Checklist for Exam 3

Chapter 15 Sections 8 - 15. (These are skills from Chapter 15 that you will need for Chapter 16)

- ❑ I can do MICE table calculations for strong acids, weak acids, strong bases, and weak bases. For example, given the initial concentration of an acid and its K_a value, I can determine the concentration of all species as well as the pH, etc. Another example, given the initial concentration of a weak base, and the pH at equilibrium, I can determine a value for K_b for the equilibrium. Third example: I can calculate the pH of any strong acid or base given the initial concentration.

- ❑ I can create a table of weak acids and their conjugate weak bases and I can use these pairs to determine K_a or K_b given one or the other using $K_w = K_a^{wa} \times K_b^{cwb}$.

- ❑ I know how to convert K_a and pK_a^{wa} and K_b and pK_b^{wb} and that $pK_a^{wa} + pK_b^{cwb} = 14$.

- ❑ I can calculate percent dissociation once I have completed my MICE table.

- ❑ I am comfortable with writing equilibrium expressions for weak acids, strong acids and calculating the pH of any solution (given the concentration) of a weak acid or weak base. I can calculate the pH for solutions of strong acids and strong bases, given the concentration.

- ❑ I can look at the formula of a salt and determine if it is acidic, basic, or neutral. I also know when I need more information. In most cases, I can solve for pH given an initial concentration.

- ❑ I know how to recognize a Lewis acid from its Lewis dot structure. I know how to identify a Lewis base, either by its Lewis structure or because iit is a metal cation. I can sketch the product of the reaction of a Lewis acid and base.

Section 16.1 Neutralization reactions.

- ❑ I know how to write net ionic equilibrium expressions and how to calculate numerical values for K_n for the following. I know that pH neutral ions are not shown in the net ionic equations.
    - ❑ Strong acids reacting with strong bases
    - ❑ Weak acids reacting with strong bases
    - ❑ Strong acids reacting with weak bases
    - ❑ Weak acids reacting with weak bases (here the net ionic is often the same as the overall reaction.)

Sections 16.2 – 16.4 Buffers.

- ❑ I know the two recipes for making a buffer. (We also did this in lab!)
    - ❑ Recipe 1. Mix a weak acid with its conjugate weak base. They do not react, only mix.
    - ❑ Recipe 2. React a weak acid with a limiting reagent amount of strong base.
    - ❑ Recipe 3. React a weak base with a limiting reagent amount of strong acid.

- ❑ I know how to determine the pH of any buffer given the concentrations or the moles of acid and base. I will use the Henderson-Hasselbalch *buffer* equation expressed in terms of concentrations (Recipe 1 only) OR moles (Recipe 1 or 2, 3) of weak base and weak acid.

- ❑ I know how to use the Henderson-Hasselbalch Buffer Equation to determine what the pH becomes when small amounts of strong acid or strong base are added to a buffer. I know to do this, I must work in moles.

- ❑ I know how to determine the buffer capacity towards strong acid or strong base.

- ❑ I know how to calculate the ratio of weak base to weak acid in order to prepare a buffer of desired pH.

Sections 16.5 and 16.6 Titration of a strong acid with a strong base.

- ❑ I can "read" a titration graph and determine if is the titration of sa + sb or wa + sb.

- ❑ Regarding sa + sb, I can calculate the pH anywhere along the way using a ***mole*** ICE table (nICE table) and the reaction: $H_3O^+ + OH^- \rightarrow 2\ H_2O$. To calculate the pH, I must first determine the concentration of excess H_3O^+ or OH^- and to do that, I must use M=n/V and that V is the total volume.

- ❑ I know that at the equivalence point, $n_{acid} = n_{base}$, and the pH = 7.

- ❑ I know that I can use n = MV anytime I want (for example, $n_{acid} = M_{acid} \times V_{acid}$, $n_{base} = M_{base} \times V_{base}$), but only at the equivalence point is the following expression true: $n_{acid} = M_{acid} \times V_{acid} = n_{base} = M_{base} \times V_{base}$

Sections 16.7 Titration of a weak acid with a strong base.

- ❑ I can "read" a titration graph and determine the pK_a which is equal to the pH half-way to the equivalence point (when $n_{HA} = n_{A^-}$).

