Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
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Centre Number | Candidate Number

# Pearson Edexcel International Advanced Level

**Time** 1 hour 20 minutes

**Paper reference** **WCH13/01**

# Chemistry

## International Advanced Subsidiary/Advanced Level
## UNIT 3: Practical Skills in Chemistry I

**You must have:**
Scientific calculator, ruler

Total Marks

## Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

## Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

## Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

*Turn over* ▶


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**Answer ALL the questions. Write your answers in the spaces provided.**

**1** This question is about ammonium chloride, $NH_4Cl$, a soluble ionic compound.

(a) An aqueous solution of $NH_4Cl$ contains both ammonium ions, $NH_4^+$, and chloride ions, $Cl^-$.

(i) State what would be **seen** on the addition of acidified silver nitrate solution to an aqueous solution of $NH_4Cl$.

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(ii) Describe a test to confirm the presence of $NH_4^+$ ions in a solution of $NH_4Cl$. Include the result of the positive test.

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(b) A student investigated the enthalpy change when dissolving $NH_4Cl$ in excess water.

$$NH_4Cl(s) + aq \rightarrow NH_4^+(aq) + Cl^-(aq)$$

**Procedure**

Step **1** Accurately weigh 7.17 g of $NH_4Cl$ into a glass beaker.

Step **2** Fill a 50 $cm^3$ measuring cylinder with deionised water. Measure the temperature of the water using a thermometer.

Step **3** Pour the water from the measuring cylinder into the beaker and at the same time start a stopwatch. Stir the solution in the beaker, using the thermometer.

Step **4** Record the temperature at 15 s, 30 s and then at 30 s intervals while continuing to stir the solution.

The data from the experiment are shown on the graph.

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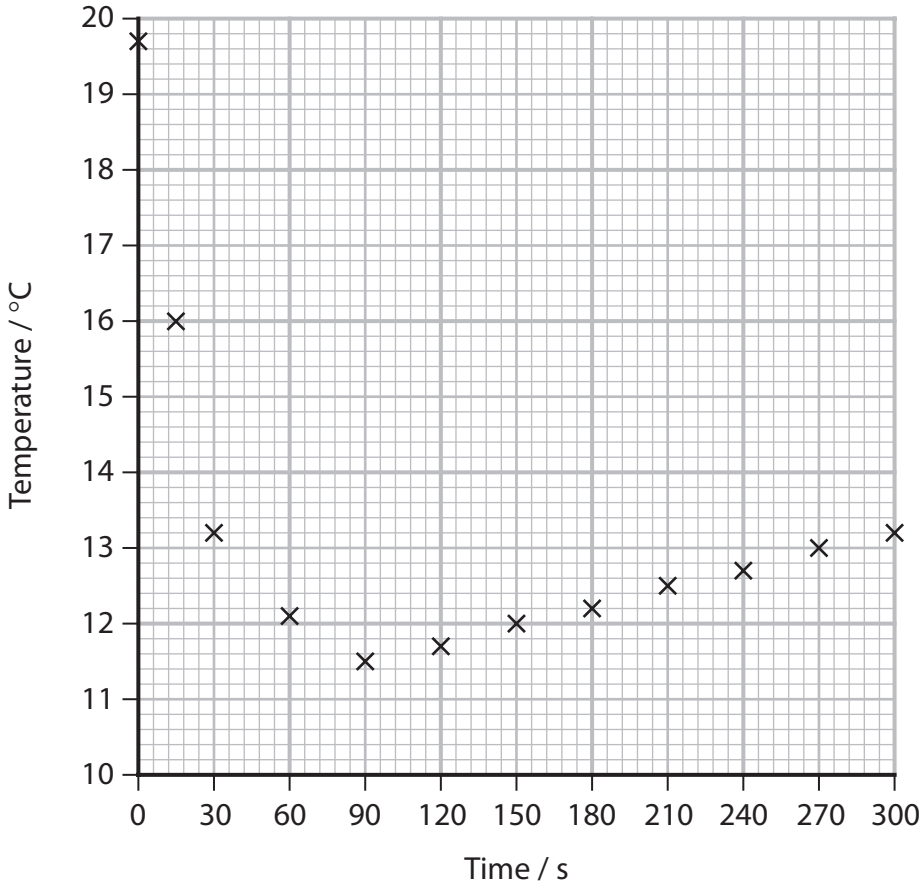


(i) Give **two** reasons why the student stirred the solution in Steps **3** and **4**.

