



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

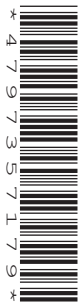
CANDIDATE
NAME

CENTRE
NUMBER

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CANDIDATE
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.

(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.

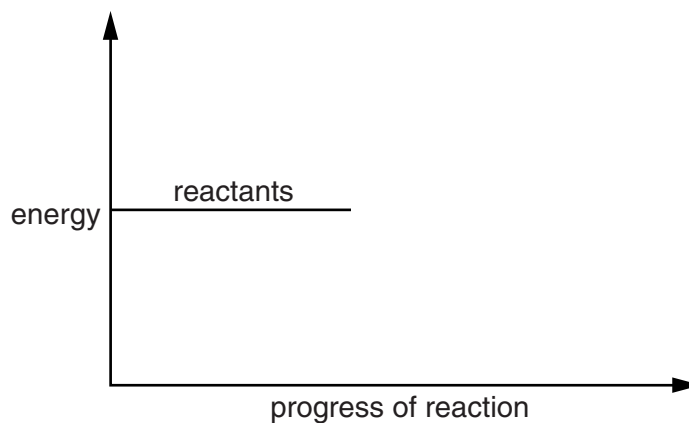
(i) Explain, in terms of the energy changes that occur during bond breaking and bond making, why photosynthesis is an endothermic reaction.

.....
.....
.....
..... [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]

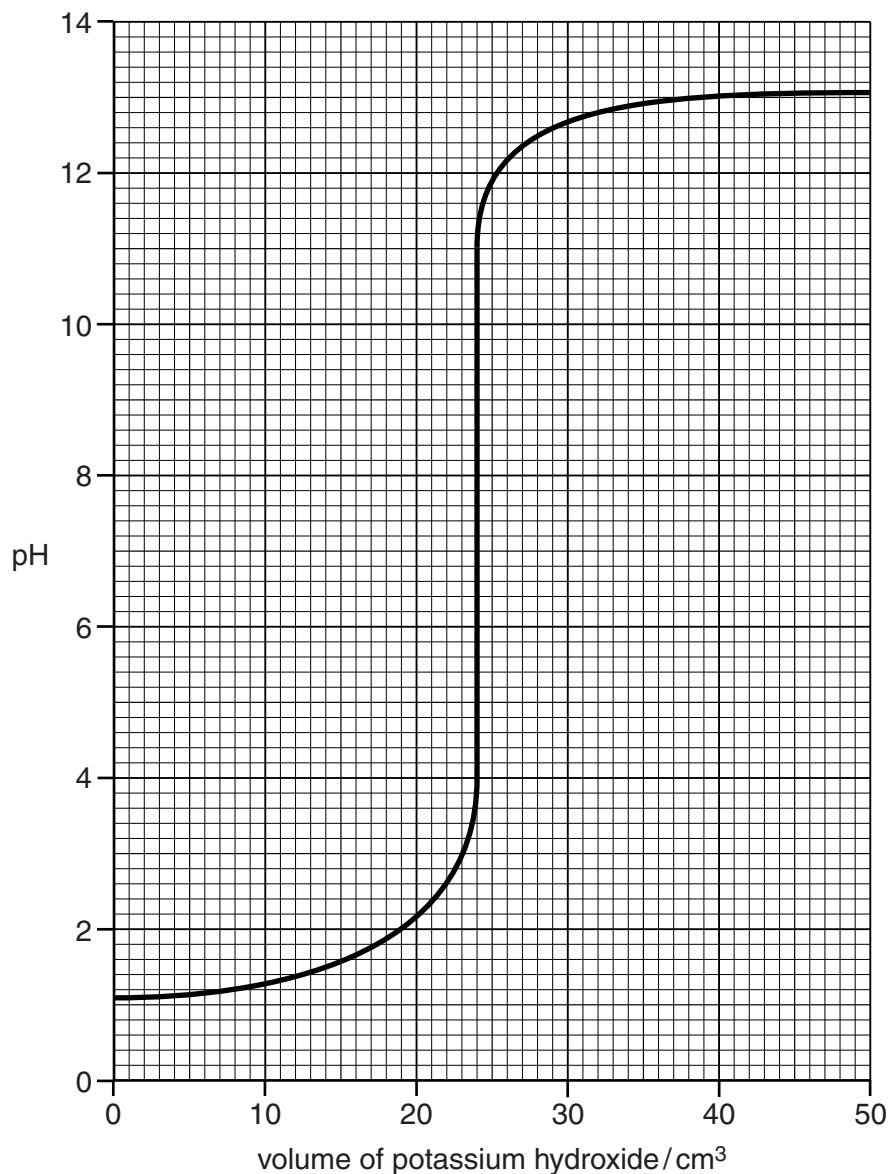
[Total: 9]

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.

