Candidate Name: _____ Class | Index No.

FUHUA SECONDARY SCHOOL

Secondary Four Express

Preliminary Examination 2025

4E

CHEMISTRY 6092/01

Paper 1 Multiple Choice

03 September 2025
0800 – 0900
1 hour

Additional Material: Optical Mark Recognition (OMR)

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, index number on the OMR and this question booklet.

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 OMR.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on this paper.
A copy of the Periodic Table is printed on page **13**.
The use of an approved scientific calculator is expected, where appropriate.

PARENT'S SIGNATURE	FOR EXAMINER'S USE	
		40

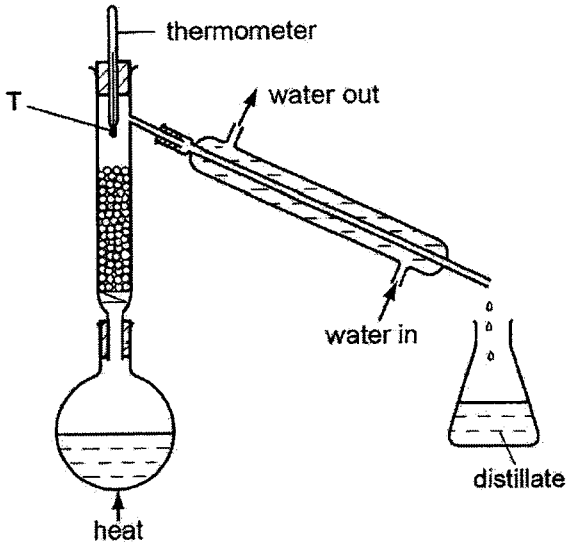
Vetter: Mr Nicholas Liu

This question paper consists of 13 printed pages including this page.

1 The melting points and boiling points of four substances are shown. Which substance exist as a monatomic gas at –200°C?

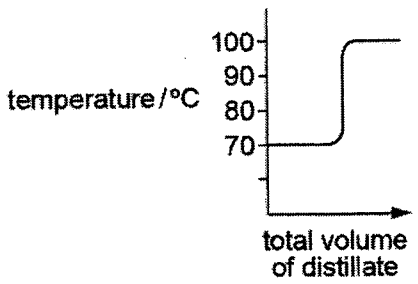
	substance	melting point / °C	boiling point / °C
A	argon	–189	–186
B	hydrogen	–259	–253
C	neon	–249	–246
D	nitrogen	–210	–196

2 The diagram shows a set-up used to separate hexane (boiling point, 70 °C) and heptane (boiling point, 98 °C).

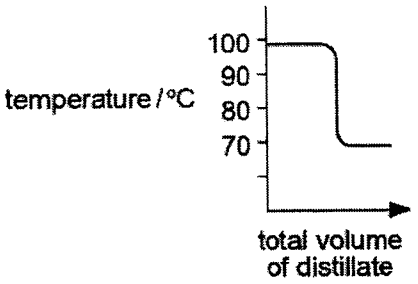


Which graph would be obtained if the temperature at point **T** was plotted against the total volume of distillate collected?

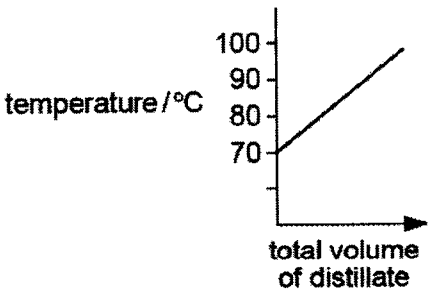
A



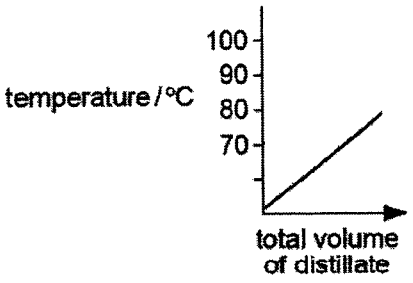
B



C



D



3 A student wants to show that the rate of the reaction between a fixed mass of calcium carbonate and dilute hydrochloric acid doubles for every 10 °C rise in temperature.
The student wants to measure the volume of carbon dioxide released to find the rate of reaction. The student has a measuring cylinder and a gas syringe.
What other essential apparatus are required?

A Bunsen burner, burette, electronic balance, stopwatch
B Bunsen burner, electronic balance, stopwatch, thermometer
C Bunsen burner, pipette, stopwatch, thermometer
D burette, pipette, electronic balance, thermometer

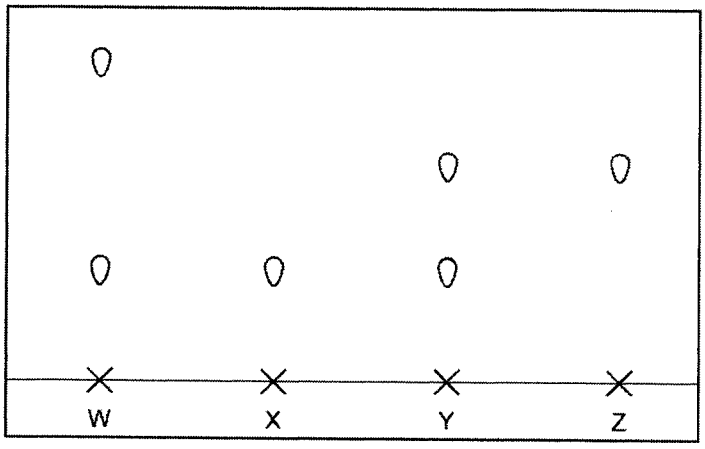
4 Some properties of substances X, Y and Z are given in the table below.

substance	percentage composition by mass	solid conducts electricity	changes on heating
X	constant	yes	solid burns in air to form an oxide
Y	constant	no	solid decomposes
Z	varies	yes	solid melts

Which classification of the substances is correct?

	element	mixture	compound
A	X	Z	Y
B	Y	Z	X
C	Z	Y	X
D	X	Y	Z

5 The diagram below shows the chromatogram of four substances, W, X, Y and Z.



Which statement is correct?

A W contains X and Y.
B X is more soluble than Z.
C Y contains three components.
D Z has a larger R_f value than X.

6 The atomic number of cerium, Ce, is 58. A Ce^{4+} ion has 140 nucleons.
How many neutrons and electrons are there in one Ce^{4+} ion?

	neutrons	electrons
A	82	54
B	82	62
C	140	54
D	140	62

7 Diamond, graphite, iodine and silicon dioxide all contain covalent bonds.
Which statement is correct?

A Diamond has atoms that are arranged in a tetrahedral structure.
B Graphite is used as a lubricant because each layer in its structure is held to the next layer by strong covalent bonds.
C Iodine changes from solid to gas upon gentle warming as its covalent bonds are weak.
D Both graphite and silicon dioxide can conduct electricity due to the presence of mobile electrons.

8 The electronic configurations of three particles, X, Y and Z are shown.

particles	electronic configuration
X	2,1
Y	1
Z	2,8,7

Which statement is true about these three particles?

A X forms covalent bonds with Z.
B X forms ionic bonds with Y.
C Y can only form ionic bonds.
D Y forms ionic bonds with Z.

9 Peeling onions often causes tearing of the eyes due to the release of a sulfide compound.
Peeling them under running water reduces the problem.
Which of the following statements are true about the sulfide compound?

1 It is volatile.
2 It is soluble in water.
3 It is an ionic compound with strong ionic bonds.
4 It is a covalent compound with weak covalent bonds.

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

10 Which molecule has the greatest number of bonded electrons?

A C_2H_4 **B** CO_2 **C** CH_3OH **D** HCO_2H

11 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 $N_2H_4 + 2Ag^+ \rightarrow N_2 + 2AgH_2$
B $N_2H_4 + Ag^+ \rightarrow N_2 + 2H_2 + Ag$
C $N_2H_4 + Ag^+ \rightarrow N_2 + H^+ + Ag$
D $N_2H_4 + 4Ag^+ \rightarrow N_2 + 4H^+ + 4Ag$

12 An element burns in air to form a compound which dissolves in dilute hydrochloric acid and aqueous sodium hydroxide.
What is the element?

A carbon **B** iron **C** aluminium **D** sulfur

13 The results of some experiments with sulfur dioxide are shown.

experiment	description	result
1	mix with dilute hydrochloric acid	does not react
2	mix with concentrated sodium hydroxide	a salt is formed
3	add Universal Indicator	Universal Indicator turns violet
4	add acidified aqueous potassium manganate(VII)	purple solution turns colourless

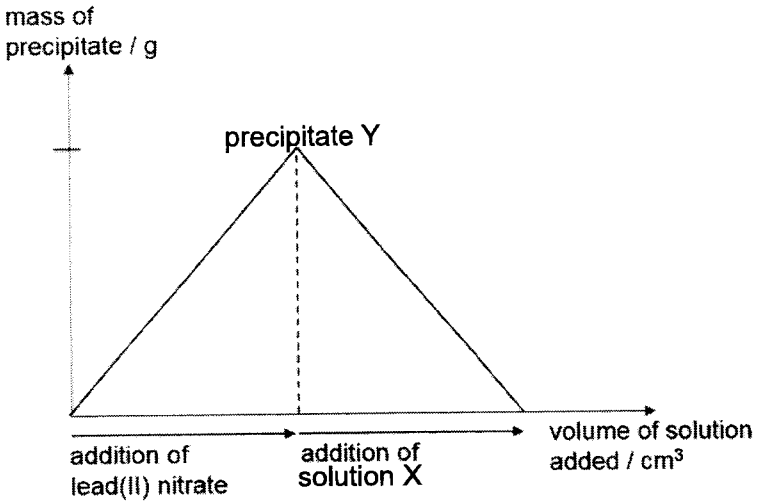
Which experiments show correct results?

