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).

Questions 1 and 2 refer to the graph below:
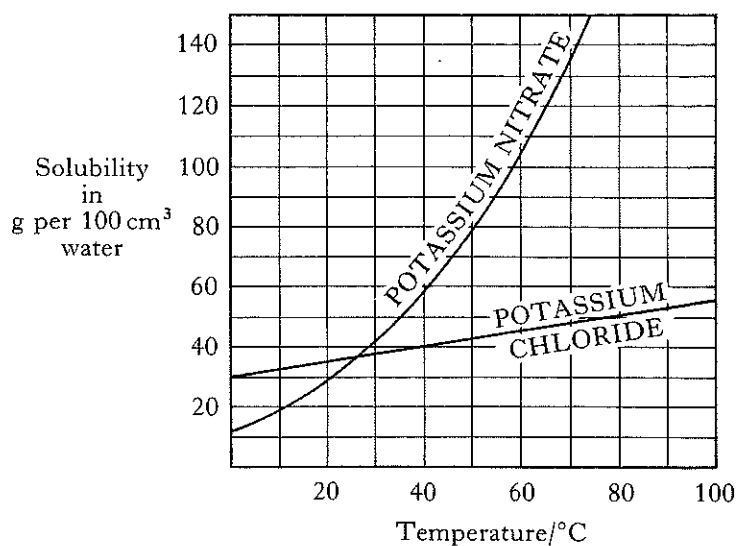
1. 50 g of potassium nitrate and 50 g of potassium chloride are dissolved in 100 cm³ of boiling water. The solution is cooled to 40 °C. Which of the following is likely to happen?

   A   No crystals form.

   B   Crystals of potassium nitrate form.

   C   Crystals of potassium chloride form.

   D   Crystals of **both** substances form.

2. After filtering off, at 40 °C, any crystals that may have formed, the solution is further cooled to 20 °C.

   What is likely to happen?

   A   No crystals form.

   B   Crystals of potassium nitrate form.

   C   Crystals of potassium chloride form.

   D   Crystals of **both** substances form.

3. What is the minimum volume of 4 M hydrochloric acid required to dissolve 0·1 mole of magnesium according to the following equation?

$$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$$

   A   25 cm³

   B   50 cm³

   C   100 cm³

   D   200 cm³

4. Two isotopic atoms must have identical

   A   nuclei

   B   electron arrangements

   C   numbers of neutrons

   D   mass numbers.

5. Which of the following solutions is the best conductor of electricity?

   A   1 M sulphuric acid

   B   2 M ammonia solution

   C   2 M ethanoic acid

   D   1 M sodium sulphate solution

6. In the diagram below, each sphere represents a particle about the size of an atom and the sign indicates the charge on the particle.
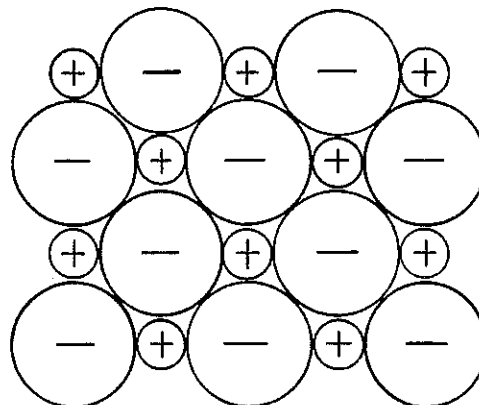
For which one of the following substances would the above model be a reasonable representation of the particles and the way they are arranged in the crystal?

   A   Tetrabromomethane

   B   Calcium fluoride

   C   Lithium bromide

   D   Diamond

7. 40 g of an oxide of iron was strongly heated and hydrogen gas passed over it. When the oxide was completely reduced, 28 g of iron remained. The relative atomic masses of iron and oxygen are approximately 56 and 16. A possible formula for the oxide is

A Fe_2O_3

B FeO_2

C Fe_2O

D FeO

8. In which of the following has a positively charged ion been reduced?

A Nitrate to nitrite

B Sulphide to sulphite

C Cobalt(II) to cobalt(III)

D Nickel(III) to nickel(II)

9. Which of the following methods, if any, would distinguish between equal volumes of 0·5 M nitric, sulphuric and phosphoric acids?

A Test with pH paper, sensitive over the range 3–11.

B Add excess zinc and compare the volumes of hydrogen produced.

C Electrolyse and identify the gases evolved.

D None of these.

10. When sodium hydroxide solution is electrolysed, hydrogen rather than sodium is released at the negative electrode. The best explanation is that

A the $H^+(aq)$ ion moves faster than the $Na^+(aq)$ ion

B $H_2O(\ell)$ is reduced more readily than $Na^+(aq)$

C there are more $H^+(aq)$ ions in the solution than $Na^+(aq)$

D the sodium which is released at first reacts with water to give off hydrogen.

Questions 11 and 12 refer to the experiment illustrated below:
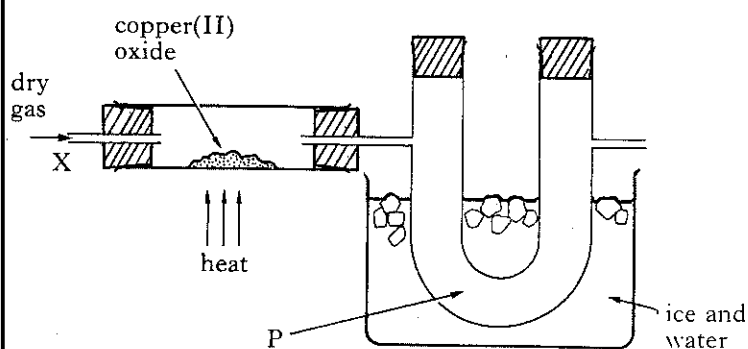
11. Which of the following gases, when passed separately into the apparatus at X, would **not** reduce the copper(II) oxide?

A Hydrogen

B Ammonia

C Ethanol vapour

D Carbon dioxide

12. Which gas, when passed into the apparatus at X, would allow a liquid to collect at P?
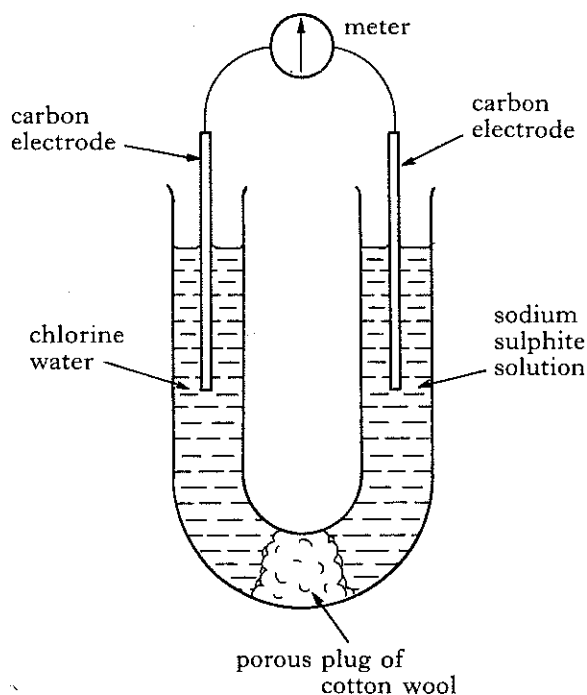
A Carbon dioxide

B Ammonia

C Carbon monoxide

D Air

13. When heated in air, a solid gave off a gas which decolourised iodine solution.
The original solid could have been

A sodium carbonate

B copper carbonate

C lead sulphide

D sodium chloride.

