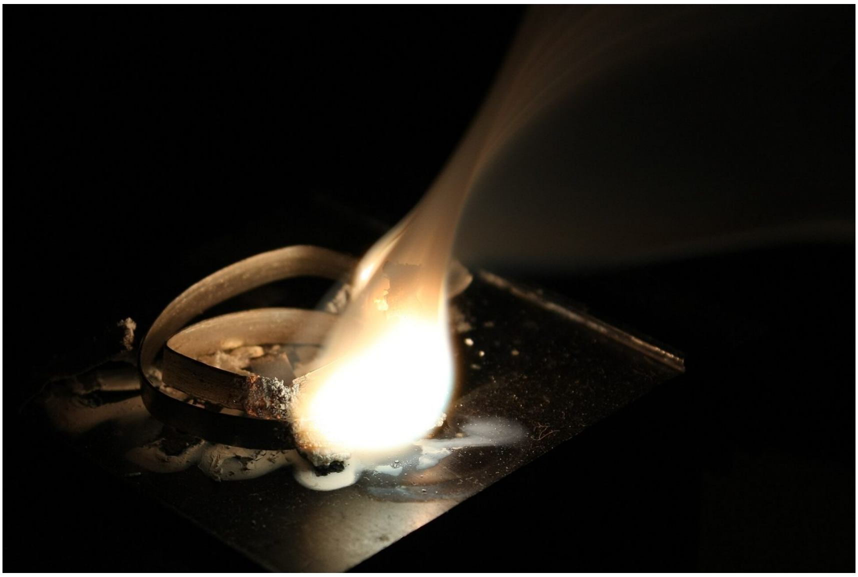
Chemical Reactions

AP Chemistry

Recognizing a Chemical Reaction

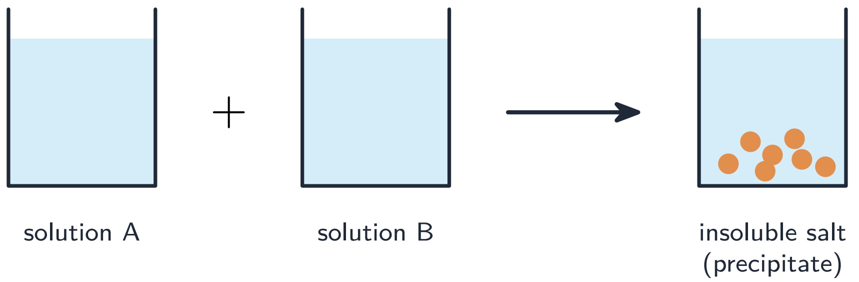


Magnesium burning: a chemical reaction rearranges atoms and releases energy as light and heat

A **chemical reaction** 化学反应 rearranges atoms into new substances. Signs one has happened: a color change, a gas or **precipitate** 沉淀 forming, or a temperature change. Atoms are conserved, so an equation must be **balanced** – the same count of each element on both sides.

Net Ionic Equations

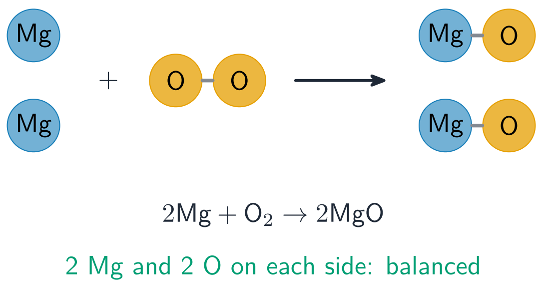
For reactions in water, ionic compounds split into ions. A **net ionic equation** 净离子方程式 shows only the species that actually change, leaving out the **spectator ions** 旁观离子 that appear unchanged on both sides. It captures the real chemistry (e.g. $Ag^+ + Cl^- \to AgCl(s)$).



Mixing two solutions can form an insoluble precipitate

Three Ways to Represent a Reaction

The same reaction can be shown as a **symbolic** equation, a **particulate** drawing (atoms and molecules), and a **macroscopic** observation (what you see). Moving between these levels – connecting the equation to the particles to the beaker – is a core skill.



