AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.1.1

Metal oxides

Past-paper questions

Tier	**Higher**
Question groups	**12**
Available paper years	**2018–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

5.4.1.1 Metal oxides

Question 01

June 2018 | 8464/C/1H | Original Q6

0 6 Group 2 metal carbonates thermally decompose to produce a metal oxide and a gas.

0 6 . 1 Give the formula of each product when calcium carbonate ($CaCO_3$) is heated.

[2 marks]

_____ and _____

0 6 . 2 The relative formula mass (M_r) of a Group 2 metal carbonate is 197

Relative atomic masses (A_r): C = 12 O = 16

Calculate the relative atomic mass (A_r) of the Group 2 metal in the metal carbonate.

Name the Group 2 metal.

[3 marks]

Relative atomic mass (A_r) = _____

Metal _____

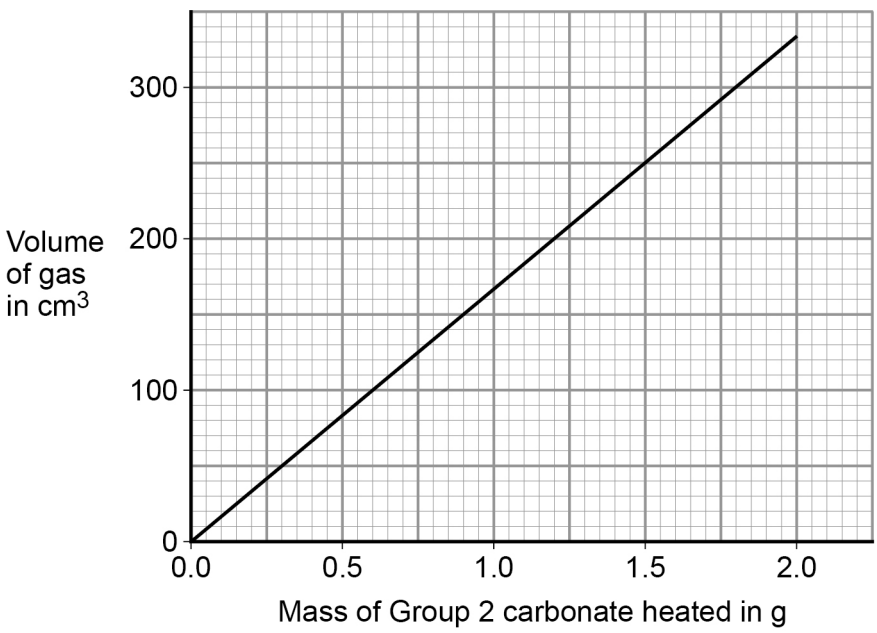
Question 6 continues on the next page

5.4.1.1 Metal oxides

Question 01 · continued

Figure 8 shows the volume of gas produced when a different Group 2 carbonate, **W**, is heated.

Figure 8



0 6 . 3 Calculate the gradient of the line in **Figure 8**

Give the unit.

[3 marks]

Gradient _____

Unit _____

5.4.1.1 Metal oxides

Question 01 · continued

0 6 . 4 24 dm^3 of gas is produced when one mole of a Group 2 carbonate is heated.

Determine the relative formula mass of the Group 2 carbonate **W**.

Use **Figure 8**

[4 marks]

Relative formula mass (M_r) = _____

12

5.4.1.1 Metal oxides

Question 02

0 7 A scientist does two tests on four white solids. The solids are labelled **A**, **B**, **C** and **D**.

Test 1 Adds the sample of the solid to distilled water and stirs.

Test 2 Measures the pH of the solution after **Test 1**

Table 2 shows the results.

Table 2

Solid	Appearance after stirring	pH
A	colourless solution, no solid	14
B	colourless solution, no solid	3
C	colourless solution, solid remains	9
D	colourless liquid, solid remains	7

These four solids are:

- magnesium oxide
- phosphorus oxide
- silicon dioxide
- sodium oxide.

Table 3 shows the solubility of these four solids in water.

Table 3

Solid	Solubility in grams per 100 cm^3 of water
Magnesium oxide	0.01
Phosphorus oxide	52
Silicon dioxide	0
Sodium oxide	109

5.4.1.1 Metal oxides

Question 02 · continued

0 7 . 1 Identify the solids **A**, **B**, **C** and **D**.

Explain your answers.

[6 marks]

Question 7 continues on the next page

5.4.1.1 Metal oxides

Question 02 · continued

0 7 . 2 10 cm^3 of solution **B** is added to a beaker.

Distilled water is added to the beaker until the final volume in the beaker is 1000 cm^3

The pH of the solution is measured before and after distilled water is added.

Table 4 shows the results.

Table 4

Volume of solution in beaker	pH of solution B
10 cm^3	3
1000 cm^3	**X**

Calculate the value of **X**.

[2 marks]

X = _____

8

5.4.1.1 Metal oxides

Question 03

November 2020 | 8464/C/1H | Original Q1

0 1 This question is about the extraction of aluminium.

