UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

**CHEMISTRY** **5070/21**

Paper 2 Theory **May/June 2011**

**1 hour 30 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 soft 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.

**Section A**
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

**Section B**
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

A copy of the Periodic Table is printed on page 20.
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 question.

| For Examiner's Use | |
|---|---|
| Section A | |
| B6 | |
| B7 | |
| B8 | |
| B9 | |
| Total | |

This document consists of **17** printed pages and **3** blank pages.


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## Section A

For Examiner's Use

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

The total mark for this section is 45.

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

| | |
|---|---|
| $AgI$ | $C_2F_3Cl_3$ |
| $CH_4$ | $C_3H_6$ |
| $C_6H_6$ | $CuCl_2$ |
| $K_2Cr_2O_7$ | $KI$ |
| $MnO_2$ | $(NH_4)_2SO_4$ |
| $V_2O_5$ | $ZnSO_4$ |

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

Which is the formula of a compound that

**(a)** is a catalyst in the Contact process,

.....[1]

**(b)** in aqueous solution reacts with aqueous sodium hydroxide to give a white precipitate that redissolves in excess sodium hydroxide,

.....[1]

**(c)** is an insoluble salt,

.....[1]

**(d)** is involved in ozone depletion in the upper atmosphere,

.....[1]

**(e)** in aqueous solution will react with aqueous barium chloride to make a white precipitate,

.....[1]

**(f)** is an alkane,

.....[1]

**(g)** is used as a fertiliser?

.....[1]

[Total: 7]

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**A2** Small pieces of copper were added to excess concentrated sulfuric acid and the mixture heated for 30 minutes. A colourless gas **Z** was formed. When **Z** was tested with filter paper dipped into acidified potassium dichromate(VI), there was a colour change from orange to green.

*For Examiner's Use*

The reaction mixture was cooled and then diluted with water. A blue solution, **Y**, was formed. Aqueous sodium hydroxide was added drop by drop to the blue solution. Eventually a blue precipitate, **X**, was formed. On heating the blue precipitate turned black to form compound **V**. Analysis of **V** showed that it contained 79.9 % copper and 20.1 % oxygen by mass.

**(a)** Name gas **Z**.

.....[1]

**(b)** Name the blue solution **Y**.

.....[1]

**(c)** When aqueous sodium hydroxide was added to the cooled reaction mixture, it initially reacted with excess sulfuric acid.
Write the ionic equation for this reaction.

[1]

**(d)** **(i)** Name the blue precipitate **X**.

.....[1]

**(ii)** Write an ionic equation, including state symbols, to show the formation of this blue precipitate.

[2]

**(e)** Calculate the empirical formula of the black solid **V**.

empirical formula of **V** is ..... [2]

[Total: 8]

**A3** Uranium is a radioactive metal. It has two main isotopes, uranium-235 with a nucleon number of 235 and uranium-238 with a nucleon number of 238.

*For Examiner's Use*

**(a) (i)** State one similarity, in terms of sub-atomic particles, between uranium-235 and uranium-238.

.....

.....[1]

**(ii)** State one difference, in terms of sub-atomic particles, between uranium-235 and uranium-238.

.....

.....[1]

**(b)** Uranium is manufactured from uranium(IV) oxide, $UO_2$, in a two-step process.

Step **1** – uranium(IV) oxide is heated with hydrogen fluoride to make uranium(IV) fluoride, $UF_4$, and water.

Step **2** – uranium(IV) fluoride is reduced by magnesium to give uranium and one other product.

**(i)** Construct the equation for step **1**.

[1]

**(ii)** Construct the equation for step **2**.

[1]

**(iii)** Step **2** involves a reduction.
Explain the meaning of the term *reduction*?

.....

.....

.....[1]

**(iv)** Calculate the mass of uranium that can be made from 1.00 tonne of uranium(IV) oxide.

[One tonne is one million grams.]

