Exercise walk-through

Properties of Buffers ▪ 8.8

eXercise

You must be able to

- explain why a buffer works best when $[HA] \approx [A^-]$
- state that a buffer's pH is near its pK_a
- choose an acid for a target buffer pH

Method — A buffer's pH is near its pKa

A buffer's pH is set by the acid's pK_a and the ratio of base to acid. When $[A^-] = [HA]$, the ratio is 1 and pH = pK_a.

Method — Best buffering near pKa

A buffer resists change best when it has **plenty of both** members and they are **comparable** in amount — near a 1:1 ratio, i.e. near $\mathrm{pH} = \mathrm{p}K_a$.

Method — Choosing the acid

To make a buffer at a target pH, pick a weak acid whose pK_a is **close to** that pH (within about ± 1). For a pH-5 buffer, choose an acid with p$K_a \approx 5$ (like acetic acid, p$K_a = 4.7$).

Method — Range

A buffer is effective roughly within $\mathrm{p}K_a \pm 1$; outside that range one component is nearly used up.

Practice 2.1 ▪ 1 mark

When $[HA] = [A^-]$, the pH equals what?

Solution 2.1

Worked steps

pK_a B1.

Practice 2.2 ▪ 1 mark

To make a buffer at pH 9, what pK_a should the acid have?

Solution 2.2

Method: Choosing the acid

Worked steps

About 9 B1.

Practice 2.3 ▪ 1 mark

Over what pH range is a buffer effective?

Solution 2.3

Method: Range

Worked steps

Roughly $\mathrm{p}K_a \pm 1$ B1.

Exam-style 3.1 ▪ 1 mark

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

A in very different amounts

B in comparable amounts

C both absent

D both strong

Solution 3.1

Method: A buffer's pH is near its pKa

- **A** in very different amounts
- **B** in comparable amounts ✓
- **C** both absent
- **D** both strong

Worked steps

B — comparable amounts.

Exam-style 3.2 ▪ 1 mark

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?
(b) Justify your choice.

Solution 3.2

Worked steps

(a) Acetic acid B1. (b) Its p$K_a = 4.7$ is closest to the target pH 4.5 (within ± 1), so the acid and base are in comparable amounts and buffer effectively M1 A1.

Exam-style 3.3 ▪ 2 marks

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

Solution 3.3

Worked steps

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 M1 A1.