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.

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International Examinations

[Turn over

Section A

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.

[1]

[Total: 8]

[Turn over

A2 Steel is more resistant to corrosion than iron.

(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]

5

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]

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

(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.

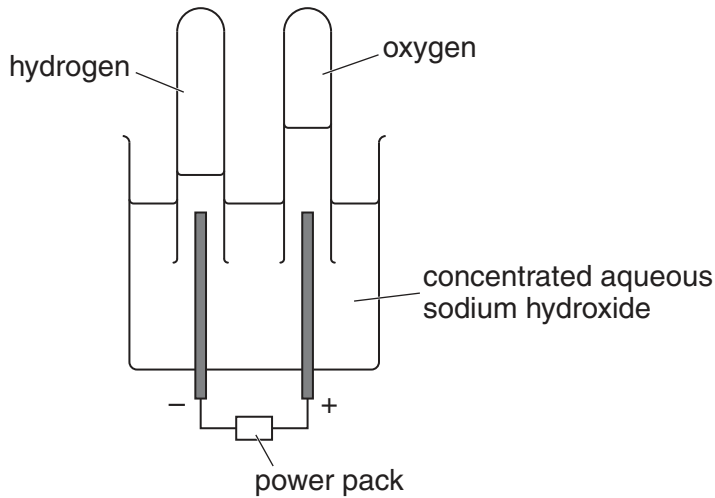**(i)** Name two ions present in fertilisers which cause eutrophication.

.... [2]

(ii) Describe the essential stages in eutrophication.

....

....

....

....

....

.... [4]
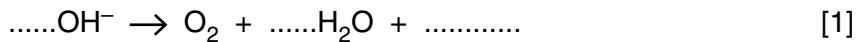
[Total: 7]

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

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.
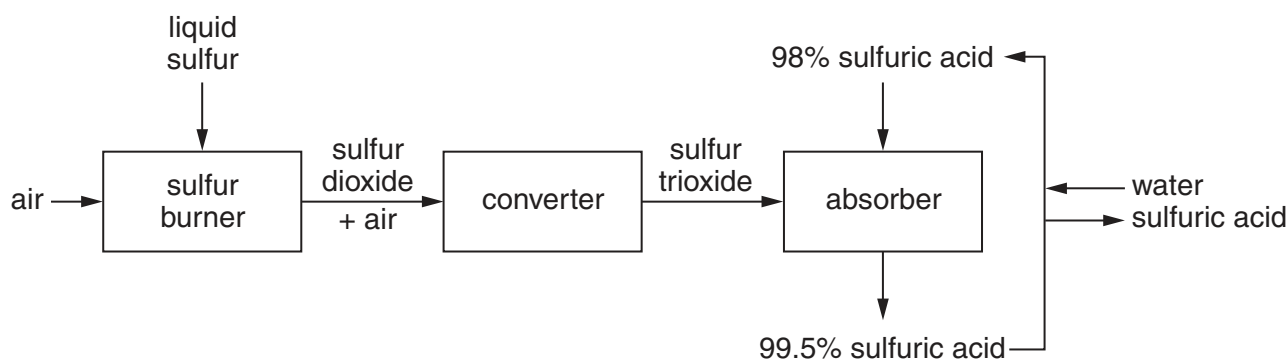
....

....

.... [2]

(ii) Suggest one disadvantage of fuel cells.

.... [1]

[Total: 6]

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

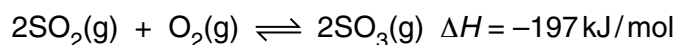**(a)** In the sulfur burner, a spray of molten sulfur is burned in a furnace.
Construct an equation for this reaction. Include state symbols.

.... [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.
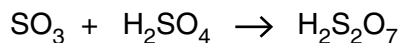
.... [1]

(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, $H_2S_2O_7$.

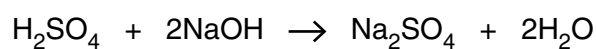$$SO_3 \ + \ H_2SO_4 \ \rightarrow \ H_2S_2O_7$$

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.

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

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]

For Examiner's Use

Section B

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.

....

....

.... [3]

[Total: 10]

 [Turn over

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B8 Petroleum is separated into fractions by fractional distillation.

(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.

(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]

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

....

.... [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.
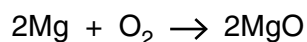
$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$
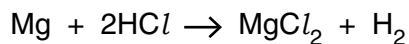
0.036 g of magnesium reacts at room temperature and pressure with excess hydrochloric acid to produce 36 cm^3 of hydrogen.
1 mole of any gas at room temperature and pressure occupies 24 dm^3.
Show by calculation that the relative atomic mass of magnesium is 24.

[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]

15

(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.

(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.

    (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
								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		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		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		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							

Transition elements:

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
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
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
227 **Ac** Actinium 89 †									

1 **H** Hydrogen 1

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

Lanthanoid series:

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

Actinoid series:

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

Key

a
X
b

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.).