[**Turn over**

14.

In an experiment using the above apparatus, it is found that

A   the chlorine water is oxidised

B   the sodium sulphite solution is reduced

C   the electron flow is from the sulphite solution to the chlorine water through the meter

D   the electron flow is from the sulphite solution to the chlorine water through the porous plug.

15. Which of the following does **not** have an isomer?

A $CH_3CH_2CH_2OH$

B $CH_3CH_2CH_3$

C $CH_3CH=CH_2$

D CH_3CHCl_2

16. When a gas was burned in air, the products formed gave a white precipitate with calcium hydroxide solution and turned anhydrous copper(II) sulphate blue.

Which of the following gases could it have been?

A   Methane

B   Carbon monoxide

C   Hydrogen

D   Ammonia

17.
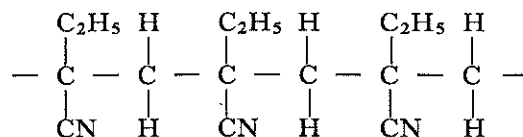
Part of a polymer is shown above.

Which of the following compounds, if polymerised, would give this polymer?

A

B.

C

D

18. A solution of ammonia has a much lower conductivity than a solution of sodium hydroxide of the same molarity because

A   the ammonium ion is less mobile than the sodium ion

B   the sodium ion is smaller than the ammonium ion

C   water is more ionised in the presence of dissolved sodium hydroxide

D   ammonia is present mainly as dissolved molecules.

19. Sparks were passed through some ammonia gas which had been collected in a tube over liquid paraffin.

What happened to the level of the liquid paraffin? (Readings were taken at the same temperature and pressure.)

A   It rose because the products occupied a smaller volume than the ammonia.

B   It fell because the products occupied a larger volume than the ammonia.

C   It remained at the same level.

D   It rose because the products dissolved in the liquid paraffin.

20. Dilute nitric acid reacts with copper and one of the products is nitrogen oxide (nitrogen monoxide).

Which of the following is the best explanation of this reaction?

A   Copper cannot displace hydrogen from acids.

B   The nitrate ion acts as an electron acceptor.

C   Dilute nitric acid has a low hydrogen ion concentration.

D   Nitric acid is a covalent compound.

21. The formation of glucose from starch is an example of

A   polymerisation

B   hydrolysis

C   dehydration

D   oxidation.

22. Some liquid oils can be converted into solid fats by

A   hydrolysis

B   hydrogenation

C   polymerisation

D   esterification.

23. Which of the following substances contains the element nitrogen?

A   Cellulose

B   Leather

C   PVC

D   Silicone rubber

24. Which one of the following identifies a substance as a thermosetting polymer?

A   It is a straight chain hydrocarbon.

B   It is formed by addition polymerisation.

C   It is resoftened on heating.

D   None of these.

25. Complete combustion of a polymer leaves a white powder. This polymer is likely to be

A   rayon

B   cellulose ethanoate

C   a silicone

D   poly(chloroethene).

26. Which would suffer the least deflection in a mass spectrometer?

A $^3_1\text{Li}^+$

B $^4_2\text{He}^{2+}$

C $^{14}_7\text{N}^{2+}$

D $^{14}_6\text{C}^{4+}$

27. Chlorine has isotopes $^{35}_{17}\text{Cl}$ and $^{37}_{17}\text{Cl}$ and has a relative atomic mass of 35·5. If chlorine molecules are analysed in a mass spectrometer, which molecular mass will **not** be found?

A   70

B   71

C   72

D   74

[Turn over

28. For the changes
$$^{231}_{91}\text{Pa} \rightarrow {}^{227}_{89}\text{Ac} \rightarrow {}^{227}_{90}\text{Th}$$
which sequence of particles is emitted?

A   An α-particle and then a neutron

B   An α-particle and then a β-particle

C   A β-particle and then an α-particle

D   A β-particle and then a proton

29. Which, if any, of the following processes would alter the half-life of a sample of radioactive calcium?

A   Cooling it to $-50°\text{C}$

B   Dissolving it in dilute hydrochloric acid

C   Burning it in air

D   None of these

30. A mixture of magnesium chloride and magnesium sulphate is known to contain 0·6 mole of chloride ions, and 0·2 mole of sulphate ions.

The number of moles of magnesium ions present is

A   0·4

B   0·5

C   0·8

D   1·0

31. How many litres of oxygen, at s.t.p., are required to completely oxidise 1 mole of carbon?

A   11·2

B   16·0

C   22·4

D   32·0

32. How many atoms of oxygen will be present in 11·2 litres of sulphur dioxide at s.t.p.?

A $\frac{1}{4} \times 6 \times 10^{23}$

B $\frac{1}{2} \times 6 \times 10^{23}$

C $1 \times 6 \times 10^{23}$

D $2 \times 6 \times 10^{23}$

33. Which of the following would be expected to react together most vigorously?

A   Caesium and fluorine

B   Magnesium and oxygen

C   Lithium and iodine

D   Sodium and chlorine

34. The $E°$ values for the following half-reactions are as shown:
$$\text{Sn}^{4+}(\text{aq}) + 2e^- \rightarrow \text{Sn}^{2+}(\text{aq}) \quad E° = +0\cdot15\,\text{V}$$
$$\text{Ce}^{4+}(\text{aq}) + e^- \rightarrow \text{Ce}^{3+}(\text{aq}) \quad E° = +1\cdot61\,\text{V}$$
From these data, it may be inferred that

A   1 mole $\text{Ce}^{4+}(\text{aq})$ would oxidise 2 moles $\text{Sn}^{2+}(\text{aq})$

B   1 mole $\text{Ce}^{3+}(\text{aq})$ would reduce 2 moles $\text{Sn}^{4+}(\text{aq})$

C   1 mole $\text{Sn}^{4+}(\text{aq})$ would oxidise 2 moles $\text{Ce}^{3+}(\text{aq})$

D   1 mole $\text{Sn}^{2+}(\text{aq})$ would reduce 2 moles $\text{Ce}^{4+}(\text{aq})$.

