



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Ordinary Level

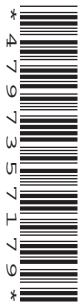
CANDIDATE  
NAME

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NUMBER

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**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.

For  
Examiner's  
Use

**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.

For  
Examiner's  
Use

**(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.

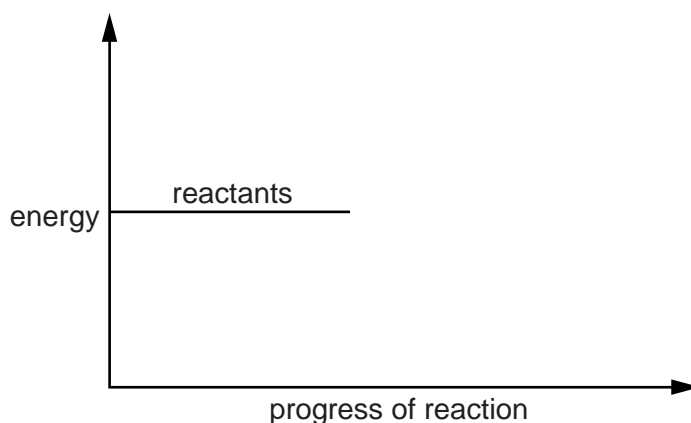
**(i)** Explain, in terms of the energy changes that occur during bond breaking and bond making, why photosynthesis is an endothermic reaction.

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

**(ii)** Complete the energy profile diagram for photosynthesis.

On your diagram label the

- products,
- enthalpy change for the reaction,  $\Delta H$ ,
- activation energy,  $E_a$ .



[3]

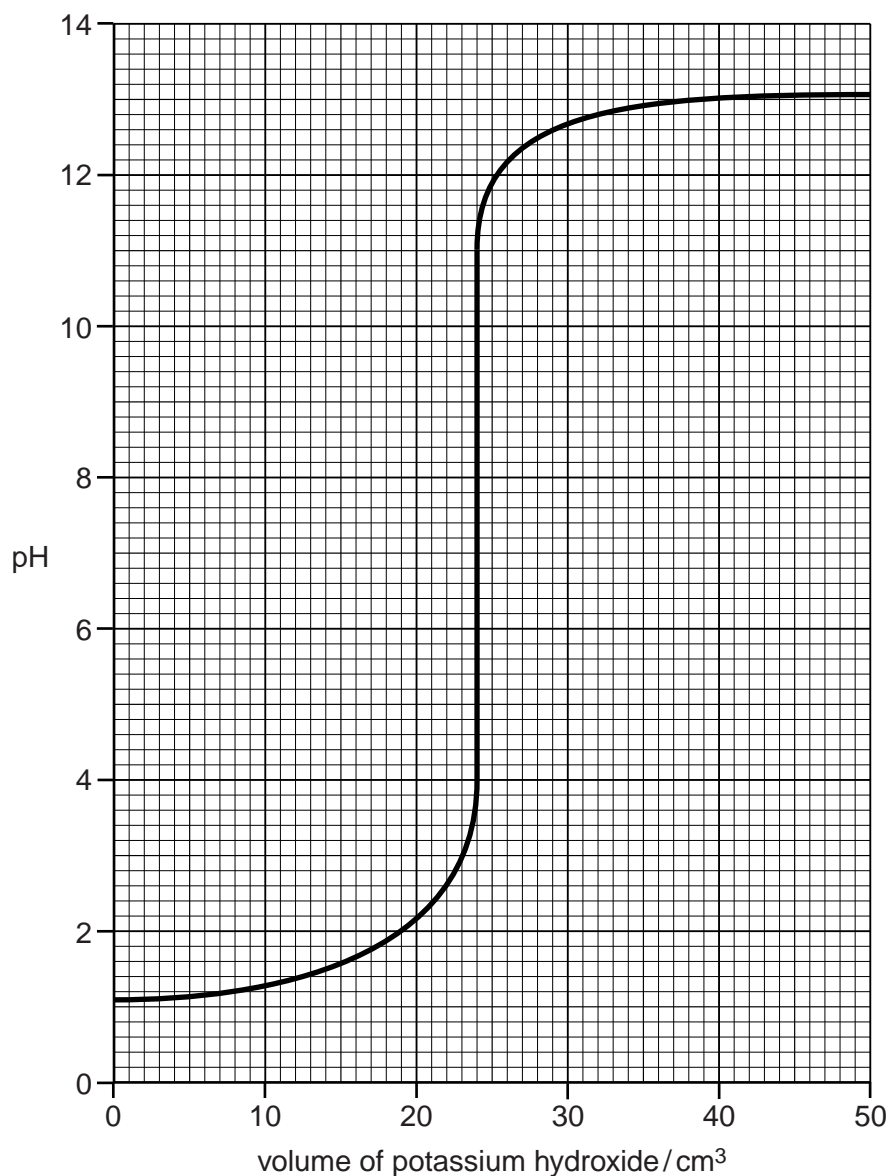
[Total: 9]

