

# **Cambridge International Examinations**

Cambridge Ordinary Level

| CANDIDATE<br>NAME |  |                     |   |  |  |
|-------------------|--|---------------------|---|--|--|
| CENTRE<br>NUMBER  |  | CANDIDATE<br>NUMBER | Ξ |  |  |

CHEMISTRY 5070/21

Paper 2 Theory

October/November 2014

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 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.

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** The diagram shows part of the Periodic Table. Only some of the elements are shown.

|    |    |  |  | Н  |  |    |    |    |    |   |   |  |
|----|----|--|--|----|--|----|----|----|----|---|---|--|
|    |    |  |  |    |  |    |    |    | С  | N | 0 |  |
| Na | Mg |  |  |    |  |    |    | Al | Si | Р |   |  |
| K  | Ca |  |  | Fe |  | Cu | Zn |    |    |   |   |  |
| Rb |    |  |  |    |  |    |    |    |    |   |   |  |

(a) Answer each of the following questions using only those elements shown in the diagram. Each element may be used once, more than once or not at all.

Give one element which

| (i)   | has a giant molecular structure,   |
|-------|--|
|       | [1]  |
| (ii)  | combines with oxygen to form a gas which contributes to acid rain,   |
|       | [1]  |
| (iii) | forms an ion of type $X^+$ which has only three completely filled shells of electrons,                                   |
|       | [1]  |
| (iv)  | has an atom with only seven protons in its nucleus,  |
|       | [1]  |
| (v)   | has an atom with only six electrons,   |
|       | [1]  |
| (vi)  | has a chloride of type $X{\rm C}l_2$ , whose aqueous solution forms a white precipitate on addition of sodium hydroxide. |
|       | [1]  |

| (b) | Under reduced pressure, potassium reacts with oxygen to form potassium oxide, K Construct the equation for this reaction.                   | <sub>2</sub> O. |
|-----|---|-----------------|
|     |   | [1]             |
| (c) | Aluminium is higher than zinc in the reactivity series.<br>Explain why aluminium foil does not react with an aqueous solution of zinc ions. |                 |
|     |   |                 |
|     |   | [2]             |
|     |   | [Total: 9]      |

**A2** The table shows some properties of the Group 0 elements (noble gases).

| element | density of liquid element in g/cm <sup>3</sup> | boiling point<br>/°C |
|---------|--|----------------------|
| helium  | 0.15   | -269                 |
| neon    | 1.20   | -246                 |
| argon   | 1.40   | -186                 |
| krypton |  | -152                 |
| xenon   | 3.52   |                      |

| (a) | Pre           | dict   |
|-----|---------------|--|
|     | (i)           | the density of liquid krypton,[1]  |
|     | (ii)          | the boiling point of xenon. [1]  |
| (b) | Arg           | on is a gas at room temperature.   |
|     | (i)           | Describe the arrangement and motion of the particles in a gas.   |
|     |               | arrangement  |
|     |               | motion   |
|     | <i>(</i> ''') | [2]  |
|     | (ii)          | State one use of argon.  |
|     |               | [1]  |
| (c) |               | noble gases are unreactive.<br>Iain why.   |
|     |               | [1]  |
| (d) | Sev           | eral compounds of the noble gases have been made in recent years.  |
|     |               | ${\rm con}({\rm IV})$ fluoride, ${\rm XeF_4}$ , reacts with water to form a mixture which contains xenon, xenon(VI) le, ${\rm XeO_3}$ , and hydrogen fluoride, HF. |
|     | Cor           | nplete the equation for the reaction of xenon(IV) fluoride with water.   |
|     |               | $\dots XeF_4 + \dots H_2O \rightarrow Xe + 2XeO_3 + 12HF$ [1]  |
| (e) |               | noble gases make up about 1% of the air. scribe and explain how fractional distillation can be used to separate the gases in the air.                              |
|     |               |  |
|     |               |  |
|     |               |  |
|     |               | [3]  |

[Total: 10]

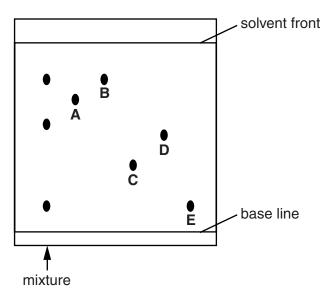
- A3 Paper chromatography can be used to separate metal ions in a mixture and identify them by comparison with known samples of metal ions (A–E).
  - (a) Draw a labelled diagram to show the apparatus used in paper chromatography.

