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 2013**

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.

Electronic calculators may be used.

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.

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 compounds to answer the questions below.

butane

calcium carbonate

carbon dioxide

copper(II) nitrate

iron(II) hydroxide

iron(III) hydroxide

propene

sodium chloride

sulfur dioxide

sulfuric acid

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

Name a compound which

(a) is a green solid,

..... [1]

(b) is a saturated hydrocarbon,

..... [1]

(c) has a molecule with only 9 atoms,

..... [1]

(d) can be used to reduce the acidity in lakes,

..... [1]

(e) will turn aqueous acidified potassium dichromate(VI) from orange to green,

..... [1]

(f) can be electrolysed in aqueous solution to form two gases.

..... [1]

[Total: 6]

A2 Photosynthesis helps to maintain the percentage of oxygen in air.

(a) What is the percentage, by volume, of oxygen in dry air?

..... [1]

(b) In addition to releasing oxygen, photosynthesis produces glucose, $C_6H_{12}O_6$.

Write the overall equation that represents photosynthesis.

..... [1]

(c) Describe the essential conditions needed for photosynthesis.

.....

.....

..... [2]

(d) Photosynthesis is an endothermic reaction.

(i) Explain, in terms of the energy changes that occur during bond breaking and bond making, why photosynthesis is an endothermic reaction.

.....

.....

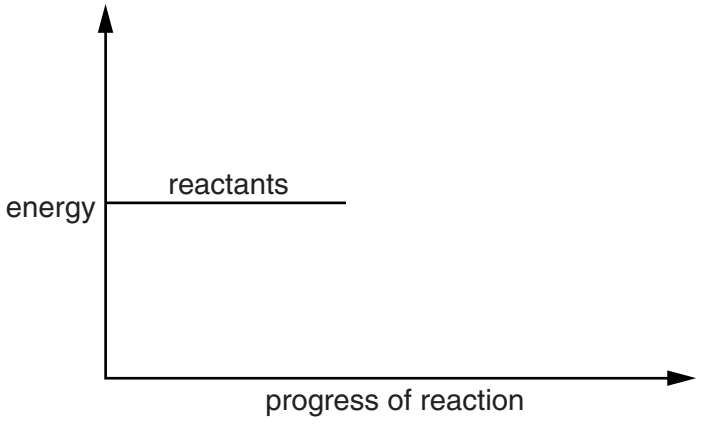
.....

..... [2]

(ii) Complete the energy profile diagram for photosynthesis.

On your diagram label the

- products,
- enthalpy change for the reaction, ΔH,
- activation energy, E_a.



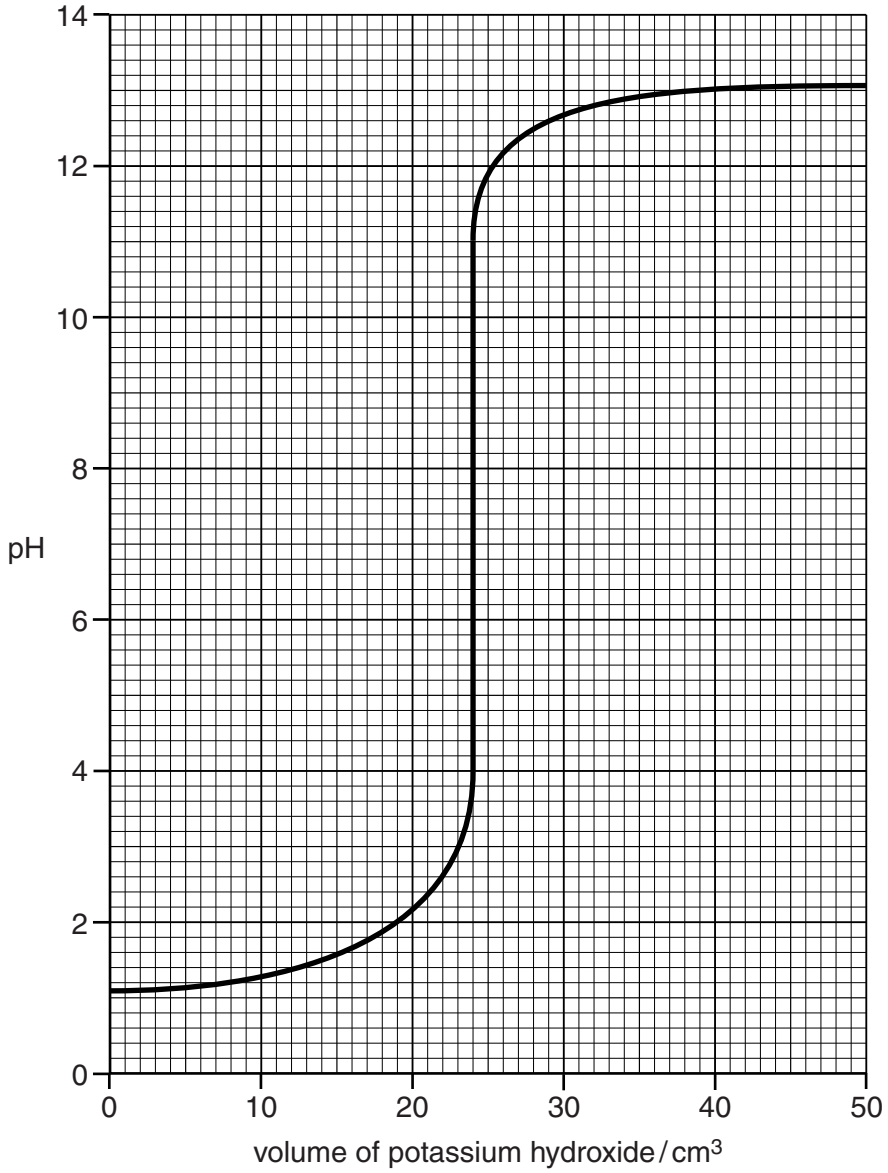
[3]