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(ii) Use the graph to determine the maximum temperature change, $\Delta T$, in this experiment. You **must** show your working on the graph.

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(iii) Another student carried out the experiment using a polystyrene cup in place of the glass beaker.

Explain how this student's graph would be different.
You may annotate the graph as part of your answer.

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(c) The experimental results of another student were used in the equation shown to calculate the enthalpy change, $\Delta H$, for dissolving one mole of $NH_4Cl$ in excess water.

$$\Delta H = \frac{m \times c \times \Delta T}{n}$$

$$= +14\,500\ \text{J mol}^{-1}$$

In the equation

$m$ = mass of solution = 50 g

$c$ = specific heat capacity of water = 4.18 J g$^{-1}$ °C$^{-1}$

$\Delta T$ = maximum temperature change of solution

$n$ = moles of $NH_4Cl$

(i) State **two** assumptions made in this calculation.
You do **not** need to justify your answers.

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(ii) The total percentage uncertainty in this experiment was 2.6 %.

Show that the enthalpy change of 14.5 kJ $mol^{-1}$ is consistent with a data book value of 14.8 kJ $mol^{-1}$.

**(2)**

**(Total for Question 1 = 14 marks)**

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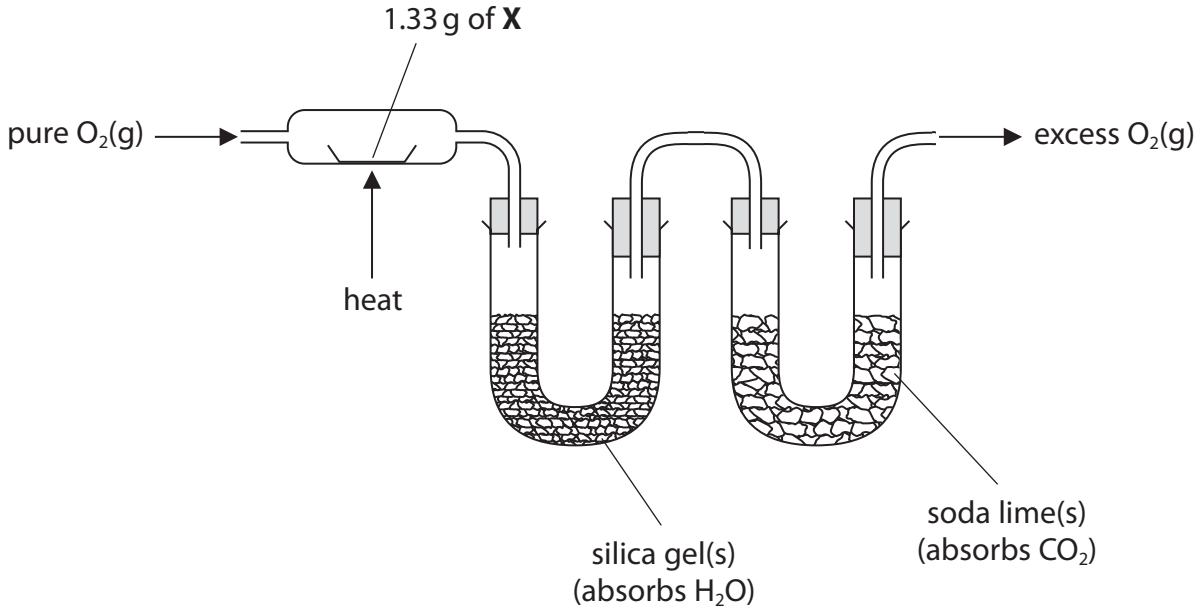
**2** This question is about two organic compounds, **X** and **Y**. Both are liquids which contain carbon, hydrogen and oxygen only.

(a) The mass of hydrogen and of carbon present in 1.33 g of **X** were determined by passing its combustion products through the apparatus shown.




(i) State the **measurements** that should be made.

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(ii) Give **two** reasons why pure $O_2$(g), and **not** air, should be used.

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(iii) The experiment showed that 1.33 g of **X** contains 0.14 g of hydrogen and 0.63 g of carbon.

