UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER



**CHEMISTRY** **0620/03**

Paper 3 (Extended) **October/November 2007**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
A copy of the Periodic Table is printed on page 16.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part questions.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| Total | |

This document consists of **13** printed pages and **3** blank pages.

*For Examiner's Use*

**1** A list of techniques used to separate mixtures is given below.

| | | | | |
|---|---|---|---|---|
| **fractional distillation** | **simple distillation** | **crystallization** | **filtration** | **diffusion** |

From the list choose the most suitable technique to separate the following.

water from aqueous copper(II) sulphate .....

helium from a mixture of helium and argon .....

copper(II) sulphate from aqueous copper(II) sulphate .....

ethanol from aqueous ethanol .....

barium sulphate from a mixture of water and barium sulphate ..... [5]

[Total: 5]

**2** The table below gives the number of protons, neutrons and electrons in atoms or ions.

| particle | number of protons | number of electrons | number of neutrons | symbol or formula |
|---|---|---|---|---|
| A | 9 | 10 | 10 | $^{19}_{9}F^-$ |
| B | 11 | 11 | 12 | |
| C | 18 | 18 | 22 | |
| D | 15 | 18 | 16 | |
| E | 13 | 10 | 14 | |

**(a)** Complete the table. The first line is given as an example. [6]

**(b)** Which atom in the table is an isotope of the atom which has the composition 11p, 11e and 14n? Give a reason for your choice.

.....

..... [2]

[Total: 8]

*For Examiner's Use*

**3** Magnesium reacts with bromine to form magnesium bromide.

**(a)** Magnesium bromide is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of outer electrons around the negative ion.
The electron distribution of a bromine atom is 2, 8, 18, 7.

Use x to represent an electron from a magnesium atom.
Use o to represent an electron from a bromine atom. [3]

**(b)** In the lattice of magnesium bromide, the ratio of magnesium ions to bromide ions is 1:2.

**(i)** Explain the term *lattice*.

.....

..... [2]

**(ii)** Explain why the ratio of ions is 1:2.

..... [1]

**(iii)** The reaction between magnesium and bromine is redox. Complete the sentences.

Magnesium is the ..... agent because it has

..... electrons.

Bromine has been ..... because it has .....

electrons. [4]

[Total: 10]

*For Examiner's Use*

**4** Zinc is extracted from zinc blende, ZnS.

**(a)** Zinc blende is heated in air to give zinc oxide and sulphur dioxide. Most of the sulphur dioxide is used to make sulphur trioxide. This is used to manufacture sulphuric acid. Some of the acid is used in the plant, but most of it is used to make fertilisers.

**(i)** Give another use of sulphur dioxide.

.....

[1]

**(ii)** Describe how sulphur dioxide is converted into sulphur trioxide.

.....

.....

.....

[3]

**(iii)** Name a fertiliser made from sulphuric acid.

.....

[1]

**(b)** Some of the zinc oxide was mixed with an excess of carbon and heated to 1000 °C. Zinc distils out of the furnace.

$$2ZnO + C \rightleftharpoons 2Zn + CO_2$$
$$C + CO_2 \rightarrow 2CO$$

**(i)** Name the **two** changes of state involved in the process of distillation.

.....

[2]

**(ii)** Why is it necessary to use an excess of carbon?

.....

.....

[2]

*For Examiner's Use*

**(c)** The remaining zinc oxide reacts with sulphuric acid to give aqueous zinc sulphate. This is electrolysed with inert electrodes (the electrolysis is the same as that of copper(II) sulphate with inert electrodes).
ions present: $Zn^{2+}(aq)$ $SO_4^{2-}(aq)$ $H^+(aq)$ $OH^-(aq)$

**(i)** Zinc forms at the negative electrode (cathode). Write the equation for this reaction.

..... [1]

**(ii)** Write the equation for the reaction at the positive electrode (anode).

..... [2]

**(iii)** The electrolyte changes from aqueous zinc sulphate to

..... [1]

**(d)** Give two uses of zinc.

1. .....