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

14 Calcium chloride is made by adding powdered calcium carbonate to dilute hydrochloric acid. Which row identifies the reagent that should be added in excess and the purification method that is used to make a pure and dry sample of calcium chloride?

	excess reagent	purification method
A	calcium carbonate	filtration only
B	calcium carbonate	filtration and crystallisation
C	dilute hydrochloric acid	filtration only
D	dilute hydrochloric acid	filtration and crystallisation

15 The graph below shows the mass of precipitate Y formed when aqueous lead(II) nitrate and solution X are added successively to unknown solution M.



What is the possible identities of precipitate Y and solution X?

	precipitate Y	solution X
A	$PbCl_2$	NaOH
B	$PbCO_3$	HNO_3
C	$Pb(NO_3)_2$	HNO_3
D	$PbSO_4$	NaOH

16 Zinc oxide is produced by heating zinc carbonate.
What is the percentage yield of zinc oxide if 125 g of zinc carbonate produces 75 g of zinc oxide on heating?

A $\frac{75}{81} \times 100$ **B** $\frac{125 \times 81}{75} \times 100$ **C** $\frac{75}{125} \times 100$ **D** $\frac{75}{81 \times 125} \times 100$

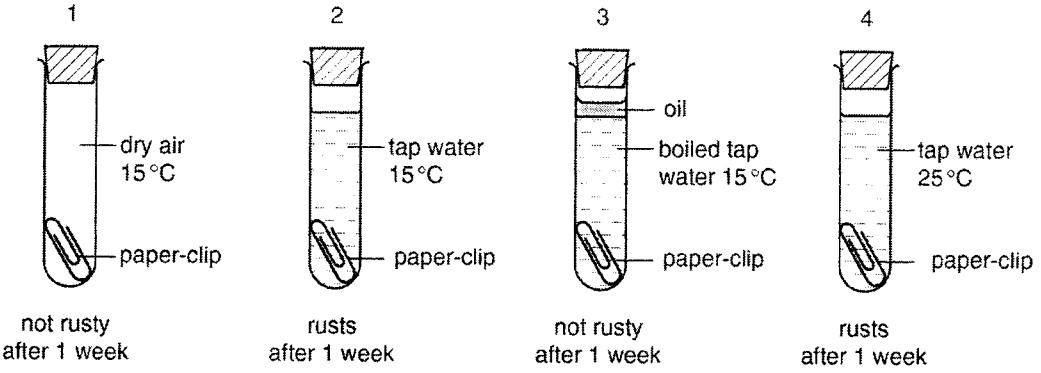
17 A fuel gas cylinder contains 6 g of ethane gas, C_2H_6, under room temperature and pressure.
Which statement is **incorrect**?

A It contains 1.2 mol of hydrogen atoms.
B It contains 0.2 mol of ethane molecules.
C It contains 1.20×10^{23} ethane molecules.
D It occupies a volume of 0.25 dm^3.

18 60 cm^3 of hydrogen are reacted with 30 cm^3 of oxygen to form water vapour.
What are the volumes of the gases remaining, at room temperature and pressure?

	hydrogen / cm^3	oxygen / cm^3	water vapour / cm^3
A	30	0	0
B	30	15	30
C	0	0	60
D	0	0	0

19 Four experiments of rusting are shown.



Which two experiments can be used to show that oxygen is needed for iron to rust?

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

20 A small piece of sodium is added to aqueous iron(II) sulfate. Which of the following is **not** observed during this reaction?

A A grey solid is formed.
B A white precipitate is formed.
C Bubbles of gas are formed.
D The pale green solution turns colourless.

21 Some reactions are stated below.

1 $H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$
2 $H_2SO_4 + Zn \rightarrow ZnSO_4 + H_2$
3 $K_2Cr_2O_7 + 2KOH \rightarrow 2K_2CrO_4 + H_2O$

How many of the reactions are redox reactions?

A 0 **B** 1 **C** 2 **D** 3

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

A argon
B krypton
C helium
D neon

23 Which pair of gases will cause the most damage to limestone buildings?

A carbon monoxide and nitrogen monoxide
B chloroflurocarbons and ozone
C methane and sulfur dioxide
D nitrogen dioxide and sulfur dioxide

24 Which property shows a general decrease when going down any group in the Periodic Table?

A the reactivity of the elements
B the oxidising ability of the elements
C the number of electrons in the valence shell
D the tendency of the elements to form positive ions

25 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

26 Magnesium reacts with acid. Which solution would give the fastest initial rate of reaction?

A 40 g of hydrochloric acid in 500 cm^3 of water
B 20 g of hydrochloric acid in 1000 cm^3 of water
C 40 g of sulfuric acid in 500 cm^3 of water
D 20 g of sulfuric acid in 1000 cm^3 of water

27 In the electrolysis of molten sodium chloride, 46 g of sodium is formed at the cathode. How many moles of chlorine gas are formed at the anode?

A 0.0 mol **B** 0.5 mol **C** 1.0 mol **D** 2.0 mol

28 The effects of a change in conditions on a chemical reaction are listed.

1 The total number of collisions per minute increased.
2 The average energy of the particles increased.
3 The activation energy increased.

Which of the above effects are result of an increase in temperature?

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

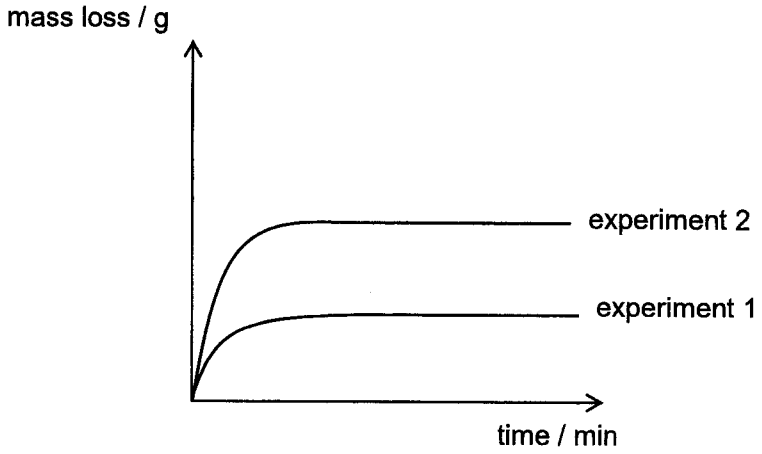
29 The enthalpy change for the reaction shown in this equation is −1560 kJ.

$$2C_2H_6\,(g) + 7O_2\,(g) \rightarrow 4CO_2\,(g) + 6H_2O\,(l)$$

What is the heat change when 1 mole of ethane is burned?

A 780 kJ of heat is absorbed
B 780 kJ of heat is released
C 1560 kJ of heat is absorbed
D 1560 kJ of heat is released

30 Dilute hydrochloric acid was added to some marble chips in a conical flask and the total mass of the flask and its contents is weighed at regular intervals. Both reactants are used up at the end of the reaction. The graph labelled experiment 1 was obtained.



If the experiment is repeated, what changes will be necessary to obtain the graph for experiment 2?

	marble chips	dilute hydrochloric acid
A	grind to powder	no change
B	no change	same volume, higher concentration
C	use more	same volume, same concentration
D	use more	larger volume, same concentration

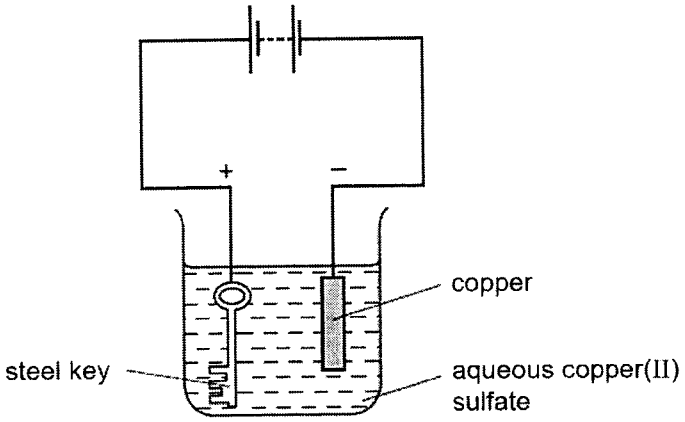
31 In Haber process, nitrogen and hydrogen react as shown.

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

How do the speed and the final yield of the reaction change, if the pressure in the vessel is increased but the temperature is kept constant?

	speed of forward reaction	final yield of reaction
A	increase	no change
B	increase	increase
C	no change	no change
D	no change	increase

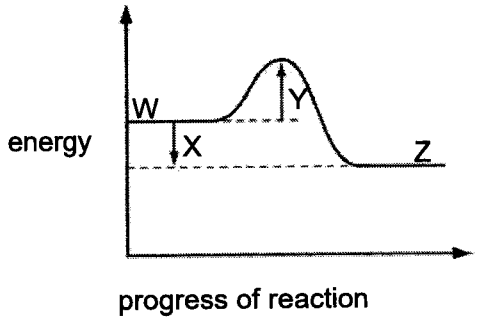
32 The apparatus shown is set up to plate a steel key with copper.



