[0500/168] 1987

SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY

Higher Grade—PAPER II

Monday, 11th May—1.30 p.m. to 4.00 p.m.

Candidates are reminded that 4 marks are allocated for communication skills, assessed in Part B of this paper.

Working should be shown in all answers involving calculations.

Necessary tables and data will be found in the booklets of Mathematical Tables and Science Data (1982 editions).

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PART A (48 marks)

All questions should be attempted. It should be noted, however, that questions 1 and 10 contain a choice.

It is suggested that about $1\frac{1}{4}$ hours be spent on this part of the paper.

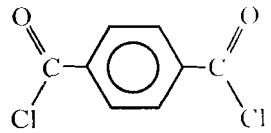
Marks

1. Answer **EITHER** A **OR** B.

A. Polymerisation occurs between the following two compounds:

$H_2NCH_2CH_2NH_2$

A



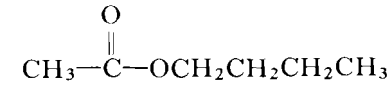
(*a*) To which class of organic compounds does A belong? **1**

(*b*) Which type of polymerisation occurs between these two compounds? **1**

(2)

OR

B.

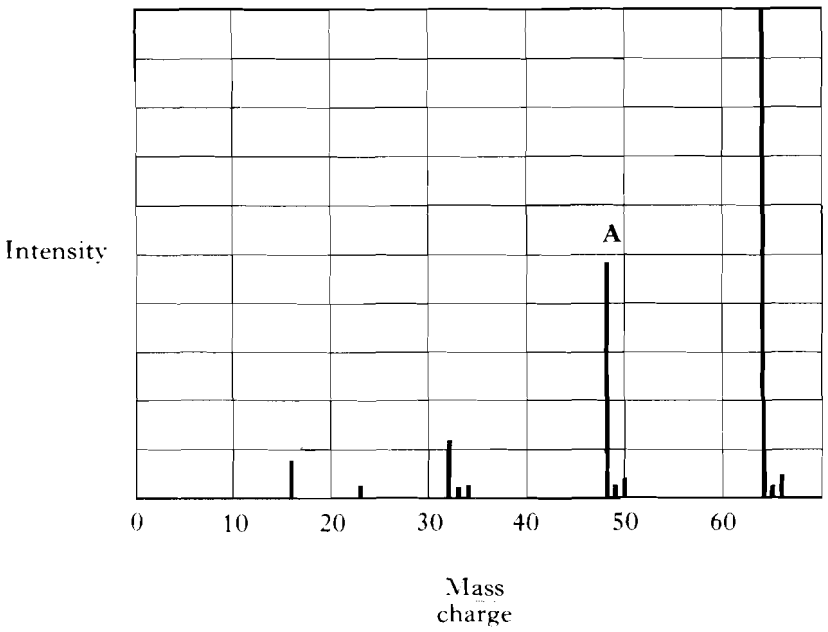


(*a*) To which class of organic compounds does this compound belong? **1**

(*b*) Which type of chemical reaction occurs between this compound and dilute acid? **1**

(2)

2. The mass spectrum of sulphur dioxide, shown below, supports the idea that molecules become fragmented when ionised in a mass spectrometer.



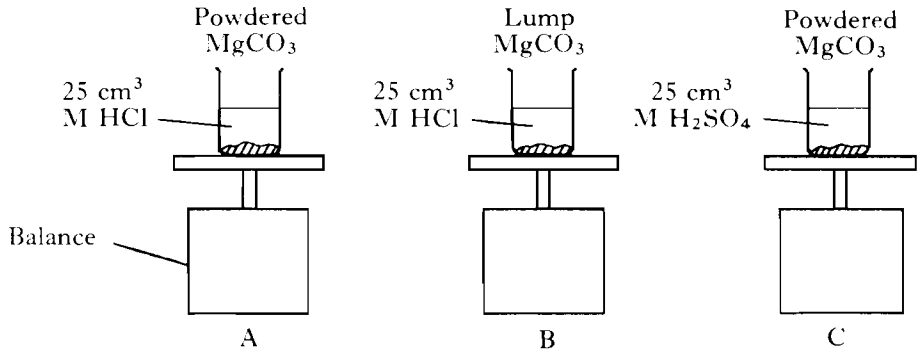
The sample of sulphur dioxide used contained only one isotope of oxygen, ($^{16}_{8}O$).

(*a*) How many isotopes of sulphur did the sample contain? **1**

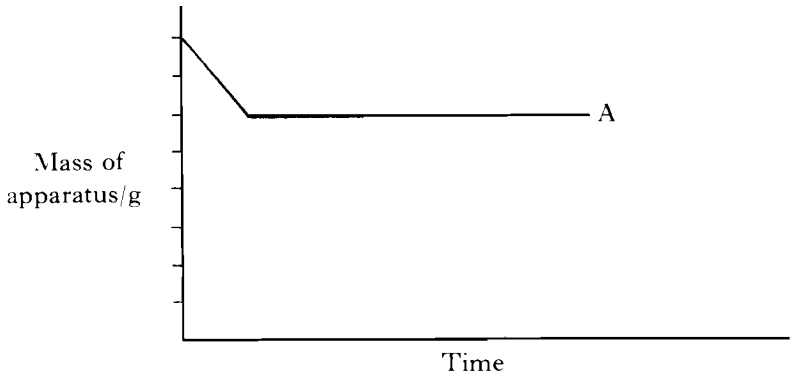
(*b*) Write the formula for the ion responsible for the group of peaks at A. **1**

