UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/21**

Paper 2 Theory **October/November 2012**

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	
B7	
B8	
B9	
B10	
Total	

This document consists of **18** printed pages and **2** blank pages.

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 (a) Define the term *element*.

..... [1]

(b) Choose from the following elements to answer the questions below.

aluminium

argon

bromine

gallium

helium

hydrogen

magnesium

nitrogen

oxygen

sodium

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

Which element

(i) is in Group III and Period 4 of the Periodic Table, ... [1]

(ii) has atoms with 8 electrons in their outer shell, ... [1]

(iii) is a liquid at room temperature, ... [1]

(iv) reduces unsaturated vegetable oils to form a solid product, ... [1]

(v) forms an ionic chloride with the formula XCl_2, ... [1]

(vi) is used in light bulbs? ..... [1]

(c) Draw the electronic structure of an aluminium atom.

For Examiner's Use

[1]

[Total: 8]

A2 Steel is more resistant to corrosion than iron.

For Examiner's Use

(a) What are the essential conditions for the corrosion of iron?

.....

..... [1]

(b) Ships' hulls can be prevented from corroding by attaching pieces of magnesium to them. Explain why this prevents the hulls from corroding.

.....

..... [2]

(c) Steel is an alloy.
Explain the meaning of the term *alloy*.

.....

..... [1]

(d) Samples of iron were placed in aqueous solutions having different pH values.
The table shows how the speed of corrosion of iron varies with the pH of the solution.

speed of corrosion/cm per year	0.043	0.029	0.012	0.010	0.010	0.010	0.009	0.006
pH	2	3	4	5	6	8	10	12

Describe how pH affects the speed of corrosion of iron.

.....

.....

..... [2]

[Total: 6]

A3 The table below shows both the formulae and boiling points of the first five members of the alcohol homologous series.

For Examiner's Use

alcohol	formula	boiling point /°C
methanol	CH_3OH	65
ethanol	C_2H_5OH	79
propanol	C_3H_7OH	98
butanol	C_4H_9OH	117
pentanol	$C_5H_{11}OH$	138

(a) (i) Deduce the formula of the sixth member of the alcohol homologous series.

..... [1]

(ii) Predict the boiling point of this alcohol.

..... [1]

(b) Ethanol can be made industrially by fermentation.
Describe one other method of making ethanol industrially, stating the conditions required for the reaction.

.....

.....

.....

..... [3]

(c) (i) Ethanol can be oxidised to ethanoic acid by atmospheric oxygen.
Name one other suitable oxidising agent which can be used.

..... [1]

(ii) Propanol can be oxidised to propanoic acid.
Draw the structure for propanoic acid.

[1]

[Total: 7]

[Turn over

A4 Water from natural sources, such as lakes and rivers, contains many dissolved substances.

For Examiner's Use

(a) Name two dissolved substances that occur naturally in unpolluted water from lakes and rivers.

..... [1]

(b) Pollution in lakes and rivers can be caused by leaching of fertilisers from farmland. This can cause eutrophication.

(i) Name two ions present in fertilisers which cause eutrophication.

..... [2]

(ii) Describe the essential stages in eutrophication.

.....

.....

.....

.....

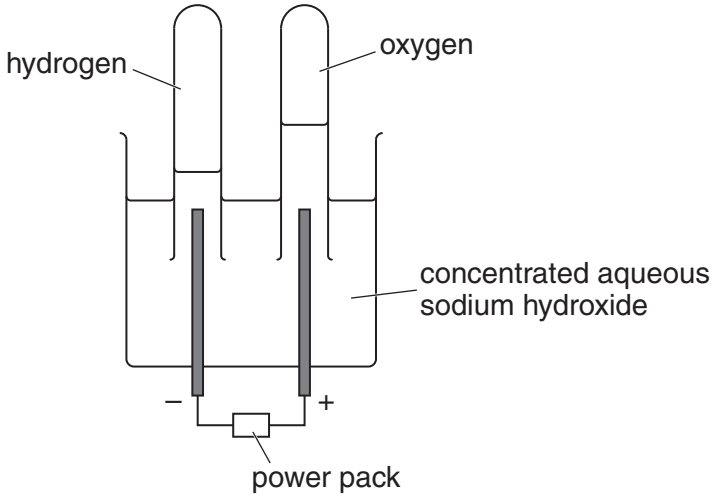
.....

