Chapter 17 – Practice Problems with Buffers Name ________________________

	Composition of Solution
Solution #1	0.025 *M* $HOCl(aq)$
Solution #2	0.025 *M* $HOCl(aq)$ and 0.015 *M* $NaOCl(aq)$

1. Solution #1 is a 0.025 *M* solution of hypochlorous acid, HOCl ($K_a = 3.0 \times 10^{-8}$). Calculate each of the following quantities for Solution #1.

   (a) $[H^+]$ in Solution #1 (Show your work for this calculation.)

   (b) The pH of Solution #1 = ____________________

   (c) The % ionization of HOCl in Solution #1 = ____________________

2. Consider the following equilibrium as you make predictions about Solution #2.

$$HOCl(aq) \rightleftarrows H^+(aq) + OCl^-(aq)$$

   The major difference between Solution #2 and Solution #1 is the presence of additional hypochlorite (OCl^-) ions in Solution #2. Due to the common ion effect, the presence of additional ClO^- ions has an effect on the equilibrium shown above.

   (a) The presence of additional OCl^- ions in the solution causes the equilibrium position to shift toward the (reactants products).

   (b) The value of $[H^+]$ in Solution #2 should be (less than greater than) the value of $[H^+]$ in Solution #1.

   (c) The pH of Solution #2 should be (less than greater than) the pH of Solution #1.

   (d) The % ionization of HOCl in Solution #2 should be (less than greater than) the % ionization of HOCl in Solution #1.

Composition of Solution #2
0.025 *M* HOCl(*aq*) <u>and</u> 0.015 *M* NaOCl(*aq*)

3. In Question #2, you made several predictions about Solution #2. Now it is time to do the calculations to verify that your predictions were correct. Calculate each of the following quantities for Solution #2.

   (a) $[H^+]$ in Solution #2 (Show your work for this calculation.)

   (b) The pH of Solution #2 = ____________________

   (c) The % ionization of HOCl in Solution #2 = ____________________

Solution A	Solution B
a mixture of 1 *M* $HNO_3(aq)$ and 1 *M* $NaNO_3(aq)$	a mixture of 1 *M* $HNO_2(aq)$ and 1 *M* $NaNO_2(aq)$

4. Which of the solutions shown above would behave as a better buffer solution? Justify your answer.

5. The value of K_a for HNO_2 is equal to 4.5×10^{-4}.

   (a) The value of pK_a for HNO_2 is equal to ________________

   (b) Make predictions about the pH of each of the following solutions.

Solution	Predict the pH of each solution by choosing one of the following options. $pH < pK_a$ $pH = pK_a$ $pH > pK_a$
a mixture of 1.0 *M* HNO_2 and 1.0 *M* $NaNO_2$	
a mixture of 0.75 *M* HNO_2 and 0.55 *M* $NaNO_2$	
a mixture of 0.83 *M* HNO_2 and 1.1 *M* $NaNO_2$	

6. In Question #5, you made predictions about the pH values for three different solutions. Now it is time to do the calculations to verify that your predictions were correct. Calculate the pH of each solution, and show the set-up for each calculation.

(a) a mixture of 1.0 *M* $HNO_2(aq)$ and 1.0 *M* $NaNO_2(aq)$

(b) a mixture of 0.75 *M* $HNO_2(aq)$ and 0.55 *M* $NaNO_2(aq)$

(c) a mixture of 0.83 *M* $HNO_2(aq)$ and 1.1 *M* $NaNO_2(aq)$

7. The pH range of a buffer is the pH range over which the buffer acts effectively. A buffer is usually chosen in which the weak acid has a pK_a close to the desired pH of the buffer. Buffers that contain equimolar quantities of weak acid and conjugate base have a usable pH range within ±1 pH unit of the pK_a. The pH range of an equimolar mixture of $HNO_2(aq)$ and $NaNO_2(aq)$

is between pH __________ and pH ___________.

8. A student prepares a buffer solution by combining 100 mL of 1.0 *M* $HNO_2(aq)$ and 100 mL of 1.0 *M* $KNO_2(aq)$. Write the net-ionic equation that represents the reaction that best helps to explain why adding a few drops of 1.0 *M* $HCl(aq)$ to the buffer does not significantly change the pH of this solution.

