



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

**October/November 2011**

**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	
<b>Section A</b>	
<b>B6</b>	
<b>B7</b>	
<b>B8</b>	
<b>B9</b>	
<b>Total</b>	

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.

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**A1** Choose from the following list of compounds to answer the questions below.

**calcium hydroxide**  
**carbon monoxide**  
**methane**  
**nitrogen dioxide**  
**potassium manganate(VII)**  
**silver nitrate**  
**sulfur dioxide**

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

Which compound

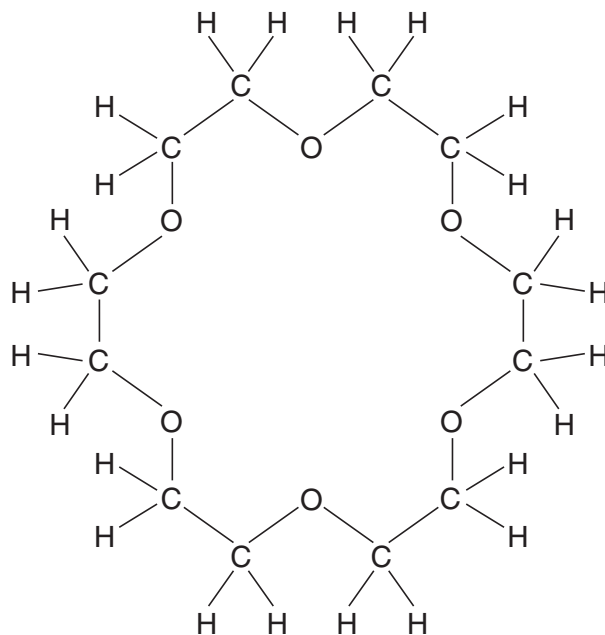
- (a) is used as a bleach in the manufacture of paper,  
..... [1]
- (b) changes from purple to colourless when its acidified solution is used to oxidise ethanol,  
..... [1]
- (c) has an aqueous solution that reacts with aqueous sodium chloride to give a white precipitate,  
..... [1]
- (d) can be formed by the action of lightning on gases in the atmosphere,  
..... [1]
- (e) is formed by the decay of vegetable matter?  
..... [1]

[Total: 5]

**A2** Sodium can react with compounds called crown ethers.

**(a)** A typical crown ether is shown below.

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Write the empirical formula for this crown ether.

..... [1]

**(b)** When sodium reacts with crown ethers it forms Na<sup>+</sup> and Na<sup>-</sup> ions.  
Draw the structure of an Na<sup>-</sup> ion.  
Show all the electrons.

[1]

(c) When sodium reacts with water, hydrogen is given off and an alkaline solution is formed.

(i) Describe **two** observations that can be made when sodium reacts with water.

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

(ii) Write an equation, including state symbols, for the reaction of sodium with water.

..... [3]

(d) Sodium is an alkali metal. Iron is a transition element.  
State the differences between these two metals in terms of

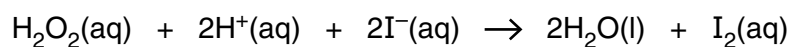
(i) melting point ..... [1]

(ii) density ..... [1]

[Total: 9]

**A3** Hydrogen peroxide is a colourless liquid.

An aqueous solution of hydrogen peroxide reacts with the iodide ions in acidified potassium iodide to form water and iodine.



- (a) (i) Explain why iodide ions are acting as the reducing agent in this reaction.

..... [1]

- (ii) What colour change would you observe in this reaction?

..... [1]

- (b) The table shows how the speed of this reaction changes when different concentrations of potassium iodide and sulfuric acid are used. The hydrogen peroxide is always in excess and the temperature remains constant.

experiment	concentration of potassium iodide in mol/dm <sup>3</sup>	concentration of sulfuric acid in mol/dm <sup>3</sup>	speed of reaction in mol/dm <sup>3</sup> /s
1	0.1	0.1	0.00017
2	0.2	0.1	0.00034
3	0.1	0.2	0.00017
4	0.3	0.1	0.00051
5	0.1	0.3	0.00017

Use the information in the table to describe how increasing the concentration of the following reagents affects the speed of reaction.

potassium iodide .....

..... [1]

sulfuric acid .....

