

Chemical Reactions

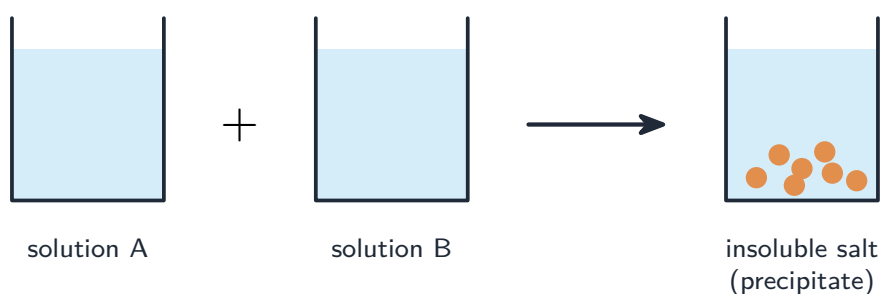
AP Chemistry

Recognizing a Chemical Reaction

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

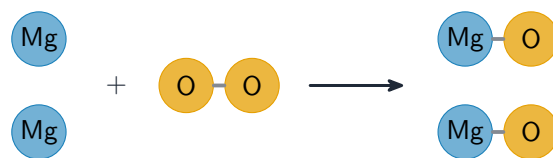
For reactions in water, ionic compounds split into ions. A **net ionic equation** 净离子方程式 shows only the species that actually change, leaving out the **spectator ions** 旁观离子 that appear unchanged on both sides. It captures the real chemistry (e.g. $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}(s)$).



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.



2 Mg and 2 O on each side: balanced

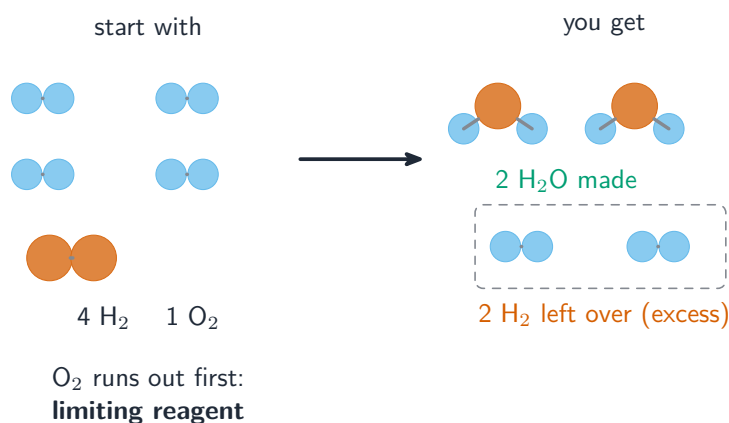
A balanced equation has the same number of each atom on both sides

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 \rightarrow moles \rightarrow (mole ratio) \rightarrow moles \rightarrow 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

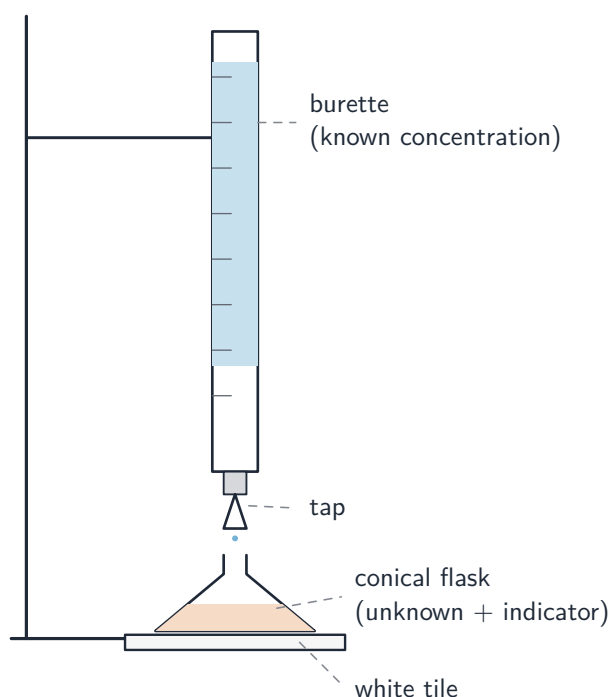
Worked example. How much water forms when 4.0 g of hydrogen burns in excess oxygen? $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$. Convert to moles, cross the mole ratio ($2 : 2 = 1 : 1$ here), convert back:

$$n(\text{H}_2) = \frac{4.0}{2.0} = 2.0 \text{ mol} \Rightarrow n(\text{H}_2\text{O}) = 2.0 \text{ mol} \Rightarrow m = 2.0 \times 18 = 36 \text{ g}.$$

Worked example (limiting reactant). 10.0 g of N_2 reacts with 5.0 g of H_2 ($\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$). Which runs out? Moles: $n(\text{N}_2) = 10.0/28 = 0.36$, $n(\text{H}_2) = 5.0/2 = 2.5$. 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:

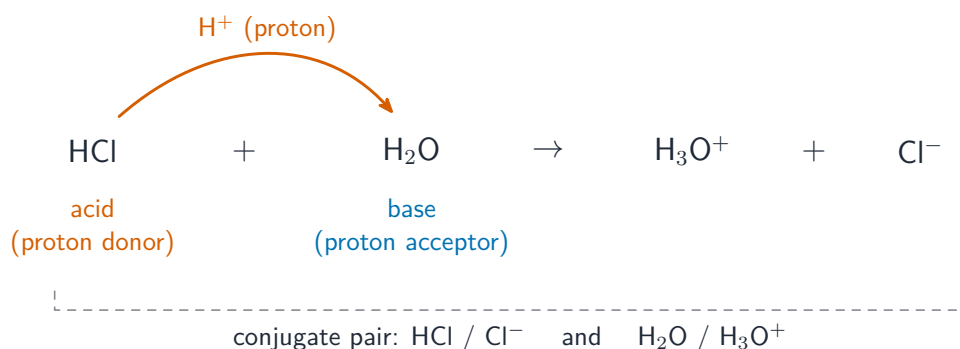
$$n(\text{NaOH}) = 0.0300 \times 0.100 = 3.00 \times 10^{-3} \text{ mol} = n(\text{HCl}), \quad [\text{HCl}] = \frac{3.00 \times 10^{-3}}{0.0250} = 0.120 \text{ M.}$$

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

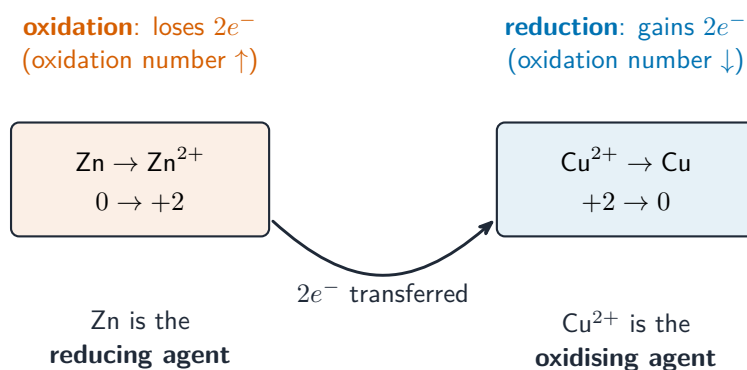
An **acid** 酸 donates a proton (H^+); a **base** 碱 accepts one (Brønsted–Lowry). They react to form water and a salt: $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$. Strong acids and bases dissociate completely; weak ones only partly.



Brønsted–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.