



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Ordinary Level

CANDIDATE  
NAME

CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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**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	
<b>Section A</b>	
<b>B6</b>	
<b>B7</b>	
<b>B8</b>	
<b>B9</b>	
<b>Total</b>	

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

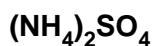
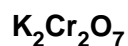
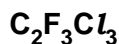


## Section A

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.



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]

**A2** Small pieces of copper were added to excess concentrated sulfuric acid and the mixture was 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.

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.

- (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,  $\text{UO}_2$ , in a two-step process.

**Step 1** – uranium(IV) oxide is heated with hydrogen fluoride to make uranium(IV) fluoride,  $\text{UF}_4$ , 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 oxide.

[One tonne is one million grams.]

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**

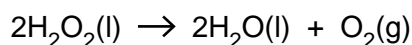
**potassium  
sodium  
calcium  
magnesium  
copper  
silver**

**least reactive**

.....[1]

[Total: 9]

- A4** Hydrogen peroxide,  $\text{H}_2\text{O}_2$ , is a covalent compound. Hydrogen peroxide decomposes into water and oxygen.



- (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]

- (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]

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

**(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]



## Section B

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]

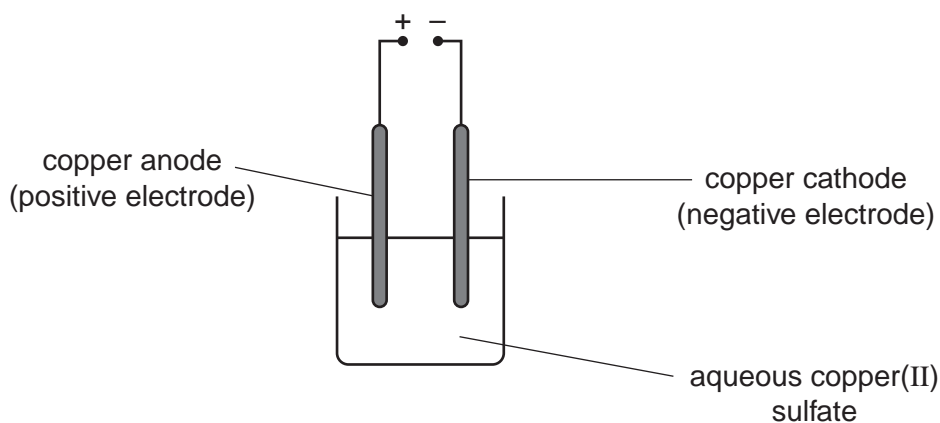
(c) State the products of the electrolysis of concentrated aqueous sodium chloride.

.....[1]

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

.....  
.....  
.....  
.....[2]

- (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]

- (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.

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.

name	molecular formula
methanol	$\text{CH}_4\text{O}$
ethanol	$\text{C}_2\text{H}_6\text{O}$
	$\text{C}_3\text{H}_8\text{O}$
butanol	$\text{C}_4\text{H}_{10}\text{O}$
pentanol	$\text{C}_5\text{H}_{12}\text{O}$

- (a) Suggest the name of the alcohol with the molecular formula  $\text{C}_3\text{H}_8\text{O}$ .

.....[1]

- (b) Draw the structure of an alcohol with the molecular formula  $\text{C}_4\text{H}_{10}\text{O}$  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]

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

.....  
.....  
.....  
.....  
.....[3]

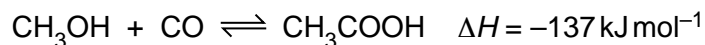
- (f) When ethanol is heated with concentrated sulfuric acid a colourless gas, **A**, is produced. Gas **A** will decolourise aqueous bromine.

Identify gas **A**.

.....[1]

[Total: 10]

**B8** Ethanoic acid is manufactured by a reaction between methanol,  $\text{CH}_3\text{OH}$ , and monoxide.



This reaction is exothermic.

**(a)** The reaction is carried out at a pressure of 30 atmospheres and a temperature of  $180^\circ\text{C}$ .

**(i)** Predict and explain the effect on the position of equilibrium if the reaction is carried out at 30 atmospheres pressure and  $20^\circ\text{C}$  rather than  $180^\circ\text{C}$ .