- ❑ Regarding wa + sb (OH^-), I can calculate the pH anywhere along the way. There are 4 regions, each with a separate calculation:
    - ❑ Region I. Before any OH^- has been added: The pH of the weak acid is determined as you did in Chapter 15, using a MICE table and the 400 Rule.

- ❑ Region II. The buffer region (between V = 0 mL and the equivalence point): This is a Recipe 2(a) buffer calculation (Reaction a weak acid with a limiting reagent amount of strong base). Use the mole version of the Henderson-Hasselbalch and use the buffer wheel! Note that the initial number of moles of weak base = 0.
- ❑ Region III. Equivalence point: Here you have completely converted all of your weak acid into weak base, so you need to do a Chapter 15 weak base K_b calculation. At the equivalence point, n_{A^-} (now present) = n_{HA} (originally present) = $M_{HA} \times V_{HA}$ = n_{OH^-} (added, but now all gone) = $M_{OH^-} \times V_{OH^-}$. Use a MICE table, and total volume.
- ❑ Region IV. After the equivalence point, there is excess OH^-. Simply determine the moles of excess hydroxide, divide by the total volume in liters and you have $[OH^-]$ using a nice table. Then I can determine pOH and pH.
- ❑ I know that at the equivalence point, $n_{acid} = n_{base}$, and the pH > 7.
- ❑ I know that I can use n = MV anytime I want (for example, $n_{HA} = M_{HA} \times V_{HA}$, $n_{OH^-} = M_{OH^-} \times V_{OH^-}$), but only at the equivalence point is the following expression true: n_{HA} (originally present) = $M_{HA} \times V_{HA}$ = n_{OH^-} (added, but now all gone) = $M_{OH^-} \times V_{OH^-}$

Sections 16.8 Titration of a weak base with a strong acid.

- ❑ I can "read" a titration graph and determine the pK_a which is equal to the pH half-way to the equivalence point (when $n_{HA} = n_{A^-}$).
- ❑ Regarding wb + sa (H_3O^+), I can calculate the pH anywhere along the way. There are 4 regions, each with a separate calculation:
  - ❑ Region I. Before any H_3O^+ has been added: The pH of the weak base is determined as you did in Chapter 15, using K_b and a MICE table.
  - ❑ Region II. The buffer region (between V = 0 mL and the equivalence point): This is a Recipe 2-b buffer calculation (Reaction a weak base with a limiting reagent amount of strong acid). Use the mole version of the Henderson-Hasselbalch and use the buffer wheel! Note that the initial number of moles of weak acid = 0.
  - ❑ Region III. Equivalence point: Here you have completely converted all of your weak base into weak acid, so you need to do a Chapter 15 weak acid K_a calculation. At the equivalence point, n_{HA} (now present) = n_{A^-} (originally present) = $M_{A^-} \times V_{A^-}$ = $n_{H_3O^+}$ = $M_{H_3O^+} \times V_{H_3O^+}$ (added, but now all gone). Use a MICE table, and total volume.
  - ❑ Region IV. After the equivalence point, there is excess H_3O^+. Simply determine the moles of excess hydroxide using a nice table, divide by the total volume in liters and you have $[H_3O^+]$. Then you can determine pH.
- ❑ I know that at the equivalence point, $n_{acid} = n_{base}$, and the pH < 7.

Section 16.9. Titration of polyprotic acids with strong base.

- ❑ I know what the titration curve looks like for a polyprotic acid with OH^-.
- ❑ I can "read" the titration curve in order to determine all of the K_a values.
- ❑ I know when I can use $M_{H_3O^+} \times V_{H_3O^+} = M_{OH^-} V_{OH^-}$ and how the first equivalence point is related to the second/third.
- ❑ I know what buffer systems exist along the titration curve (what the wa and wb base are that constitute a buffer).
- ❑ I can list all of the major acid and base species present at various points along the titration curve.
- ❑ I can pick a reasonable indictor (given K_a values for the indicator and the color changes they undergo) for each equivalence point

Section 16.10. Solubility expressions.

- ❑ I know the solubility rules well enough to recognize an insoluble salt.
- ❑ I can write the solubility equilibrium expression and the K_{sp} expressions for any "insoluble" salt.

Section 16.11. Solubility and K_{sp}.