2. ..... [2]

[Total: 15]

*For Examiner's Use*

**5** Methylamine, $CH_3NH_2$, is a weak base. Its properties are similar to those of ammonia.

**(a)** When methylamine is dissolved in water, the following equilibrium is set up.

$$\underset{\text{base}}{CH_3NH_2} + \underset{\text{acid}}{H_2O} \rightleftharpoons CH_3NH_3^+ + OH^-$$

**(i)** Suggest why the arrows are not the same length.

.....

[1]

**(ii)** Explain why water is stated to behave as an acid and methylamine as a base.

.....

.....

[2]

**(b)** An aqueous solution of the strong base, sodium hydroxide, is pH 12. Predict the pH of an aqueous solution of methylamine which has the same concentration. Give a reason for your choice of pH.

.....

.....

[2]

**(c)** Methylamine is a weak base like ammonia.

**(i)** Methylamine can neutralise acids.

$$2CH_3NH_2 + H_2SO_4 \rightarrow \underset{\text{methylammonium sulphate}}{(CH_3NH_3)_2\,SO_4}$$

Write the equation for the reaction between methylamine and hydrochloric acid. Name the salt formed.

.....

.....

[2]

**(ii)** When aqueous methylamine is added to aqueous iron(II) sulphate, a green precipitate is formed. What would you see if iron(III) chloride solution had been used instead of iron(II) sulphate?

.....

[1]

**(iii)** Suggest the name of a reagent that will displace methylamine from one of its salts, for example methylammonium sulphate.

.....

[1]

[Total: 9]

**6** The alcohols form a homologous series. The first four members are methanol, ethanol, propan-1-ol and butan-1-ol.

**(a)** One characteristic of a homologous series is that the physical properties vary in a predictable way. The table below gives the heats of combustion of the first three alcohols.

| alcohol | formula | heat of combustion in kJ / mol |
|---|---|---|
| methanol | $CH_3OH$ | -730 |
| ethanol | $CH_3$-$CH_2$-OH | -1370 |
| propan-1-ol | $CH_3$-$CH_2$-$CH_2$-OH | -2020 |
| butan-1-ol | $CH_3$-$CH_2$-$CH_2$-$CH_2$-OH | |

**(i)** The minus sign indicates that there is less chemical energy in the products than in the reactants. What form of energy is given out by the reaction?

..... [1]

