| Centre Number | Candidate Number | Name |
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CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

**CHEMISTRY** **5070/02**

Paper 2 Theory

May/June 2003

**1 hour 30 minutes**

Candidates answer on the Question Paper.
Additional Materials: Answer Paper

**READ THESE INSTRUCTIONS FIRST**

Write your name, Centre number and candidate number in the spaces at the top of this page and on any separate answer paper used.

**Sections A**
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

**Section B**
Answer any **three** questions.
Write your answers on the separate answer paper.
At the end of the examination, fasten any separate answer paper used securely to the question paper.

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 16.

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **B8** | |
| **B9** | |
| **B10** | |
| **B11** | |
| **TOTAL** | |

This document consists of **14** printed pages and **2** blank pages.



UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate
**[Turn over**

## Section A

Answer **all** the questions in this section in the spaces provided.

**A1** Choose from the following elements to answer the questions below.

| | | | |
|---|---|---|---|
| argon | bromine | carbon | hydrogen |
| iodine | iron | neon | sulphur |

Each element can be use used once, more than once, or not at all.

Name an element which

**(a)** forms a basic oxide,

.....[1]

**(b)** is a liquid at room temperature and pressure,

.....[1]

**(c)** reacts with aqueous copper(II) sulphate to give a pink solid,

.....[1]

**(d)** is formed during the electrolysis of concentrated aqueous sodium chloride,

.....[1]

**(e)** has a giant molecular structure.

.....[1]

**A2** Ethanol, $CH_3CH_2OH$, is a liquid fuel. Ethanol can be manufactured either from glucose, $C_6H_{12}O_6$, or from ethene.

**(a)** Briefly describe the manufacture of ethanol from glucose.
Include the balanced equation in your answer.

.....

.....

.....

.....[4]

**(b)** **(i)** Draw the displayed formula for ethene.

**(ii)** Name the substance that reacts with ethene to make ethanol.

.....

**(iii)** Give the conditions needed for this reaction.

.....

.....
[4]



**[Turn over**

**A3** Petroleum is a complex mixture of hydrocarbons. Petroleum is a source of many useful fuels.

**(a)** What is meant by the term *hydrocarbon*?

.....

.....[1]

**(b)** Petroleum is separated by fractional distillation.

**(i)** Complete the following table about the fractions obtained from petroleum.

| fraction | use |
|---|---|
| petrol (gasoline) | fuel for cars |
| paraffin (kerosene) | |
| diesel | fuel for diesel engines |
| bitumen | |

**(ii)** Name one **other** fraction obtained from petroleum.

.....
[3]

**(c)** Fractional distillation of petroleum does not produce sufficient of some fractions to match demand.
Cracking is used to convert large hydrocarbon molecules into smaller molecules that are more in demand.

A hydrocarbon of molecular formula $C_{12}H_{26}$ is cracked.

**(i)** Suggest the formula of one **alkane** that may be produced.

.....

**(ii)** Suggest the formula of one **alkene** that may be produced.

.....

**(iii)** Describe a chemical test that can be used to distinguish between an alkene and an alkane.

chemical test .....

result with alkane .....

result with alkene .....
[4]

**A4** Carbon dioxide is a greenhouse gas. Carbon dioxide is given a greenhouse factor of 1. Other gases are given a greenhouse factor that compares their effect with carbon dioxide. The greenhouse effect increases as the factor value increases. The table gives some information about four different gases.

| gas | greenhouse factor | percentage of gas in the atmosphere |
|---|---|---|
| $CO_2$ | 1 | 0.036 |
| $CH_4$ | 30 | 0.0017 |
| $N_2O$ | 160 | $3.0 \times 10^{-4}$ |
| $CCl_3F$ | 21000 | $2.8 \times 10^{-8}$ |

**(a)** State **one** possible consequence of an increased greenhouse effect.

.....[1]

**(b)** Give **one** source of methane.

.....[1]

**(c)** Why is an increase in the percentage of methane more worrying than the same percentage increase of carbon dioxide?

.....