*For Examiner's Use*

mass of uranium = ..... tonnes [3]

**(c)** Uranium reacts with dilute hydrochloric acid to form hydrogen.
Using this information and your knowledge of the reactivity of metals, suggest where in the following reactivity series you would place uranium.

| | |
|---|---|
| **most reactive** | **potassium** |
| | **sodium** |
| | **calcium** |
| | **magnesium** |
| | **copper** |
| **least reactive** | **silver** |

.....[1]

[Total: 9]

**A4** Hydrogen peroxide, $H_2O_2$, is a covalent compound. Hydrogen peroxide decomposes to form water and oxygen.

*For Examiner's Use*

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

**(a)** Draw a 'dot-and-cross' diagram for a molecule of hydrogen peroxide.

[2]

**(b)** The decomposition of hydrogen peroxide involves a change from the liquid state to the gaseous state. Describe the difference in both the movement and arrangement of particles in a liquid and in a gas.

.....

.....

.....

.....[2]

**(c)** At room temperature pure hydrogen peroxide decomposes much faster than dilute aqueous hydrogen peroxide.
Explain why in terms of collision theory.

.....

.....

.....

.....[2]

**(d)** When aqueous iron(II) ions are warmed with aqueous hydrogen peroxide, iron(III) ions are formed.

**(i)** Construct an ionic equation for the oxidation of iron(II) ions to iron(III) ions.

[1]

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**(ii)** Describe a chemical test that can be used to confirm that iron(II) ions have been oxidised to form iron(III) ions.

.....

.....

.....

.....[2]

**(e)** Aqueous hydrogen peroxide was added to acidified aqueous potassium manganate(VII). The purple solution turned colourless.

Aqueous hydrogen peroxide was added to acidified aqueous potassium iodide. The colourless solution turned brown.

What deductions can you make about hydrogen peroxide from these two observations? Explain your answer.

.....

.....

.....

.....[2]

[Total: 11]

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**[Turn over**

**A5** Clean, dry air contains a mixture of gases including oxygen, nitrogen, carbon dioxide and the noble gases.

*For Examiner's Use*

**(a)** Give the percentage by volume of nitrogen in clean, dry air.

.....[1]

**(b)** State and explain how oxygen is extracted from air.

.....

.....

.....

.....

.....[3]

**(c)** Explain how the carbon cycle helps to keep the composition of air relatively constant.

.....

.....

.....

.....

.....

.....

.....

.....[4]

**(d)** Many electricity power stations burn fossil fuels. Sulfur dioxide is a pollutant produced during the burning of fossil fuels. Sulfur dioxide causes acid rain.

Describe **two** ways in which calcium carbonate can be used to reduce the effects of burning fossil fuels.

1 .....

.....

2 .....

.....[2]

[Total: 10]

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## Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

**B6** Electrolysis involves the chemical decomposition of a compound, either when molten or in aqueous solution, by the passage of an electric current.

**(a)** Explain why aqueous calcium nitrate can be electrolysed but liquid pentane cannot.

.....

.....

.....

.....[2]

**(b)** State the products of the electrolysis of molten sodium chloride.

.....[1]

**(c)** State the products of the electrolysis of concentrated aqueous sodium chloride.

.....[1]

**(d)** Describe the essential details of the manufacture of aluminium by electrolysis.

.....

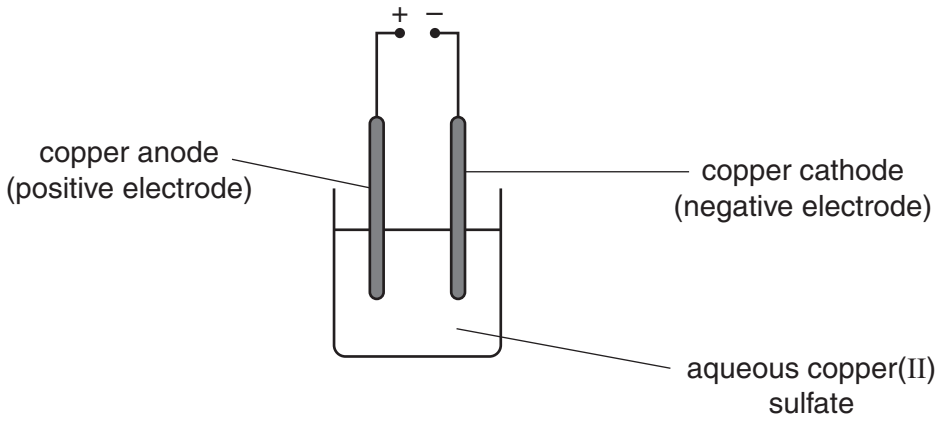
.....

