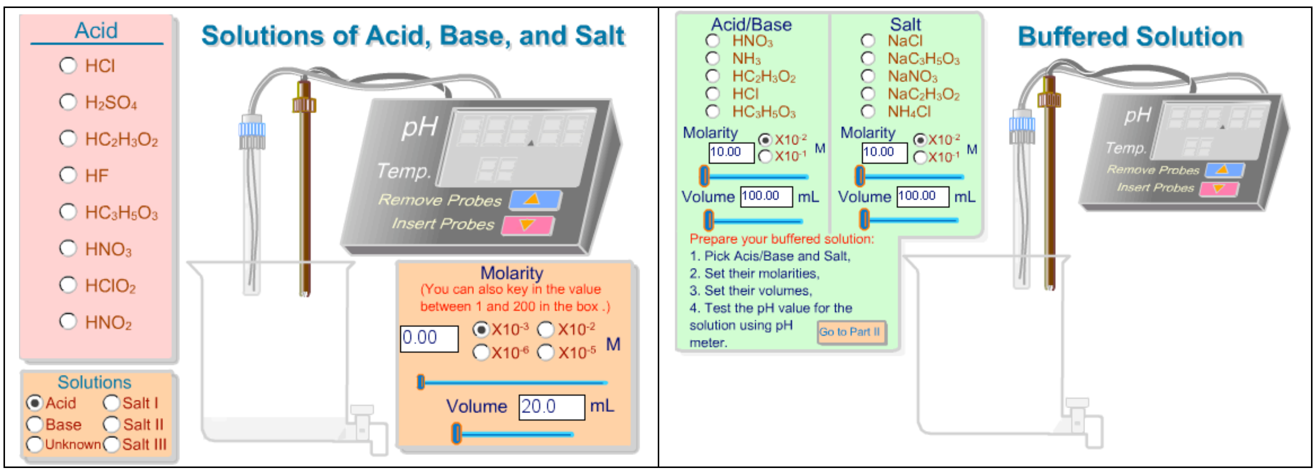
Acid/Base Buffers

Name________________________________ Lab Section___________________________

Problem Statement: What are the characteristics of buffer solutions?

I. Data Collection:

A. Go to http://cheminfo.chem.ou.edu/~mra/home.html and open both the Acid/Base pH simulation and the Buffers simulation in separate windows. Your screen should look like the following figures.



These simulations contain pH meters. You can test the pH of solutions consisting of various combinations of acid, bases and salts. You will set up the conditions of each pH measurement using the radio buttons and then insert the pH probes into the solution to obtain the pH of the solution.

According to BrØnsted-Lowry theory, an acid is a substance that donates a proton in a chemical reaction. The substance that accepts the proton is defined as a base. The products that result from such a reaction also act as proton donors and acceptors for the reverse reaction. When an acid donates a proton the substance that results is called its conjugate. Because the conjugate of an acid acts as a base in the reverse reaction it is called its conjugate base. In the following hypothetical reaction: HX is an acid and Y is a base, HY^+ is an acid and X^- is a base for the reverse reaction, and X^- is the conjugate base for HX.

$$HX + Y \rightleftarrows HY^+ + X^-$$

A buffer solution is made by combining a weak acid or weak base with its conjugate. So in the above example, you could construct a buffer solution by combining HX with X^-. A convenient source of X^- could be the salt NaX. In a similar fashion, the base Y has a conjugate acid HY^+. A buffer solution could be made from Y and the salt HYCl.

One of the characteristics of buffer solutions is that they are resistant to change in pH with additions of small amounts of strong acids or bases. This makes them useful for a number of applications in medicine and as standardized solutions.

B. Using the Acid/Base pH simulation, determine the pH of a 0.10 M solution of $HC_2H_3O_2$. (Under acid solutions, choose $HC_2H_3O_2$. Set the concentration of the solution at 10.00 X 10^{-2} M. Set the volume at 100 mL. Click on the Insert Probes button on the pH meter.) Enter your pH data in the following table.

Solution	Concentration (M)	pH	Acid, Base, Neutral
$HC_2H_3O_2$ (aq)	0.10		
HCl (aq)	0.10		
NaCl (aq)	0.10		
$NaC_2H_3O_2$ (aq)	0.10		

C. Determine the pH of a 0.10 M solution of HCl. Under salt I solutions, determine the pH of 0.10 M solutions of NaCl and $NaC_2H_3O_2$.

II. Data Analysis and Interpretation

A. Classify each of the solutions you measured in the previous section as acid, base, or neutral. If a solution is an acid or base indicate if it is strong or weak. Record your findings in the previous table.

B. Write a chemical equation that reflects the acid, base or neutral nature of each solution.

III. Data Collection:

A. Using the Buffers simulation, determine the pH of a solution made by mixing 100 mL of 20.0 X 10^{-2} M HCl and 100 mL of 20.0 X 10^{-2} M NaCl. Enter your pH data in the following table.

