



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Ordinary Level

CANDIDATE  
NAME

CENTRE  
NUMBER

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**CHEMISTRY**

**5070/22**

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

This document consists of **19** printed pages and **1** blank page.



## 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 particles to answer the questions below.



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

Which particle

(a) has only eight electrons,

..... [1]

(b) is attracted to the cathode during electrolysis,

..... [1]

(c) has only four electrons in its outer shell,

..... [1]

(d) has only eight neutrons,

..... [1]

(e) has only ten protons,

..... [1]

(f) has four occupied electron shells?

..... [1]

[Total: 6]

**A2** Small pieces of a silver coloured metal, **X**, were added to concentrated nitric acid. A brown gas, **Z**, and a colourless solution containing salt **Y** were formed.

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Analysis of a 0.0914 mol sample of **Z** showed it contained 1.28 g of nitrogen and 2.93 g of oxygen.

The small sample of the colourless solution was diluted with water and then divided into two portions.

- To one portion, aqueous sodium hydroxide was added drop by drop until it was in excess. A white precipitate, **W**, was formed that redissolved in the excess sodium hydroxide.
- To the other portion, aqueous ammonia was added drop by drop until it was in excess. A white precipitate, **W**, was formed that redissolved in the excess ammonia.

**(a) (i)** Name the white precipitate, **W**.

..... [1]

**(ii)** Construct the ionic equation, with state symbols, for the formation of **W**.

..... [2]

**(b)** Name **X** and **Y**.

**X** is .....

**Y** is ..... [2]

**(c) (i)** Calculate the relative formula mass,  $M_r$ , for gas **Z**.

$M_r =$  ..... [2]

**(ii)** Determine the molecular formula for **Z**.

molecular formula is ..... [2]

[Total: 9]

A3 The typical composition of solid domestic waste in a city is shown below.

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type of solid waste	percentage by mass
glass	9
metals	8
organic waste including food	22
paper	38
plastics	9
textiles	2
other	12

- (a) The most abundant metals in the solid waste are aluminium, copper and iron. Describe **two** advantages of recycling these metals.

.....

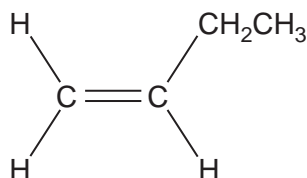
.....

.....

.....

..... [2]

- (b) One of the polymer molecules in the plastic waste is made from the monomer shown below.



Draw the partial structure of the polymer formed from this monomer showing two repeats.

[2]

- (c) Many of the polymers found in the plastic waste are non-biodegradable.

Describe **two** pollution problems caused by the disposal of non-biodegradable polymers.

.....

.....

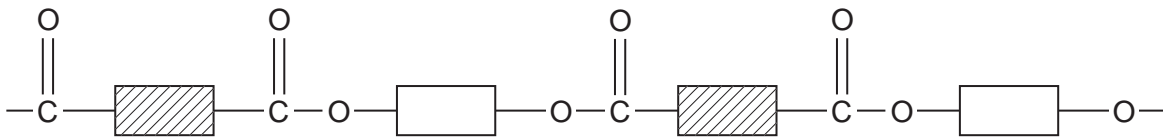
.....

.....

..... [2]

- (d) *Terylene* and nylon are two of the textiles present in the solid waste.

The partial structure of *Terylene* is shown below.



- (i) *Terylene* is a polyester.

What type of polymerisation is used to make *Terylene*?

..... [1]

- (ii) Complete the diagram below to show the partial structure for nylon.



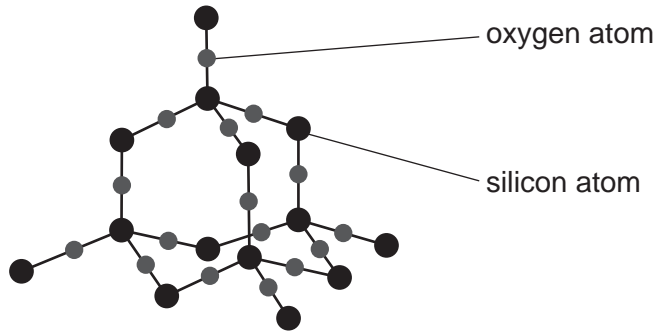
[1]

- (iii) Give the name of one **type** of food that has molecules containing the same linkages as *Terylene*.

..... [1]

(e) Glass is made from sand.

Pure sand has a giant molecular structure.



(i) What is the formula for pure sand?

..... [1]

(ii) Explain why sand has a very high melting point.

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

(iii) Explain why sand does not conduct electricity.

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

[Total: 13]

- A4** Many electricity generating power stations burn fossil fuels. The combustion of these fuels produces waste gases called flue gas.