.....

.....[2]

For Examiner's Use

**(e)** A student investigates the electrolysis of aqueous copper(II) sulfate using the apparatus shown below.




The student weighs the copper cathode before and after the electrolysis.

| experiment number | current used / A | time taken / s | mass of cathode | |
|---|---|---|---|---|
| | | | before starting / g | after electrolysis / g |
| 1 | 2.0 | 180 | 1.24 | 1.36 |
| 2 | 4.0 | 180 | 1.20 | 1.44 |
| 3 | 2.0 | 360 | 1.34 | 1.58 |

**(i)** Explain, with the aid of an equation, why the cathode increases in mass.

.....

.....

.....[2]

**(ii)** In experiment **2** the student measures the mass of the anode both before and after the electrolysis.
At the start the anode has a mass of 1.45 g.
Determine the mass of the anode at the end of the electrolysis.

mass of anode at end = ..... g [1]

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**(iii)** The student does a fourth experiment, this time using a current of 8.0 A for 90 seconds. At the start the cathode has a mass of 1.51 g.
Predict the mass of the cathode at the end of the electrolysis.

*For Examiner's Use*

mass of cathode at end = ..... g [1]

[Total: 10]

**B7** Alcohols are a homologous series of organic compounds.
The table shows some information about the first five alcohols.

*For Examiner's Use*

| name | molecular formula |
|---|---|
| methanol | $CH_4O$ |
| ethanol | $C_2H_6O$ |
| | $C_3H_8O$ |
| butanol | $C_4H_{10}O$ |
| pentanol | $C_5H_{12}O$ |

**(a)** Suggest the name of the alcohol with the molecular formula $C_3H_8O$.

.....[1]

**(b)** Draw the structure of an alcohol with the molecular formula $C_4H_{10}O$ and explain why this alcohol is saturated.

.....

.....[2]

**(c)** Deduce the molecular formula of an alcohol that contains seven carbon atoms.

.....[1]

**(d)** Ethanol reacts with ethanoic acid to form ethyl ethanoate.

**(i)** Draw the structure of ethyl ethanoate.

[1]

**(ii)** Suggest a use for ethyl ethanoate.

.....[1]

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**(e)** Describe, with the aid of an equation, how ethanol is manufactured by fermentation.

*For Examiner's Use*

.....

.....

.....

.....

.....[3]

**(f)** When ethanol is heated with concentrated sulfuric acid a colourless gas, **A**, is produced. Gas **A** will decolourise aqueous bromine.

Identify gas **A**.

.....[1]

[Total: 10]

**B8** Ethanoic acid is manufactured by a reaction between methanol, $CH_3OH$, and carbon monoxide.

For Examiner's Use

$$CH_3OH + CO \rightleftharpoons CH_3COOH \quad \Delta H = -137\,kJ\,mol^{-1}$$

This reaction is exothermic.

**(a)** The reaction is carried out at a pressure of 30 atmospheres and a temperature of 180 °C.

**(i)** Predict and explain the effect on the position of equilibrium if the reaction is carried out at 30 atmospheres pressure and **20 °C** rather than 180 °C.

.....

.....

