Stoichiometry

IGCSE Chemistry ▪ Topic 3

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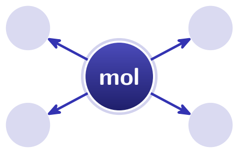
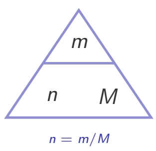


What we will cover

1. Formulae & equations
2. The mole & molar mass
3. Gas volumes & concentration
4. Reaction calculations
5. Limiting reactant & titration
6. Empirical formulae & percentages



the mole and molar mass

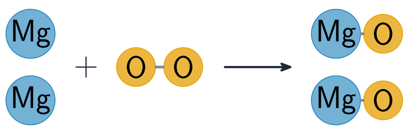
1 Formulae and equations

Chemical formulae

the charge numbers cross over to become the subscripts (then simplify if they share a factor)

- The **molecular formula** 分子式 is the actual number of each atom in one **molecule** 分子. For glucose it is $C_6H_{12}O_6$.
- The **empirical formula** 实验式 is the simplest whole-number **ratio** 比例 of the atoms or **ions** 离子 in a **compound** 化合物. For glucose it is CH_2O.

Writing and balancing equations



$$2Mg + O_2 \rightarrow 2MgO$$

2 Mg and 2 O on each side: balanced

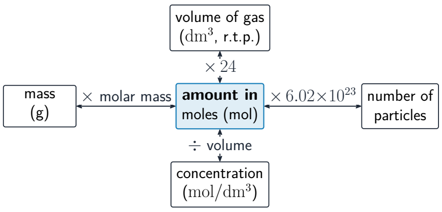
A **balanced** 配平 symbol equation has the same number of each atom on both sides.

$$2Mg + O_2 \rightarrow 2MgO$$

State symbols 状态符号: (*s*) (*l*) (*g*) (*aq*).

2 The mole

The mole and molar mass



One **mole** 摩尔 $= 6.02 \times 10^{23}$ particles (the **Avogadro constant** 阿伏伽德罗常数).

$$n = \frac{\text{mass}}{\text{molar mass}}$$

Example

36 g of water: $n = \frac{36}{18} = 2$ mol.

Gas volumes and concentration

At r.t.p. one mole of any gas fills $24\ \mathrm{dm}^3$.

$V = n \times 24$

Example

0.25 mol CO_2: $V = 0.25 \times 24 = 6\ \mathrm{dm}^3$.

$$\text{conc}\ (\mathrm{mol/dm}^3) = \frac{n}{V(\mathrm{dm}^3)}$$

Convert volume first: $1\ \mathrm{dm}^3 = 1000\ \mathrm{cm}^3$.

Reaction calculations

Three steps:

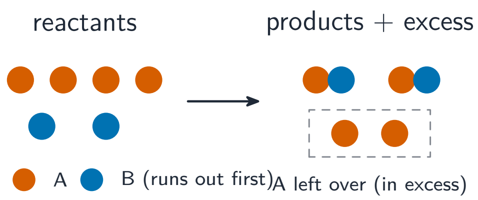
1. known mass → moles
2. use the equation ratio
3. moles → mass / volume

12 g Mg burns: mass of MgO?

$2Mg + O_2 \rightarrow 2MgO$
moles Mg $= 12/24 = 0.5$
ratio $1{:}1 \Rightarrow 0.5$ mol MgO
mass $= 0.5 \times 40 = \mathbf{20}$ g

3 Applications

Limiting reactant



The **limiting reactant** 限量反应物 runs out first and decides how much product forms. The other reactant is left over **in excess** 过量.

Titration

25.0 cm^3 NaOH neutralised by 20.0 cm^3 of 0.10 HCl

moles HCl $= 0.10 \times \dfrac{20.0}{1000} = 0.0020$

ratio $1{:}1 \Rightarrow 0.0020$ mol NaOH

conc $= \dfrac{0.0020}{25.0/1000} = \mathbf{0.08}$ mol/dm^3

Empirical formula and percentages

$$\% \text{ by mass} = \frac{\text{mass of element}}{M_r} \times 100$$

40% Ca, 12% C, 48% O

$\div A_r$: $1,\ 1,\ 3$
ratio $1{:}1{:}3 \Rightarrow \mathbf{CaCO_3}$

% N in NH_4NO_3

$\frac{28}{80} \times 100 = \mathbf{35}\%$

4 Recap

Topic 3 – key takeaways

1. **Mole**
   n = mass / molar mass; 6.02×10^{23}

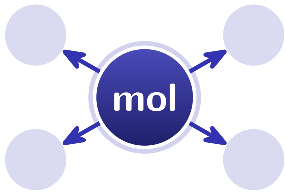
2. **Gas & conc**
   $24\ \text{dm}^3$ per mole; conc $= n/V$

3. **Calculations**
   to moles, use the ratio, back again

4. **Limiting**
   the reactant that runs out sets the yield

Check yourself

1. How many moles are in 18 g of water?
2. What volume does 1 mol of gas fill at r.t.p.?
3. What is a spectator ion?
4. How do you find an empirical formula from masses?



Answers **1.** 1 mol **2.** 24 dm^3 **3.** an ion unchanged on both sides **4.** divide each mass by A_r, then by the smallest