SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY

Higher Grade—PAPER II

Friday, 10th May—1.30 p.m. to 4.00 p.m.

Candidates are reminded that 4 marks in this paper are allocated for communication skills.

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).
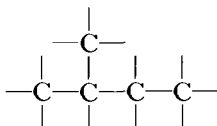
PART A (48 marks)

All questions should be attempted. It should be noted, however, that questions 2 and 6 contain a choice.

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

Marks

1. Copy the following carbon skeleton into your answer book **three** times.

$$
\begin{array}{c}
\quad\;\; | \\
\;\; -C- \\
\;\; | \quad\;\; | \quad\;\; | \\
-C-C-C-C- \\
\;\; | \quad\;\; | \quad\;\; | \quad\;\; |
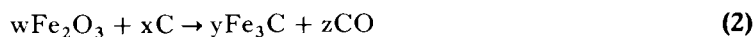\end{array}
$$

Add a hydroxyl group to each skeleton to make

   (a) a primary alkanol;

   (b) a secondary alkanol;

   (c) a tertiary alkanol. **(3)**

2. Answer **EITHER** A **OR** B.

   A. Find values for w, x, y and z, such that the following equation will be balanced.

$$wFe_2O_3 + xC \rightarrow yFe_3C + zCO$$ **(2)**

   OR

   B. Sodium thiosulphate ($Na_2S_2O_3$) decomposes when heated, forming sodium sulphate, sodium sulphide and sulphur. Write a chemical equation for this reaction. (The equation need **not** be balanced.) **(2)**

3. (a) An atom loses successively an alpha particle, a beta particle and a gamma ray. What **nett** effect would this have on the parent nucleus? **2**

   (b) Both radium oxide (RaO) and radium sulphate ($RaSO_4$) are radioactive. Compare the intensities of radiation from a 1 g sample of each compound. Explain your answer. **2**

                                                                   (4)

4. Assume that, during the electrolysis of $250\ cm^3$ $0{\cdot}1$ M copper(II) sulphate solution, all of the copper ions are reduced to copper metal at the negative electrode.

   (a) What quantity of electricity must pass during this reduction? **3**

   (b) Name the gas obtained at the positive electrode. **1**

   (c) Calculate the volume of gas (at s.t.p.) obtained at the positive electrode. **2**

                                                                   (6)

5. (*a*) In acid solution, iodate ions, IO_3^-(aq), are readily converted into iodine.
    Write an ion–electron equation for this half-reaction. **2**

   (*b*) Use the equation to **explain** whether the iodate ion is an oxidising or reducing agent. **2**

   (4)

6. Answer **EITHER A OR B**.

   A. Calculate the number of ammonium ions present in 1·32 g of ammonium sulphate. (Show all your working.) **(3)**

   OR

   B. Given 0·25 moles of ammonia gas,
      (*a*) what is the mass of this sample?
      (*b*) how many **atoms** are contained in this sample?
   (*c*) what volume (at s.t.p.) will be occupied by this sample? **(3)**

7. (*a*) Use the enthalpies of formation (ΔH_f) in the table below to calculate the enthalpy of combustion of the gas, diborane (B_2H_6).

	$\Delta H_f/kJ\,mol^{-1}$
$B_2H_6(g)$	$+32·0$
$H_2O(l)$	$-286·0$
$B_2O_3(s)$	$-1225·0$

   4

   (*b*) **Explain** whether ethane or diborane is the better fuel. (Data Booklet, page 10.) **2**

   (6)

8. When calcium ethanoate is strongly heated, one of the products is an alkanone (ketone):

   $$(CH_3COO)_2Ca \xrightarrow{heat} X + C_3H_6O$$
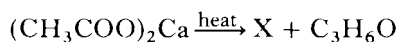
   (*a*) Name the substance X. **1**

   (*b*) Name the alkanone C_3H_6O. **1**

   (*c*) If this reaction is carried out using a mixture of $(CH_3COO)_2Ca$ and $(C_2H_5COO)_2Ca$, one of the products is the alkanone C_4H_8O. Draw the extended structural formula of this alkanone. **1**

   (3)