0 1 . 1 An aluminium atom is represented as:

$$^{27}_{13}Al$$

Give the number of electrons and neutrons in the aluminium atom.

[2 marks]

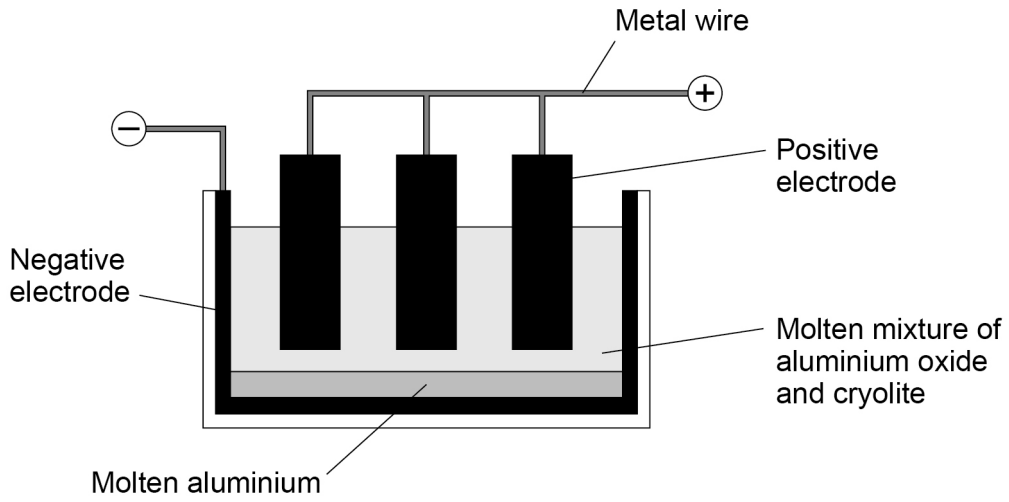
Number of electrons _____

Number of neutrons _____

Aluminium is extracted by the electrolysis of a molten mixture of aluminium oxide and cryolite.

Figure 1 shows the cell used for the electrolysis.

Figure 1



0 1 . 2 Aluminium is produced by the reduction of aluminium oxide (Al_2O_3).

What is meant by the term reduction?

[1 mark]

_____

_____

5.4.1.1 Metal oxides

Question 03 · continued

0 1 . 3 Oxygen is formed at the positive carbon electrodes.

Explain why the positive carbon electrodes must be continually replaced.

[3 marks]

0 1 . 4 A substance conducts electricity because of free moving, charged particles.

What are the free moving, charged particles in a:

- carbon electrode (made from graphite)
- molten mixture of aluminium oxide and cryolite
- metal wire?

[3 marks]

Carbon electrode (made from graphite) _____

Molten mixture of aluminium oxide and cryolite _____

Metal wire _____

9

5.4.1.1 Metal oxides

Question 04

0 3 Some students investigated the thermal decomposition of metal carbonates.

The word equation for the reaction is:

metal carbonate → metal oxide + carbon dioxide

The students made the following hypothesis:

'When heated the same mass of any metal carbonate produces the same mass of carbon dioxide.'

The students heated a test tube containing copper carbonate.

Table 1 shows their results.

Table 1

Time the test tube containing copper carbonate was heated in mins	0	2	4	6
Mass of test tube and contents in g	17.7	17.1	17.0	17.0

5.4.1.1 Metal oxides

Question 04 · continued

Plan a method the students could use to test their hypothesis.

You should show how the students use their results to test the hypothesis.

You do **not** need to write about safety precautions.

[6 marks]

6

5.4.1.1 Metal oxides

Question 05

November 2021 | 8464/C/1H | Original Q2

0 2 Acids react to produce salts.

Universal indicator is added to water and then nitric acid is added to the mixture.

0 2 . 1 Give the colour change when nitric acid is added to the mixture of universal indicator and water.

[1 mark]

Tick (✓) **one** box.

- Blue to red ☐
- Green to purple ☐
- Green to red ☐
- Red to purple ☐

0 2 . 2 What happens to the pH of water when nitric acid is added?

[1 mark]

Tick (✓) **one** box.

- Decreases ☐
- Stays the same ☐
- Increases ☐

0 2 . 3 What is the state symbol for nitric acid?

[1 mark]

_____

5.4.1.1 Metal oxides

Question 05 · continued

Zinc carbonate reacts with nitric acid.

The word equation for the reaction is:

zinc carbonate (white solid) + nitric acid → zinc nitrate (colourless solution) + water + carbon dioxide

0 2 . 4 Give **two** observations that would be made when zinc carbonate is added to nitric acid until the zinc carbonate is in excess.

[2 marks]

1 _____

_____

2 _____

_____

0 2 . 5 The formula of the zinc ion is Zn^{2+}

The formula of the nitrate ion is NO_3^-

What is the formula for zinc nitrate?

[1 mark]

Tick (✓) **one** box.