(2)

3. Several experiments were carried out at room temperature with magnesium carbonate and acids. In each case, the same mass (excess) of the carbonate was present at the start. The rate of mass loss was studied for various conditions as shown below:

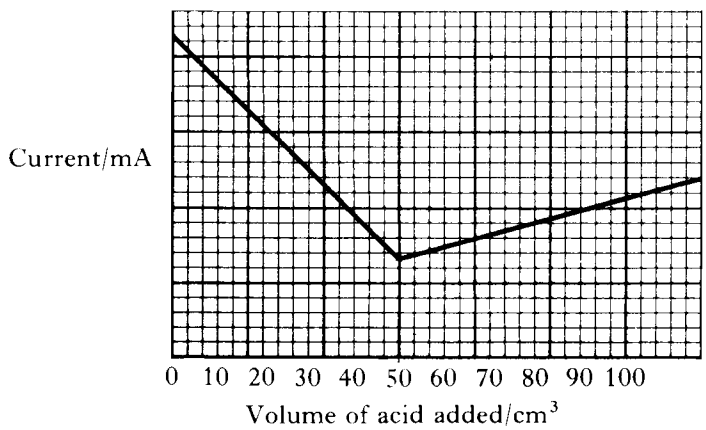


The results for experiment A were plotted on a graph:



Copy the graph showing reaction A on to your answer book (no graph paper required). On the **same** set of axes, draw and **label clearly** the graphs which would be obtained for experiments B and C. **(2)**

4. In a conductivity experiment, the following graph was obtained during the neutralisation of a solution of potassium hydroxide with 0·1 M ethane-1,2-dioic acid, $\begin{matrix}COOH\\|\\COOH\end{matrix}$.

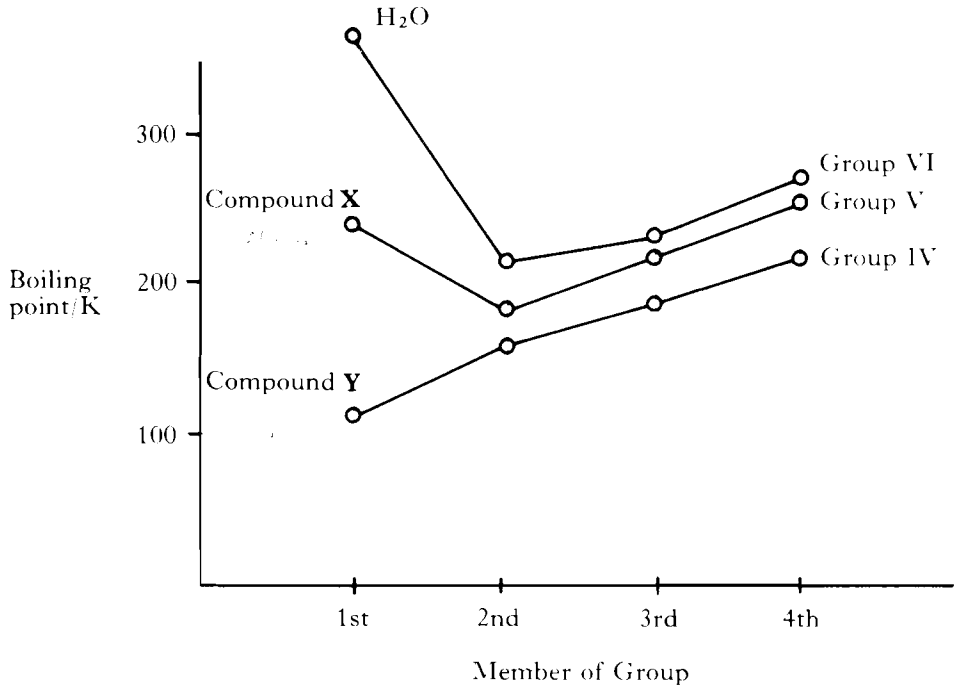


(*a*) How many moles of 0·1 M ethane-1,2-dioic acid were used to neutralise the alkali? **1**

(*b*) What mass of potassium hydroxide was present, originally, in the potassium hydroxide solution? **2**

(3)

5.



The graph shows the boiling points of the hydrides of elements in Groups IV, V and VI of the Periodic Table.

(*a*) Identify compounds **X** and **Y**. **1**

(*b*) Why is there a fairly steady increase in the boiling points of the Group IV hydrides? **1**

(*c*) What causes water and compound **X** to have boiling points considerably higher than expected? **1**

(3)

6. (*a*) Copy and complete the following table:

	Lithium hydride	*Hydrogen bromide*
Type of bonding		
Effect on moist pH paper		

2

(*b*) Write the ion-electron equation for the reaction at the **positive** electrode when each of the following is electrolysed:

(i) molten lithium hydride;

(ii) a molar aqueous solution of hydrogen bromide. **2**

(4)

7. The isotope $^{131}_{53}I$ is radioactive and is manufactured, for medicinal use, by the neutron bombardment of $^{127}_{53}I$.

$$^{127}_{53}I + 4\ ^{1}_{0}n \rightarrow\ ^{131}_{53}I$$

(*a*) Calculate the number of neutrons required to produce 1 mole of radioactive iodine molecules. **2**

(*b*) If, 24 days after manufacture, only 32·75 g of the original mole of radioactive iodine remains, calculate the half-life of the isotope $^{131}_{53}I$. **2**

