

Buffers and Titrations

1. What is the maximum and minimum pH that can be buffered by each of the following buffers?

Chloroacetic acid – chloroacetate

$$pK_a = 2.87$$

$$1.87 \rightarrow 3.87$$

carbonic acid - bicarbonate

$$pK_a = 6.35$$

$$5.35 \rightarrow 7.35$$

2. For each of the following, determine which form of the buffer (HA or A⁻) will be present at higher concentration.

Buffer pK_a = 5.75 Solution pH = 4.5

$$pH < pK_a$$

more HA

Buffer pK_a = 3.75 Solution pH = 4.5

$$pH > pK_a$$

more A⁻

3. Calculate the pH of a 500 mL solution that is:

0.15 M CH₃CO₂H and 0.25 M CH₃CO₂⁻.

$$pK_a = 4.75$$

$$pH = 4.75 + \log \frac{0.25}{0.15}$$

$$pH = 4.97$$

1.6 M fluoride and 1.1 M hydrofluoric acid

$$pK_a = 3.2$$

$$pH = 3.2 + \log \frac{1.6}{1.1}$$

$$pH = 3.36$$

4. Calculate the [weak acid] and [weak base] in a solution of hypochlorite and hypochlorous acid buffered at pH 7.0. The total buffer concentration is 50 mM.

Hint: You have two variables and 2 equations – total concentration and Henderson-Hasselbach. Use both and make a substitution.

$$7.0 = 7.40 + \log \frac{A^-}{HA}$$

$$\frac{A^-}{HA} = 10^{-0.4} \quad A^- = 10^{-0.4} [HA]$$

$$[A^-] + [HA] = 50 \text{ mM}$$

$$10^{-0.4} [HA] + [HA] = 50 \text{ mM}$$

$$1.398 [HA] = 50 \text{ mM}$$

$$[HA] = 35.76 \text{ mM}$$

$$50 \text{ mM} = 35.76 + [A^-]$$

$$[A^-] = 14.24 \text{ mM}$$

5. What mass of sodium acetate needs to be added to 500 mL of 1.00 M acetic acid to create a buffer at pH 5.3?

$$5.3 = 4.75 + \log \frac{[A^-]}{1M} \quad [A^-] = 3.55M$$

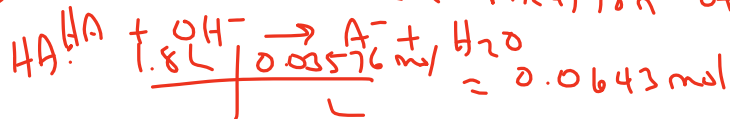
$$\frac{0.5L}{L} \left| \frac{3.55 \text{ mol}}{L} \right. = 1.77 \text{ mol NaC}_2\text{H}_3\text{O}_2 \left| \frac{82.05 \text{ g}}{\text{mol}} \right. = 145.23 \text{ g}$$

6. Calculate the resulting pH when 10 mL of 0.5 M NaOH is added to a 1.8 L solution of 50 mM hypochlorite buffered at a pH of 7.0

Hint: Note the volume changes in this reaction. Be very careful with moles, volume, and Molarity.

① Concentrations of A^- and HA determined in #4

② Use moles to avoid complication of ΔV



$$A^-: \frac{1.8L}{L} \left| \frac{0.01424 \text{ mol}}{L} \right. = 0.0256 \text{ mol}$$

$$\text{OH}^-: \frac{0.01L}{L} \left| \frac{0.5 \text{ mol}}{L} \right. = 0.005 \text{ mol}$$



$$\text{I} \quad 0.064 \quad 0.005 \quad 0.0256$$

$$\text{C} \quad -0.005 \quad -0.005 \quad +0.005$$

$$\text{E} \quad 0.0693 \quad \varnothing \quad 0.0306$$

$$\text{pH} = 7.4 + \log \frac{0.0169}{0.0383}$$

$$\text{pH} = 7.045$$

$$\text{New Volume: } 1.8L + 0.01L = 1.81L$$

$$[\text{HA}] = \frac{0.0693 \text{ mol}}{1.81L} = 0.0383M$$

$$[\text{A}^-] = \frac{0.0306}{1.81} = 0.0169M$$