CH102 Spring 2019
Discussion #8
Chapter 14 and 15

Student name_____ TA name_____ Section_____

******http://quantum.bu.edu/courses/ch102-spring-2019/notes/AcidBaseOverview.pdf********

1. How can you make a solution that best resists change in pH?

2. Define 'buffer' in your own words:

3. Which of the following could be added to an aqueous solution of a weak acid HA to convert the solution into a solution that resists change in pH (buffer)? *Hint: think how to create the appropriate conditions for a buffer.*

   NaCl(s) HA(s) NaOH(s) HCl(aq) NaA(s)

4. Which of the following could be added to an aqueous solution of a weak base A^- to convert the solution into a buffer?

   NaCl(s) HA(s) NaOH(s) HCl(aq) NaA(s)

5. Using an expression for K_a derive an expression for $[H_3O^+]$

6. How can you make a buffer solution where $[H_3O^+] = K_a$. (or $pH = pK_a$)

7. If a 1.0 liter solution has 4.4mol HCl, 4.6mol NaOH and 0.50mol HB, what is the pH when the resulting solution reaches equilibrium? K_a of HB is 5.0×10^{-5}. *Hint: To decide which equilibrium to use compare K_a and K_b.*
   Write the chemical reaction(s) that will proceed 100%. *Hint: limiting reagent*

   What is the chemical equilibrium reaction?

   What is the equilibrium expression of K?

   ICE table:

   $[H_3O^+(aq)] =$
   $pH =$

8. If a 1.0-liter solution has 4.40mol HCl, 4.60mol NaOH and 0.50mol HA, what is the pH when the resulting solution reaches equilibrium? K_a of HA is 5.0×10^{-10}.
   Write the chemical reaction(s) that will precede 100%. *Hint: limiting reagent*

   What is the chemical equilibrium reaction?

   What is the equilibrium expression of K?

   ICE table:

   pH=

9. 0.400 mol NaOH(s) is added to 1.00L of a 1.00 M solution of an acid HA with Ka = 1.00×10^{-4}. Calculate $[H_3O^+ (aq)]$ and the pH of the resulting solution. Assume the volume of the solution does not change when the NaOH(s) is added.

   Write the chemical reaction that will proceed 100%.

   What is the chemical equilibrium reaction?

   What is the equilibrium expression of K_a?

   ICE table:

   $[H_3O^+ (aq)]$ =
   pH =

10. A buffer is made by adding 6.0 mol of HA and 4.0 mol of A^- to enough water to make 1.0 L of solution. If K_a is 2.0×10^{-5} calculate the pH of this solution.

    What is the chemical equilibrium reaction?

    ICE table:

    pH =

11. Calculate the pH of this solution **after** 1.0 L of 2.0 M HCl is added to the buffer solution from the previous question (#10).

    a. Will the addition of HCl increase, decrease, or not change the pH?

    b. What will be the limiting reagent (make a limiting reagent table).

    c. What is the chemical equilibrium reaction?

    d. Calculate the pH of the solution at equilibrium. *Hint: use an ICE table and be careful with final volumes of the solution.*

    e. Did the pH change drastically compared to the previous? Why or why not?

12. 1.0L of 4 M HCl is added to the buffer solution in question 10. *Hint: is it still a buffer?*

    a. Will the addition of HCl increase, decrease, or not change the pH?

    b. What will be the limiting reagent? *Hint: make a limiting reagent table*

    c. What is the chemical equilibrium reaction?

d. Calculate the pH of the solution at equilibrium. *Hint: use an ICE table and be careful with final volumes of the solution.*

e. Did the pH change drastically compared to the pH in question 10? Why or why not?

13. Calculate the pH of the solution in question 10 after 5.0 mol of HCl is added. Assume the change in volume due to the addition of HCl is negligible. (Ask yourself: What will be the limiting reagent? What is the chemical equilibrium reaction?)

a. Did the pH change drastically compared to the change in questions 11 and 12? Why or why not?

14. Calculate the pH of the solution in question 10 after 1.0L of 5.0 M NaOH is added. *Hint: Does the final volume of the solution change?* (Ask yourself: What will be the limiting reagent reaction? What is the chemical equilibrium reaction?)

15. Calculate pH of the solution in question 10 after 6.0 moles of NaOH is added. Assume the change in volume due to the addition of NaOH is negligible.

16. Buffer solution has pH=5.0 and pK_a=5.3. What is the ratio of the weak acid concentration to its conjugate base, $\frac{[HA]}{[A^-]}$, that is needed to make a buffer of the given pH? What are some concentrations of acid and base you need to achieve that ratio?

