Cambridge
O Level

**Cambridge International Examinations**
Cambridge Ordinary Level

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|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CENTRE NUMBER | | | | | | CANDIDATE NUMBER | | | |

*5907051958*

**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.


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

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | H | | | | | | | | | | |
| | | | | | | | | | | | | | C | N | O | | |
| Na | Mg | | | | | | | | | | | Al | Si | P | | | |
| 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 $XCl_2$, whose aqueous solution forms a white precipitate on addition of sodium hydroxide.

.....[1]

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**(b)** Under reduced pressure, potassium reacts with oxygen to form potassium oxide, $K_2O$.
Construct the equation for this reaction.

.....[1]

**(c)** Aluminium is higher than zinc in the reactivity series.
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$^3$ | boiling point /°C |
|---|---|---|
| helium | 0.15 | –269 |
| neon | 1.20 | –246 |
| argon | 1.40 | –186 |
| krypton | | –152 |
| xenon | 3.52 | |

**(a)** Predict

**(i)** the density of liquid krypton, .....[1]

**(ii)** the boiling point of xenon. .....[1]

**(b)** Argon is a gas at room temperature.

**(i)** Describe the arrangement and motion of the particles in a gas.

arrangement .....

motion .....
[2]

**(ii)** State one use of argon.

.....[1]

**(c)** The noble gases are unreactive.
Explain why.

.....[1]

**(d)** Several compounds of the noble gases have been made in recent years.

Xenon(IV) fluoride, $XeF_4$, reacts with water to form a mixture which contains xenon, xenon(VI) oxide, $XeO_3$, and hydrogen fluoride, HF.

Complete the equation for the reaction of xenon(IV) fluoride with water.

$$\ldots\ XeF_4 + \ldots\ H_2O \rightarrow Xe + 2XeO_3 + 12HF$$ [1]

**(e)** The noble gases make up about 1% of the air.
Describe and explain how fractional distillation can be used to separate the gases in the air.

.....

.....

.....

.....[3]

[Total: 10]

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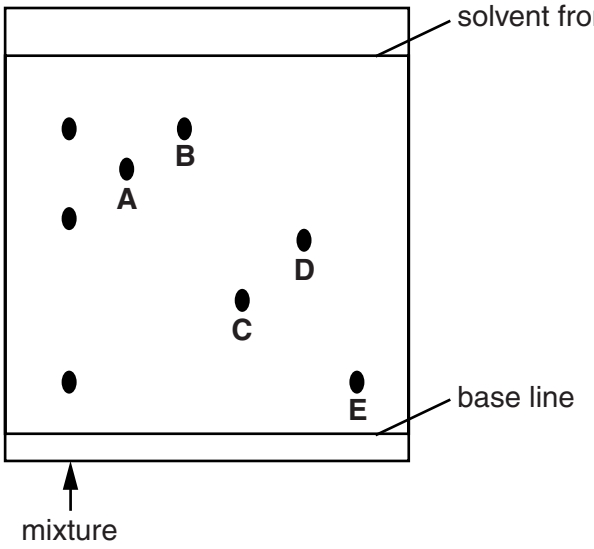
**A3** Paper chromatography can be used to separate metal ions in a mixture and identify them by comparison with known samples of metal ions (**A**–**E**).

**(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, **A**–**E**, were present in the mixture?

.....[1]

**(ii)** Calculate the $R_f$ value of metal ion **A**.

$R_f$ value = .....[1]

**(c)** 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(II) sulfate until the ammonia is in excess.

Describe what you would observe as the ammonia is added.

.....

.....

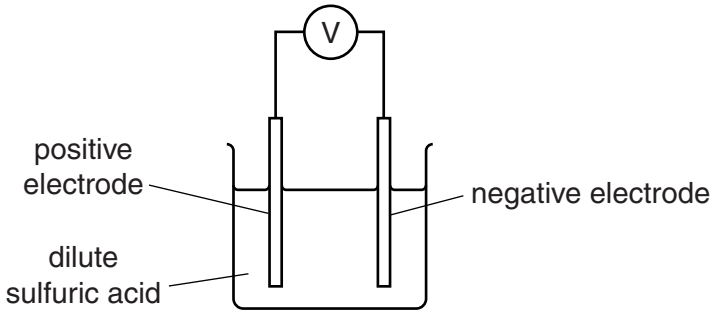
.....[2]

**(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 equation 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)** Which combination of metals in the table above will give the highest voltage?

.....[1]

**(iv)** Use the information in the table to deduce the order of reactivity of the metals copper, iron, magnesium, tin and zinc. Explain your answer.

most reactive .....

.....

.....

.....

least reactive .....

.....

.....[2]

**(b)** Refer to the structure of metals to explain

**(i)** why metals are malleable,

.....

.....

.....[2]

**(ii)** why metals conduct electricity.

.....[1]

**(c)** Explain why plating iron with tin prevents the iron from rusting.

.....

.....[1]

[Total: 9]

**A5** A student titrates 20.0 $cm^3$ of a metal hydroxide, $M(OH)_2$, of concentration 0.060 $mol/dm^3$ with a strong acid of concentration 0.050 $mol/dm^3$.
It requires 24.0 $cm^3$ of acid to neutralise the metal hydroxide.