[Total: 9]

A3 Salts are often made by the neutralisation of bases.

(a) Aqueous potassium hydroxide, of concentration 0.150 mol / dm^3, is added to 25.0 cm^3 of sulfuric acid in a flask.

The graph shows how the pH of the liquid in the flask changes as aqueous potassium hydroxide is added to it.



(i) Construct the equation for the complete neutralisation of sulfuric acid by potassium hydroxide.

..... [1]

(ii) Use the graph to deduce the volume of aqueous potassium hydroxide required to neutralise 25.0 cm^3 of sulfuric acid.

..... [1]

(iii) Use your answers to **(i)** and **(ii)** to calculate the concentration of sulfuric acid

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

(b) Describe the essential experimental details for preparing a pure sample of zinc nitrate crystals from zinc oxide.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 9]

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A4 The table shows the number of electrons, neutrons and protons in seven different par

particle	number of		
	electrons	neutrons	protons
A	12	12	12
B	15	16	15
C	17	18	17
D	17	20	17
E	18	16	16
F	18	22	18
G	18	20	20

(a) What is the nucleon number for **F**?

..... [1]

(b) Explain why **A** is a neutral particle.

.....

.....

..... [2]

(c) Which particles are isotopes of the same element?

..... [1]

(d) What is the charge on **E**?

..... [1]

(e) Which particles have the same relative mass?

..... [1]

[Total: 6]

A5 Analysis of compound **X** shows it has the following composition.

element	percentage by mass
nitrogen	11.1
hydrogen	3.20
chromium	41.3
oxygen	44.4

(a) Show that **X** has the formula $N_2H_8Cr_2O_7$.

[3]

(b) An aqueous solution of **X** is orange.

Suggest which element in **X** is responsible for the orange colour.

..... [1]

(c) An acidified aqueous solution of **X** reacts with aqueous potassium iodide to form iodine.

State and explain what you can conclude about the chemical nature of **X**.

.....

.....

..... [2]

(d) Aqueous sodium hydroxide is added to solid **X** and the mixture is warmed. A gas that turns moist red litmus blue is evolved.

(i) Give the formula of the positive ion present in **X**.

..... [1]

(ii) Suggest the formula of the other ion present in **X**.

..... [1]

(e) When solid **X** is heated only Cr_2O_3, water and gas **Z** are formed.

Name gas **Z**.

..... [1]

[Total: 9]

Question A6 starts on page 10.

A6 Potassium is in Group I and chlorine is in Group VII of the Periodic Table.

Potassium forms an oxide with the formula K_2O and chlorine forms an oxide with the formula Cl_2O.

(a) (i) Draw a 'dot-and-cross' diagram for Cl_2O.

You only need to draw the outer shell electrons.

[1]

(ii) Explain, using ideas about structure and bonding, why Cl_2O has a low melting point.

.....

.....

.....

..... [2]

(b) Draw diagrams to show the electronic structures and charges of both ions present in potassium oxide.

[2]

(c) Chlorine forms another oxide Cl_2O_7. One mole of this oxide reacts with one mole of water to make two moles of an acid and no other products.

Construct the equation for this reaction.

..... [1]

[Total: 6]

Section B

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

The total mark for this section is 30.

B7 Malachite is an ore of copper. The formula of malachite is $CuCO_3.Cu(OH)_2$.

