5-3 Quantitative chemistry – Trilogy

1.0 This question is about carbonates.

1.1 Sodium carbonate, Na_2CO_3, is used as a water softener.
Give the number of atoms of each type in sodium carbonate.

[3 marks]

Sodium (Na) atom(s): _____

Carbon (C) atom(s): _____

Oxygen (O) atom(s): _____

1.2 Calculate the relative formula mass (M_r) of sodium carbonate, Na_2CO_3
Relative atomic masses (A_r): Na = 23; C = 12; O = 16.

[2 marks]

Relative formula mass (M_r) of sodium carbonate =_____

1.3 A student heated a sample of calcium carbonate.
The equation for the reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

This is an example of thermal decomposition.
What is meant by 'thermal decomposition'?

[2 marks]

_____

_____

1.4 Both calcium carbonate and calcium oxide are white solids.
The student weighed the white solid before and after heating.
Explain why a decrease in mass was observed.
Use the equation in **part 1.3** to help you answer the question.

[2 marks]

_____

_____

1.5 One type of copper ore is mainly copper carbonate. When producing copper, the ore reacts with carbon.

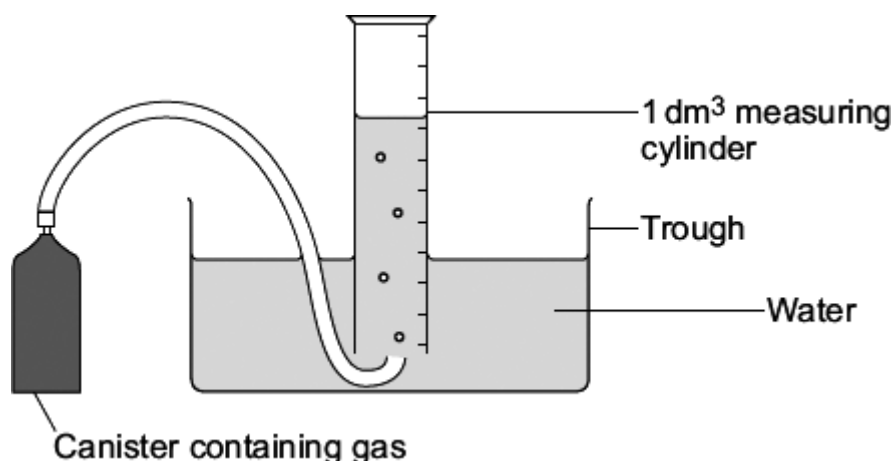| copper carbonate	+ carbon	→	copper	+ carbon dioxide
_____ tonnes	24 tonnes		254 tonnes	264 tonnes
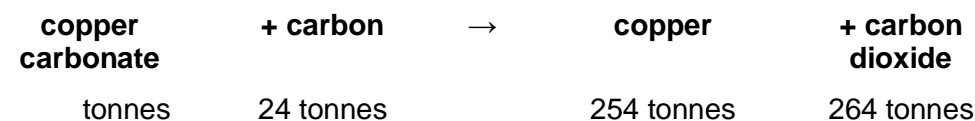
Calculate the mass of copper carbonate needed to produce 254 tonnes of copper.

[2 marks]

Mass = _____ tonnes

2.0 A student did an experiment to find the relative formula mass (M_r) of a gas.
The equipment used is shown in **Figure 1**

Figure 1

The student:

- measured the mass of the canister of gas
- filled the measuring cylinder with 1 dm^3 of the gas from the canister
- measured the mass of the canister of gas again
- measured the temperature of the laboratory
- measured the air pressure in the laboratory
- repeated the experiment.

2.1 The student calculated values for the relative formula mass (M_r) of the gas.
The results are shown in the table below.

Experiment	1	2	3	4
Relative formula mass (M_r)	45.4	51.5	46.3	45.8

Calculate the mean value for these results.
Give your answer to 3 significant figures.

[2 marks]

2.2 The experiments gave different results for the relative formula mass of the gas. This was caused by experimental error.
Suggest **one** experimental error that the student may have made.