35. Consider a vertical group on the left-hand side of the Periodic Table. As the atomic number of the elements increases, which of the following is true?

A   There is a decrease in the first ionisation energy.

B   The tendency to form positive ions decreases.

C   The electronegativity increases.

D   The atomic radius decreases.

36. Which of the following statements is correct?
An ionic compound is likely to

A   have a low melting point

B   dissolve in polar solvents

C   be an electrical insulator when molten

D   consist of elements of similar electronegativities.

37. From the equation:

$$X_2 + Y_2 \rightarrow 2XY \,(\Delta H \text{ is negative}),$$
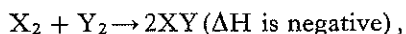
which deduction can be correctly made?

A   This is a reaction between gases.

B   The reaction goes to completion.

C   XY is more stable than $X_2 + Y_2$

D   The reaction will not require heating.

38. Molar solutions of the following pairs of substances are mixed. In which case is there **least** reaction?

A   Hydrochloric acid and sodium carbonate

B   Hydrochloric acid and potassium hydroxide

C   Hydrochloric acid and lithium bromide

D   Hydrochloric acid and silver nitrate

39. Liquid petrol does not ignite spontaneously when exposed to the air because

A   the ΔH for the combustion of petrol is positive

B   reaction between petrol and oxygen requires a catalyst

C   the reactants are in different physical states

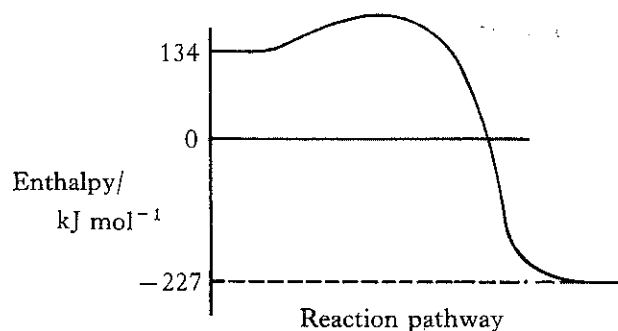D   not enough molecules possess sufficient energy to react.

40. In a reversible reaction, which of the following can influence the position of equilibrium?

A   Particle size

B   Reaction rate

C   Catalytic action

D   Temperature change

41. The enthalpy diagram for the reaction

$$CO(g) + NO_2(g) \rightarrow CO_2(g) + NO(g)$$
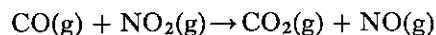
is shown below.

The enthalpy change, ΔH, (in kJ mol^{-1}) for the reaction is
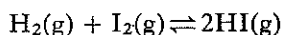
A $+361$

B $-\ 93$

C -227

D -361

42. The explosion of hydrogen with chlorine is initiated by light. The reaction probably involves several stages such as:

A $Cl_2 \rightarrow 2Cl\cdot$

B $H_2 + Cl\cdot \rightarrow HCl + H\cdot$

C $H\cdot + Cl_2 \rightarrow HCl + Cl\cdot$

D $Cl\cdot + Cl\cdot \rightarrow Cl_2$

Which step is likely to involve the greatest activation energy?

[Turn over

43. Hydrogen and iodine at 500 °C react according to the equation

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Vessel X contains 1 mole H_2 and 1 mole I_2.

Vessel Y contains 2 moles HI.

X and Y are left at 500 °C until no further change occurs.

Which statement is true?

A   X will contain more hydrogen than Y.

B   X will contain less iodine than Y.

C   X and Y will contain the same amount of HI(g).

D   Y will contain 1 mole of $I_2(g)$.

44. $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

$$\Delta H_{(forward)} = -560\,kJ\,mol^{-1}$$

Which conditions **both** favour the formation of NO_2?

A   High temperature, high pressure

B   High temperature, low pressure

C   Low temperature, high pressure

D   Low temperature, low pressure

45. Which of the following, when dissolved in water, will give an alkaline solution?

A   Ammonium sulphate

B   Potassium carbonate

C   Magnesium chloride

D   Sodium nitrate

46. Which of the following is an isomer of oct-1-ene?

A   2,3-dimethylpent-l-ene

B   2-methylheptane

C   2,3,4-trimethylhex-l-ene

D   1,2-dimethylcyclohexane

47. Which of the following will dissolve in sodium hydroxide solution?
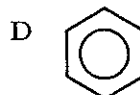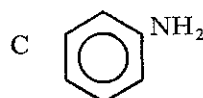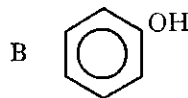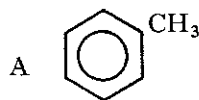
48. Which of the following statements is true of methanol?

A   It gives an alkene with concentrated sulphuric acid.

B   It does **not** react with phosphorus pentachloride.

C   It boils at a temperature greater than 100 °C.

D   On oxidation, it gives a monocarboxylic acid.

49. Which of the following would **not** react with hydrochloric acid?

A NH_4Cl

B CH_3NH_2

C $C_6H_5NH_2$

D NH_3

50. Which of the following is true of alkanones?

A   They are formed by oxidation of primary alkanols.

B   They can be easily oxidised to acids.

C   They contain the structure

, where R is an alkyl group.
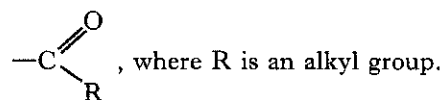
D   They will reduce Fehling's (Benedict's) solution.

[END OF QUESTION PAPER]

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 1¼ hours be spent on this part of the paper.
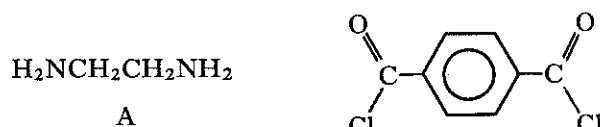
Marks

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. $$CH_3-\overset{O}{\underset{\|}{C}}-OCH_2CH_2CH_2CH_3$$

   (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.

