



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Ordinary Level

CANDIDATE  
NAME

CENTRE  
NUMBER

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**CHEMISTRY**

**5070/02**

Paper 2 Theory

**May/June 2007**

**1 hour 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: Answer Booklet/Paper

**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.

Do not use staples, paper clips, highlighters, glue or correction fluid.

DO **NOT** WRITE ON ANY BARCODES.

**Section A**

Answer **all** questions.

Write your answers in the spaces provided on the Question Paper.

**Section B**

Answer any **three** questions.

Write your answers on any lined pages and/or separate answer paper.

A copy of the Periodic Table is printed on page 16.

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	
Section A	
B9	
B10	
B11	
B12	
Total	

This document consists of **16** printed 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 oxides to answer the questions below.

- aluminium oxide**
- calcium oxide**
- carbon monoxide**
- copper(II) oxide**
- sulphur dioxide**
- sulphur trioxide**
- vanadium(V) oxide**

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

Name an oxide which

- (a)** is used as a catalyst in the Contact process,  
.....[1]
- (b)** is formed during the incomplete combustion of propane,  
.....[1]
- (c)** reacts with dilute sulphuric acid to give a blue solution,  
.....[1]
- (d)** reacts with water to give sulphurous acid,  
.....[1]
- (e)** when heated in a Blast Furnace with sand makes slag.  
.....[1]

[Total: 5]

**A2** A fertiliser contains three compounds:

- ammonium sulphate,  $(\text{NH}_4)_2\text{SO}_4$ ,
- iron(II) sulphate,  $\text{FeSO}_4$ ,
- sand,  $\text{SiO}_2$ .

**(a)** Calculate the percentage by mass of nitrogen in ammonium sulphate.

..... % [2]

**(b)** Aqueous iron(II) ions and aqueous iron(III) ions can be distinguished by reaction with aqueous sodium hydroxide. Describe what you would observe as a result of each reaction.

observation with aqueous iron(II) ions .....

observation with aqueous iron(III) ions .....

**(c)** Aqueous iron(II) ions can be oxidised by reaction with acidified potassium manganate(VII),  $\text{KMnO}_4$ . The colour change during the reaction shows that iron(II) ions act as a reducing agent.

**(i)** Describe the colour change during the reaction.  
.....[1]

**(ii)** In terms of oxidation numbers, explain the meaning of the term *reducing agent*.  
.....[1]

- (d) The mass of iron(II) ions in a sample of fertiliser can be determined by the reaction between iron(II) ions and acidified potassium manganate(VII),  $\text{KMnO}_4$ .

A student analysed a sample of the fertiliser. He dissolved the sample in  $25.0\text{cm}^3$  of dilute sulphuric acid and titrated the solution formed with  $0.0200\text{mol/dm}^3$  potassium manganate(VII).

The student used  $22.5\text{cm}^3$  of potassium manganate(VII) to reach the end-point.

- (i) Calculate the number of moles of potassium manganate(VII) used in the titration.

..... moles [1]

- (ii) One mole of potassium manganate(VII) reacts with five moles of iron(II) ions. Calculate the mass, in grams, of iron(II) ions in the sample analysed.

..... g [2]

[Total: 9]

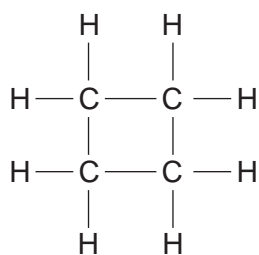
- A3** Complete the table below to show the number of subatomic particles in each of the two ions.

ion	number of protons	number of neutrons	number of electrons
$^{40}\text{Ca}^{2+}$			
$^{37}\text{Cl}^-$			

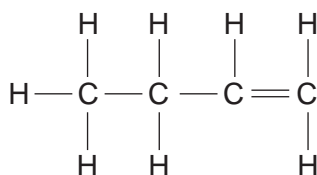
[2]

[Total: 2]

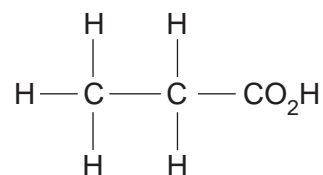
**A4** Structures of six organic compounds are shown.