Calculate the empirical formula of **X**, using these data.
You **must** show your working.

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(b) When phosphorus(V) chloride is added to **X**, steamy white fumes are seen.

State what can be deduced about compound **X** from this observation only.

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(c) Compound **X** is converted into compound **Y** when refluxed with **excess** sodium dichromate(VI) in sulfuric acid.

Compound **Y** is a liquid that is soluble in the reaction mixture.

Draw a **labelled** diagram of the apparatus that could be used to separate **Y** from the reaction mixture.

**(3)**

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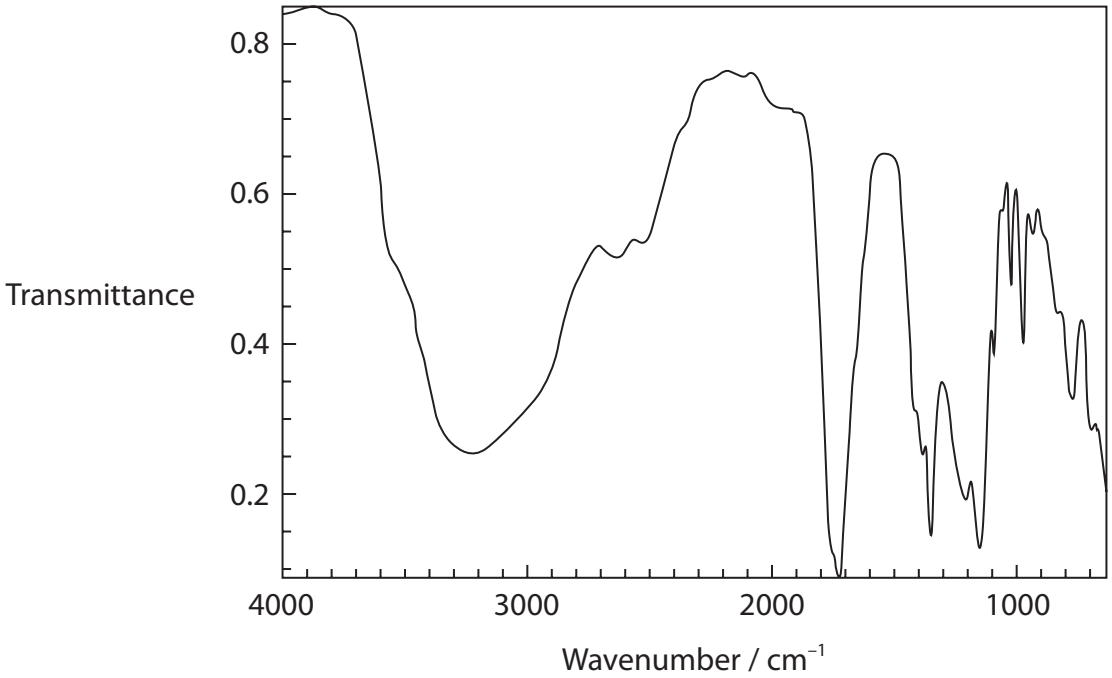
(d) The infrared spectrum of **Y** is shown.




The table shows some infrared absorption data.

| Bond | Wavenumber range / cm$^{-1}$ |
|---|---|
| C—H (alkane) | 2962 – 2853 |
| O—H (alcohols and phenols) | 3750 – 3200 |
| O—H (carboxylic acids) | 3300 – 2500 |
| C═C (alkene) | 1669 – 1645 |
| C═O (aldehydes, ketones, carboxylic acids) | 1740 – 1680 |

Explain how this spectrum shows that **Y** contains a carboxylic acid functional group, quoting data from the table.