Solution	pH	Concentration of Acid (M)	Concentration of Salt (M)
HCl (aq) + NaCl (aq)			
$HC_2H_3O_2$ (aq) + NaCl (aq)			
$HC_2H_3O_2$ (aq) + $NaC_2H_3O_2$ (aq)			

B. Using the Buffers simulation, determine the pH of a solution made by mixing 100 mL of 20.0 X 10^{-2} M $HC_2H_3O_2$ and 100 mL of 20.0 X 10^{-2} M NaCl. Enter your pH data in the preceding table.

C. Using the Buffers simulation, determine the pH of a solution made by mixing 100 mL of 20.0 X 10^{-2} $HC_2H_3O_2$M and 100 mL of 20.0 X 10^{-2} M $NaC_2H_3O_2$. Enter your pH data in the preceding table.

IV. Data Analysis and Interpretation

A. Calculate the initial concentrations of HCl and NaCl in the solution after the acid and salt solutions are mixed together in section III. A. Enter your findings in the previous table.

B. Calculate the initial concentrations of $HC_2H_3O_2$ and NaCl in the solution when the acid and salt solutions are mixed together in section III. B. Enter your findings in the previous table.

C. Calculate the initial concentrations of $HC_2H_3O_2$ and $NaC_2H_3O_2$ in the solution when the acid and salt solutions are mixed together in section III. C. Enter your findings in the previous table.

D. Compare the initial concentrations of the HCl solutions in sections I. B. and III.A.

E. Compare the initial concentrations of the NaCl solutions in sections I. B. and III.A.

F. Compare the pH of the HCl (section I. B.) and NaCl solutions to the pH of the combined solutions (section III. A.). How do you account for your findings.

G. Compare the concentrations of the $HC_2H_3O_2$ solutions in sections I. B. and III.A.

H. Compare the concentrations of the $NaC_2H_3O_2$ solutions in sections I. B. and III.A.

I. Compare the pH of the $HC_2H_3O_2$ (section I. B.) and $NaC_2H_3O_2$ solutions to the pH of the combined solutions (section III. A.). How do you account for your findings

J. Compare the pH of the HCl/NaCl solution, $HC_2H_3O_2$/NaCl, and $HC_2H_3O_2/NaC_2H_3O_2$ solutions. How would you account for the differences and similarities?

V. Data Collection:

A. Using the Acid/Base pH simulation, determine the pHs of 100 mL volumes of 1.82 x 10^{-5} M HCl and 3.8 x 10^{-5} M $HC_2H_3O_2$ solutions. Enter your pH data in the following table.

Solution	pH	pH after adding 1 x 10^{-3} mol acid	pH after adding 1 x 10^{-3} mol base
1.82 x 10^{-5} M in HCl (aq)			
1.82 x 10^{-5} M in HCl (aq) and 1.82 x 10^{-5} M in NaCl (aq)	4.74	2.3	11.7
3.8 x 10^{-5} M in $HC_2H_3O_2$ (aq)			
3.8 x 10^{-5} M in $HC_2H_3O_2$ (aq) and 3.8 x 10^{-5} M in NaCl (aq)	4.74	2.3	11.7
0.1 M in $HC_2H_3O_2$ (aq) and 0.1 M in $NaC_2H_3O_2$ (aq)			

B. Using the Buffers simulation, determine the pH of a solution that is 0.1 M in $HC_2H_3O_2$ and 0.1 M in $NaC_2H_3O_2$. (Add 100mL of 20 X 10^{-2} M $HC_2H_3O_2$ to 100 mL of 20 X 10^{-2} M $NaC_2H_3O_2$.) Enter your pH data in the preceding table. Then click on the Go to Part II button and add 1.00 X 10^{-3} moles of HCl to the mixture. Enter your pH data in the preceding table. Finally, add 1.00 X 10^{-3} moles of NaOH to the original mixture. Enter your pH data in the preceding table.

VI Data Analysis and Interpretation

A. Compare the pH of the 1.82 x 10^{-5} M HCl solution with the pH of the combined 1.82 x 10^{-5} M HCl and 1.82 x 10^{-5} M NaCl solution. Explain any similarities or differences that you observe.

B. Compare the pH of the 3.8 x 10^{-5} M in $HC_2H_3O_2$ solution with the pH of the combined 3.8 x 10^{-5} M $HC_2H_3O_2$ and 3.8 x 10^{-5} M NaCl solution. Explain any similarities or differences that you observe.

C. According to the definition in section I. A. which of the combination solutions in section V. A. is a (are) buffer(s). Explain your choice(s).

D. What would happen to the pH of a buffer solution if you changed the initial concentrations of its components? Try out your prediction and test it with the software. Record your data below.

E. List all of the buffer solutions that can be made from the acids, bases, and salts listed in Part I of the Buffer simulation.

F. The chemical equation and conditions for a hypothetical buffer solution is:

$$\underset{.1M}{HW\ (aq)} + H_2O\ (l) \rightleftarrows H_3O^+\ (aq) + \underset{.1M}{W^-\ (aq)}$$

The solution is made by adding the salt NaW to the weak acid HW. Use this equation and LeChâtelier's Principle to explain how a buffer resists a change in pH when an acid or base is added to it.