$ZnNO_3$ ☐

$Zn(NO_3)_2$ ☐

Zn_2NO_3 ☐

$Zn_2(NO_3)_2$ ☐

Question 2 continues on the next page

5.4.1.1 Metal oxides

Question 05 · continued

0 2 . 6 Acids react with insoluble metal oxides to produce salts.

Plan a method to produce a pure, dry sample of the soluble salt copper chloride from an acid and a metal oxide.

[6 marks]

12

5.4.1.1 Metal oxides

Question 06

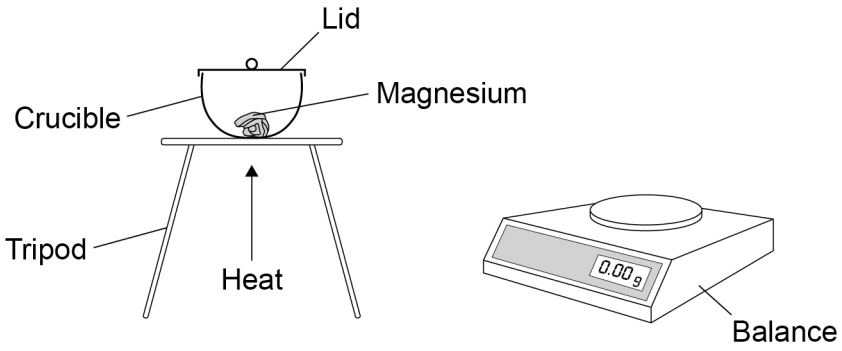
November 2021 | 8464/C/1H | Original Q6

0 6 Metal oxides are produced when metals are heated in air.

A student investigated the change in mass when 0.12 g of magnesium was heated in air.

Figure 5 shows the apparatus.

Figure 5



The student measured the mass of magnesium oxide produced.

0 6 . 1 0.12 g of magnesium reacted to produce 0.20 g of magnesium oxide.

Calculate the number of moles of oxygen gas (O_2) that reacted.

Relative atomic mass (A_r): O = 16

[3 marks]

Moles of oxygen gas = _____

5.4.1.1 Metal oxides

Question 06 · continued

0 6 . 2 The student repeated the experiment **without** a lid on the crucible.

Suggest why the mass of magnesium oxide produced would be different without a lid on the crucible.

[2 marks]

0 6 . 3 Copper reacts with oxygen to produce copper oxide.

63.5 g of copper produces 79.5 g of copper oxide.

Calculate the mass of copper oxide produced when 0.50 g of copper reacts with oxygen.

Give your answer to 3 significant figures.

[3 marks]

Mass (3 significant figures) = _____ g

Question 6 continues on the next page

5.4.1.1 Metal oxides

Question 06 · continued

0 6 . 4 Iron reacts with oxygen to produce an oxide of iron.

0.015 moles of iron reacts with 0.010 moles of oxygen gas (O_2).

Determine:

- the formula of the iron oxide produced
- the balanced symbol equation for the reaction.

[4 marks]

Formula of iron oxide = _____

Balanced symbol equation

_____

12

5.4.1.1 Metal oxides

Question 07

June 2023 | 8464/C/1H | Original Q3

0 3 Sodium is in Group 1 of the periodic table.

Sodium reacts with oxygen to produce sodium oxide.

0 3 . 1 Balance the equation for the reaction.

[1 mark]

$$___\ Na + O_2 \rightarrow ___\ Na_2O$$

0 3 . 2 Explain what happens to sodium atoms and to oxygen atoms when sodium reacts with oxygen to produce sodium oxide (Na_2O).

Answer in terms of electrons.

[4 marks]

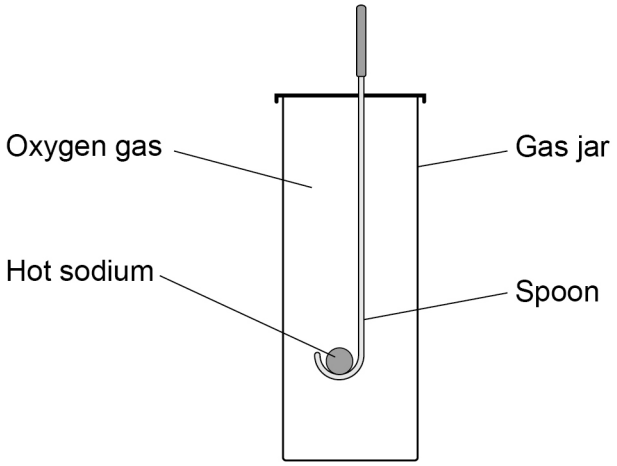
5.4.1.1 Metal oxides

Question 07 · continued

0 3 . 3 Sodium burns in a gas jar of oxygen.

Figure 3 shows the apparatus.

Figure 3



Give **two** observations seen during the reaction.

[2 marks]

1 _____

_____

2 _____

_____

0 3 . 4 Describe **two** differences in the observations if potassium is used instead of sodium.