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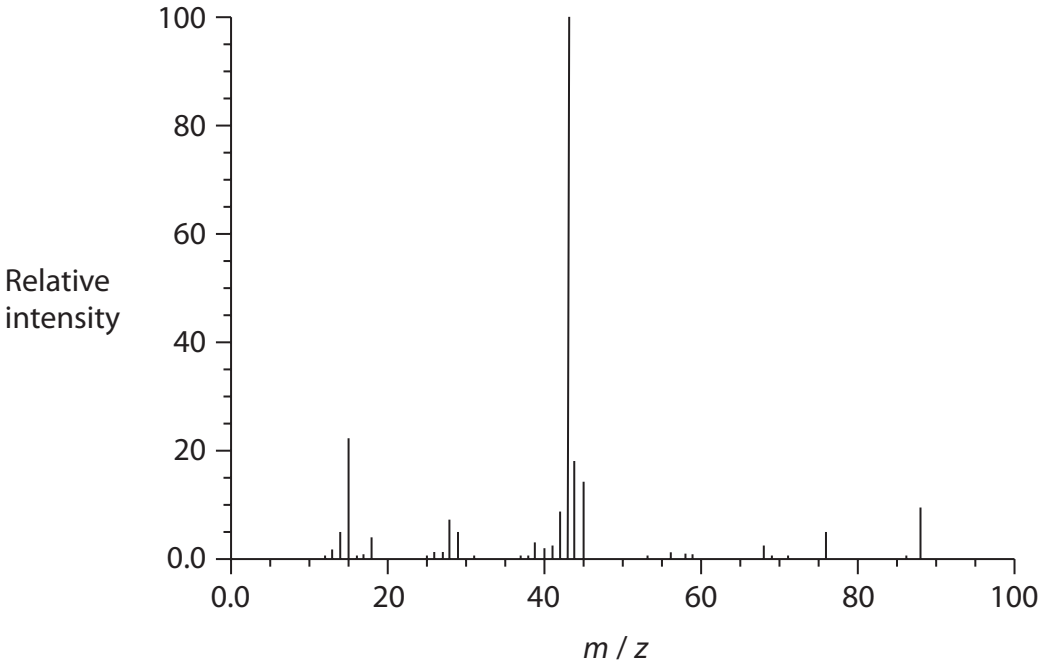
(e) The mass spectrum of **Y** is shown.




(i) Show that the mass spectrum is consistent with **Y** having the molecular formula $C_3H_4O_3$.

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(ii) Suggest the structure of the ion causing the peak at $m / z = 43$ in the mass spectrum of **Y**.

**(1)**

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(f) Compound **X** contains one type of functional group.

Compound **Y** contains two different functional groups.

Use the information in the question to deduce the structures of **X** and **Y**.

**(2)**

Compound **X**

Compound **Y**

**(Total for Question 2 = 17 marks)**

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**3** A student used a precipitation titration to determine the value of **x** in the formula of a sample of hydrated barium chloride, $BaCl_2 \cdot \mathbf{x}\,H_2O$.

**Procedure**

Step **1** Prepare a solution by dissolving 1.57 g of $BaCl_2 \cdot \mathbf{x}\,H_2O$ in deionised water, making the solution up to the mark in a 250.0 $cm^3$ volumetric flask and then mixing thoroughly.

Step **2** Use a pipette to transfer 10.0 $cm^3$ of the barium chloride solution into a conical flask.
Add excess sodium sulfate solution and swirl the mixture.

Step **3** Fill a burette with 0.0324 mol $dm^{-3}$ silver nitrate solution.

Step **4** Add three drops of potassium chromate(VI) solution to the conical flask and titrate the contents, while swirling, with the silver nitrate solution.
The end-point is shown by the appearance of a permanent pale red precipitate.

Step **5** Repeat Steps **2** to **4** until concordant results are obtained.

During the titration, two precipitation reactions occur.

Reaction **1** Silver ions react with chloride ions forming silver chloride.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

Reaction **2** Once all chloride ions have reacted, silver ions react with chromate(VI) ions to form a red precipitate of silver chromate(VI).

$$2Ag^+(aq) + CrO_4^{2-}(aq) \rightarrow Ag_2CrO_4(s)$$

(a) (i) Give the **ionic** equation for the reaction that occurs when sodium sulfate solution is added to the conical flask in Step **2**.
Include state symbols.

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(ii) Give a possible reason why it is necessary to add sodium sulfate solution.
Justify your answer.

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(b) Suggest why the red precipitate of silver chromate(VI) only forms after all the chloride ions have reacted.

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(c) Some data obtained in the experiment are shown.

| Titration number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Burette reading (final) / $cm^3$ | 16.15 | 32.05 | 48.30 | 47.40 |
| Burette reading (initial) / $cm^3$ | 0.00 | 16.15 | 32.50 | 31.55 |
| Titre / $cm^3$ | 16.15 | | | |

(i) Complete the table and use the concordant results to calculate the mean titre.

