AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.1.1

Metal oxides

Past-paper questions

Tier	**Foundation**
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/1F | Original Q3

0 3 This question is about acids and bases.

0 3 . 1 Which ion is found in all acids?

[1 mark]

Tick **one** box.

Cl^- ☐ H^+ ☐ Na^+ ☐ OH^- ☐

0 3 . 2 Zinc nitrate can be produced by reacting an acid and a metal oxide.

Name the acid and the metal oxide used to produce zinc nitrate.

[2 marks]

Acid _____

Metal oxide _____

0 3 . 3 In an equation, zinc nitrate is written as $Zn(NO_3)_2(aq)$.

What does (aq) mean?

[1 mark]

Tick **one** box.

Dissolved in water ☐

Insoluble ☐

Not all reacted ☐

Reactant ☐

0 3 . 4 The pH of a solution is 8

Some hydrochloric acid is added to the solution.

Suggest the pH of the solution after mixing.

[1 mark]

pH = _____

5.4.1.1 Metal oxides

Question 01 · continued

0 3 . 5 **Table 2** shows the solubility of three solids in water at room temperature.

Table 2

Solid	The mass of the solid that dissolves in 100 cm^3 of water
Phosphorus oxide	50 g
Silicon dioxide	0 g
Sodium hydroxide	100 g

A teacher labelled these three solids **A**, **B** and **C**.

She gave a student the information shown in **Table 3**

Table 3

Solid	Observation when added to water	pH of the solid in water
A	colourless solution	14
B	colourless solution	2
C	solid does not dissolve	7

Describe a method that could be used to identify each of the three solids **A**, **B** and **C**.

You must use an indicator in the method.

Use information in **Table 2** and **Table 3**

[4 marks]

9

5.4.1.1 Metal oxides

Question 02

June 2019 | 8464/C/1F | Original Q2

0 2 This question is about salts and electrolysis.

A student wants to make copper chloride crystals.

The student adds excess copper oxide to some hot acid.

The student stirs the mixture.

0 2 . 1 Which acid should the student use?

[1 mark]

Tick (✓) **one** box.

Hydrochloric acid ☐

Nitric acid ☐

Sulfuric acid ☐

0 2 . 2 Suggest how the student would know that excess copper oxide has been added.

[1 mark]

_____

_____

Question 2 continues on the next page

5.4.1.1 Metal oxides

Question 02 · continued

0 2 . 3 There are four more stages, **A**, **B**, **C** and **D**, to make copper chloride crystals.

The stages **A**, **B**, **C** and **D** are not in the correct order.

Stage **A**	Partially evaporate by heating with a water bath
Stage **B**	Filter the mixture into an evaporating basin
Stage **C**	Leave to crystallise
Stage **D**	Remove and dry the crystals

Put stages **A**, **B**, **C** and **D** in the correct order.

[2 marks]

First stage _____

Second stage _____

Third stage _____

Fourth stage _____

0 2 . 4 Molten copper chloride can be electrolysed.

State the product at each electrode when molten copper chloride is electrolysed.

[2 marks]

Negative electrode _____

Positive electrode _____

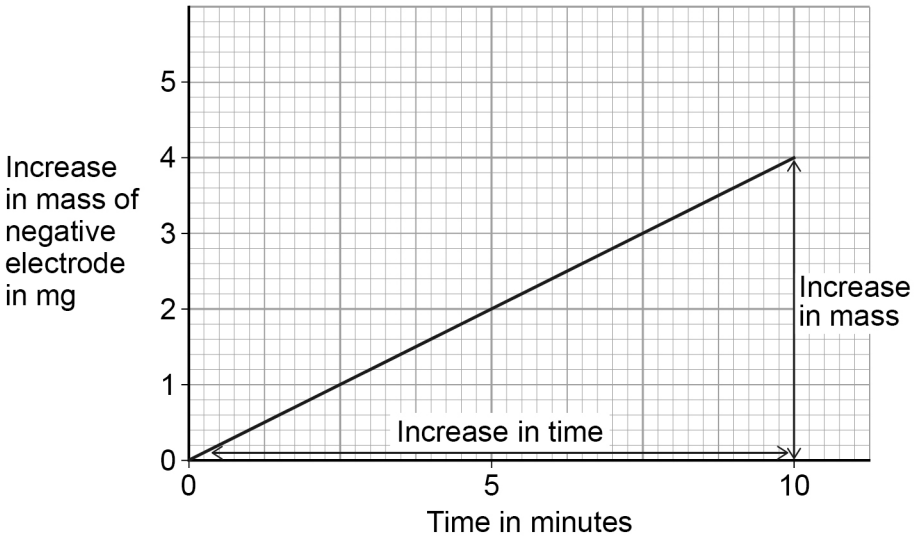
Question 02 · continued

0 2 . 5 A solution of copper chloride is electrolysed.