   Intensity

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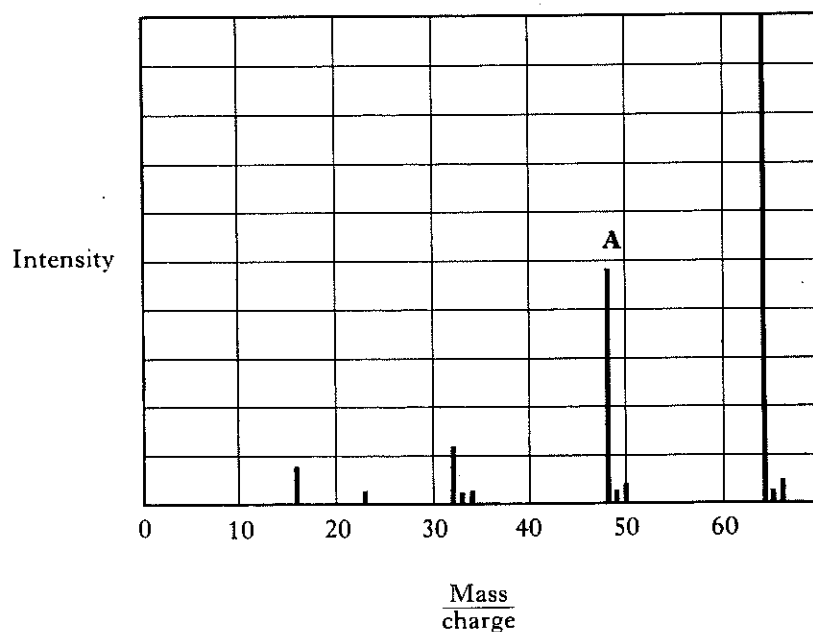
   The sample of sulphur dioxide used contained only one isotope of oxygen, ($^{16}_{8}O$).

   (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:
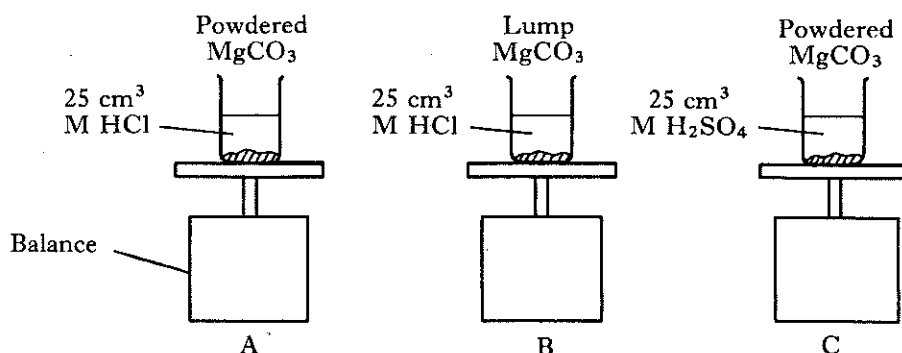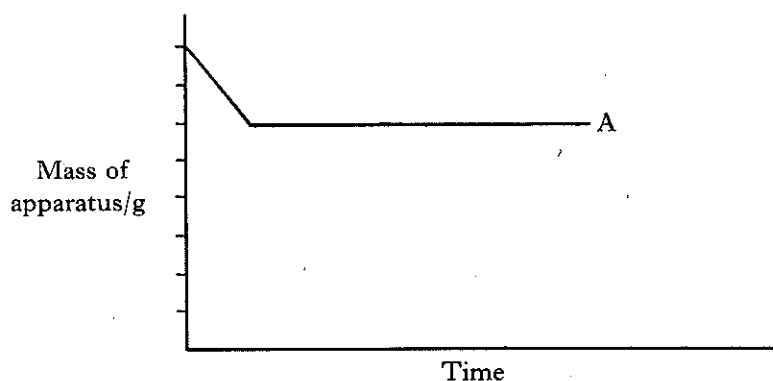

The results for experiment A were plotted on a graph:

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, COOH .

$$\underset{\text{COOH}}{|}$$
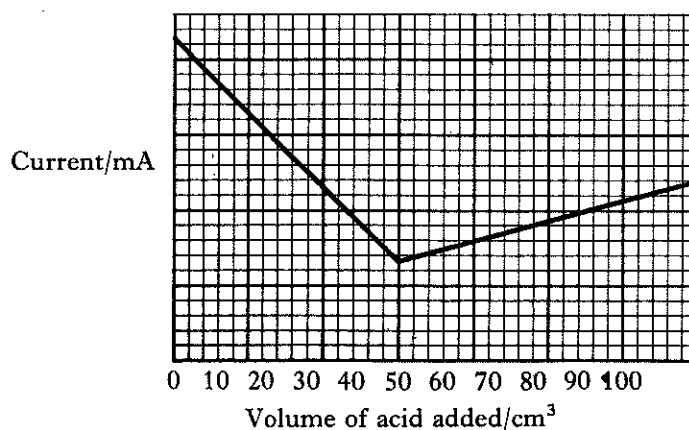
(a) How many moles of 0.1 M ethane-1,2-dioic acid were used to neutralise the alkali?   **1**

(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**

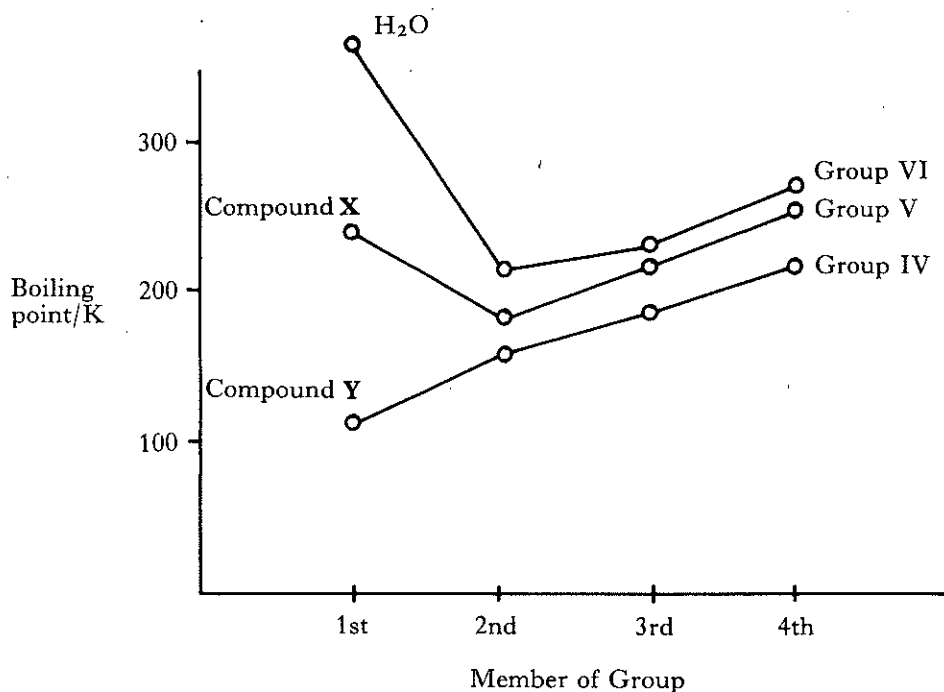(*c*) What causes water and compound **X** to have boiling points considerably higher than expected?   **1**

(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 $^{131}_{53}\text{I}$ is radioactive and is manufactured, for medicinal use, by the neutron bombardment of $^{127}_{53}\text{I}$.

