

Exercise walk-through

1.1.2

Experimental formulae and molar gas volume

Pearson Edexcel · International A-Level · Chemistry

Compare fuels using their whole pathway

- 1** Cracking makes smaller hydrocarbons including alkenes; balance atoms in proposed products.
- 2** CO reduces oxygen transport; nitrogen/sulfur oxides can contribute to acid pollution.
- 3** Bioethanol growth can absorb CO₂, but processing and transport still emit. Hydrogen production also matters.

Choose reagents and conditions

- 1 **1** H_2/Ni adds hydrogen; steam/acid catalyst adds water; Br_2 adds bromine across $\text{C}=\text{C}$.
- 2 **2** Cold dilute acidified manganate(VII) gives a diol. Bromine decolourisation supports unsaturation, not a unique identity.
- 3 **3** Addition polymerisation opens $\text{C}=\text{C}$, retains side groups and loses no small molecule.

Final transfer: a biased measurement

Your turn

A 0.480 g sample produces 0.240 dm³ of gas in a 1:1 reaction. Use $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$. A leak makes gas volume too low. What happens to inferred sample molar mass?

- A. It is too high
- B. It is too low
- C. It stays correct
- D. It becomes negative

Exercises 2.1·2.2

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

2.2 A 0.120 g magnesium sample reacts with excess acid and gives 118 cm^3 hydrogen

Exercises 2.1·2.2

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]

2.1 $n(\text{Al}) = 1.08/27.0 = 0.0400$ mol and $n(\text{O}) = 0.960/16.0 = 0.0600$ mol. Ratio = 1:1.5 = 2:3, giving Al_2O_3 .

2.2 A 0.120 g magnesium sample reacts with excess acid and gives 118 cm³ hydrogen

2.2 $n(\text{Mg}) = 0.120/24.0 = 0.00500$ mol; the 1:1 ratio gives the same hydrogen amount. $V = 0.118$ dm³.

$$V_m = V/n = 0.118/0.00500 = 23.6 \text{ dm}^3 \text{ mol}^{-1}$$

This value belongs to the actual measurement conditions, not every temperature and pressure.

Exercises 2.3·3.1

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]

3.1 A heated sample of copper oxide loses 0.160 g when completely reduced to 0.635 g copper. Use $\text{Cu} = 63.5$, $\text{O} = 16.0$. 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]

Exercises 2.3·3.1

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2.3 A leak lowers recorded gas volume, so V/n and calculated molar volume are too low when n is fixed by the known magnesium amount. If instead gas volume determines n for an unknown substance, inferred n is too low and $M = m/n$ is too high.

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3.1 Oxygen removed = 0.160 g. $n(\text{O}) = 0.160/16.0 = 0.0100$ mol and $n(\text{Cu}) = 0.635/63.5 = 0.0100$ mol. Ratio 1:1 gives CuO . Incomplete reduction leaves oxygen in the residue, so recorded oxygen loss is too low; treating the heavier residue as all copper also overestimates copper amount, further lowering the inferred O:Cu ratio.

Exercises 3.2·3.3

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 $\text{Mg}:\text{O}$ 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]

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3.2 $n(\text{Ca}) = 0.200/40.0 = 0.00500 \text{ mol}$. The proposed equation predicts $n(\text{H}_2) = 0.00500 \text{ mol}$ and $V = nV_m = 0.00500 \times 24.0 = 0.120 \text{ dm}^3 = 120 \text{ cm}^3$. The measured value agrees, but one volume cannot establish every product identity or exclude compensating measurement errors. Agreement supports the proposed ratio rather than proving the complete equation alone.

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3.3 Incomplete oxidation leaves a smaller oxygen mass gain, so oxygen amount is underestimated and Mg:O is too high; repeat heat–cool–weigh until constant mass with oxygen access. Escaping oxide lowers final mass and the inferred oxygen gain while the initial magnesium mass is still used; use a lid slightly open for oxygen and control heating to retain smoke.

Exercise 3.4

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

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3.4 $n(C) = 3.60/12.0 = 0.300$ mol and $n(H) = 0.600/1.00 = 0.600$ mol. $C:H = 1:2$ gives CH_2 . Empirical-formula mass = 14.0; factor = $56.0/14.0 = 4$. Multiply every subscript by four to obtain C_4H_8 . This formula does not alone identify connectivity.