A-LEVEL CHEMISTRY • EXERCISE SHEET

25.1 Acids and bases

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

Objective

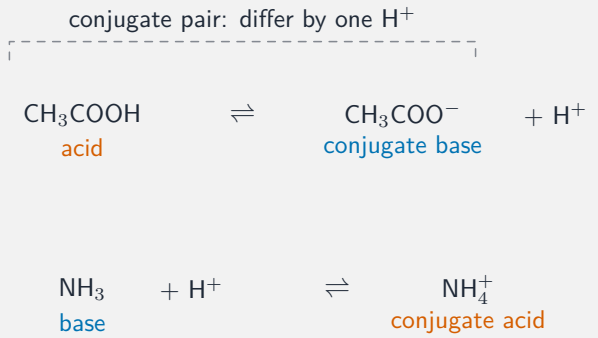
Build the skills to answer exam questions on **acids and bases** —**conjugate pairs** 共轭对, **pH**, K_a, K_w, **buffers** 缓冲液 and **solubility product** 溶度积 (K_{sp}).

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

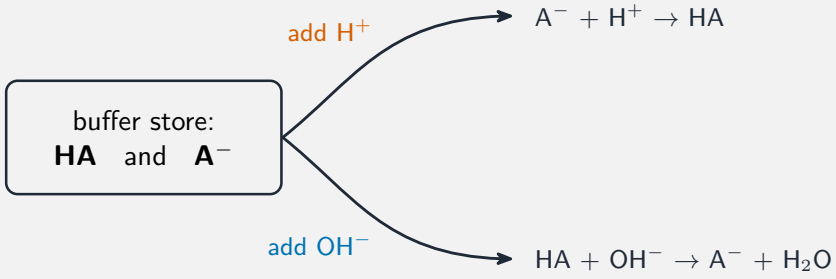


A conjugate pair differs by one H

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

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

■



either way, the pH barely changes

A 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. $K_{\mathbf{sp}}$ = 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 . [1]

2.2 Calculate the pH of 0.010 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 $K_a = 1.8 \times 10^{-5}$ 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]

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4 Go further

You are now ready for the real exam questions on this subtopic. Open the **25.1 Acids and bases** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/42 N25 —Q3 (acids and bases)
- 9701/51 N25 —Q1 (acids and bases)

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

3.3 (a) $[H^+] = \sqrt{K_a[HA]} = \sqrt{1.8 \times 10^{-5} \times 0.10} = \sqrt{1.8 \times 10^{-6}} = 1.34 \times 10^{-3}$; $\text{pH} = -\log(1.34 \times 10^{-3}) = 2.87$.
(b) HA is only partly dissociated, so $[H^+]$ is lower than for fully-dissociated HCl, giving a higher pH.

3.4 (a) $[H^+] = K_a \dfrac{[HA]}{[A^-]} = 1.8 \times 10^{-5} \times \dfrac{0.20}{0.20} = 1.8 \times 10^{-5}$; pH = 4.74.
(b) added H reacts with the ethanoate ion: $CH_3COO^- + H^+ \rightarrow CH_3COOH$, removing most of the added H so the pH barely changes.