Figure 3 shows a graph of the increase in mass of the negative electrode.

This increase is shown over a time of 10 minutes.

Figure 3



Calculate the gradient of the line in **Figure 3**.

Use the equation:

$$\text{Gradient} = \frac{\text{increase in mass in mg}}{\text{increase in time in minutes}}$$

[3 marks]

Increase in mass _____

_____

Increase in time _____

_____

Gradient _____

_____

_____

_____

Gradient = _____ mg per minute

5.4.1.1 Metal oxides

Question 02 · continued

0 2 . 6 Aluminium is produced by electrolysis of a molten mixture.

Complete the sentence.

Choose the answers from the box.

[2 marks]

carbon	**chloride**	**cryolite**	**oxide**	**sulfate**	**water**

The molten mixture contains _____ and

aluminium _____ .

11

5.4.1.1 Metal oxides

Question 03

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

0 1 This question is about acids and bases.

0 1 . 1 What is the pH of sulfuric acid?

[1 mark]

Tick (✓) **one** box.

1 ☐ 7 ☐ 14 ☐

0 1 . 2 An acid reacts with zinc to produce zinc chloride and hydrogen.

Which acid reacts with zinc to produce zinc chloride?

[1 mark]

Tick (✓) **one** box.

Hydrochloric acid ☐

Nitric acid ☐

Sulfuric acid ☐

0 1 . 3 What type of substance is zinc chloride?

[1 mark]

Tick (✓) **one** box.

Alkali ☐ Base ☐ Salt ☐

5.4.1.1 Metal oxides

Question 03 · continued

0 1 . 4 An alkali is a base in solution.

Which compound is an alkali?

[1 mark]

Tick (✓) **one** box.

Sodium hydroxide ☐

Sodium nitrate ☐

Sodium sulfate ☐

0 1 . 5 The formula of the copper ion is Cu^{2+}

The formula of the oxide ion is O^{2-}

What is the formula of copper oxide?

[1 mark]

Tick (✓) **one** box.

Cu_2O_2 ☐ CuO_2 ☐ CuO ☐

Question 1 continues on the next page

5.4.1.1 Metal oxides

A student reacts an acid with copper oxide.

0 1 . 6 The reaction between the acid and copper oxide is very slow at room temperature.

How could the student speed up the reaction?

[1 mark]

0 1 . 7 Complete the sentence to show how the student makes sure that **all** the acid reacts.

Choose the answer from the box.

[1 mark]

in excess	**in solution**	**molten**	**soluble**

The student adds copper oxide to the acid until the

copper oxide is _____.

5.4.1.1 Metal oxides

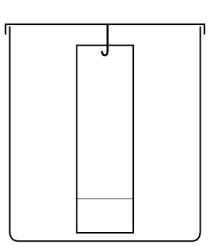
Question 03 · continued

0 1 . 8 The student filters the unreacted copper oxide from the solution.

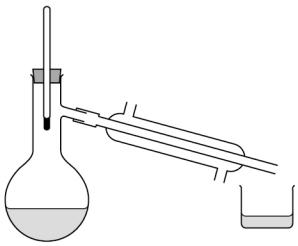
Which apparatus does the student use?

[1 mark]

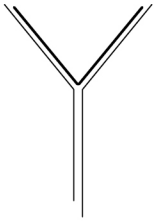
Tick (✓) **one** box.



☐



☐



☐



☐

0 1 . 9 What process is used to produce crystals of a salt from a salt solution?

[1 mark]

_____

_____

9

5.4.1.1 Metal oxides

Question 04

November 2020 | 8464/C/1F | Original Q6

0 6 This question is about the extraction of aluminium.

