Worksheet 24 - Buffers

A buffer solution is one which maintains an approximately constant pH when small amounts of either a strong acid or base are added. Solutions containing either weak acids and their conjugate bases, or weak bases and their conjugate acids, can be buffering solutions.

1. The number of moles of the conjugate pairs must be large compared to the moles of added strong acids or bases.

2. The ratio of the conjugate pair ([weak acid]/[conjugate base] or [weak base] / [conjugate acid]) should lie between 0.1 and 10, with optimal buffering at a 1:1 ratio.

3. The pH of a 1:1 ratio buffer is equal to the $pK_a$ of the weak acid or $pK_b$ of the weak base. The effective range is ± 1 from the $pK_a$ or $pK_b$.

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\begin{align*}
\text{CH}_3\text{COOH/CH}_3\text{COO}^- & \quad K_a = 1.8 \times 10^{-5} \\
\text{NH}_3/\text{NH}_4^+ & \quad K_b = 1.8 \times 10^{-5} \\
\text{HCO}_3^-/\text{CO}_3^{2-} & \quad K_a = 5.6 \times 10^{-11} \\
\text{H}_2\text{PO}_4^-/\text{HPO}_4^{2-} & \quad K_a = 6.2 \times 10^{-8}
\end{align*}
\]

1. Which of the conjugate pairs, shown above would be appropriate for preparing a buffer at pH = 7.0?

2. What is the pH of a buffer formed from 50 mL of 15.0 M NH$_3$ and 53.5 g of NH$_4$Cl in enough water to make 500 mL of solution?

3. What is the pH of the previous solution after addition of 100 mL of 0.2 M NaOH?
Buffers can also be made by **partially** neutralizing a weak acid with a strong base, or a weak base with a strong acid.

4. Which of the following mixtures result in a buffering solution when equal volumes of the two solutions are mixed?

   a) 0.1 M HCl and 0.1 M NH₄Cl

   b) 0.1 M HCl and 0.1 M NH₃

   c) 0.2 M HCl and 0.1 M NH₃

   d) 0.1 M HCl and 0.2 M NH₃

5. What is the pH of a solution made by adding 0.40 g of NaOH to 100 ml of a 0.4 M solution of CH₃COOH? Is it a buffering solution?

6. What volume of 2.0 M NaOH must be added to 100.0 mL of 2.5 M CHOOH (Kₐ = 1.8 x 10⁻⁴) to prepare a buffer with a pH of 4.0?