On your diagram show

- the solvent,
- where the mixture of metal ions and known samples of metal ions are placed at the start of the experiment.

[2]

(b) The completed chromatogram is shown below.

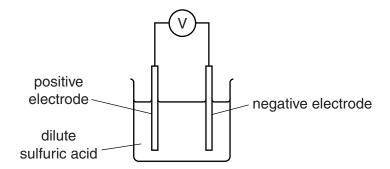


| (i) | Which of the metal ions | , <b>A</b> – <b>E</b> , | were present | in the | mixture? |
|-----|-------------------------|-------------------------|--------------|--------|----------|
|-----|-------------------------|-------------------------|--------------|--------|----------|

(ii) Calculate the  $R_{\rm f}$  value of metal ion **A**.

| (c) | Amr   | Ammonia can be used as a locating agent for some metal ions on the chromatogram.  |  |  |  |  |
|-----|-------|---|--|--|--|--|
|     | (i)   | Suggest why a locating agent may need to be used.   |  |  |  |  |
|     |       |   |  |  |  |  |
|     |       | [1]   |  |  |  |  |
|     | (ii)  | Aqueous ammonia is added slowly to aqueous copper( $\operatorname{II}$ ) sulfate until the ammonia is in excess.                |  |  |  |  |
|     |       | Describe what you would observe as the ammonia is added.  |  |  |  |  |
|     |       |   |  |  |  |  |
|     |       |   |  |  |  |  |
|     |       | [2]   |  |  |  |  |
| (   | (iii) | Construct the ionic equation, with state symbols, for the reaction of aqueous copper(II) sulfate with aqueous sodium hydroxide. |  |  |  |  |
|     |       | [2]   |  |  |  |  |
|     |       | [Total: 9]  |  |  |  |  |

# A4 The diagram shows a simple electrochemical cell.



The voltages produced by different combinations of metal electrodes are shown in the table below. The more reactive metal is always the negative electrode.

| positive electrode | negative electrode | voltage/V |
|--------------------|--------------------|-----------|
| copper             | zinc               | 1.10      |
| copper             | tin                | 0.48      |
| copper             | magnesium          | 2.70      |
| copper             | iron               | 0.78      |
| silver             | copper             | 0.46      |

| (a) | (i)   | Write an equa  | tion showing the conversion of zinc to zinc ions.   |
|-----|-------|----------------|---|
|     |       |                | [1]   |
|     | (ii)  | How does the   | table above show that copper is above silver in the reactivity series?  |
|     |       |                | [1]   |
| (   | (iii) |                | ation of metals in the table above will give the highest voltage?   |
|     |       |                | [1]   |
| (   | (iv)  |                | nation in the table to deduce the order of reactivity of the metals copper,<br>um, tin and zinc. Explain your answer. |
|     |       | most reactive  |   |
|     |       |                |   |
|     |       |                |   |
|     |       |                |   |
|     |       | least reactive |   |
|     |       |                |   |
|     |       |                | [2]   |