0 6 . 1 An aluminium atom is represented as:

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

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

[2 marks]

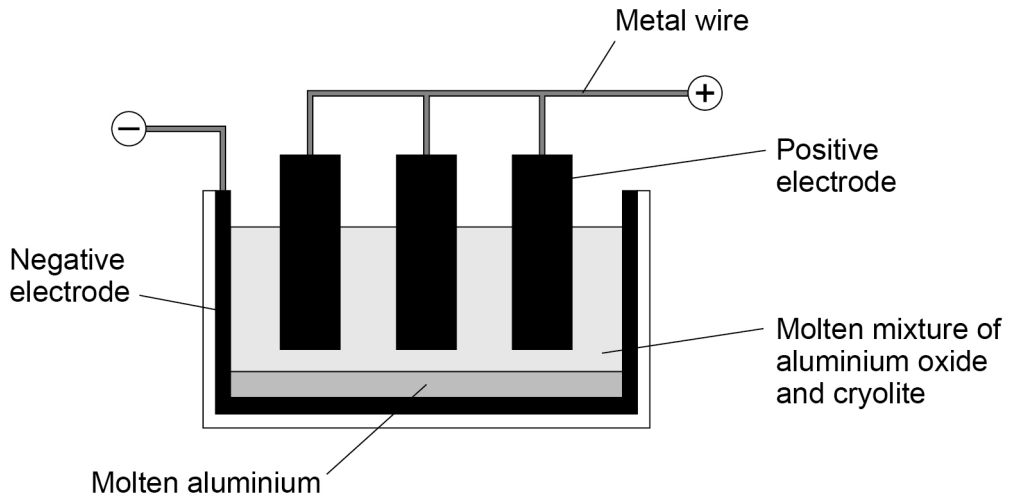
Number of electrons _____

Number of neutrons _____

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

Figure 11 shows the cell used for the electrolysis.

Figure 11



0 6 . 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 04 · continued

0 6 . 3 Oxygen is formed at the positive carbon electrodes.

Explain why the positive carbon electrodes must be continually replaced.

[3 marks]

0 6 . 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 05

November 2020 | 8464/C/1F | Original Q8

0 8 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 4 shows their results.

Table 4

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 05 · 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 06

November 2021 | 8464/C/1F | Original Q1

0 1 Magnesium is in Group 2 of the periodic table.

1.0 g of magnesium reacted with chlorine to produce magnesium chloride.

0 1 . 1 Which types of element react when magnesium reacted with chlorine?

[1 mark]

Tick (✓) **one** box.

- A metal and a metal ☐
- A metal and a non-metal ☐
- A non-metal and a non-metal ☐

0 1 . 2 Write the word equation for the reaction when magnesium reacts with chlorine.

[1 mark]

_____ + _____ → _____

0 1 . 3 What apparatus was used to measure the mass of 1.0 g of magnesium?

[1 mark]

Tick (✓) **one** box.

- Balance ☐
- Beaker ☐
- Ruler ☐

5.4.1.1 Metal oxides

Question 06 · continued

0 1 . 4 What mass of magnesium chloride was produced?

[1 mark]

Tick (✓) **one** box.

Less than 1.0 g ☐

1.0 g ☐

More than 1.0 g ☐

0 1 . 5 Magnesium reacts with oxygen to produce magnesium oxide.

Calculate the percentage mass of magnesium in magnesium oxide (MgO).

Relative atomic mass (A_r): Mg = 24

Relative formula mass (M_r): MgO = 40

[2 marks]

Percentage mass of magnesium = _____ %

Question 1 continues on the next page

Question 06 · continued

Magnesium carbonate decomposes to produce magnesium oxide and carbon dioxide.

The word equation for the reaction is:

magnesium carbonate → magnesium oxide + carbon dioxide

Four students heated 2.00 g of magnesium carbonate for 10 minutes.

Table 1 shows the results.

Table 1

Mass of carbon dioxide produced in g				
Student 1	**Student 2**	**Student 3**	**Student 4**	**Mean**
0.97	0.91	0.50	0.95	**X**

0 1 . 6 What is the most likely reason for **Student 3**'s anomalous result?

[1 mark]

Tick (✓) **one** box.

The student heated more than 2.00 g of magnesium carbonate. ☐

The student heated the magnesium carbonate for less than 10 minutes. ☐

The student used a higher temperature. ☐

0 1 . 7 Calculate value **X** in **Table 1**.

Do **not** use the anomalous result.

Give your answer to 2 significant figures.

[3 marks]

X (2 significant figures) = _____ g

10

5.4.1.1 Metal oxides

Question 07

November 2021 | 8464/C/1F | Original Q7

0 7 Acids react to produce salts.

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

0 7 . 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 7 . 2 What happens to the pH of water when nitric acid is added?

[1 mark]

Tick (✓) **one** box.

- Decreases ☐
- Stays the same ☐
- Increases ☐

0 7 . 3 What is the state symbol for nitric acid?

[1 mark]

_____

5.4.1.1 Metal oxides

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 7 . 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 7 . 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 7 continues on the next page

5.4.1.1 Metal oxides

Question 07 · continued

0 7 . 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 08

0 4 This question is about elements and compounds.

