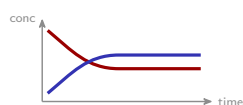


Equilibrium

AP Chemistry • Unit 7

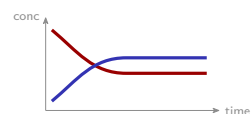
AP Chemistry



Equilibrium

What we will cover

- 1 Dynamic equilibrium
- 2 The reaction quotient and K
- 3 ICE tables
- 4 Magnitude and properties of K
- 5 Le Chatelier's principle
- 6 Solubility equilibria



1

Dynamic

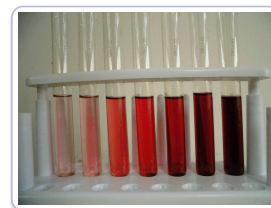
Equilibrium

Dynamic

Dynamic equilibrium

Chemical equilibrium 化学平衡 is **dynamic** 动态的: the forward and reverse reactions run at the **same rate**, so concentrations stay constant (not zero).

Reached from **either side** – all reactant or all product gives the same mixture.



Dynamic equilibrium: forward and reverse still run

2

Q and K

Equilibrium

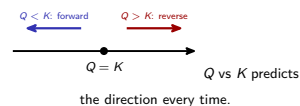
Q and K

The reaction quotient and K

Equilibrium constant

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

Reaction quotient 反应商 Q has the same form at any moment. Leave out pure solids and liquids.



3 ICE

Equilibrium
↳ ICE

ICE tables

Organise the work in an **ICE table** ICE 表:
Initial, Change ($\pm x$ by coefficient),
Equilibrium.

Then substitute into K

When K is tiny, assume $x \ll$ initial (avoid the quadratic) – and check.

	HA	H ⁺	A ⁻
I	0.10	0	0
C	-x	+x	+x
E	0.10-x	x	x

$$K = \frac{x^2}{0.10 - x} \approx \frac{x^2}{0.10}$$

4 Magnitude

Equilibrium
↳ Magnitude

Magnitude and properties of K

The **size** of K shows where the balance sits:

- $K \gg 1$ – product-favored
- $K \ll 1$ – reactant-favored
- $K \approx 1$ – comparable amounts

Manipulating K

- reverse: $K \rightarrow 1/K$
- scale by n : $K \rightarrow K^n$
- add reactions: $K \rightarrow K_1 K_2$

5 Le Chatelier

Equilibrium
↳ Le Chatelier

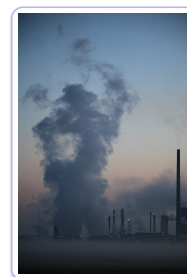
Le Chatelier's principle

Le Chatelier 勒夏特列原理: a disturbed system shifts to **partly undo** the change.

add a substance $\Rightarrow$ shift away from it

raise pressure $\Rightarrow$ toward fewer gas moles

add heat $\Rightarrow$ shift as if heat were added



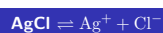
Industry
shifts equilibrium with Le Chatelier

6 Solubility

Equilibrium
↳ Solubility

Solubility equilibria

A sparingly soluble salt has a **solubility product** 溶度积 K_{sp} (solid left out):



$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = s^2$$

$$s = \sqrt{1.8 \times 10^{-10}} = 1.3 \times 10^{-5} \text{ M.}$$

Common-ion effect 同离子效应:
adding a shared ion shifts dissolving **backward** – less dissolves (K_{sp} unchanged).

In 0.10 M NaCl, AgCl solubility drops to 1.8×10^{-9} M.

7 Recap

Equilibrium
↳ Recap

Unit 7 – key takeaways

1 Equilibrium

dynamic; equal forward and reverse rates

2 Q vs K

$Q < K$ forward, $Q > K$ reverse;
ICE table for K

3 Le Chatelier

shift to undo a stress; only T changes K

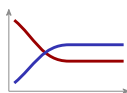
4 Solubility

K_{sp} ; common ion suppresses dissolving

Equilibrium
↳ Recap

Check yourself

- 1 At equilibrium, how do the forward and reverse rates compare?
- 2 If $Q < K$, which way does the reaction run?
- 3 Which stress actually changes the value of K ?
- 4 Does adding a common ion raise or lower solubility?



Answers 1. they are equal 2. forward 3. temperature 4. lower