Exercise walk-through

Henderson-Hasselbalch Equation ▪ 8.9

eXercise

You must be able to

- use $\mathrm{pH} = \mathrm{p}K_a + \log \dfrac{[\mathrm{A}^-]}{[\mathrm{HA}]}$
- find a buffer's pH from the ratio
- find the ratio needed for a target pH

Method — The equation

$$\mathrm{pH} = \mathrm{p}K_a + \log \frac{[\mathrm{A}^-]}{[\mathrm{HA}]}.$$

It gives a buffer's pH from the base-to-acid ratio.

Method — Equal amounts

When $[\mathrm{A}^-] = [\mathrm{HA}]$, the log term is $\log 1 = 0$, so $\mathrm{pH} = \mathrm{p}K_a$.

Method — A worked pH

A buffer with $\mathrm{p}K_a = 4.7$, $[\mathrm{A}^-] = 0.20$, $[\mathrm{HA}] = 0.10$:

$$\mathrm{pH} = 4.7 + \log \frac{0.20}{0.10} = 4.7 + \log 2 = 4.7 + 0.30 = 5.0.$$

Method — Finding the ratio for a target pH

Rearrange: $\log \dfrac{[\mathrm{A}^-]}{[\mathrm{HA}]} = \mathrm{pH} - \mathrm{p}K_a$, then take $10^{(\mathrm{pH}-\mathrm{p}K_a)}$.

Practice 2.1 ▪ 1 mark

Write the Henderson-Hasselbalch equation.

Solution 2.1

Worked steps

$$\mathrm{pH} = \mathrm{p}K_a + \log \frac{[\mathrm{A}^-]}{[\mathrm{HA}]}$$ **B1**.

Practice 2.2 ▪ 1 mark

A buffer has $pK_a = 4.7$ with equal acid and base. Find the pH.

Solution 2.2

Method: The equation

Worked steps

pH $= 4.7$ B1.

Practice 2.3 ▪ 2 marks

Find the pH of a buffer with $pK_a = 5.0$ and $\frac{[A^-]}{[HA]} = 10$.

Solution 2.3

Worked steps

$\mathrm{pH} = 5.0 + \log 10 = 5.0 + 1 = 6.0$ M1 A1.

Exam-style 3.1 ▪ 1 mark

When $[A^-] = [HA]$, the Henderson-Hasselbalch equation gives pH $=$

A 0

B 7

C pK_a

D p$K_a + 1$

Solution 3.1

Method: The equation

A 0

B 7

C $\mathrm{p}K_a$ ✓

D $\mathrm{p}K_a + 1$

Worked steps

C — $\mathrm{pH} = \mathrm{p}K_a$.

Exam-style 3.2 ▪ 1 mark

A buffer uses an acid with $pK_a = 4.74$, with $[HA] = 0.30$ M and $[A^-] = 0.15$ M.

(a) Find the ratio $\dfrac{[A^-]}{[HA]}$.

(b) Find the pH.

Solution 3.2

Method: The equation

Worked steps

(a) $\dfrac{0.15}{0.30} = 0.5$ B1. (b) $\text{pH} = 4.74 + \log(0.5) = 4.74 - 0.30 = 4.44$ M1 M1 A1.

Exam-style 3.3 ▪ 3 marks

You want a buffer at pH 5.0 using an acid with $pK_a = 4.7$. Find the required ratio $\dfrac{[A^-]}{[HA]}$.

Solution 3.3

Method: The equation

Worked steps

$\log \dfrac{[\mathrm{A}^-]}{[\mathrm{HA}]} = 5.0 - 4.7 = 0.3$ M1; ratio $= 10^{0.3} = 2.0$ M1 A1.