0 4 . 1 Magnesium and oxygen react to produce magnesium oxide.

Balance the equation for the reaction.

[1 mark]

$$_____ Mg + O_2 \rightarrow 2\,MgO$$

0 4 . 2 Suggest **one** safety precaution that should be taken when heating magnesium and oxygen.

[1 mark]

0 4 . 3 Calculate the relative formula mass (M_r) of magnesium fluoride (MgF_2).

Relative atomic masses (A_r): F = 19 Mg = 24

[2 marks]

Relative formula mass (M_r) = _____

0 4 . 4 Argon is a noble gas.

Explain why **no** product is formed when magnesium and argon are heated together.

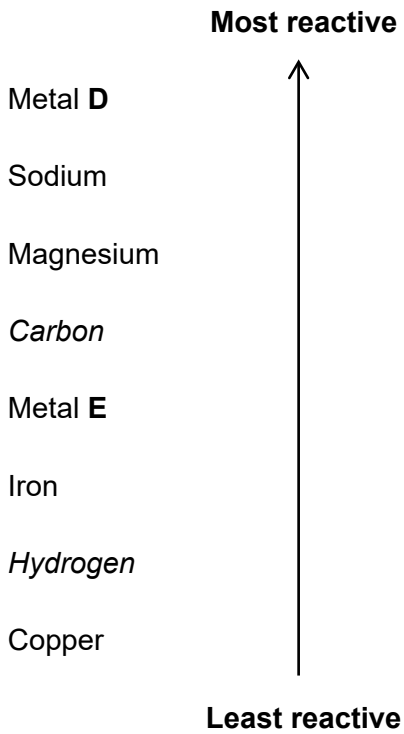
[2 marks]

5.4.1.1 Metal oxides

Question 08 · continued

0 4 . 5 **Figure 10** shows a reactivity series.

Figure 10



5.4.1.1 Metal oxides

Question 08 · continued

Draw **one** line from each metal to the method used to extract that metal.

Use **Figure 10**.

[2 marks]

Metal	Method used to extract that metal
	Extracted by electrolysis of a molten ionic compound.
Metal **D**	Extracted from its oxide by reduction with carbon.
	Extracted from its oxide by reduction with hydrogen.
Metal **E**	
	Removed from the Earth as the metal itself.

Question 4 continues on the next page

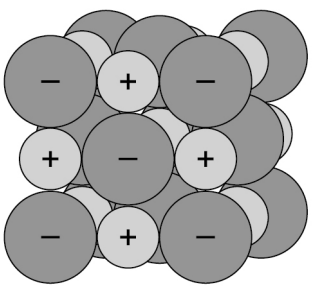
5.4.1.1 Metal oxides

Question 08 · continued

A substance conducts electricity when it has charged particles that are free to move.

0 4 . 6 **Figure 11** represents the structure of sodium chloride.

Figure 11



Sodium chloride

Explain why sodium chloride conducts electricity when molten but **not** when solid.

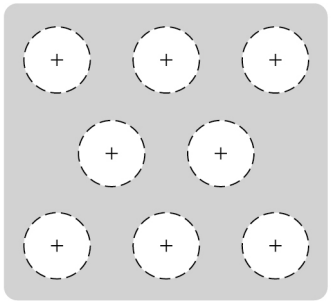
[3 marks]

5.4.1.1 Metal oxides

Question 08 · continued

0 4 . 7 **Figure 12** represents the structure of sodium metal.

Figure 12



Sodium metal

Explain why sodium metal conducts electricity when solid.

[2 marks]