$$^{127}_{53}\text{I} + 4\,^{1}_{0}\text{n} \rightarrow\ ^{131}_{53}\text{I}$$
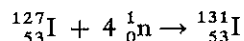
   (*a*) Calculate the number of neutrons required to produce 1 mole of radioactive iodine molecules.   **2**

   (*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 $^{131}_{53}\text{I}$.   **2**

                                                                   (4)

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

          pentane + water → carbon monoxide + hydrogen
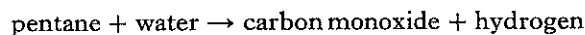
   (*a*) Write a balanced equation for the reaction.   **1**

   (*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:

$$2\text{C}_3\text{H}_6 + 9\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$$
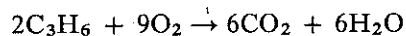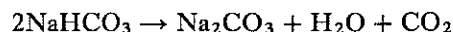
   (*a*) Explain why this equation is unlikely to represent the mechanism of the reaction.   **1**

   (*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**
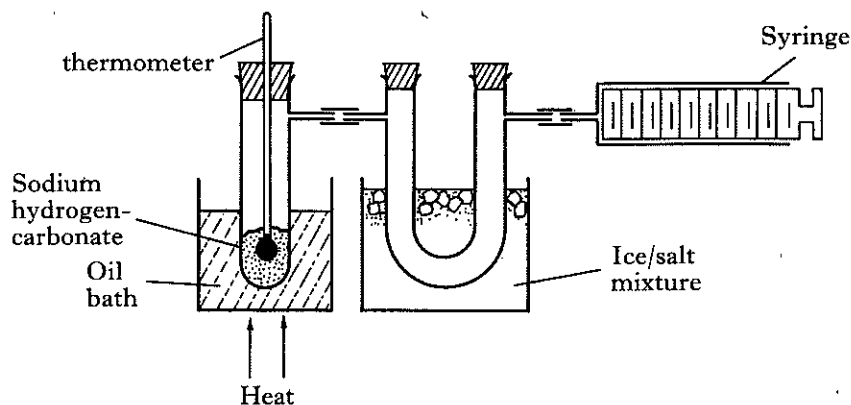
                                                                      (3)

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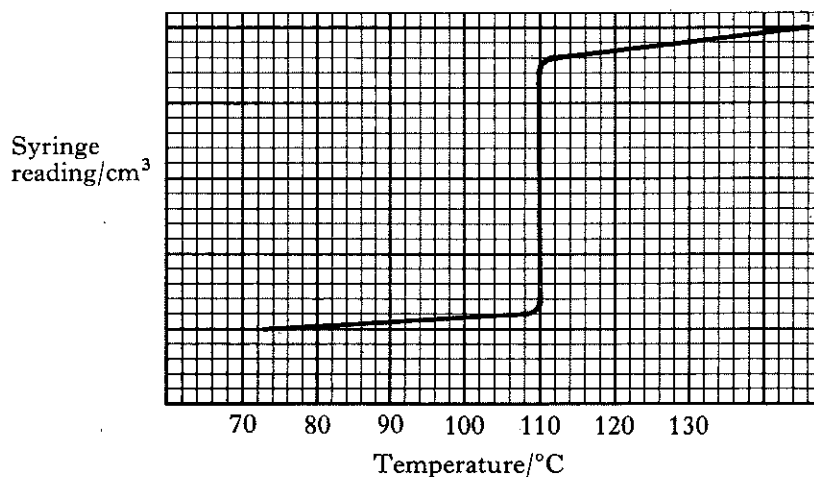
(i) At what temperature did the sodium hydrogencarbonate decompose?

(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:

$$2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$$
$$4OH^-(aq) \rightarrow 2H_2O(\ell) + O_2(g) + 4e^-$$
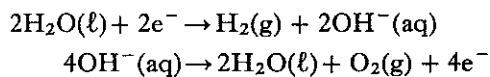
Explain what would happen to the **overall** pH of the solution as the electrolysis progresses. **2**

(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:
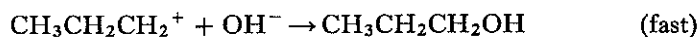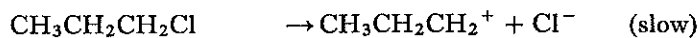
$$CH_3CH_2CH_2Cl \qquad \rightarrow CH_3CH_2CH_2{}^+ + Cl^- \qquad (slow)$$

$$CH_3CH_2CH_2{}^+ + H_2O \rightarrow CH_3CH_2CH_2OH + H^+ \qquad (fast)$$

$$CH_3CH_2CH_2{}^+ + OH^- \rightarrow CH_3CH_2CH_2OH \qquad (fast)$$

$$H^+ + OH^- \rightarrow H_2O \qquad (fast)$$

A graph drawn from the results is shown below:

pH (vertical axis) / Time/sec (horizontal axis)
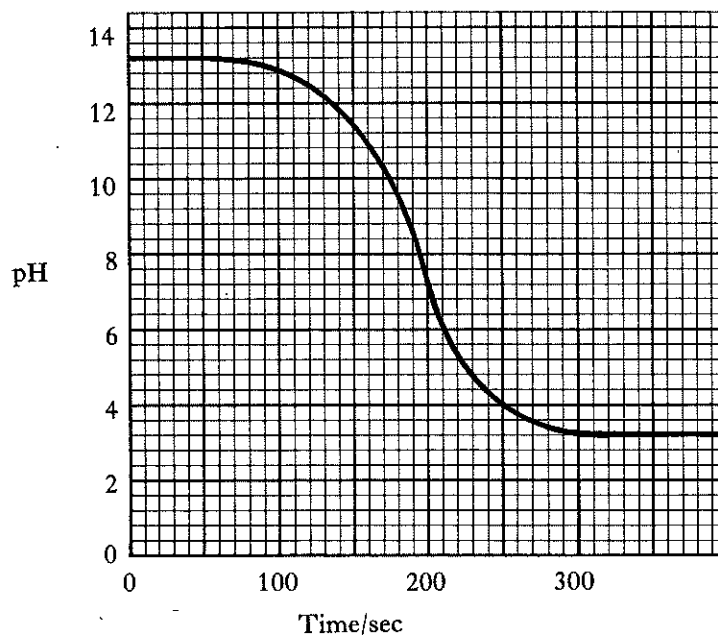
(a) Which is the rate-determining step of the reaction?   **1**