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The flue gas contains nitrogen oxides, sulfur dioxide and carbon dioxide.

Nitrogen oxides and sulfur dioxide contribute towards acid rain and must be removed from the flue gas before it is allowed to reach the atmosphere.

- (a)** One of the nitrogen oxides is nitrogen monoxide, NO.

- (i)** Nitrogen monoxide is formed by the direct reaction between oxygen and nitrogen.

Construct the equation for this reaction.

..... [1]

- (ii)** When cold nitrogen monoxide comes into contact with oxygen it forms nitrogen dioxide, NO<sub>2</sub>.

Construct the equation for this reaction.

..... [1]

- (b)** Some power stations spray the flue gas with seawater. This removes about 99% of the nitrogen dioxide and sulfur dioxide.

The gases react with water to form aqueous acids. Nitrogen dioxide forms nitric acid and another acid with the formula, HNO<sub>2</sub>.

Construct the equation for this reaction.

..... [1]

- (c)** In other power stations the flue gases are reacted with moist calcium carbonate. This removes about 90% of the nitrogen dioxide and sulfur dioxide from the flue gas.

- (i)** Sulfur dioxide reacts with calcium carbonate to form solid calcium sulfite, CaSO<sub>3</sub>. Suggest the name of the other product of this reaction.

..... [1]

- (ii)** Nitrogen dioxide reacts with calcium carbonate to form two salts. Suggest the name and formula of one of these salts.

name .....

formula ..... [2]

- (d) Suggest **two** advantages of treating flue gas with seawater rather than calcium carbonate.

For  
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Use

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

- (e) Carbon dioxide is a greenhouse gas. This is because its covalent bonds can absorb infra-red radiation.

Draw a 'dot-and-cross' diagram to show the bonding in a molecule of carbon dioxide. Show only the outer shell electrons.

[1]

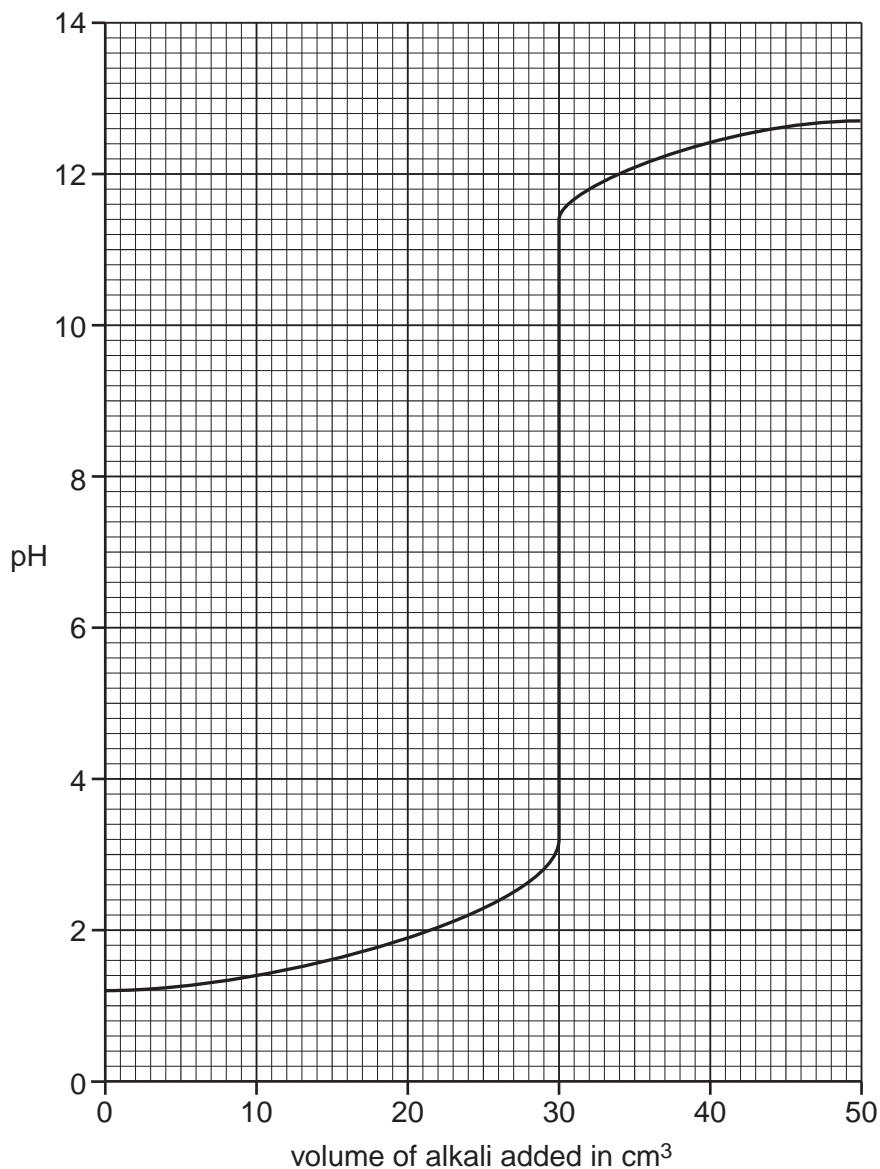
[Total: 9]



