What are Buffers and Buffering Capacity?

Worksheet

Buffers work because the weak acid HA and its conjugate base A exist in equilibrium. When H+ is added, A neutralizes it. When OH is added, HA neutralizes it. Buffering capacity depends on the concentrations of both components and is highest when [HA] = [A] (pH = pKa).

pH = pKa + log([A]/[HA])

Questions

1. What is the main component of a buffer?

A) Strong acid and strong base
B) Weak acid and strong base
C) Weak acid and its conjugate base
D) Weak base and strong acid

2. pH = pKa when:

A) [HA] > [A]
B) [HA] < [A]
C) [HA] = [A]
D) [HA] = 0

3. Buffer capacity is best within

A) 2 units of pKa
B) 1 unit of pKa
C) 0.5 units of pKa
D) 3 units of pKa

4. Diluting a buffer solution:

A) increases pH
B) decreases buffering capacity
C) does not affect pH
D) completely destroys the buffer

5. A buffer contains 0.1 M acetic acid (CH3COOH, pKa = 4.75) and 0.1 M sodium acetate (NaCH3COO). Calculate the pH.

6. In the same buffer, 0.05 M HCl is added. How does pH change? (Assume volume negligible)

7. What is the buffering capacity range of an acetate buffer (pKa 4.75)?

8. Define: What is a buffer?

9. Define: What is buffering capacity?

10. Define: When is buffering capacity maximum?

Answer Key

1. C) Weak acid and its conjugate base - A buffer needs both the weak acid (to neutralize added base) and conjugate base (to neutralize added acid).

2. C) [HA] = [A] - log(1) = 0, so pH = pKa + 0 = pKa.

3. B) 1 unit of pKa - Buffers are typically useful within about 1 unit of the pKa.

4. B) decreases buffering capacity - Dilution lowers the concentrations of both HA and A, reducing capacity to neutralize added acid/base.

5. pH = pKa + log([A]/[HA]) pH = 4.75 + log(0.1/0.1) pH = 4.75 + log(1) pH = 4.75 + 0 pH = 4.75 (pKa when concentrations are equal)

6. Added H+ = 0.05 M H+ + A HA New [A] 0.1 0.05 = 0.05 M New [HA] 0.1 + 0.05 = 0.15 M pH = 4.75 + log(0.05/0.15) = 4.75 + log(0.33) = 4.75 0.48 = 4.27 (Without buffer, 0.05 M HCl alone would give pH 1.3)

7. Buffering capacity is best within 1 pH unit of pKa Range: 4.75 1 = 3.75 to 4.75 + 1 = 5.75 Outside this range the buffer becomes ineffective

8. A solution of a weak acid and its conjugate base (or weak base and its conjugate acid) that resists pH changes.

9. The amount of acid or base a buffer can neutralize before the pH changes significantly.

10. When [HA] = [A], so pH = pKa.