Cambridge
O Level

**Cambridge International Examinations**
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER



**CHEMISTRY** **5070/21**

Paper 2 Theory **October/November 2015**

**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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, 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.
You may lose marks if you do not show your working or if you do not use appropriate units.
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.




CAMBRIDGE
International Examinations

[Turn over

## 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 gases to answer the questions below.

**ammonia**
**argon**
**carbon dioxide**
**chlorine**
**ethane**
**ethene**
**nitrogen**
**nitrogen(II) oxide**
**oxygen**
**sulfur dioxide**

Each of these gases can be used once, more than once or not at all.

Which gas

**(a)** forms approximately 1% of the air,

.....[1]

**(b)** bleaches damp litmus paper,

.....[1]

**(c)** reacts with water to form an alkaline solution,

.....[1]

**(d)** can undergo polymerisation,

.....[1]

**(e)** is a compound formed in the atmosphere as a result of lightning activity,

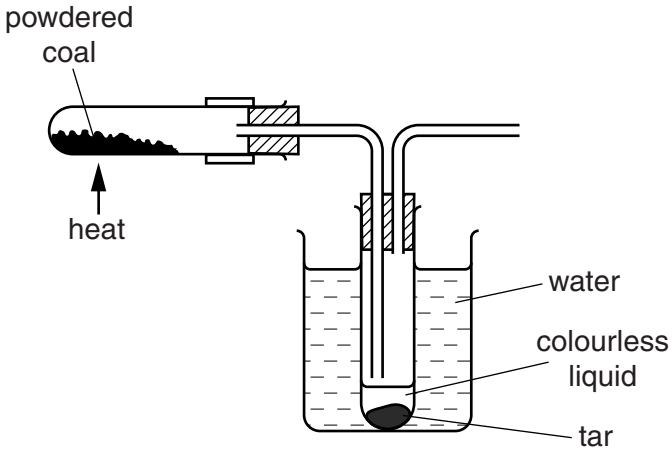
.....[1]

**(f)** is a diatomic molecule containing a total of 16 electrons?

.....[1]

[Total: 6]

**A2** Coal is a mixture of carbon compounds with a small amount of sulfur.
A sample of coal is heated in the absence of air using the apparatus shown.




The distillate is a mixture of a colourless liquid and tar.

**(a)** The colourless liquid contains ammonia, $NH_3$.

Draw a 'dot-and-cross' diagram for ammonia.
Show only the outer shell electrons.

[2]

**(b)** The tar contains ethanoic acid.
When warmed in the presence of sulfuric acid, ethanoic acid reacts with propanol to form an ester.

Name and draw the structure of this ester showing all the atoms and all the bonds.

name.....

structure

[2]

**(c)** The tar also contains a compound with the following composition.

| element | percentage by mass |
|---|---|
| carbon | 76.60 |
| hydrogen | 6.38 |
| oxygen | 17.02 |

Deduce the empirical formula of this compound.

empirical formula .....[2]

**(d)** When coal is burned, an acidic gas is produced which decolourises acidified aqueous potassium manganate(VII). This gas contributes to acid rain.

**(i)** Identify this gas and describe how acid rain is formed.

.....

.....

.....[2]

**(ii)** Give one adverse effect of acid rain on buildings.

.....[1]

**(iii)** Acid rain can have an adverse effect on respiration.

Write an equation to represent the process of respiration.

.....[2]

[Total: 11]

**A3** A layer of ozone is present in the stratosphere about 30 km above the Earth's surface.

**(a)** Compounds with formulae such as $CCl_3F$ and $C_2Cl F_5$ are responsible for the depletion of ozone.

**(i)** Give the general name for these compounds.

.....[1]

**(ii)** Explain, in terms of human health, why it is important that the ozone in the stratosphere does not become too depleted.

.....

.....[2]

**(b)** In the stratosphere, ozone, $O_3$, is broken down to oxygen by photochemical reactions.

**(i)** What is meant by the term *photochemical reaction*?

.....

.....[1]

**(ii)** Construct an equation for the breakdown of ozone molecules to oxygen molecules.

.....[1]

**(c)** Ozone oxidises $Fe^{2+}$ ions to $Fe^{3+}$ ions.

Complete the ionic equation for this reaction.

$$\ldots. Fe^{2+} + \ldots. H^+ + O_3 \rightarrow \ldots. Fe^{3+} + H_2O + O_2$$ [1]

[Total: 6]

**A4** Copper is a metal.

**(a)** Draw a labelled diagram to show the bonding in copper.

[2]

**(b)** Explain why metals are malleable.

.....

.....