$\longrightarrow$

9. A student prepares a buffer solution by combining 100 mL of 1.0 *M* $HNO_2(aq)$ and 100 mL of 1.0 *M* $KNO_2(aq)$. Write the net-ionic equation that represents the reaction that best helps to explain why adding a few drops of 1.0 *M* $NaOH(aq)$ to the buffer does not significantly change the pH of the solution.

$\longrightarrow$

Buffer X	Buffer Y
mixture of 1 M $HNO_2(aq)$ and 1 M $NaNO_2(aq)$	mixture of 0.1 M $HNO_2(aq)$ and 0.1 M $NaNO_2(aq)$

10. Which of the buffer solutions shown above will be more resistant to changes in pH when either a strong acid or a strong base is added to the buffer? Justify your answer.

11. Determine the volume, in mL, of 1.0 M $NaOH(aq)$ that should be added to 100. mL of 1.0 M $HNO_2(aq)$ in order to create a buffer solution that has a pH of 3.35. Justify your answer.

Substance	Formula	K_a
butanoic acid	$HC_4H_7O_2$	1.5×10^{-5}
dihydrogen phosphate	$H_2PO_4^-$	6.2×10^{-8}
ammonium	NH_4^+	5.6×10^{-10}

12. Use the information in the table above to calculate the pH for each of the following solutions.

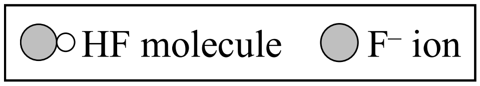
(a) mixture of 1.0 M $HC_4H_7O_2(aq)$ and 1.0 M $NaC_4H_7O_2(aq)$ ________________

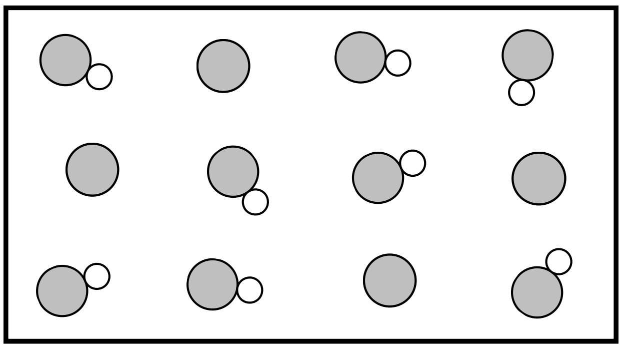
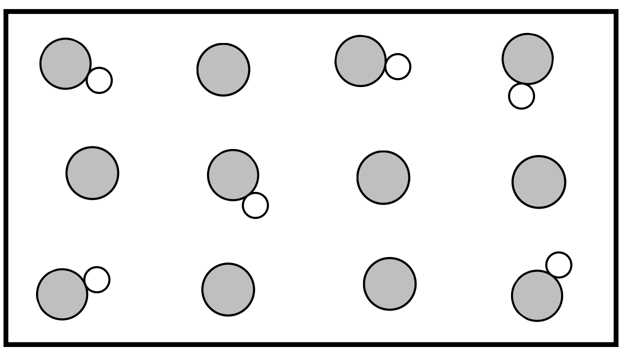
(b) mixture of 1.0 M $NaH_2PO_4(aq)$ and 1.0 M $Na_2HPO_4(aq)$ ________________

(c) mixture of 1.0 M $NH_3(aq)$ and 1.0 M $NH_4Cl(aq)$ ________________

13. Hydrofluoric acid, HF, is a weak acid with a K_a of 6.8×10^{-4} and a pK_a of 3.17. Three different buffer solutions are prepared in the laboratory that contain mixtures of HF(aq) and NaF(aq). A particulate representation of a small representative portion of each buffer solution is shown in the table below. Cations and water molecules are not shown.

Make predictions about the pH of each of these buffer solutions.



Buffer Solution	Particulate Diagram of the Buffer Solution	Predict the pH of each buffer solution by choosing one of the following options. pH < 3.17 pH = 3.17 pH > 3.17
#1		
#2		
#3