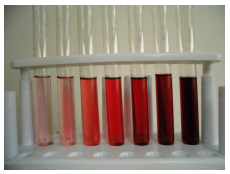
Equilibria

A-Level Chemistry ▪ Topic 7

A-Level Chemistry

What we will cover

1. Dynamic equilibrium
2. Le Chatelier's principle
3. Equilibrium constants
4. Haber & Contact
5. Brønsted–Lowry acids
6. Strong



a shifting equilibrium

1 Equilibrium

Dynamic equilibrium

A **dynamic equilibrium** 动态平衡 is a closed system where the forward and reverse rates are equal. Concentrations stay constant, but both reactions still run.

reactants ⇌ products

It is dynamic: molecules keep reacting. It is equilibrium: nothing measurable changes.

Le Chatelier's principle

the equilibrium shifts to *oppose* the change you make

- increase [reactant] → towards the **products**
- increase pressure → to the **fewer-gas-molecules** side
- increase temperature → in the **endothermic** direction

a **catalyst** speeds both directions equally, so it gives *no shift*

Le Chatelier's principle 勒夏特列原理: the equilibrium shifts to oppose a change.

- more reactant → towards products
- more pressure → fewer-gas side
- more heat → endothermic way
- a **catalyst** 催化剂 → no shift

Equilibrium constants

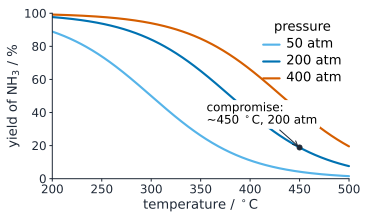
$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$H_2 + I_2 \rightleftharpoons 2HI$

$K_c = \frac{1.6^2}{0.20 \times 0.20} = 64$ (no units here)

Only temperature changes K_c or K_p. For gases use **partial pressure** 分压 = **mole fraction** 摩尔分数 × total pressure.

The Haber and Contact processes



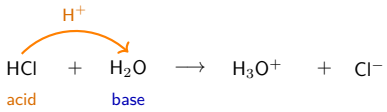
Conditions balance yield, rate & cost:

- **Haber** 哈伯法:
  $N_2 + 3H_2 \rightleftharpoons 2NH_3$ –
  $\sim 450\,°C$, 200 atm, Fe
- **Contact** 接触法:
  $2SO_2 + O_2 \rightleftharpoons 2SO_3$ – V_2O_5

Low temperature gives more yield but too slowly.

2 Acids and bases

Brønsted–Lowry acids and bases

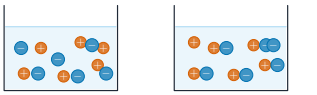


conjugate acid–base pairs:
HCl / Cl^- and H_2O / H_3O^+

- an **acid** 酸 is a **proton donor** 质子供体
- a **base** 碱 is a **proton acceptor** 质子受体

The reaction makes two **conjugate** 共轭 acid–base pairs.

Strong and weak acids



strong acid
fully dissociated: many ions

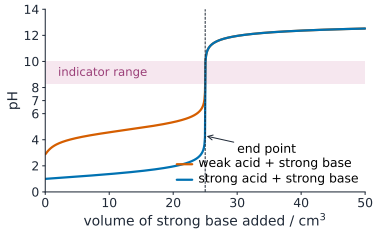
weak acid
mostly molecules: few ions

This is about ionisation, not concentration:

- **strong acid** 强酸 – fully **dissociated** 解离
- **weak acid** 弱酸 – only partly dissociated

A strong acid has a lower **pH** pH & conducts better.

Titration curves



Neutralisation 中和: $H^+ + OH^- \rightarrow H_2O$, forming a **salt** 盐.

> A **titration curve** 滴定曲线 has a steep pH jump at the end point – pick an **indicator** 指示剂 that changes colour inside it.

3 Recap

Topic 7 – key takeaways

1. **Equilibrium**
   equal forward & reverse rates
2. **Le Chatelier**
   the equilibrium opposes any change
3. K_c
   products over reactants; only T changes it
4. **Acids**
   donate protons; strong = fully dissociated

Check yourself

1. At equilibrium, how do the forward & reverse rates compare?
2. Raising pressure shifts to which side?
3. What only changes the value of K_c?
4. A proton donor is an acid or a base?

Answers **1.** they are equal **2.** the side with fewer gas molecules **3.** temperature **4.** an acid