(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

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

$$Mg^{2+}(g) + 2e^- + 2Cl(g)$$

ΔH_5 | $-728\,kJ$

$+1460\,kJ$ | ΔH_4

$$Mg^{2+}(g) + 2Cl^-(g)$$

A

$+744\,kJ$ | ΔH_3

ΔH_6 | $-2489\,kJ$

$$Mg(g) + 2Cl(g)$$

ΔH_2

$$Mg(g) + Cl_2(g)$$

$+149\,kJ$ | ΔH_1

$$Mg(s) + Cl_2(g)$$

$$Mg^{2+}(Cl^-)_2(s)$$
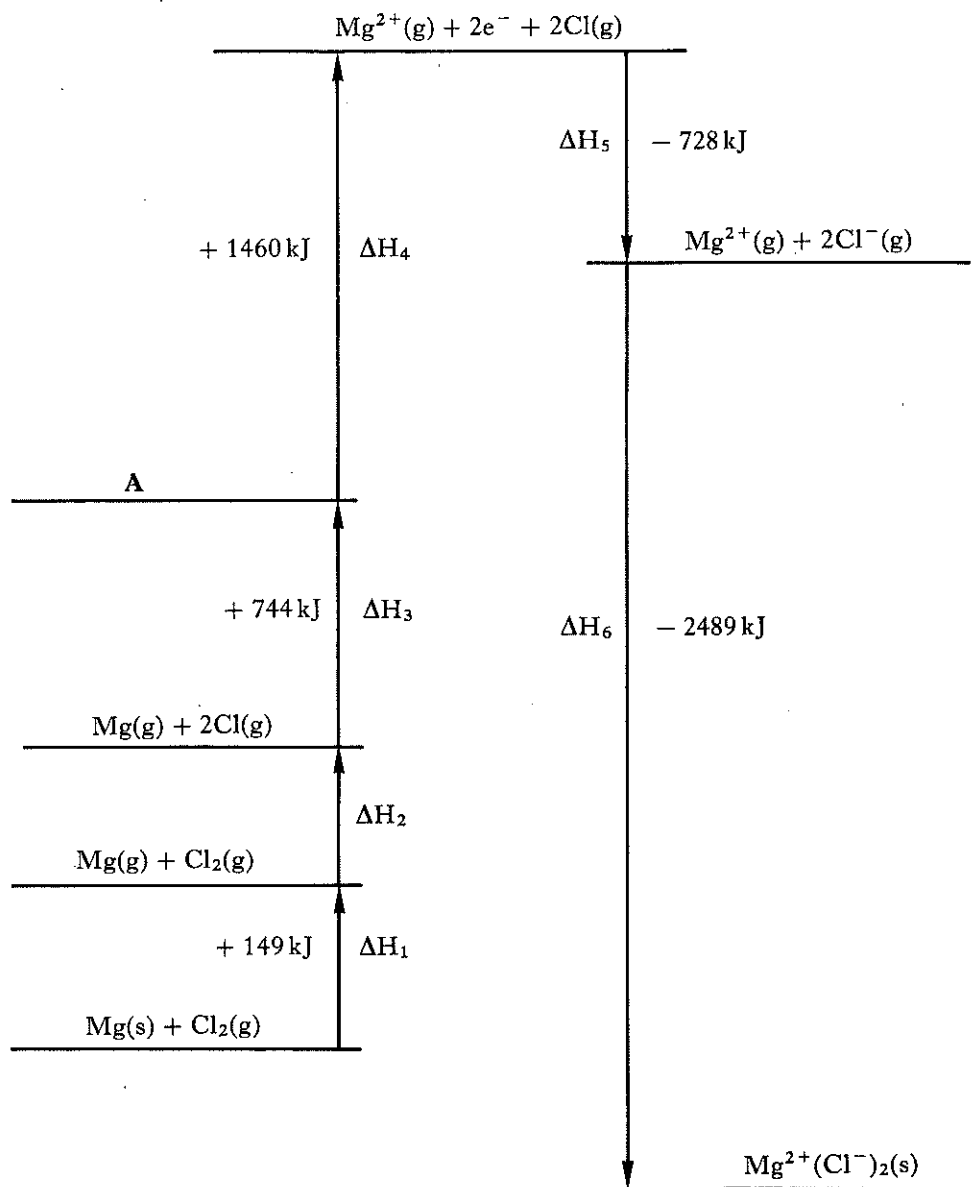
ΔH_1 = Enthalpy of sublimation
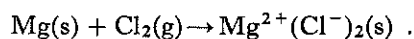ΔH_2 = Mean bond enthalpy
ΔH_6 = Lattice enthalpy

(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.

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

$$\downarrow H_2O$$

$$CH_3CH(CH_3)CH(OH)CH_3$$
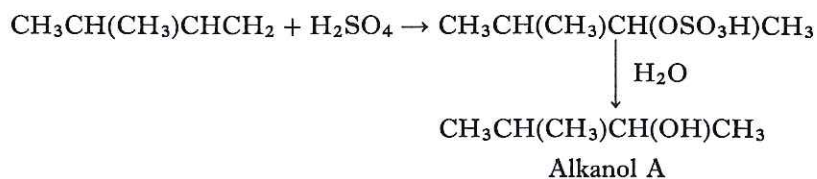
Alkanol A

(*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.

Alkanol A —— Reagent B → 3-methylbut-1-ene
　　　　　　　　　　　↘ Alkene C
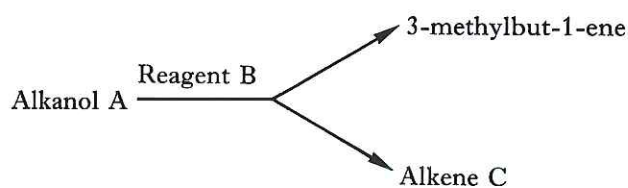
(i) Name reagent B.

(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

13.
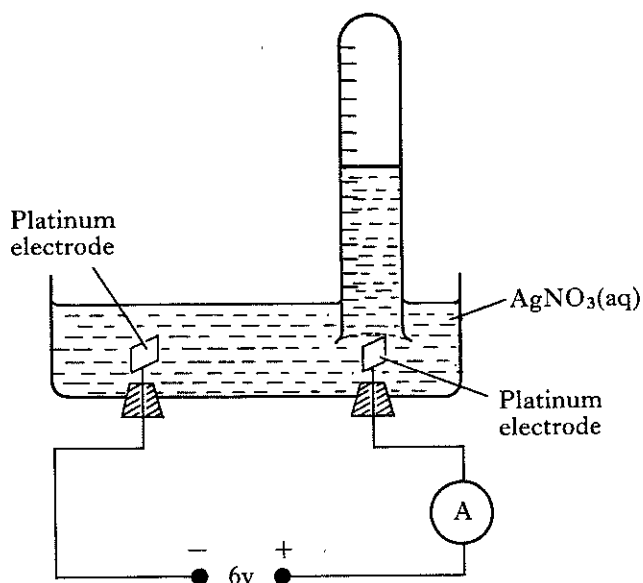
In the above experiment, a constant current of 0·5 A was passed for a time of 32 minutes 10 seconds.