.....[2]

**(c)** Copper corrodes slowly in damp air.
One of the corrosion products has the formula $CuCO_3.Cu(OH)_2$.

**(i)** Calculate the percentage by mass of copper in this compound.

[2]

**(ii)** How could you show that $CuCO_3.Cu(OH)_2$ contains carbonate ions?

.....

.....

.....[2]

**(d)** Copper is oxidised by concentrated sulfuric acid.
This redox reaction can be represented by equations **A** and **B**.

**A** $Cu \longrightarrow Cu^{2+} + 2e^-$

**B** $4H^+ + SO_4^{2-} + 2e^- \longrightarrow 2H_2O + SO_2$

Which reaction, **A** or **B**, is oxidation and which is reduction? Explain your answer.

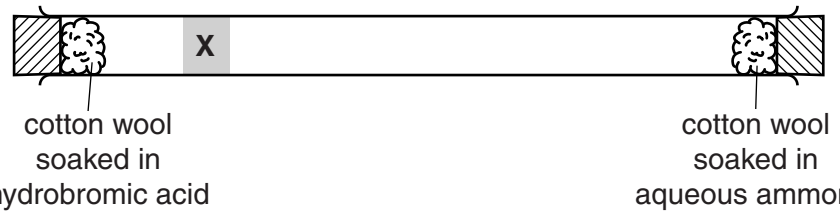
.....

.....

.....[2]

[Total: 10]

**A5** A student set up a tube as shown in the diagram.




Concentrated hydrobromic acid produces fumes of hydrogen bromide.
Concentrated aqueous ammonia produces fumes of ammonia.

**(a)** After some time, solid ammonium bromide appeared on the walls of the tube at point **X**.

Use the kinetic particle theory to explain this result.

.....

.....

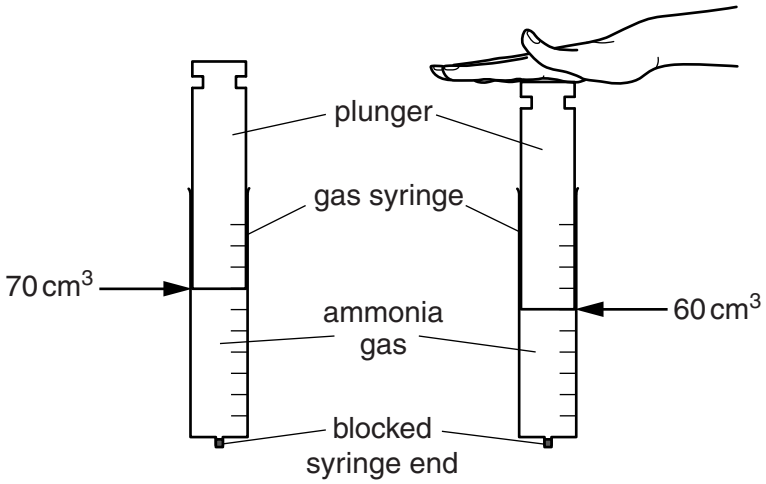
.....

.....

.....

.....[4]

**(b)** A gas syringe is filled with 70 $cm^3$ of ammonia gas.
The pressure on the plunger is increased.
The temperature does not change but the volume in the syringe decreases to 60 $cm^3$.




Use the kinetic particle theory to explain why the volume decreases.

.....

.....[1]

[Total: 5]

**A6** When 1 mole of sodium hydroxide reacts with excess hydrochloric acid, 57.1 kJ of energy is released.

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

**(a)** Calculate the energy released when 12.0 g of sodium hydroxide reacts with excess hydrochloric acid.

[2]

**(b)** Calculate the volume of 0.200 mol / $dm^3$ $HCl$ which contains 2.19 g of $HCl$.

[2]

**(c)** Aqueous hydrochloric acid contains chloride ions.

Describe a test for chloride ions.

test .....

result .....[2]

**(d)** Zinc oxide reacts with both hydrochloric acid and sodium hydroxide.

Which term describes this behaviour of zinc oxide?

