = \frac{0.15 \text{ mol}}{1 \text{ dm}^3}$$ method [1]

Hence, volume of water required = **1.00 dm³** = **1000 cm³** [1]

Max mark [1] if students show understanding that moles of hydrogen peroxide will remain constant.