Chapter 14 Part 5

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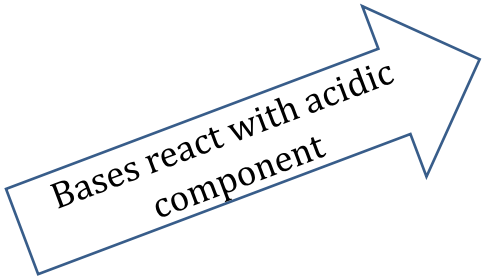
Buffers

- A buffer is a mixture of a weak acid and its conjugate base (or a mixture of weak base and its conjugate acid) is called a buffer.
- Buffers resist a change in pH when small amounts of a strong acid or a strong base are added.

Buffering Action

$HC_2H_3O_2/C_2H_3O_2^-$

Buffering Action



$HC_2H_3O_2/C_2H_3O_2^-$

$NaOH + HC_2H_3O_2 \rightarrow NaC_2H_3O_2 + H_2O$ (to completion)

Buffering Action

$HC_2H_3O_2/C_2H_3O_2^-$

Acids react with basic component

$HCl + C_2H_3O_2^- \rightarrow HC_2H_3O_2 + Cl^-$ (to completion)

Buffers

Identify the combination that will result in a buffer solution.

A. equal concentrations of HCl and H_2O
B. equal concentrations of HCN and KCN
C. equal concentrations of NaCl and NaOH
D. equal concentrations of HNO_3 and NH_3
E. equal concentrations of NaOH and H_2O

Henderson-Hasselbalch equation

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

- pH: the pH of the buffer solution
- pK_a: the pK_a of the acidic part of the buffer
- $[A^-]$: is the basic part of the buffer
- $[HA]$: is the acidic part of the buffer

Calculating Buffer pH

Consider a solution a solution that is 0.10 M in $HC_2H_3O_2$ and 0.10 M in $NaC_2H_3O_2$. The K_a of $HC_2H_3O_2$ is 1.8×10^{-5}. (A) Write a hydrolysis reaction relating both parts of the buffer. (B) Calculate the pH of the solution.

Adding acids or bases to buffers

- When adding an acid to base, you can still use the Henderson-Hasselbach equation.
- BUT FIRST:
  1. Write the equation of adding the acid or base to the appropriate part of the buffer
  2. Make an ICE[E] table to find the new concentrations of the acidic and basic parts of the buffer
  3. And then, plug these new concentrations into the Henderson-Hasselbach equation

Adding a base to a buffer

If 10.0 mL of 1.0 M NaOH is added to 1.0 liter of a buffer solution that is 0.10 M in $HC_2H_3O_2$ and 0.10 M in $NaC_2H_3O_2$, how much will the pH change? The K_a of $HC_2H_3O_2$ is 1.8×10^{-5}.

Adding an acid to a buffer

If 10.0 mL of 1.0 M HCl is added a 1.0 liter of a buffer solution that is 0.10 M in $HC_2H_3O_2$ and 0.10 M in $NaC_2H_3O_2$, how much will the pH change? The K_a of $HC_2H_3O_2$ is 1.8×10^{-5}.

Summary Table

	When we add 0.010 mol NaOH	When we add 0.010 mol HCl
We have 1.00 L of original solution	**pH increased by**	**pH decreased by**
buffer solution 0.10 M $NaCH_3COO$ & 0.10 M CH_3COOH	+0.08	-0.08
unbuffered solution 0.10 M CH_3COOH	+0.91	-0.89

Buffers

What is the pH of a buffer solution prepared by dissolving 25.5 g $NaC_2H_3O_2$ (82.04 g/mol) in a sufficient volume of 0.550 M $HC_2H_3O_2$ to make 500.0 mL of the buffer? The K_a of $HC_2H_3O_2$ is 1.8×10^{-5}.

Preparing Buffer Solutions of Desired pH

What mass of $NaC_2H_3O_2$ (82.04 g/mol) must be dissolved in 0.300 L of 0.25 M $HC_2H_3O_2$ to produce a solution with a pH of 5.09? (Assume that the solution volume remains constant at 0.300L.) The K_a of $HC_2H_3O_2$ is 1.8×10^{-5}.

Working Buffer Problems

- Buffer problems can be recognized because you will have a weak acid and its conjugate base
- If you just need to find the pH of an undisturbed buffer, plug the concentrations into the Henderson-Hasselbach equation
- If you need to find the pH of a buffer after a strong acid or strong base has been added to it
  1. Write the equation of adding the acid or base to the appropriate part of the buffer
  2. Make an ICE[E] table to determine the new $[A^-]$ and [HA] concentrations
  3. Plug them into the Henderson-Hasselbach Equation

Recognizing Types of Problems

Identify each of the following as a strong acid, strong base, weak acid, weak base, or buffer

A. 0.100 M $LiOH$
B. 0.100 M NaF and 0.100 M HF (K_a $HF = 6.6 \times 10^{-4}$)
C. 0.100 M $HClO_4$
D. 0.100 M $HC_2H_3O_2$ (K_a $HC_2H_3O_2 = 1.8 \times 10^{-5}$)
E. 0.100 M $NaCN$ (K_a $HCN = 6.2 \times 10^{-10}$)
F. 0.100 M CH_2NH_2 (K_a $CH_2NH_3^+ = 2.3 \times 10^{-11}$)

Finding pH values of solutions

Solution Type	How to find pH
Strong acid	Write reaction with water to determine the $[H_3O^+]$ from the strong acid molarity
Strong base	Write decomposition reaction to determine the $[OH^-]$ from the strong base molarity
Weak acid/acidic salt	Use initial weak acid concentration, K_a, and ICE table to find $[H_3O^+]_{eq}$
Weak base/basic salt	Use initial weak base concentration, K_b, and ICE table to find $[OH^-]_{eq}$
Polyprotic acid	Use initial polyprotic acid concentration, K_{a_1}, and ICE table to find $[H_3O^+]_{eq}$ from first ionization step
Buffer	Use Henderson-Hasselbalch equation
Buffer (with strong acid or base added)	Use ICE[E] table and then Henderson-Hasselbalch equation