[2 marks]

1 _____

_____

2 _____

_____

9

5.4.1.1 Metal oxides

Question 08

June 2023 | 8464/C/1H | Original Q7

0 7 This question is about structure and properties.

0 7 . 1 Which pair of substances **both** contain atoms in hexagonal rings?

[1 mark]

Tick (✓) **one** box.

- Diamond and graphite ☐
- Fullerenes and graphene ☐
- Nanotubes and silica ☐

0 7 . 2 Explain why the structure of copper allows the conduction of thermal energy.

[3 marks]

5.4.1.1 Metal oxides

Question 08 · continued

0 7 . 3 Explain why copper oxide (CuO) has a high melting point.

[3 marks]

0 7 . 4 Explain why water (H_2O) has a low melting point.

[3 marks]

10

5.4.1.1 Metal oxides

Question 09

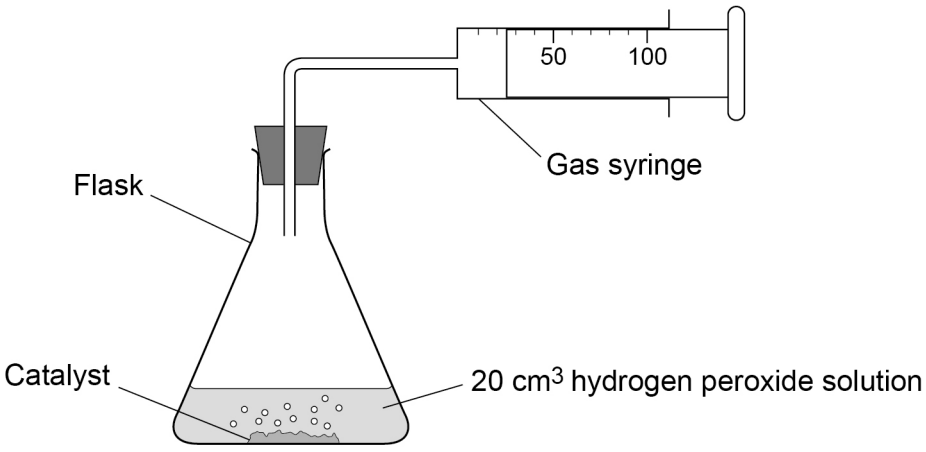
June 2023 | 8464/C/2H | Original Q6

0 6 A student investigated the rate of decomposition of hydrogen peroxide using three different catalysts:

- manganese dioxide
- copper oxide
- zinc oxide.

Figure 2 shows the apparatus.

Figure 2



This is the method used.

1. Measure 20 cm^3 of hydrogen peroxide solution into a flask.

2. Add 0.5 g of manganese dioxide catalyst to the flask.

3. Attach a gas syringe to the flask.

4. Measure the volume of oxygen produced every 30 seconds for 180 seconds.

5. Repeat steps 1 to 4 two more times.

6. Repeat steps 1 to 5 using copper oxide catalyst.

7. Repeat steps 1 to 5 using zinc oxide catalyst.

0 6 . 1 The equation for the decomposition of hydrogen peroxide is:

$$2\,H_2O_2 \rightarrow 2\,H_2O + O_2$$

Describe a test to identify the gas produced in the reaction.

[2 marks]

Test _____

_____

Result _____

_____

0 6 . 2 Using 10 cm^3 of hydrogen peroxide solution gives less accurate results than using 20 cm^3 of hydrogen peroxide solution of the same concentration.

Explain why.

[2 marks]

_____

_____

_____

_____

0 6 . 3 Suggest **one** possible source of systematic error in the investigation.

[1 mark]

_____

_____

Question 6 continues on the next page

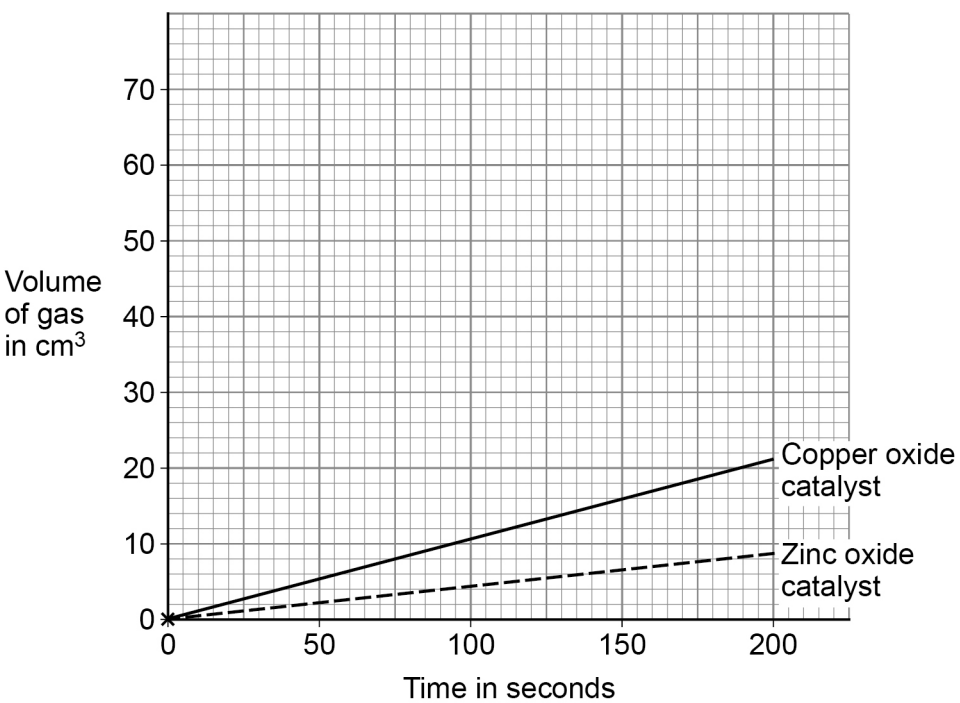
Table 3 shows the results for manganese dioxide catalyst.