**[Turn over**

9. A concentrated aqueous solution of $MgBr_2$, containing a little universal indicator, is electrolysed in a U-tube.

Low voltage supply

Electrode A

Electrode B

$MgBr_2$ solution
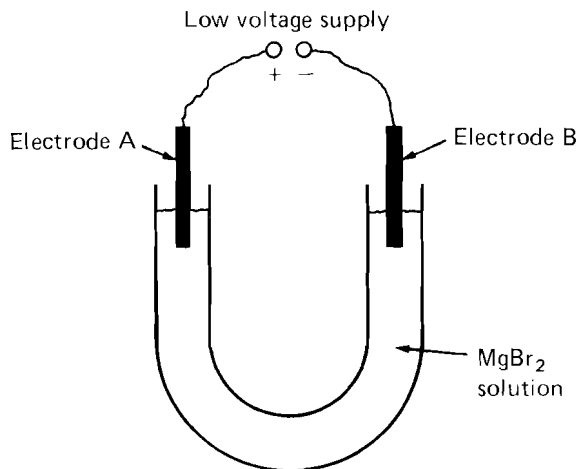
(*a*) Name the product obtained at each electrode, A and B.	**2**
(*b*) Write an ion–electron equation for the half-reaction occurring at electrode B.	**1**
(*c*) **Explain** what would happen to the indicator at electrode B.	**2**
	(5)

10. A mixture of $80\,cm^3$ CO and $150\,cm^3$ O_2 was exploded.

(*a*) Write a balanced equation for the reaction.	**1**
After cooling, the residual gas was shaken with sodium hydroxide solution.	
(*b*) Which gas would be absorbed by the sodium hydroxide?	**1**
(*c*) What would be the reduction in volume of the residual gas on shaking with the sodium hydroxide?	**1**
(*d*) What volume of gas would remain?	**1**
(Assume all volumes measured at s.t.p.)	**(4)**

11. The overall rate of a chemical reaction is often taken as the reciprocal of time (1/time). Graphs of rate of reaction against concentration and rate of reaction against temperature are shown.
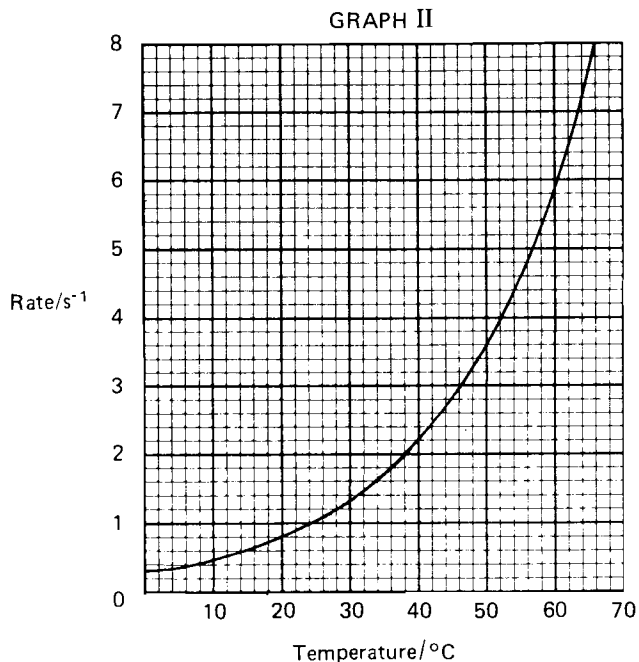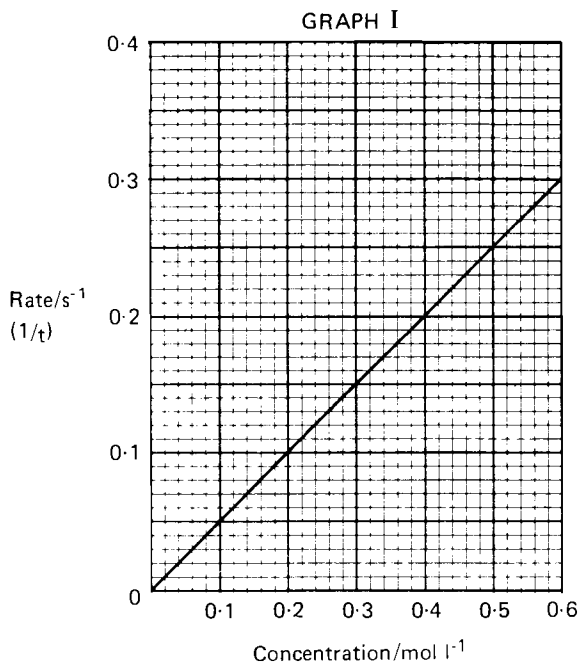
GRAPH I

