Chemistry 102 20118 Discussion #8, Chapter 14 and 15

- http://quantum.bu.edu/courses/ch102-spring-2018/notes/AcidBaseOverview.pdf

Student name_____ TA name_____ Section_____

1. If 1.0 liter solution has 5.6mol HCl, 5.3mol NaOH and 0.30mol NaA is added together what is the pH when the resulting solution reaches equilibrium?(K_a of HA is 5.0×10^{-10})(Answer:4.9)

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

   What is the chemical equilibrium reaction?

   ICE table:

   pH=

2. If 1.0 liter solution has 5.30mol HCl, 5.60mol NaOH and 0.30mol HA is added together what is the pH when the resulting solution reaches equilibrium?(K_a of HA is 5.0×10^{-10})(Answer:11.39)

   Write the chemical reaction(s) that will precede 100%? (Hint: limiting reagent)

   What is the chemical equilibrium reaction?

   ICE table:

   pH=

3. If 1.0 liter solution has 5.80mol HCl, 5.30mol NaOH and 0.30mol A^- is added together what is the pH when the resulting solution reaches equilibrium?(K_a of HA is 5.0×10^{-10})(Answer:0.70)

4. If 1.0 liter solution has 4.4mol HCl, 4.6mol NaOH and 0.50mol HA is added together what is the pH when the resulting solution reaches equilibrium?(K_a of HA is 5.0×10^{-5})(Hint: To decide which equilibrium to use compare K_a and K_b) (Answer:4.1)
   Write the chemical reaction(s) that will precede 100%? (Hint: limiting reagent)

   What is the chemical equilibrium reaction?

   ICE table:

   pH=

5. If 1.0 liter solution has 4.40mol HCl, 4.60mol NaOH and 0.50mol HA is added together what is the pH when the resulting solution reaches equilibrium?(K_a of HA is 5.0×10^{-10})(Hint: To decide which equilibrium to use compare K_a and K_b) (Answer:9.11)

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

7. Define in your own words what is a buffer.

8. 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*)

9. 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*)

10. Using an expression for K_a derive an expression for $\mathbf{[H_3O^+]}$

11. How can you make a buffer solution where $\mathbf{[H_3O^+]}=K_a$. (or $pH=pK_a$)

12. 0.400 mol NaOH(*s*) is added to 1.00L of a 1.00 M solution of an acid (HA) with Ka = $1.00\cdot10^{-4}$. 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.(Answer: $1.5*10^{-4}$, 3.824)

    Write the chemical reaction that will precede 100%? (Hint: limiting reagent)

    What is the chemical equilibrium reaction?

    What is the equilibrium **expression** of K_a:

    ICE table:

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

13. 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. ($K_a = 2.0 * 10^{-5}$) Calculate the pH of this solution. (Answer: 4.52)

    What is the chemical equilibrium reaction?

    ICE table:

    pH=

14. Calculate the pH of this solution *after* 1.0 L of 2.0 M HCl is added to the buffer solution in question 13. (Answer:4.10)

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

    b) What will react first? 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. (Use an ICE table and be careful with final volumes of the solution.)

    e) Did the pH change dramatically compared to the question 13? Why or why not?

15. After 1.0L of 4 M HCl is added to the buffer solution in question 13. (Hint: at the very end what is still in the solution? Is it still a buffer?)(Answer: 2.0)

    f) Will the addition of HCl increase, decrease, or not change the pH?

    g) What will react first? What will be the limiting reagent (make a limiting reagent table)

    h) What is the chemical equilibrium reaction?

    i) Calculate the pH of the solution at equilibrium. (Use an ICE table and be careful with final volumes of the solution.)

    j) Did the pH change dramatically compared to the pH in question 13? Why or why not?

16. Calculate the pH of the solution in question 13 after 5 mol of HCl is added. Assume the change in volume due to the addition of HCl is negligible. (Ask yourself: What will react first? What will be the limiting reagent (make a limiting reagent table)(What is the chemical equilibrium reaction?) (Answer: 0)

    a) Did the pH change dramatically compared to the change in question 14 and 15? Why or why not?