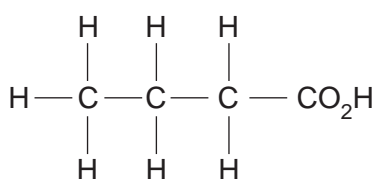
compound **A**



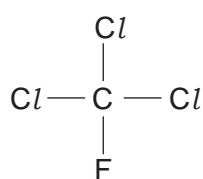
compound **B**



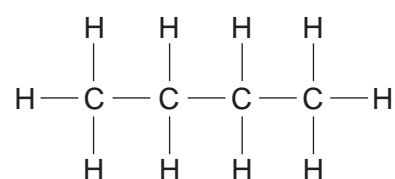
compound **C**



compound **D**



compound **E**



compound **F**

(a) Which **two** compounds have the same molecular formula?

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

(b) Which compound is butanoic acid?

.....[1]

(c) Which compound contributes to ozone depletion in the upper atmosphere?

.....[1]

(d) Name compound **B**.

.....[1]

[Total: 4]

**A5 (a)** Concentrated aqueous sodium chloride contains  $H^+$  and  $OH^-$  ions.

**(i)** Give the formulae of **two** other ions present in concentrated aqueous sodium chloride.

.....[1]

**(ii)** Concentrated aqueous sodium chloride is electrolysed using inert graphite electrodes.

Name the product formed at each electrode.

product at anode .....

product at cathode .....[2]

**(b)** Impure copper can be purified by electrolysis.

Draw a labelled diagram of the electrolytic cell that can be used to purify copper.

[3]

**(c)** Aluminium is extracted commercially from an aluminium ore by electrolysis.

**(i)** Name an ore containing aluminium.

.....[1]

**(ii)** Name the element used as the anode in this process.

.....[1]

[Total: 8]

**A6** Chlorine is in Group VII of the Periodic Table.

Chlorine reacts with aqueous potassium iodide to form potassium chloride and iodine.

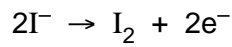
**(a)** Describe what you would see when chlorine is added to aqueous potassium iodide.

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

**(b)** Write the equation for the reaction between chlorine and potassium iodide.

.....[1]

**(c)** When chlorine reacts with potassium iodide, iodine molecules are formed.



Explain why the formation of an iodine molecule from iodide ions is an example of oxidation.

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

**(d)** Astatine is another element in Group VII. It is highly radioactive and so is very difficult to study.

**(i)** Predict, with reasons, whether astatine will react with aqueous potassium iodide.

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

**(ii)** Write the equation for the reaction between astatine and sodium.

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

[Total: 5]

**A7** The carbonates of many metallic elements decompose when heated.

- (a) Name the gas produced during the decomposition of a metal carbonate and describe a chemical test for this gas.

gas produced .....

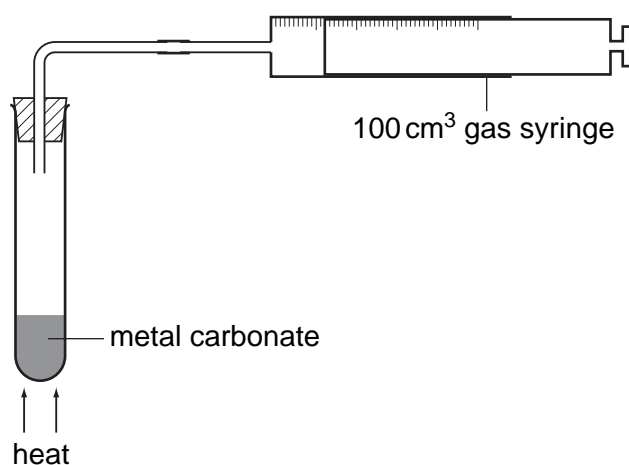
chemical test .....

.....[2]

- (b) Calcium oxide is manufactured by the decomposition of calcium carbonate. Write the equation for this decomposition.

.....[1]

- (c) A student investigates the decomposition of five different metal carbonates. The diagram shows the apparatus the student uses.



The student heats a 0.010 mol sample of each carbonate using the blue flame of the same Bunsen burner. She measures the time it takes for 100 cm<sup>3</sup> of gas to be collected in the gas syringe.

The table shows her results.

carbonate	time taken to collect 100 cm <sup>3</sup> of gas /s
metal <b>U</b> carbonate	25
metal <b>V</b> carbonate	100
metal <b>X</b> carbonate	300
metal <b>Y</b> carbonate	no gas produced after 1000 seconds
metal <b>Z</b> carbonate	50

The student used calcium carbonate, copper(II) carbonate, magnesium carbonate, sodium carbonate and zinc carbonate.