Table 3

Time in seconds	0	30	60	90	120	150	180
Volume of gas in cm^3	0	22	38	41	54	58	60

Figure 3 shows a graph of the results with copper oxide catalyst and with zinc oxide catalyst.

Figure 3



0 6 . 4 Complete **Figure 3**.

You should:

- plot the data from **Table 3**
- draw a line of best fit.

The first point has been plotted for you.

[3 marks]

5.4.1.1 Metal oxides

Question 09 · continued

0 6 . 5 Which catalyst gives the fastest **rate** of reaction?

Give **one** reason for your answer.

Use the completed **Figure 3**.

[2 marks]

Catalyst _____

Reason _____

_____

0 6 . 6 The rate of reaction is **not** dependent on the volume of hydrogen peroxide solution.

Explain why.

[2 marks]

_____

_____

_____

_____

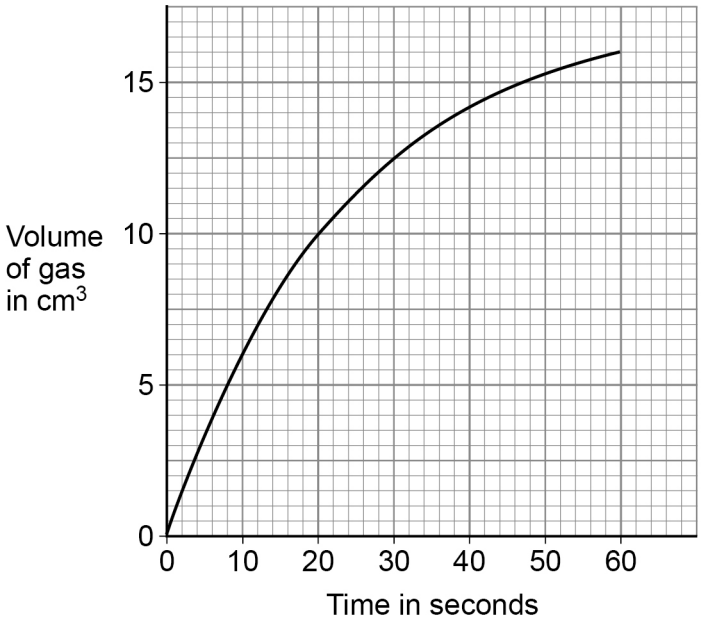
Question 6 continues on the next page

5.4.1.1 Metal oxides

Question 09 · continued

0 6 . 7 **Figure 4** shows the results from a different investigation.

Figure 4



Determine the rate of reaction at 20 seconds.

Show your working on **Figure 4**.

Give your answer to 3 significant figures.

[5 marks]

Rate (3 significant figures) = _____ cm^3/s

17

5.4.1.1 Metal oxides

Question 10

June 2024 | 8464/C/1H | Original Q6

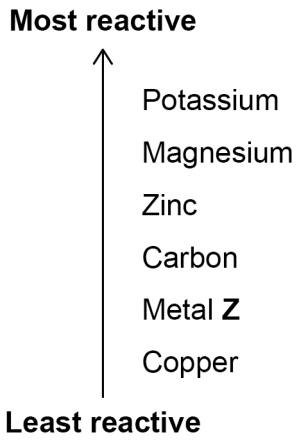
0 6 In the Earth most metals are found as compounds.

0 6 . 1 Name **one** metal that is found in the Earth as the metal itself.

[1 mark]

Figure 9 shows a reactivity series.

Figure 9



0 6 . 2 Suggest the most economical method for extracting metal **Z** from an oxide of metal **Z**.

