

Exercise walk-through

8.8

Properties of Buffers

AP Chemistry

Buffers and Henderson-Hasselbalch

- A **buffer** holds pH steady with **both** a weak acid and its conjugate base:
- added acid $\Rightarrow$ conjugate base soaks up H^+
 - added base $\Rightarrow$ weak acid soaks up OH^-

Henderson-Hasselbalch

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

Equal amounts $\Rightarrow \text{pH} = \text{p}K_a$.
Capacity grows with total concentration.

Worked example – the Henderson-Hasselbalch equation

A buffer holds 0.20 M acetic acid ($pK_a = 4.74$) and 0.30 M acetate. Find its pH.

- $pH = pK_a + \log \frac{[A^-]}{[HA]}$
- $= 4.74 + \log \frac{0.30}{0.20} = 4.74 + 0.18$
- $= 4.92$

When the two concentrations are **equal** the log is zero and $pH = pK_a$ exactly. That is the point of maximum **buffer capacity**.

pH and Solubility

The solubility of a salt with a basic anion **rises** in acidic solution: the added H^+ reacts with the anion.

So pH can control whether an ionic solid dissolves.

Exercises 2.1·2.3

2.1 When $[\text{HA}] = [\text{A}^-]$, the pH equals what? [1]

2.2 To make a buffer at pH 9, what $\text{p}K_a$ should the acid have? [1]

2.3 Over what pH range is a buffer effective? [1]

Exercises 2.1·2.3

2.1 When $[\text{HA}] = [\text{A}^-]$, the pH equals what? [1]

2.1

- $\text{p}K_a$
-

2.2 To make a buffer at pH 9, what $\text{p}K_a$ should the acid have? [1]

2.2

- About 9
-

2.3 Over what pH range is a buffer effective? [1]

2.3

- Roughly $\text{p}K_a \pm 1$

Exercise 3.1

3.1 A buffer works best when the acid and its conjugate base are

[1]

☐

A in very different amounts

B in comparable amounts

C both absent

D both strong

Exercise 3.1

3.1 A buffer works best when the acid and its conjugate base are

[1]

☐

A in very different amounts

B in comparable amounts

C both absent

D both strong

3.1 B

- comparable amounts

Exercise 3.2 (a)

3.2 You need a buffer at pH 4.5. Available acids: formic ($pK_a = 3.7$), acetic ($pK_a = 4.7$), and hypochlorous ($pK_a = 7.5$).

(a) Which is the best choice?

[1]

Exercise 3.2 (a)

3.2 You need a buffer at pH 4.5. Available acids: formic ($pK_a = 3.7$), acetic ($pK_a = 4.7$), and hypochlorous ($pK_a = 7.5$).

(a) Which is the best choice?

[1]

(a)

- Acetic acid

Exercise 3.2 (b)

3.2 You need a buffer at pH 4.5. Available acids: formic ($pK_a = 3.7$), acetic ($pK_a = 4.7$), and hypochlorous ($pK_a = 7.5$).

(b) Justify your choice.

[2]

Exercise 3.2 (b)

3.2 You need a buffer at pH 4.5. Available acids: formic ($pK_a = 3.7$), acetic ($pK_a = 4.7$), and hypochlorous ($pK_a = 7.5$).

(b) Justify your choice.

[2]

(b)

- Its $pK_a = 4.7$ is closest to the target pH 4.5 (within ± 1), so the acid and base are in comparable amounts and buffer effectively

Exercise 3.3

3.3 Explain why a buffer loses its effectiveness far from its pK_a .

[2]

Exercise 3.3

3.3 Explain why a buffer loses its effectiveness far from its pK_a . [2]

3.3

- Far from pK_a the ratio $[A^-]/[HA]$ is extreme, so one component is nearly depleted and cannot neutralize added acid or base – buffering fails