**1** Formulae and equations are used to describe chemical reactions.

(a) Aluminium reacts with sulfuric acid ($H_2SO_4$) to produce aluminium sulfate, $Al_2(SO_4)_3$ and hydrogen ($H_2$).

Complete and balance the equation for this reaction.

____Al + _____ ⟶ _____ + _____

**(2)**

(b) Calcium carbonate reacts with nitric acid to produce calcium nitrate.

Calculate the relative formula mass ($M_r$) of calcium nitrate, $Ca(NO_3)_2$

Relative atomic masses ($A_r$): N = 14; O = 16; Ca = 40

_____

_____

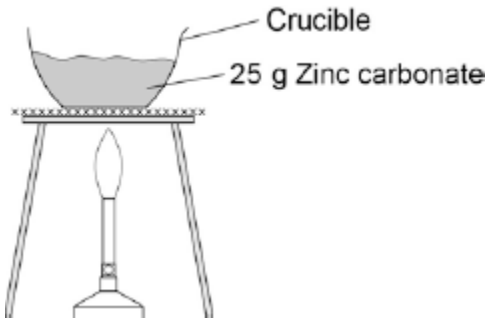
Relative formula mass ($M_r$) = _____

**(2)**

(c) Zinc carbonate decomposes when heated.

A student heated 25 g zinc carbonate ($ZnCO_3$).

The figure below shows how he set up the apparatus.




The balanced chemical equation for the decomposition reaction is:

$ZnCO_3$ (s) ⟶ ZnO (s) + $CO_2$ (g)

The student measured the mass of solid product after heating until there was no further change in mass.

The student did the experiment four times. The table below shows the results.

| **Experiment** | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Mass of solid product in g** | 17.4 | 19.7 | 17.6 | 16.9 |

Calculate the mean mass of the solid product.

Do **not** use any anomalous results in your calculation.

_____

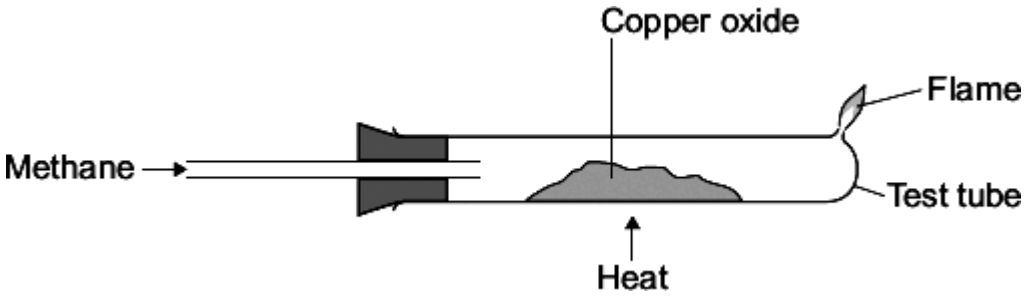
_____

Mean mass = _____ g

**(2)**

**(Total 6 marks)**

**2** An experiment was done on the reaction of copper oxide (CuO) with methane ($CH_4$).




(a) The equation for this reaction is shown below.

$$4CuO(s) + CH_4(g) \rightarrow 4Cu(s) + 2H_2O(g) + CO_2(g)$$

The water and carbon dioxide produced escapes from the test tube.

Use information from the equation to explain why.

_____

**(1)**

(b) (i) Calculate the relative formula mass ($M_r$) of copper oxide (CuO).

Relative atomic masses ($A_r$): O = 16; Cu = 64.

_____

_____

_____

Relative formula mass ($M_r$) = _____

**(2)**

(ii) Calculate the percentage of copper in copper oxide.

_____

_____

_____

Percentage of copper = _____ %

**(2)**

(iii) Calculate the mass of copper that could be made from 4.0 g of copper oxide.

_____

_____

Mass of copper = _____ g

**(1)**

(c) The experiment was done three times.
The mass of copper oxide used and the mass of copper made was measured each time.
The results are shown in the table.

| | Experiment | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| Mass of copper oxide used in g | 4.0 | 4.0 | 4.0 |
| Mass of copper made in g | 3.3 | 3.5 | 3.2 |

(i) Calculate the mean mass of copper made in these experiments.

_____

_____

Mean mass of copper made = _____ g

**(1)**

(ii) Suggest how the results of these experiments could be made more precise.

