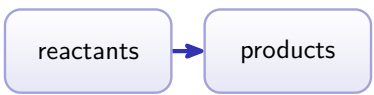
Chemical Reactions

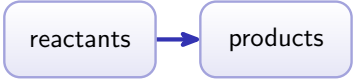
AP Chemistry ▪ Unit 4

AP Chemistry



What we will cover

1. Recognizing a chemical reaction
2. Net ionic equations
3. Stoichiometry
4. Titration
5. Types of reactions
6. Acid-base reactions
7. Oxidation-reduction



1 Recognizing

Recognizing a chemical reaction

A **chemical reaction** 化学反应 rearranges atoms: old **bonds** 化学键 break, new ones form – atoms are conserved.

> A **chemical change** 化学变化 makes new substances; a **physical change** 物理变化 only moves molecules apart.

Evidence of reaction: heat, light, gas, solid

Three ways to represent the same reaction

Symbolic	The balanced equation: formulas, coefficients, states. Compact, and the only level you can calculate with.
Particulate	A drawing of the atoms and molecules – how many of each particle before and after. AP asks you to draw and to read these.
Macroscopic	What you actually observe in the beaker: a colour change, a gas, a precipitate, a temperature change.

Moving between the levels – equation $\rightarrow$ particles $\rightarrow$ beaker – is a core AP skill; questions routinely give you one level and ask for another.

2 Net ionic

Net ionic equations

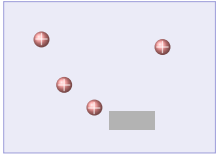
A **precipitation reaction** 沉淀反应 makes an insoluble solid. Strip out the **spectator ions** 旁观离子 that do not change:

Silver + chloride

molecular: $\mathrm{AgNO_3 + NaCl \rightarrow AgCl\downarrow + NaNO_3}$

$$\mathrm{Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)}$$

Use **solubility rules** 溶解度规则 to see which product is insoluble.



AgCl solid

3 Stoichiometry

Stoichiometry

Use the **mole ratio** 摩尔比 from the balanced equation: moles → ratio → moles.

Worked example

$8.0\,\mathrm{g\ H_2}$ burns ($2\mathrm{H_2} + \mathrm{O_2} \rightarrow 2\mathrm{H_2O}$):

$$n = \frac{8.0}{2.02} = 3.96\,\mathrm{mol} \Rightarrow 71\,\mathrm{g\ H_2O}$$

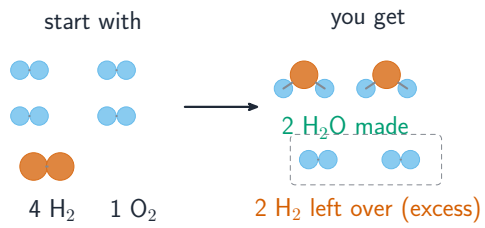
The **limiting reactant** 限量反应物 runs out first and caps the product.

Percent yield

$$\frac{\text{actual}}{\text{theoretical}} \times 100\%$$

The limiting reactant runs out first and caps the product

$$2\mathbf{H}_2 + \mathbf{O}_2 \rightarrow 2\mathbf{H}_2\mathbf{O}$$



The limiting reactant runs out first and decides how much product forms

4 Titration

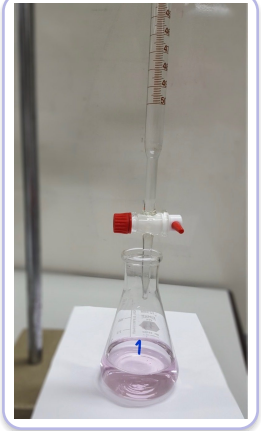
Titration

A **titration** 滴定 finds an unknown concentration. Add **standard solution** 标准溶液 until the reaction is just complete – the **equivalence point** 等当点 (an **indicator** 指示剂 shows it).

Worked example

$25\,\mathrm{mL}$ of $0.100\,M$ NaOH neutralizes $20\,\mathrm{mL}$ HCl:

$$n = 0.00250 \Rightarrow c_{\mathrm{HCl}} = 0.125\,M$$



Titration finds concentration by volume

5 Types

Types of chemical reactions

Knowing the family helps you predict the products:

Synthesis 化合: $\mathrm{A} + \mathrm{B} \rightarrow \mathrm{AB}$

Decomposition 分解: $\mathrm{AB} \rightarrow \mathrm{A} + \mathrm{B}$

Precipitation: an insoluble solid forms

Acid-base: transfers a **proton** 质子 H^+

Redox: transfers **electrons** 电子

6 Acid-base

Acid-base reactions

Bronsted-Lowry 布朗斯特-劳里: an **acid** 酸 donates a proton, a **base** 碱 accepts one.

$$\underset{\text{acid}}{\mathrm{HCl}} + \underset{\text{base}}{\mathrm{H_2O}} \rightarrow \underset{\text{conj. acid}}{\mathrm{H_3O^+}} + \underset{\text{conj. base}}{\mathrm{Cl^-}}$$

> **Conjugate pairs** 共轭酸碱对 differ by one $\mathrm{H^+}$.

- **strong** 强 – ionizes almost completely (HCl, NaOH)
- **weak** 弱 – ionizes only slightly (vinegar)

Acid + base → salt + water (**neutralization** 中和).