Complete the table to show the identity of each metal **U**, **V**, **X**, **Y** and **Z**.

metal	name of metal
<b>U</b>	.....
<b>V</b>	.....
<b>X</b>	.....
<b>Y</b>	.....
<b>Z</b>	.....

Explain how you used the student's results to identify each metal.

.....

.....

.....

[3]

- (d) The nitrates of metallic elements also decompose when heated.  
Calcium nitrate decomposes to form calcium oxide, nitrogen dioxide and oxygen.



A 0.010 mol sample of calcium nitrate is heated. Calculate the number of moles of gas produced when this sample is completely decomposed.

..... moles [1]

[Total: 7]

**A8** Between the 13<sup>th</sup> and the 19<sup>th</sup> Century artists used a green pigment called verdigris. They made the pigment by hanging copper foil over boiling vinegar.

- (a) Vinegar is an aqueous solution of ethanoic acid.  
Draw the structure of ethanoic acid.

[1]

- (b) During the preparation of verdigris, copper atoms, oxygen molecules and hydrogen ions combine to form copper(II) ions and water.

Write the ionic equation for this reaction.

.....[2]

- (c) Verdigris has the formula  $[\text{Cu}(\text{CH}_3\text{CO}_2)_2]_2 \cdot \text{Cu}(\text{OH})_2 \cdot x\text{H}_2\text{O}$ .  
It has a relative formula mass of 552.  
Calculate the value of  $x$  in the formula.

 $x$  is ..... [2]

[Total: 5]

**Section B**

Answer **three** questions from this section.

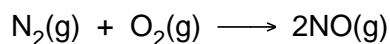
The total mark for this section is 30.

**B9** This question is about the chemistry of the elements in Period 3 of the Periodic Table.

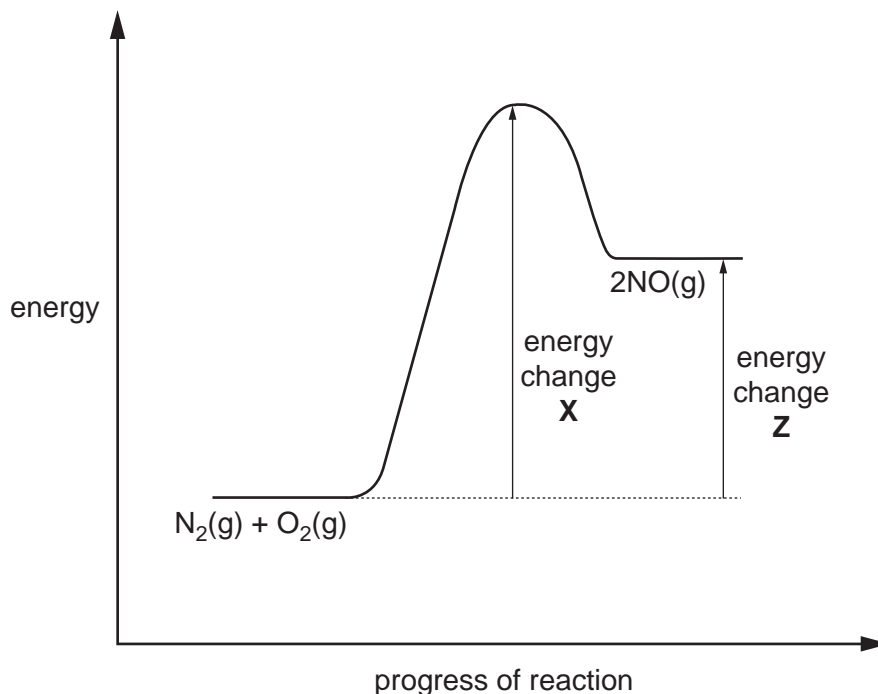
- (a) Compare the reactions of sodium and of magnesium with cold water. In each case identify the products formed. [3]
- (b) Draw electronic structures, including the charges, of the ions present in sodium oxide. Hence deduce the formula for sodium oxide. [2]
- (c) Write an equation for the formation of aluminium oxide from its elements. [1]
- (d) Pure sand is silicon(IV) oxide. It has a giant molecular structure similar to that of diamond. Suggest **two** physical properties of silicon(IV) oxide. [2]
- (e) Chlorine(VII) oxide,  $\text{Cl}_2\text{O}_7$ , has a simple molecular structure. Suggest one **physical** and one **chemical** property of  $\text{Cl}_2\text{O}_7$ . [2]

[Total: 10]

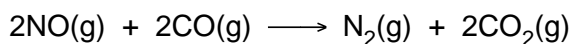
**B10** Oxides of nitrogen are atmospheric pollutants. Nitrogen monoxide, NO, is formed in an internal combustion engine when nitrogen and oxygen react together.