_____

_____

**(1)**

(iii) The three experiments gave slightly different results for the mass of copper made.
This was caused by experimental error.

Suggest **two** causes of experimental error in these experiments.

1. _____

_____

2. _____

_____

**(2)**

**(Total 10 marks)**

**3** Calcium oxide (quicklime) is made by heating calcium carbonate (limestone).

calcium carbonate → calcium oxide + carbon dioxide
100 g ? 44 g

(a) 44 grams of carbon dioxide is produced when 100 grams of calcium carbonate is heated.

Calculate the mass of calcium oxide produced when 100 grams of calcium carbonate is heated.

_____

mass _____ g

**(1)**

(b) What mass of carbon dioxide could be made from 100 tonnes of calcium carbonate?

mass _____ tonnes

**(1)**

**(Total 2 marks)**

**4** Calamine lotion is used to treat itching. The main ingredients are two metal oxides.


(a) One of the metal oxides has a relative formula mass ($M_r$) of 81.

The formula of this metal oxide is MO.
(M is **not** the correct symbol for the metal.)

The relative atomic mass ($A_r$) of oxygen is 16.

(i) Calculate the relative atomic mass ($A_r$) of metal M.

_____

_____

_____

Relative atomic mass ($A_r$) = _____

**(2)**

(ii) Use your answer to part (a)(i) and the periodic table on the Data Sheet to name metal M.

The name of metal M is _____ .

**(1)**

(b) The other metal oxide is iron(III) oxide.

This contains iron(III) ions ($Fe^{3+}$) and oxide ions ($O^{2-}$).

(i) Explain in terms of electrons how an iron atom (Fe) can change into an iron(III) ion ($Fe^{3+}$).

_____

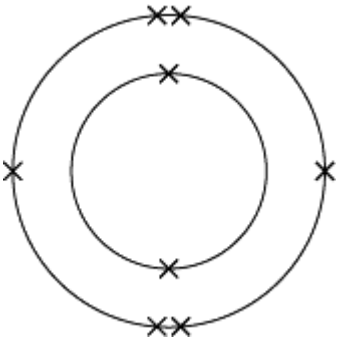
_____

_____

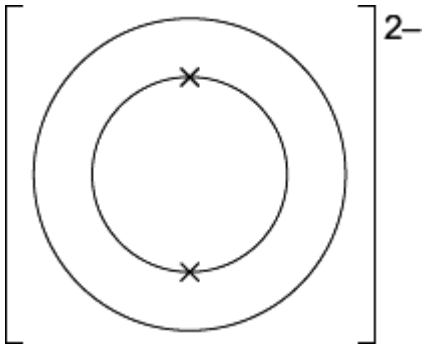
_____

**(2)**

(ii) The diagram below represents the electronic structure of an oxygen atom (O).



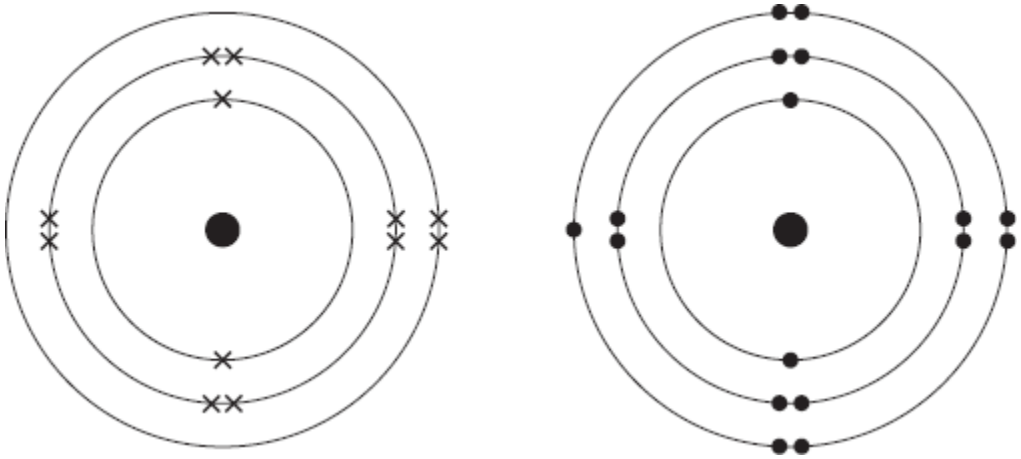
Complete the diagram below to show the electronic structure of an oxide ion ($O^{2-}$).