Which of the following explains the observation that will be made on the electrolyte?

A Water is electrolysed leading to volume of water decreasing.
B Concentration of Cu^{2+} decreases leading to the fading of $CuSO_4$ colour.
C Concentration of Cu^{2+} increases leading to the darkening of $CuSO_4$ colour.
D Concentration of Cu^{2+} remains unchanged leading to no change in colour intensity of $CuSO_4$.

33 The energy profile diagram for the Haber process is shown below.



Which statement is correct?

A The reverse reaction is exothermic.
B The enthalpy change of the forward reaction is equal to (W – Z).
C The activation energies of the forward and reverse reactions are equal to Y.
D The activation energy of the reverse reaction is greater than that of the forward reaction.

34 Which of the following is true of a homologous series?

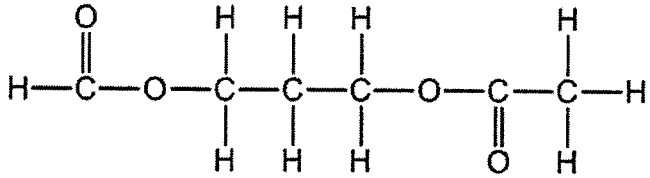
A Each member differs from the previous one by one carbon and four hydrogen atoms.
B The viscosity increases as the carbon chain of the members increases.
C The members have the same empirical formula.
D The members have the same structural formula.

35 Which statement about vegetable oil and the margarine made from it is correct?

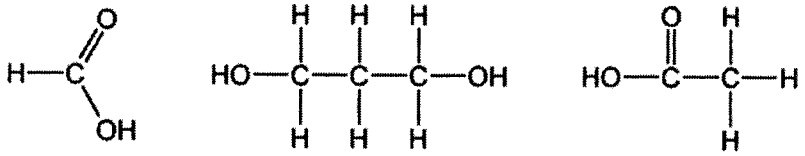
A Both are liquids at room temperature.
B Both occur naturally.
C Margarine has higher melting point than vegetable oil.
D Vegetable oil has fewer carbon-carbon double bonds than margarine.

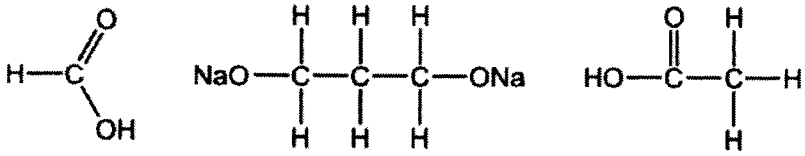
36 Hydrolysis using an alkali will result in the ester linkage being broken and the carboxyl functional group reacting with the base to form a salt.

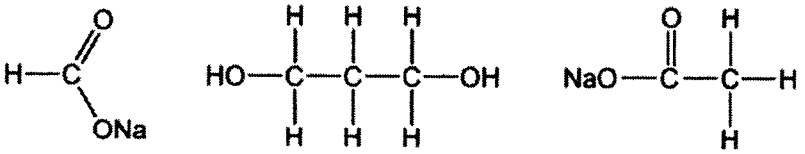
The diester below can be hydrolysed by heating with aqueous sodium hydroxide.

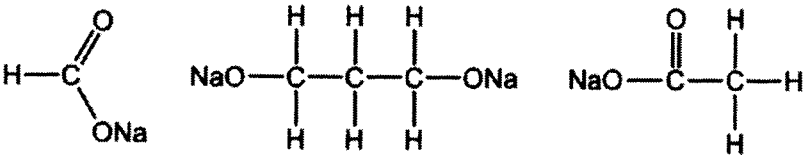


What would be the products of the reaction?

A


B


C


D


37 How many of the following reactions involve the formation of water?

1 ethanol and ethanoic acid
2 glucose and yeast
3 ethene and oxygen
4 ethane and chlorine

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

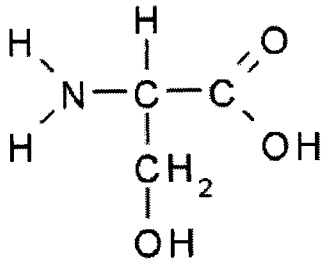
38 You are provided with the following list of chemicals.

1 aqueous bromine
2 aqueous sodium carbonate
3 litmus solution
4 propanol

How many of these chemicals can be used to distinguish between propene and propanoic acid at room temperature?

A 0 **B** 2 **C** 3 **D** 4

39 The structure of serine is shown below.



Which statement about serine is **false**?

A It produces carbon dioxide when reacted with sodium carbonate.
B It burns in air to produce carbon dioxide, water and oxides of nitrogen.
C It can undergo condensation polymerisation with other molecules of serine.
D It causes acidified potassium manganate(VII) to turn from colourless to purple.

40 In the electrolysis of an aqueous solution of vanadium chloride, 76.5 g of vanadium, V (A_r = 51), is deposited at the cathode by 4.5 moles of electrons. What is the charge on the vanadium ion?

A 1+ **B** 2+ **C** 3+ **D** 6+

– End of Paper –

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$.

Candidate Name:	Class:	Index No.:

FUHUA SECONDARY SCHOOL
Secondary Four Express
PRELIMINARY EXAMINATION 2025

4E

CHEMISTRY **6092/2**

Paper 2

DATE **22 August 2025**
TIME **1045 - 1230**
DURATION **1 hour 45 minutes**

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

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

PARENT'S SIGNATURE

FOR EXAMINER'S USE		
Section A	Section B	Total
/70	/10	/80

Section A

Answer **all** questions.

1 Fig. 1.1 shows the electron arrangement of six elements from Period 3 of the Periodic Table. The elements are represented by the letters, **A**, **B**, **C**, **D**, **E** and **F**.

Each diagram shows outer electrons only.

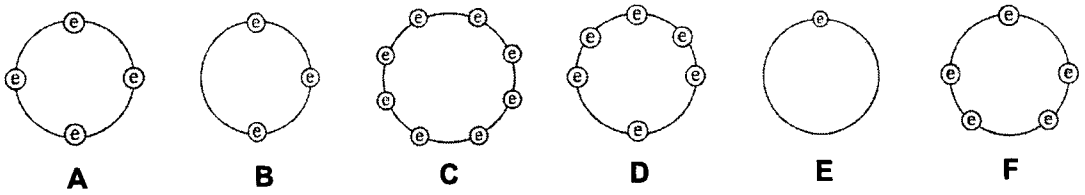


Fig. 1.1

(a) Which elements are reducing agents?

.....

[1]

(b) Which elements form oxides that react with aqueous sodium hydroxide only?

.....

[1]

(c) Which element exists as a giant network of atoms that are covalently bonded?

.....

[1]

(d) Draw a 'dot-and-cross' diagram to show the bonding of the compound formed between element **B** and **D**.

[2]

[Total: 5]

2 Sulfuric acid, widely used in the production of detergents and fertilisers, is manufactured on an industrial scale via the Contact Process. The process involves the following key reactions as shown in Table 2.1.

Table 2.1

stage	reaction	conditions
1	$S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$	ΔH = - 297 kJ/mol
2	$2SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)$	450 °C 1- 2 atm V_2O_5 as catalyst ΔH = - 196 kJ/mol
3	$SO_3\ (g) + H_2SO_4\ (l) \rightarrow H_2S_2O_7\ (l)$	Heat produced varies.
4	$H_2S_2O_7\ (l) + H_2O\ (l) \rightarrow 2H_2SO_4\ (aq)$	Heat produced varies.

(a) A student made the following comment.
'In stage 2, the catalyst reduces the activation energy for the reaction and therefore the enthalpy change of the reaction is lower.'
Do you agree with this statement. Explain why.

[2]

(b) Explain, in terms of oxidation state, which stage(s) involve(s) redox reactions.

[3]

(c) The percentage yield to produce sulfuric acid from sulfur is only 96 – 98%.
Using the information in Table 2.1, explain why.

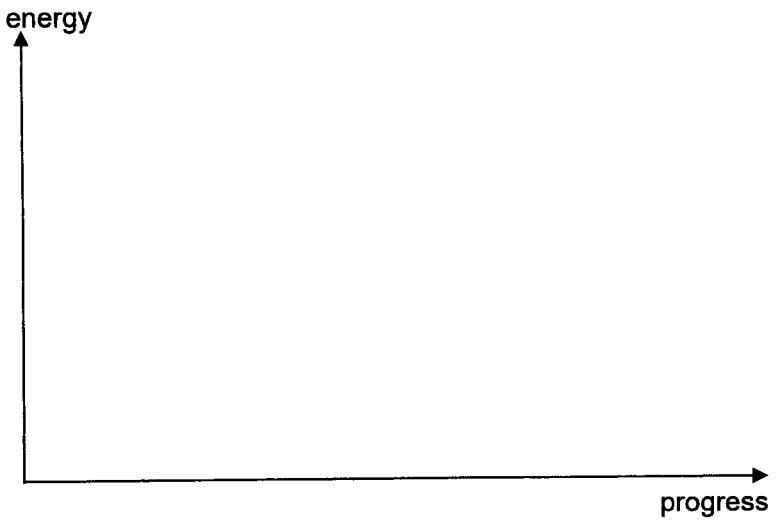
[1]

(d) **(i)** Draw an energy profile diagram for the backward reaction in stage 2 of the contact process.

$$2SO_3\,(g) \rightarrow 2SO_2\,(g) + O_2\,(g)$$

Label clearly the

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



[2]

(ii) Calculate the total amount of heat produced from stage 2 when 50 kg of SO_3 is produced.