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(ii) Determine the value of **x** in the formula of the hydrated salt, $BaCl_2 \cdot \mathbf{x}\,H_2O$.
Use information from the procedure and your mean titre from (c)(i).
You **must** show your working.

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**(Total for Question 3 = 10 marks)**

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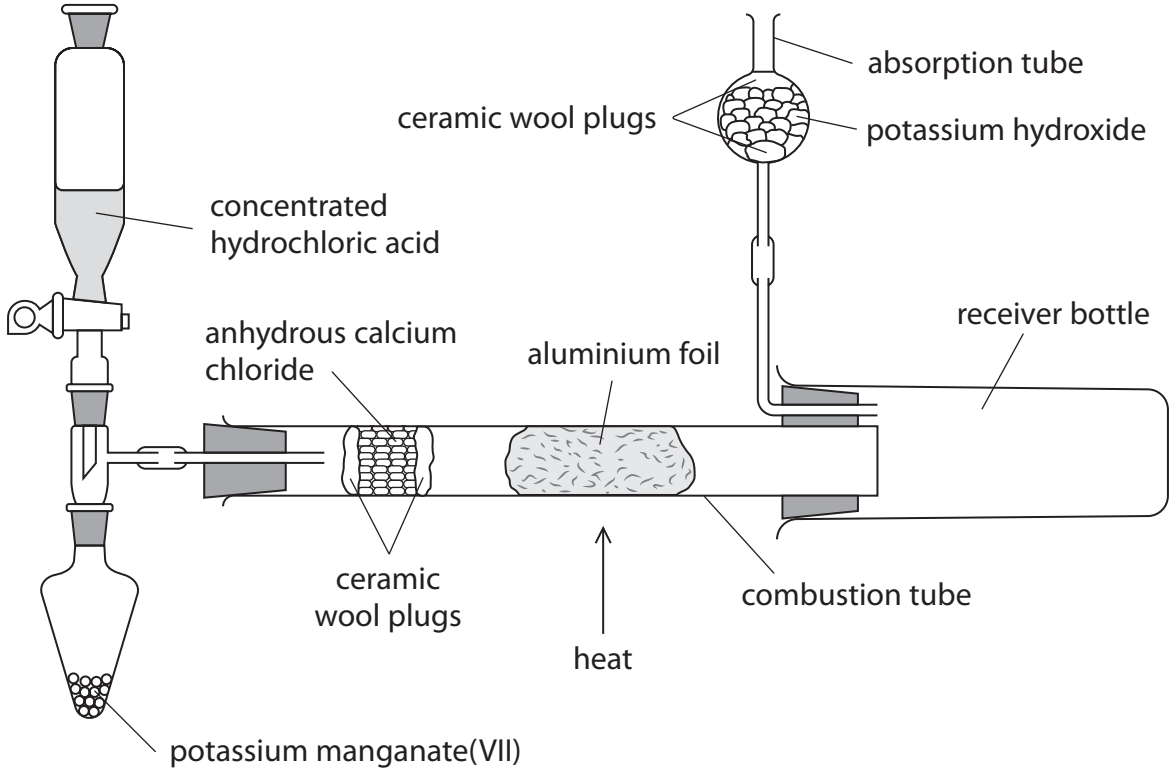
**4** This question is about the preparation of anhydrous aluminium chloride, $AlCl_3$, which reacts vigorously with water and must be stored in tightly sealed containers.

A sample of anhydrous $AlCl_3$ was prepared by passing chlorine gas over hot aluminium foil using the apparatus shown.

$$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$$




**Procedure**

Step **1** Assemble the apparatus with about 5 g of potassium manganate(VII) in the pear-shaped flask, 10 $cm^3$ of concentrated hydrochloric acid in the tap funnel and a known mass of aluminium foil in the combustion tube.

Step **2** Carefully open the tap of the funnel, allowing the acid to enter the pear-shaped flask drop by drop. Wait for twenty seconds.

Step **3** Heat the aluminium foil until it glows brightly. Continue heating until the reaction is complete. Allow the apparatus to cool before closing the tap of the funnel.

Step **4** Remove the receiver bottle, quickly scrape the product into a sample tube and seal with a lid.

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(a) Granules of anhydrous calcium chloride are held between two ceramic wool plugs in the combustion tube.