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 cm^3 of sulfuric acid.

..... [1]

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

For
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Use

concentration of sulfuric acid = mol/dm³ [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 particles.

For
Examiner's
Use

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.

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 Cr_2O_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 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, 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 ₂ H	8	100
ethanoic acid	CH ₃ CO ₂ H	17	118
	C ₂ H ₅ CO ₂ H	-22	141
butanoic acid	C ₃ H ₇ CO ₂ H		
hexadecanoic acid	C ₁₅ H ₃₁ CO ₂ H	63	269

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

.....

 [2]

(b) Name the carboxylic acid with the formula C₂H₅CO₂H.

..... [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.

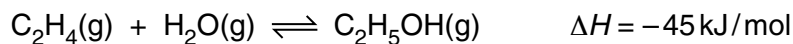
.....
.....
..... [2]

(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.



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).

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 cannot.

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

*For
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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	0																																																																																																																																																																																																																																
7 Li Lithium 3	9 Be Beryllium 4	1 H Hydrogen 1	11 B Boron 5	12 C Carbon 6	13 Al Aluminium 13	14 Si Silicon 14	15 P Phosphorus 15	16 S Sulfur 16	17 Cl Chlorine 17	18 Ar Argon 18	19 F Fluorine 9	20 Ne Neon 10	21 Sc Scandium 21	22 Ti Titanium 22	23 V Vanadium 23	24 Cr Chromium 24	25 Mn Manganese 25	26 Fe Iron 26	27 Co Cobalt 27	28 Ni Nickel 28	29 Cu Copper 29	30 Zn Zinc 30	31 Ga Gallium 31	32 Ge Germanium 32	33 As Arsenic 33	34 Se Selenium 34	35 Br Bromine 35	36 Kr Krypton 36	37 Rb Rubidium 37	38 Sr Strontium 38	39 Y Yttrium 39	40 Ca Calcium 20	41 Nb Niobium 41	42 Mo Molybdenum 42	43 Tc Technetium 43	44 Ru Ruthenium 44	45 Rh Rhodium 45	46 Pd Palladium 46	47 Ag Silver 47	48 Cd Cadmium 48	49 In Indium 49	50 Sn Tin 50	51 Sb Antimony 51	52 Te Tellurium 52	53 I Iodine 53	54 Xe Xenon 54	55 Cs Caesium 55	56 Ba Barium 56	57 La Lanthanum 57	58 Ce Cerium 58	59 Pr Praseodymium 59	60 Nd Neodymium 60	61 Pm Promethium 61	62 Sm Samarium 62	63 Eu Europium 63	64 Gd Gadolinium 64	65 Tb Terbium 65	66 Dy Dysprosium 66	67 Ho Holmium 67	68 Er Erbium 68	69 Tm Thulium 69	70 Yb Ytterbium 70	71 Lu Lutetium 71	72 Fr Francium 87	73 Ra Radium 88	74 Ac Actinium 89	75 Th Thorium 90	76 Pa Protactinium 91	77 U Uranium 92	78 Np Neptunium 93	79 Pu Plutonium 94	80 Am Americium 95	81 Cm Curium 96	82 Bk Berkelium 97	83 Cf Californium 98	84 Es Einsteinium 99	85 Fm Fermium 100	86 Md Mendelevium 101	87 No Nobelium 102	88 Lr Lawrencium 103	89 Fr Francium 87	90 Ra Radium 88	91 Ac Actinium 89	92 Th Thorium 90	93 Pa Protactinium 