

1.1.1 Concentrations, gas equations and limiting amounts

Name: _____ Class: _____ Date: _____

Total: 24 marks

KEY WORDS molar mass • concentration • limiting reagent

Objective

Choose consistent units for concentration, ppm and gas calculations, then use a balanced equation. Original practice for specification 1.3–1.8.

1 Key knowledge and worked examples

■ Concentration is an amount divided by a volume

Mass concentration = mass/solution volume; amount concentration = amount/solution volume. For 5.85 g NaCl in 0.500 dm³, with $M = 58.5 \text{ g mol}^{-1}$:

$$n = m/M = 5.85/58.5 = 0.100 \text{ mol}$$

$$c = n/V = 0.100/0.500 = 0.200 \text{ mol dm}^{-3}$$

Mass concentration is 11.7 g dm⁻³. State which concentration you calculated. For gases, use $n = pV/(RT)$ with Pa, m³ and K. Parts per million is the stated fraction $\times 10^6$.

■ Remove spectator ions only after balancing

$\text{Zn(s)} + \text{CuSO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{Cu(s)}$ becomes $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$. Sulfate ions remain unchanged.

2 Practice

2.1 Define relative formula mass and molar mass. Explain why sodium chloride has a formula mass rather than a molecular mass. [3]

2.2 Dissolve 4.00 g NaOH and make the solution up to 250 cm³. Use $M = 40.0 \text{ g mol}^{-1}$. Calculate both amount concentration and mass concentration. [4]

2.3 Air contains 0.0420% carbon dioxide by volume. Calculate its concentration in ppm by volume. [2]

3 Exam-style questions

3.1 A volatile liquid of mass 0.230 g becomes 100 cm³ of vapour at 373 K and 1.00×10^5 Pa. Use $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$. Calculate its molar mass, assuming ideal behaviour. [4]

3.2 A mixture contains 0.0600 mol aluminium and 0.0600 mol chlorine. Use $2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$. Identify the limiting reactant, calculate the amount of product, and calculate the amount of aluminium left. [4]

3.3 A student adds aqueous sodium carbonate to aqueous calcium chloride. A white solid forms. Write a balanced full equation and the net ionic equation with state symbols, and identify the spectator ions. [4]

3.4 A process has theoretical product mass 4.00 g but gives 3.20 g isolated dry product. Calculate percentage yield. Explain why a 100% atom-economy reaction can still give this yield. [3]