[2]

[Total: 10]

3 **(a)** A student investigated the electrolysis of concentrated aqueous potassium chloride using the set-up as shown in Fig. 3.1.

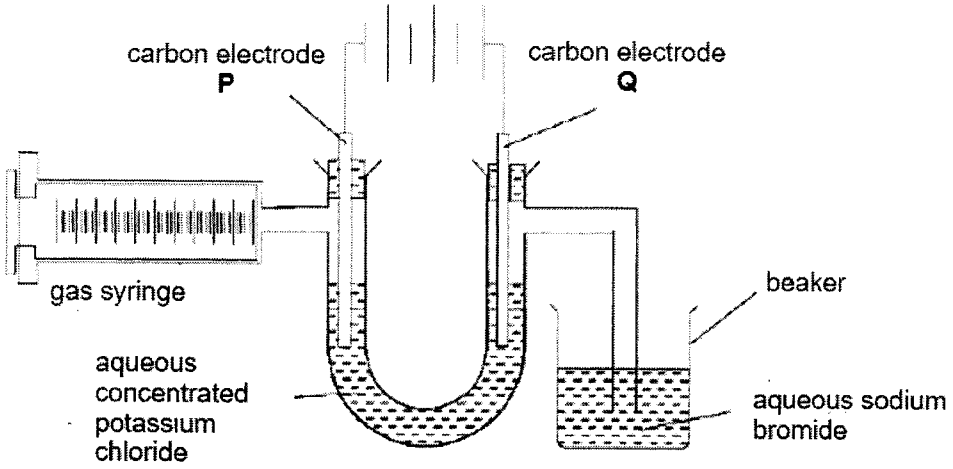


Fig. 3.1

(i) Construct the half-equation, with state symbols, for the reaction at electrode **P**.

[1]

(ii) Describe and explain what you will observe in the beaker containing aqueous sodium bromide as the electrolysis experiment proceeds.

[3]

(iii) The student conducted a second experiment.
Dilute copper (II) chloride was used instead of concentrated potassium chloride.
Predict and explain the expected observations in the gas syringe and beaker containing aqueous sodium bromide.

[3]

(b) Fig. 3.2 shows a set-up to electroplate an object with silver.

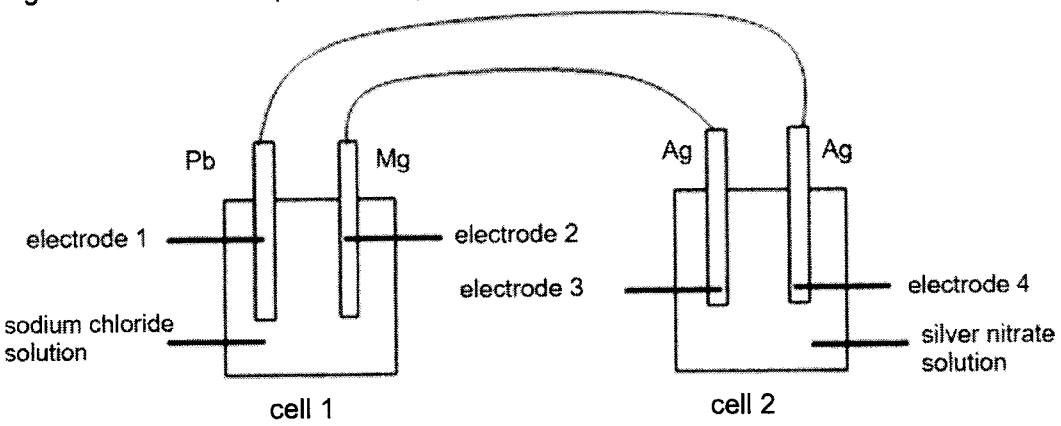


Fig. 3.2

(i) On Fig. 3.2, indicate the direction of electron flow. [1]

(ii) A student would like to coat his metal toy car with silver. In which electrode, 1, 2, 3 or 4, should he place his toy car?
With the help of a half-equation, explain your answer.

[2]

(iii) Describe and explain how the pH of the electrolyte in cell 2 changes during the experiment.

[2]

[Total: 12]

4 Fig. 4.1 shows the setup with two tubes, 1 and 2, to investigate the rate of diffusion of gases. Two pieces of cotton wool soaked in fluorine and chlorine solution were placed in one end of tubes 1 and 2 respectively. The solution on the filter papers of both tubes turned brown.

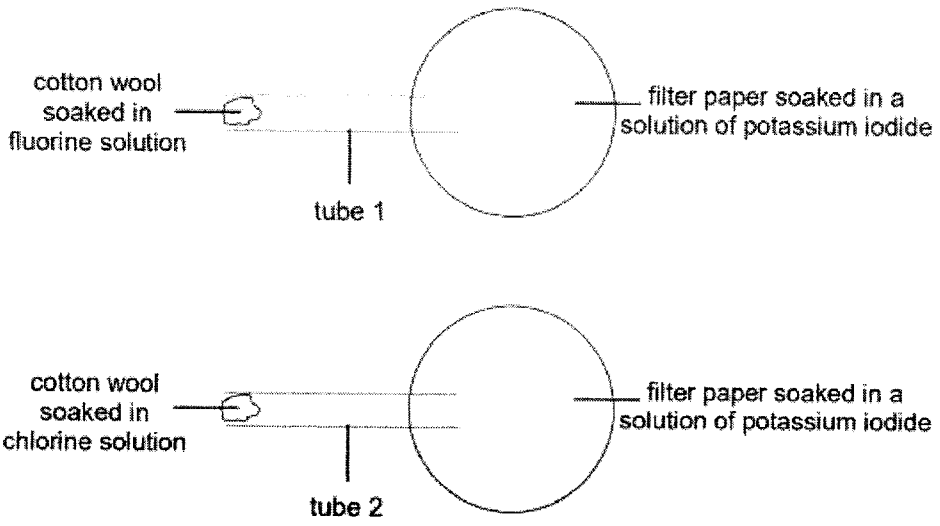


Fig. 4.1

Table 4.1 shows the time taken for the gases to diffuse and for the solution on the filter paper to turn brown.

Table 4.1

gas	M_r	time taken / s
fluorine, F_2		16
chlorine, Cl_2		29

(a) Complete Table 4.1 by filling in the M_r for each gas. [1]

(b) Construct an ionic equation for the reaction in tube 1.

_____ [1]

(c) A student makes this conclusion:
'The rate of diffusion is directly proportional to the relative molecular mass of each gas.'
Do the measurements obtained in the experiment support this conclusion?
Explain your reasoning.

_____

_____

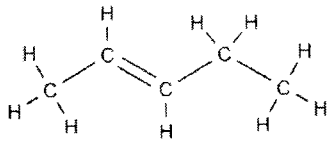
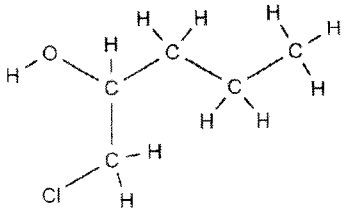
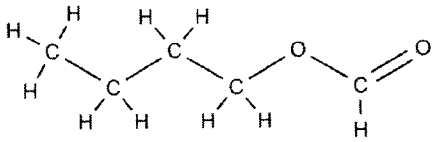
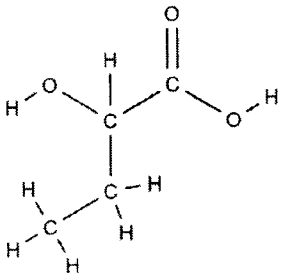
_____

_____ [2]

[Total: 4]

5 (a) Table 5.1 gives the structures of four organic substances, **A**, **B**, **C** and **D**.

Table 5.1

A	**B**
	
C	**D**
	

(i) Substance **B** can be synthesised from substance **A** in two consecutive reaction steps.
Write the chemical equation for each step involved, showing displayed formulae of all organic substances.

step 1:

step 2:

[3]

(ii) State the names of the two organic substances that react to form **C**.

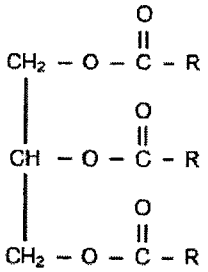
[1]

(iii) The labels of the four solutions, **A**, **B**, **C** and **D** have been misplaced.
A chemist must conduct chemical tests to distinguish and identify each solution.
Describe chemical tests the chemist could conduct to identify each of the four solutions in a sequential manner.

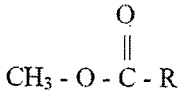
[3]

(b) Used cooking oil being processed to produce biodiesel has gained a significant amount of consideration within the world of fuel production.
During the conversion process, fatty acid triglycerides in vegetable oil react with methanol, in presence of an alkali catalyst, to produce biodiesel. Biodiesels are fatty acid methyl esters (FAME), which has similar properties to petrol diesel. The by-product of this reaction is glycerol, a tri-ol, which is extracted and used for other products including soaps and cosmetics.

