Worksheet 1.1: Mean Rate of Reaction

ChemistrySheets

Specification: GCSE Chemistry (AQA 5.6.1.1 / Edexcel SC17 / OCR Gateway C6.1)

Core Formula: The mean rate of reaction is calculated using the formula:

$$\text{Rate} = \frac{\text{Quantity of reactant used or product formed}}{\text{Time}}$$

This formula can be rearranged to find other variables:

$$\text{Quantity} = \text{Rate} \times \text{Time} \quad \text{and} \quad \text{Time} = \frac{\text{Quantity}}{\text{Rate}}$$

Units:

- **Rate:** g/s, cm^3/s, or mol/s
- **Quantity:** g (grams), cm^3 (cubic centimetres), or mol (moles)
- **Time:** s (seconds)

Section A: Understanding the Formula & Units

1. Complete the table below with the correct SI unit and common units used for each variable in rate calculations.

Variable	Common Units
Rate	**g/s, cm^3/s, mol/s**
Quantity	**g, cm^3, mol**
Time	**s**

2. Write down the two rearranged forms of the mean rate of reaction formula:

   a) Quantity of reactant used or product formed = **Rate × Time**

   b) Time = **Quantity / Rate**

3. Perform the following unit conversions:

   a) 3.5 minutes = **210** seconds

   b) 250 cm^3 = **0.25** dm^3

   c) The relative formula mass (M_r) of calcium carbonate ($CaCO_3$) (Ca=40.1, C=12.0, O=16.0) = **100.1**

   d) How many moles are in 22 g of carbon dioxide (CO_2)? (M_r CO_2=44.0) = **0.5** mol

   e) What is the mass of 0.15 mol of magnesium oxide (MgO)? (M_r MgO=40.3) = **6.045** g

Section B: Practice Calculations

1. A reaction produces 45.0 g of a solid product in 150 seconds. Calculate the mean rate of reaction in g/s.

Model Answer:

Rate = Quantity / Time
Rate = 45.0 g / 150 s
Rate = 0.30 g/s

2. During a decomposition reaction, 360 cm^3 of gas is collected over a period of 2 minutes. Calculate the mean rate of reaction in cm^3/s.

Model Answer:

Time = 2 minutes × 60 s/minute = 120 s
Rate = Quantity / Time
Rate = 360 cm^3 / 120 s
Rate = 3.0 cm^3/s

3. A chemical process has a mean rate of 0.25 mol/s. How many moles of product would be formed after 5 minutes?

Model Answer:
Time = 5 minutes × 60 s/minute = 300 s
Quantity = Rate × Time
Quantity = 0.25 mol/s × 300 s
Quantity = 75 mol

4. A student wants to produce 1200 cm^3 of hydrogen gas. If the reaction proceeds at a mean rate of 4.0 cm^3/s, how long will it take to produce the required volume of gas? Give your answer in seconds and minutes.

Model Answer:
Time = Quantity / Rate
Time = 1200 cm^3 / 4.0 cm^3/s
Time = 300 s
Time in minutes = 300 s / 60 s/minute = 5 minutes
It will take 300 seconds or 5 minutes.

Section C: Challenge Context

1. Magnesium reacts with hydrochloric acid to produce hydrogen gas:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

In an experiment, 0.24 g of magnesium ribbon completely reacted in 80 seconds. Calculate the mean rate of hydrogen gas production in mol/s. (Relative atomic mass: Mg = 24.3)

Model Answer:
Moles of Mg reacted = Mass / Ar = 0.24 g / 24.3 g/mol = 0.0098765 mol
From the stoichiometry, 1 mole of Mg produces 1 mole of H_2. So, moles of H_2 produced = 0.0098765 mol
Mean rate of H_2 production = Moles / Time = 0.0098765 mol / 80 s = 0.00012345 mol/s (or 1.23×10^{-4} mol/s to 3 s.f.)

2. A student investigates the rate of reaction between calcium carbonate chips and dilute hydrochloric acid by measuring the mass loss over time. The reaction produces carbon dioxide gas, which escapes through cotton wool placed in the neck of the flask (see Figure 1).

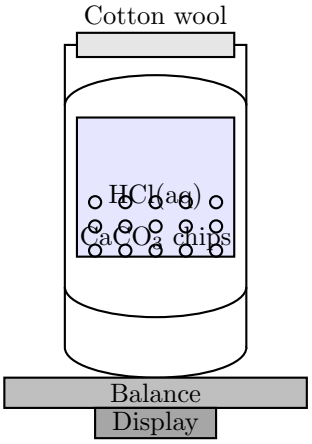

Figure 1: Setup for measuring mass loss during a reaction.

The initial mass of the flask and its contents was 185.50 g. After 3 minutes, the mass had decreased to 183.94 g. Calculate the mean rate of carbon dioxide (CO_2) production in:

a) g/s

b) mol/s (M_r CO_2=44.0)

Model Answer:

Total mass loss = 185.50 g - 183.94 g = 1.56 g. This is the mass of CO_2 produced.
Time = 3 minutes × 60 s/minute = 180 s
a) Mean rate of CO_2 production (g/s) = Mass loss / Time = 1.56 g / 180 s = 0.008666... g/s ≈ 0.00867 g/s (3 s.f.)
b) Moles of CO_2 produced = Mass / Mr = 1.56 g / 44.0 g/mol = 0.035454... mol
Mean rate of CO_2 production (mol/s) = Moles / Time = 0.035454 mol / 180 s = 0.00019696... mol/s ≈ 1.97×10^{-4} mol/s (3 s.f.)