[1 mark]

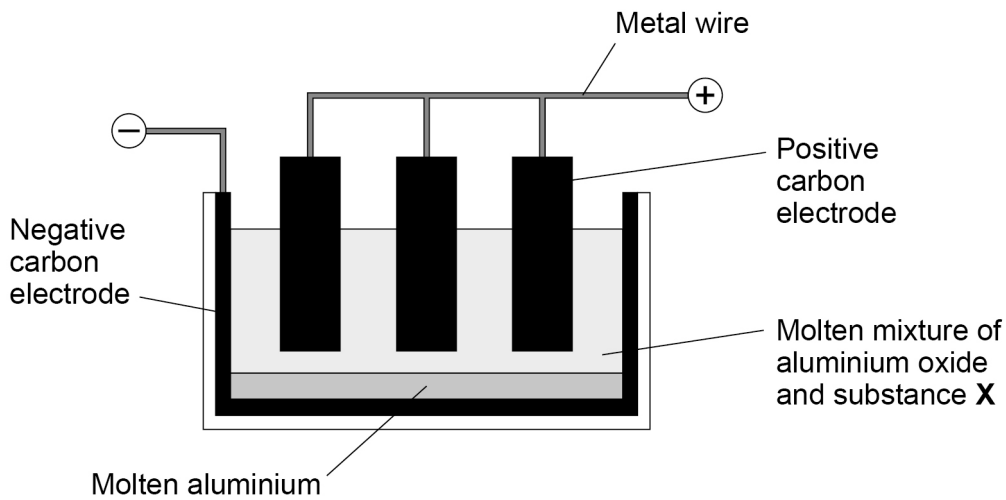
Question 6 continues on the next page

5.4.1.1 Metal oxides

Question 10 · continued

Figure 10 shows the electrolysis cell used to extract aluminium from aluminium oxide.

Figure 10



0 6 . 3 Name substance **X** shown in **Figure 10**.

[1 mark]

5.4.1.1 Metal oxides

Question 10 · continued

0 6 . 4 Explain what happens to the **positive** carbon electrodes during the extraction of aluminium from aluminium oxide.

[3 marks]

0 6 . 5 The formula of aluminium oxide is Al_2O_3

Write a half equation for the reaction at the **negative** electrode in **Figure 10**.

[2 marks]

_____ + _____ → _____

8

5.4.1.1 Metal oxides

Question 11

June 2025 | 8464/C/1H | Original Q4

0 4 This question is about metals.

0 4 . 1 Iron is extracted from iron oxide by reduction with carbon.

Why can iron be extracted by reduction with carbon?

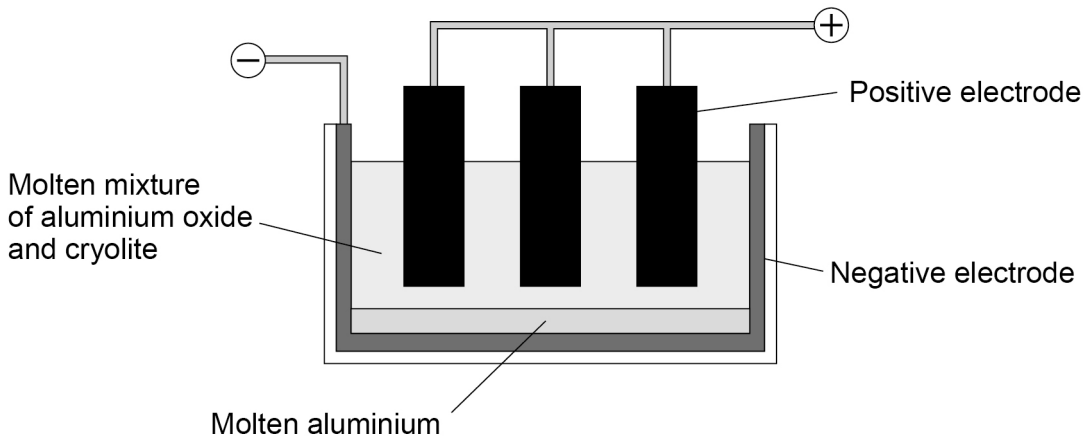
Answer in terms of reactivity.

[1 mark]

Aluminium is extracted by the electrolysis of aluminium oxide.

Figure 4 shows the apparatus used to extract aluminium.

Figure 4



5.4.1.1 Metal oxides

Question 11 · continued

0 4 . 2 Explain why a mixture of aluminium oxide and cryolite is used as the electrolyte instead of only aluminium oxide.

[2 marks]

0 4 . 3 Oxygen gas is produced at the positive electrode.

Write a balanced half equation for the production of oxygen at the positive electrode.

[2 marks]

_____ → _____ + _____

Question 4 continues on the next page

5.4.1.1 Metal oxides

Question 11 · continued

Chromium is extracted by reacting chromium oxide with aluminium.

The equation for the reaction is:

$$Cr_2O_3 + 2\,Al \rightarrow Al_2O_3 + 2\,Cr$$

0 4 . 4 Which substance in the equation is reduced?

[1 mark]

Table 3 shows the relative cost of extracting equal masses of aluminium, chromium and iron.