7 Redox

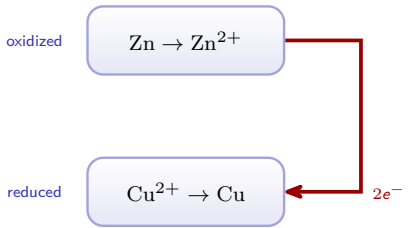
Oxidation-reduction

A **redox** 氧化还原反应 transfers electrons, tracked by **oxidation numbers** 氧化数:

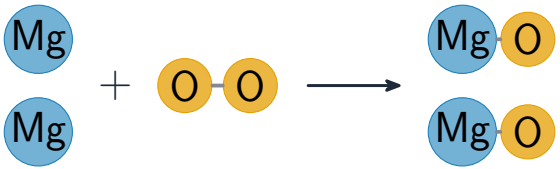
OIL RIG

Oxidation Is Loss, Reduction Is Gain

The **oxidizing agent** 氧化剂 is itself reduced; the **reducing agent** 还原剂 is oxidized.



Three Ways to Represent a Reaction

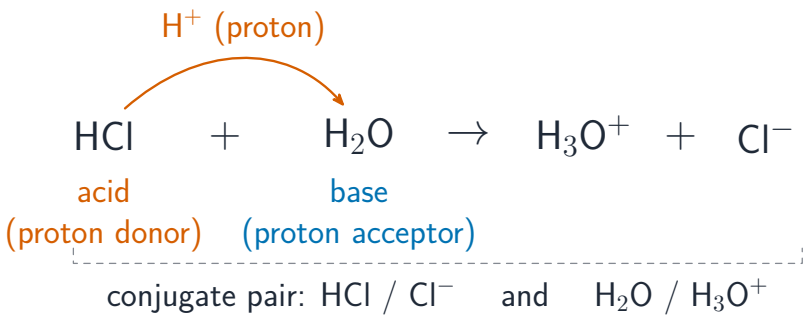


$$2\mathrm{Mg} + \mathrm{O_2} \rightarrow 2\mathrm{MgO}$$

2 Mg and 2 O on each side: balanced

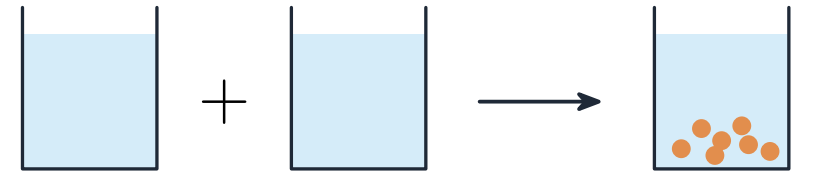
A balanced equation has the same number of each atom on both sides

Acid-Base Reactions, continued



Bronsted-Lowry: an acid donates a proton to a base, forming two conjugate pairs

Net Ionic Equations, continued



Mixing two solutions can form an insoluble precipitate

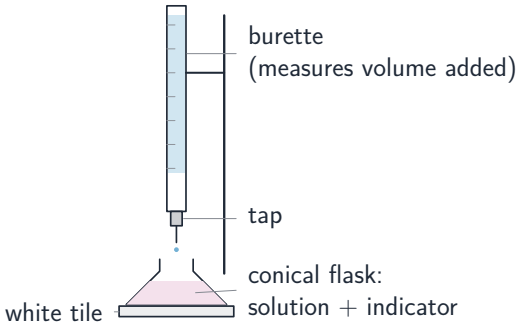
Oxidation-Reduction (Redox) Reactions

oxidation: loses $2e^-$
(oxidation number ↑)

reduction: gains $2e^-$
(oxidation number ↓)

Redox is electron transfer: the reducing agent is oxidised, the oxidising agent reduced

Introduction to Titration



Titration apparatus: a burette delivers a known solution into a conical flask

Exam tips

- Balance every equation and work in **moles** – convert grams→moles, cross the mole ratio, then convert back.
- Find the **limiting reactant** by comparing mole ratios; it sets the maximum product (theoretical yield).
- In redox, remember **OIL RIG**: oxidation is loss of electrons, reduction is gain; every oxidation is paired with a reduction.
- For titrations use the balanced ratio to link the known and unknown at the **equivalence point**.
- A **net ionic equation** shows only the species that change; leave out spectator ions.

8 Recap

Unit 4 – key takeaways

1 Net ionic

drop spectator ions; keep only what changes

2 Stoichiometry

mole ratio; limiting reactant caps the yield

3 Acid-base

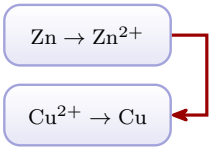
Bronsted-Lowry proton transfer; conjugate pairs

4 Redox

OIL RIG electron transfer; oxidation numbers change

Check yourself

1. What are the ions removed from a net ionic equation called?
2. Which reactant caps how much product can form?
3. In Bronsted-Lowry terms, what does an acid do?
4. $Zn \rightarrow Zn^{2+}$: is zinc oxidized or reduced?



Answers **1.** spectator ions **2.** the limiting reactant **3.** donates a proton **4.** oxidized