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**

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

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.

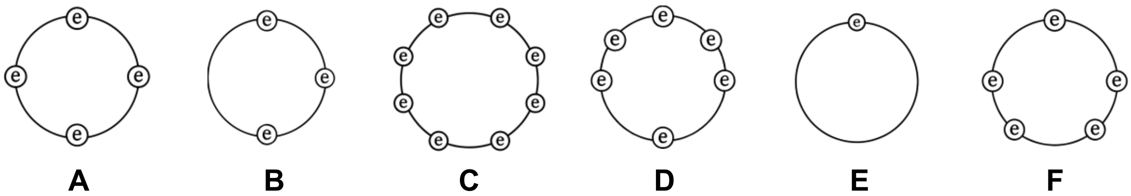

Fig. 1.1

(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.

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.... [2]

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

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.... [3]

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

....

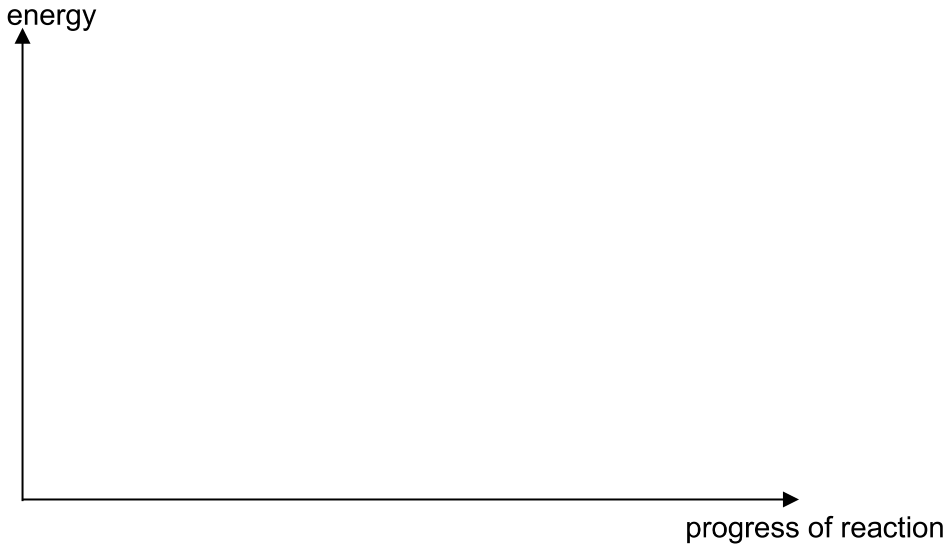
.... [1]

(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.

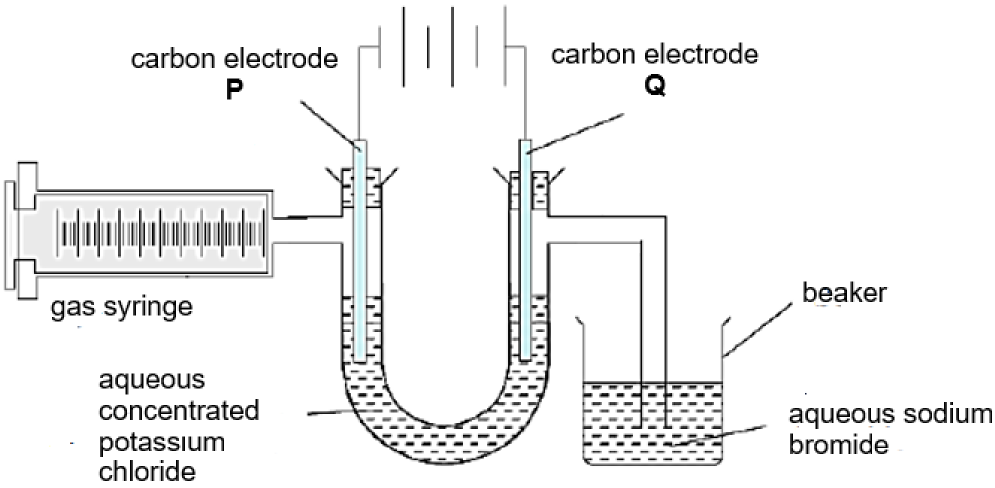


Fig. 3.1

(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.