GRAPH II

(a) From GRAPH I:

   (i) Calculate the time taken for the reaction when the concentration is $0.4\,mol\,l^{-1}$. **2**

   (ii) Explain why the rate increases as the concentration increases. **1**

(b) From GRAPH II:

   (i) Find the temperature rise required to double the rate of the reaction. **1**

   (ii) Explain why the rate increases very rapidly as the temperature increases. **1**

   (5)

12. Consider the following reaction:
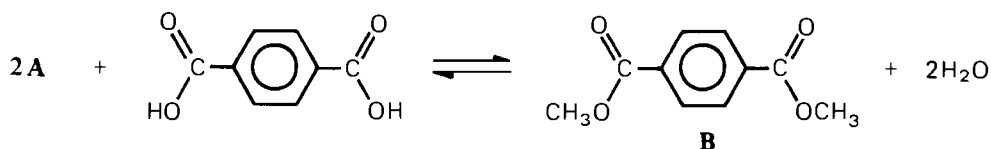
(a) Name reactant **A**.

(b) To which class of substance does product **B** belong?

(c) Name a reagent which could be used to improve the yield of **B**. **(3)**

[Turn over

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

13. **Use the Data Booklet (pages 4 and 5)** to answer the questions which follow.

    (*a*) (i) Name the element with the lowest first ionisation energy.

    (ii) Why does this element have the lowest value?

    (iii) The third ionisation energy for Mg is greater than that for Al. Explain why.   **3**

    (*b*) (i) Name a **compound** formed between two non-metallic elements in which the bonding is likely to be pure covalent (non-polar).

    Give a reason for your choice of compound.   **2**

    (ii) Which pair of elements will be likely to combine to give a compound with most ionic character?

    Explain your choice.   **2**

    (*c*) Suggest why the ionic radius of the hydride ion (H^-) is given in the Data Booklet rather than the ionic radius of the more common positive hydrogen ion (H^+).   **1**

    (*d*) Write a paragraph accounting for the differences in values in **each** of the following:

    (i) the covalent radii of chlorine and sodium;

    (ii) the ionic radii of chlorine and sodium.   **4**

    (12)

14. The equation below represents the catalytic oxidation of ammonia.

    $$4NH_3(g) + 5O_2(g) \xrightarrow{heat} 4NO(g) + 6H_2O(g)$$
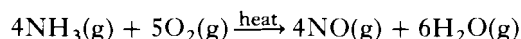
    (*a*) (i) Which catalyst is used in this process?

    (ii) Why is the catalyst used in the form of a fine wire mesh?

    (iii) What would be the products if no catalyst were used?   **3**

    (*b*) The catalyst used in this reaction is an example of a heterogeneous catalyst. What is meant here by the term "heterogeneous"?   **1**

    (*c*) In a reversible reaction, a catalyst lowers the activation energy of both the forward and reverse reactions. Why then, are catalysts used in industrial reactions involving reversible reactions?

    Give **two** reasons.   **2**

    (*d*) Catalysts often undergo a temporary colour change during a reaction.

    Give a possible explanation.   **1**

    (*e*) Consider the following industrial processes:

    Contact Process $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ ΔH (forward reaction) -ve.

    Haber Process $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ ΔH (forward reaction) -ve.

    (i) **Explain** which way the equilibria positions would move with increasing temperature.   **2**

    (ii) **Discuss** why the Contact Process uses atmospheric pressure whereas the Haber Process uses pressures in excess of 200 atmospheres.   **3**

    (12)

15. (*a*) Which reagent would you use to convert iron into

   (i) iron(II) chloride?

