

Exercise walk-through

Acids and bases ■ 25.1

eXercise

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}

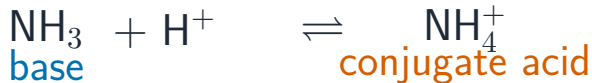
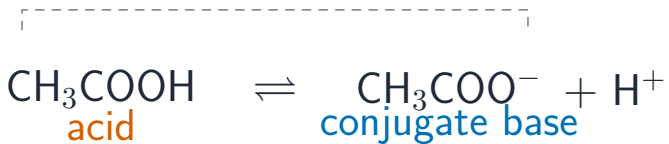
Method — Conjugate pairs and key relationships

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

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

Method — Conjugate pairs and key relationships

conjugate pair: differ by one H^+

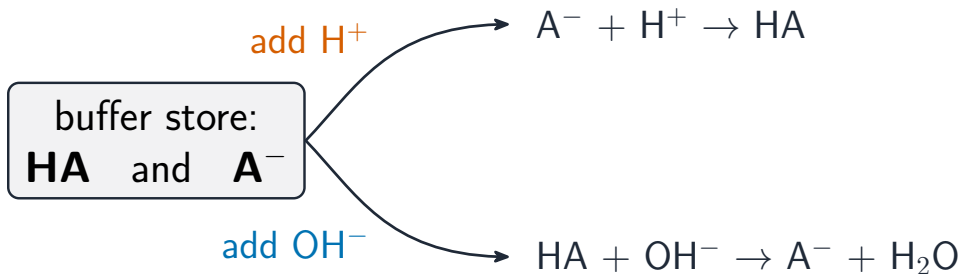


Ethanoic acid losing H to its conjugate base; ammonia gaining H to its conjugate acid

Method — Buffers

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.

Method — Buffers



either way, the pH barely changes

A buffer resisting pH change: added acid removed by A⁻, added alkali removed by HA

Practice 2.1 ■ 1 mark

Write the conjugate base of HNO_2 .

Solution 2.1

Method: Conjugate pairs and key relationships

Worked steps

NO_3^- **B1**.

Practice 2.2 ■ 1 mark

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

Solution 2.2

Method: Conjugate pairs and key relationships

Worked steps

$$\text{pH} = -\log(0.010) = 2.0 \quad \text{B1}.$$

Exam-style 3.1 ■ 1 mark

A buffer solution can be made from:

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

Solution 3.1

Method: Buffers

A a strong acid and a strong base

B a weak acid and its sodium salt



C water only

D two strong acids

Worked steps

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

Exam-style 3.2 ■ 1 mark

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

A 1

B 7

C 13

D 14

Solution 3.2

Method: Conjugate pairs and key relationships

A 1

B 7

C 13



D 14

Worked steps

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

Exam-style 3.3 ■ 3 marks

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

Solution 3.3

Worked steps

(a) $[\text{H}^+] = \sqrt{K_a[\text{HA}]} = \sqrt{1.8 \times 10^{-5} \times 0.10}$ **M1** $= \sqrt{1.8 \times 10^{-6}} = 1.34 \times 10^{-3}$ **M1**; $\text{pH} = -\log(1.34 \times 10^{-3}) = 2.87$ **A1**.

(b) HA is only partly dissociated, so $[\text{H}^+]$ is lower than for fully-dissociated HCl **M1**, giving a higher pH **A1**.

Exam-style 3.4 ■ 2 marks

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

Solution 3.4

Worked steps

(a) $[\text{H}^+] = K_a \frac{[\text{HA}]}{[\text{A}^-]} = 1.8 \times 10^{-5} \times \frac{0.20}{0.20} = 1.8 \times 10^{-5}$ **M1**; $\text{pH} = 4.74$ **A1**.

(b) added H reacts with the ethanoate ion: $\text{CH}_3\text{COO}^- + \text{H}^+ \rightarrow \text{CH}_3\text{COOH}$ **M1**, removing most of the added H so the pH barely changes **A1**.