During Class Invention
Buffers

Name_____

1. Complete the following problems

a. Calculate the pH of a solution prepared by mixing 20.0 mL of 0.300 M $HC_2H_3O_2$ with 20.0 mL of 0.350 M $NaC_2H_3O_2$.

Dilution calculation:

$$[HC_2H_3O_2] = 0.300\ M \left(\frac{20.0\ mL}{40.0\ mL}\right) = 0.150\ M$$

$$[C_2H_3O_2^-] = 0.350\ M \left(\frac{20.0\ mL}{40.0\ mL}\right) = 0.175\ M$$

	$HC_2H_3O_2(aq)$	$\rightleftharpoons$	$H^+(aq)$	$+C_2H_3O_2^-(aq)$	
I	0.150 M		~0	0.175 M	
C	-x		+x	+x	$x = [HC_2H_3O_2]_{diss}$
E	0.150 - x		x	0.175 + x	

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$1.8 \times 10^{-5} = \frac{(x)(0.175 + x)}{0.150 - x} \quad \text{assume } x << 0.150$$

$$1.8 \times 10^{-5} = \frac{(x)(0.175)}{0.150}$$

$$1.54 \times 10^{-5} = x = [H^+]$$

$$pH = 4.81$$

b. Calculate the pH after adding 0.0000200 moles of NaOH to the buffer in part a.

Add .0000200 mol of NaOH

	$HC_2H_3O_2(aq)$ +	$NaOH(aq)$	$\rightleftharpoons$	$C_2H_3O_2^-(aq)$ +	$H_2O(l)$
I	0.0060 mol	0.000020 mol		0.0070 mol	-
F	0.00598 mol	0		0.00702 mol	-

$$[HC_2H_3O_2] = \frac{0.00598\ mol}{0.040\ L} = 0.149\ M$$

$$[C_2H_3O_2^-] = \frac{0.00702\ mol}{0.040\ L} = 0.176\ M$$

	$HC_2H_3O_2(aq)$	$\rightleftharpoons$	$H^+(aq)$	$+C_2H_3O_2^-(aq)$
I	.149 M		~0	0.176 M

C	**-x**	**+x**	**+x**	**x = $[HC_2H_3O_2]_{diss}$**
E	**.149 - x**	**x**	**0.176 + x**	

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$1.8 \times 10^{-5} = \frac{(x)(0.176 + x)}{0.149-x} \text{ assume } x << 0.100$$

$$1.8 \times 10^{-5} = \frac{(x)(0.176)}{0.149}$$

$$1.52 \times 10^{-5} = x = [H^+]$$

$$pH = 4.82$$

changed by 0.01 pH units

c. Calculate the pH after adding 0.0000200 mole of HCl to a new sample of the buffer in part a.

Add .00200 mol of HCl

	$C_2H_3O_2^-(aq)$ +	$HCl(aq)$ ⇌	$HC_2H_3O_2(aq)$ +	$Cl^-(aq)$
I	**0.0070 mol**	**0.000020 mol**	**0.0060 mol**	**-**
E	**0.00698 mol**	**0**	**0.00602 mol**	**-**

$$[HC_2H_3O_2] = \frac{0.00602 \text{ mol}}{0.040 \text{ L}} = 0.151 \text{ M}$$

$$[C_2H_3O_2^-] = \frac{0.00698 \text{ mol}}{0.040 \text{ L}} = 0.174 \text{ M}$$

	$HC_2H_3O_2(aq)$ ⇌	$H^+(aq)$ +	$C_2H_3O_2^-(aq)$	
I	**.151 M**	**~0**	**0.174 M**	
C	**-x**	**+x**	**+x**	**$x = [HC_2H_3O_2]_{diss}$**
E	**.151 - x**	**x**	**0.174 + x**	

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$1.8 \times 10^{-5} = \frac{(x)(0.174 + x)}{0.151 - x} \text{ assume } x << 0.125$$

$$1.8 \times 10^{-5} = \frac{(x)(0.174)}{0.151}$$

$$1.56 \times 10^{-5} = x = [H^+]$$

$$pH = 4.80$$

changed by 0.01 pH units

d. Calculate the pH after adding 0.0000200 mole of HCl to an unbuffere solution of 20.0 mL of a 0.300 M solution of $HC_2H_3O_2$

Add .0000200 mol of HCl

$$[HC_2H_3O_2] = 0.300 \text{ M}$$

$$[H^+] = \left(\frac{0.0000200 \text{ mol}}{0.020 \text{ L}}\right) = 0.001 \text{ M}$$

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

I	**.300 M**	**0.001**		
C	**-x**	**+x**	**+x**	**x = $[HC_2H_3O_2]_{diss}$**
E	**.300 - x**	**0.001 + x**	**x**	

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$1.8 \times 10^{-5} = \frac{(x)(0.001 + x)}{0.300-x} \text{ assume } x << 0.001$$

$$1.8 \times 10^{-5} = \frac{(x)(0.001 + x)}{0.300}$$

solving the quadratic equation

$$0.0054 \text{ M} = x = [H^+]$$

$$\text{pH} = 4.82$$

changed by 0.01 pH units