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.... [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.

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.... [3]

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

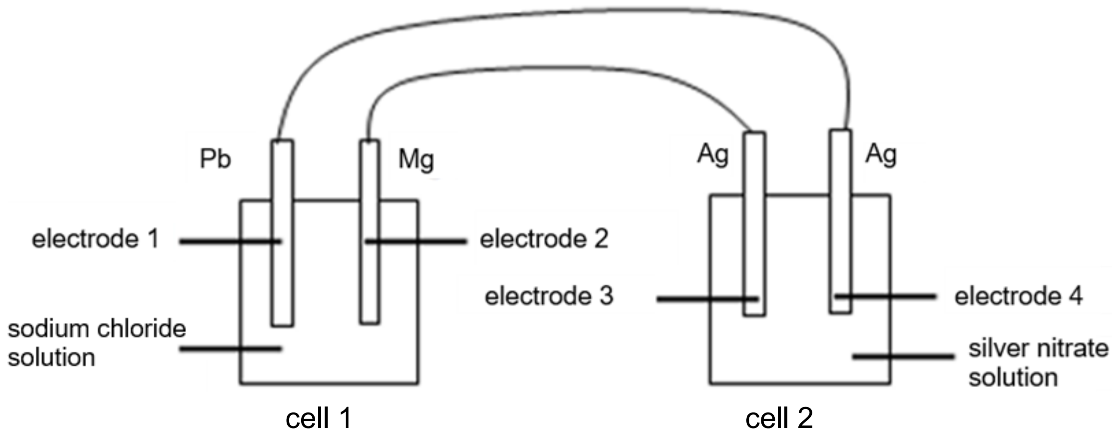

Fig. 3.2

(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.

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.... [2]

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

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.... [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.

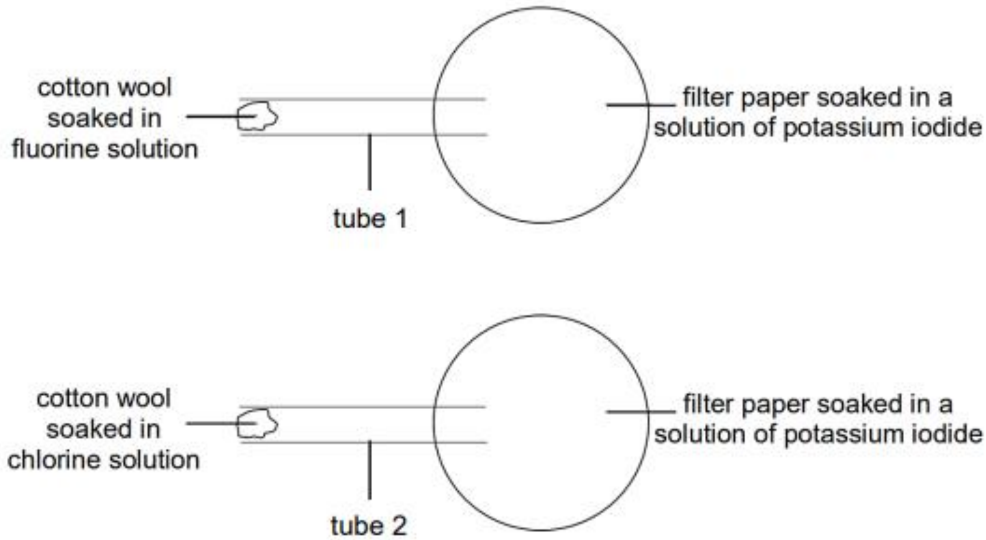

Fig. 4.1

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.