**(1)**

**(Total 6 marks)**

**5** (a) The diagram shows an atom of magnesium and an atom of chlorine.



**Magnesium** **Chlorine**

Describe, in terms of electrons, how magnesium atoms and chlorine atoms change into ions to produce magnesium chloride ($MgCl_2$).

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

(b) Calculate the relative formula mass ($M_r$) of magnesium chloride ($MgCl_2$).

Relative atomic masses ($A_r$): magnesium = 24; chlorine = 35.5

_____

_____

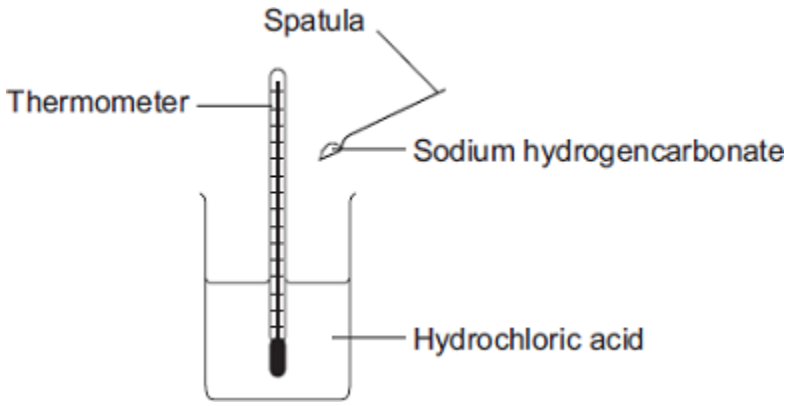
_____

Relative formula mass ($M_r$) = _____

**(2)**

**(Total 6 marks)**

**6** (a) Some students did an experiment to find the temperature change when hydrochloric acid reacts with sodium hydrogencarbonate.




The results are in the table.

| Number of spatula measures of sodium hydrogencarbonate | Start temperature in °C | Final temperature in °C | Change in temperature in °C |
|---|---|---|---|
| **2** | 20 | 16 | 4 |
| **4** | 20 | 14 | 6 |
| **6** | 19 | 11 | 8 |
| **8** | 20 | 10 | 10 |
| **10** | 19 | 9 | 10 |
| **12** | 20 | 10 | 10 |

(i) Describe, as fully as you can, the trends shown in the students' results.

**(3)**

(ii) State the type of energy transfer for this reaction.

_____

_____

**(1)**

(b) Sodium hydrogencarbonate is used as baking powder for making cakes.

When the cake mixture is baked the sodium hydrogencarbonate decomposes.

The equation for the reaction is:

$$2\,NaHCO_3(s) \xrightarrow{Heat} Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

(i) The cake mixture rises when baked.

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Use the equation to suggest why.

_____

_____

**(1)**

(ii) The same reaction can be reversed to produce sodium hydrogencarbonate from sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2NaHCO_3$$

Do the reactants need to be heated?

Give a reason for your answer.

_____

_____

**(1)**

(c) (i) Calculate the relative formula mass of sodium hydrogencarbonate ($NaHCO_3$).

Relative atomic masses ($A_r$): H=1; C=12; O=16; Na=23

Relative formula mass ($M_r$) = _____

**(2)**

(ii) Calculate the percentage by mass of carbon in sodium hydrogencarbonate.

Percentage of carbon = _____ %

**(1)**

**(Total 9 marks)**

**7** Some students investigated magnesium oxide.

(a) Magnesium oxide has the formula MgO.

(i) Calculate the relative formula mass ($M_r$) of magnesium oxide.

Relative atomic masses: O = 16; Mg = 24.

Relative formula mass = _____

**(2)**

(ii) Calculate the percentage by mass of magnesium in magnesium oxide.