Malachite reacts as though it is a mixture of copper(II) carbonate and copper(II) hydroxide.

A small sample of malachite is added to excess dilute hydrochloric acid, HC*l*(aq). The carbon dioxide formed is collected and has a volume of 96 cm^3 at room temperature and pressure.

(a) What would you observe when malachite reacts with HC*l*(aq)?

.....

..... [2]

(b) Construct the equation for the reaction between malachite and HC*l*(aq).

..... [2]

(c) Calculate the mass of carbonate ion, CO_3^{2-}, in the sample of malachite.

mass of CO_3^{2-} = ... g [3]

(d) Copper is extracted from malachite by heating with carbon.

(i) Construct an equation for the reduction of malachite by carbon.

..... [2]

(ii) Malachite is a finite resource. Give one **other** reason why copper should be recycled.

.....

..... [1]

[Total: 10]

B8 Carboxylic acids are a homologous series of organic compounds.

The table shows information about some carboxylic acids.

carboxylic acid	formula	melting point/°C	boiling point/°C
methanoic acid	HCO_2H	8	100
ethanoic acid	CH_3CO_2H	17	118
	$C_2H_5CO_2H$	–22	141
butanoic acid	$C_3H_7CO_2H$		
hexadecanoic acid	$C_{15}H_{31}CO_2H$	63	269

(a) What is meant by the term *homologous series*?

.....

.....

.....

..... [2]

(b) Name the carboxylic acid with the formula $C_2H_5CO_2H$.

..... [1]

(c) Deduce the general formula for a carboxylic acid.

..... [1]

(d) It is more difficult to estimate the melting point of butanoic acid than its boiling point. Use the data in the table to explain why.

.....

..... [1]

(e) When warmed in the presence of concentrated sulfuric acid, butanoic acid reacts with ethanol to make an ester.

Name and draw the structure, showing all the atoms and all the bonds, of this ester.

name .....

structure

[2]

(f) Hexadecanoic acid, $C_{15}H_{31}CO_2H$, is a weak acid.

(i) Write an equation to show the dissociation of hexadecanoic acid when dissolved in water. Use the equation to explain the meaning of the term weak acid.

.....

.....

..... [2]

(ii) What is the formula of the salt formed when hexadecanoic acid reacts with aqueous sodium hydroxide?

..... [1]

[Total: 10]

B9 Ethanol is manufactured by the hydration of ethene.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\,kJ/mol$$

This reaction is exothermic.

The reaction is normally carried out at a pressure of 70 atmospheres and a temperature of 300 °C.

(a) The reaction is carried out at 70 atmospheres pressure and at **600 °C** rather than 300 °C.

Predict and explain the effect of raising the temperature on

(i) the rate of reaction,

.....

.....

..... [2]

(ii) the position of equilibrium.

.....

.....

..... [2]

(b) The reaction is carried out at **20 atmospheres** rather than 70 atmospheres, and at 300 °C.

Predict and explain the effect of decreasing the pressure on

(i) the rate of reaction,

.....

.....

..... [2]

(ii) the position of equilibrium.

.....

.....

..... [2]

(c) Calculate the energy released when 10 moles of ethanol are formed.

energy released = ... kJ [1]

(d) The hydration of ethene uses an acid catalyst.

Explain how a catalyst can increase the rate of reaction.

.....

..... [1]

[Total: 10]

B10 Aqueous silver nitrate can be electrolysed using inert electrodes.
Solid silver is formed on the cathode (negative electrode).

The table shows how the mass of silver formed is affected by four factors.

temperature of solution /°C	duration of electrolysis /seconds	current passed through solution/amps	concentration of solution /mol/dm^3	mass of silver formed /g
25	100	9.65	1.0	0.108
30	100	9.65	1.0	0.108
25	100	9.65	0.5	0.108
25	200	9.65	0.5	0.216
25	100	19.3	1.0	0.216

(a) The electrode reaction at the cathode is reduction.

(i) Construct the equation for the reaction which occurs at the cathode.

..... [1]

(ii) Explain why this reaction is reduction.

.....

..... [1]

(b) State how each of the following factors affects the mass of silver formed at the cathode.

temperature of solution

.....

.....

duration of electrolysis

.....

.....

current used

.....

.....

concentration of solution

.....

.....

[4]

(c) Explain why aqueous silver nitrate can be electrolysed but solid silver nitrate can

.....

.....

..... [2]

(d) Aqueous silver nitrate reacts with dilute hydrochloric acid to form a white precipitate.

Construct the ionic equation, including state symbols, for the formation of this white precipitate.

..... [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.).