**A3** Salts are often made by the neutralisation of bases.

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

For  
Examiner's  
Use

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  $25.0 \text{ cm}^3$  of sulfuric acid.

..... [1]

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

For  
Examiner's  
Use

concentration of sulfuric acid = ..... mol/dm<sup>3</sup> [3]

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 9]



**A4** The table shows the number of electrons, neutrons and protons in seven different particles.

For  
Examiner's  
Use

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

For  
Examiner's  
Use

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

**(a)** Show that **X** has the formula  $\text{N}_2\text{H}_8\text{Cr}_2\text{O}_7$ .

[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  $\text{Cr}_2\text{O}_3$ , water and gas **Z** are formed.

Name gas **Z**.

..... [1]

[Total: 9]

For  
Examiner's  
Use

**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  $Cl_2O$ .

For  
Examiner's  
Use

**(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.

For  
Examiner's  
Use

**B7** Malachite is an ore of copper. The formula of malachite is  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ .

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,  $\text{HCl}(\text{aq})$ . The carbon dioxide formed is collected and has a volume of  $96 \text{ cm}^3$  at room temperature and pressure.

**(a)** What would you observe when malachite reacts with  $\text{HCl}(\text{aq})$ ?

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

**(b)** Construct the equation for the reaction between malachite and  $\text{HCl}(\text{aq})$ .

..... [2]

**(c)** Calculate the mass of carbonate ion,  $\text{CO}_3^{2-}$ , in the sample of malachite.

mass of  $\text{CO}_3^{2-} = \dots\dots\dots \text{ g}$  [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.

For  
Examiner's  
Use

carboxylic acid	formula	melting point/°C	boiling point/°C
methanoic acid	HCO <sub>2</sub> H	8	100
ethanoic acid	CH <sub>3</sub> CO <sub>2</sub> H	17	118
	C <sub>2</sub> H <sub>5</sub> CO <sub>2</sub> H	-22	141
butanoic acid	C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> H		
hexadecanoic acid	C <sub>15</sub> H <sub>31</sub> CO <sub>2</sub> H	63	269

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

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

(b) Name the carboxylic acid with the formula C<sub>2</sub>H<sub>5</sub>CO<sub>2</sub>H.

..... [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.

For  
Examiner's  
Use

(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.

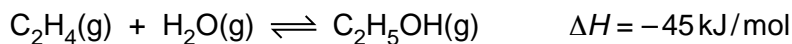
.....  
.....  
..... [2]

(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.



For  
Examiner's  
Use

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.

For  
Examiner's  
Use

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).

For  
Examiner's  
Use

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 <sup>3</sup>	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 cannot.