.....[1]

**(d)** What other environmental problem, beside its action as a greenhouse gas, is caused by $CCl_3F$?

.....[1]



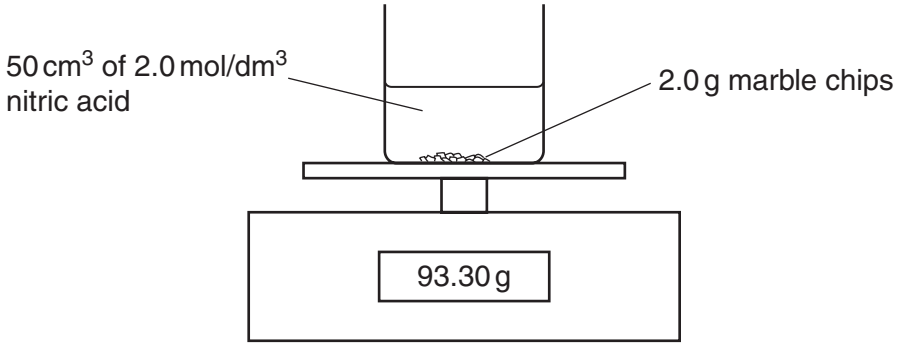
**[Turn over**

**A5** Marble statues are being damaged by acid rain. The chemical name for marble is calcium carbonate.

A student investigated the reaction between marble chips and nitric acid.

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

The diagram shows the apparatus the student used.




The student recorded the balance reading every minute.

The table shows the results.

| time / minutes | balance reading / g |
|---|---|
| 0 | 93.30 |
| 1 | 93.28 |
| 2 | 93.26 |
| 3 | 93.24 |
| 4 | 93.22 |
| 5 | 93.21 |
| 6 | 93.20 |
| 7 | 93.19 |
| 8 | 93.18 |
| 9 | 93.17 |
| 10 | 93.16 |
| 11 | 93.15 |
| 12 | 93.15 |
| 13 | 93.14 |
| 14 | 93.14 |

**(a)** Explain why the balance reading decreases during the experiment.

.....

.....[1]

**(b)** How can the student tell when the reaction has finished?

.....

.....[1]

**(c)** **(i)** Calculate the number of moles of nitric acid in 50 $cm^3$ of 2.0 mol / $dm^3$ solution.

**(ii)** Calculate the number of moles of calcium carbonate in 2.0 g.

**(iii)** Which reagent, calcium carbonate or nitric acid, is in excess?
Explain your answer.

[5]

**(d)** The student repeats the experiment using the same quantities of calcium carbonate and nitric acid. This time the acid is at a higher temperature. Describe and explain, in terms of collisions between reacting particles, the effect of increasing the temperature on the rate of reaction.

.....

.....

.....[2]

**A6** A student adds aqueous sodium hydroxide from a burette into 25.0 $cm^3$ of dilute sulphuric acid. The student measures the pH value of the mixture during the addition of the sodium hydroxide.

**(a)** Describe how the pH value changes.

.....[1]

**(b)** Give an ionic equation to represent the neutralisation reaction between sodium hydroxide and sulphuric acid.

.....[1]

**(c)** Sulphuric acid is a strong acid.

**(i)** What is meant by the term *acid*?

.....

.....

**(ii)** What is the difference between a strong acid and a weak acid?

.....

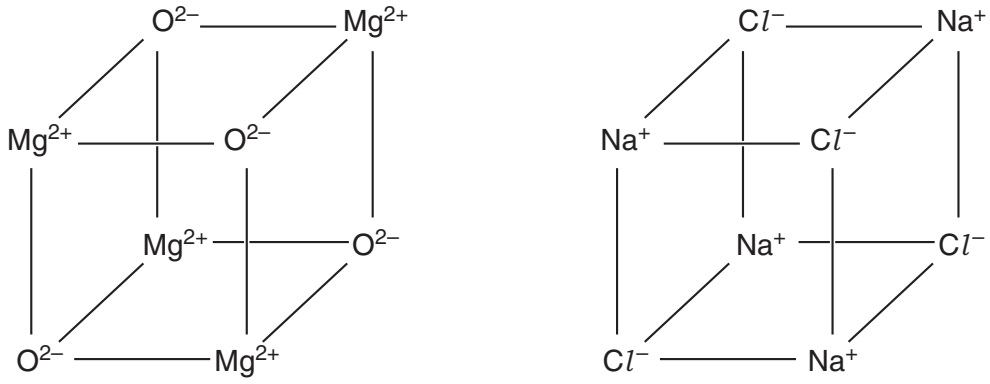
.....