(4)

8. Hydrogen, for use in the Haber Process, can be produced by the reaction:

pentane + water → carbon monoxide + hydrogen

(*a*) Write a balanced equation for the reaction. **1**

(*b*) The carbon monoxide formed must be removed or it will poison the catalyst used in the Haber Process.
Explain briefly how the catalyst works and what happens when it is "poisoned". **2**

(*c*) Carbon dioxide is much more easily removed from a gaseous mixture than is carbon monoxide. The following reaction is therefore carried out.

carbon monoxide + steam → carbon dioxide + hydrogen (ΔH positive)

(i) Suggest a method by which the carbon dioxide could be removed. **1**

(ii) What other advantage is there in carrying out the conversion of carbon monoxide to carbon dioxide? **1**

(5)

9. The balanced equation for the complete combustion of propene is:

$$2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$$

(*a*) Explain why this equation is unlikely to represent the mechanism of the reaction. **1**

(*b*) If 100 cm^3 propene are burned completely with 900 cm^3 oxygen, what will be the volume and composition of the resulting gas mixture? (All volumes at s.t.p.) **2**

(3)

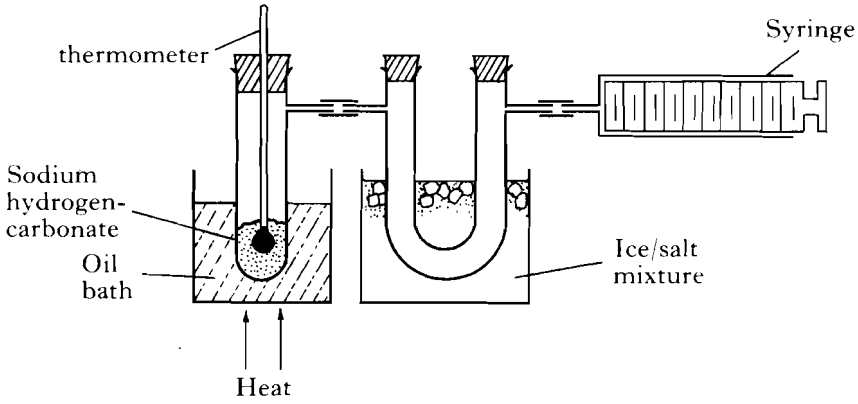
[Turn over

10. ANSWER **EITHER** A **OR** B

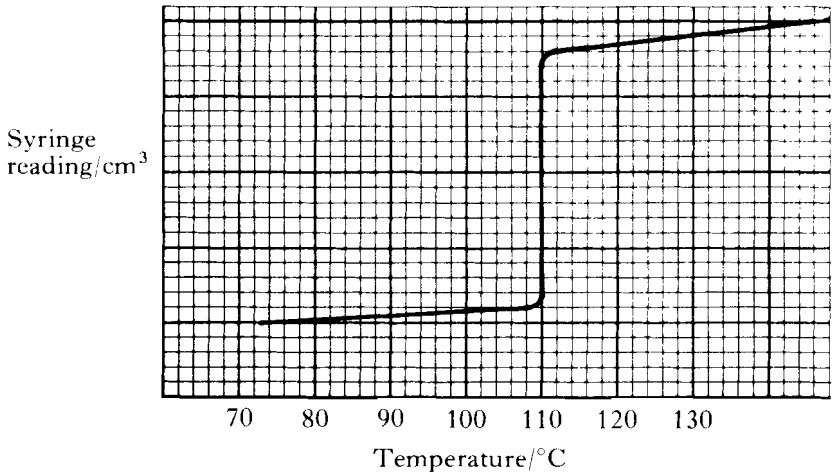
A. (*a*) Sodium hydrogencarbonate decomposes when heated:

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

The decomposition can be carried out in the following apparatus:



When a graph of syringe reading against temperature is plotted, the result is:



(i) At what temperature did the sodium hydrogencarbonate decompose?

(ii) Why was it necessary to use an oil bath instead of a water bath? **2**

(*b*) When sodium carbonate solution is electrolysed, the following reactions take place at the electrodes:

$$2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$$

$$4OH^-(aq) \rightarrow 2H_2O(\ell) + O_2(g) + 4e^-$$

Explain what would happen to the **overall** pH of the solution as the electrolysis progresses. **2**

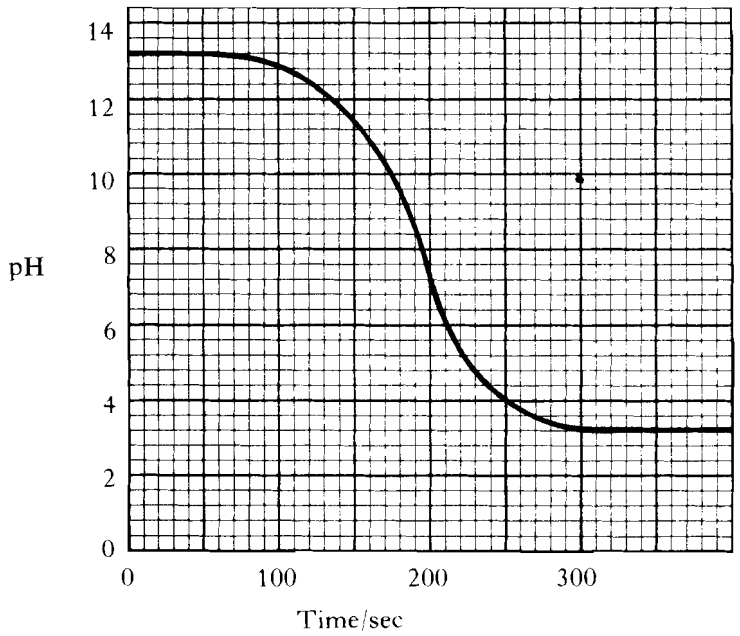
(4)