13

5.4.1.1 Metal oxides

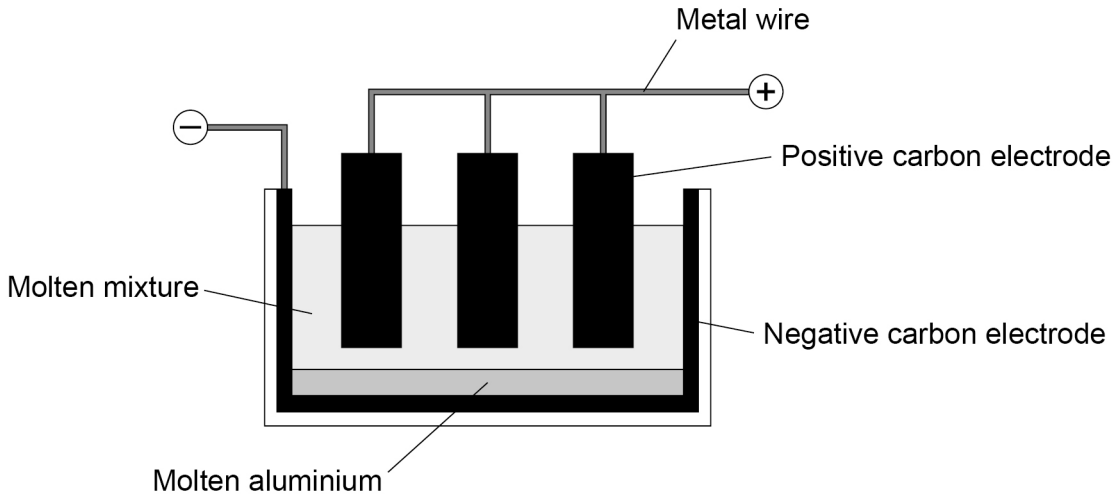
Question 09

0 5 This question is about extraction of metals.

Aluminium is extracted from a molten mixture of aluminium oxide and cryolite using electrolysis.

Figure 12 shows the electrolysis cell.

Figure 12



0 5 . 1 Complete the sentence.

[1 mark]

The extraction of aluminium is expensive because the process uses large amounts of _____ .

0 5 . 2 Oxygen is produced at the positive carbon electrodes.

The oxygen reacts with the carbon electrodes.

Which gas is produced when oxygen reacts with the positive carbon electrodes?

[1 mark]

_____

5.4.1.1 Metal oxides

Question 09 · continued June 2023 | 8464/C/1F | Original Q5

Titanium is extracted from titanium chloride by reacting titanium chloride with sodium.

The reaction between titanium chloride and sodium is carried out in an inert atmosphere.

0 5 . 3 Suggest why the reaction is carried out in an inert atmosphere.

[1 mark]

0 5 . 4 Complete the sentence.

Choose the answer from the box.

[1 mark]

argon	**chlorine**	**hydrogen**

The gas used for the inert atmosphere is _____ .

0 5 . 5 Balance the equation for the reaction.

[1 mark]

$$TiCl_4 + 4\,Na \rightarrow Ti + ____\ NaCl$$

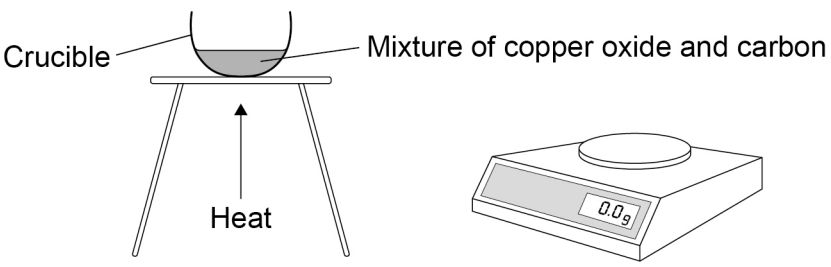
5.4.1.1 Metal oxides

Question 09 · continued

Copper is extracted from copper oxide by reacting copper oxide with carbon.

Figure 13 shows the apparatus.

Figure 13



The equation for the reaction is:

$$2\,CuO(s) + C(s) \rightarrow 2\,Cu(s) + CO_2(g)$$

In an experiment 15.9 g of copper oxide and 1.2 g of carbon reacted.

12.7 g of copper was produced in the reaction.

0 5 . 6 Calculate the mass of carbon dioxide produced in this experiment.

[1 mark]

Mass of carbon dioxide = _____ g

0 5 . 7 Explain why the mass of the contents in the crucible changed during the experiment.

[2 marks]

5.4.1.1 Metal oxides

Question 09 · continued

0 5 . 8 What happens to copper oxide in the reaction?

Give **one** reason for your answer.

Use the equation for the reaction.

[2 marks]

Tick (✓) **one** box.

The copper oxide is dissolved ☐

The copper oxide is oxidised ☐

The copper oxide is reduced ☐

Reason _____

_____

10

Turn over for the next question

5.4.1.1 Metal oxides

Question 10

0 4 A catalyst is used to increase the rate of decomposition of hydrogen peroxide.

0 4 . 1 Hydrogen peroxide decomposes to produce water and oxygen.

Write a word equation for the reaction.