5070/21/O/N/14

[Turn over

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|           | (b)  | Ref   | er to the structure of metals to explain  |
|-----------|------|-------|---|
|           |      | (i)   | why metals are malleable,   |
|           |      |       |   |
|           |      | (ii)  | why metals conduct electricity.   |
|           |      | ( )   | [1]   |
|           | (c)  | Exp   | lain why plating iron with tin prevents the iron from rusting.  |
|           |      |       | [1]   |
|           |      |       | [Total: 9]  |
| <b>A5</b> | stro | ng a  | Int titrates $20.0\mathrm{cm^3}$ of a metal hydroxide, $M(\mathrm{OH})_2$ , of concentration $0.060\mathrm{mol/dm^3}$ with a cid of concentration $0.050\mathrm{mol/dm^3}$ . Les $24.0\mathrm{cm^3}$ of acid to neutralise the metal hydroxide. |
|           | (a)  | (i)   | Calculate the number of moles of acid in 24.0 cm <sup>3</sup> of the acid.  |
|           |      |       |   |
|           |      |       | moles [1]   |
|           |      | (ii)  | Calculate the number of moles of OH <sup>-</sup> ions in 20.0 cm <sup>3</sup> of the metal hydroxide.   |
|           |      |       |   |
|           |      |       | moles [1]   |
|           |      | (iii) | Deduce whether the acid used is more likely to be hydrochloric acid or sulfuric acid. Explain your answer.  |
|           |      |       | [1]   |
|           |      |       | [']   |

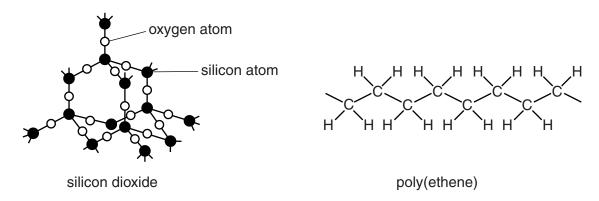
| (b) | A st  | tudent added excess calcium carbonate to 50 cm <sup>3</sup> of 0.10 mol/dm <sup>3</sup> hydrochloric acid.                    |
|-----|-------|---|
|     | (i)   | Construct an equation for the reaction of calcium carbonate with hydrochloric acid.   |
|     |       | [1]   |
|     | (ii)  | The volume of gas produced in the first 2 minutes is 24 cm <sup>3</sup> .   |
|     |       | Calculate the average rate of reaction over the first 2 minutes, in cm <sup>3</sup> /s.                                       |
|     |       |   |
|     |       |   |
|     |       |   |
|     |       |   |
|     |       | reaction rate =cm <sup>3</sup> /s [1]   |
|     | (iii) | The student repeats the experiment using 50 cm <sup>3</sup> of 0.10 mol/dm <sup>3</sup> ethanoic acid.                        |
|     |       | Use the kinetic particle theory to explain why the rate of reaction is slower with ethanoic acid than with hydrochloric acid. |
|     |       |   |
|     |       |   |
|     |       |   |
|     |       |   |
|     |       |   |
|     |       | [3]   |
|     |       | [Total: 8]  |

## **Section B**

Answer three questions from this section in the spaces provided.

The total mark for this section is 30.

**B6** Parts of the structures of silicon dioxide and poly(ethene) are shown below.



(a) The melting point of silicon dioxide is 1610 °C. Poly(ethene) starts to melt at 130 °C.

|     | Explain, in terms of structure and bonding, the difference between the melting points of these two substances.    |
|-----|---|
|     |   |
|     |   |
|     |   |
|     |   |
|     |   |
|     | [4]   |
| (b) | What type of polymerisation is used to make poly(ethene)?   |
|     | [1]   |
| (c) | Poly(ethene) is made from ethene monomers.  Explain why ethene is both a hydrocarbon and an unsaturated compound. |
|     |   |
|     |   |
|     | [2]   |

(d) Silicone fluids are polymers. Part of the structure of a silicone fluid is shown below.

The monomer used in making this silicone fluid is a saturated compound with two -OH groups.

Deduce the structure of this monomer.