The diagram shows the energy profile for this reaction.



- (a) Identify the energy changes **X** and **Z**. [2]
- (b) The reaction between nitrogen and oxygen is endothermic.
- (i) Explain how you can tell from the diagram that the reaction is endothermic. [1]
- (ii) Explain, using ideas about bond breaking and bond making, why the overall reaction is endothermic. [3]
- (c) The exhaust system of a motor car is fitted with a catalytic converter. When nitrogen monoxide passes through the converter it reacts with carbon monoxide.



The catalyst increases the rate of this reaction.

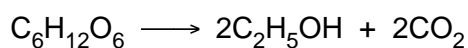
- (i) Explain how the catalyst in the converter increases the rate of this reaction. [1]
- (ii) During the course of a journey  $2.4 \text{ dm}^3$  of nitrogen monoxide was produced by the engine. Calculate the volume of nitrogen gas produced if all the nitrogen monoxide reacted in the converter. [1]
- (iii) In reality, only  $1.0 \text{ dm}^3$  of nitrogen was produced after the gases had passed over the catalytic converter. Calculate the percentage of nitrogen monoxide that had reacted. [2]

[Total: 10]

**B11** The table shows the formula of the first three members of the alcohol homologous series.

alcohol	formula
methanol	CH <sub>3</sub> OH
ethanol	C <sub>2</sub> H <sub>5</sub> OH
propanol	C <sub>3</sub> H <sub>7</sub> OH

- (a) Deduce the general formula for the alcohol homologous series. [1]
- (b) Name the products of the complete combustion of methanol. [1]
- (c) Ethanol can be manufactured from either ethene or glucose.
- (i) Write an equation for the production of ethanol from ethene and state the conditions under which the reaction takes place. [2]
- (ii) The fermentation of glucose can be represented by the following equation.

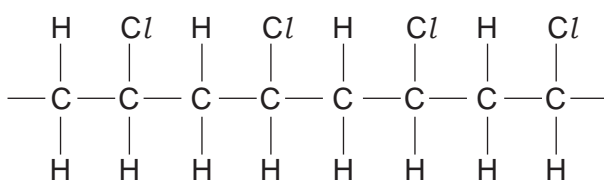


Calculate the maximum mass of ethanol that could be made from 36 tonnes of glucose. [3]

- (iii) Explain why ethanol made from ethene is a non-renewable fuel but that made from glucose is a renewable fuel. [2]
- (d) Propanol reacts in a similar way to ethanol.  
Name the organic product of the reaction between propanol and warm acidified potassium dichromate(VI). [1]

[Total: 10]

**B12** The macromolecule below is an addition polymer.



polymer **X**

- (a) Draw the structure of the monomer from which polymer **X** is formed. [1]
- (b) The atoms in polymer **X** are covalently bonded.
- (i) Explain what is meant by a covalent bond. [1]
- (ii) Polymer **X** is used as an insulating cover for electrical wires. Explain why polymer **X** does not conduct electricity. [1]
- (c) Polymer **X** is non-biodegradable.
- (i) Describe one pollution problem that this causes. [1]
- (ii) Polymer **X** can be disposed of by burning at high temperature. This produces waste gases, some of which are toxic such as hydrogen chloride. The hydrogen chloride can be removed by reacting the waste gases with moist calcium carbonate powder. Name the three products of this reaction. [3]
- (d) Ethene can be used to make poly(ethene).
- (i) Draw a 'dot-and-cross' diagram for an ethene molecule,  $\text{C}_2\text{H}_4$ . You must draw all of the electrons. [2]
- (ii) What is the maximum mass of poly(ethene) that can be made from 28 tonnes of ethene? [1]

[Total: 10]

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**DATA SHEET**  
**The Periodic Table of the Elements**