[1 mark]

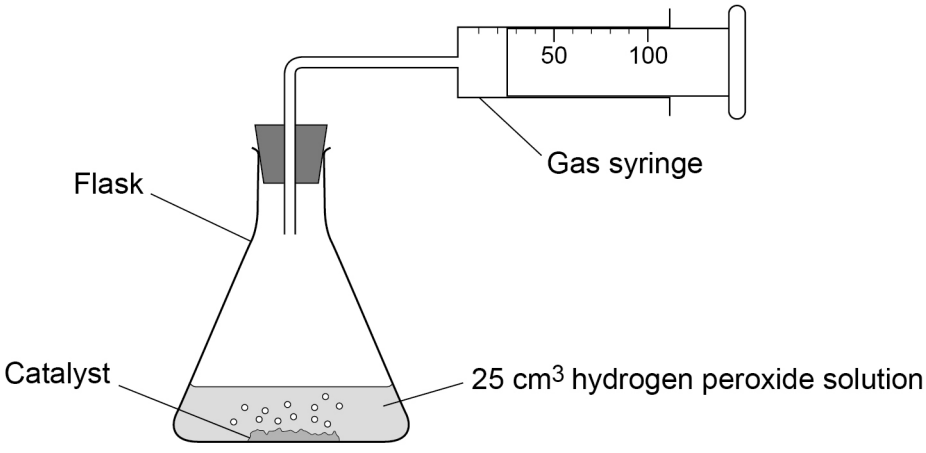
_____ → _____ + _____

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

- manganese dioxide
- copper oxide
- zinc oxide.

Figure 7 shows the apparatus.

Figure 7



5.4.1.1 Metal oxides

Question 10 · continued

This is the method used.

1. Measure 25 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 20 seconds for 120 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 4 . 2 Which **two** control variables are used in the investigation?

[2 marks]

Tick (✓) **two** boxes.

- Mass of catalyst ☐
- Shape of flask ☐
- Time of taking readings ☐
- Volume of hydrogen peroxide solution ☐
- Volume of oxygen produced ☐

Question 4 continues on the next page

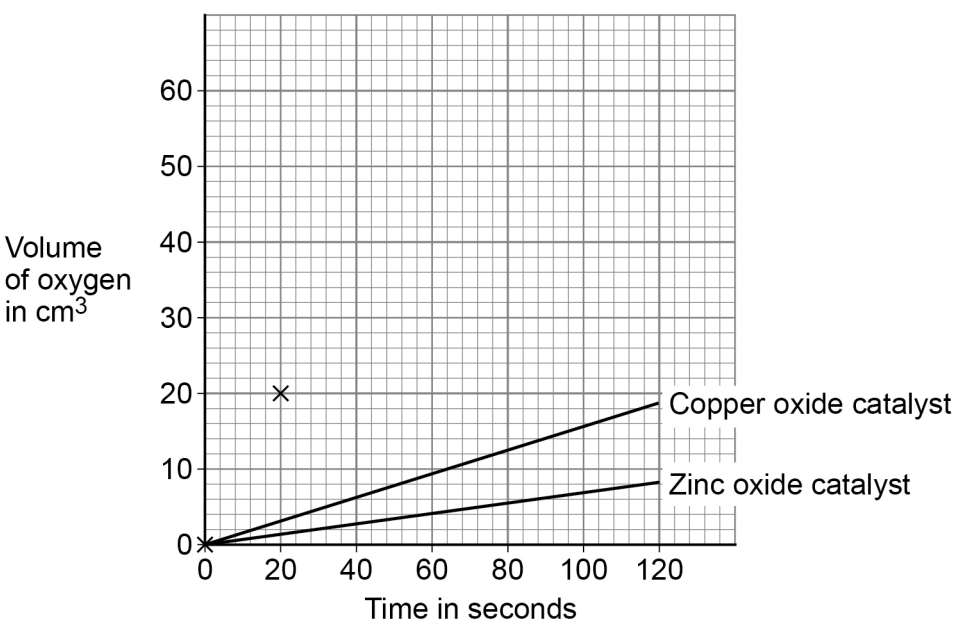
Table 3 shows the results with manganese dioxide catalyst.

Table 3

Time in seconds	0	20	40	60	80	100	120
Volume of oxygen in cm^3	0	20	32	40	45	49	50

Figure 8 shows a graph of the results with copper oxide catalyst and with zinc oxide catalyst.

Figure 8



0 4 . 3 Complete **Figure 8**.

You should:

- plot the data for the manganese dioxide catalyst from **Table 3**
- draw a line of best fit.

The first two points have been plotted for you.

[3 marks]

Question 10 · continued

0 4 . 4 Which is the best catalyst?

Give **one** reason for your answer.

Use the completed **Figure 8**.

[2 marks]

Tick (✓) **one** box.

