Buffers

- Consists of weak acid or weak base and its salt; resists changes in pH upon addition of small amounts of acid or base

ex. Acetic acid and sodium acetate

Add acid:

$$C_2H_3O_2^-(aq) + H^+(aq) \longrightarrow HC_2H_3O_2(aq)$$

consumes H^+

Add base:

$$HC_2H_3O_2(aq) + OH^-(aq) \longrightarrow C_2H_3O_2^-(aq) + H_2O(l)$$

consumes OH^-

ex. Which of the following are buffer systems?

a.) KH_2PO_4 / H_3PO_4 yes!

b.) $NaClO_4 / HClO_4$ no - $HClO_4$ strong

c.) $C_5H_5N / \underline{C_5H_5NHCl}$ yes

weak base: pyridine; cation

ex. How would you prepare a phosphate buffer with a pH of 7.40?

Choose a buffer system with a pKa closest to the desired pH:

$$H_2PO_4^-(aq) \rightleftharpoons H^+(aq) + HPO_4^{2-}(aq) \quad pKa = 7.21$$

$$pH = pKa + \log \frac{[HPO_4^{2-}]}{[H_2PO_4^-]}$$

$$7.40 = 7.21 + \log \frac{[base]}{[acid]}$$

$$\log \frac{[HPO_4^{-2}]}{[H_2PO_4^-]} = 0.19$$

$$10^{0.19} = 1.5$$

$$\frac{[HPO_4^{-2}]}{[H_2PO_4^-]} = \boxed{1.5}$$ mole ratio

Buffer Example:

A buffer is formed by adding 1.00mol lactic acid ($K_a = 1.4 \times 10^{-4}$) and 1.00 mol sodium lactate in enough water to make 550mL of solution.

a) Calculate H^+ and pH:

$$HLac \rightleftharpoons H^+ + Lac^-$$

$$K_a = \frac{[H^+][Lac^-]}{[HLac]}$$

$$1.4 \times 10^{-4} = \frac{[H^+][1.00]}{1.00} \qquad H^+ = 1.4 \times 10^{-4}$$

$$pH = -\log(1.4 \times 10^{-4}) = 3.85$$

b) Calculate pH after addition of 0.08 mol HCl: $H^+ + Lac^- \rightarrow HLac$

0.08mol H^+ added so,

could do ICE table

$HLac = 1.00 + .08 = 1.08 mol$

$Lac = 1.00 - 0.08 = 0.92 mol$

$$pH = -\log 1.4 \times 10^{-4} + \log \frac{.92}{1.08} = 3.78$$

c) Calculate pH after addition of 0.08mol NaOH: $HLac + OH^- \rightarrow Lac^- + H_2O$

0.08mol OH^+ added so,

$HLac = 1.00 - .08 = 0.92 mol$

$Lac = 1.00 + .08 = 1.08 mol$

$$pH = -\log 1.4 \times 10^{-4} + \log \frac{1.08}{.92} = 3.92$$

Buffer Example:

ex. A 100.0mL buffer sample is made of 0.120M benzoic acid (C_6H_5COOH) and 0.105M sodium benzoate ($NaC_6H_5COO^-$) (K_a for benzoic acid is 6.5×10^{-5})

a) Calculate pH of the buffer soln:

$$pH = pK_a + \log \frac{[Bz^-]}{[HBz]}$$

$$= -\log 6.5 \times 10^{-5} + \log \frac{.105M}{.120M} = \boxed{4.13}$$

b) Calculate pH of the buffer soln after adding 0.100M NaOH 10mL

$(.0100L)(.100M\ OH^-) = .00100\ mol\ OH^-$

$(.1000L)(.120M\ HBz) = 0.0120\ mol\ HBz$

$(.1000L)(.105M\ Bz^-) = 0.0105\ mol\ Bz^-$

$$HBz + OH^- \rightarrow H_2O + Bz^-$$

HBz	$+\ OH^-$		Bz^-
.0120	.00100		.0105
−.00100	−.00100		+.00100
.0110	0		.0115

$$pH = -\log 6.5 \times 10^{-5} + \log \frac{.0115}{.0110} = \boxed{4.21}$$

Calculate pH of the solution when 20.0mL of 0.100M NaOH is added to 0.100M HNO_3

NaOH: (20.0mL)(.100M) = 2.00mmol OH^-

HNO_3: (30.0mL)(.100M) = 3.00mmol H^+

$H^+ + OH^- \rightarrow H_2O$

3.00	2.00	
-2.00	-2.00	X
1.00	0	

$[H^+] = \frac{1.00mmol}{50mL} = .0200M_{H^+}$

$pH = -\log .0200 = \boxed{1.70}$