.....  
 .....  
 .....[2]

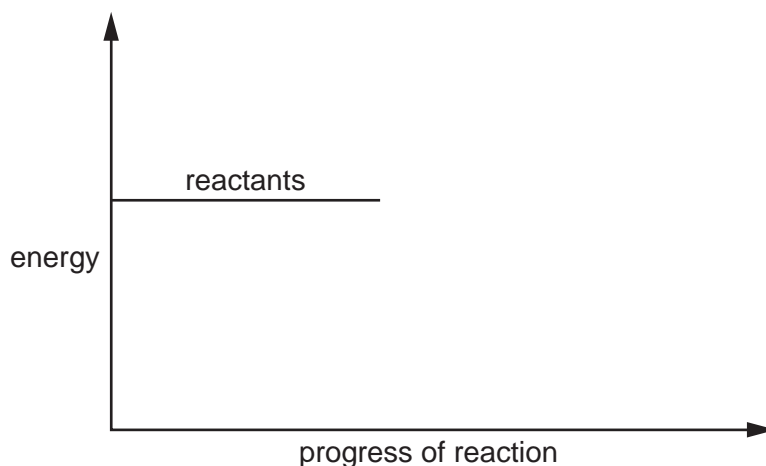
**(ii)** Suggest one reason why the reaction is carried out at  $180^\circ\text{C}$  rather than  $20^\circ\text{C}$ .

.....  
 .....[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.

.....  
.....[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,  $\text{SO}_3\text{NH}_2$ , is a weak acid used to remove limescale from kettles.

(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  $25.0\text{cm}^3$  of water. The sulfamic acid solution requires  $10.8\text{cm}^3$  of  $0.100\text{mol dm}^{-3}$  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,  $\text{Mg}(\text{SO}_3\text{NH}_2)_2$ .

(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,  $\text{NaNO}_2$ , to form water, sodium hydrogensulfate,  $\text{NaHSO}_4$ , and a colourless gas. Suggest the identity of the colourless gas.

.....[1]









## DATA SHEET

### The Periodic Table of the Elements

Group		I	II	III	IV	V	VI	VII	0																																								
		1 <b>H</b> Hydrogen 1							4 <b>He</b> Helium 2																																								
7 <b>Li</b> Lithium 4	9 <b>Be</b> Beryllium 4							16 <b>O</b> Oxygen 8	19 <b>F</b> Fluorine 9	20 <b>Ne</b> Neon 10																																							
23 <b>Na</b> Sodium 12	24 <b>Mg</b> Magnesium 12	11 <b>B</b> Boron 5	12 <b>C</b> Carbon 6	13 <b>Al</b> Aluminium 13	14 <b>Si</b> Silicon 14	15 <b>P</b> Phosphorus 15	16 <b>S</b> Sulfur 16	17 <b>Cl</b> Chlorine 17	18 <b>Ar</b> Argon 18																																								
39 <b>K</b> Potassium 3	40 <b>Ca</b> Calcium 20	27 <b>Ga</b> Gallium 31	28 <b>Ni</b> Nickel 28	29 <b>Cu</b> Copper 29	30 <b>Zn</b> Zinc 30	31 <b>As</b> Arsenic 33	32 <b>Ge</b> Germanium 32	33 <b>Br</b> Bromine 35	34 <b>Kr</b> Krypton 36																																								
85 <b>Rb</b> Rubidium 7	88 <b>Sr</b> Strontium 38	49 <b>In</b> Indium 49	50 <b>Ag</b> Silver 47	51 <b>Au</b> Gold 79	52 <b>Hg</b> Mercury 80	53 <b>Sb</b> Antimony 51	54 <b>Sn</b> Tin 50	55 <b>I</b> Iodine 53	56 <b>Xe</b> Xenon 54																																								
133 <b>Cs</b> Caesium 5	137 <b>Ba</b> Barium 56	81 <b>Tl</b> Thallium 81	78 <b>Pt</b> Platinum 78	79 <b>Au</b> Gold 79	80 <b>Hg</b> Mercury 80	83 <b>Bi</b> Bismuth 83	82 <b>Pb</b> Lead 82	85 <b>At</b> Astatine 85	86 <b>Rn</b> Radon 86																																								
223 <b>Fr</b> Francium 7	226 <b>Ra</b> Radium 88	204 <b>Po</b> Polonium 84	195 <b>Pt</b> Platinum 78	197 <b>Au</b> Gold 79	201 <b>Hg</b> Mercury 80	209 <b>Bi</b> Bismuth 83	207 <b>Pb</b> Lead 82	210 <b>At</b> Astatine 85	222 <b>Rn</b> Radon 86																																								
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