.....
[3]

**(d)** Dilute sulphuric acid reacts with magnesium to give hydrogen.
Give the ionic equation for this reaction.

.....[1]

**A7** The structures of two ionic lattices are shown below.




magnesium oxide

sodium chloride

**(a)** Explain why these two solids do not conduct electricity.

.....

.....[1]

**(b)** **(i)** Explain why magnesium oxide has a very high melting point.

.....

.....

**(ii)** Suggest why the melting point of magnesium oxide is much higher than that of sodium chloride.

.....

.....

.....

[2]

**(c)** Draw the electronic structure of a magnesium ion and of an oxide ion.

magnesium ion

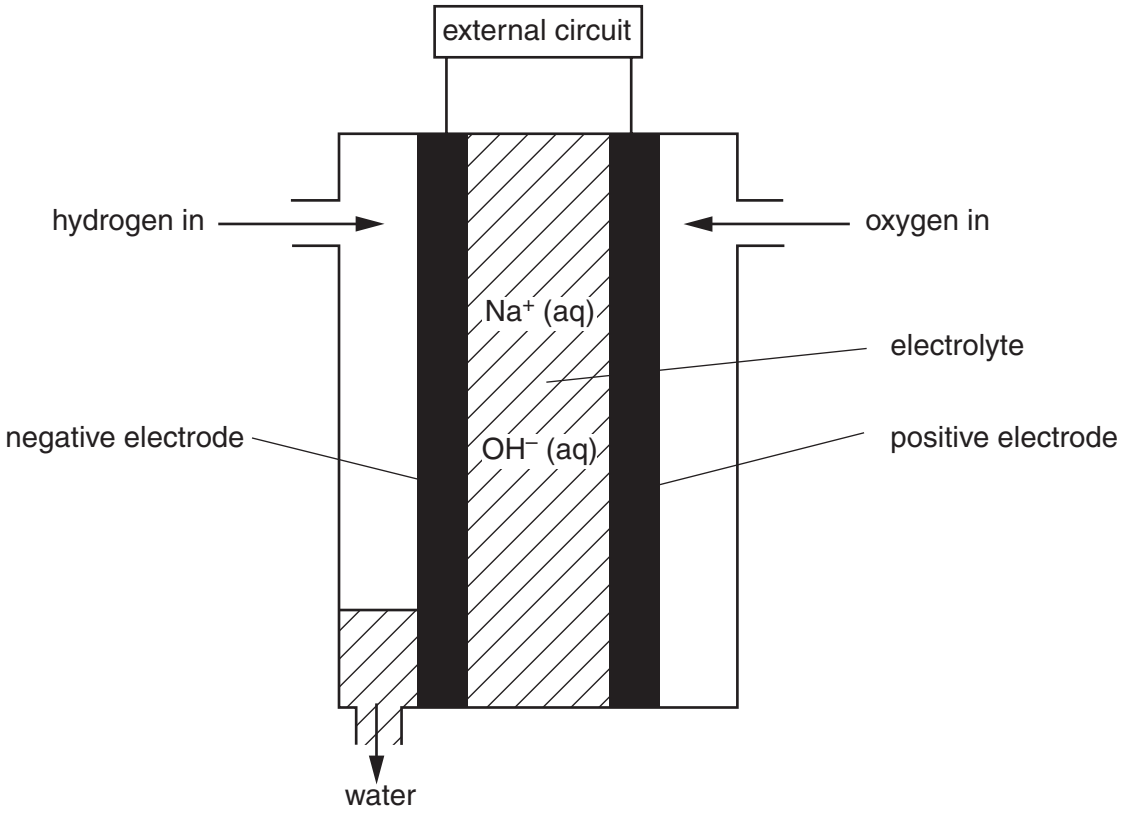
oxide ion

[2]

## Section B

Answer **three** questions from this section.

**B8** The NASA space shuttle uses fuel cells to generate electricity. The diagram below shows a hydrogen-oxygen fuel cell.




At the positive electrode, oxygen reacts with water as shown.

$$O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$$

At the negative electrode, hydrogen reacts with hydroxide ions as shown.

$$H_2(g) + 2OH^-(aq) \longrightarrow 2H_2O(l) + 2e^-$$

The overall reaction in the fuel cell is the reaction between hydrogen and oxygen to make water.