**A5** Aqueous potassium hydroxide, KOH, is added slowly from a burette into a flask containing  $25.0\text{cm}^3$  of  $0.0500\text{mol/dm}^3$  dilute sulfuric acid,  $\text{H}_2\text{SO}_4$ . At the same time the pH of the contents of the flask is measured until all of the aqueous potassium hydroxide has been added.

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The graph shows how the pH changes with the addition of the aqueous potassium hydroxide.



**(a)** What is the pH of  $0.0500\text{mol/dm}^3$  sulfuric acid?

..... [1]

**(b)** Construct the equation for the reaction between sulfuric acid and potassium hydroxide.

..... [1]

- (c) (i) What volume of aqueous potassium hydroxide has been added when the mixture has a pH of 7?

volume = ..... cm<sup>3</sup> [1]

- (ii) Calculate the concentration, in mol/dm<sup>3</sup>, of the aqueous potassium hydroxide.

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

- (d) The experiment is repeated with 25.0 cm<sup>3</sup> of 0.0500 mol/dm<sup>3</sup> ethanoic acid, CH<sub>3</sub>COOH, instead of 25.0 cm<sup>3</sup> of 0.0500 mol/dm<sup>3</sup> sulfuric acid.

Describe and explain any differences in the graph which would be obtained.

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

[Total: 8]

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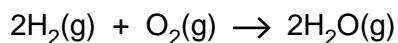
## Section B

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

The total mark for this section is 30.

For  
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- B6** Hydrogen-oxygen fuel cells are used to generate electricity.  
The overall reaction in a hydrogen-oxygen fuel cell is shown below.



This reaction is exothermic.

- (a)** Explain the meaning of the term *exothermic*.

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

- (b)** Explain, in terms of the energy changes associated with bond breaking and bond forming, why the reaction is exothermic.

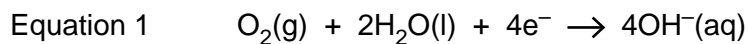
.....  
.....  
.....  
..... [2]

- (c)** A hydrogen-oxygen fuel cell uses 2000 dm<sup>3</sup> of hydrogen measured at room temperature and pressure.  
Calculate the volume of oxygen, measured at room temperature and pressure, used by the fuel cell.  
[One mole of any gas at room temperature and pressure occupies a volume of 24 dm<sup>3</sup>.]

.....  
.....  
.....

volume of oxygen = ..... dm<sup>3</sup> [2]

(d) The electrode reactions in an oxygen-hydrogen fuel cell are shown below.



Explain why the reaction in a fuel cell involves both oxidation **and** reduction.

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

(e) Name one source of the hydrogen needed for a fuel-cell.

..... [1]

(f) State one advantage and one disadvantage of using an oxygen-hydrogen fuel cell.

advantage .....

.....

disadvantage .....

..... [2]

[Total: 10]

**B7** Many carbonates thermally decompose to form carbon dioxide and an oxide.

Copper carbonate forms carbon dioxide and copper oxide.



Six 2.00 g samples of carbonates are heated strongly until there is no further change in mass. The table shows the mass of solid remaining at the end of the heating.

carbonate	mass before heating/g	mass after heating/g
calcium carbonate	2.00	1.12
copper(II) carbonate	2.00	1.29
iron(II) carbonate	2.00	1.24
magnesium carbonate	2.00	0.95
sodium carbonate	2.00	2.00
zinc carbonate	2.00	1.30

(a) What is the mass of carbon dioxide formed when 2.00 g of copper(II) carbonate is heated?

mass of carbon dioxide = ..... g [1]

(b) The thermal stability of the carbonates is related to the reactivity of the metal. Which carbonate is the **least** thermally stable?

..... [1]

(c) For each carbonate, a 2.00 g sample was heated. Explain why the mass of carbon dioxide formed is different for each carbonate.

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

(d) The decomposition of calcium carbonate forms carbon dioxide and calcium oxide.

(i) Draw the electronic configuration and state the charge on each of the ions in calcium oxide.

[2]

(ii) Explain why calcium oxide is used in a blast furnace.

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

(e) Copper(II) chloride can be prepared by the reaction between copper(II) carbonate and hydrochloric acid.

(i) Construct the ionic equation for this reaction.