.....[1]

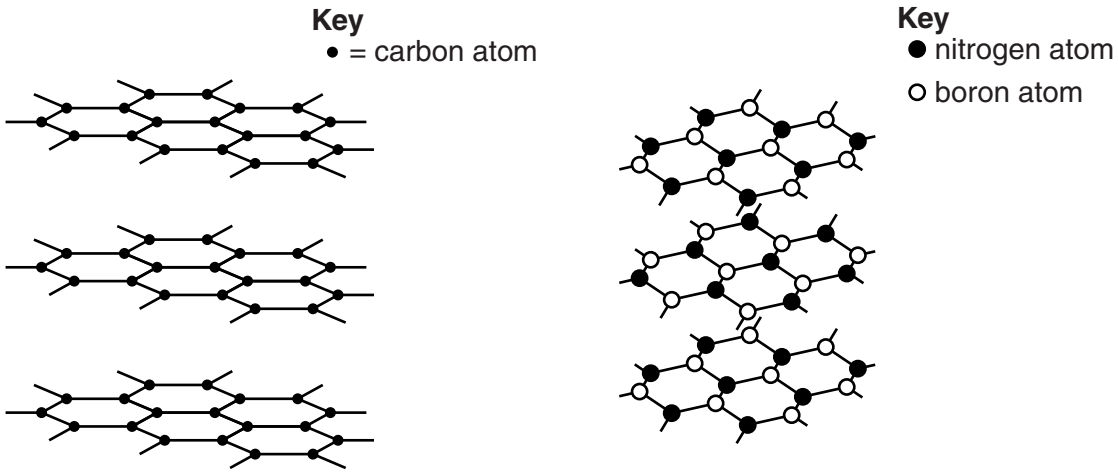
[Total: 7]

## Section B

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

The total mark for this section is 30.

**B7** The structures of graphite and boron nitride are shown below.




graphite boron nitride

**(a)** Like graphite, boron nitride feels slippery to the touch.

Explain, in terms of structure and bonding, why boron nitride feels slippery to the touch.

.....

.....

.....[2]

**(b)** An isotope of boron is represented by the symbol $^{11}_{5}B$.

Deduce the number of protons and neutrons in this isotope of boron.

number of protons .....

number of neutrons .....[1]

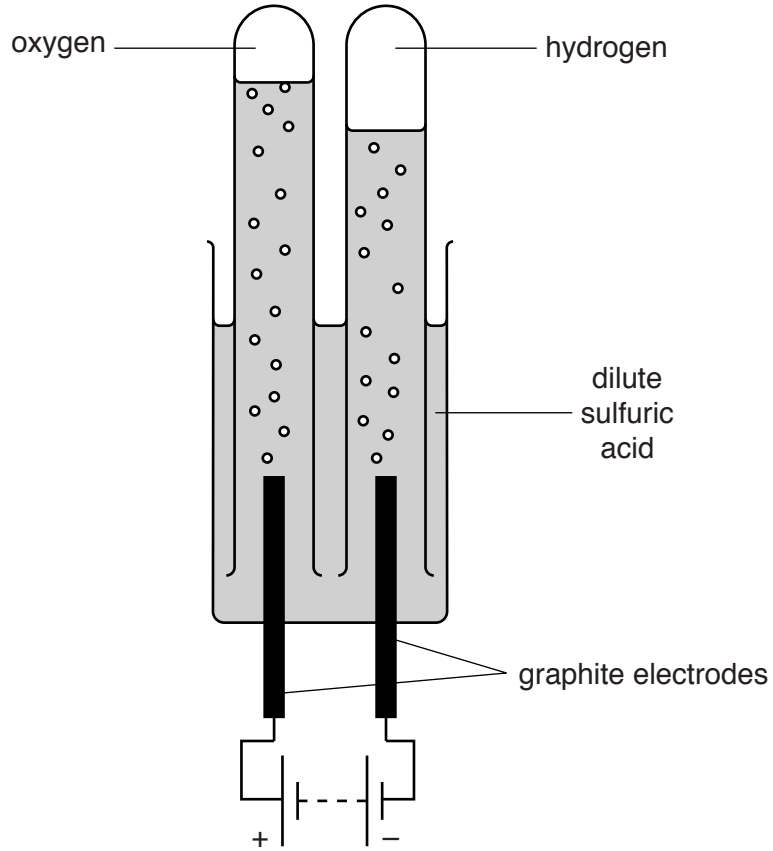
**(c)** Explain why graphite has a high melting point.

.....

.....

.....[2]

**(d)** Dilute sulfuric acid can be electrolysed using graphite electrodes.




**(i)** Graphite is a good electrical conductor.

Explain why graphite conducts electricity.

.....[1]

**(ii)** Give another property of graphite that makes it useful as an electrode in this electrolysis.

.....[1]

**(e)** During the electrolysis of dilute sulfuric acid, oxygen is released at the anode (positive electrode) and hydrogen is released at the cathode (negative electrode).

**(i)** Complete the equation for the reaction at the anode.

$$4OH^- \rightarrow O_2 + \text{.....} + \text{.....}$$ [1]

**(ii)** Construct the equation for the reaction at the cathode.

.....[1]

**(iii)** Explain why the volume of hydrogen produced is approximately double that of the oxygen.

.....

