

Atoms, Molecules & Stoichiometry

A-Level Chemistry ■ Topic 2

A-Level Chemistry



Atoms, Molecules & Stoichiometry

What we will cover

- 1 Relative masses
- 2 The mole
- 3 Formulas & equations
- 4 Reacting masses & yield
- 5 Gas volumes
- 6 Titration



mass is the basis

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Masses and the mole

Atoms, Molecules & Stoichiometry

└─ Masses and the mole

Relative masses

Masses are compared with $\frac{1}{12}$ of a ^{12}C atom (the unified atomic mass unit, u).

A_r

相对原子质量
average mass
of an element's
atoms – weighted
over its isotopes

M_r

相对分子质量
sum of the A_r
values of every atom
in the molecule

formula mass

相对式量

the same idea for
an ionic compound

Chlorine is 75% ^{35}Cl and 25% ^{37}Cl

$$A_r = (75 \times 35 + 25 \times 37) / 100 = 35.5$$

Atoms, Molecules & Stoichiometry

└─ Masses and the mole

The mole

$$n = \frac{m}{M}$$

$$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$$

Worked example

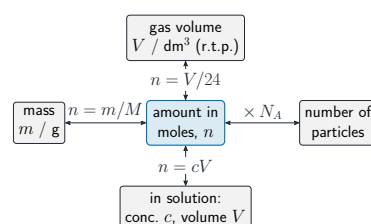
moles in 8.0 g of CH_4 ($M = 16$): $n = \frac{8.0}{16} = 0.50 \text{ mol}$

One **mole** 摩尔 contains N_A particles (atoms, molecules or ions); the **molar mass** 摩尔质量 M in g mol^{-1} equals A_r or M_r .

Atoms, Molecules & Stoichiometry

└─ Masses and the mole

The mole map



The mole is the hub of every amount calculation:

- mass: $n = m/M$
- particles: $\times N_A$
- gas: $n = V/24$
- solution: $n = cV$

2 Formulas and reacting masses

Atoms, Molecules & Stoichiometry
└ Formulas and reacting masses

Formulas and equations

empirical formula 实验式

simplest ratio – CH₃

molecular formula 分子式

actual atoms – C₂H₆

Equations are **balanced** 配平 with **state symbols** 状态符号 (s, l, g, aq). An **ionic equation** 离子方程式 drops **spectator ions** 旁观离子: Ag⁺(aq) + Cl⁻(aq) → AgCl(s).

Atoms, Molecules & Stoichiometry
└ Formulas and reacting masses

Reacting masses and yield

Worked example: 2Mg + O₂ → 2MgO

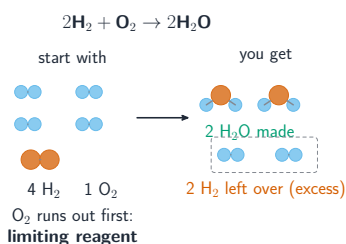
4.8 g Mg = 0.20 mol; ratio 1:1 ⇒ 0.20 mol MgO = 0.20 × 40 = 8.0 g

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

The numbers in a balanced equation give the mole ratio – the **stoichiometry** 化学计量.

Atoms, Molecules & Stoichiometry
└ Formulas and reacting masses

Limiting reagent



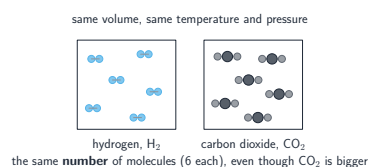
The **limiting reagent** 限量试剂 runs out first and decides how much product forms.

The leftover reagent is in **excess** 过量试剂. Always base the calculation on the limiting reagent.

3 Gases and solutions

Atoms, Molecules & Stoichiometry
└ Gases and solutions

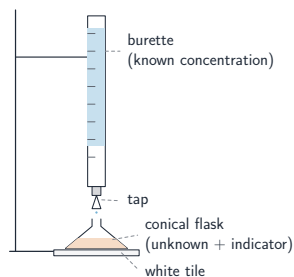
Gas volumes



Equal volumes of any gases (same temperature & pressure) hold equal numbers of molecules.

At r.t.p., one mole of any gas is 24.0 dm³, so $n = \frac{V}{24.0}$.

Titration



Concentration 浓度: $n = c \times V$ (in mol dm^{-3} , V in dm^3).

NaOH neutralised by HCl

20.0 cm^3 of 0.100 mol dm^{-3} HCl $\Rightarrow$
NaOH = 0.0800 mol dm^{-3}

A **titration** 滴定 finds an unknown concentration.

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Recap

Topic 2 – key takeaways

1 The mole

$$n = m/M_r; N_A = 6.02 \times 10^{23}$$

2 Formulas

empirical (ratio) vs molecular (actual)

3 Reacting masses

use the mole ratio; limiting reagent

4 Gases & solutions

$$n = V/24 \text{ at r.t.p.}; n = cV$$

Check yourself

- 1 How many moles in 16 g of CH_4 ?
- 2 Empirical formula of C_2H_6 ?
- 3 What volume does 1 mol of gas occupy at r.t.p.?
- 4 Which reagent decides how much product forms?



Answers 1. 1 mol 2. CH_3 3. 24.0 dm^3 4. the limiting reagent