OR

B. 1-Chloropropane is hydrolysed by water to propan-1-ol. The rate of reaction can be followed by adding a known amount of sodium hydroxide solution and following the pH of the mixture as the reaction progresses. The following steps are involved:

$$CH_3CH_2CH_2Cl \rightarrow CH_3CH_2CH_2^+ + Cl^- \quad \text{(slow)}$$
$$CH_3CH_2CH_2^+ + H_2O \rightarrow CH_3CH_2CH_2OH + H^+ \quad \text{(fast)}$$
$$CH_3CH_2CH_2^+ + OH^- \rightarrow CH_3CH_2CH_2OH \quad \text{(fast)}$$
$$H^+ + OH^- \rightarrow H_2O \quad \text{(fast)}$$

A graph drawn from the results is shown below:



(*a*) Which is the rate-determining step of the reaction? **1**

(*b*) How long did it take to neutralise all the sodium hydroxide? **1**

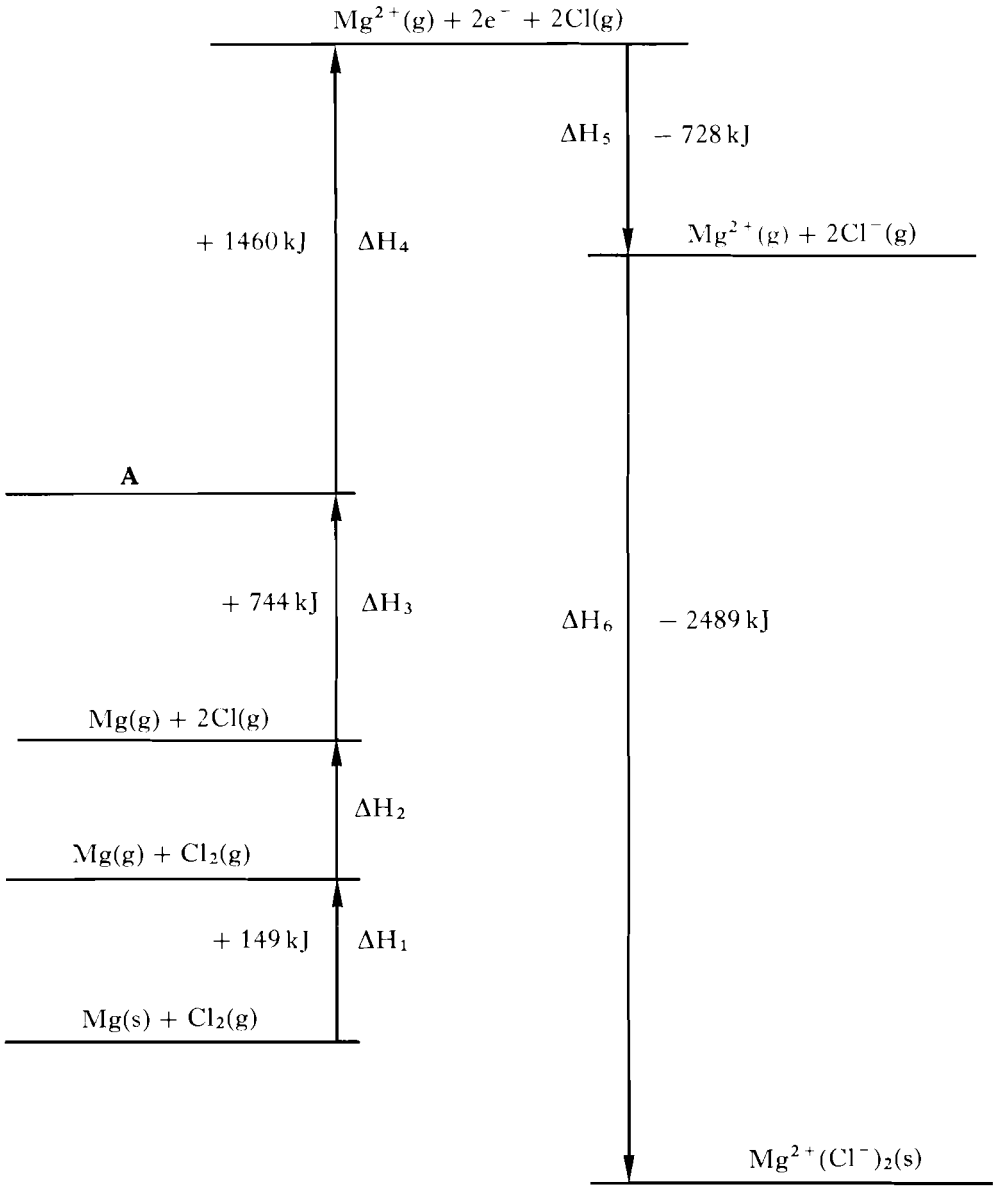
(*c*) A similar reaction occurs with 1-bromopropane. Describe how you could compare the rates of hydrolysis of 1-chloropropane and of 1-bromopropane, using a few drops of pH indicator to follow the reaction in each case. **2**

(4)

[Turn over

Marks

11. Consider the following enthalpy diagram, which is **not** drawn to scale.



ΔH_1 = Enthalpy of sublimation
ΔH_2 = Mean bond enthalpy
ΔH_6 = Lattice enthalpy

(*a*) What should be written at **A**? **1**

(*b*) What name is given to the enthalpy change ΔH_5? **1**

(*c*) The enthalpy of formation (ΔH_f) of magnesium chloride is represented by the equation:

$$Mg(s) + Cl_2(g) \rightarrow Mg^{2+}(Cl^-)_2(s) \ .$$

(i) Write an equation to show the relationship between ΔH_f and the enthalpy changes ΔH_1 to ΔH_6.