- ❑ Given K_{sp}, I can calculate the molar solubility of a salt in pure water. I know that I must follow the 3-step process of 1. write the equilibrium expression and the associated K_{sp} expression; 2. Set up the MICE table; and 3. Solve for x, the molar solubility.
- ❑ Given the molar solubility, I can calculate K_{sp} of a salt in pure water. I know that I must follow the same 3-step process as above.
- ❑ I know solubility is most conveniently given in molarity, the molar solubility, but sometimes it is given in other units such as mg/L. When this happens, I know I must be able to convert from those units to molarity.

❑ I can solve for solubility for two or more salts and list them in order of increasing (or decr) molar solubility.

Section 16.12. Common ion problems.

❑ Given K_{sp}, I can calculate the molar solubility of an insoluble salt in the presence of one of the ions from another source. I know that I must follow the 3-step process of 1. Write the equilibrium expression and the associated K_{sp} expression; 2. Set up the MICE table (this time, one of the two ions will have a numerical value (the molarity of the common ion) in the "I" line); and 3. Solve for x, the molar solubility. Don't forget UNITS!

Section 16.13. Will a precipitate form?

❑ Given K_{sp} and the initial concentrations of two ions, I can determine if a precipitate will form. This involves: 1. write the equilibrium expression and the associated K_{sp} expression; 2. Set up the MICE table (we will only use the "I" line), but this line needs to be filled in correctly (see next item); 3. Write the Q_{sp} expression for the "I" line; 4. Compare Q_{sp} and K_{sp}.

❑ One "issue" is that the concentrations you want to use in the "I" line may not be the ones listed if a "mutual dilution" has taken place. This can be determined by the wording of the problem. If two solutions were mixed, they mutually diluted one another and you must use the dilution formula, $M_c V_c = M_d V_d$ in order to determine the correct concentrations to list in the "I" line.

Chapter 17 Entropy and free energy
Section 17.1 and 17.2. Predicting the signs of ΔH, ΔS and ΔG.

❑ I know how to assess a process or chemical reaction and assign signs (+, 0, -) for each ΔH, ΔS, and ΔG.
   ❑ I know for ΔH, I ask myself, "Does this take heat or give off heat?"
   ❑ For ΔS, I ask myself, "Does this create more disorder or less disorder?"
   ❑ For ΔG, I ask myself, "Does this or can this process happen at the temperature indicated?"

Sections 17.5 Calculating ΔH⁰, ΔS⁰ and ΔG⁰ from the tables.

❑ I know how to calculate ΔH⁰, ΔS⁰ and ΔG⁰ from the standard tables.

❑ Alternatively, once I have ΔH⁰ and ΔS⁰, I can calculate ΔG⁰ from the equation, ΔG⁰ = ΔH⁰ - TΔS⁰.

Sections 17.7 – 17.9 Using ΔG = ΔH - TΔS and ΔG⁰ = ΔH⁰ - TΔS⁰.

❑ I know that for ΔH and ΔS are relatively temperature independent as long as we do not stray too far from 298 K. This allows us to estimate ΔG at temperatures other than 298 K by using the standard tables for ΔH⁰ and saying this is approximately the same as ΔH. Ditto for ΔS. We can then approximate ΔG = ΔH⁰ -TΔS⁰.

❑ Given the signs for ΔH and ΔS, I can determine at what temperature conditions the reaction will be spontaneous, if ever, This is the "4 scenarios" view of things:
   ❑ ΔH > 0 and ΔS > 0, the reaction is spontaneous at high temperatures but not low temperatures.
   ❑ ΔH < 0 and ΔS < 0, the reaction is spontaneous at low temperatures but not high temperatures
   ❑ ΔH < 0 and ΔS > 0, the reaction is always spontaneous at any temperature.
   ❑ ΔH > 0 and ΔS < 0, the reaction is never spontaneous.

Sections 17.10 – 17.11 ΔG, K_p, and Q_p

❑ I know the formula ΔG = ΔG⁰ + RTlnQ_p and how to use it to determine if a process is spontaneous under non-standard conditions.

❑ I know that at equilibrium, ΔG = 0, so the formula ΔG = ΔG⁰ + RTlnQ_p becomes ΔG = 0 = ΔG⁰ + RTlnK_p
or
ΔG⁰ = -RTlnK_p. I can use this formula as well.