The structure of triglycerides and FAME are



fatty acid triglycerides



FAME

where R is a hydrocarbon chain.

(i) One mole of fatty acid triglyceride reacts with 3 moles of methanol to produce FAME and glycerol.

Construct a chemical equation for this reaction. Show the structural formulae of the organic molecules.

[2]

(ii) Suggest why glycerol is known as a tri-ol.

[1]

(iii) Methanol is used due to its accessibility and low cost. However, other alcohols such as ethanol and propanol can also be used in the conversion process.

Draw the structure of FAME if propanol is used in place of methanol.

[1]

[Total: 11]

6 Ethylamine, $CH_3CH_2NH_2$, behaves similarly to ammonia in terms of its chemical properties. The equation below shows what happens when ethylamine is dissolved in water.

$$CH_3CH_2NH_2 + H_2O \rightleftharpoons CH_3CH_2NH_3^+ + OH^-$$

(a) According to the Bronsted-Lowry theory, an acid is defined as a species that can donate protons (H^+), while a base is a species that can accept protons.
Based on the Bronsted-Lowry theory and the given equation, explain why ethylamine acts as a base.

.....

[1]

(b) A pH probe attached to a computer measures pH changes during titration experiments. In experiment 1, 0.25 mol/dm^3 sulfuric acid was added from a burette to 25.0 cm^3 of dilute sodium hydroxide in a conical flask. This is shown in Fig. 6.1.

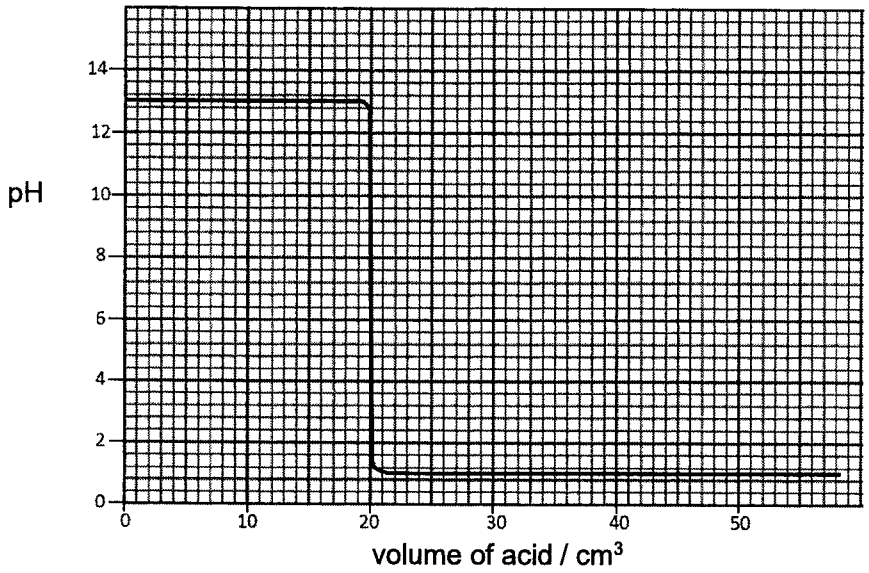


Fig. 6.1

(i) Using the information in Figure 6.1, calculate the concentration of sodium hydroxide used in experiment 1.

[2]

(ii) A second experiment was carried out. This time, 0.25 mol/dm^3 hydrochloric acid was added from the burette to 25.0 cm^3 of ethylamine solution of the same concentration as sodium hydroxide in experiment 1 (calculated in **(b)(i)**) in a conical flask.
On Fig. 6.1, sketch the graph you would expect from this experiment. Label as experiment 2.
Explain your answer.

.....

.....

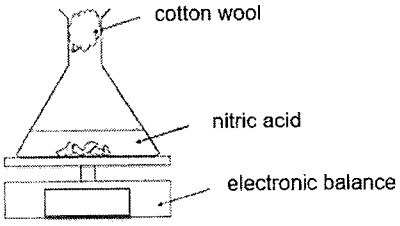
.....

.....

[3]

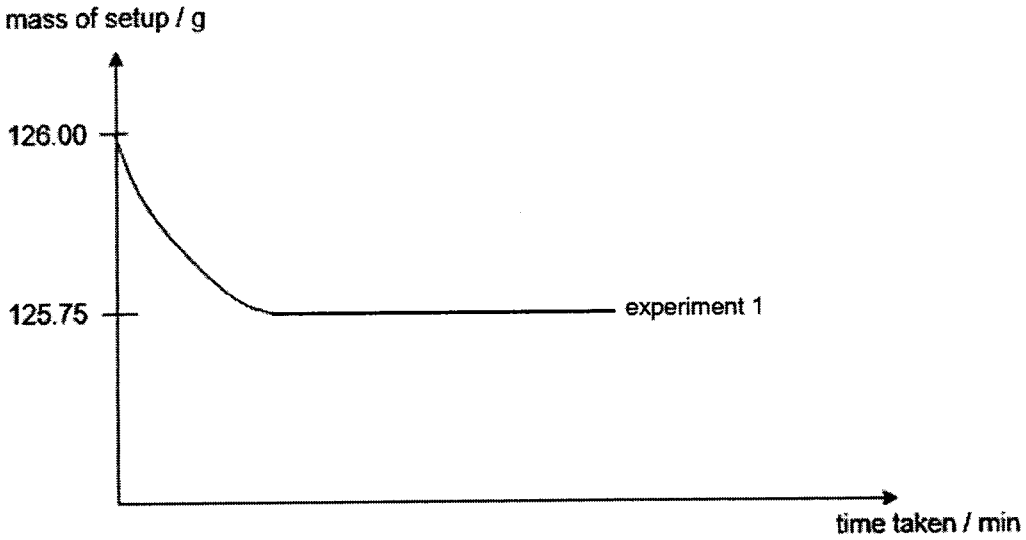
[Total: 6]

7 A student conducted an experiment using 2.00 g of impure lead (II) carbonate and excess nitric acid of concentration 0.150 mol/dm^3 in a conical flask.



She measured the mass of the setup at fixed time intervals and obtained the following graph, experiment 1, as shown in Fig. 7.1.

Fig. 7.1



(a) Calculate the percentage purity of the lead (II) carbonate sample.

[2]

(b) The student conducted a second experiment using sulfuric acid of the same concentration and volume. All other variables are kept constant.

(i) On the same axes in Fig. 7.1, draw the graph that he would obtain for the experiment using sulfuric acid. Label it as experiment 2.

[1]

(ii) Explain the difference between the graphs drawn for experiment 1 and 2.

.....

.....

.....

.....

.....

.....

..... [2]

(c) The student conducted a third experiment using ethanoic acid of the same concentration and volume. All other variables are kept constant. Lead (II) ethanoate is soluble in water.

(i) On the same axes in Fig. 7.1, draw the graph that he would obtain for the experiment using ethanoic acid. Label it as experiment 3.

[1]

(ii) Explain your reasoning for the graph obtained for **(c)(i)**.

.....

.....

.....

.....

..... [2]

(d) Describe how you would prepare a dry sample of lead (II) carbonate in the laboratory.

.....

.....

.....

.....

..... [2]

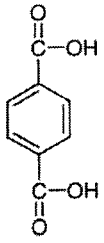
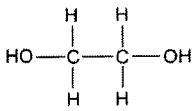
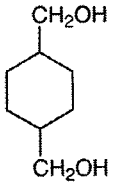
[Total:10]

8 Non-BPA bottles

Due to health concerns, many manufacturers now produce Bisphenol A (BPA) — BPA-free bottles, especially for items used by infants and for food storage. There are three main types of BPA-free bottles: PET (Polyethylene terephthalate), HDPE (High-density polyethylene) and co-polyester.

Table 8.1 gives some information on the three types of bottles.

Table 8.1

	PET	**HDPE**	**co-polyester**
polymer type	condensation	addition	condensation
monomers	terephthalic acid (TPA), $C_8H_6O_4$  and ethylene glycol (EG), $C_2H_6O_2$ 	ethene	terephthalic acid (TPA) and cyclohexanedimethanol (CHDM), $C_8H_{16}O_2$ 

In the context of polymer chemistry and packaging, sustainability refers to how well a material minimises environmental impact over its entire life cycle, from production to disposal.

When evaluating the sustainability of plastic bottles, three key indicators are commonly used, *atom economy*, *carbon footprint* and *recyclability*.

Atom economy is defined as the proportion of reactant atoms that are incorporated into the final product, rather than ending up as waste or by-products.

$$\textbf{atom economy} = \frac{\textbf{mass of desired product}}{\textbf{mass of all reactants}} \times 100\%$$

Carbon Footprint is defined as the total mass of CO_2 emitted during the production of 1 kg of material.

Recyclability is the ease with which a material can be collected, processed, and reused at the end of its life.

Table 8.2 gives more information on each bottle type.

Table 8.2

bottle type	material	average mass per bottle (g)	carbon footprint of material (kg CO_2 / kg)	can be recycled	reuse
disposable water bottle	PET	30	1.9	yes	no
milk or detergent bottle	HDPE	40	1.8	yes	twice
baby bottle	co-polyester	150	4.5	no	50 times

(a) Referring to Table 8.1, draw the structural formula of one repeat unit of PET and HDPE respectively.