   (ii) iron(III) chloride?   **2**

(*b*) Iron(III) chloride sublimes on heating.

   (i) What is the meaning of the term sublimation?

   (ii) Which type of bonding is implied by the fact that iron(III) chloride sublimes?   **2**

(*c*)
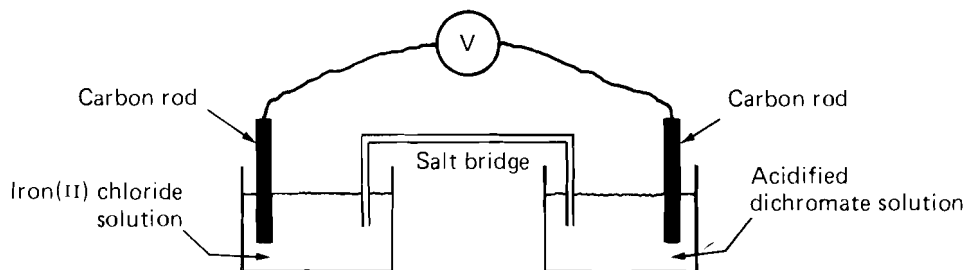
In acid solution, dichromate ions ($Cr_2O_7^{2-}$(aq)) are reduced to Cr^{3+}(aq) ions.

   (i) Calculate the voltage of the cell shown above. (Data Booklet, page 6.)   **2**

   (ii) Write a balanced chemical equation for the overall reaction.   **2**

   (iii) How many moles of iron(II) ions would be required to react completely with $250\,cm^3$ 0·1 M $Cr_2O_7^{2-}$(aq) solution?   **2**

(*d*) (i) What other reaction might occur if the iron(II) chloride solution were replaced with iron(II) bromide solution?   **1**

   (ii) How would you detect the presence of iron(III) ions in a solution?   **1**

   (12)

   [Turn over

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

   A. The diagram below shows various compounds to which ethanol may be converted directly or indirectly.

   ETHENE   PROPANOIC ACID

   ETHANOL

   ETHANAL   PROPANAL
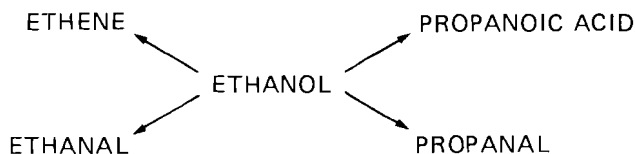
   (*a*)   (i) Name a suitable reagent **and** the type of chemical reaction involved in the conversion of ethanol to ethene.   2

        (ii) Draw a labelled diagram of the apparatus you would use in this reaction.   2

   (*b*)   (i) How would you convert ethanol to ethanal?   1

        (ii) How would you distinguish experimentally between ethanol and ethanal?   2

   (*c*) Draw the extended structural formula of propanal.   1

   (*d*)   (i) Write a balanced equation for the reaction which occurs between propanoic acid and magnesium.   2

        (ii) Use your equation to calculate the mass of magnesium which reacts with 3·7 g of propanoic acid.   2

                                                     (12)

OR

   B. The detection of carbon and hydrogen in organic compounds may be carried out by heating the compound with dry copper(II) oxide. The water vapour formed is condensed and the carbon dioxide is bubbled through lime water.

   (*a*) Draw a labelled diagram to show how you would carry out this experiment in the laboratory.   2

   (*b*) An organic compound X contains 53·3% carbon, 15·6% hydrogen and 31·1% nitrogen. Its molecular mass is 45.

        (i) Calculate the molecular formula of compound X.   3

        (ii) Draw **two** possible extended structural formulae for X and name **one** of them.   3

   (*c*) Compound X reacts with hydrochloric acid to form a product Y.

        (i) Why is X able to react with hydrochloric acid?

        (ii) Write an equation for the reaction occurring in (*c*)(i) above.

        (iii) What would you expect to happen if product Y were treated with sodium hydroxide?   3

   (*d*) What would be observed if the original compound X were allowed to react with copper(II) sulphate solution?   1

                                                     (12)

[END OF QUESTION PAPER]