

Chapter 15

Applications of Aqueous Equilibria

Common Ion Effect

When a strong electrolyte containing an ion in common with an already established equilibrium is added, the system will shift to relieve the stress (Le' Chatelier's Principle)

1. As solid sodium acetate is slowly added to 0.500 M acetic acid, what happens to the pH, $[\text{H}_3\text{O}^+]$, pOH, $[\text{OH}^-]$ and percent ionization? Will addition of NaCl affect the pH in the same way?
2. As solid ammonium chloride is slowly added to 0.500 M ammonia, what happens to the pH, $[\text{H}_3\text{O}^+]$, pOH, $[\text{OH}^-]$ and percent ionization? Will addition of KNO_3 affect the pH in the same way?
3. Which of the following substances will affect the percent dissociation of HNO_2 ?
 - a. NaNO_2 (yes)
 - b. NaCl (no)
 - c. HCl (yes)
 - d. $\text{Ba}(\text{NO}_2)_2$ (yes)

Calculation of pH in Presence of Common Ion

- A. Calculate the pH and percent ionization of 0.500 M acetic acid.
- B. Calculate the pH and percent ionization of a solution that is 0.500 M acetic acid and 0.250 M sodium acetate.

What type of solution is formed in B (i.e. when weak acid is in solution with conjugate base)?

Buffer Solution

A solution that resists changes in pH when small amounts of acid or base are added to it!!

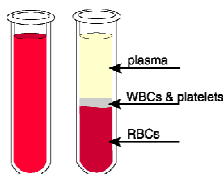
Definition of Buffer Solutions: 1.
2.

Function of Buffer Solution:

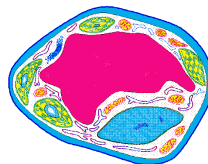
- * added acid reacts with the _____ part of the buffer
- * added base reacts with the _____ part of the buffer

Q. Explain how the $\text{HC}_2\text{H}_3\text{O}_2/\text{NaC}_2\text{H}_3\text{O}_2$ buffer system maintains a relatively constant pH when small quantities of acid (eg. HCl) or base (eg. NaOH) are added.

$\text{H}_2\text{CO}_3/\text{HCO}_3^-$ buffer in blood plasma maintains pH of 7.35-7.45



$\text{H}_2\text{PO}_4^-/\text{HPO}_4^{2-}$ buffer in cells maintains pH of 6.9-7.4



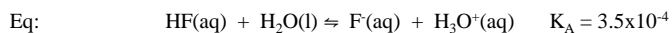
Sample Questions

- If the following substances are mixed in equimolar amounts, will a buffer solution be formed?
 - HF and NaF
 - NH_3 and NH_4Cl
 - NaOH and NaCl
 - HCl and KCl
 - NH_3 and HCl
 - HCN and NaCN
 - HF and NaOH
 - $\text{KH}_2\text{PO}_4/\text{H}_3\text{PO}_4$
- Which of the following gives a buffer solution when equal volumes of the two solutions are mixed?
 - 0.10 M HF and 0.10 M NaF
 - 0.20 M HF and 0.10 M NaOH
 - 0.20 M HF and 0.30 M NaOH
 - 0.10 M HCl and 0.20 M NaF
- Which of the following gives a buffer solution when equal volumes of the two solutions are mixed?
 - 0.50 M NH_3 and 1.0 M HCl ^(aq)
 - 0.20 M HCN and 0.20 M KOH ^(aq)
 - 0.30 M HOCl and 0.15 M $\text{Ba}(\text{OH})_2$ ^(aq)
 - 0.30 M HOCl and 0.10 M $\text{Ba}(\text{OH})_2$ ^(aq)

Henderson – Hasselbalch Equation

A shorthand way of calculating the pH of a buffer solution

Consider the HF/NaF (or F⁻) buffer system.....



Derive the Henderson-Hasselbalch Equation for this system.

What is the general form of the Henderson-Hasselbalch Equation for any buffer system?

The Henderson Hasselbalch Equation shows:

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.

Sample Questions

1. Calculate the pH of a buffer solution that is 0.45 M in NH_4Cl and 0.15 M in NH_3 . (8.77)
2. Calculate the pH of a buffer solution that is 0.25 M in HNO_2 ($K_A=4.5 \times 10^{-4}$) and 0.15 M in NaNO_2 .
3. A buffer solution with a pH of 4.00 is needed in an experiment. Which of the following buffer systems should be used? For the chosen buffer system, what concentration ratio of conjugate base/ acid should be used to attain pH = 4.00?
 - a. $\text{HNO}_2/\text{NaNO}_2$; $K_a = 4.5 \times 10^{-4}$
 - b. $\text{CH}_3\text{COOH}/\text{CH}_3\text{COONa}$; $K_a = 1.8 \times 10^{-5}$
 - c. $\text{HCOOH}/\text{NaCOOH}$; $K_a = 1.8 \times 10^{-4}$
 - d. $\text{C}_6\text{H}_5\text{COOH}/\text{C}_6\text{H}_5\text{COONa}$; $K_a = 6.5 \times 10^{-5}$
 - e. HCN/NaCN ; $K_a = 4.9 \times 10^{-10}$
 - f. $\text{NH}_3/\text{NH}_4\text{Cl}$; $K_b = 1.8 \times 10^{-5}$
4. A buffer with a pH=10.00 is to be prepared from the $(\text{CH}_3)_3\text{N}/(\text{CH}_3)_3\text{NHCl}$ system with $K_B=6.5 \times 10^{-5}$. What concentration ratio of base to salt should be used?

Calculation of Buffer pH After Addition of Strong Acid or Base

Q A buffer solution is 0.10 M $\text{HC}_2\text{H}_3\text{O}_2$ ($K_A = 1.8 \times 10^{-5}$) and 0.20 M $\text{NaC}_2\text{H}_3\text{O}_2$. What is the pH of this buffer solution?

What is the pH of this buffer solution after the addition of 0.0040 mol HCl to 100. mL of this buffer solution?

What is the pH of this buffer solution after the addition of 0.0060 mol NaOH to 100. mL of this buffer solution?