(ii) Use the Data booklet to find the value of ΔH_2.

(iii) Calculate the value of ΔH_f. **3**

(5)

12. 3-Methylbut-1-ene reacts with concentrated sulphuric acid as shown and the product obtained is hydrolysed by water to produce alkanol A.

$$CH_3CH(CH_3)CHCH_2 + H_2SO_4 \rightarrow CH_3CH(CH_3)CH(OSO_3H)CH_3$$

$$\downarrow H_2O$$

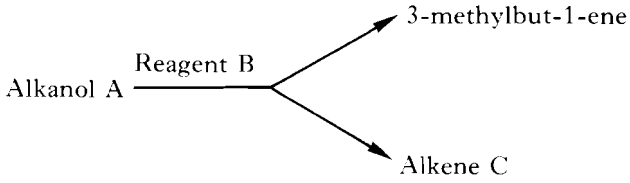
$$CH_3CH(CH_3)CH(OH)CH_3$$

Alkanol A

(*a*) Which type of chemical reaction occurs between the 3-methylbut-1-ene and the concentrated sulphuric acid? **1**

(*b*) Which class of organic compound is formed on mild oxidation of alkanol A? **1**

(*c*) Alkanol A reacts further with reagent B to produce 2 isomeric alkenes.



(i) Name reagent B.

(ii) Draw the full structural formula for alkene C. **2**

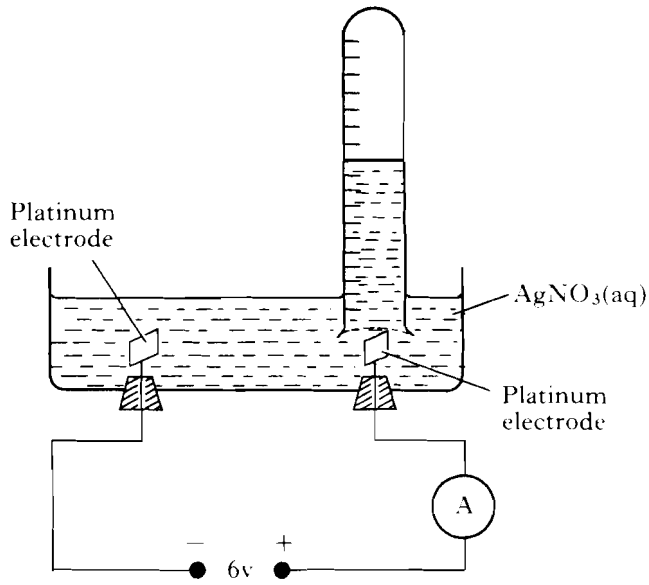
(*d*) Name the compound formed when 3-methylbut-1-ene reacts with chlorine. **1**

(5)

[Turn over

Marks

13.



In the above experiment, a constant current of 0·5 A was passed for a time of 32 minutes 10 seconds.

(*a*) (i) Write the ion-electron equation for the reaction occurring at the negative electrode.

(ii) Calculate the number of moles of silver deposited. **3**

(*b*) The reaction occurring at the positive electrode is:

$$2H_2O(\ell) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$$

Calculate (i) the number of moles of oxygen liberated;

(ii) the volume of oxygen collected (at s.t.p.). **3**

(6)

PART B (48 marks)

All four questions should be attempted. It should be noted however that question 16 contains a choice.

Candidates are advised to spend about 1¼ hours on this part.

Marks

14. The structure and reactions of carbon and its compounds are often quite different from those of adjacent elements in the Periodic Table.

	C	N
Al	Si	

(*a*) Carbon and aluminium

Both carbon (graphite) and aluminium conduct electricity, but have different types of bonding.

Explain, in terms of bonding, how each is able to conduct. **2**

(*b*) Carbon dioxide and silicon dioxide

Explain why the melting point of silicon dioxide (1880K) is much higher than that of carbon dioxide (216K). **2**

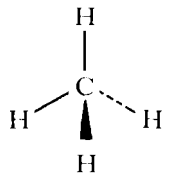
(*c*) Carbon dioxide and aluminium oxide

Carbon dioxide dissolves in water to form an acidic solution. Aluminium oxide is insoluble and can be described as "amphoteric".

Write two equations, involving aluminium oxide, to illustrate what is meant by the term "amphoteric". (Equations need not be balanced.) **2**

(*d*) Methane and ammonia

(i) A methane molecule has the shape shown by its perspective formula:



Draw a similar formula to show the shape of an ammonia molecule. **1**

(ii) Ammonia reacts with hydrogen ions to form the ammonium ion:

$$NH_3 + H^+ \rightarrow NH_4^+$$

Methane does not react with hydrogen ions.

