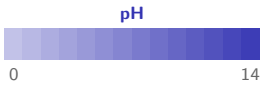
Equilibria

A-Level Chemistry ▪ Topic 25

A-Level Chemistry



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

1 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^+

$$\underset{\text{acid}}{CH_3COOH} \rightleftharpoons \underset{\text{conjugate base}}{CH_3COO^-} + H^+$$

pH and the constants

$$pH = -\log[H^+] \qquad K_a = \frac{[H^+][A^-]}{[HA]} \qquad K_w = [H^+][OH^-]$$

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.

Calculating pH

strong acid – $[H^+]$ = 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 $= 2.87$

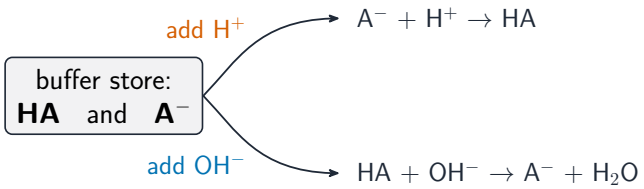
2 Buffers and solubility

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.



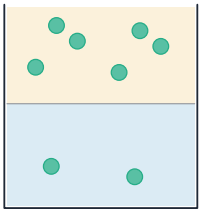
either way, the pH barely changes

Solubility product

The **solubility product** 溶度积 $K_{sp} = [Ag^+][Cl^-]$ (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).

Partition coefficients



solvent 1 (non-polar)

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

solvent 2 (water)

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

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

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

3 Recap

Worked example – pH of a strong acid

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

- HCl is a strong acid: it dissociates completely.
- So $[\text{H}^+] = 0.050\,\text{mol}\,\text{dm}^{-3}$ – 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 pairs

differ by one H^+

2 pH

$-\log[H^+]$; K_a, K_w for weak/strong

3 Buffers

weak acid + its salt resist pH change

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