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 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	
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 gases to answer the questions below.

ammonia	**carbon monoxide**
chlorine	**ethane**
fluorine	**methane**
neon	**nitrogen**
nitrogen monoxide	**oxygen**
propane	**propene**
sulfur dioxide	**sulfur trioxide**

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

Which gas

(a) turns moist red litmus paper blue,

..... [1]

(b) decolourises bromine water,

..... [1]

(c) is used in the manufacture of steel,

..... [1]

(d) is a monatomic element,

..... [1]

(e) is used as a food preservative,

..... [1]

(f) is used to disinfect water,

..... [1]

(g) is a molecule with 14 protons?

..... [1]

[Total: 7]

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A2 Iron(II) sulfate crystals decompose when heated to give three gases **U**, **V** and **W** and an orange-brown solid **T**.

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- Gas **U** was tested with filter paper soaked with acidified potassium dichromate(VI). The filter paper changed colour from orange to green.
- Analysis of gas **V** showed it contained 40.0% sulfur and 60.0% oxygen by mass.
- When gas **W** was condensed it formed a colourless liquid that turned anhydrous copper(II) sulfate from white to blue.

- Solid **T** was dissolved in dilute nitric acid. Aqueous ammonia was added drop by drop and a red-brown precipitate was obtained.

(a) (i) What is the formula for gas **U**?

..... [1]

(ii) Calculate the empirical formula of gas **V**.

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

(iii) Name gas **W**.

..... [1]

(iv) Give the name or the formula of the metal ion present in solid **T**.

..... [1]

(b) Iron(II) sulfate dissolves in water to give a green solution **X**. Aqueous sodium hydroxide was added drop by drop to solution **X**. A green precipitate, **Y**, was formed.

(i) Name precipitate **Y**.

..... [1]

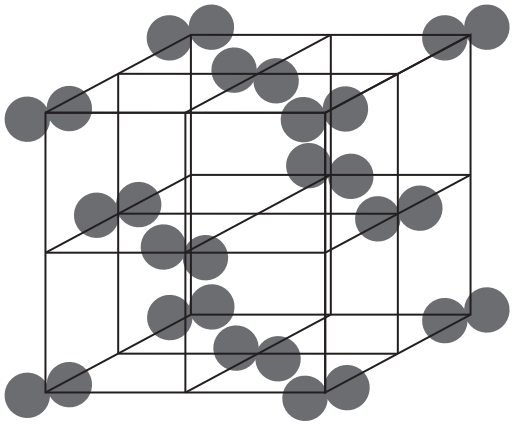
(ii) Construct the ionic equation, with state symbols, to show the formation of the precipitate, **Y**.

..... [2]

[Total: 8]

A3 Iodine forms a diatomic molecule, I_2.
It has a simple molecular structure.
The diagram shows the structure of the simple molecular lattice of iodine.

For Examiner's Use



Each iodine molecule is held in place by weak intermolecular forces.
Within each iodine molecule the atoms are covalently bonded.

(a) Explain why solid iodine does not conduct electricity.

.....

..... [1]

(b) When heated, **solid** iodine turns directly into iodine **gas**.
Use the kinetic particle theory to explain this change of state.

.....

.....

.....

..... [2]

(c) Draw a 'dot-and-cross' diagram to show the bonding in an iodine molecule.
Show only the outer shell electrons.

[1]

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(d) Chlorine, bromine, iodine and astatine are all in Group VII.

(i) What is the formula for an astatide ion?

..... [1]

(ii) Complete the table about the appearance at room temperature of the elements in Group VII.

element	atomic number	colour	state
Cl_2	17	green	
Br_2	35		
I_2	53		solid

[2]

(iii) Predict the appearance of astatine at room temperature.

..... [1]

(e) Chlorine is bubbled into aqueous potassium iodide.

(i) Describe what you would see.

..... [1]

(ii) Construct the ionic equation for the reaction that takes place.