17. Calculate the pH of the solution in question 13 after 1.0L of 5 M NaOH is added. (Hint: does the final volume of the solution changes? Ask yourself: What will react first? What will be the limiting reagent reaction? What is the chemical equilibrium reaction?)(Answer: 5.7)

18. Calculate pH of the solution in question 13 after 6 moles of NaOH(aq) is added. Assume the change in volume due to the addition of NaOH(aq) is negligible. (Ask yourself: What will react first? What will be the limiting reagent reaction? What is the chemical equilibrium reaction? (Answer: 9.8)

19. Buffer Solution has pH=5 and pK_a=5.3. What is the ratio of the weak acid concentration to its conjugate base that is needed to make a buffer of the given pH, [HA (aq)]/[A^- (aq)]? Propose what concentrations of acid and base you need to achieve that ratio?(Answer: 2M and 1M)

20. You are asked to create a buffer solution by adding NaOH(*aq*) to 100.0 mL of a 0.100 M solution of weak acid with $Ka = 1 \cdot 10^{-4}$. What value of c_a / c_b is required for the buffer solution to have pH = 3.3?(Answer:5)

21. You are asked to create a buffer for which $c_a / c_b = 0.0500$. 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 $K_a = 2.00 \cdot 10^{-4}$? (Answer: (286ml))

22. 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 $8 \cdot 10^{-8}$ 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. (Answer:7.4)

    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

23. You have a 1M solution 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}

24. *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 ^oC?(Answer: 2.46)

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 0.50 M NaOH solution must be added to reach this point?(Answer: 800mL)

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 0.50 M NaOH solution must be added to reach this point? (Answer: 400mL)

25. Acetic acid is a weak acid with $K_a = 2 \times 10^{-5}$. 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.(Answer: $4*10^{-2}$)

26. In a 1.0 M NaOH solution at 25 ^oC, for every hydronium ion how many water molecules must be present?(Answer:$55*10^{14}$)

Chapter 15 starts here not part of exam 2:

- **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**
- **Solubility product:** **MX_2 (s) <=> M^{2+} (aq)+ $2X^-$(aq)**
  K_{sp}= [M^{2+} (aq)][X^- (aq)]^2
- Oxidation Reduction Reactions

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

a. Chemical equilibrium reaction:

b. Construct the ICE table:

c. **K_{sp}=**

d. **s=**

e. What is $[Ca^{2+}]$ = and $[F^-]$=

2. What is the molar solubility "s" of **CaF_2** in an aqueous solution of **0.10 M NaF**?
(Answers: **$4.0 \cdot 10^{-9}$, 0.10)**

a. Chemical equilibrium reaction:

b. Construct an ICE table:

c. **K_{sp}=**

d. **s=** $[Ca^{2+}]$ = $[F^-]$=

3. What is the molar solubility "s" of **CaF_2** in an aqueous solution of **0.10 M $CaCl_2$**? **(Answers: $1.0 \cdot 10^{-5}$, $2.0 \cdot 10^{-5}$, 0.10)**

a. Chemical equilibrium reaction:

b. Construct an ICE table:

c. **K_{sp}=**

d. **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
- **Precipitation will occur**
- **Precipitation will not occur**
- **More information needed**

5. The number of moles of a solid that dissolves in 1 liter of water is called the molar solubility. For **Ag_2SO_4**, the molar solubility is **$1.4 \cdot 10^{-2}$ M**. What is the **K_{sp}** for this compound? **(Answers:$1.1 \cdot 10^{-5}$)**

a. Chemical equilibrium reaction:

b. Construct an ICE table:

c. **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 $x10^{-12}$. (Answer:9.3)

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? (Answer: $1.3*10^{-7}$)

8. The molar solubility of silver chloride is $4.0x10^{-5}$. Calculate the K_{sp} of silver chloride.(**Answer**: $16*10^{-10}$)