[1 mark]

_____

2.3 Give **one** reasons why it is important to repeat the experiment.

[1 mark]

_____

_____

3.0 A student investigated the thermal decomposition of calcium carbonate.
The equation for the reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

The relative formula masses (M_r) are: $CaCO_3$ = 100; CaO = 56; CO_2 = 44

Describe how this experiment could be used to provide evidence for the law of conservation of mass.
Include in your answer:

• The method

• Which measurements should be taken

• How the student could show evidence for conservation of mass

[6 marks]

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

4.0 A student made some copper sulfate crystals, $CuSO_4$.
The student used 7.95 g of copper oxide and 100 cm^3 of a 2.00 mol/dm^3 solution of sulfuric acid.
The equation for the reaction is:

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$
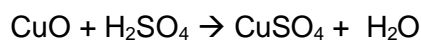
4.1 Calculate the number of moles of copper oxide in 7.95 g copper oxide.
Relative atomic masses A_r: O = 16; Cu = 63.5

[2 marks]

Answer = _____ moles

4.2 Calculate the number of moles of sulfuric acid in 100 cm^3 of 2.00 mol/dm^3 sulfuric acid.

[2 marks]

Answer = _____ moles

4.3 It is common to use an excess of one reactant.
Explain why a reactant is used in excess.

[2 marks]

_____

_____

4.4 Another student made copper sulfate using 0.250 moles of copper oxide and 0.500 moles of sulfuric acid.
Calculate the **maximum** mass of copper sulfate which could be produced.
Give your answer to 3 significant figures.
Relative formula mass (M_r) $CuSO_4$ = 159.5

[4 marks]

Maximum mass of copper sulfate = _____ g

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	2	In this order	1
	1		1
	3		1
1.2	(2 x 23) + 12 + (3 x 16) **or** 46 + 12 + 48		1
	106	An answer of 106 without any working shown gains **2** marks	1
1.3	Breaking down		1
	Using heat		1
1.4	Carbon dioxide is produced	Allow a gas is produced	1
	which goes into the atmosphere		1
1.5	(254 + 264) − 24 **or** 518 − 24		1
	494 (tonnes)	An answer of 494 (tonnes) without any working shown gains **2** marks	1

Qu No.		Extra Information	Marks
2.1	(45.4 + 46.3 + 45.8) ÷ 3	Allow 46 or 45.83(33…) Allow 47.3	1
	45.8	Allow **2** marks for an answer of 45.8 without working	1
2.2	Any **one** from: • Loss of gas or leak • Error in measurement of volume of gas • Error in weighing the canister / gas at start • Error in weighing the canister / gas at end • Change in temperature • Change in pressure	 Allow incorrect measurement of temperature Allow incorrect measurement of pressure	1
2.3	Any **one** from: • To check for anomalous results • To find the mean	 Allow to find the average	1

Qu No.		Extra Information	Marks
3.0			
Level 3:	A coherent method is described and explained with relevant detail, which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered and would lead to the production of valid results. An explanation of the expected results is provided.		5–6
Level 2:	The bulk of a method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail. An attempted explanation of the expected results is given.		3–4
Level 1:	Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.		1–2
	No relevant content		0
Indicative content			

Method
- Measure mass of suitable container eg boiling tube
- Mass measured using balance
- Place calcium carbonate in boiling tube
- Measure mass of boiling tube and calcium carbonate
- Heat boiling tube and calcium carbonate
- Allow to cool
- Reweigh tube and contents
- Repeat heating, cooling and weighing until constant mass is obtained

Conservation of mass
- Identifies the conservation of mass
- Carbon dioxide produced as a gas
- Carbon dioxide escapes to the surroundings
- So mass will decrease during the reaction
- Suggests initial mass to be heated
- Use the initial mass to suggest final mass in boiling tube
- Use suggested masses to confirm law of conservation of mass

Qu No.		Extra Information	Marks
4.1	$\frac{7.95}{16+63.5}$ or $\frac{7.95}{79.5}$		1
	0.1 (moles)	Allow **2** marks for an answer of 0.1 (moles) without working	1
4.2	$\frac{100}{1000} \times 2$		1
	0.2 (moles)	Allow **2** marks for an answer of 0.2 (moles) without working	1
4.3	(So that) the other reactant		1
	is completely used up		1
4.4	Evidence of sulfuric acid in excess or Copper oxide limiting reagent		1
	Moles of copper sulfate = moles of copper oxide = 0.250		1
	(Mass of copper sulfate =) 0.25 x 159.5		1
	39.9 (g)	Allow ecf for steps 2/3/4	1
		Allow **4** marks for an answer of 0.2 (moles) without working	