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

(ii) Describe the essential practical details for the preparation of a crystalline sample of copper(II) chloride.

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

[Total: 10]

- B8** Alkenes are a homologous series of organic compounds.  
The table shows some information about the first six alkenes.

For  
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Use

name	molecular formula	melting point/°C	boiling point/°C
ethene	C <sub>2</sub> H <sub>4</sub>	-169	-104
propene	C <sub>3</sub> H <sub>6</sub>	-185	-48
butene	C <sub>4</sub> H <sub>8</sub>	-185	-6
pentene	C <sub>5</sub> H <sub>10</sub>	-165	30
hexene	C <sub>6</sub> H <sub>12</sub>	-139	63
heptene	C <sub>7</sub> H <sub>14</sub>		

- (a) Draw the structure, showing all the atoms and bonds, of propene.

Use the structure to explain why propene is both a *hydrocarbon* and *unsaturated*.

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

- (b) There are several compounds with molecular formula C<sub>4</sub>H<sub>8</sub>, each has a different structure.  
What name is given to compounds with the same molecular formula but different structures?

..... [1]

- (c) Deduce the molecular formula for decene, an alkene with 10 carbon atoms per molecule.

..... [1]

- (d) Explain why it is easier to predict the boiling point of heptene rather than its melting point.

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

- (e) What is the physical state for butene at room temperature and pressure? Explain your answer.

physical state .....

explanation .....

..... [1]

- (f) Many alkenes are manufactured by the cracking of long chain alkanes such as hexadecane,  $C_{16}H_{34}$ .  
Construct an equation to show the cracking of hexadecane to form butane and butene only.

..... [1]

- (g) Butene reacts with bromine and with steam.

- (i) Give the molecular formula of the product with bromine.

..... [1]

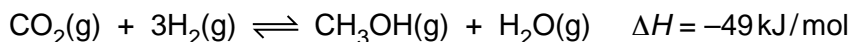
- (ii) Suggest the name of the product with steam.

..... [1]

[Total: 10]



**B9** Methanol, CH<sub>3</sub>OH, is manufactured from carbon dioxide and hydrogen.



For  
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Use

The reaction is carried out in the presence of a catalyst containing copper. The conditions used are 70 atmospheres pressure and a temperature of 250 °C.

**(a)** If the temperature of the reaction mixture is **increased** to 400 °C, explain, in terms of collisions between reacting particles, what happens to the speed of the forward reaction.

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

**(b)** If the pressure of the reaction mixture is **decreased** to 50 atmospheres, explain what happens to the position of equilibrium.

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

**(c)** In the reaction when 3.0 moles of hydrogen react, 49 kJ of heat energy is released.  
 Calculate how much heat energy is released when 500 kg of hydrogen react.

heat energy = ..... kJ [2]

**(d)** Methanol can be used as a fuel.

Construct the equation for the complete combustion of methanol.

..... [1]

(e) Methanol can be oxidised to form methanoic acid.

(i) State the reagents and conditions needed for this reaction.

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

(ii) Draw the structure of methanoic acid.

[1]

[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 1										2 <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	96 <b>Mo</b> Molybdenum 42	101 <b>Ru</b> Ruthenium 44	103 <b>Rh</b> Rhodium 45	106 <b>Pd</b> Palladium 46	108 <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	147 <b>Pm</b> Promethium 61	150 <b>Sm</b> Samarium 62	152 <b>Eu</b> Europium 63	157 <b>Gd</b> Gadolinium 64	159 <b>Tb</b> Terbium 65	162 <b>Dy</b> Dysprosium 66	165 <b>Ho</b> Holmium 67	167 <b>Er</b> Erbium 68	169 <b>Tm</b> Thulium 69	175 <b>Lu</b> Lutetium 71
223 <b>Fr</b> Francium 87	226 <b>Ra</b> Radium 88	232 <b>Th</b> Thorium 90	231 <b>Pa</b> Protactinium 91	237 <b>Np</b> Neptunium 93	238 <b>U</b> Uranium 92	243 <b>Am</b> Americium 95	244 <b>Pu</b> Plutonium 94	247 <b>Cm</b> Curium 96	247 <b>Cm</b> Curium 96	247 <b>Bk</b> Berkelium 97	251 <b>Cf</b> Californium 98	252 <b>Es</b> Einsteinium 99	257 <b>Fm</b> Fermium 100	258 <b>Md</b> Mendelevium 101	260 <b>Lr</b> Lawrencium 103
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 5px;"> <math>\begin{matrix} a \\ \mathbf{X} \\ b \end{matrix}</math> </div> <div style="text-align: right;"> <p>a = relative atomic mass X = atomic symbol b = atomic (proton) number</p> </div> </div>													

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

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