17. You are asked to create a buffer for which the ratio of $\frac{[HA]}{[A^-]} = 0.0500$. What volume, in mL, of a 0.100 M solution of NaOH must be added to 100.0 mL of a 0.300 M solution of weak acid whose ionization constant is $K_a = 2.00\times10^{-4}$?

18. One of the most important buffering systems in the biological realm is the carbonic acid (H_2CO_3) and carbonate ion (HCO_3^-) system that maintains the pH of blood plasma to a relatively constant value. In blood at 37°C, the K_a the carbonic acid is 8×10^{-8} and the concentrations of the buffer components in blood plasma are 0.24 M HCO_3^- and 0.12 M H_2CO_3. Calculate the pH of blood for these conditions.

    a. The actual concentrations of the buffer components in blood plasma are 0.024 M HCO_3^- and 0.0012 H_2CO_3. Circle the condition for which buffering in blood is most effective.

    added acid added base equal response to acid or base

19. You have a 1M solutions of each of the following: HF, NaCl, NaF, $HClO_2$, and NH_2OH. The data in the table below will be helpful in answering the questions:

    (a) The solution with the **highest** pH is _____

    (b) The solution with the **lowest** pH is _____

	K_a	K_b
HF	4×10^{-4}	
$HClO_2$	1×10^{-2}	
NH_2OH		1×10^{-8}

20. *Para*-aminobenzoic acid, $H_2NC_6H_4CO_2H$ or PABA, has been used in sunscreens as a UV filter as early as 1948 after *in vivo* studies on mice showed that PABA reduced UV damage. In the 1980's, however, animal studies suggested that PABA might increase the risk of cellular UV damage. Since then, PABA is no longer a preferred ingredient in sunscreens. Benzoic acid, $C_6H_5CO_2H$, is a synthetic precursor to PABA and a weak acid with $K_a = 6.0 \times 10^{-5}$.

    a. What is the pH of a solution made from 0.40 mol of benzoic acid in 2.0 L of water at 25°C

    b. NaOH is added to the solution in (a) until *just enough* base has been added to completely consume all of the benzoic acid. What volume (in mL) of 0.5 M NaOH solution must be added to reach this point?

    c. Write the balanced, net ionic acid-base chemical equation that will take place in solution once all of the NaOH solution, which was just enough to consume the benzoic acid, has been added in (b).

    d. NaOH is added to the solution in (a) until *just enough* base has been added so the pH of the solution was equivalent to the pK_a. What volume (in mL) of 0.5 M NaOH solution must be added to reach this point?

21. Acetic acid is a weak acid with $K_a = 2\times10^{-5}$. How many moles of acetate ion need to be added to 1.0 L of 0.10 M acetic acid to get a buffer with pH = 4.3? Assume that added acetate ion does not change the volume of the solution.

22. In a 1.0 M NaOH solution at 25°C, for every hydronium ion how many water molecules must be present?

23. If a 1.0 liter solution has 5.6mol HCl, 5.3mol NaOH and 0.30mol NaA, what is the pH when the resulting solution reaches equilibrium? K_a of HA is 5.0×10^{-10}

    Write the chemical reaction(s) that will proceed 100%. *Hint: limiting reagent*

    What is the chemical equilibrium reaction?

    ICE table:

    pH=

24. If a 1.0 liter solution has 5.30mol HCl, 5.60mol NaOH and 0.30mol HA, what is the pH when the resulting solution reaches equilibrium? K_a of HA is 5.0×10^{-10}

    Write the chemical reaction(s) that will proceed 100%. *Hint: limiting reagent*

    What is the chemical equilibrium reaction?

    ICE table:

    pH=

25. If a 1.00 liter solution has 5.80mol HCl, 5.30mol NaOH and 0.30mol A^-, what is the pH when the resulting solution reaches equilibrium? K_a of HA is 5.00×10^{-10}

In preparation for chapter 15:

- Molar Solubility is the number of moles of the solid that dissolves in 1L of solution to form saturated solution. $K_{eq} = K_{sp}$ – Solubility product constant
- Example of Solubility product: $MX_{2\,(s)} \rightleftharpoons M^{2+}_{(aq)} + 2X^-_{(aq)}$; $K_{sp} = [M^{2+}_{(aq)}][X^-_{(aq)}]^2$

