A-LEVEL CHEMISTRY • EXERCISE SHEET

2.4 Reacting masses and volumes

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS limiting reagent 限量试剂 • titration 滴定 • percentage yield 产率 • stoichiometry 化学计量 • ion 离子

Objective

Build the skills to answer exam questions on **reacting masses and volumes** — **stoichiometry** 化学计量, **percentage yield** 产率, **limiting reagent** 限量试剂, gas volumes, and **titration** 滴定 calculations.

You must be able to:

- calculate reacting masses and percentage yield from a balanced equation
- identify the limiting reagent and calculate gas volumes ($n = V/24$)
- calculate solution concentrations from a titration ($n = cV$)

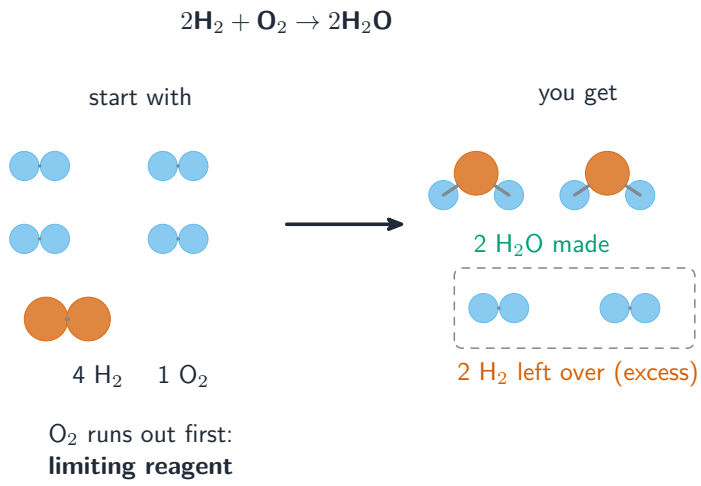
1 Worked examples

■ Reacting masses and percentage yield

Mole ratio comes from the equation. **Example.** Mass of MgO from 4.8 g Mg: $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$. Moles Mg $= 4.8/24 = 0.20$; ratio 1:1 $\rightarrow$ 0.20 mol MgO; $m = 0.20 \times 40 = 8.0$ g.

$$\text{percentage yield} = \frac{\text{actual product}}{\text{maximum possible}} \times 100\%$$

■ Limiting reagent

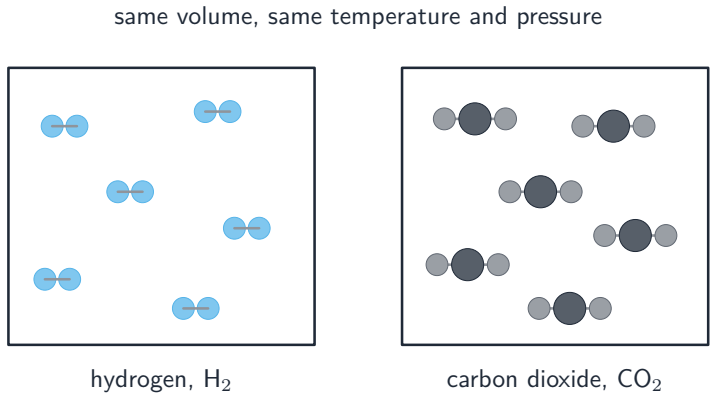


The limiting reagent runs out first and decides the product; the leftover is in excess

Find moles of each reactant, divide by its equation number — the smallest is the **limiting reagent**.

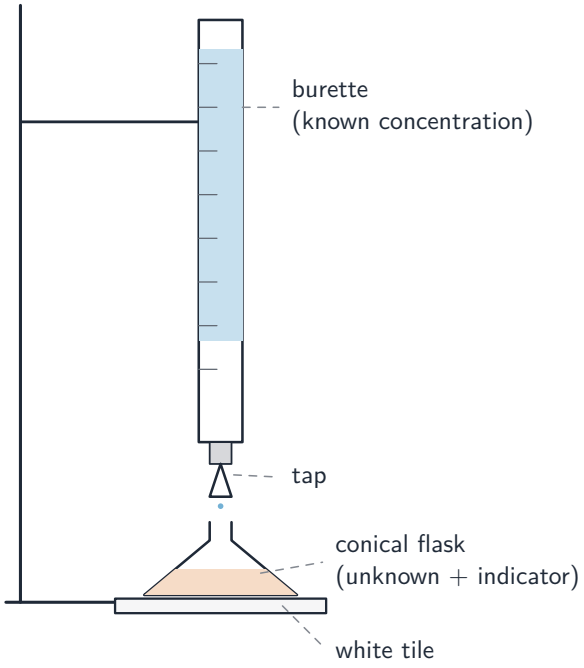
Gas volumes

At r.t.p. one mole of any gas = 24.0 dm^3, so $n = V/24.0$.



Equal gas volumes (same T, p) hold equal numbers of molecules

Titration ($n = cV$)



A titration finds an unknown concentration using a solution of known concentration

Example. 20.0 cm^3 of 0.100 mol dm^{-3} HCl neutralises 25.0 cm^3 NaOH (1:1). Moles HCl $= 0.100 \times 0.0200 = 2.00 \times 10^{-3}$; so NaOH conc $= 2.00 \times 10^{-3} / 0.0250 = 0.0800$ mol dm^{-3}.

2 Practice

2.1 Calculate the mass of carbon dioxide made when 10 g of calcium carbonate decomposes: $CaCO_3 \rightarrow CaO + CO_2$ (M_r: $CaCO_3$ 100, CO_2 44). [2]

2.2 Calculate the volume of 0.50 mol of gas at r.t.p. [1]

3 Exam-style questions

3.1 24 cm^3 of methane is burned completely in oxygen: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. What volume of CO_2 is made (same conditions)? [1]

- **A** 12 cm^3
- **B** 24 cm^3

- **C** 48 cm^3
- **D** 96 cm^3

3.2 0.30 mol of H_2 reacts with 0.20 mol of O_2: $2H_2 + O_2 \rightarrow 2H_2O$. The limiting reagent is: [1]

- **A** hydrogen
- **B** oxygen
- **C** water
- **D** neither — they react exactly

3.3 In a titration, 25.0 cm^3 of sulfuric acid is exactly neutralised by 20.0 cm^3 of 0.100 mol dm^{-3} NaOH: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$.

(a) Calculate the moles of NaOH used. [1]

(b) Calculate the concentration of the sulfuric acid. [3]

3.4 8.0 g of methanol is made from a reaction whose maximum possible yield is 12.8 g. Calculate the percentage yield. [2]

Solutions

2.1 moles $CaCO_3 = 10/100 = 0.10$; ratio 1:1 $\rightarrow$ 0.10 mol CO_2; $m = 0.10 \times 44 = 4.4$ g.

2.2 $V = 0.50 \times 24.0 = 12$ dm^3.

3.1 B. Ratio CH_4 : CO_2 is 1:1, so 24 cm^3 of CO_2.

3.2 A. $0.30/2 = 0.15$ for H_2 vs $0.20/1 = 0.20$ for O_2; H_2 gives the smaller value, so hydrogen is limiting.

3.3 (a) $n = 0.100 \times 0.0200 = 2.00 \times 10^{-3}$ mol.
(b) ratio H_2SO_4 : NaOH is 1:2, so moles $H_2SO_4 = 1.00 \times 10^{-3}$; $c = n/V = 1.00 \times 10^{-3}/0.0250 = 0.0400$ mol dm^{-3}.

3.4 $\dfrac{8.0}{12.8} \times 100 = 62.5\%$.