..... [1]

- (c) Explain, in terms of collisions between reacting particles, why decreasing the temperature decreases the speed of reaction between hydrogen peroxide and acidified potassium iodide.

.....

.....

.....

.....

.....

..... [2]

(d) Iodine-127 has the symbol  ${}_{53}^{127}\text{I}$ .

State the number of subatomic particles in an iodide **ion**  ${}_{53}^{127}\text{I}^{-}$ .

protons .....

electrons .....

neutrons .....

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[2]

[Total: 8]

**A4** A plant contains the coloured compounds chlorophyll and carotene.

**(a)** The mixture of coloured compounds is extracted with propanone to give a brown solution.

**(i)** Describe, with the aid of a labelled diagram, how you can show that there is more than one coloured compound in the brown solution.

.....  
 .....  
 .....  
 ..... [3]

**(ii)** You are given a pure sample of chlorophyll.  
 How can you show that the brown solution contains chlorophyll?

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

**(b)** In green plants chlorophyll acts as a catalyst in photosynthesis.

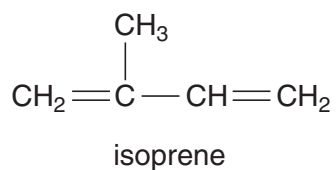
**(i)** Complete the word equation which describes photosynthesis.

..... + water → ..... + oxygen [1]

**(ii)** During one stage in photosynthesis, electrons are removed from water to produce hydrogen ions and oxygen gas.  
 Write an equation for this reaction.

..... [2]

- (c) Chlorophyll and carotene can be made in the laboratory from isoprene.



- (i) Isoprene is an unsaturated compound.

What do you understand by the term *unsaturated*?

..... [1]

- (ii) What would you observe when excess isoprene is added to aqueous bromine?

..... [1]

- (d) In many plants, the alkene ethene promotes the ripening of fruits.

- (i) Write the general formula for an alkene.

[1]

- (ii) Draw the structure of an alkene containing four carbon atoms.  
Show all atoms and bonds.

[1]

- (iii) Describe how ethanol can be formed from ethene, stating the necessary reaction conditions.

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

[Total: 14]



**A5** Three types of bonding are covalent, ionic and metallic.

**(a) (i)** Draw a labelled diagram to illustrate metallic bonding.

[2]

**(ii)** Use ideas about the structure of metals to explain why metals are

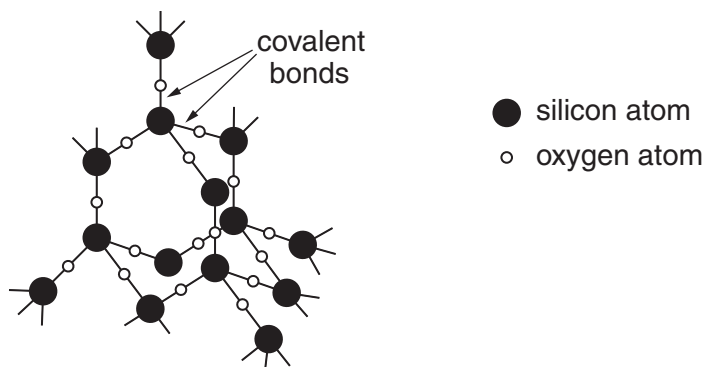
malleable, .....

..... [1]

good conductors of electricity. ....

..... [1]

**(b)** Silicon dioxide has a similar structure to diamond.



Suggest why silicon dioxide

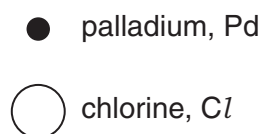
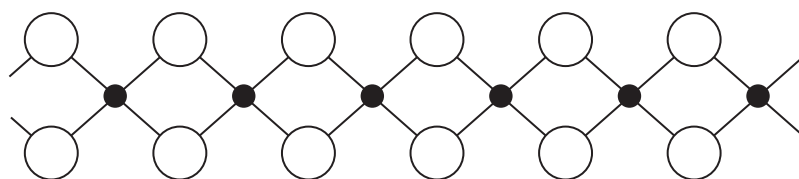
does not conduct electricity, .....

..... [1]

is hard. ....

..... [1]

(c) Part of the structure of palladium chloride is shown below.



Deduce the empirical formula for palladium chloride.