PET

HDPE

[2]

(b) Using information from Table 8.2,

(i) calculate the carbon footprint of producing one bottle of each material, PET, HDPE and co-polyester.
Show your working and give your answer to 3 significant figures.

[2]

(ii) A co-polyester bottle is reused 50 times. Calculate the average carbon footprint per use of the co-polyester bottle.

[1]

(c) Using the data provided in Table 8.1 and 8.2, evaluate and compare which bottle material is most sustainable in terms of *atom economy*, *carbon footprint* and *recyclability*.
Support your answer with calculated data and evidence for each factor.

[5]

(d) A baby bottle manufacturer requires the chain length of co-polyester to be controlled so that the polymer molecules have an average relative molecular mass in the range of 42000 to 50400.

What is the range of the average number of repeat units in the polymer molecules? Show your working.

[2]

[Total: 12]

Section B

Answer **one** question from this section.

9 **(a)** In a laboratory experiment, manganese was added to solutions of manganese (II) nitrate, nickel (II) nitrate and copper (II) nitrate respectively. This experiment is an exothermic reaction. The experiment was repeated with two other metals, nickel and copper. The results are shown in Table 9.1 below.

Table 9.1

		metal nitrate		
		manganese (II) nitrate solution	nickel (II) nitrate solution	copper(II) nitrate solution
metal	manganese	no observed change	green solution turned pink and manganese coated with a silver solid	blue solution turned pink and manganese coated with a pink solid
	nickel		no observed change	
	copper	no observed change	no observed change	no observed change

(i) Complete the table to predict what results he should expect when nickel is added to the three salt solutions and explain how you arrived at your answers.

[4]

(ii) Another experiment is carried out as shown in Fig. 9.1.

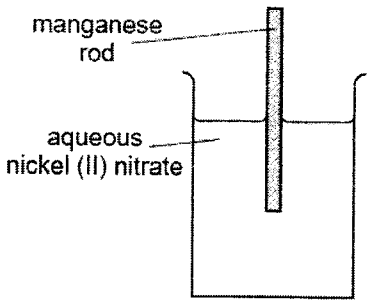


Fig. 9.1

A known mass of aqueous nickel (II) nitrate is first poured into a beaker, before a manganese rod is placed into it.
After the experiment, the manganese rod is removed from the set-up, and the mass of solution is measured after solid deposits are removed by filtration.

Predict how the mass of the solution is expected to change during this experiment.
Explain your answer.

.....

.....

.....

..... [2]

(b) A fixed mass of calcium was allowed to react completely with water. The volume of gas given off was recorded at fixed time intervals during the reaction. The experiment was repeated using strontium but keeping all the conditions the same. The graph obtained from the results is shown in Fig. 9.2 below.

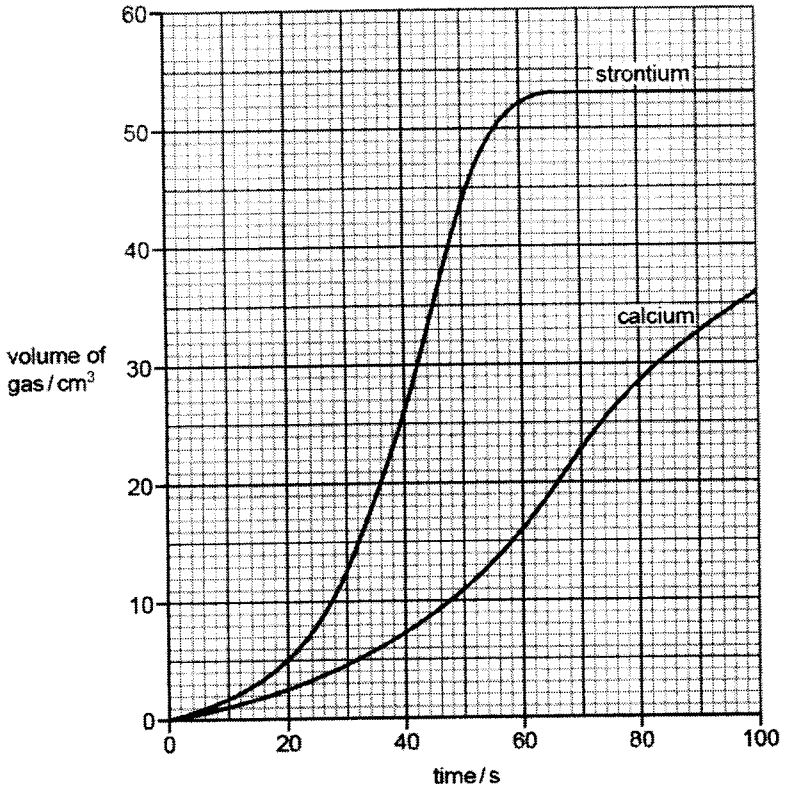


Fig. 9.2

(i) Using the information from Fig. 9.2, compare the reactivity of strontium and calcium.

[2]

(ii) The solution formed at the end of the reaction between strontium and water was tested with Universal Indicator.
With the aid of a chemical equation, predict and explain the expected observation.

[2]

[Total: 10]

10 This information is about the physical properties of the elements in Period 2 of the Periodic Table.

Fig. 10.1 and Table 10.1 gives the trend in melting point and relative electrical conductivity of elements across Period 2 respectively.

Exclude boron from your responses to the following question.

Fig. 10.1

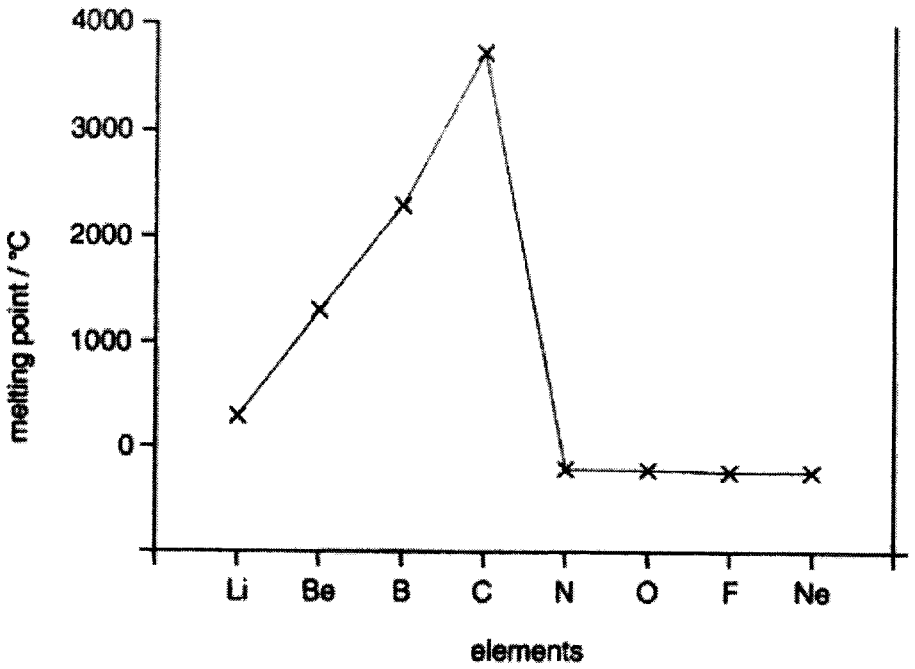


Table 10.1

element	electrical conductivity at room temperature and pressure
Li	good
Be	good
C	good
N	does not conduct
O	does not conduct
F	does not conduct
Ne	does not conduct

(a) In terms of structure and bonding, describe and explain the trend in melting point of the elements across Period 2.

[5]

(b) In terms of structure and bonding, describe and explain the trend in electrical conductivity of the elements across Period 2 as shown in Table 10.1.

[3]

(c) An element in Period 3 has the following properties.

- melting point: 98°C
- conductivity good

Use the information given in this question, suggest which element this data is most likely to refer to.
Explain your answer.