.....[1]

[Total: 10]

**B8** A sample of 0.030 g of small pieces of magnesium is added to 20 $cm^3$ of 0.10 mol/dr.. hydrochloric acid.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

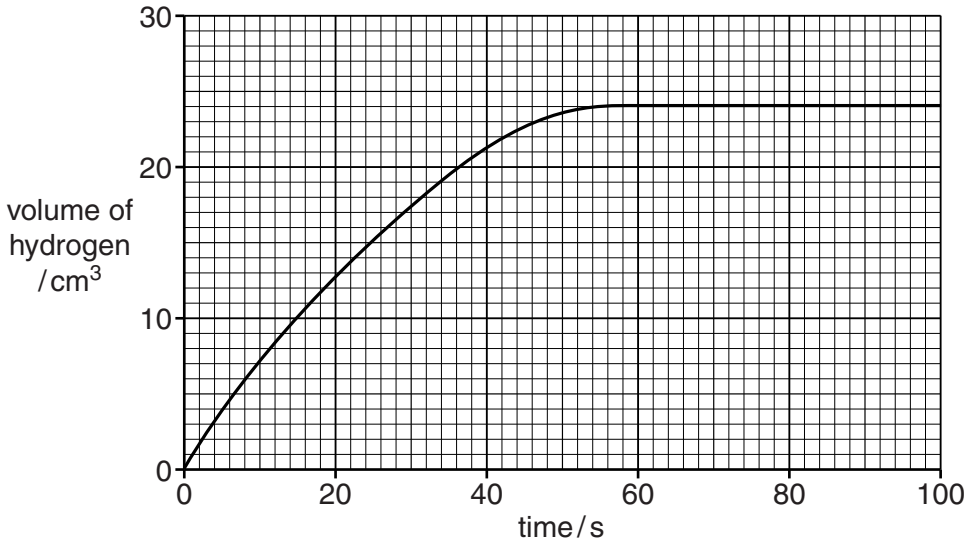
**(a) (i)** Show by calculation which reactant is in excess.

[3]

**(ii)** What would you observe in this reaction?

.....[1]

**(b)** The graph shows how the volume of hydrogen gas produced, at room temperature and pressure, changes with time.




Calculate the total mass of hydrogen formed.

mass of hydrogen = ..... g [2]

**(c)** The experiment is repeated at the same temperature and pressure. The same mass of magnesium is added but magnesium powder is used instead of small pieces.

The rate of reaction is faster. Explain why.

.....

.....

.....[2]

**(d)** Magnesium reacts with nitrogen when heated. The ionic compound magnesium nitride, $Mg_3N_2$, is formed.

**(i)** Construct the equation, including state symbols, for this reaction.

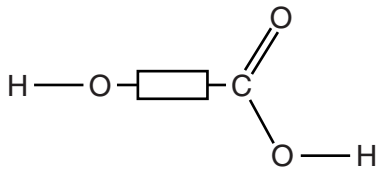
.....[1]

**(ii)** Deduce the charge on the nitride ion.

.....[1]

[Total: 10]

**B9** The structure of glycolic acid can be represented as shown.




**(a)** Glycolic acid is a solid at room temperature.

Describe the arrangement and motion of the molecules in glycolic acid at room temperature.

arrangement .....

motion .....[2]

**(b)** Glycolic acid can polymerise with itself to form a polyester called poly(glycolic acid).

**(i)** What type of polymer is a polyester?

.....[1]

**(ii)** Draw a section of the polymer chain of poly(glycolic acid) showing at least two repeating units.

[2]

**(c)** Glycolic acid is produced by heating methanal, carbon monoxide and water in the presence of a sulfuric acid catalyst.

$$\underset{\text{methanal}}{CH_2O} + CO + H_2O \longrightarrow \underset{\text{glycolic acid}}{CH_2(OH)COOH}$$

**(i)** A sample of 1800 g of methanal reacts with excess carbon monoxide and water. The percentage yield of glycolic acid is 45%.

Calculate the mass, in grams, of glycolic acid produced.

mass of glycolic acid = ..... g [3]

**(ii)** Glycolic acid is a weak acid. Sulfuric acid is a strong acid.

Explain the difference between a strong acid and a weak acid.

.....

.....

.....[2]

[Total: 10]

**B10** Methanol is manufactured by reacting carbon monoxide with hydrogen. The forward reaction is exothermic.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91\,kJ/mol$$

**(a)** Predict and explain the effect of increasing the pressure on the position of equilibrium. The temperature remains constant.