..... [1]

(d) Sodium chloride has an ionic structure.

Explain why sodium chloride conducts electricity when molten but does not conduct electricity when in the solid state.

.....

.....

..... [2]

[Total: 9]

**Section B**

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

The total mark for this section is 30.

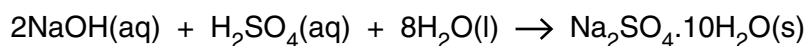
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**B6** A student prepares some crystals of hydrated sodium sulfate by titrating aqueous sodium hydroxide with sulfuric acid.

(a) Describe how he can obtain pure dry crystals of sodium sulfate using this method.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
..... [4]

(b) The student uses 25.0 cm<sup>3</sup> of 1.60 mol/dm<sup>3</sup> sodium hydroxide to prepare the crystals.



Calculate the maximum mass of hydrated sodium sulfate crystals that can be formed.

[4]

(c) When hydrated sodium sulfate crystals are heated gently, water is given off.

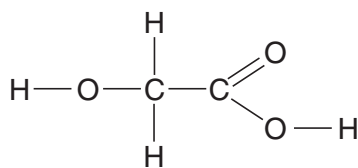
Describe a chemical test for water.

test .....

observation ..... [2]

[Total: 10]

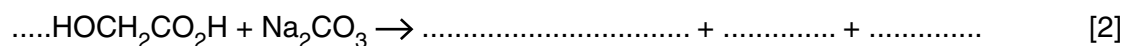
**B7** The structure of glycollic acid is shown below.



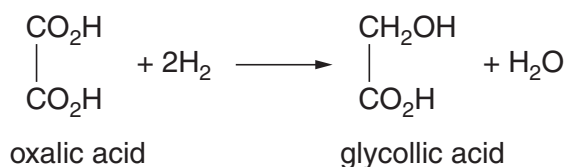
**(a)** Name the two functional groups present in glycollic acid.

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

**(b)** Glycollic acid undergoes similar reactions to ethanoic acid. Complete the equation for the reaction of glycollic acid with sodium carbonate.



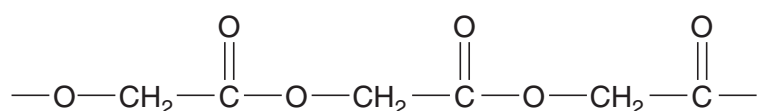
**(c)** Glycollic acid can be prepared from oxalic acid.



How does this equation shows that oxalic acid has been reduced?

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

**(d)** Glycollic acid polymerises to form poly(glycollic acid). The diagram shows a section of this polymer.



**(i)** Is poly(glycollic acid) an addition polymer or a condensation polymer? Give a reason for your answer.

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

**(ii)** Name another polymer with the same linkage as poly(glycollic acid).

..... [1]

(e) Poly(glycollic acid) is biodegradable whereas poly(ethene) is non-biodegradable.

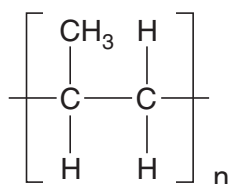
(i) Suggest two environmental advantages of using biodegradable polymers.

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

(ii) State one use of poly(ethene).

..... [1]

(iii) The diagram shows the repeat unit of poly(propene).



Draw the structure of the monomer used to make poly(propene).

[1]

[Total: 10]

**B8** Aluminium is extracted from bauxite ore.

**(a)** One stage in purifying bauxite to obtain pure aluminium oxide involves mixing the crushed ore with concentrated aqueous sodium hydroxide. The products of the reaction are aqueous sodium aluminate,  $\text{NaAlO}_2$ , and water.

**(i)** What type of oxide is aluminium oxide? Give a reason for your answer.

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

**(ii)** Write an equation for the reaction of aluminium oxide with aqueous sodium hydroxide.

..... [1]

**(iii)** The impurities in the ore are insoluble in water. Suggest how the impurities are separated from the aqueous sodium aluminate.

..... [1]

**(b)** Pure aluminium oxide is electrolysed in the presence of cryolite to produce aluminium.

**(i)** Aluminium forms at the cathode and oxygen at the anode. Write ionic equations for the reaction at

the cathode ..... [1]

the anode. .... [2]

**(ii)** Explain why cryolite is added to the aluminium oxide.

..... [1]

**(c) (i)** Aluminium is higher in the metal reactivity series than iron. Apart from differences in malleability, explain why fizzy drinks cans are made from aluminium rather than iron.