[2]

[Total: 10]

BLANK PAGE

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

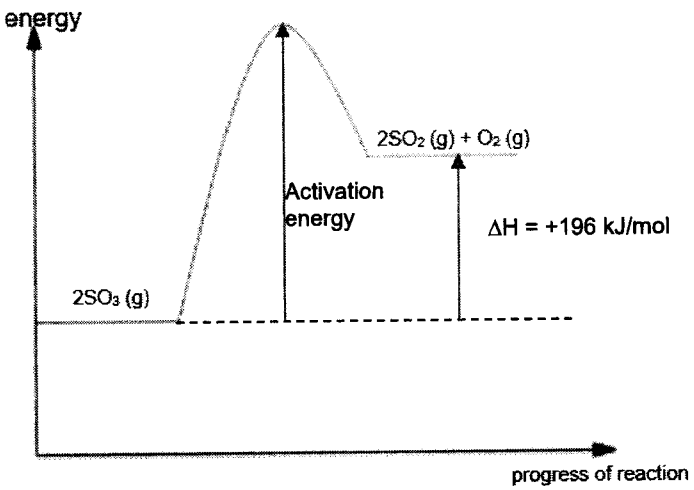
The Avogadro constant, $L = 6.02 \times 10^{23} mol^{-1}$

FUHUA SECONDARY SCHOOL
Sec 4E Chemistry 6092
Preliminary Examinations 2025 – Mark Scheme

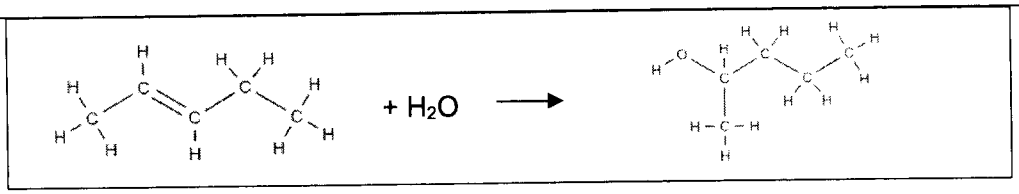
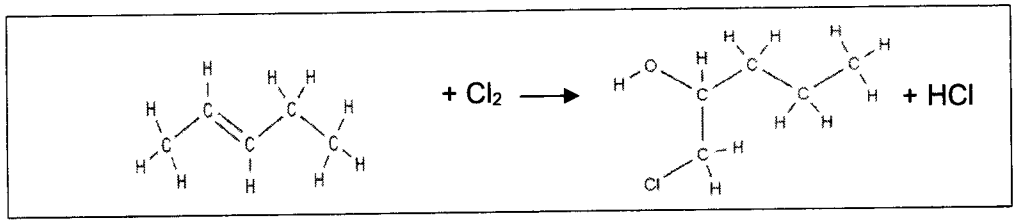
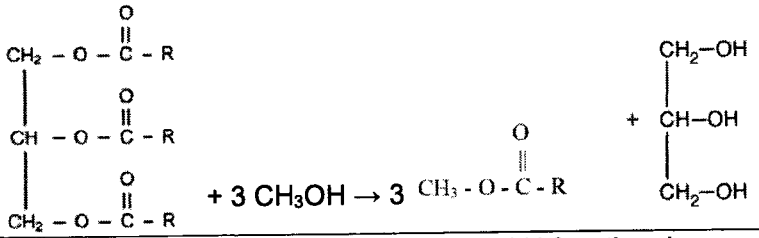
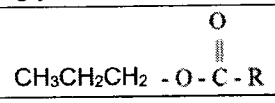
PAPER 1

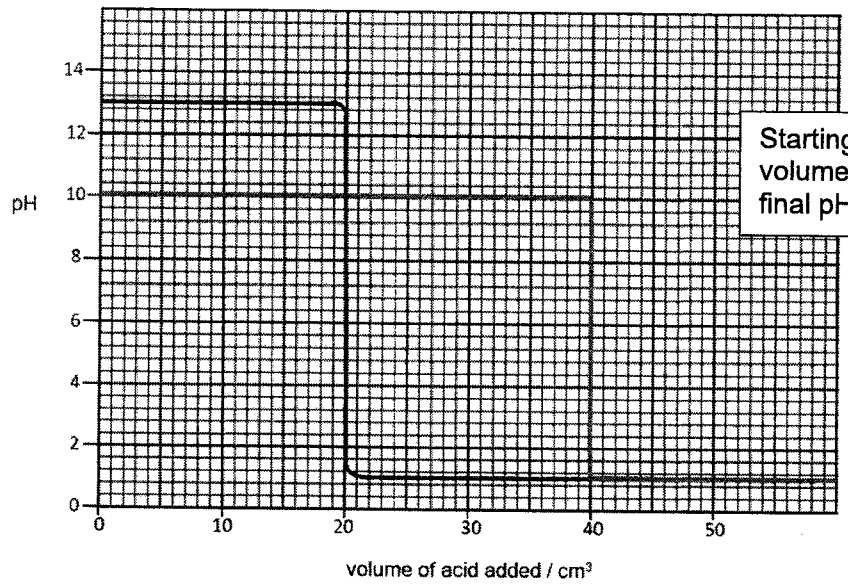
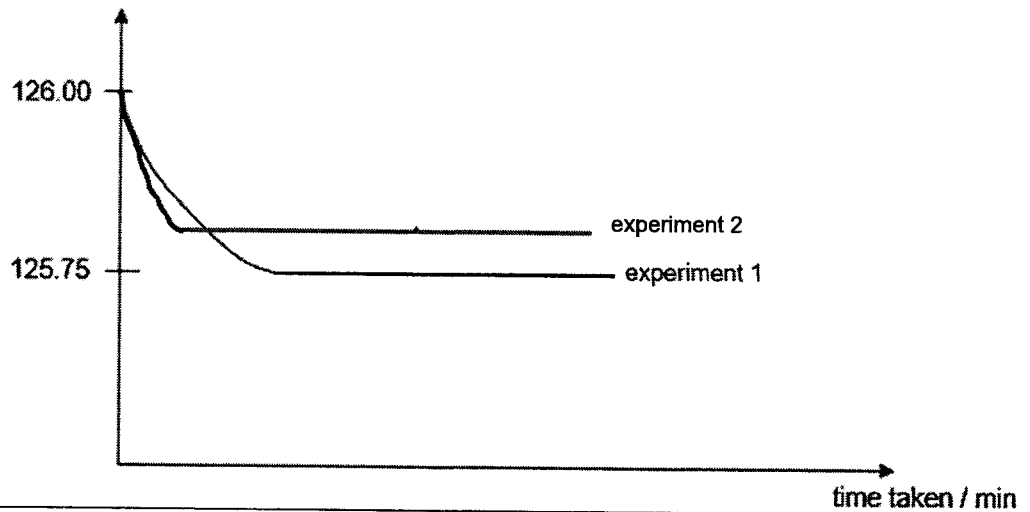
1	2	3	4	5	6	7	8	9	10
C	A	B	A	D	A	A	B	A	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
D	C	C	B	B	A	D	D	C	B
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
B	A	D	B	A	A	C	C	B	D
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
A	B	D	B	C	C	B	C	D	C

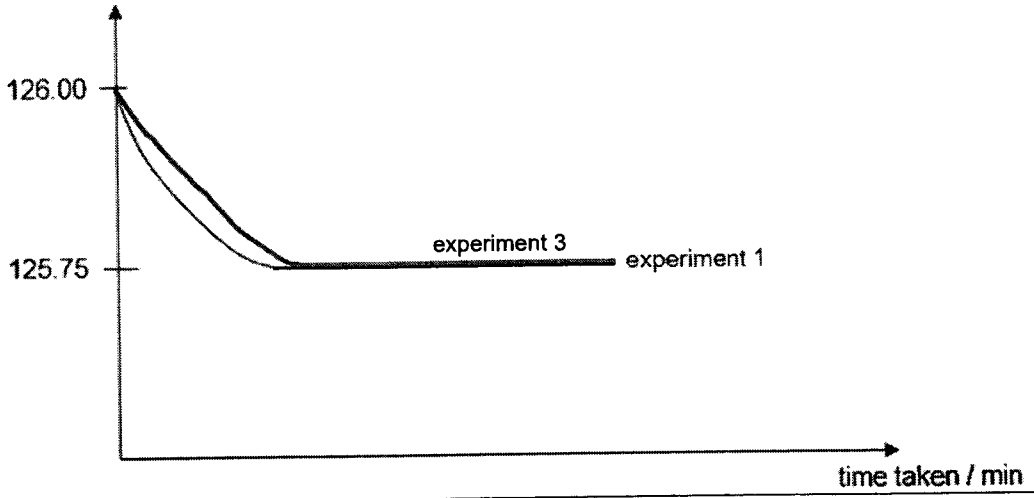
FUHUA SECONDARY SCHOOL
Sec 4E Chemistry 6092
Preliminary Examinations 2025 – Mark Scheme
PAPER 2
Section A [70 marks]

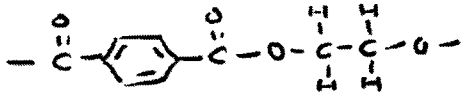
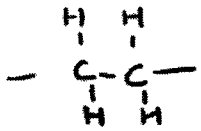
Q	Answer	Ma	Remarks
1a	B and E	1	
b	A, D and F	1	
c	A	1	
d	Two B^{3+} ions Three D^{2-} ions	1 1	
	Total	5 marks	
2a	No. I disagree with the student. A catalyst provides an alternative pathway with lower activation energy for the reaction to proceed but the enthalpy change remains unchanged as the energy levels of reactant and product remain the same. Accept both not accepted be catalyst.	1 1	
b	Stage 1: S is oxidised as the oxidation state of sulfur increases from 0 in S to +4 in SO_2 . O_2 is reduced as the oxidation state of oxygen decreases from 0 in O_2 to -2 in SO_2 . Stage 2: SO_2 is oxidised as the oxidation state of sulfur increases from +4 in SO_2 to +6 in SO_3 and O_2 is reduced as its oxidation state decreases from 0 in O_2 to -2 in SO_3.	; ; ; ;	4; [3]
c	Stage 2 is a reversible reaction AND some of the sulfur trioxide formed decompose to form sulfur dioxide and oxygen.	1	
di	Shape of graph Label axes with units and include correct reactant and product Enthalpy change and activation energy, arrow must be correct  	; ; ;	3; [2]
ii	Moles of $SO_3 = \frac{500000}{(32+3\times16)} = 625$ Moles of SO_2 = SO_3 = 625 Total amount of heat released = 625/2 × 196 = 61 300 kJ	1 1	
	Total	10 marks	