.....

.....

.....[2]

**(b)** Predict and explain the effect of decreasing the temperature on the position of equilibrium. The pressure remains constant.

.....

.....

.....[2]

**(c)** The rate of reaction decreases when the temperature is lowered.

Explain why.

.....

.....

.....[2]

**(d)** The reaction is catalysed by copper.

**(i)** Describe and explain the effect of a catalyst on this reaction.

.....

.....

.....[2]

**(ii)** Copper is a transition element. Many transition elements are catalysts.

Give **two** other properties of copper that identify it as a transition element.

.....

.....[2]

[Total: 10]

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# DATA SHEET
## The Periodic Table of the Elements

| Group I | Group II | | | | | | | | | | | Group III | Group IV | Group V | Group VI | Group VII | Group 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 H Hydrogen 1 | | | | | | | | | | 4 He Helium 2 |
| 7 Li Lithium 3 | 9 Be Beryllium 4 | | | | | | | | | | | 11 B Boron 5 | 12 C Carbon 6 | 14 N Nitrogen 7 | 16 O Oxygen 8 | 19 F Fluorine 9 | 20 Ne Neon 10 |
| 23 Na Sodium 11 | 24 Mg Magnesium 12 | | | | | | | | | | | 27 Al Aluminium 13 | 28 Si Silicon 14 | 31 P Phosphorus 15 | 32 S Sulfur 16 | 35.5 Cl Chlorine 17 | 40 Ar Argon 18 |
| 39 K Potassium 19 | 40 Ca Calcium 20 | 45 Sc Scandium 21 | 48 Ti Titanium 22 | 51 V Vanadium 23 | 52 Cr Chromium 24 | 55 Mn Manganese 25 | 56 Fe Iron 26 | 59 Co Cobalt 27 | 59 Ni Nickel 28 | 64 Cu Copper 29 | 65 Zn Zinc 30 | 70 Ga Gallium 31 | 73 Ge Germanium 32 | 75 As Arsenic 33 | 79 Se Selenium 34 | 80 Br Bromine 35 | 84 Kr Krypton 36 |
| 85 Rb Rubidium 37 | 88 Sr Strontium 38 | 89 Y Yttrium 39 | 91 Zr Zirconium 40 | 93 Nb Niobium 41 | 96 Mo Molybdenum 42 | Tc Technetium 43 | 101 Ru Ruthenium 44 | 103 Rh Rhodium 45 | 106 Pd Palladium 46 | 108 Ag Silver 47 | 112 Cd Cadmium 48 | 115 In Indium 49 | 119 Sn Tin 50 | 122 Sb Antimony 51 | 128 Te Tellurium 52 | 127 I Iodine 53 | 131 Xe Xenon 54 |
| 133 Cs Caesium 55 | 137 Ba Barium 56 | 139 La Lanthanum 57 * | 178 Hf Hafnium 72 | 181 Ta Tantalum 73 | 184 W Tungsten 74 | 186 Re Rhenium 75 | 190 Os Osmium 76 | 192 Ir Iridium 77 | 195 Pt Platinum 78 | 197 Au Gold 79 | 201 Hg Mercury 80 | 204 Tl Thallium 81 | 207 Pb Lead 82 | 209 Bi Bismuth 83 | 209 Po Polonium 84 | 210 At Astatine 85 | 222 Rn Radon 86 |
| 223 Fr Francium 87 | 226 Ra Radium 88 | 227 Ac Actinium 89 † | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 Ce Cerium 58 | 141 Pr Praseodymium 59 | 144 Nd Neodymium 60 | 147 Pm Promethium 61 | 150 Sm Samarium 62 | 152 Eu Europium 63 | 157 Gd Gadolinium 64 | 159 Tb Terbium 65 | 162 Dy Dysprosium 66 | 165 Ho Holmium 67 | 167 Er Erbium 68 | 169 Tm Thulium 69 | 173 Yb Ytterbium 70 | 175 Lu Lutetium 71 |
| 232 Th Thorium 90 | 231 Pa Protactinium 91 | 238 U Uranium 92 | 237 Np Neptunium 93 | 244 Pu Plutonium 94 | 243 Am Americium 95 | 247 Cm Curium 96 | 247 Bk Berkelium 97 | 251 Cf Californium 98 | 252 Es Einsteinium 99 | 257 Fm Fermium 100 | 258 Md Mendelevium 101 | 259 No Nobelium 102 | 260 Lr Lawrencium 103 |

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

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

The volume of one mole of any gas is 24 $dm^3$ at room temperature and pressure (r.t.p.).