Copper oxide ☐

Manganese dioxide ☐

Zinc oxide ☐

Reason _____

_____

0 4 . 5 The student repeated the investigation with manganese dioxide catalyst.

The results were all close to the true value.

Complete the sentence.

Choose the answer from the box.

[1 mark]

accurate	**approximate**	**random**

Results that are close to the true value are _____.

Question 4 continues on the next page

5.4.1.1 Metal oxides

Question 10 · continued

0 4 . 6 The student repeated the investigation using manganese dioxide catalyst at a higher temperature.

Complete the sentence.

Choose the answer from the box.

[1 mark]

decrease	**stay the same**	**increase**

At a higher temperature, the rate of reaction will _____.

10

5.4.1.1 Metal oxides

Question 11

June 2024 | 8464/C/1F | Original Q5

0 5 Magnesium chloride is a soluble salt.

0 5 . 1 Magnesium reacts with hydrochloric acid to produce magnesium chloride and a gas.

Which gas is produced?

[1 mark]

Tick (✓) **one** box.

- Hydrogen ☐
- Nitrogen ☐
- Oxygen ☐

Question 5 continues on the next page

5.4.1.1 Metal oxides

Question 11 · continued

Magnesium chloride ($MgCl_2$) can be electrolysed when molten.

0 5 . 2 Which represents molten magnesium chloride?

[1 mark]

Tick (✓) **one** box.

$MgCl_2(g)$ ☐

$MgCl_2(l)$ ☐

$MgCl_2(s)$ ☐

0 5 . 3 Magnesium chloride contains Mg^{2+} ions and Cl^- ions.

Name the product at each electrode when molten magnesium chloride is electrolysed.

[2 marks]

Negative electrode _____

Positive electrode _____

5.4.1.1 Metal oxides

Question 11 · continued

A student investigated the reactivity of three metals: copper, magnesium and iron.

The student mixed each metal with each metal chloride solution.

Table 6 shows the results.

Table 6

	Copper chloride solution	**Magnesium chloride solution**	**Iron chloride solution**
Copper	No reaction	No reaction	No reaction
Magnesium	Reaction	No reaction	Reaction
Iron	Reaction	No reaction	No reaction

0 5 . 4 What is the order of reactivity for copper, magnesium and iron?

Give **two** reasons for your answer.

Use **Table 6**.

[3 marks]

Most reactive _____

_____

Least reactive _____

Reason 1 _____

_____

Reason 2 _____

_____

Question 5 continues on the next page

5.4.1.1 Metal oxides

Question 11 · continued

0 5 . 5 When heated 0.72 g of magnesium reacts with iron oxide to produce 2.32 g of products.

Calculate the mass of iron oxide that reacts with 0.72 g of magnesium.

[1 mark]

Mass of iron oxide = _____ g

0 5 . 6 The student used 30 cm^3 of magnesium chloride solution.

1 dm^3 of magnesium chloride solution contains 180 g of magnesium chloride.

1 dm^3 = 1000 cm^3

Calculate the mass of magnesium chloride in 30 cm^3 of magnesium chloride solution.

[3 marks]

Mass of magnesium chloride = _____ g

11

5.4.1.1 Metal oxides

Question 12

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

0 4 This question is about metals.

0 4 . 1 Complete the sentence.

Choose the answer from the box.

[1 mark]

compounds	elements	polymers

Most metals are found in the Earth as _____.

0 4 . 2 Iron is extracted from iron oxide by reduction with carbon.

Why is iron extracted by reduction with carbon?

[1 mark]

Tick (✓) **one** box.