3ai	$2H^+(aq) + 2e \rightarrow H_2(g)$	1	
ii	Solution turned from colourless to reddish-brown. Chlorine is produced at electrode Q as chloride ions are selectively oxidised. Chlorine is more reactive than bromine [;] and displaces bromine from its halide solution.[;] Aqueous bromine formed is reddish-brown.	1 1 1	2; [1]
iii	No gas collected in the gas syringe / reading on syringe is 0 cm^3 [;] as Cu^{2+} ions are selectively reduced at electrode P to form Cu. [;] No visible change / solution remained colourless [;] Oxygen gas, instead of chlorine gas is produced at electrode Q.[;] as OH^- ions are selected oxidised at electrode Q to form oxygen gas. [;]	3	5; [3] 3-4;[2] 1-2; [1]
bi	Electrons flow from Mg to Pb.	1	
ii	Electrode 3 [;] as Ag^+ ions are selectively reduced by gaining electrons at electrode 3 to form Ag deposited on toy car. [;] $Ag^+(aq) + e \rightarrow Ag(s)$ [;]		3 ; [2]
iii	pH decreases to below 7. As Ag^+ ions and OH^- ions are selectively reduced and oxidised at electrode 3 and 4 respectively [;], H^+ and NO_3^- ions are left in the electrolyte / concentration of H^+ ions in electrolyte increases / electrolyte becomes increasingly acidic.[;]	1 1	2; [1]
	Total	12 marks	
4a	38 and 71	1	
b	$F_2(g) + 2I^-(aq) \rightarrow 2F^-(aq) + I_2(aq)$	1	
c	Rate of diffusion of gases is directly proportional to 1/time taken AND for Rate to be directly proportional to 1/t and 1/t has to be directly proportional to M_r of the gas, the product of M_r × time taken must be equal. Data Processing For F_2, $M_r \times t = 38 \times 16 = 608$ s For Cl_2, $Mr \times t = 71 \times 29 = 2059$ s Since the products are different, the measurements do not support the data. OR Rate of diffusion of gases is indirectly proportional to time taken AND for M_r of the gas to be indirectly proportional to time taken, the product of M_r × time taken must be equal.	1 1	
	Total	4 marks	

5ai		1	
		1	
	displayed formula for organic compounds	1	
ii	butanol and methanoic acid	1	
iii	Add aqueous bromine to a sample of each solution. If reddish brown aqueous bromine decolourise rapidly, the solution is A. Add magnesium/sodium carbonate to remaining three solutions, if effervescence is observed, the solution is D. Add acidified potassium manganate (VII) to a sample of remaining two solutions and warm them. If purple potassium manganate (VII) turns colourless, the solution is B. The remaining unidentified solution is C.	; ; ; ;	Sequence to be correct to be awarded full credit. 4; [3]
bi	correct formula for all the structures [1] balanced chemical equation [1] 	2	
ii	A glycerol molecule contains 3 hydroxyl/-OH functional groups.	1	
iii		1	
	Total	11 marks	
6a	Ethylamine acts as a base as it accepts a proton from water.	1	
bi	Moles of sulfuric acid = 20/1000 ×0.25 = 0.005 Moles of sodium hydroxide = 0.01 Concentration of sodium hydroxide = 0.01 / (25/1000) = 0.400 mol/dm^3	1 1	

ii	 ethylamine is a weak base that ionises partially to give a lower concentration of OH^- ions and hence a lower initial pH. Hydrochloric acid is a monobasic acid and hence one acid unit gives half the no. of moles of H^+ ions and hence double the volume of acid required to neutralise the ethylamine.	1 1 1	
		Total	6 marks
7a	Mass of CO_2 given off = 0.25 g Moles of $PbCO_3$ = Moles of CO_2 = 0.25 / 44 = <u>0.0056818</u> Mass of $PbCO_3$= 0.0056818 × (207 + 12 + 3 × 16) = 1.5170 g % purity of $PbCO_3$ sample = 1.517 / 2.00 × 100% = <u>75.9%</u>	1 1	Ignore if no 'g' Ignore if > 3sg but reject if no '%'
bi	steeper gradient but yield lower, final mass above 125.75 	1	
ii	Lead (II) carbonate reacts with sulfuric acid to form <u>insoluble lead(II) sulfate which coats</u> around lead(II) carbonate <u>prevents it from further reaction</u> with acid, giving a low yield of carbon dioxide gas Sulfuric acid is a <u>dibasic acid</u> which will give <u>twice the concentration of H^+ ions</u> leading to a faster rate of reaction.	1 1	

ci	gentler gradient and yield same at 125.75. mass of setup / g  	1	
ii	Ethanoic acid <u>dissociate partially in aqueous solution</u> to produce H^+ ions [;] Ethanoic acid produces a <u>lower initial concentration of H^+ ions</u> [;] in aqueous solution than hydrochloric acid. Hence produces a slower initial rate of reaction. However, <u>same mass/moles of the limiting reactant $PbCO_3$</u> is used and hence gives the same yield of gas.	1 1	2;[1]
d	Add <u>aqueous</u> lead(II) nitrate to a fixed volume of <u>aqueous</u> sodium carbonate till no precipitate is formed. Filter the mixture to remove lead(II) carbonate as residue. AND Wash the residue with distilled water and leave the precipitate to dry.	1 1	
		Total	10 marks

8ai	PET:  HDPE: 	1 1	
bi	PET: 0.03 kg × 1.9 = 57 g CO_2 HDPE: 0.04 kg × 1.8 = 72 g CO_2 Tritan: 0.15 kg × 4.5 = 675 g CO_2	; ; ;	3; [2] 1-2; [1]
ii	copolyester per use = 675 ÷ 50 = 13.5 g CO_2/use	1	

c						
		PET	HDPE	copolyester		
	Factor 1: atom economy	PET = (238-36)/238 × 100% = 84.2%	HDPE = highest (100%), no by-products	copolyester = (310-36)/310 × 100% = 88.4%	1	[1] for calculated data on atom economy [1] for comparison
		HDPE is most sustainable as it has 100% economy, no wastage of raw material and is widely recycled. [1]				
	Factor 2: carbon footprint	PET = 57 g CO_2 per use	HDPE = 36 g CO_2 per use	copolyester = lowest per use, 13.5 g	1	
		Copolyester yields the lowest carbon footprint per use. [1]				
	Factor 3 recyclability	widely recycled	widely recycled	not recycled	1	
d	Mr of repeat unit = $[C_8H_6O_4 - 2OH] + [C_8H_{16}O_2 - 2H] = 132 + 142 = 274$ When M_r = 42 000, number of repeating units = 42 000/274 = 153.28 [;] = 154 **[round up]** When Mr = 50 400, number of repeating units = 50 000/274 = 183.94 = 183 **[round down]** [;] Therefore, the range of the average number of repeating units is between 154 and 183 inclusive.				1 1	
				Total	12 marks	

Section B [10 marks]

Q	Answer	M	Remarks
9ai	manganese (II) nitrate solution: no observed change	1	
	copper(II) nitrate solution: blue solution turned green and nickel coated with a pink solid.	1	
	nickel is **<u>less reactive</u>** than manganese, hence nickel is unable to displace manganese from manganese nitrate solution / no reaction take place between manganese and nickel (II) nitrate solution.	1	
	Nickel is **<u>more reactive</u>** than copper, hence nickel displaces pink copper metal from blue copper(II) nitrate solution, forming a solution of green nickel(II) nitrate solution.	1	
ii	Mass of solution decreases. [no mark] In the displacement reaction, the nickel (II) ions in solution are replaced with manganese (II) ions.	1	
	As the relative atomic mass of manganese (55) is smaller than that of nickel (59), the mass of solution will decrease.	1	
bi	Strontium is more reactive than calcium	1 1	

	As initial gradient of graph steeper for graph for strontium/ a greater volume of gas produced in a fixed time [1]		
ii	$Sr + 2\ H_2O \rightarrow Sr(OH)_2 + H_2$ Solution turns purple/violet/from green to violet AND Sr reacts with water to produce strontium hydroxide which is an alkali / alkaline / base / contains OH^-	1 1	
	Total	10 marks	
10a	The melting point increases for the first four elements from Li to C and decreases sharply for N then remains constant from N to Ne. Li and Be are metals and the melting points increase as the strength of the electrostatic forces of attraction between the increasing charge of cations and increased number of delocalised electrons increases. C has the highest melting point because of its giant molecular structure with strong covalent bonds between the C atoms. N, O, F and Ne have low melting point as they form simple covalent structures with weak intermolecular forces of attraction between the molecules/atoms Largest amount of energy required to break the covalent bonds in C and lowest amount of energy required to overcome weak intermolecular forces of attraction in N, O, F and Ne.	; ; 1 1 1 1	2; [1]
b	Li and Be have giant lattices of cations in a sea of delocalised electrons. The delocalised electrons move freely within the lattice C has giant covalent structure. Each carbon atom uses 3 out 4 valence electrons to form covalent bonds, leaving one unused. These delocalised electrons conduct electricity. N, O, F and Ne are covalent molecules / monoatomic and possess no mobile charged carriers.	1 1 1	
c	The element has good electrical conductivity and hence a metal. Most metals have high melting points except for Group 1 metals. Hence metal is sodium.	; ; ;	3; [2] 1-2;[1]
	Total	10 marks	