[1]

**(e)** The compound used to make the monomer of the silicone fluid has the following composition by mass.

$$C = 18.6 \,\mathrm{g}, \,Cl = 55.0 \,\mathrm{g}, \,H = 4.65 \,\mathrm{g}, \,\mathrm{Si} = 21.7 \,\mathrm{g}$$

Deduce the empirical formula of this compound.

empirical formula .....[2]

[Total: 10]

| B7 | Thre | ee im        | portant processes in the carbon cycle are combustion, respiration and photosynthesis.                                     |
|----|------|--------------|---|
|    | (a)  | Cor          | struct the equation for the complete combustion of propane, C <sub>3</sub> H <sub>8</sub> .                               |
|    |      |              | [1]   |
|    | (b)  | (i)          | Describe how the processes in the carbon cycle regulate the amount of carbon dioxide in the atmosphere.                   |
|    |      |              | [2]   |
|    |      | (ii)         | Carbon dioxide is a greenhouse gas. What do you understand by the term <i>greenhouse gas</i> ?                            |
|    |      |              | [1]   |
|    |      | (iii)        | Methane is also a greenhouse gas. Give one source of methane in the atmosphere.   |
|    |      |              | [1]   |
|    |      | (iv)         | The percentage of methane by volume in the air is 0.00014%. Calculate the mass of methane in 1000 dm <sup>3</sup> of air. |
|    |      |              |   |
|    |      |              |   |
|    |      |              | rol   |
|    |      |              | mass =g [2]   |
|    | (c)  | Plar<br>plar | nts use water in photosynthesis. Water containing the radioactive isotope <sup>18</sup> O is fed to a not.                |
|    |      | The          | resulting radioactivity in the products of photosynthesis is shown in the equation below.                                 |
|    |      |              | $6CO_2 + 6H_2^{18}O \rightarrow C_6H_{12}O_6 + 6^{18}O_2$ glucose   |
|    |      | (i)          | What does this tell you about the origin of the oxygen in each of the products?   |
|    |      |              | [1]   |
|    |      | (ii)         | Deduce the number of protons, neutrons and electrons in an atom of <sup>18</sup> O.                                       |
|    |      |              | protons   |
|    |      |              | neutrons  |
|    |      |              | electrons[2]  |
|    |      |              | [Total: 10]   |

| B8 | Sulf | furic | acid is manufactured by the Contact process.   |
|----|------|-------|--|
|    | (a)  |       | some chemical plants zinc sulfide, ZnS, is roasted in air to form zinc oxide and sulfu   |
|    |      | Cor   | nstruct the balanced equation for this reaction.   |
|    |      |       | [1   |
|    | (b)  | The   | sulfur dioxide is then converted to sulfur trioxide.   |
|    |      |       | $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \Delta H = -98 \text{ kJ/mol}$  |
|    |      | (i)   | Describe how and explain why increasing the pressure affects the position of equilibrium. The temperature remains constant.          |
|    |      |       |  |
|    |      |       |  |
|    |      |       | [2   |
|    |      | (ii)  | Describe how and explain why increasing the temperature affects the position o equilibrium. The pressure remains constant.           |
|    |      |       |  |
|    |      |       |  |
|    |      |       | [2   |
|    |      | (iii) | $\label{eq:Vanadium} \mbox{Vanadium}(V) \mbox{ oxide is used as a catalyst in the conversion of sulfur dioxide to sulfur trioxide.}$ |
|    |      |       | Explain how using vanadium(V) oxide reduces the energy costs of the Contact process.   |
|    |      |       |  |
|    |      |       |  |
|    |      |       | [2   |

| (c) | Sulfuric acid is used to make superphosphate fertilisers. A mixture of the fertiliser and calcium |
|-----|---|
|     | sulfate is formed. This mixture is used by farmers.   |

| (i) | Calculate   | the   | percentage     | by    | mass    | of  | calcium  | sulfate   | in   | the | mixture | of | calcium |
|-----|-------------|-------|----------------|-------|---------|-----|----------|-----------|------|-----|---------|----|---------|
|     | superphos   | sphat | te and calciur | ท รเ  | ulfate. |     |          |           |      |     |         |    |         |
|     | (The relati | ve fo | rmula mass     | of ca | alcium  | sup | erphosph | ate is 23 | 34.) |     |         |    |         |

| % [2] ne problem involved in either the transport of this mixture or its use as a | Suggest fertiliser. | (ii) |
|---|---------------------|------|
| [1]   |                     |      |
| [Total: 10]   |                     |      |

