Buffers : Notes/W.S.-205

The word **buffer** comes from the German word "puffer", which means pad or cushion.

In chemistry, a buffer is a solution that resists a change in its pH. It is a "cushion", protecting against the effects of acids and bases. If a small amount of an acid or a base is added, the pH doesn't change too much.

Buffers are important because many chemical reactions will take place only if the pH is relatively constant. For example, your blood has several buffers in it, to minimize changes in the pH, so important chemical reactions can take place in your body.

In general, buffer solutions consist (usually) of mixtures of equal amounts of a weak acid and its conjugate base (or a weak base and its conjugate acid).

An example of a buffer system is the acetic acid/acetate ion equilibrium system.

In an acetic acid solution, the concentration of acetate ions is very small ($K_a = 1.74 \times 10^{-5}$). So this solution is not a buffer. But we can make a buffer, by adding the salt, sodium acetate, to the solution. The sodium ions are spectator ions which do not contribute to the reaction. The concentration of acetic acid and acetate ion should be approximately equal.

The equilibrium is given below.

$$HC_2H_3O_2 + H_2O \leftrightarrow H_3O^+ + C_2H_3O_2^-$$

Assume that $[HC_2H_3O_2] = [C_2H_3O_2^-]$. If a small amount of an acid is added, the equilibrium shifts left, and some of the acetate ion is consumed. Since there is a large amount of the acetate ion, the excess hydronium is easily "absorbed", so the pH change is small. If a small amount of a base is added, the equilibrium shifts right, and the hydroxide is "consumed" by the hydronium ions, so again the pH change is small.

For the above equilibrium:

$$K_a = \{[H_3O^+][C_2H_3O_2^-]\}/[HC_2H_3O_2] = [H_3O^+]$$

Since $[HC_2H_3O_2] = [C_2H_3O_2^-]$, the pH = $-\log[H_3O^+] = -\log[K_a]$. = 4.74.

Problems:

1) What is the purpose of a buffer?

2) Explain briefly how to prepare a buffer.

3) Find the pH for the following buffer systems. Assume that both species have an equal concentration.

a) H_3PO_4/NaH_2PO_4

b) C_6H_5COOH/NaC_6H_5COO

c) $H_2CO_3/NaHCO_3$

d) NH_4^+/NH_3

4) Write down the equilibrium reaction for the basic buffer system: ammonia/ammonium ion (NH_3/NH_4^+).

5) Determine the pH of a buffer solution containing 50. mL of 0.30 M CH_3COOH, mixed with 50. mL of 0.50 M CH_3COONa.

6) Determine the pH of a buffer solution containing 220 mL of 0.15 M NH_3, mixed with 350 mL of 0.10 M NH_4Cl.

7) The pH of pure water is 7.0. If 1.0 mL of 4.0 M HCl is added to 1.0 L of pure water, find the new pH.

8) One liter of acetic acid/acetate ion buffer is prepared from a solution of 0.200 mol of acetic acid and 0.200 mol of acetate ion. The pH is 4.74. Find the new pH, if 1.00 mL of 4.00 M HCl is added to this buffer.

Answers: 1) The purpose of a buffer solution is to reduce the change in the pH of a solution when a small amount of an acid or a base is added., 2) A buffer is usually prepared by adding equal amounts of a weak acid and its conjugate base to water., 3)a) 2.1, b) 4.2, c) 6.4, d) 9.3, 4) $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$, 5) 5.0, 6) 9.2, 7) 2.4, 8) 4.73.