..... [1]

(f) Explain why astatine will not react with aqueous potassium iodide.

.....

..... [1]

[Total: 11]

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[Turn over

A4 This question is about some Group II elements and their compounds.

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Magnesium reacts with oxygen to form magnesium oxide.

(a) The table shows information about the ions in magnesium oxide.

(i) Complete the table.

ion	electron configuration	number of protons	number of neutrons
$^{24}_{12}Mg^{2+}$	.....	.....	.....
$^{16}_{8}O^{2-}$	.....	.....	.....

[3]

(ii) Describe how a magnesium atom and an oxygen atom form a magnesium ion and an oxide ion.

.....

.....

..... [1]

(b) Explain, in terms of structure and bonding, why magnesium oxide has a very high melting point.

.....

.....

.....

..... [2]

(c) Barium sulfate is an insoluble salt.
Describe how a pure dry sample of barium sulfate can be prepared from aqueous barium chloride in a laboratory.

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 10]

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A5 Displacement reactions occur when a metal reacts with a metal compound.

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The table shows the results of some displacement reactions.

In each case a sample of powdered metal is added to an aqueous metal sulfate.

	aqueous copper(II) sulfate	aqueous iron(II) sulfate	aqueous magnesium sulfate	aqueous nickel(II) sulfate
copper		no reaction	no reaction	no reaction
iron	reaction		no reaction	reaction
magnesium	reaction	reaction		reaction
nickel	reaction	no reaction	no reaction	

(a) Place the four metals in order of increasing reactivity.

least reactive ……

……

……

most reactive ……. [1]

(b) Iron powder is added to aqueous copper(II) sulfate.

What you would observe in this reaction?

.....

..... [2]

(c) Aluminium foil is added to aqueous copper(II) chloride. A displacement reaction takes place. The temperature of the reaction mixture increases.

(i) Name the type of reaction in which the temperature of the reaction mixture increases.

..... [1]

(ii) Construct the ionic equation for this displacement reaction.

..... [1]

(d) Explain why, even though it is high up in the reactivity series, aluminium does not react with cold water.

.....

.....

..... [2]

(e) Molybdenum, atomic number 42, is manufactured by the displacement reaction between molybdenum(VI) oxide and aluminium.

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$$MoO_3 + 2Al \longrightarrow Mo + Al_2O_3$$

Calculate the mass of aluminium needed to make 1 tonne of molybdenum.
[1 tonne is one million grams.]

mass of aluminium = ... [2]

[Total: 9]

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 Seawater contains many dissolved ions. The table shows the concentration of some of these ions in a typical sample of seawater.

ion	formula	concentration / g/dm^3
chloride	Cl^-	19.00
sodium	Na^+	10.56
sulfate	SO_4^{2-}	2.65
magnesium	Mg^{2+}	1.26
calcium	Ca^{2+}	0.40
potassium	K^+	0.38
hydrogencarbonate	HCO_3^-	0.14

(a) Suggest the formula of one salt dissolved in seawater.

..... [1]

(b) Calculate the concentration, in mol/dm^3, of sulfate ions in seawater.

.....

.....

..... [1]

(c) Excess aqueous silver nitrate is added to a 25.0 cm^3 sample of seawater.
What mass of silver chloride is precipitated in this reaction?

$$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$$

.....

.....

.....

.....

..... [3]

(d) Some countries purify seawater to make drinking water.
Name the process by which seawater is purified into drinking water.

For Examiner's Use

..... [1]

(e) The pH of seawater is 7.9.

(i) State the formula of an ion, other than those in the table, which must be present in seawater to account for this pH. Explain your answer.

formula of ion .....

explanation .....

..... [2]

(ii) One way of measuring the pH of seawater is to use a pH meter.
Describe an alternative method of measuring the pH of seawater.

.....

.....

..... [2]

[Total: 10]

B7 Carboxylic acids are a homologous series of organic compounds.
The table shows some information about the first five carboxylic acids.