Explain how ammonia can react with the hydrogen ion, even though the nitrogen atom in the ammonia molecule has a completely filled outer energy level. **1**

(*e*) Ethane (C_2H_6) and hydrazine (N_2H_4)

(i) Draw the full structural formula for hydrazine. **1**

(ii) The enthalpy of formation of ethane is $-84{\cdot}5\ kJ\ mol^{-1}$.

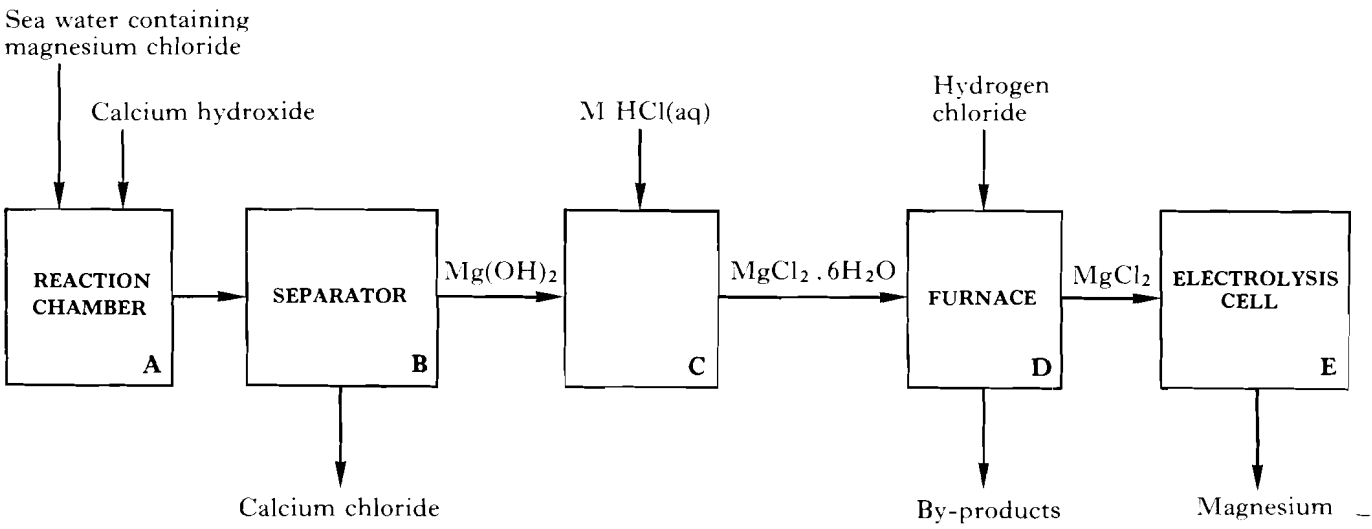
Calculate the enthalpy of formation of hydrazine using information on page 7 of the Data booklet.

(The mean bond enthalpy for the N—N bond is $163 kJ\ mol^{-1}$.) **3**

(12)

Marks

15. In Britain, the main source of magnesium is sea water. The production of magnesium is outlined in the following flow chart.



(*a*) (i) Write an equation for the reaction in **A**. **1**

(ii) How could the $Mg(OH)_2$ be separated from the calcium chloride in **B**? **1**

(iii) Which type of chemical reaction takes place in **C**? **1**

(*b*) In **D**, the water of crystallisation in the $MgCl_2 . 6H_2O$ is removed by heating. However, this can cause the formation of magnesium oxide as shown in the equation:

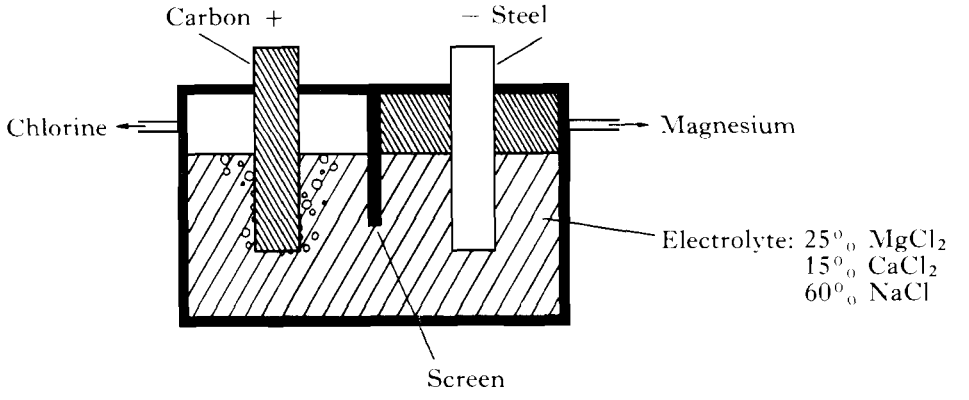
$$MgCl_2 . 6H_2O \rightleftharpoons MgO + 2HCl + 5H_2O$$

(i) In the flow chart, which chemical is used to prevent this? **1**

(ii) Explain how this chemical prevents the formation of magnesium oxide. **1**

(Question 15 continued)

(*c*) The electrolysis cell (**E**) is shown in the diagram below.



The $CaCl_2$/NaCl mixture is used to lower the melting point and to increase the electrolyte density.