		Group									
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
		1 <b>H</b> Hydrogen 1									
7 <b>Li</b> Lithium 3	9 <b>Be</b> Beryllium 4										
23 <b>Na</b> Sodium 11	24 <b>Mg</b> Magnesium 12										
39 <b>K</b> Potassium 19	40 <b>Ca</b> Calcium 20										
85 <b>Rb</b> Rubidium 37	88 <b>Sr</b> Strontium 38										
133 <b>Cs</b> Caesium 55	137 <b>Ba</b> Barium 56										
226 <b>Fr</b> Francium 87	227 <b>Ra</b> Radium 88										
		58-71 Lanthanoid series †90-103 Actinoid series									
		a = relative atomic mass X = atomic symbol b = proton (atomic) number									
		Key									
		a      X      b									
11 <b>B</b> Boron 5	12 <b>C</b> Carbon 6	13 <b>Al</b> Aluminium 13	14 <b>Si</b> Silicon 14	15 <b>P</b> Phosphorus 15	16 <b>S</b> Sulphur 16	17 <b>Cl</b> Chlorine 17	18 <b>Ar</b> Argon 18	19 <b>F</b> Fluorine 9	20 <b>Ne</b> Neon 10		
27 <b>Al</b> Aluminium 13	28 <b>Si</b> Silicon 14	29 <b>Zn</b> Zinc 30	31 <b>Ga</b> Gallium 31	32 <b>Ge</b> Germanium 32	33 <b>As</b> Arsenic 33	34 <b>Se</b> Selenium 34	35 <b>Br</b> Bromine 35	36 <b>Kr</b> Krypton 36			
56 <b>Fe</b> Iron 26	57 <b>Co</b> Cobalt 27	58 <b>Ni</b> Nickel 28	59 <b>Cu</b> Copper 29	60 <b>Zn</b> Zinc 30	61 <b>Ga</b> Gallium 31	62 <b>Ge</b> Germanium 32	63 <b>As</b> Arsenic 33	64 <b>Se</b> Selenium 34	65 <b>Br</b> Bromine 35	66 <b>Kr</b> Krypton 36	67 <b>Xe</b> Xenon 54
93 <b>Nb</b> Niobium 41	94 <b>Zr</b> Zirconium 40	95 <b>Y</b> Yttrium 39	96 <b>Hf</b> Hafnium 72	97 <b>Ta</b> Tantalum 73	98 <b>W</b> Tungsten 74	99 <b>Re</b> Rhenium 75	100 <b>Os</b> Osmium 76	101 <b>Ir</b> Iridium 77	102 <b>Pt</b> Platinum 78	103 <b>Au</b> Gold 79	104 <b>Hg</b> Mercury 80
140 <b>Ce</b> Cerium 58	141 <b>Pr</b> Praseodymium 59	142 <b>Nd</b> Neodymium 60	143 <b>Pm</b> Promethium 61	144 <b>Sm</b> Samarium 62	145 <b>Eu</b> Europium 63	146 <b>Gd</b> Gadolinium 64	147 <b>Tb</b> Terbium 65	148 <b>Dy</b> Dysprosium 66	149 <b>Ho</b> Holmium 67	150 <b>Er</b> Erbium 68	151 <b>Tm</b> Thulium 69
232 <b>Th</b> Thorium 90	233 <b>Pa</b> Protactinium 91	234 <b>U</b> Uranium 92	235 <b>Np</b> Neptunium 93	236 <b>Pu</b> Plutonium 94	237 <b>Am</b> Americium 95	238 <b>Cm</b> Curium 96	239 <b>Bk</b> Berkelium 97	240 <b>Cf</b> Californium 98	241 <b>Es</b> Einsteinium 99	242 <b>Fm</b> Fermium 100	243 <b>Md</b> Mendelevium 101
175 <b>Lu</b> Lutetium 71	176 <b>Yb</b> Ytterbium 70	177 <b>Lu</b> Lutetium 71	178 <b>Yb</b> Ytterbium 70	179 <b>Lu</b> Lutetium 71	180 <b>Yb</b> Ytterbium 70	181 <b>Lu</b> Lutetium 71	182 <b>Yb</b> Ytterbium 70	183 <b>Lu</b> Lutetium 71	184 <b>Yb</b> Ytterbium 70	185 <b>Lu</b> Lutetium 71	186 <b>Yb</b> Ytterbium 70
175 <b>Lu</b> Lutetium 71	176 <b>Yb</b> Ytterbium 70	177 <b>Lu</b> Lutetium 71	178 <b>Yb</b> Ytterbium 70	179 <b>Lu</b> Lutetium 71	180 <b>Yb</b> Ytterbium 70	181 <b>Lu</b> Lutetium 71	182 <b>Yb</b> Ytterbium 70	183 <b>Lu</b> Lutetium 71	184 <b>Yb</b> Ytterbium 70	185 <b>Lu</b> Lutetium 71	186 <b>Yb</b> Ytterbium 70

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