....

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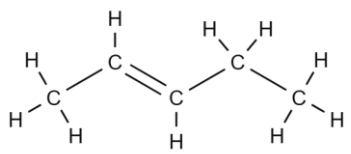
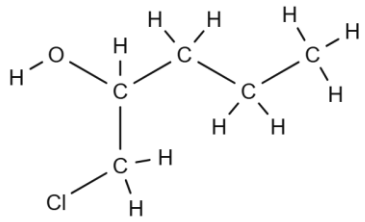
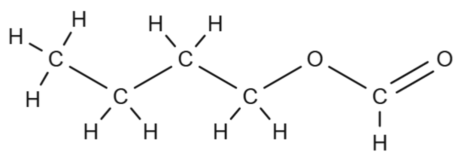
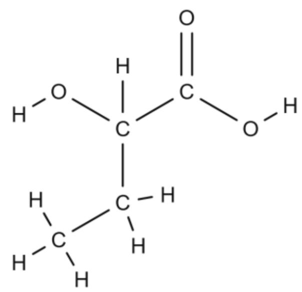
.... [2]

[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**.

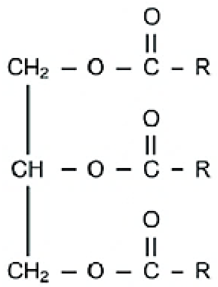
[1]

(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.

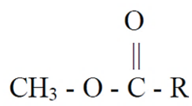
[3]

(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.

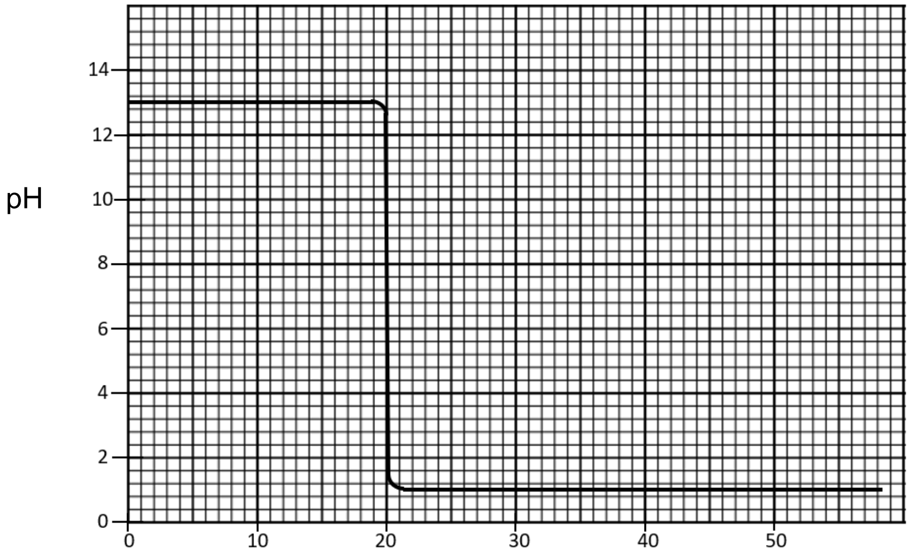


Fig. 6.1

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

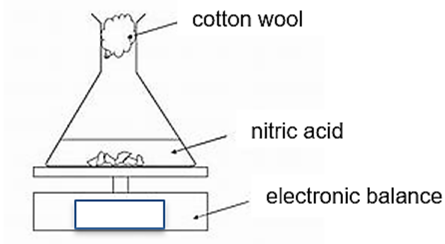
[2]

(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]