(i) What is the purpose of increasing the electrolyte density? **1**

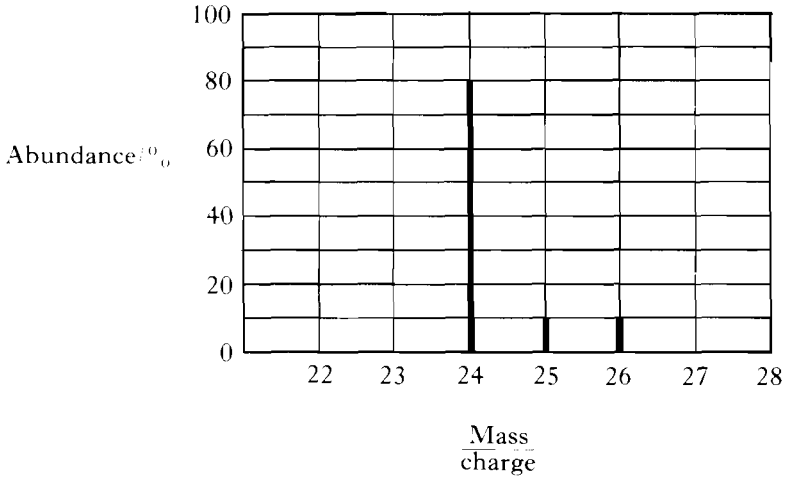
(ii) What advantage is there in having an electrolyte with a lower melting point? **1**

(iii) Why is there a screen between the positive and negative electrodes? **1**

(iv) Why are sodium and calcium not formed in the electrolysis? **1**

(v) Which products would be obtained from electrolysis of aqueous magnesium chloride? **1**

(*d*) Magnesium is found to have the following mass spectrum:



Calculate the relative atomic mass of magnesium from this data. **2**

(12)

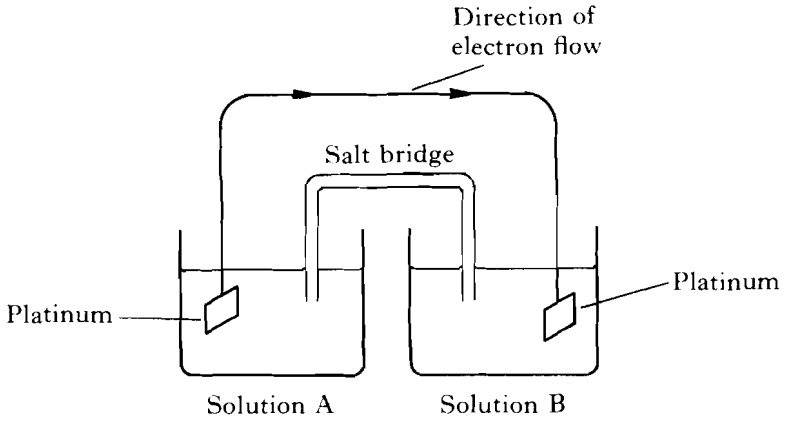
[Turn over

16. Answer **EITHER** A **OR** B.

A. (*a*) The following equation represents a redox reaction.
(The equation is incomplete.)

$$5CrCl_2 + KMnO_4 + xHCl \rightarrow 5CrCl_3 + Y + MnCl_2 + 4H_2O$$

The reaction can be used in an electrochemical cell.



(i) Name substance Y. **1**

(ii) What is the value of x needed to balance the equation? **1**

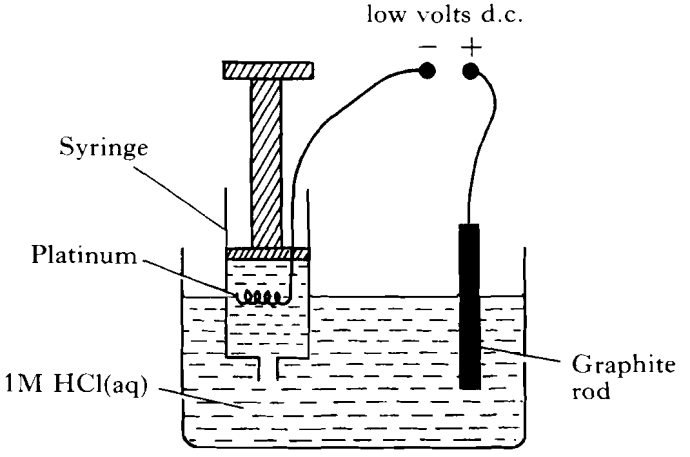
(iii) Which two reactants are present in solution B? **1**

(iv) Write an ion-electron equation for the **oxidation** part of the reaction. **1**

(v) Assuming standard conditions, calculate the voltage produced by the cell. (Refer to the Data booklet.) **2**

(vi) From the Data booklet, which other reaction, involving chromium ions, can possibly occur once the main reaction has started? **1**

(*b*) A simple hydrogen electrode can be prepared as in the diagram below.



Electricity is passed through this apparatus for 5 minutes and the hydrogen electrode is then ready for use.

