

25.1 Acids and bases

Name: _____ Class: _____ Date: _____

Total: 13 marks

KEY WORDS buffer solution 缓冲溶液 • conjugate acid 共轭酸 • solubility product 溶度积
• conjugate base 共轭碱 • conjugate acid–base pair 共轭酸碱对

Objective

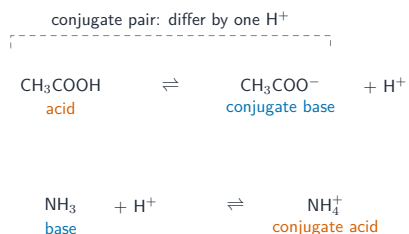
Build the skills to answer exam questions on **acids and bases** — **conjugate pairs** 共轭对, **pH**, K_a , K_w , **buffers** 缓冲液 and **solubility product** 溶度积 (K_{sp}).

You must be able to:

- identify conjugate acid–base pairs and use pH, K_a , pK_a , K_w
- calculate pH for strong acids, strong alkalis, weak acids and buffers
- define a buffer, explain its action, and use K_{sp}

1 Worked examples

■ Conjugate pairs and key relationships

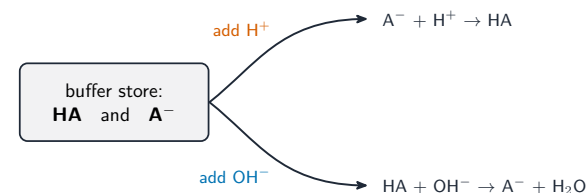


A conjugate pair differs by one H^+

$$pH = -\log[H^+]; K_a = \frac{[H^+][A^-]}{[HA]}; K_w = [H^+][OH^-] = 1.0 \times 10^{-14}.$$

- **strong acid:** $[H^+] =$ the acid concentration.
- **strong alkali:** $[H^+] = K_w/[OH^-]$.
- **weak acid:** $[H^+] = \sqrt{K_a \times [HA]}$.

■ Buffers



either way, the pH barely changes

$$A \text{ buffer (a weak acid + its salt) resists pH change: } [H^+] = K_a \frac{[HA]}{[A^-]}$$

Added H^+ reacts with A^- ; added OH^- reacts with HA . In blood, HCO_3^- buffers the pH. K_{sp} = the product of the ion concentrations of a saturated solution of a sparingly soluble salt.

2 Practice

2.1 Write the conjugate base of HNO_3 . [1]

2.2 Calculate the pH of $0.010 \text{ mol dm}^{-3}$ hydrochloric acid (a strong acid). [1]

3 Exam-style questions

3.1 A buffer solution can be made from: [1]

- **A** a strong acid and a strong base
- **B** a weak acid and its sodium salt
- **C** water only
- **D** two strong acids

3.2 The pH of 0.10 mol dm^{-3} NaOH (a strong base) is ($K_w = 1.0 \times 10^{-14}$): [1]

- A 1
- B 7
- C 13
- D 14

3.3 A weak acid HA has $K_a = 1.8 \times 10^{-5} \text{ mol dm}^{-3}$.

(a) Calculate the pH of a 0.10 mol dm^{-3} solution of HA. [3]

(b) Explain why this pH is higher than that of 0.10 mol dm^{-3} HCl. [2]

3.4 A buffer contains 0.20 mol dm^{-3} ethanoic acid and 0.20 mol dm^{-3} sodium ethanoate ($K_a = 1.8 \times 10^{-5}$).

(a) Calculate its pH. [2]

(b) Explain, with an equation, how the buffer resists a small addition of acid. [2]

Solutions

2.1 NO_3^- .

2.2 $\text{pH} = -\log(0.010) = 2.0$.

3.1 B. A weak acid and its salt make a buffer.

3.2 C. $[\text{H}^+] = 10^{-14}/0.10 = 10^{-13}$, so $\text{pH} = 13$.

3.3 (a) $[\text{H}^+] = \sqrt{K_a[\text{HA}]} = \sqrt{1.8 \times 10^{-5} \times 0.10} = \sqrt{1.8 \times 10^{-6}} = 1.34 \times 10^{-3}$; $\text{pH} = -\log(1.34 \times 10^{-3}) = 2.87$.

(b) HA is only partly dissociated, so $[\text{H}^+]$ is lower than for fully-dissociated HCl, giving a higher pH.

3.4 (a) $[\text{H}^+] = K_a \frac{[\text{HA}]}{[\text{A}^-]} = 1.8 \times 10^{-5} \times \frac{0.20}{0.20} = 1.8 \times 10^{-5}$; $\text{pH} = 4.74$.

(b) added H^+ reacts with the ethanoate ion: $\text{CH}_3\text{COO}^- + \text{H}^+ \rightarrow \text{CH}_3\text{COOH}$, removing most of the added H^+ so the pH barely changes.