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 $\textbf{B9} \quad \text{Bromate(V) ions, BrO}_3^-\text{, react with bromide ions, Br}^-\text{, in acidic solution to form bromine.}$ 

|     |               | $\mathrm{BrO_3^-}(\mathrm{aq}) + 5\mathrm{Br^-}(\mathrm{aq}) + 6\mathrm{H^+}(\mathrm{aq}) \longrightarrow 3\mathrm{Br_2}(\mathrm{aq}) + 3\mathrm{H_2O(I)}$ |
|-----|---------------|--|
| (a) | (i)           | Explain why the acidity of the reaction mixture decreases as the reaction proceeds.  |
|     |               |  |
|     | <i>(</i> 11)  | [2]  |
|     | (ii)          | State the colour of aqueous bromine.   |
|     | (iii)         | Explain, using the kinetic particle theory, why increasing the temperature increases the   |
| ,   | (''' <i>)</i> | rate of this reaction.   |
|     |               |  |
|     |               |  |
|     |               | [2]  |
| (b) |               | mine oxidises aqueous iodide ions to iodine.<br>te the equation for this reaction.   |
|     |               | [1]  |
| (c) | Aqu           | neous potassium iodide can be used to test for oxidising agents.   |
|     |               | scribe and explain the colour change when excess aqueous potassium iodide is added to eous acidified potassium manganate(VII), $KMnO_4$ .                  |
|     |               |  |
|     |               | [2]  |
| (d) | Des           | scribe how aqueous bromine is used to test for an unsaturated hydrocarbon.   |
|     |               | [1]  |
| (e) |               | w a 'dot-and-cross' diagram for a bromine molecule.  |

[1]