(i) Why is it necessary to pass electricity through the apparatus before use as a hydrogen electrode? **1**

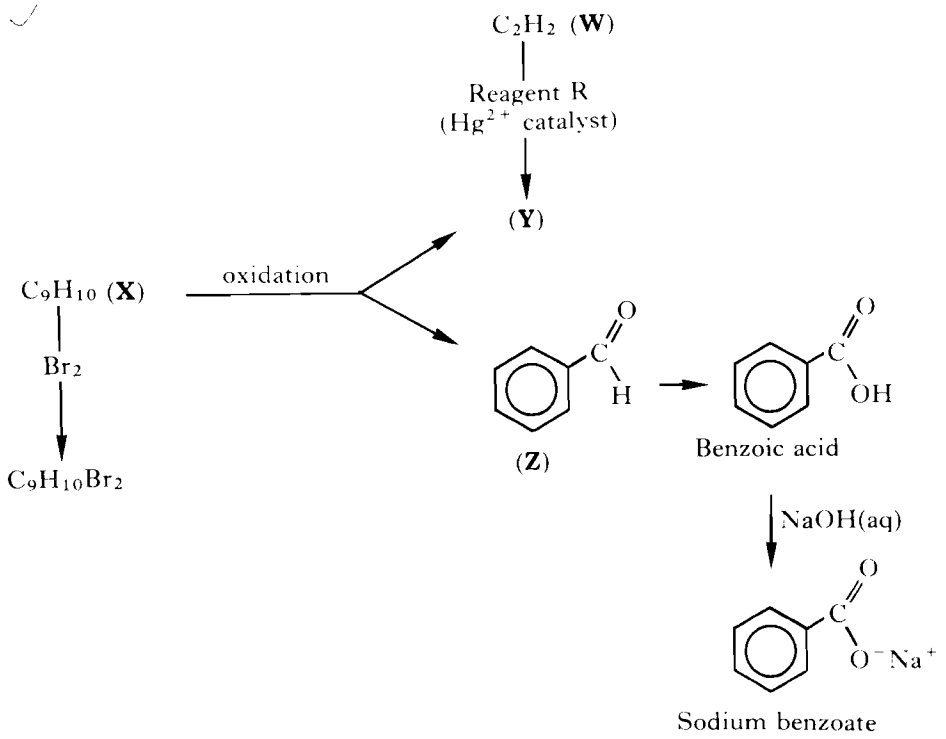
(ii) One reason why platinum metal is used is because it is chemically inert. Give another reason. **1**

(iii) Draw a labelled diagram to show how the hydrogen electrode could then be used to measure the standard reduction potential of zinc. **3**

(12)

OR

B.



Oxidation of compound **X** produces compounds **Y** and **Z**, **both of which give a positive Benedict's (or Fehling's) test.**

(*a*) From its reaction with bromine, which functional group must compound **X** contain? **1**

(*b*) Name compound **W**. **1**

(*c*) How many moles of bromine are required to saturate 1 mole of compound **W**? **1**

(*d*) To which class of organic compounds does **Y** belong? **1**

(*e*) Reagent R is used in the presence of a mercury(II) catalyst. Name reagent R. **1**

(*f*) Draw the full structural formula for compound **X**. **1**

(*g*) Name a reagent capable of converting compound **Z** to benzoic acid. **1**

(*h*) Benzoic acid is a weak acid.
Explain why the pH of sodium benzoate solution is alkaline (pH > 7). **2**

(*i*) The benzene ring can be drawn in two ways:

Structure A Structure B

Discuss, giving reasons, why structure B is considered to be the better representation of the benzene ring. **3**

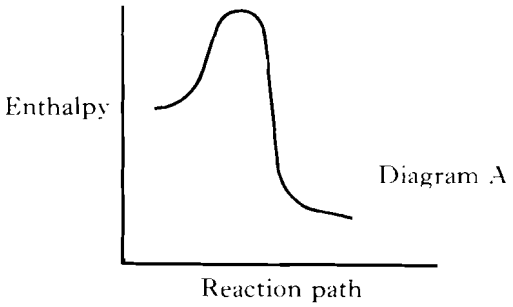
(12)

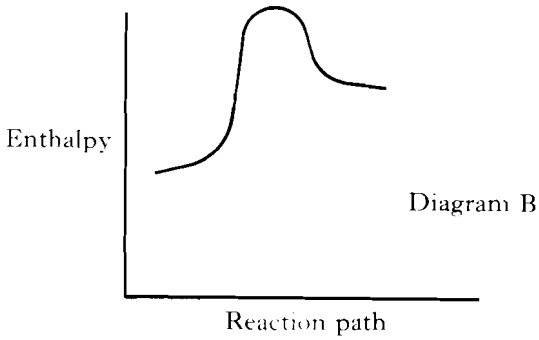
17. Two enthalpy changes occur when a substance dissolves in water—lattice enthalpy and hydration enthalpy.

The enthalpy of solution, $\Delta H_{solution}$, can be calculated from these two values.

Compound	*Lattice enthalpy/kJ mol^{-1}*	*Hydration enthalpy/kJ mol^{-1}*
NaCl	771	767
NaBr	733	734
NaI	684	692

Knowledge of these values also allows enthalpy diagrams to be drawn:





(*a*) Which salt(s) in the above table, when dissolved in water, would give an enthalpy diagram similar to diagram B? **1**

(*b*) Predict how the lattice enthalpies for caesium chloride, caesium bromide and caesium iodide will compare with the values for the corresponding sodium compounds in the table. Explain your answer. **2**

(*c*) Taking sodium chloride as your example, explain, in terms of bonding, what happens to an ionic crystal when it dissolves in water. **2**

(*d*) (i) When potassium bromide is dissolved in water, a fall in temperature occurs. Which diagram, A or B, applies in this case? **1**

(ii) In an experiment using 11·9g of potassium bromide, the amount of heat absorbed was 2·1kJ. Calculate the enthalpy of solution of potassium bromide. **2**

(*e*) Describe how you would test a solution of sodium iodide to show the presence of the iodide ion. **2**

(*f*) The sodium ion and the fluoride ion both have the same electron arrangement. Explain the difference in size of these two ions. **2**

(12)

[END OF QUESTION PAPER]