**(a)** Give **one** source for hydrogen and **one** source for oxygen for use in a fuel cell. [2]

**(b)** What is the name of the electrolyte used in the fuel cell? [1]

**(c)** What type of reaction takes place, reduction or oxidation, at the positive electrode? Explain your answer. [1]

**(d)** A fuel cell uses 240 $dm^3$ of hydrogen. Calculate the volume of oxygen needed, and the mass of water formed. All gas volumes measured at room temperature and pressure. [3]

**(e)** Describe some advantages and disadvantages of using a fuel cell to generate electricity. [3]

**B9** The table gives information about the first five members of the homologous series of carboxylic acids.

| name of acid | formula | relative molecular mass | melting point / °C | boiling point / °C |
|---|---|---|---|---|
| methanoic acid | $HCO_2H$ | 46 | 8.4 | 101 |
| ethanoic acid | $CH_3CO_2H$ | 60 | 17 | 118 |
| propanoic acid | $C_2H_5CO_2H$ | 74 | –22 | 141 |
| butanoic acid | $C_3H_7CO_2H$ | 88 | –8 | 164 |
| pentanoic acid | | | | |

**(a)** **(i)** Predict the formula and the relative molecular mass for pentanoic acid.

**(ii)** Explain why it is easier to predict the boiling point of pentanoic acid than the melting point.

[3]

**(b)** Draw the displayed formula for propanoic acid. [1]

**(c)** Analysis of an organic acid isolated from red ants shows that it contains 0.060 g of carbon, 0.010 g of hydrogen and 0.16 g of oxygen.
Calculate the empirical formula for this acid. [2]

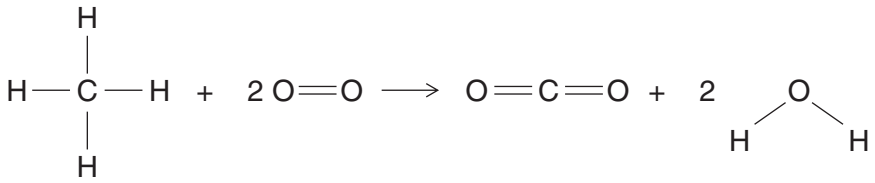
**(d)** Ethanoic acid reacts with magnesium oxide.
Name the products formed and write a balanced equation for the reaction. [2]

**(e)** Describe how ethanoic acid can be converted into ethyl ethanoate. [2]



**[Turn over**

**B10** Methane, $CH_4$, is used as a fuel. The complete combustion of methane can be represented by the equation below.



$\Delta H = -890\,\text{kJ/mol}$

**(a)** Explain why this reaction is exothermic in terms of the energy changes that take place during bond breaking and bond making. [3]

**(b)** Calculate the energy released when 4.0 g of methane is completely combusted. [2]

**(c)** Draw the energy profile diagram for the complete combustion of methane.
Label on the diagram the activation energy and the enthalpy change. [3]

**(d)** Draw a 'dot and cross' diagram to show the bonding in methane.
You only need to draw the outer (valence) electrons of carbon. [2]

**B11** Coal-burning power stations produce sulphur dioxide and oxides of nitrogen.
These two gases cause acid rain.

**(a)** Nitric oxide, NO, is made in a power station when nitrogen and oxygen react together.
Write the equation for this reaction. [1]

**(b)** Many coal burning power stations are now fitted with a flue gas desulphurisation plant which removes sulphur dioxide and nitrogen dioxide from the gaseous emissions.

In a flue gas desulphurisation plant, powdered calcium carbonate reacts with sulphur dioxide as shown.

$$SO_2(g) + CaCO_3(s) \longrightarrow CaSO_3(s) + CO_2(g)$$

**(i)** Suggest why the calcium carbonate is powdered. [1]

**(ii)** Calculate the mass of calcium carbonate needed to react with 8000 kg of sulphur dioxide. [3]

**(iii)** Nitrogen dioxide also reacts with calcium carbonate. Suggest the name of the solid product of this reaction. [1]

**(c)** In the air sulphur dioxide reacts with nitrogen dioxide forming sulphur trioxide. The reactions that take place are shown in the equations.