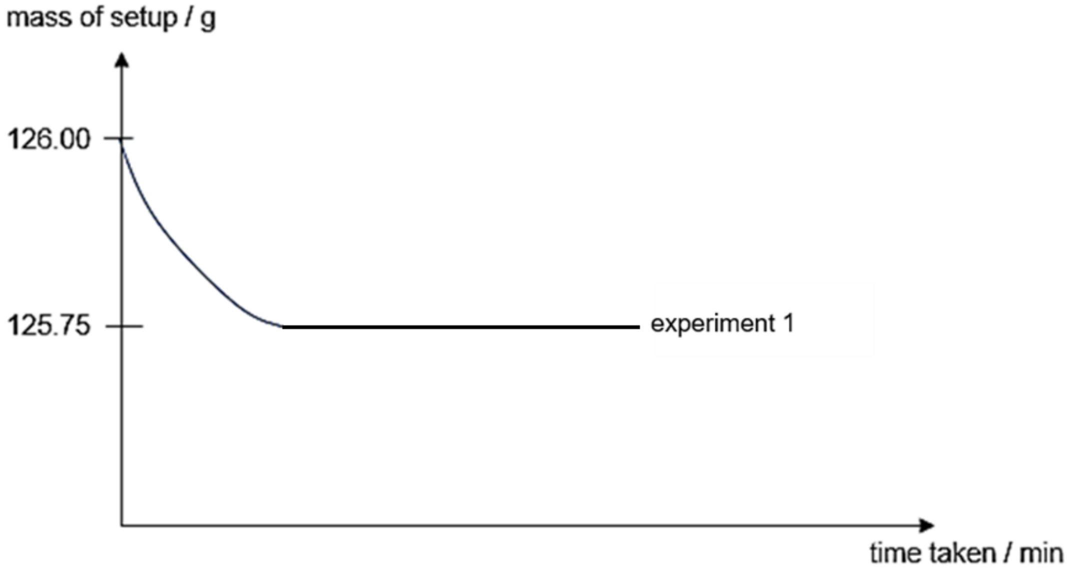
[Total: 6]

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.

....

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.... [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)**.

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.... [2]

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

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....

.... [2]

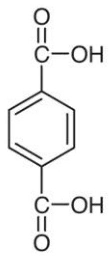
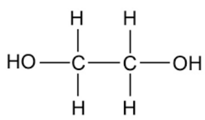
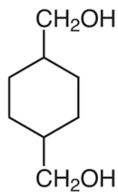
[Total:10]

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.

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

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.

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[4]

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

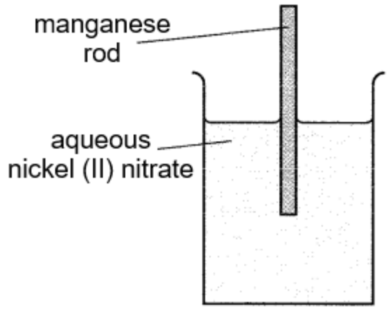

Fig. 9.1

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.

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....

....

.... [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.