..... [4]

[Total: 7]

A5 The diagram below shows the apparatus used to electrolyse aqueous sodium hydroxide in the laboratory.

For Examiner's Use



Electrolysis of the aqueous sodium hydroxide, results in the formation of hydrogen at the cathode (negative electrode) and oxygen at the anode (positive electrode).

(a) Complete the equation for the formation of oxygen at the anode.

$$.....OH^- \rightarrow O_2 + ...H_2O + ...$$ [1]

(b) (i) When the power pack is replaced by a voltmeter, the apparatus acts like a fuel cell. The left hand electrode in the diagram becomes the negative pole of the cell and the right hand electrode becomes the positive pole.

State the direction of the electron flow in the external circuit.
Give a reason for your answer.

.....

..... [1]

(ii) In this fuel cell, hydrogen reacts with aqueous hydroxide ions to form water.
Construct an equation for this reaction.

[1]

(c) (i) Suggest two advantages of using a fuel cell rather than petrol to power a car.

.....

.....

..... [2]

(ii) Suggest one disadvantage of fuel cells.

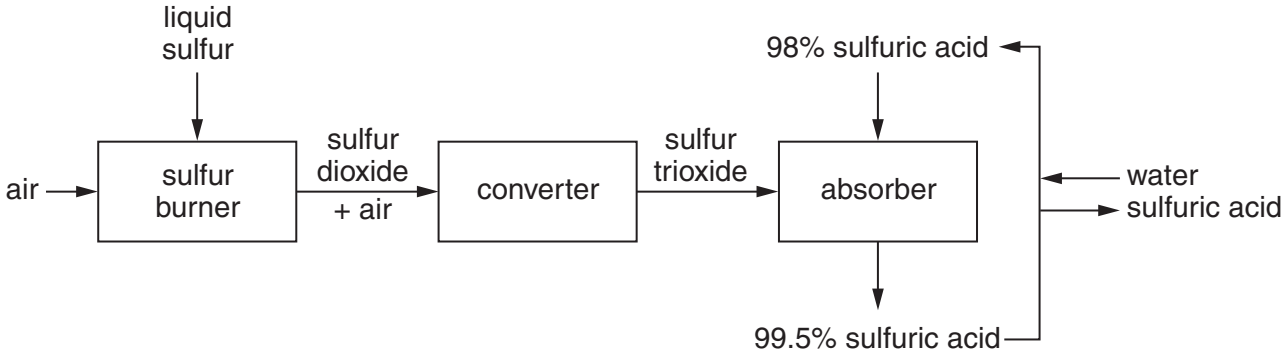
..... [1]

[Total: 6]

[Turn over

A6 A flow diagram for the manufacture of sulfuric acid is shown below.

For Examiner's Use



(a) In the sulfur burner, a spray of molten sulfur is burned in a furnace. Construct an equation for this reaction. Include state symbols.

[1]

(b) In the converter, the following reaction occurs:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -197\,kJ/mol$$

The yield of SO_3 is 95% at 450 °C and atmospheric pressure.

(i) Name the catalyst used in this reaction.

..... [1]

(ii) Explain why increasing the pressure shifts the position of equilibrium further to the right.

..... [1]

(iii) Explain why the reaction is carried out at atmospheric pressure even though an increase in pressure shifts the position of equilibrium further to the right.

..... [1]

(iv) Explain why the reaction is carried out at 450 °C and not at a higher or lower temperature.

.....

.....

..... [3]

(c) Sulfuric acid is formed from sulfur trioxide in two stages.
Firstly, the sulfur trioxide, SO_3, is absorbed in concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

$$SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7$$

The oleum is then mixed with water to form sulfuric acid.
Construct an equation for this reaction.

[1]

(d) Aqueous sulfuric acid is titrated with aqueous sodium hydroxide.

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

It requires 28.0 cm^3 of 0.100 mol/dm^3 aqueous sodium hydroxide to neutralise 9.50 cm^3 of sulfuric acid.
Calculate the concentration, in mol/dm^3, of the aqueous sulfuric acid.
Give your answer to 3 significant figures.

concentration of the aqueous sulfuric acid ..... mol/dm^3 [3]

[Total: 11]

[Turn over

Section B

For Examiner's Use

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

The total mark for this section is 30.

B7 Tin is a metal in Group IV of the Periodic Table.

(a) Draw a labelled diagram to show the structure of a metal.

[2]

(b) Explain why metals

(i) conduct electricity, ...