91	94 U Uranium 92	95 Np Neptunium 93	96 Pu Plutonium 94	97 Am Americium 95	98 Cm Curium 96	99 Bk Berkelium 97	100 Cf Californium 98	101 Es Einsteinium 99	102 Fm Fermium 100	103 Md Mendelevium 101	104 No Nobelium 102	105 Lr Lawrencium 103	106 Fr Francium 87	107 Ra Radium 88	108 Ac Actinium 89	109 Th Thorium 90	110 Pa Protactinium 91	111 U Uranium 92	112 Np Neptunium 93	113 Pu Plutonium 94	114 Am Americium 95	115 Cm Curium 96	116 Bk Berkelium 97	117 Cf Californium 98	118 Es Einsteinium 99	119 Fm Fermium 100	120 Md Mendelevium 101	121 No Nobelium 102	122 Lr Lawrencium 103	123 Fr Francium 87	124 Ra Radium 88	125 Ac Actinium 89	126 Th Thorium 90	127 Pa Protactinium 91	128 U Uranium 92	129 Np Neptunium 93	130 Pu Plutonium 94	131 Am Americium 95	132 Cm Curium 96	133 Bk Berkelium 97	134 Cf Californium 98	135 Es Einsteinium 99	136 Fm Fermium 100	137 Md Mendelevium 101	138 No Nobelium 102	139 Lr Lawrencium 103	140 Ce Cerium 58	141 Pr Praseodymium 59	142 Nd Neodymium 60	143 Pm Promethium 61	144 Nd Neodymium 60	145 Sm Samarium 62	146 Eu Europium 63	147 Pm Promethium 61	148 Sm Samarium 62	149 Gd Gadolinium 64	150 Sm Samarium 62	151 Eu Europium 63	152 Eu Europium 63	153 Gd Gadolinium 64	154 Tb Terbium 65	155 Dy Dysprosium 66	156 Ho Holmium 67	157 Er Erbium 68	158 Tm Thulium 69	159 Tb Terbium 65	160 Dy Dysprosium 66	161 Ho Holmium 67	162 Dy Dysprosium 66	163 Er Erbium 68	164 Tm Thulium 69	165 Ho Holmium 67	166 Er Erbium 68	167 Er Erbium 68	168 Tm Thulium 69	169 Tm Thulium 69	170 Yb Ytterbium 70	171 Lu Lutetium 71	172 Fr Francium 87	173 Ra Radium 88	174 Ac Actinium 89	175 Th Thorium 90	176 Pa Protactinium 91	177 U Uranium 92	178 Np Neptunium 93	179 Pu Plutonium 94	180 Am Americium 95	181 Cm Curium 96	182 Bk Berkelium 97	183 Cf Californium 98	184 Es Einsteinium 99	185 Fm Fermium 100	186 Md Mendelevium 101	187 No Nobelium 102	188 Lr Lawrencium 103	189 Fr Francium 87	190 Ra Radium 88	191 Ac Actinium 89	192 Th Thorium 90	193 Pa Protactinium 91	194 U Uranium 92	195 Np Neptunium 93	196 Pu Plutonium 94	197 Am Americium 95	198 Cm Curium 96	199 Bk Berkelium 97	200 Cf Californium 98	201 Es Einsteinium 99	202 Fm Fermium 100	203 Md Mendelevium 101	204 No Nobelium 102	205 Lr Lawrencium 103	206 Fr Francium 87	207 Ra Radium 88	208 Ac Actinium 89	209 Th Thorium 90	210 Pa Protactinium 91	211 U Uranium 92	212 Np Neptunium 93	213 Pu Plutonium 94	214 Am Americium 95	215 Cm Curium 96	216 Bk Berkelium 97	217 Cf Californium 98	218 Es Einsteinium 99	219 Fm Fermium 100	220 Md Mendelevium 101	221 No Nobelium 102	222 Lr Lawrencium 103	223 Fr Francium 87	224 Ra Radium 88	225 Ac Actinium 89	226 Th Thorium 90	227 Pa Protactinium 91	228 U Uranium 92	229 Np Neptunium 93	230 Pu Plutonium 94	231 Am Americium 95	232 Cm Curium 96	233 Bk Berkelium 97	234 Cf Californium 98	235 Es Einsteinium 99	236 Fm Fermium 100	237 Md Mendelevium 101	238 No Nobelium 102	239 Lr Lawrencium 103

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

Key

a	X	a = relative atomic mass
	X	X = atomic symbol
b		b = atomic (proton) number

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).