Worksheet 1.1: Reacting Masses Calculations

ChemistrySheets

Specification: GCSE Chemistry (AQA 5.3.1.2 / Edexcel SC14 / OCR Gateway C4.1)

Key Formula: Moles (mol) $= \frac{\text{Mass (g)}}{M_r}$ Mass (g) $=$ Moles $\times M_r$ $M_r = \frac{\text{Mass (g)}}{\text{Moles}}$

Units: Moles (mol), Mass (g), M_r (Relative formula mass, no units). **Also consider Mole Ratios from balanced equations.**

Core Concepts: This worksheet focuses on applying the mole concept to calculate quantities of reactants and products in chemical reactions. Remember the law of conservation of mass and how to use mole ratios from balanced equations.

Section A: Formula Recall & Rearrangement

1. Complete the table below with the correct SI unit and symbol for each variable in the formula.

Variable	Unit Name	Unit Symbol
Moles	**mole**	**mol**
Mass	**gram**	**g**
Relative formula mass (M_r)	**no unit**	**no unit**

2. Rearrange the key formula (Moles $= \frac{\text{Mass}}{M_r}$) to make Mass and M_r the subject.

a) Mass (g) $=$ **Moles** $\times M_r$

b) $M_r =$ **Mass (g) / Moles**

3. Perform the following conversions or calculations. Use the following approximate relative atomic masses (A_r): H=1, C=12, O=16, Mg=24, Cl=35.5.

a) Calculate the mass of 2.5 mol of H_2O ($M_r = 18$). **45 g**

b) Calculate the moles in 120 g of Mg ($M_r = 24$). **5 mol**

c) Calculate the mass of 0.05 mol of CO_2 ($M_r = 44$). **2.2 g**

d) Calculate the moles in 177.5 g of Cl_2 ($M_r = 71$). **2.5 mol**

e) An unknown substance has a mass of 10 g and contains 0.25 mol. Calculate its M_r. **40**

Section B: Practice Calculations

Show all your working clearly for each question. Use the following approximate relative atomic masses (A_r): Ca=40, C=12, O=16, Na=23, H=1.

a) Calculate the number of moles in 100 g of calcium carbonate ($CaCO_3$).

Model Answer:
$M_r(CaCO_3) = A_r(Ca) + A_r(C) + 3 \times A_r(O)$
$M_r(CaCO_3) = 40 + 12 + (3 \times 16) = 100$
Moles $= \frac{\text{Mass}}{M_r} = \frac{100\text{ g}}{100} = 1.0$ mol

b) Calculate the number of moles in 22 g of carbon dioxide (CO_2).

Model Answer:
$M_r(CO_2) = A_r(C) + 2 \times A_r(O)$
$M_r(CO_2) = 12 + (2 \times 16) = 44$
Moles $= \frac{\text{Mass}}{M_r} = \frac{22\text{ g}}{44} = 0.5$ mol

c) Calculate the mass of 0.2 mol of sodium hydroxide (NaOH).

Model Answer:
$M_r(NaOH) = A_r(Na) + A_r(O) + A_r(H)$
$M_r(NaOH) = 23 + 16 + 1 = 40$
Mass $=$ Moles $\times M_r = 0.2$ mol $\times 40 = 8.0$ g

d) A sample of an unknown compound has a mass of 4.9 g and contains 0.05 mol. Calculate its relative formula mass (M_r).

Model Answer:
$M_r = \frac{\text{Mass}}{\text{Moles}}$
$M_r = \frac{4.9\text{ g}}{0.05\text{ mol}} = 98$

Section C: Challenge Context

Show all your working clearly for each question. Use the following approximate relative atomic masses (A_r): Na=23, Cl=35.5, Cu=63.5, C=12, O=16.

a) Sodium (Na) reacts with chlorine (Cl_2) to produce sodium chloride (NaCl) according to the balanced equation: $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$
If 4.6 g of sodium reacts completely, calculate the mass of sodium chloride (NaCl) produced.

Model Answer:
1. Calculate moles of Na:
$M_r(\text{Na}) = 23$
Moles Na $= \frac{\text{Mass}}{M_r} = \frac{4.6\text{ g}}{23} = 0.2$ mol
2. Use mole ratio to find moles of NaCl:
From the balanced equation, the mole ratio Na : NaCl is 2 : 2 (or 1 : 1).
Therefore, Moles NaCl = 0.2 mol
3. Calculate mass of NaCl:
$M_r(\text{NaCl}) = A_r(\text{Na}) + A_r(\text{Cl}) = 23 + 35.5 = 58.5$
Mass NaCl = Moles $\times$ M_r = 0.2 mol $\times$ 58.5 = 11.7 g

b) Copper carbonate ($CuCO_3$) decomposes when heated to form copper oxide (CuO) and carbon dioxide (CO_2). The reaction is shown below: $CuCO_3(s) \xrightarrow{\text{heat}} CuO(s) + CO_2(g)$

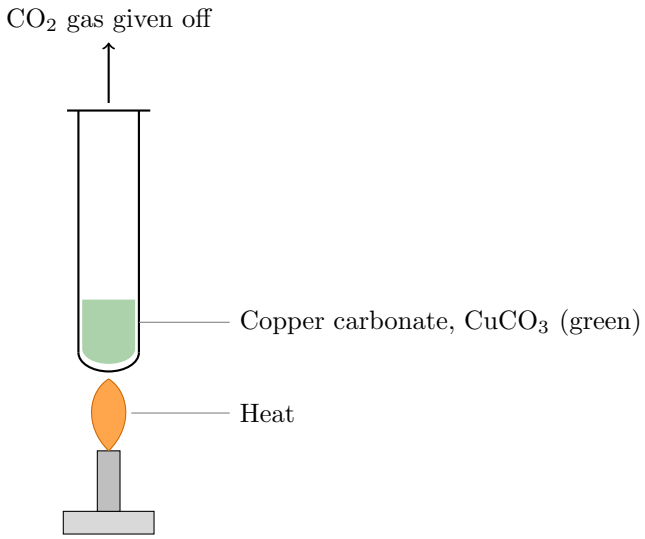

Figure 1: Thermal decomposition of copper carbonate.

In an experiment, 12.4 g of copper carbonate was heated, and 8.0 g of copper oxide was produced. Calculate the mass of carbon dioxide (CO_2) produced.

Model Answer:

1. Calculate M_r values:

$M_r(\text{CuCO}_3) = A_r(\text{Cu}) + A_r(\text{C}) + 3 \times A_r(\text{O}) = 63.5 + 12 + (3 \times 16) = 123.5$

$M_r(\text{CO}_2) = A_r(\text{C}) + 2 \times A_r(\text{O}) = 12 + (2 \times 16) = 44$

2. Calculate moles of CuCO_3 reacted:

Moles $\text{CuCO}_3 = \frac{\text{Mass}}{M_r} = \frac{12.4 \text{ g}}{123.5} \approx 0.1004$ mol

3. Use mole ratio to find moles of CO_2:

From the balanced equation, the mole ratio $\text{CuCO}_3 : \text{CO}_2$ is $1 : 1$.

Therefore, Moles $\text{CO}_2 = 0.1004$ mol

4. Calculate mass of CO_2:

Mass CO_2 = Moles $\times M_r = 0.1004 \text{ mol} \times 44 = 4.4176$ g

Rounding to 3 significant figures (consistent with input masses): **4.42 g**

(Alternatively, by conservation of mass: Mass CO_2 = Mass $CuCO_3$ - Mass CuO = 12.4 g - 8.0 g = 4.4 g)