1. The K_{sp} of CaF_2 is 4.0×10^{-11}, what is the molar solubility "s" for this compound in water?

Write the chemical equilibrium reaction:

Construct the ICE table:

K_{sp} =

s =

What are the equilibrium concentrations of $[Ca^{2+}]$ = and $[F^-]$=

2. What is the molar solubility "s" of CaF_2 in an aqueous solution of 0.10 M NaF?

Write the chemical equilibrium reaction:

Construct the ICE table:

K_{sp} =

s =

$[Ca^{2+}]$ = and $[F^-]$=

3. What is the molar solubility "s" of CaF_2 in an aqueous solution of 0.10 M $CaCl_2$?

Write the chemical equilibrium reaction:

Construct the ICE table:

K_{sp} =

s =

$[Ca^{2+}]$ = and $[F^-]$=

4. If you mix 0.5L of 0.1M NaF with 0.5L of 0.1M $CaCl_2$, there is the possibility of $CaF_2(s)$ forming.

   a. With regards to CaF_2, circle the correct choice: $Q_{sp} < K_{sp}$; $Q_{sp} = K_{sp}$; $Q_{sp} > K_{sp}$

   b. With regards to CaF_2, circle the correct choice:
      I. Precipitation will occur
      II. Precipitation will not occur
      III. More information needed

5. The number of moles of a solid that dissolves in 1.0 liter of water is called the molar solubility. For Ag_2SO_4, the molar solubility is 1.4×10^{-2} M. What is the K_{sp} for this compound?

Chemical equilibrium reaction:

Construct an ICE table:

$K_{sp=}$

6. A solution is prepared from 0.02 mol of $MgCl_2$ and 0.004 mol of NaOH in 1L of water. What is the pH of the solution? The K_{sp} of $Mg(OH)_2$ is 6×10^{-12}.

7. An 80. mL sample of 0.040 M lead nitrate, $Pb(NO_3)_2$, is titrated with 0.010 M sodium fluoride, NaF, until the first appearance of precipitate. The precipitate first appears after 20. mL of sodium fluoride are added. You can assume that the total final volume is 100. mL. What is the value of K_{sp} for PbF_2?

8. The molar solubility of silver chloride is 4.0×10^{-5}. Calculate the K_{sp} of silver chloride.

Hand out numerical answers

1.
2.
3. NaOH, NaA
4. HA, HCl
5. $[H_3O^+] = K_a\,[HA]/[A]$
6. $[HA]=[A]$
7. pH =4.11
8. pH =9.11
9. 1.5×10^{-4}, 3.82
10. pH = 4.52
11. pH = 4.10
12.
    a. Decrease
    b. pH = 2.0
13. pH = 0
14. pH = 5.65
15. pH = 9.85
16. $[HA]/[A] = 2$
17. 286 mL
18. pH = 7.4, added acid
19.
    a. NH_2OH
    b. $HClO_2$
20.
    a. pH = 2.46
    b. 800 mL
    c.
    d. 400 mL
21. 4×10^{-2}
22. 55×10^{14}
23. 4.91
24. 11.39
25. 0.698

Numerical answers for chapter 15

1.
   $CaF_{2(s)} \rightleftharpoons Ca^{2+}_{(aq)} + 2F^-_{(aq)}$
   $K_{sp} = [2s]^2[s]$
   $s = 2.2\times10^{-4}$ M
   $[Ca^{2+}] = 2.2\times10^{-4}$ M; $[F^-] = 4.4\times10^{-4}$ M
2.
   $CaF_{2(s)} \rightleftharpoons Ca^{2+}_{(aq)} + 2F^-_{(aq)}$
   $K_{sp} = [s][0.10]^2$
   $s = 4.0\times10^{-9}$ M
   $[Ca^{2+}] = 4.0\times10^{-9}$ M; $[F^-] = 0.10$ M
3.
   $CaF_{2(s)} \rightleftharpoons Ca^{2+}_{(aq)} + 2F^-_{(aq)}$
   $K_{sp} = [2s]^2[0.10]$
   $s = 1.0\times10^{-5}$
   $[Ca^{2+}] =0.10$ M; $[F^-] = 2.0\times10^{-5}$ M
4.
   a. $Q_{sp} > K_{sp}$
   b. I
5.
   $Ag_2SO_{4(s)} \rightleftharpoons 2Ag^+_{(aq)} + SO_4^{2-}{}_{(aq)}$
   $K_{sp} = 1.1\times10^{-5}$
6. 9.3
7. 1.3×10^{-7}
8. 16×10^{-10}