.....[2]

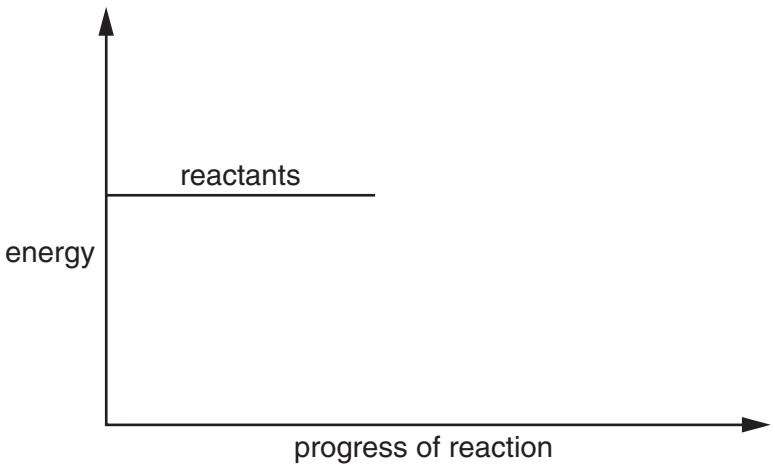
**(ii)** Suggest one reason why the reaction is carried out at 180 °C rather than 20 °C.

.....

.....[1]

**(b)** Complete the energy profile diagram for the reaction between methanol and carbon monoxide.
On your diagram label the

- product,
- activation energy, $E_a$,
- enthalpy change for the reaction, $\Delta H$.




[3]

**(c)** The manufacture of ethanoic acid from methanol also uses a catalyst to increase the speed of reaction.
Explain how a catalyst increases the speed of reaction.

For Examiner's Use

.....

.....[1]

**(d)** In an investigation 10.0 moles of methanol are mixed with 20.0 moles of carbon monoxide.
At the end of the reaction 9.8 moles of ethanoic acid are formed.
Calculate the percentage yield of ethanoic acid.

percentage yield = ..... % [2]

**(e)** Ethanoic acid reacts with ammonia to form a salt.
Give the formula of this salt.

.....[1]

[Total: 10]

**B9** Sulfamic acid, $SO_3NH_3$, is a weak acid used to remove limescale from kettles.

*For Examiner's Use*

**(a)** Explain the meaning of the term *weak acid*?

.....

.....[1]

**(b)** The pH of an aqueous solution of sulfamic acid can be determined using a pH meter. Describe another way of estimating the pH of a solution of sulfamic acid.

.....

.....

.....[2]

**(c)** A 0.105 g sample of sulfamic acid is dissolved in 25.0 $cm^3$ of water. The sulfamic acid solution requires 10.8 $cm^3$ of 0.100 mol $dm^{-3}$ potassium hydroxide for complete neutralisation.

Calculate the number of moles of sulfamic acid that react with one mole of potassium hydroxide.

number of moles of sulfamic acid = ..... [3]

**(d)** Aqueous sulfamic acid reacts with magnesium to form magnesium sulfamate, $Mg(SO_3NH_2)_2$.

**(i)** Write an equation for this reaction.

[1]

**(ii)** Limescale contains calcium carbonate. Describe, with the aid of an equation, how aqueous sulfamic acid reacts with calcium carbonate.

.....[2]

**(e)** Sulfamic acid reacts with sodium nitrite, $NaNO_2$, to form water, sodium hydrogensulfate, $NaHSO_4$, and a colourless gas.
Suggest the identity of the colourless gas.

.....[1]

[Total: 10]

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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 Sulfur 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 | 55 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 | 209 Po Polonium 84 | 210 At Astatine 85 | 222 Rn Radon 86 |
| 223 Fr Francium 87 | 226 Ra Radium 88 | 227 Ac Actinium 89 † | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 Ce Cerium 58 | 141 Pr Praseodymium 59 | 144 Nd Neodymium 60 | 147 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 | 231 Pa Protactinium 91 | 238 U Uranium 92 | 237 Np Neptunium 93 | 244 Pu Plutonium 94 | 243 Am Americium 95 | 247 Cm Curium 96 | 247 Bk Berkelium 97 | 251 Cf Californium 98 | 252 Es Einsteinium 99 | 257 Fm Fermium 100 | 258 Md Mendelevium 101 | 259 No Nobelium 102 | 260 Lr Lawrencium 103 |

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

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

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