**(ii)** Is the reaction exothermic or endothermic?

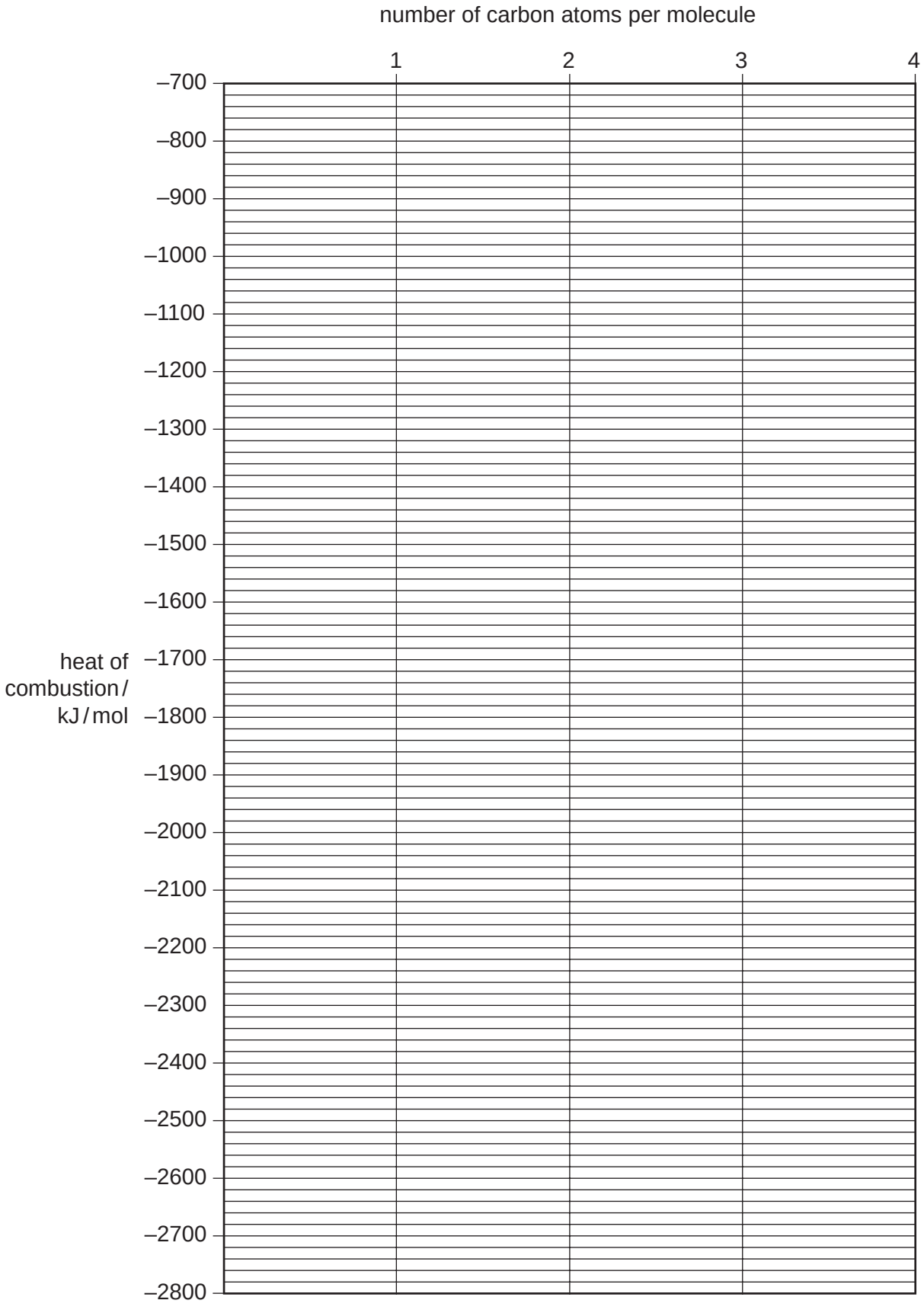
..... [1]

**(iii)** Complete the equation for the complete combustion of ethanol.

$C_2H_5OH$ + ..... $O_2 \rightarrow$ ..... + ..... [2]

**(iv)** Determine the heat of combustion of butan-1-ol by plotting the heats of combustion of the first three alcohols against the number of carbon atoms per molecule.

*For Examiner's Use*




The heat of combustion of butan-1-ol = ..... kJ / mol [3]

**(v)** Describe **two** other characteristics of homologous series.

.....

..... [2]

**(b)** Give the name and structural formula of an isomer of propan-1-ol.
structural formula

name ..... [2]

**(c)** Methanol is made from carbon monoxide.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ the forward reaction is exothermic

**(i)** Describe how hydrogen is obtained from alkanes.

.....

..... [2]

**(ii)** Suggest a method of making carbon monoxide from methane.

..... [2]

**(iii)** Which condition, high or low pressure, would give the maximum yield of methanol? Give a reason for your choice.

pressure .....

reason ..... [2]

**(d)** For each of the following predict the name of the organic product.

**(i)** reaction between methanol and ethanoic acid

..... [1]

**(ii)** oxidation of propan-1-ol by potassium dichromate(VI)

..... [1]

**(iii)** removal of $H_2O$ from ethanol (dehydration)

..... [1]

[Total: 20]

*For Examiner's Use*

**7** **(a)** A small piece of marble, calcium carbonate, was added to 5 $cm^3$ of hydrochloric acid at 25 °C. The time taken for the reaction to stop was measured.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