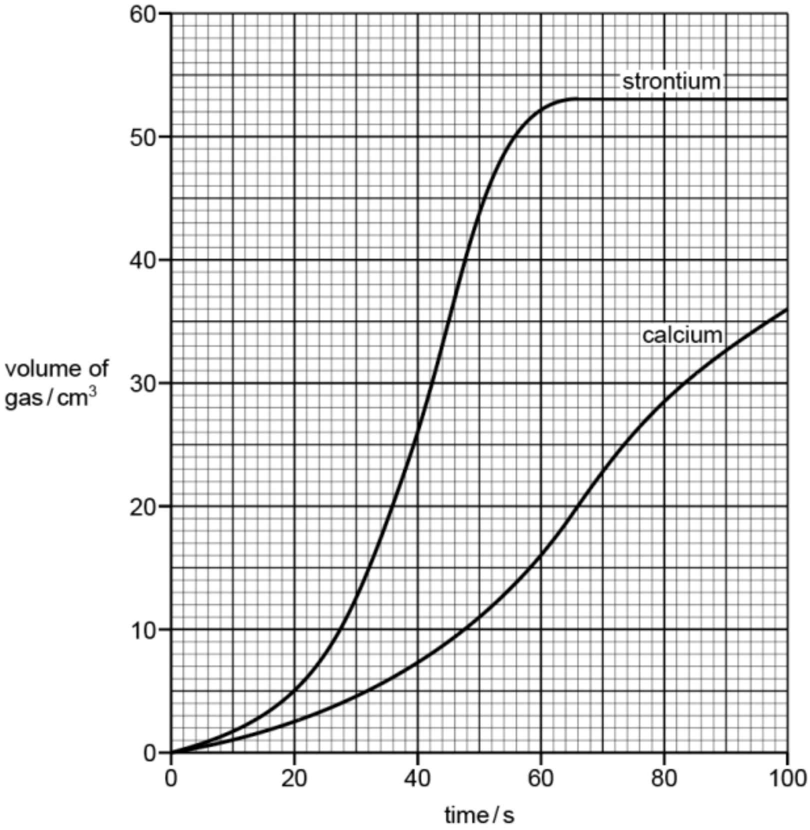

Fig. 9.2

(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

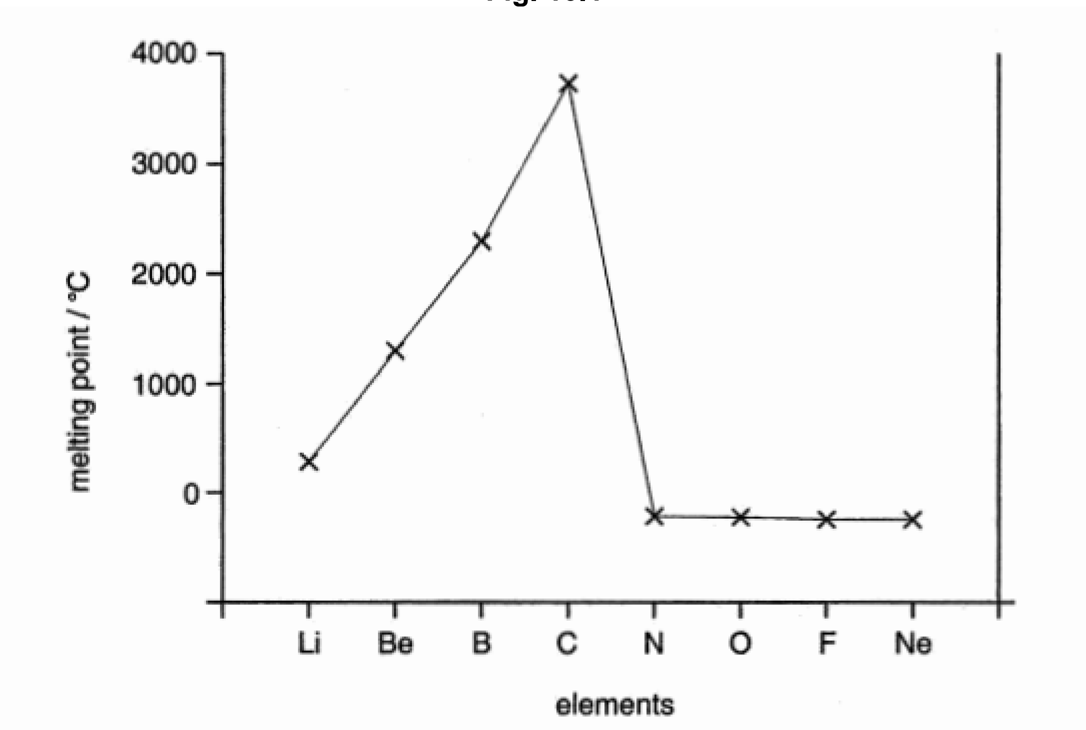

Table 10.1

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]

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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			**Key** proton (atomic) number atomic symbol name relative atomic mass								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 A*l* aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 C*l* 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 T*l* 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 F*l* flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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