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

**(ii)** Aluminium is often used in the form of alloys.

What do you understand by the term *alloy*?

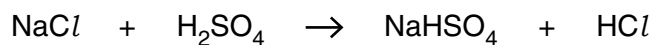
.....  
..... [1]

[Total: 10]

**B9** Hydrogen fluoride, hydrogen chloride and hydrogen iodide are all acidic gases.

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- (a) A student makes hydrogen chloride by reacting sodium chloride with excess concentrated sulfuric acid at room temperature and pressure.



- (i) Calculate the maximum volume of hydrogen chloride that can be made from 0.2 moles of sodium chloride at room temperature and pressure.

[1]

- (ii) Draw a 'dot-and-cross' diagram for hydrogen chloride.  
Show only the outer electrons.

[1]

- (b) Hydrogen fluoride is made by heating calcium fluoride,  $\text{CaF}_2$ , with concentrated sulfuric acid.  
Give an equation for this reaction.

..... [2]

- (c) Hydrogen chloride dissolves in water to form hydrochloric acid. Hydrogen fluoride dissolves in water to form hydrofluoric acid.  
A  $0.1 \text{ mol/dm}^3$  solution of hydrochloric acid is completely ionised.  
A  $0.1 \text{ mol/dm}^3$  solution of hydrofluoric acid is only 10% ionised.

Use this information to compare and explain

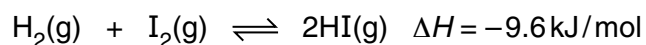
the strength of each acid, .....

.....

the pH of each of these solutions. ....

..... [2]

- (d) When hydrogen and iodine are heated in a sealed container an equilibrium is reached with the product, hydrogen iodide.



- (i) Predict the effect of the following on this equilibrium:

increasing the temperature,

..... [1]

decreasing the concentration of hydrogen iodide.

..... [1]

- (ii) At 400 °C the equilibrium mixture contains 0.4000 moles of hydrogen, 0.07560 moles of iodine and 1.344 moles of hydrogen iodide.  
Calculate the percentage of iodine molecules, I<sub>2</sub>, by mass in this equilibrium mixture.