Ī DATA SHEET Ċ F

|                                    |       | 0        | 4 <b>Heli</b> um          |   | 20 | Ne | Neon           | 40   | Ar | Argon            | 84 | Ż      | Krypton<br>36   | 131 | Xe       | Xenon           | 222 | R        | Radon             |     |    |                  |
|------------------------------------|-------|----------|---------------------------|---|----|----|----------------|------|----|------------------|----|--------|-----------------|-----|----------|-----------------|-----|----------|-------------------|-----|----|------------------|
|                                    |       |          |                           | 7 |    |    | 9              |      |    | 18               |    |        | 36 K            |     | _        | × 45            |     | _        | 86<br>R           |     |    |                  |
| The Periodic Table of the Elements |       | II/      |                           |   | 19 | ш  | Fluorine<br>9  | 35.5 | CI | Chlorine<br>17   | 80 | Ā      | Bromine<br>35   | 127 | H        | 53              |     | ¥        | Astatine<br>85    |     |    |                  |
|                                    |       | IN       |                           |   | 16 | 0  | Oxygen<br>8    | 32   | ഗ  | Sulfur<br>16     | 62 | Se     | Selenium<br>34  | 128 | <u>e</u> | Tellurium<br>52 | 209 | S<br>S   | Polonium<br>84    |     |    |                  |
|                                    |       | >        |                           |   | 14 | z  | Nitrogen 7     | 31   | Δ. | Phosphorus<br>15 | 75 | As     | Arsenic<br>33   | 122 | Sp       | Antimony<br>51  | 209 | ï        | Bismuth<br>83     |     |    |                  |
|                                    |       | <b>\</b> |                           |   | 12 | ပ  | Carbon<br>6    |      |    | Silicon<br>14    | 73 | Ge     | Germanium<br>32 | 119 | Sn       | Tin<br>50       | 207 | Pb       | Lead<br>82        |     |    |                  |
|                                    |       | ≡        |                           |   | =  | Ω  | Boron<br>5     | 27   | Αl | Aluminium<br>13  | 20 | Са     | Gallium<br>31   |     |          | Indium<br>49    |     | 11       | Thallium<br>81    |     |    |                  |
| ts                                 |       |          |                           |   |    |    |                |      |    |                  | 65 | Zu     | Zinc<br>30      | 112 | ဦ        | Cadmium<br>48   | 201 | Ę        | Mercury<br>80     |     |    |                  |
| Elemen                             |       |          |                           |   |    |    |                |      |    |                  | 64 | D<br>C | Copper<br>29    | 108 | Ag       | Silver<br>47    | 197 | Au       | Gold<br>79        |     |    |                  |
| le of the                          | Group |          |                           |   |    |    |                |      |    |                  | 29 | Ż      | Nickel<br>28    |     | Pq       | 4               |     | 풉        | Platinum<br>78    |     |    |                  |
| dic Tabl                           | Gr    |          |                           |   | 1  |    |                |      |    |                  | 29 | ပိ     | Cobalt<br>27    | 103 | 뜐        | Rhodium<br>45   | 192 | À        | Iridium<br>77     |     |    |                  |
| he Perio                           |       |          | 1<br><b>T</b><br>Hydrogen | - |    |    |                |      |    |                  | 56 | æ      | Iron<br>26      |     |          | Ruthenium<br>44 |     | SO       | Osmium<br>76      |     |    |                  |
| Ė                                  |       |          |                           |   |    |    |                |      |    |                  | 55 | Mn     | Manganese<br>25 |     | ဥ        | n Technetium 43 | 186 | Re       | Rhenium<br>75     |     |    |                  |
|                                    |       |          |                           |   |    |    |                |      |    |                  | 52 | င်     | Chromium<br>24  |     | Mo       |                 |     | >        | Tungsten<br>74    |     |    |                  |
|                                    |       |          |                           |   |    |    |                |      |    |                  | 51 | >      | Vanadium<br>23  | 93  | Q<br>N   |                 | 181 | <u>Б</u> | Tantalum<br>73    |     |    |                  |
|                                    |       |          |                           |   |    |    |                |      |    |                  | 48 | F      | Titanium<br>22  | 91  | Z        | Zirconium<br>40 | 178 | Ξ        | Hafnium<br>72     |     |    |                  |
|                                    |       |          |                           |   |    |    |                |      |    |                  |    | လွ     | Scandium<br>21  | 68  |          | Yttrium<br>39   | 139 | Гa       | Lanthanum<br>57 * | 227 | Ac | Actinium<br>89 † |
|                                    |       | =        |                           |   | 6  | Be | Beryllium<br>4 | 24   | Mg | Magnesium<br>12  | 40 | Ca     | Calcium<br>20   |     | Š        | 38 g            | 137 | Ва       |                   | 226 | Ва | Radium<br>88     |
|                                    |       | _        |                           |   | 7  | =  | Lithium<br>3   |      | Na |                  |    | ¥      | Potassium<br>19 | 85  | 絽        | Rubidium<br>37  | 133 | Cs       | Caesium<br>55     | 223 | ъ  | Francium<br>87   |
| 201                                | 4     |          |                           |   |    |    |                |      |    |                  |    | 50     | 70/2            |     |          |                 |     |          |                   |     |    |                  |

28 a = relative atomic mass \* 58-71 Lanthanoid series † 90-103 Actinoid series а **×** 

X = atomic symbol

Key

159 **7** Terbium 247 **BK** 65 **Curium** 152 **Eu** Europium Am Plutonium 150 **Sm** Samarium 244 **Pu** 237 **Np** ‡ **B** 238 231 **Pa** 140 Cerium Thorium 232 **Th** 90 b = atomic (proton) number

260 **Lr** Lawrengium 103

259 Nobelium

258 **Md** 

257 **Fm** 

252 **ES** 

**5**21

175 **Lu** Lutetium

173 **Yb** 

169 **Thulium** 

167 **Er**bium

165 **Holmium** 

68

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