$$SO_2 + NO_2 \longrightarrow SO_3 + NO$$

$$2NO + O_2 \longrightarrow 2NO_2$$

Suggest the role of nitrogen dioxide in these reactions. Explain your answer. [2]

**(d)** Sulphur dioxide is used in the Contact process to make sulphuric acid.
Describe the conditions and name the catalyst in the Contact process. [2]

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# DATA SHEET
## The Periodic Table of the Elements

| Group | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | II | | | | | | | | | | | III | IV | V | VI | VII | 0 |
| | | | | | | | 1 H Hydrogen 1 | | | | | | | | | | 4 He Helium 2 |
| 7 Li Lithium 3 | 9 Be Beryllium 4 | | | | | | | | | | | 11 B Boron 5 | 12 C Carbon 6 | 14 N Nitrogen 7 | 16 O Oxygen 8 | 19 F Fluorine 9 | 20 Ne Neon 10 |
| 23 Na Sodium 11 | 24 Mg Magnesium 12 | | | | | | | | | | | 27 Al Aluminium 13 | 28 Si Silicon 14 | 31 P Phosphorus 15 | 32 S Sulphur 16 | 35.5 Cl Chlorine 17 | 40 Ar Argon 18 |
| 39 K Potassium 19 | 40 Ca Calcium 20 | 45 Sc Scandium 21 | 48 Ti Titanium 22 | 51 V Vanadium 23 | 52 Cr Chromium 24 | 55 Mn Manganese 25 | 56 Fe Iron 26 | 59 Co Cobalt 27 | 59 Ni Nickel 28 | 64 Cu Copper 29 | 65 Zn Zinc 30 | 70 Ga Gallium 31 | 73 Ge Germanium 32 | 75 As Arsenic 33 | 79 Se Selenium 34 | 80 Br Bromine 35 | 84 Kr Krypton 36 |
| 85 Rb Rubidium 37 | 88 Sr Strontium 38 | 89 Y Yttrium 39 | 91 Zr Zirconium 40 | 93 Nb Niobium 41 | 96 Mo Molybdenum 42 | Tc Technetium 43 | 101 Ru Ruthenium 44 | 103 Rh Rhodium 45 | 106 Pd Palladium 46 | 108 Ag Silver 47 | 112 Cd Cadmium 48 | 115 In Indium 49 | 119 Sn Tin 50 | 122 Sb Antimony 51 | 128 Te Tellurium 52 | 127 I Iodine 53 | 131 Xe Xenon 54 |
| 133 Cs Caesium 55 | 137 Ba Barium 56 | 139 La Lanthanum 57 * | 178 Hf Hafnium 72 | 181 Ta Tantalum 73 | 184 W Tungsten 74 | 186 Re Rhenium 75 | 190 Os Osmium 76 | 192 Ir Iridium 77 | 195 Pt Platinum 78 | 197 Au Gold 79 | 201 Hg Mercury 80 | 204 Tl Thallium 81 | 207 Pb Lead 82 | 209 Bi Bismuth 83 | Po Polonium 84 | At Astatine 85 | Rn Radon 86 |
| Fr Francium 87 | 226 Ra Radium 88 | 227 Ac Actinium 89 † | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 Ce Cerium 58 | 141 Pr Praseodymium 59 | 144 Nd Neodymium 60 | Pm Promethium 61 | 150 Sm Samarium 62 | 152 Eu Europium 63 | 157 Gd Gadolinium 64 | 159 Tb Terbium 65 | 162 Dy Dysprosium 66 | 165 Ho Holmium 67 | 167 Er Erbium 68 | 169 Tm Thulium 69 | 173 Yb Ytterbium 70 | 175 Lu Lutetium 71 |
| 232 Th Thorium 90 | Pa Protactinium 91 | 238 U Uranium 92 | Np Neptunium 93 | Pu Plutonium 94 | Am Americium 95 | Cm Curium 96 | Bk Berkelium 97 | Cf Californium 98 | Es Einsteinium 99 | Fm Fermium 100 | Md Mendelevium 101 | No Nobelium 102 | Lr Lawrencium 103 |

*58-71 Lanthanoid series
†90-103 Actinoid series

Key: a = relative atomic mass; X = atomic symbol; b = proton (atomic) number

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