For Examiner's Use

name	molecular formula	melting point / °C	boiling point / °C
methanoic acid	CH_2O_2	8	101
ethanoic acid	$C_2H_4O_2$	17	118
propanoic acid	$C_3H_6O_2$	–21	141
	$C_4H_8O_2$	–6	164
pentanoic acid	$C_5H_{10}O_2$		

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

.....

.....

.....

..... [2]

(b) Suggest the name of the carboxylic acid with the molecular formula $C_4H_8O_2$.

..... [1]

(c) Draw the structure, showing all atoms and all bonds, of the carboxylic acid with the molecular formula $C_3H_6O_2$.

[1]

(d) Deduce the molecular formula for a molecule of a carboxylic acid that contains seven carbon atoms.

..... [1]

(e) Explain why it is easier to predict the boiling point of pentanoic acid rather than its melting point.

.....

.....

..... [1]

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[Turn over

(f) Ethanoic acid is a weak acid whereas hydrochloric acid is a strong acid.
Describe the difference between a *weak acid* and a *strong acid*.
Include equations in your answer.

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.....

.....

.....

..... [2]

(g) Powdered calcium carbonate, $CaCO_3$, is added to a sample of dilute ethanoic acid. The mixture fizzes and eventually forms a colourless solution.
Construct the equation, including state symbols, for this reaction.

..... [2]

[Total: 10]

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B8 Solid sodium hydroxide, NaOH, has a giant ionic structure.

For Examiner's Use

(a) How many electrons are there in one hydroxide ion?

..... [1]

(b) Explain why solid sodium hydroxide cannot be electrolysed but aqueous sodium hydroxide can be electrolysed.

.....

.....

..... [2]

(c) The electrolysis of aqueous sodium hydroxide produces hydrogen and oxygen as shown by the electrode reactions.

at anode $4OH^-(aq) \longrightarrow O_2(g) + 2H_2O(l) + 4e^-$

at cathode $2e^- + 2H_2O(l) \longrightarrow H_2(g) + 2OH^-(aq)$

Explain why the electrolysis of aqueous sodium hydroxide involves both oxidation **and** reduction.

.....

.....

.....

..... [2]

(d) The overall reaction for the electrolysis of aqueous sodium hydroxide is shown below.

For Examiner's Use

$$2H_2O(l) \longrightarrow 2H_2(g) + O_2(g)$$

This reaction is endothermic.

(i) Explain, in terms of the energy changes associated with bond breaking and bond forming, why the reaction is endothermic.

.....

.....

.....

..... [2]

(ii) Some submarines use this reaction to provide oxygen for the occupants to breathe.

Calculate the mass of water which must be electrolysed to make 2500 dm^3 of oxygen at room temperature and pressure.
[One mole of any gas at room temperature and pressure occupies a volume of 24 dm^3.]

mass of water = ... g [3]

[Total:10]

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B9 Hydrogen has many industrial uses. One possible way to manufacture hydrogen involves the reversible reaction between methane and steam.

For Examiner's Use

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +210\,kJ/mol$$

The reaction is carried out in the presence of a nickel catalyst. The conditions used are 30 atmospheres pressure and a temperature of 750 °C.

(a) If the temperature of the reaction mixture is **increased** to 900 °C, explain what happens to the position of equilibrium.

.....

.....

.....

..... [2]

(b) If the pressure of the reaction mixture is **increased** to 50 atmospheres explain, in terms of collisions between reacting particles, what happens to the speed of the forward reaction.

.....

.....

.....

..... [2]

(c) Explain the advantages of using a catalyst in this manufacture of hydrogen.

.....

.....

.....

..... [2]

(d) In the reaction, 210 kJ of heat energy is used to form 3.0 moles of hydrogen.

Calculate how much heat energy is needed to make 1000 kg of hydrogen.

heat energy = ... kJ [2]

(e) Describe how hydrogen is used to manufacture margarine.

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.....

.....

.....

..... [2]

[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.).