Percentage by mass of magnesium in magnesium oxide = _____%

**(2)**

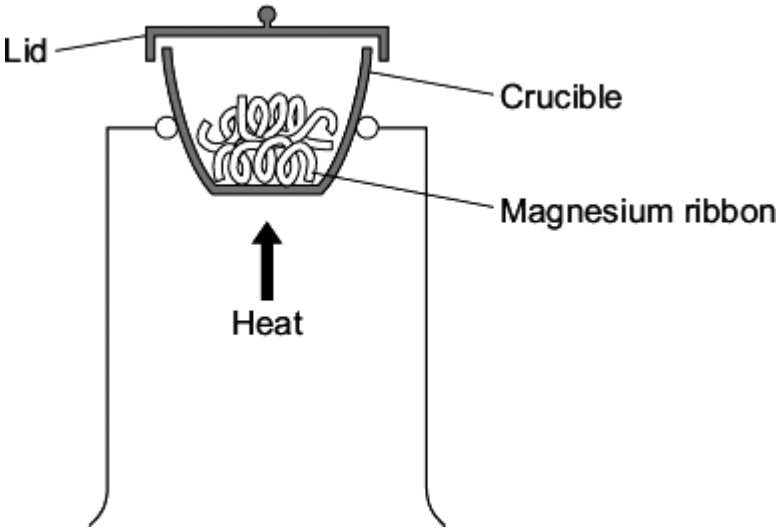
(iii) Calculate the mass of magnesium needed to make 25 g of magnesium oxide.

Mass of magnesium = _____ g

**(1)**

(b) The students calculated that if they used 0.12 g of magnesium they should make 0.20 g of magnesium oxide.

They did this experiment to find out if this was correct.




- The students weighed 0.12 g of magnesium ribbon into a crucible.
- They heated the magnesium ribbon.
- They lifted the lid of the crucible slightly from time to time to allow air into the crucible.
- The students tried to avoid lifting the lid too much in case some of the magnesium oxide escaped.
- When all of the magnesium appeared to have reacted, the students weighed the magnesium oxide produced.

The results of the experiment are shown below.

| | |
|---|---|
| Mass of magnesium used in grams | 0.12 |
| Mass of magnesium oxide produced in grams | 0.18 |

(i) The mass of magnesium oxide produced was lower than the students had calculated. They thought that this was caused by experimental error.

Suggest **two** experimental errors that the students had made.

_____

_____

_____

_____

**(2)**

(ii) The students only did the experiment once.

Give **two** reasons why they should have repeated the experiment.

_____

_____

_____

_____

**(2)**

**(Total 9 marks)**

## Mark schemes

**1**

(a) $2Al + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2$

*formulae correct*

**1**

*balancing correct*

**1**

(b) $40 + 2(14 + (3 \times 16))$

**1**

$= 164$

*allow 164 with no working shown for **2** marks*

**1**

(c) $(17.4 + 17.6 + 16.9) / 3$

**1**

$= 17.3$

*allow 17.3 with no working shown for **2** marks*

**1**

**[6]**

**2**

(a) because they are gases

*ignore vapours / evaporate / (g)*

*allow it is a gas*

**1**

(b) (i) 80 / 79.5

*correct answer with or without working = **2** marks*

*ignore units*

*if no answer **or** incorrect answer then evidence of 64 / 63.5 + 16 gains **1** mark*

**2**

(ii) 80 / 79.87 / 79.9 / 79.375 / 79.38 / 79.4

*correct answer with or without working = **2** marks*

*if no answer **or** incorrect answer*

*then*

*evidence of* $\frac{64}{80}$ ***or*** $\frac{63.5}{79.5}$ *(x100) gains **1** mark*

*accept (ecf)*

$\frac{64 or 63.5}{answer(b)(i)}(\times 100)$ *for **2** marks if correctly calculated*

*if incorrectly calculated*

*evidence of* $\frac{64 or 63.5}{answer(b)(i)}(\times 100)$

*gains **1** mark*

**2**

(iii) 3.2

*correct answer with or without working = **1** mark*

*allow (ecf)*

*4 x ((b)(ii)/100) for **1** mark if correctly calculated*

**1**

(c) (i) 3.3

*accept 3.33…… or* $3\frac{1}{3}$ *or 3.3· or 3.3r*

**1**

(ii) measure to more decimal places

**or** use a more sensitive balance / apparatus

*allow use smaller scale (division)*

***or** use a smaller unit*

*ignore accurate / repeat*

**1**

(iii) any **two** from:

- ignore systematic / human / apparatus / zero / measurement / random / weighing / reading errors unless qualified
- different balances used **or** faulty balance
  *ignore dirty apparatus*
- reading / using the balance incorrectly **or** recording error
  *accept incorrect weighing of copper / copper oxide*
- spilling copper oxide / copper
  *allow some copper left in tube*
- copper oxide impure
  *allow impure copper (produced)*
- not all of the copper oxide was reduced / converted to copper **or** not enough / different amounts of methane used
  *accept not all copper oxide (fully) reacted*
- heated for different times
- heated at different temperatures
  *accept Bunsen burner / flame at different temperatures*
- some of the copper made is oxidised / forms copper oxide
- some of the copper oxide / copper blown out / escapes (from tube)
  *ignore some copper oxide / copper lost*
- some water still in the test tube

**2**

**[10]**

**3** (a) 56g

*for 1 mark*

**1**

(b) 44 tonnes

*for 1 mark*

**1**

**[2]**

**4** (a) (i) 65

*correct answer with or without working = **2** marks*
*if answer incorrect*
*evidence of (81 - 16) for **1** mark*
*ignore units*

**2**

(ii) zinc

*accept error carried forward from (a)(i)*

*allow correct symbol*

*answer given should be element / metal closest to their answer*

*do **not** allow compounds*

**1**

(b) (i) • it loses electrons

*sharing / covalency = max **1** mark*

**1**

• three electrons

**1**

(ii) 8 electrons shown in second shell.

*accept dots / crosses / mixture of dots and crosses / e*

*electrons do not need to be paired*

*do **not** allow extra electrons in first shell*

**1**

**[6]**

**5** (a) magnesium <u>loses electrons</u>

*there are four ideas here that need to be linked in two pairs.*

**1**

<u>two electrons</u>

**1**

<u>chlorine gains electrons</u>

*magnesium <u>loses</u> electrons and chlorine <u>gains</u> electrons scores **2** marks.*

**1**

<u>two atoms of chlorine</u>

*magnesium <u>loses</u> <u>two</u> electrons and <u>two chlorines</u> each <u>gain</u> one electron will score full marks.*

**1**

(b) 95

*correct answer with or without working gains **2** marks*

*if answer incorrect, allow 24 + 35.5 + 35.5 for **1** mark*

**2**

**[6]**

**6** (a) (i) the more sodium hydrogencarbonate the greater the temperature change

*accept examples from the table*

**1**

up to 8 spatula measures

*accept any correct indication of when change occurs*

**1**

then the temperature change is constant

*if no marks awarded allow **1** mark for:*
*the more sodium hydrogencarbonate the lower the final temperature*

**1**

(ii) energy is taken in from the surroundings **or** endothermic

**1**

(b) (i) gas / carbon dioxide / steam / water is produced

*accept carbon dioxide is a gas **or** steam / water is a gas*

*allow gas / air expands when heated*

**1**

(ii) no, because (reaction) is exothermic
**or**
yes, to start the reaction

*allow no, because (reactants) were formed by heating*

*ignore references to cooling*

**1**

(c) (i) 84

*correct answer with or without working gains **2** marks*

*if no answer or incorrect answer then evidence of 23 +1 + 12 + (3 × 16) gains **1** mark*

**2**

(ii) 14.29

*accept rounding to 14.3 or 14*

*allow ecf from (c)(i)*

**1**

**[9]**

**7** (a) (i) 40

*correct answer with or without working **or** incorrect working*

*if the answer is incorrect then evidence of 24 + 16 gains **1** mark*

*ignore units*

**2**

(ii) 60

*correct answer with **or** without working or incorrect working*

*if the answer is incorrect then evidence of 24/40 **or** 24/(i) gains **1** mark*

*ecf allowed from part(i)*

*ie 24/(i) ×100*

*ignore units*

**2**

(iii) 15

*ecf allowed from parts(i) and (ii)*
*24/(i) × 25 or (ii)/100 × 25*
*ignore units*

**1**

(b) (i) any **two** from:

*ignore gas is lost*

- error in weighing magnesium / magnesium oxide
  *allow some magnesium oxide left in crucible*
- loss of magnesium oxide / magnesium
  *allow they lifted the lid too much*
  *allow loss of reactants / products*
- not all of the magnesium has reacted
  *allow not heated enough*
  *allow not enough oxygen / air*

**2**

(ii) any **two** from:

*ignore fair test*

- check that the result is not anomalous
- to calculate a mean / average
  *allow improve the accuracy of the mean / average*
- improve the reliability
  *allow make it reliable*
- reduce the effect of errors

**2**

**[9]**