

1.1.2 Experimental formulae and molar gas volume

Name: _____ Class: _____ Date: _____

Total: 26 marks

KEY WORDS empirical formula • molar volume • constant mass

Objective

Use experimental masses and gas volumes to test formulae and equations. Evaluate a specific error direction rather than saying only that the result is inaccurate.

1 Key knowledge and worked examples

■ Separate the container from the chemical mass

A crucible weighs 18.00 g, with metal 18.48 g, and with its oxide after repeated heating 18.80 g. Metal mass = 0.48 g; oxygen mass = 0.32 g. For Mg = 24.0 and O = 16.0:

$$n(\text{Mg}) = 0.48/24.0 = 0.0200 \text{ mol}; \quad n(\text{O}) = 0.32/16.0 = 0.0200 \text{ mol}$$

The ratio is 1:1, giving MgO. Cool before weighing and repeat heat-cool-weigh until constant mass. A lid limits loss while admitting oxygen.

■ Gas volume tests a mole ratio

For a known limiting amount, molar volume = measured gas volume/amount of gas. A leak lowers the measured volume. To test a proposed reaction equation, predict gas amount from its coefficients and compare with evidence.

2 Practice

2.1 A metal oxide contains 1.08 g aluminium and 0.960 g oxygen. Use Al = 27.0, O = 16.0. Find its empirical formula. [3]

2.2 A 0.120 g magnesium sample reacts with excess acid and gives 118 cm³ hydrogen at the measured room conditions. Use $M_r = 24.0$ and $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$. Calculate the experimental molar gas volume in dm³ mol⁻¹. [3]

2.3 For the experiment in 2.2, explain the effect of a gas leak on the calculated molar volume and on a molar mass inferred from the same gas measurement. [3]

3 Exam-style questions

3.1 A heated sample of copper oxide loses 0.160 g when completely reduced to 0.635 g copper. Use $M_r = 63.5$, $O = 16.0$. Find the oxide formula. Explain why incomplete reduction would give an oxygen-to-copper ratio that is too low when final residue is assumed to be pure copper. [5]

3.2 A student proposes $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$. At a stated molar volume of $24.0 \text{ dm}^3 \text{ mol}^{-1}$, 0.200 g calcium gives 120 cm^3 hydrogen. Use $\text{Ca} = 40.0$. Test whether these data support the equation. State one limitation of concluding that it is proven. [4]

3.3 A magnesium oxidation experiment ends with a high calculated Mg:O ratio. Two possible causes are incomplete oxidation and loss of oxide smoke. Explain how each can produce this result. Suggest a distinct procedural control for each. [4]

3.4 A hydrocarbon contains 3.60 g carbon and 0.600 g hydrogen. Its relative molecular mass is 56.0. Use $\text{C} = 12.0$ and $\text{H} = 1.00$. Find its empirical and molecular formulae. [4]