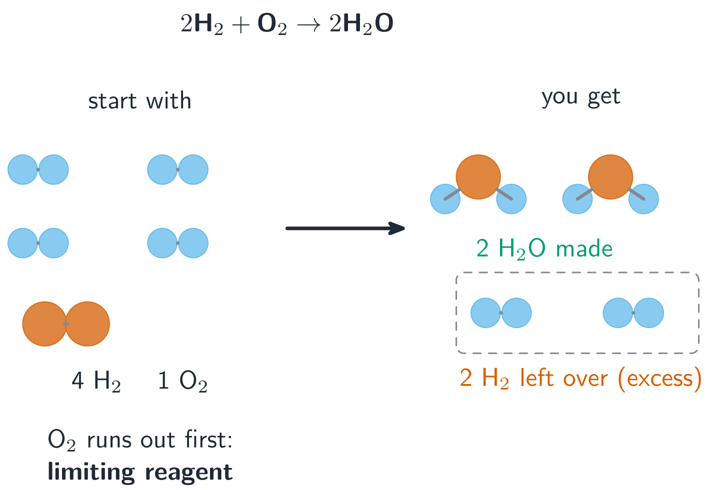
A balanced equation has the same number of each atom on both sides

Physical Changes versus Chemical Changes

A **physical change** 物理变化 alters form but not identity (melting, dissolving); a **chemical change** 化学变化 makes new substances by breaking and forming bonds. Dissolving salt is physical; the salt is unchanged and recoverable.

Stoichiometry

Stoichiometry 化学计量 uses the balanced equation's mole ratios to relate amounts of reactants and products. The path is always grams → moles → (mole ratio) → moles → grams. The **limiting reactant** 限量反应物 runs out first and sets the maximum product (the **theoretical yield** 理论产量); the **percent yield** compares actual to theoretical.



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

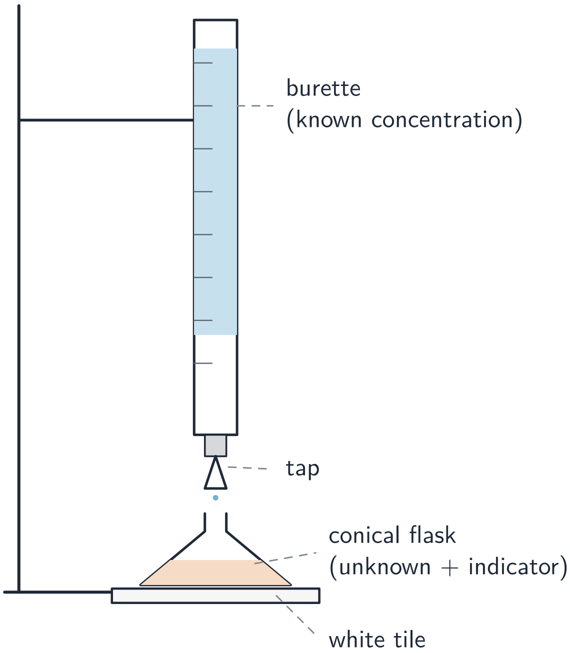
Worked example. How much water forms when 4.0 g of hydrogen burns in excess oxygen? $2H_2 + O_2 \rightarrow 2H_2O$. Convert to moles, cross the mole ratio ($2 : 2 = 1 : 1$ here), convert back:

$$n(\mathrm{H_2}) = \frac{4.0}{2.0} = 2.0 \text{ mol} \;\Rightarrow\; n(\mathrm{H_2O}) = 2.0 \text{ mol} \;\Rightarrow\; m = 2.0 \times 18 = 36 \text{ g}.$$

Worked example (limiting reactant). 10.0 g of N_2 reacts with 5.0 g of H_2 ($N_2 + 3H_2 \rightarrow 2NH_3$). Which runs out? Moles: $n(\mathrm{N_2}) = 10.0/28 = 0.36$, $n(\mathrm{H_2}) = 5.0/2 = 2.5$. The reaction needs 3 H_2 per N_2; you have $2.5/0.36 = 7.0$, far more than 3, so **N_2 is limiting**. It makes $2 \times 0.36 = 0.72$ mol of ammonia, with hydrogen left over.