(ii) are malleable. .....

..... [2]

(c) At high temperatures, tin reacts with steam to form tin(II) oxide, SnO, and one other product.
This reaction is reversible.
The other product is a gas which gives a 'pop' with a lighted splint.

(i) Construct an equation for this reaction.

[1]

(ii) Tin(II) oxide is an amphoteric oxide.
Explain the meaning of the term *amphoteric oxide*.

..... [1]

(d) **(i)** Concentrated nitric acid reacts with tin to form tin(IV) oxide, SnO_2, nitrogen dioxide and water.
Construct an equation for this reaction.

[1]

(ii) Nitric acid contains nitrate ions.
Describe a test for nitrate ions.
Give the result of a positive test.

For Examiner's Use

.....

.....

..... [3]

[Total: 10]

[Turn over

B8 Petroleum is separated into fractions by fractional distillation.

For Examiner's Use

(a) Explain how fractional distillation separates petroleum into different fractions.

.....

.....

.....

.....

..... [3]

(b) The refinery gas fraction contains the first four members of the alkane homologous series.

(i) Explain the meaning of the term *homologous series*.

.....

.....

..... [2]

(ii) Draw the structure, showing all atoms and bonds, of the two isomers of butane, the fourth member of the alkane homologous series.

[2]

(c) Construct an equation for the complete combustion of hexane, C_6H_{14}.

[1]

(d) When long-chained alkanes are cracked in an oil refinery, shorter-chained alkanes and alkenes are formed.

For Examiner's Use

(i) Explain why the process of cracking needs to be carried out.

.....

..... [1]

(ii) Describe a chemical test to distinguish between an alkane and an alkene.

test .....

result ..... [1]

[Total: 10]

[Turn over

B9 **(a)** Define the term *relative atomic mass*.

For Examiner's Use

.....

..... [1]

(b) The relative atomic mass of magnesium can be determined in the laboratory by finding the volume of hydrogen given off when magnesium reacts with hydrochloric acid.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

0.036 g of magnesium reacts at room temperature and pressure with excess hydrochloric acid to produce 36 cm^3 of hydrogen.
1 mole of any gas at room temperature and pressure occupies 24 dm^3.
Show by calculation that the relative atomic mass of magnesium is 24.

[3]

(c) Magnesium reacts with oxygen in the air to form magnesium oxide.

$$2Mg + O_2 \longrightarrow 2MgO$$

(i) If the yield of the reaction is 75% calculate the mass of magnesium oxide formed when 12 kg of magnesium burns in excess air.

[2]

(ii) Magnesium nitride is also formed when magnesium burns in air.
Magnesium nitride is an ionic compound.
Deduce the formula for magnesium nitride.

..... [1]

(d) When magnesium is heated with silicon, magnesium silicide, Mg_2Si, is formed. Magnesium silicide reacts with water to form silane, SiH_4, and magnesium oxide.

For Examiner's Use

(i) Construct an equation for the reaction of magnesium silicide with water.

[1]

(ii) Silane has a structure similar to methane.
Draw a 'dot-and-cross' diagram for silane.
Show only the outer shell electrons.

[1]

(iii) Silane reacts with oxygen to form silicon dioxide and water.
Construct an equation for this reaction.

[1]

[Total: 10]

B10 Limestone consists mainly of the compound calcium carbonate.

For Examiner's Use

(a) Explain why limestone is used in the blast furnace for the extraction of iron.
Include any relevant equations in your answer.

.....

.....

.....

.....

.....

..... [3]

(b) Group II carbonates decompose on heating.
The temperatures at which some Group II carbonates decompose are given in the table below.

Group II carbonate	decomposition temperature /°C
barium carbonate	1360
calcium carbonate	900
magnesium carbonate	540
strontium carbonate	1280

(i) Which one of these carbonates is least likely to decompose on heating?

..... [1]

(ii) Describe how the thermal stability of these carbonates changes with the reactivity of the metal.

..... [1]

(c) The speed of reaction of calcium carbonate with hydrochloric acid can be calculated by measuring the volume of gas given off at various time intervals.

For Examiner's Use

(i) Draw a labelled diagram of the apparatus you could use to follow the course of this reaction.

[2]

(ii) State and explain the effect of the following on the volume of a fixed mass of gas
- increasing the pressure,
- increasing the temperature.

.....

.....

.....

..... [3]

[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	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.).