Table 3

Metal	Relative cost of extraction
Aluminium	2
Chromium	20
Iron	1

0 4 . 5 Give **one** reason for the difference in the cost of extracting aluminium and **iron**.

Use **Table 3**.

[1 mark]

5.4.1.1 Metal oxides

Question 11 · continued

0 4 . 6 Give **one** reason for the difference in the cost of extracting aluminium and **chromium**.

Use **Table 3**.

[1 mark]

0 4 . 7 Metals are mixed together to form alloys.

Explain why alloys are harder than pure metals.

[3 marks]

11

5.4.1.1 Metal oxides

Question 12

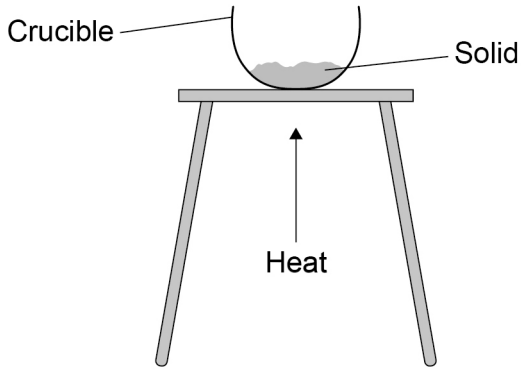
June 2025 | 8464/C/1H | Original Q6

0 6 Some reactions appear to involve a change in mass.

A student investigated the change in mass when solids were heated.

Figure 7 shows the apparatus.

Figure 7



The student determined the mass of the contents of the crucible at regular intervals.

0 6 . 1 The student used a Bunsen burner instead of a water bath to heat the crucible.

Suggest **one** reason why.

[1 mark]

Question 6 continues on the next page

The student planned to heat:

- 0.01 mol of magnesium
- 0.01 mol of magnesium carbonate.

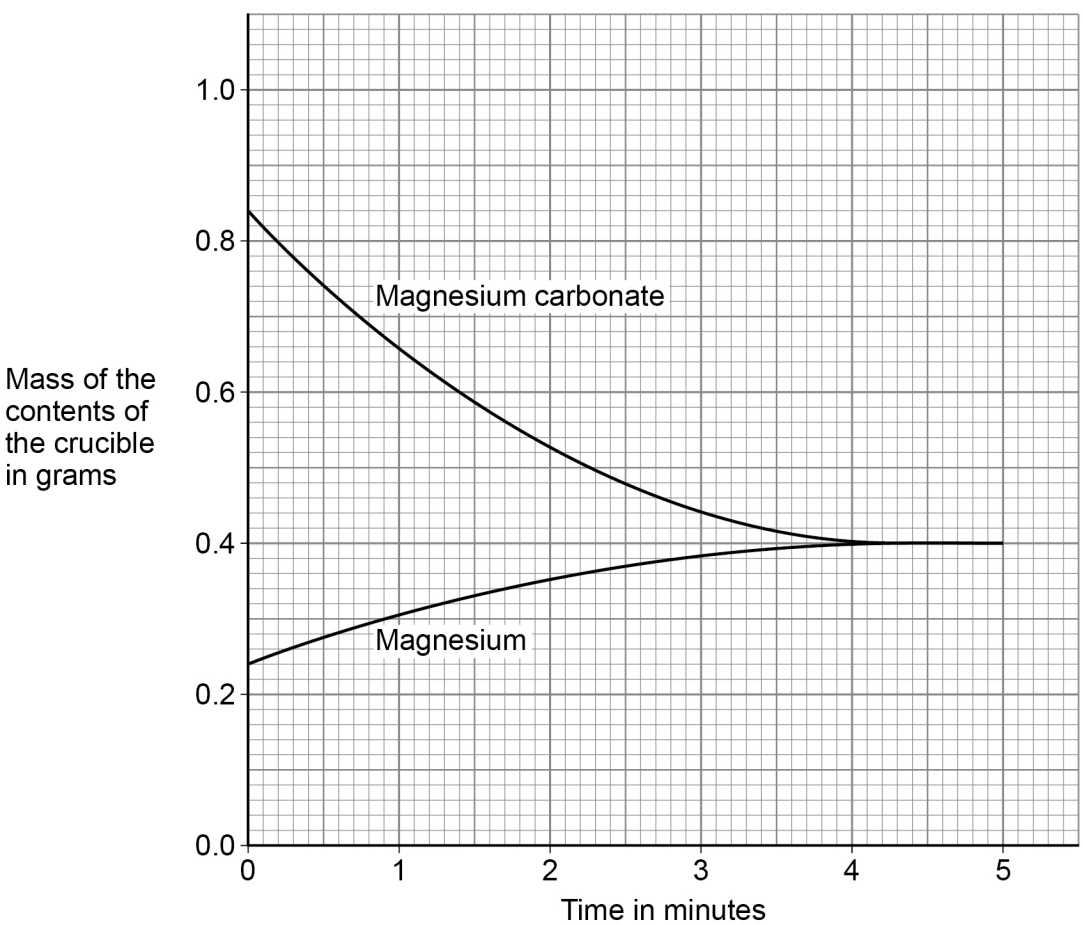
The equations for the reactions are:

$$Mg + \tfrac{1}{2}O_2 \rightarrow MgO$$

$$MgCO_3 \rightarrow MgO + CO_2$$

Figure 8 shows the student's **predicted** results.