Introduction to Titration

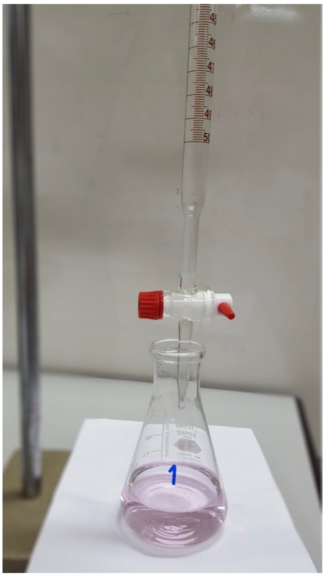
A **titration** 滴定 finds an unknown concentration by reacting it with a solution of known concentration until they reach the **equivalence point** 等当点 (stoichiometrically equal). From the known volume and concentration, use the mole ratio to find the unknown. An **indicator** or a pH curve signals the endpoint.



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

Worked example. 25.0 mL of hydrochloric acid is exactly neutralized by 30.0 mL of 0.100 M NaOH. Find the acid's concentration. The reaction is 1 : 1, so the moles match:

$$n(\mathrm{NaOH}) = 0.0300 \times 0.100 = 3.00 \times 10^{-3}\ \mathrm{mol} = n(\mathrm{HCl}), \qquad [\mathrm{HCl}] = \frac{3.00 \times 10^{-3}}{0.0250} = 0.120\ \mathrm{M}.$$



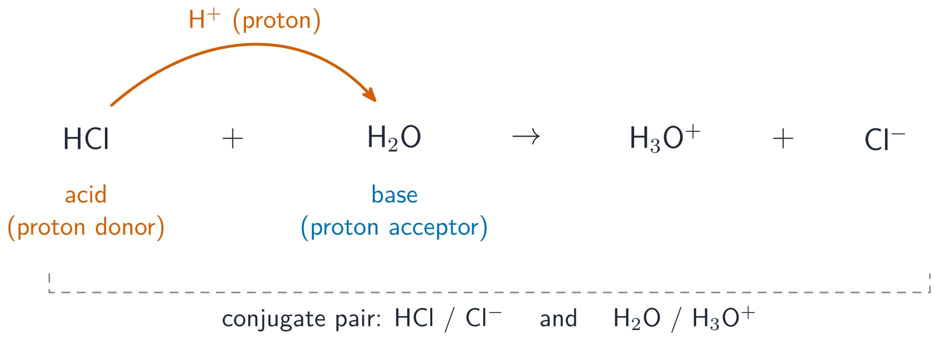
A titration setup: reacting volumes from a burette find the concentration of an unknown solution

Types of Chemical Reactions

Common patterns include **synthesis** (combining), **decomposition** (breaking apart), **combustion** (with oxygen, releasing energy), **precipitation** (forming an insoluble solid), **acid–base** (proton transfer), and **redox** (electron transfer). Recognizing the type helps predict the products.

Acid-Base Reactions

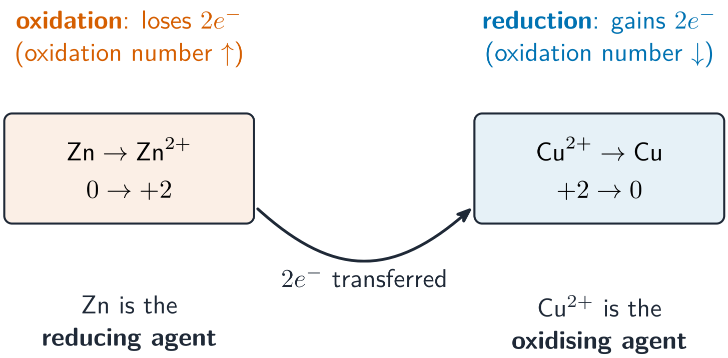
An **acid** 酸 donates a proton (H^+); a **base** 碱 accepts one (Brønsted–Lowry). They react to form water and a salt: $H^+ + OH^- \rightarrow H_2O$. Strong acids and bases dissociate completely; weak ones only partly.



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

Oxidation-Reduction (Redox) Reactions

In a **redox** 氧化还原 reaction, electrons transfer between species. **Oxidation** 氧化 is loss of electrons (oxidation number rises); **reduction** 还原 is gain (oxidation number falls). Track changes with **oxidation numbers**, and remember every oxidation is paired with a reduction – the electrons lost equal the electrons gained.



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

Worked example. Find the oxidation number of manganese in permanganate, $KMnO_4$. Potassium is $+1$ and each oxygen is -2 (four of them, -8). The whole formula is neutral, so $(+1) + \text{Mn} + (-8) = 0$, giving $\text{Mn} = +7$ – its maximum, which is why permanganate is a powerful oxidizing agent (it can only gain electrons).

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.