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

For  
Examiner's  
Use

(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	O																										
		1 <b>H</b> Hydrogen 1										4 <b>He</b> Helium 2																							
7 <b>Li</b> Lithium 3	9 <b>Be</b> Beryllium 4											20 <b>Ne</b> Neon 10																							
23 <b>Na</b> Sodium 11	24 <b>Mg</b> Magnesium 12											35.5 <b>Cl</b> Chlorine 17																							
39 <b>K</b> Potassium 19	40 <b>Ca</b> Calcium 20	55 <b>Mn</b> Manganese 25	56 <b>Fe</b> Iron 26	59 <b>Co</b> Cobalt 27	58 <b>Ni</b> Nickel 28	64 <b>Cu</b> Copper 29	65 <b>Zn</b> Zinc 30	73 <b>Ge</b> Germanium 32	75 <b>As</b> Arsenic 33	79 <b>Se</b> Selenium 34	80 <b>Br</b> Bromine 35	84 <b>Kr</b> Krypton 36																							
85 <b>Rb</b> Rubidium 37	88 <b>Sr</b> Strontium 38	91 <b>Ti</b> Titanium 22	92 <b>Zr</b> Zirconium 40	93 <b>Nb</b> Niobium 41	94 <b>Mo</b> Molybdenum 42	101 <b>Ru</b> Ruthenium 44	102 <b>Rh</b> Rhodium 45	106 <b>Pd</b> Palladium 46	107 <b>Ag</b> Silver 47	112 <b>Cd</b> Cadmium 48	115 <b>In</b> Indium 49	119 <b>Sn</b> Tin 50	122 <b>Sb</b> Antimony 51	127 <b>I</b> Iodine 53	131 <b>Xe</b> Xenon 54																				
133 <b>Cs</b> Caesium 55	137 <b>Ba</b> Barium 56	141 <b>Pr</b> Praseodymium 59	142 <b>Nd</b> Neodymium 60	143 <b>Pm</b> Promethium 61	144 <b>Nd</b> Neodymium 60	145 <b>Pr</b> Praseodymium 59	146 <b>Sm</b> Samarium 62	147 <b>Pm</b> Promethium 61	148 <b>Nd</b> Neodymium 60	149 <b>Pr</b> Praseodymium 59	150 <b>Sm</b> Samarium 62	151 <b>Eu</b> Europium 63	152 <b>Eu</b> Europium 63	153 <b>Gd</b> Gadolinium 64	154 <b>Tb</b> Terbium 65	155 <b>Dy</b> Dysprosium 66	156 <b>Ho</b> Holmium 67	157 <b>Pb</b> Lead 82	158 <b>Tl</b> Thallium 81	159 <b>Hg</b> Mercury 80	160 <b>Au</b> Gold 79	161 <b>Pt</b> Platinum 78	162 <b>Ir</b> Iridium 77	163 <b>Os</b> Osmium 76	164 <b>Rh</b> Rhodium 45	165 <b>Pd</b> Palladium 46	166 <b>Ag</b> Silver 47	167 <b>Cd</b> Cadmium 48	168 <b>In</b> Indium 49	169 <b>Sn</b> Tin 50	170 <b>Sb</b> Antimony 51	171 <b>Te</b> Tellurium 52	172 <b>I</b> Iodine 53	173 <b>At</b> Astatine 85	174 <b>Rn</b> Radon 86
223 <b>Fr</b> Francium 87	226 <b>Ra</b> Radium 88	227 <b>Ac</b> Actinium 89											228 <b>Rn</b> Radon 86																						
		* 58–71 Lanthanoid series										175 <b>Lu</b> Lutetium 71																							
		† 90–103 Actinoid series										176 <b>Lr</b> Lawrencium 103																							
		Key										177 <b>Yb</b> Ytterbium 70																							
		a = relative atomic mass										178 <b>Yb</b> Ytterbium 70																							
		X = atomic symbol										179 <b>No</b> Nobelium 102																							
		b = atomic (proton) number										180 <b>Md</b> Mendelevium 101																							
												181 <b>Fm</b> Fermium 100																							
												182 <b>Es</b> Einsteinium 99																							
												183 <b>Cf</b> Californium 98																							
												184 <b>Bk</b> Berkelium 97																							
												185 <b>Cm</b> Curium 96																							
												186 <b>Am</b> Americium 95																							
												187 <b>Am</b> Americium 95																							
												188 <b>Eu</b> Europium 63																							
												189 <b>Gd</b> Gadolinium 64																							
												190 <b>Tb</b> Terbium 65																							
												191 <b>Dy</b> Dysprosium 66																							
												192 <b>Ho</b> Holmium 67																							
												193 <b>Er</b> Erbium 68																							
												194 <b>Tm</b> Thulium 69																							
												195 <b>Po</b> Polonium 84																							
												196 <b>Bi</b> Bismuth 83																							
												197 <b>Po</b> Polonium 84																							
												198 <b>At</b> Astatine 85																							
												199 <b>Rn</b> Radon 86																							

The volume of one mole of any gas is 24dm<sup>3</sup> at room temperature and pressure (r.t.p.).