[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 <b>H</b> Hydrogen																	
3 <b>Li</b> Lithium	4 <b>Be</b> Beryllium	5 <b>B</b> Boron	6 <b>C</b> Carbon	7 <b>N</b> Nitrogen	8 <b>O</b> Oxygen	9 <b>F</b> Fluorine	10 <b>Ne</b> Neon	11 <b>B</b> Boron	12 <b>C</b> Carbon	13 <b>Al</b> Aluminium	14 <b>Si</b> Silicon	15 <b>P</b> Phosphorus	16 <b>S</b> Sulfur	17 <b>Cl</b> Chlorine	18 <b>Ar</b> Argon	19 <b>F</b> Fluorine	20 <b>Ne</b> Neon
19 <b>K</b> Potassium	20 <b>Ca</b> Calcium	21 <b>Sc</b> Scandium	22 <b>Ti</b> Titanium	23 <b>V</b> Vanadium	24 <b>Cr</b> Chromium	25 <b>Mn</b> Manganese	26 <b>Fe</b> Iron	27 <b>Co</b> Cobalt	28 <b>Ni</b> Nickel	29 <b>Cu</b> Copper	30 <b>Zn</b> Zinc	31 <b>Ga</b> Gallium	32 <b>Ge</b> Germanium	33 <b>As</b> Arsenic	34 <b>Se</b> Selenium	35 <b>Br</b> Bromine	36 <b>Kr</b> Krypton
37 <b>Rb</b> Rubidium	38 <b>Sr</b> Strontium	39 <b>Y</b> Yttrium	40 <b>Zr</b> Zirconium	41 <b>Nb</b> Niobium	42 <b>Mo</b> Molybdenum	43 <b>Tc</b> Technetium	44 <b>Ru</b> Ruthenium	45 <b>Rh</b> Rhodium	46 <b>Pd</b> Palladium	47 <b>Ag</b> Silver	48 <b>Cd</b> Cadmium	49 <b>In</b> Indium	50 <b>Sn</b> Tin	51 <b>Sb</b> Antimony	52 <b>Te</b> Tellurium	53 <b>I</b> Iodine	54 <b>Xe</b> Xenon
55 <b>Cs</b> Caesium	56 <b>Ba</b> Barium	57 <b>La</b> Lanthanum	72 <b>Hf</b> Hafnium	73 <b>Ta</b> Tantalum	74 <b>W</b> Tungsten	75 <b>Re</b> Rhenium	76 <b>Os</b> Osmium	77 <b>Ir</b> Iridium	78 <b>Pt</b> Platinum	79 <b>Au</b> Gold	80 <b>Hg</b> Mercury	81 <b>Tl</b> Thallium	82 <b>Pb</b> Lead	83 <b>Bi</b> Bismuth	84 <b>Po</b> Polonium	85 <b>At</b> Astatine	86 <b>Rn</b> Radon
87 <b>Fr</b> Francium	88 <b>Ra</b> Radium	89 <b>Ac</b> Actinium															
103 <b>Lr</b> Lawrencium	104 <b>Rf</b> Rutherfordium	105 <b>Db</b> Dubnium	106 <b>Sg</b> Seaborgium	107 <b>Bh</b> Bohrium	108 <b>Hs</b> Hassium	109 <b>Mt</b> Meitnerium	110 <b>Ds</b> Darmstadtium	111 <b>Rg</b> Roentgenium	112 <b>Cn</b> Copernicium	113 <b>Nh</b> Nihonium	114 <b>Fl</b> Flerovium	115 <b>Mc</b> Moscovium	116 <b>Lv</b> Livermorium	117 <b>Ts</b> Tennessine	118 <b>Og</b> Oganesson	119 <b>Uu</b> Ununennium	120 <b>Uub</b> Unbibium
121 <b>Uue</b> Ununennium	122 <b>Uub</b> Unbibium	123 <b>Uut</b> Untrium	124 <b>Uuq</b> Unquadrium	125 <b>Uuq</b> Unquadrium	126 <b>Uuq</b> Unquadrium	127 <b>Uuq</b> Unquadrium	128 <b>Uuq</b> Unquadrium	129 <b>Uuq</b> Unquadrium	130 <b>Uuq</b> Unquadrium	131 <b>Uuq</b> Unquadrium	132 <b>Uuq</b> Unquadrium	133 <b>Uuq</b> Unquadrium	134 <b>Uuq</b> Unquadrium	135 <b>Uuq</b> Unquadrium	136 <b>Uuq</b> Unquadrium	137 <b>Uuq</b> Unquadrium	138 <b>Uuq</b> Unquadrium
175 <b>Lu</b> Lutetium	176 <b>Hf</b> Hafnium	177 <b>Ta</b> Tantalum	178 <b>W</b> Tungsten	179 <b>Re</b> Rhenium	180 <b>Os</b> Osmium	181 <b>Ir</b> Iridium	182 <b>Pt</b> Platinum	183 <b>Au</b> Gold	184 <b>Hg</b> Mercury	185 <b>Tl</b> Thallium	186 <b>Pb</b> Lead	187 <b>Bi</b> Bismuth	188 <b>Po</b> Polonium	189 <b>At</b> Astatine	190 <b>Rn</b> Radon	191 <b>Fr</b> Francium	192 <b>Ra</b> Radium
260 <b>Lr</b> Lawrencium	261 <b>Rf</b> Rutherfordium	262 <b>Db</b> Dubnium	263 <b>Sg</b> Seaborgium	264 <b>Bh</b> Bohrium	265 <b>Hs</b> Hassium	266 <b>Mt</b> Meitnerium	267 <b>Ds</b> Darmstadtium	268 <b>Rg</b> Roentgenium	269 <b>Cn</b> Copernicium	270 <b>Nh</b> Nihonium	271 <b>Fl</b> Flerovium	272 <b>Mc</b> Moscovium	273 <b>Lv</b> Livermorium	274 <b>Ts</b> Tennessine	275 <b>Og</b> Oganesson	276 <b>Uu</b> Ununseptium	277 <b>Uub</b> Unbibium

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

**Key**  

a	<b>X</b>
b	

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

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