(*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:

$$2H_2O(\ell) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$$
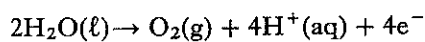
Calculate   (i) the number of moles of oxygen liberated;

(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**
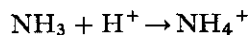
(d) Methane and ammonia

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

$$\begin{array}{c} H \\ | \\ H {\overset{\displaystyle C}{\diagup \big| \diagdown}} H \\ H \end{array}$$
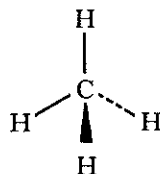
Draw a similar formula to show the shape of an ammonia molecule.   **1**

(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 $-84 \cdot 5 \, kJ \, mol^{-1}$.
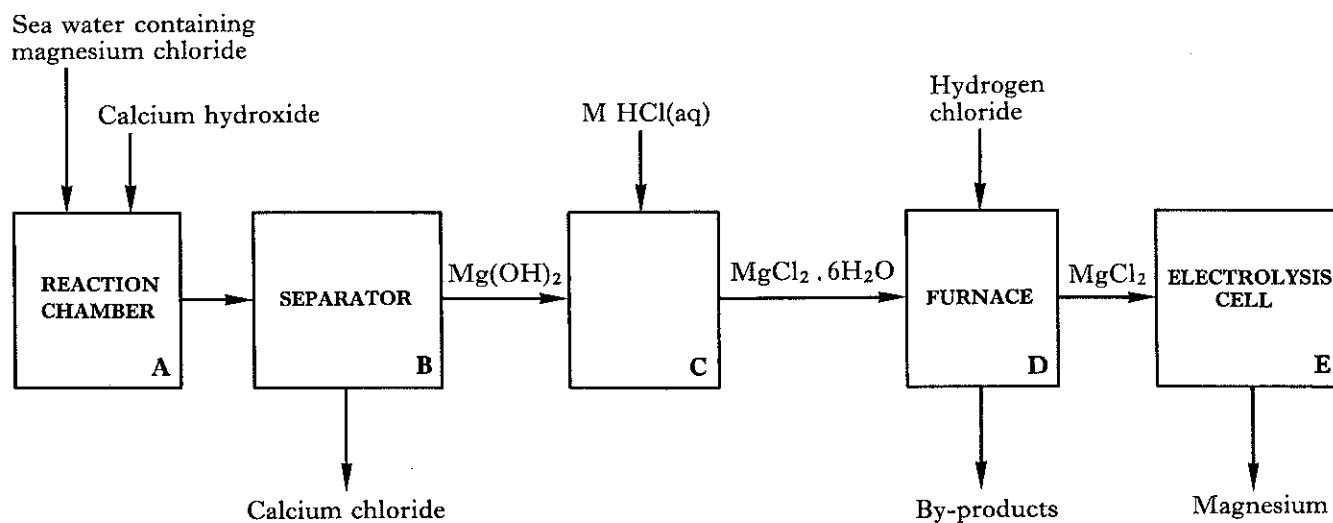
Calculate the enthalpy of formation of hydrazine using information on page 7 of the Data booklet.

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

(12)

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

Sea water containing
magnesium chloride

Calcium hydroxide   M HCl(aq)   Hydrogen
                                                                  chloride

| REACTION CHAMBER A | → | SEPARATOR B | $Mg(OH)_2$ → | C | $MgCl_2 . 6H_2O$ → | FURNACE D | $MgCl_2$ → | ELECTROLYSIS CELL E |

Calcium chloride   By-products   Magnesium

(*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:

$$MgCl_2 . 6H_2O \rightleftharpoons MgO + 2HCl + 5H_2O$$
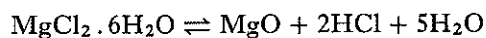
(i) In the flow chart, which chemical is used to prevent this?   1

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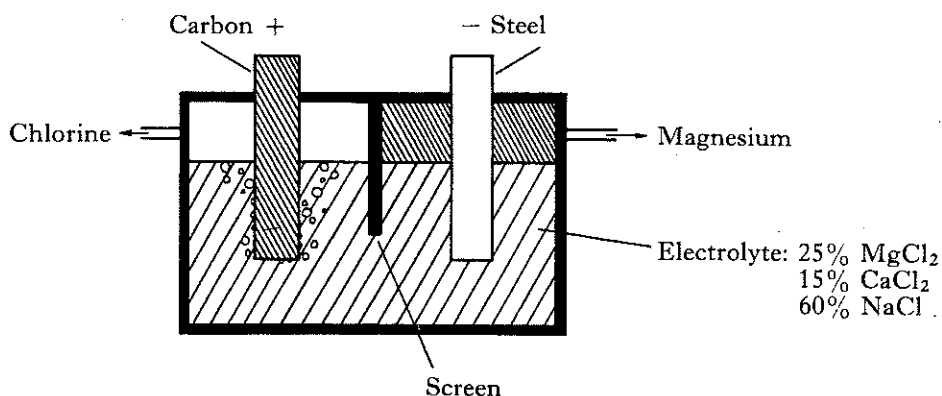
The $CaCl_2/NaCl$ mixture is used to lower the melting point and to increase the electrolyte density.

    (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**

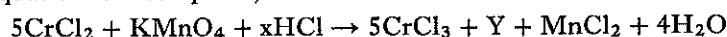(d) Magnesium is found to have the following mass spectrum:
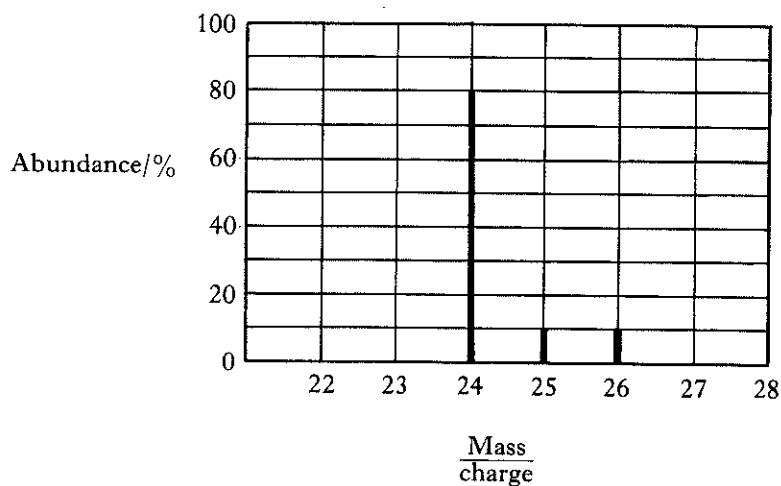
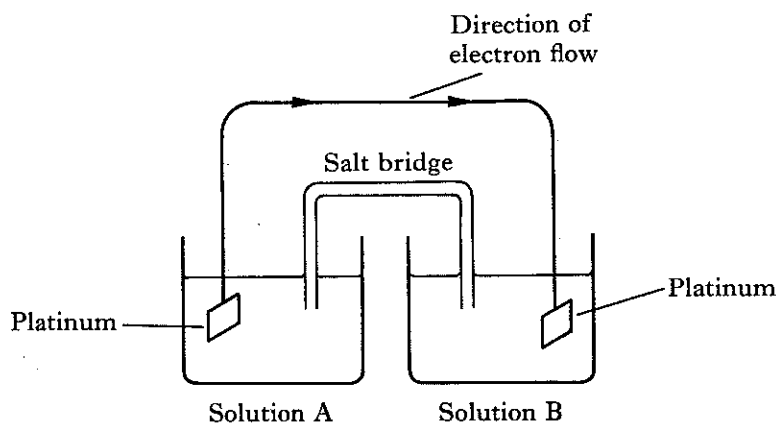Calculate the relative atomic mass of magnesium from this data.   **2**

