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 pKa = 5.75 Solution pH = 4.5

$pH < pK_a$

more HA

Buffer pKa = 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 CH_3CO_2H and 0.25 M $CH_3CO_2^-$.

$pK_a = 4.75$

$pH = 4.75 + \log \frac{0.25}{0.15}$ $\quad pH = 4.97$

1.6 M fluoride and 1.1 M hydrofluoric acid

$pK_a = 3.2$ $\quad pH = 3.2 + \log \frac{1.6}{1.1}$ $\quad pH = 3.36$

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 variable and 2 equations – total concentration and Henderson-Hasselbach. Use both and make a substitution.

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

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

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

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

$1.398[HA] = 50\ mM$

$[HA] = 35.76\ mM$

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

$[A^-] = 14.24\ mM$

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?

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

$0.5\,L \left| \frac{3.55\,mol}{L} \right. = 1.77\,mol\,NaC_2H_3O_2 \left| \frac{82.03\,g}{mol} \right. = 145.23\,g$

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

HA: $1.8\,L \left| \frac{0.03576\,mol}{L} \right. = 0.0643\,mol$

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

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

$HA + OH^- \rightarrow A^- + H_2O$

	HA	OH^-	A^-	H_2O
I	0.064	0.005	0.0256	
C	−0.005	−0.005	+0.005	
E	0.0593	0	0.0306	

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

$pH = 7.045$

New Volume: $1.8\,L + 0.01\,L = 1.81\,L$

$[HA] = \frac{0.0693\,mol}{1.81\,L} = 0.0383\,M$ $\quad [A^-] = \frac{0.0306}{1.81} = 0.0169\,M$