(i) Explain the purpose of the anhydrous calcium chloride.

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(ii) Give the reason why granules of anhydrous calcium chloride are used rather than powder.

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(b) The reaction occurring in Step **2** produces chlorine gas.

(i) Identify the main hazard related to chlorine gas, giving the **best** way of minimising the risk when using this gas.

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(ii) Give a reason why the concentrated hydrochloric acid is added 'drop by drop' to the pear-shaped flask.

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(c) Suggest why the heating of the aluminium in Step **3** is delayed by 20 s after the initial production of chlorine gas.

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(d) State how you would know the reaction is complete in Step **3**.

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(e) Suggest the purpose of the potassium hydroxide in the absorption tube.

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**(Total for Question 4 = 9 marks)**

**TOTAL FOR PAPER = 50 MARKS**

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# The Periodic Table of Elements

Key

relative atomic mass
**atomic symbol**
name
atomic (proton) number

| 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 (8) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | (18) |
| | | | | | | | 1.0 H hydrogen 1 | | | | | | | | | | 4.0 He helium 2 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | | | | | | | | | | 10.8 B boron 5 | 12.0 C carbon 6 | 14.0 N nitrogen 7 | 16.0 O oxygen 8 | 19.0 F fluorine 9 | 20.2 Ne neon 10 |
| 23.0 Na sodium 11 | 24.3 Mg magnesium 12 | | | | | | | | | | | 27.0 Al aluminium 13 | 28.1 Si silicon 14 | 31.0 P phosphorus 15 | 32.1 S sulfur 16 | 35.5 Cl chlorine 17 | 39.9 Ar argon 18 |
| 39.1 K potassium 19 | 40.1 Ca calcium 20 | 45.0 Sc scandium 21 | 47.9 Ti titanium 22 | 50.9 V vanadium 23 | 52.0 Cr chromium 24 | 54.9 Mn manganese 25 | 55.8 Fe iron 26 | 58.9 Co cobalt 27 | 58.7 Ni nickel 28 | 63.5 Cu copper 29 | 65.4 Zn zinc 30 | 69.7 Ga gallium 31 | 72.6 Ge germanium 32 | 74.9 As arsenic 33 | 79.0 Se selenium 34 | 79.9 Br bromine 35 | 83.8 Kr krypton 36 |
| 85.5 Rb rubidium 37 | 87.6 Sr strontium 38 | 88.9 Y yttrium 39 | 91.2 Zr zirconium 40 | 92.9 Nb niobium 41 | 95.9 Mo molybdenum 42 | [98] Tc technetium 43 | 101.1 Ru ruthenium 44 | 102.9 Rh rhodium 45 | 106.4 Pd palladium 46 | 107.9 Ag silver 47 | 112.4 Cd cadmium 48 | 114.8 In indium 49 | 118.7 Sn tin 50 | 121.8 Sb antimony 51 | 127.6 Te tellurium 52 | 126.9 I iodine 53 | 131.3 Xe xenon 54 |
| 132.9 Cs caesium 55 | 137.3 Ba barium 56 | 138.9 La* lanthanum 57 | 178.5 Hf hafnium 72 | 180.9 Ta tantalum 73 | 183.8 W tungsten 74 | 186.2 Re rhenium 75 | 190.2 Os osmium 76 | 192.2 Ir iridium 77 | 195.1 Pt platinum 78 | 197.0 Au gold 79 | 200.6 Hg mercury 80 | 204.4 Tl thallium 81 | 207.2 Pb lead 82 | 209.0 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 | [261] Rf rutherfordium 104 | [262] Db dubnium 105 | [266] Sg seaborgium 106 | [264] Bh bohrium 107 | [277] Hs hassium 108 | [268] Mt meitnerium 109 | [271] Ds darmstadtium 110 | [272] Rg roentgenium 111 | | | | | | | |

Elements with atomic numbers 112-116 have been reported but not fully authenticated

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 163 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 | [242] Pu plutonium 94 | [243] Am americium 95 | [247] Cm curium 96 | [245] Bk berkelium 97 | [251] Cf californium 98 | [254] Es einsteinium 99 | [253] Fm fermium 100 | [256] Md mendelevium 101 | [254] No nobelium 102 | [257] Lr lawrencium 103 |

* Lanthanide series

* Actinide series

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