Similar experiments were performed always using 5 $cm^3$ of hydrochloric acid.

| experiment | number of pieces of marble | concentration of acid in mol / $dm^3$ | temperature / °C | time / min |
|---|---|---|---|---|
| 1 | 1 | 1.00 | 25 | 3 |
| 2 | 1 | 0.50 | 25 | 7 |
| 3 | 1 piece crushed | 1.00 | 25 | 1 |
| 4 | 1 | 1.00 | 35 | 2 |

Explain each of the following in terms of **collisions between reacting particles.**

**(i)** Why is the rate in experiment 2 slower than in experiment 1?

.....

..... [2]

**(ii)** Why is the rate in experiment 3 faster than in experiment 1?

.....

..... [2]

**(iii)** Why is the rate in experiment 4 faster than in experiment 1?

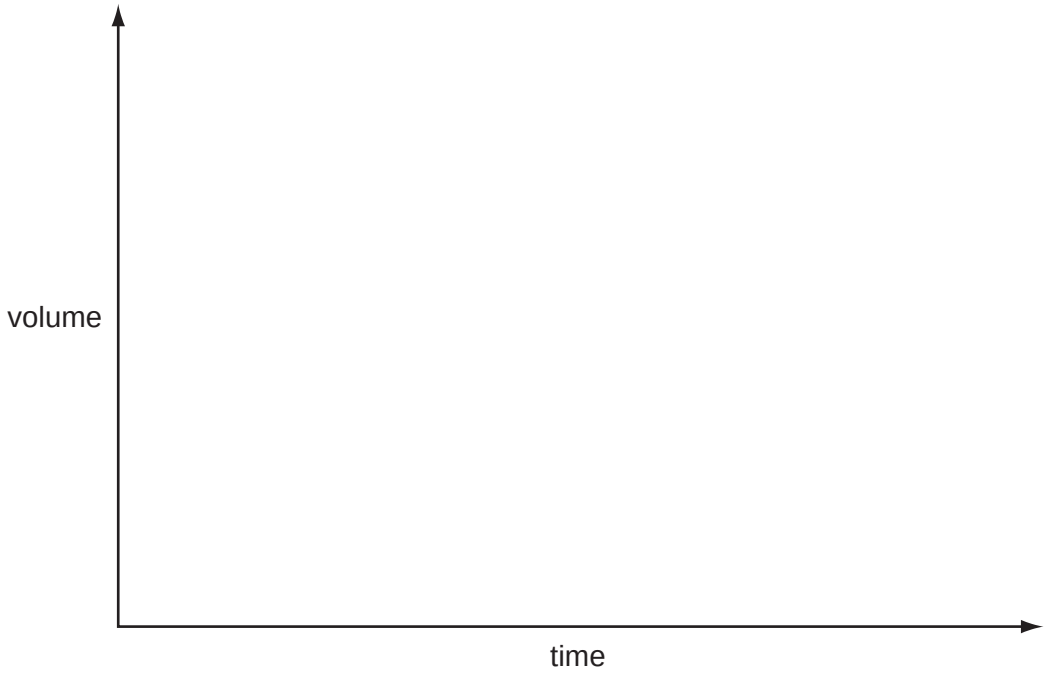
.....

..... [2]

*For Examiner's Use*

**(b)** An alternative method of measuring the rate of this reaction would be to measure the volume of carbon dioxide produced at regular intervals.

**(i)** Sketch this graph




[2]

**(ii)** One piece of marble, 0.3 g, was added to 5 $cm^3$ of hydrochloric acid, concentration 1.00 mol / $dm^3$. Which reagent is in excess? Give a reason for your choice.

mass of one mole of $CaCO_3$ = 100 g

number of moles of $CaCO_3$ = .....

number of moles of $HCl$ = .....

reagent in excess is .....

reason ..... [4]

**(iii)** Use your answer to **(ii)** to calculate the maximum volume of carbon dioxide produced measured at r.t.p.

..... [1]

[Total: 13]

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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.).