Figure 8



5.4.1.1 Metal oxides

Question 12 · continued

0 6 . 2 Look at **Figure 8**.

Explain the **two** trends for the first 3 minutes.

[4 marks]

Magnesium _____

_____

_____

_____

Magnesium carbonate _____

_____

_____

_____

0 6 . 3 **Figure 8** shows that both reactions are complete after 5 minutes.

Why is the final mass of the contents of the crucible the same for both reactions?

[1 mark]

_____

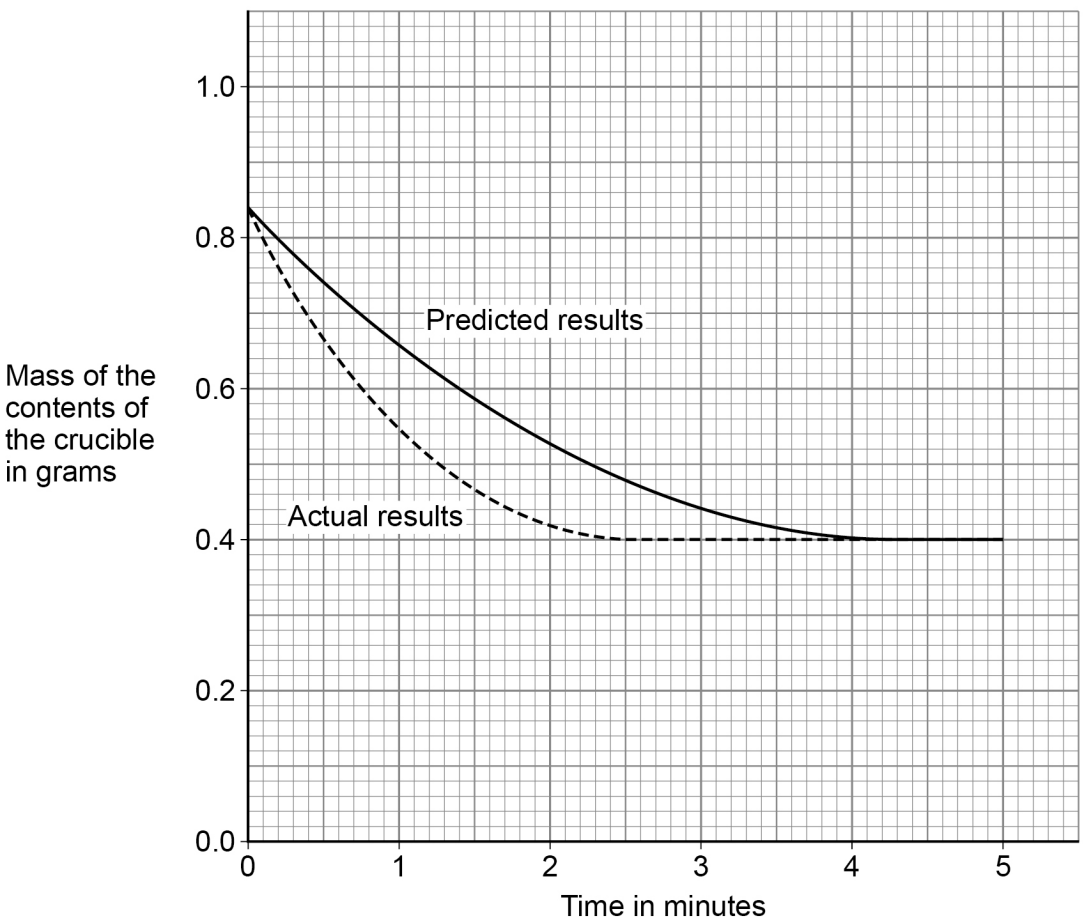
_____

Question 6 continues on the next page

0 6 . 4 The student heated magnesium carbonate.

Figure 9 shows the results.

Figure 9



The student concluded:

'The difference between the predicted results and the actual results is caused by solid escaping from the crucible.'

Give **one** reason why the results show the student is **not** correct.

[1 mark]

5.4.1.1 Metal oxides

Question 12 · continued

0 6 . 5 Iron reacts with steam (H_2O) to produce an oxide of iron and hydrogen gas.

0.120 moles of iron reacts with 0.160 moles of steam.

Determine the balanced equation for the reaction.

You should determine:

- the simplest whole number mole ratio of Fe : H_2O
- the formula of the iron oxide produced.

[4 marks]

Simplest mole ratio of Fe : H_2O = _____ : _____

Formula of the iron oxide = _____

Balanced equation for the reaction:

_____ + _____ → _____ + _____

11