Iron is less reactive than carbon. ☐

Iron has the same reactivity as carbon. ☐

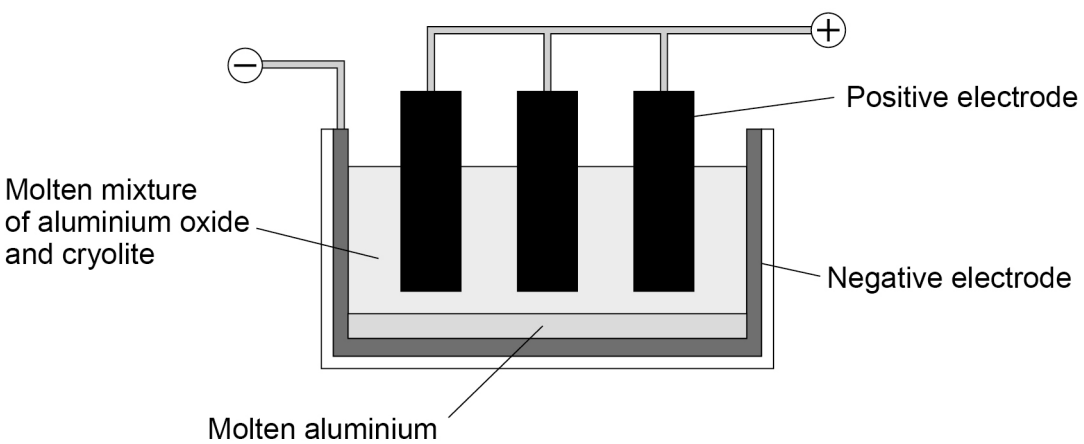
Iron is more reactive than carbon. ☐

Question 4 continues on the next page

Aluminium is extracted by the electrolysis of aluminium oxide.

Figure 8 shows the apparatus used to extract aluminium.

Figure 8



0 4 . 3 The mixture of aluminium oxide and cryolite has a lower melting point than aluminium oxide alone.

Why is the melting point lowered?

[1 mark]

Tick (✓) **one** box.

To reduce the amount of energy used ☐

To reduce the purity of the aluminium formed ☐

To reduce the rate of reaction ☐

5.4.1.1 Metal oxides

Question 12 · continued

0 4 . 4 After some time, the positive electrodes need to be replaced.

Why must the positive electrodes be replaced?

[1 mark]

Tick (✓) **one** box.

- The electrodes dissolve in the molten mixture. ☐
- The electrodes melt in the molten mixture. ☐
- The electrodes react with aluminium. ☐
- The electrodes react with oxygen gas. ☐

Question 4 continues on the next page

5.4.1.1 Metal oxides

Question 12 · continued

Aluminium can be mixed with other metals to form alloys.

0 4 . 5 How does the hardness of an alloy of aluminium compare with the hardness of pure aluminium?

[1 mark]

Tick (✓) **one** box.

The alloy is harder than the pure metal. ☐

The alloy and the pure metal have the same hardness. ☐

The alloy is less hard than the pure metal. ☐

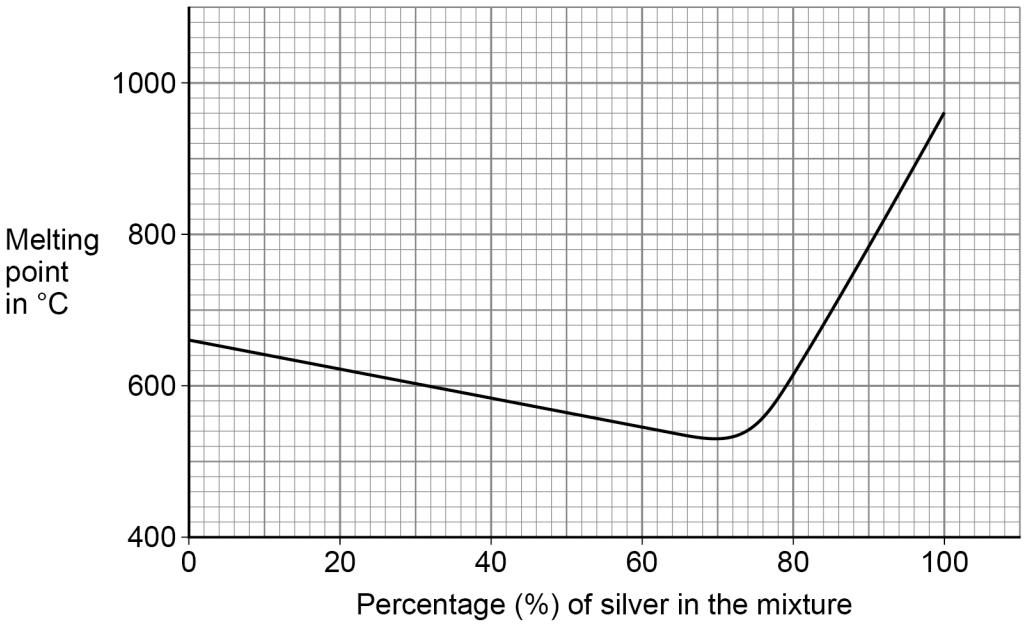
5.4.1.1 Metal oxides

Question 12 · continued

0 4 . 6 Aluminium can form an alloy with silver.

Figure 9 shows how the melting point of the alloy changes with the percentage (%) of silver in the mixture.

Figure 9



Describe how the melting point of the alloy changes as the percentage of silver in the mixture increases.

Use data from **Figure 9**.

[3 marks]

8