                                                  (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.

Direction of electron flow

Salt bridge

Platinum — Platinum

Platinum

Solution A   Solution B

    (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.

low volts d.c.
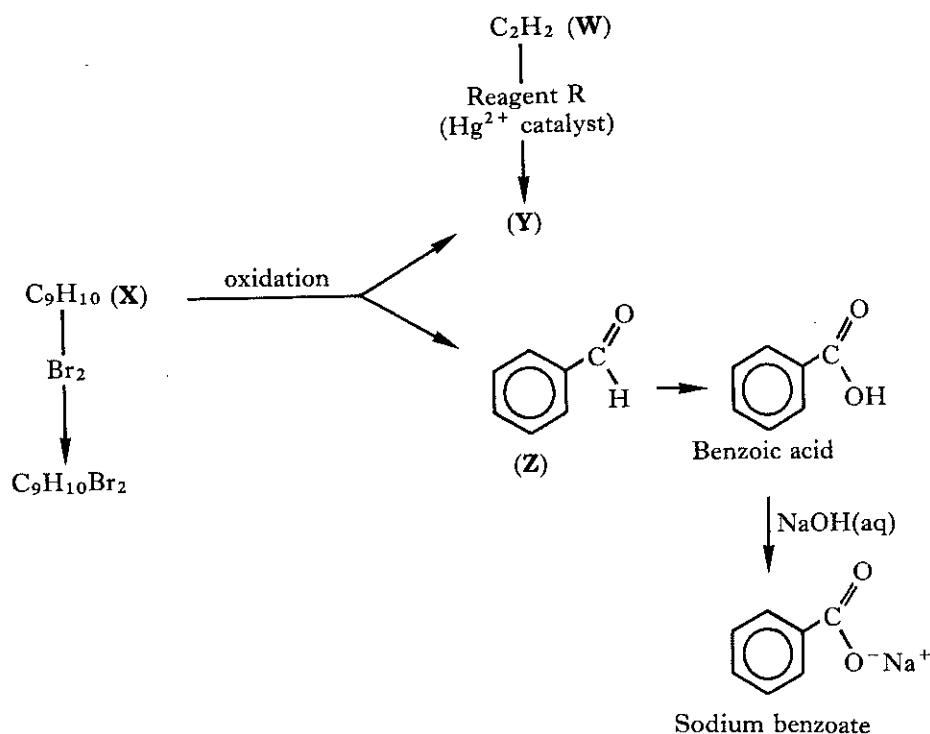
− +

Syringe

Platinum

Graphite rod

1M HCl(aq)
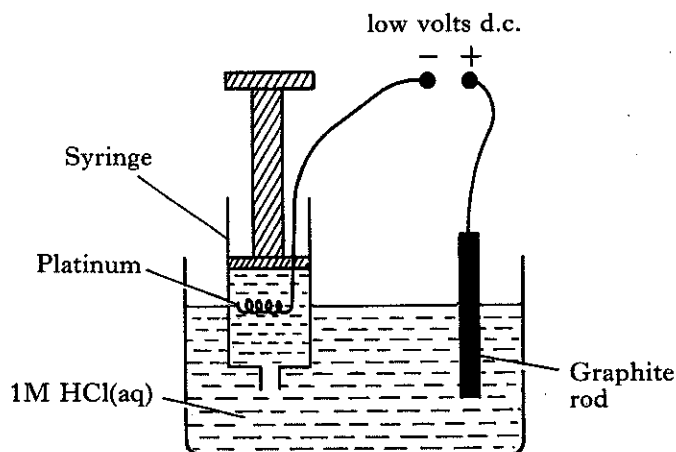
Electricity is passed through this apparatus for 5 minutes and the hydrogen electrode is then ready for use.

    (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.

C_2H_2 **(W)**

|

Reagent R
(Hg^{2+} catalyst)

↓

(Y)

C_9H_{10} **(X)** — oxidation →

|

Br_2

↓

$C_9H_{10}Br_2$

(Z)

Benzoic acid

| NaOH(aq)

↓

Sodium benzoate

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:
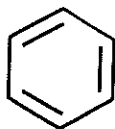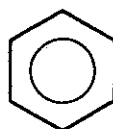
Structure A   Structure B

Discuss, giving reasons, why structure B is considered to be the better representation of the benzene ring.   **3**
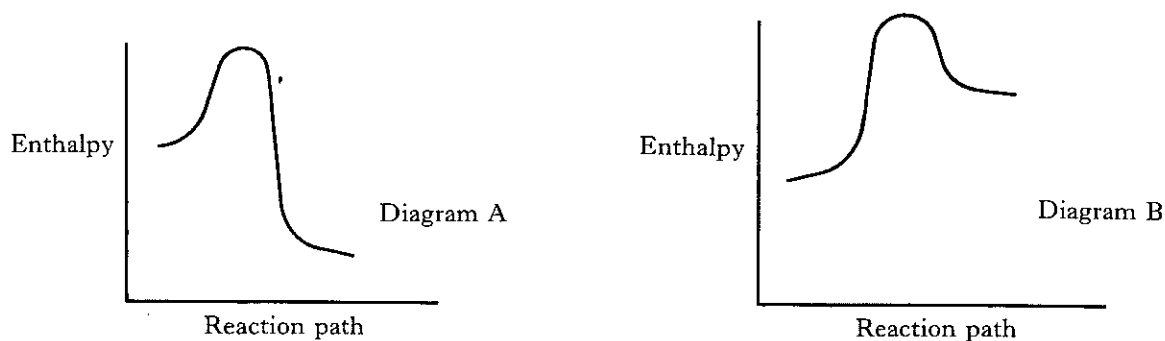
(12)

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*]