**(a) (i)** Calculate the number of moles of acid in 24.0 $cm^3$ of the acid.

..... moles [1]

**(ii)** Calculate the number of moles of $OH^-$ ions in 20.0 $cm^3$ 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 student added excess calcium carbonate to 50 $cm^3$ of 0.10 mol / $dm^3$ 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 $cm^3$.

Calculate the average rate of reaction over the first 2 minutes, in $cm^3/s$.

reaction rate = .....$cm^3/s$ [1]

**(iii)** The student repeats the experiment using 50 $cm^3$ of 0.10 mol / $dm^3$ ethanoic acid.

Use the kinetic particle theory to explain why the rate of reaction is slower with ethanoic acid than with hydrochloric acid.

.....

.....

.....

.....

.....

.....[3]

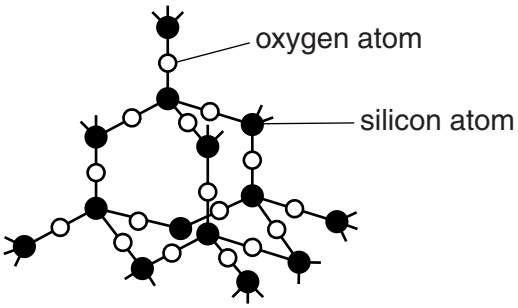
[Total: 8]

## Section B

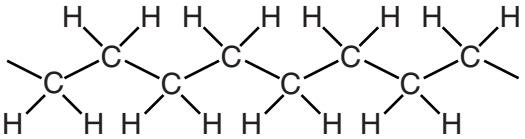
Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

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




silicon dioxide



poly(ethene)

**(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.

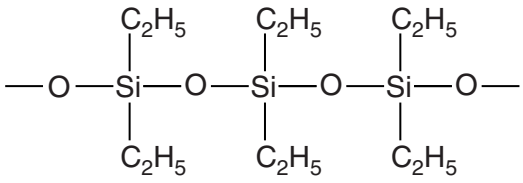
.....

.....

.....[2]

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**(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 g, C*l* = 55.0 g, H = 4.65 g, Si = 21.7 g

Deduce the empirical formula of this compound.

empirical formula .....[2]

[Total: 10]

**B7** Three important processes in the carbon cycle are combustion, respiration and photosynthesis.

**(a)** Construct the equation for the complete combustion of propane, $C_3H_8$.

.....[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 *greenhouse gas*?

.....[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 1 000 $dm^3$ of air.

mass = .....g [2]

**(c)** Plants use water in photosynthesis. Water containing the radioactive isotope $^{18}O$ is fed to a plant.

The resulting radioactivity in the products of photosynthesis is shown in the equation below.

$$6CO_2 + 6H_2{}^{18}O \rightarrow \underset{\text{glucose}}{C_6H_{12}O_6} + 6{}^{18}O_2$$

**(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 $^{18}O$.

protons .....

neutrons .....

electrons ..... [2]

[Total: 10]

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**B8** Sulfuric acid is manufactured by the Contact process.

**(a)** In some chemical plants zinc sulfide, ZnS, is roasted in air to form zinc oxide and sulfur dioxide.

Construct the balanced equation for this reaction.

.....[1]

**(b)** The sulfur dioxide is then converted to sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -98\,kJ/mol$$

**(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 of equilibrium. The pressure remains constant.

.....

.....

.....[2]

**(iii)** Vanadium(V) 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.

$$Ca_3(PO_4)_2 + 2H_2SO_4 \rightarrow \underset{\text{calcium superphosphate}}{Ca(H_2PO_4)_2} + 2CaSO_4$$

**(i)** Calculate the percentage by mass of calcium sulfate in the mixture of calcium superphosphate and calcium sulfate.
(The relative formula mass of calcium superphosphate is 234.)

..... % [2]

**(ii)** Suggest one problem involved in either the transport of this mixture or its use as a fertiliser.

.....

.....[1]

[Total: 10]

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**B9** Bromate(V) ions, $BrO_3^-$, react with bromide ions, $Br^-$, in acidic solution to form bromine.

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

**(a) (i)** Explain why the acidity of the reaction mixture decreases as the reaction proceeds.

.....

.....[2]

**(ii)** State the colour of aqueous bromine.

.....[1]

**(iii)** Explain, using the kinetic particle theory, why increasing the temperature increases the rate of this reaction.

.....

.....

.....[2]

**(b)** Bromine oxidises aqueous iodide ions to iodine.
Write the equation for this reaction.

.....[1]

**(c)** Aqueous potassium iodide can be used to test for oxidising agents.

Describe and explain the colour change when excess aqueous potassium iodide is added to aqueous acidified potassium manganate(VII), $KMnO_4$.

.....

.....[2]

**(d)** Describe how aqueous bromine is used to test for an unsaturated hydrocarbon.

.....[1]

**(e)** Draw a 'dot-and-cross' diagram for a bromine molecule.
Show only the outer electrons.

[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 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 Radius 88 | 227 Ac Actinium 89 † | | | | | | | | | | | | | | | |

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

| | | |
|---|---|---|
| 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 | |

Key: a X b — 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.).