

Equilibria

A-Level Chemistry • Topic 25

A-Level Chemistry



Equilibria

What we will cover

- 1 Conjugate acids & bases
- 2 pH & the constants
- 3 Calculating pH
- 4 Buffer solutions
- 5 Solubility & partition



pH paper estimates acidity

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Acids and pH

Equilibria
↳ Acids and pH

Conjugate acids and bases

An acid loses H^+ to give its **conjugate base** 共轭碱; a base gains H^+ to give its **conjugate acid** 共轭酸.

A **conjugate pair** 共轭酸碱对 differs by just one H^+ – e.g. CH_3COOH and CH_3COO^- .

conjugate pair: differ by one H^+



Equilibria
↳ Acids and pH

pH and the constants

$$pH = -\log[H^+]$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$K_w = [H^+][OH^-]$$

A larger K_a 酸解离常数 (smaller pK_a) is a stronger acid; $K_w = 1.0 \times 10^{-14}$ at 298 K.

Equilibria
↳ Acids and pH

Calculating pH

strong acid – $[H^+] = \text{conc.}$; HCl 0.050 $\Rightarrow$ $pH = 1.30$

strong base – $[H^+] = K_w/[OH^-]$; $NaOH$ 0.10 $\Rightarrow$ $pH = 13.0$

weak acid – $[H^+] = \sqrt{K_a[HA]}$; ethanoic 0.10 $\Rightarrow$ $pH = 2.87$

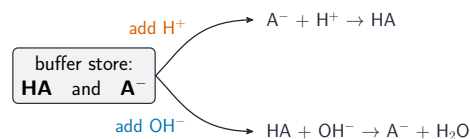
2 Buffers and solubility

Equilibria
└ Buffers and solubility

Buffer solutions

A **buffer** 缓冲溶液 (a weak acid + its conjugate base) resists pH change:

- added H^+ removed by A^-
 - added OH^- removed by HA
- HCO_3^- keeps blood near pH 7.4.



either way, the pH barely changes

Equilibria
└ Buffers and solubility

Solubility product

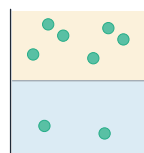


The **solubility product** 溶度积 $K_{sp} = [\text{Ag}^+][\text{Cl}^-]$ (each ion to the power of its number).

The **common ion effect** 同离子效应: a salt is **less** soluble in a solution already containing one of its ions (Le Chatelier).

Equilibria
└ Buffers and solubility

Partition coefficients



$$K_{pc} = \frac{[\text{solute in 1}]}{[\text{solute in 2}]}$$

solvent 1 (non-polar)
solvent 2 (water)

The **partition coefficient** 分配系数 is the ratio of a solute's concentrations in two immiscible solvents.

$$K_{pc} = \frac{[\text{solute in 1}]}{[\text{solute in 2}]}$$

It depends on the **polarity** 极性 of the solute & solvents.

3 Recap

Equilibria
└ Recap

Worked example – pH of a strong acid

Find the pH of $0.050 \text{ mol dm}^{-3}$ hydrochloric acid.

- HCl is a **strong** acid: it dissociates completely.
- So $[\text{H}^+] = 0.050 \text{ mol dm}^{-3}$ – the concentration itself.
- $\text{pH} = -\log_{10}[\text{H}^+] = -\log_{10}(0.050)$
- = 1.30.

Strong acid: $[\text{H}^+]$ is the concentration.
Weak acid: you must go through K_a – never assume full dissociation.

Topic 25 – key takeaways

1 Conjugate pairsdiffer by one H^+ **3 Buffers**

weak acid + its salt resist pH change

2 pH $-\log[\text{H}^+]$; K_a , K_w for weak/strong**4 Solubility** K_{sp} ; the common ion effect

Check yourself

- 1 Write the pH formula.
- 2 What does a buffer resist?
- 3 What two things make a buffer?
- 4 What does the common ion effect do to solubility?

Answers 1. $\text{pH} = -\log[\text{H}^+]$ 2. a change in pH 3. a weak acid & its conjugate base
4. lowers it