

## Textbook Chapters for Exam 2

Chapters 6 and 7. You're responsible for any material covered in class whether it was on the homework or not. This review sheet covers most everything we have done. Also remember that no equations are given on the exams. Values for equilibrium constants are given where needed although you should know  $K_w$ .

## Chemical Equilibrium

- Know how to WRITE the **mass action expression** — same as equilibrium equation

How does this expression change and the value of  $K$  when a reaction is "flipped", doubled, halved?

When is this expression equal to  $Q$ ? When is it equal to  $K$ ?

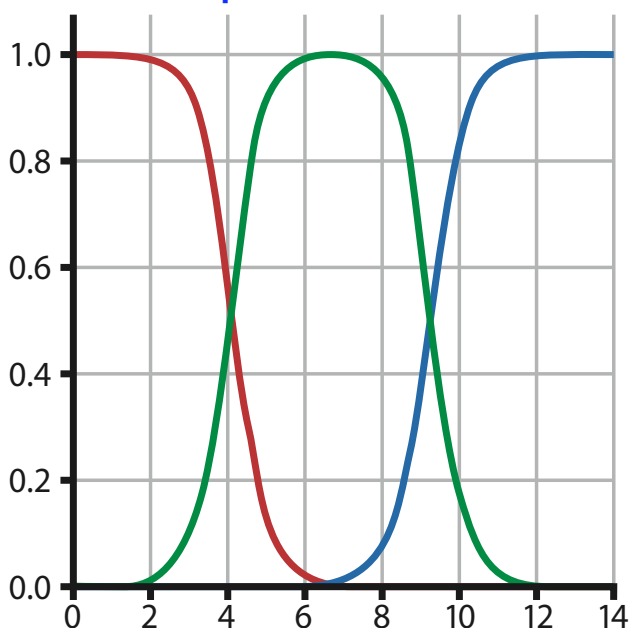
- What is thermodynamic  $K$ ? How does that relate to  $K_p$  and  $K_c$ ?
- How does  $K_p$  relate to  $K_c$ ? When would they be equal?
- What is the relationship between  $\Delta G_{\text{rxn}}$  and  $Q$ ?  
between  $\Delta G^0_{\text{rxn}}$  and  $K$ ?
- What are the units for an equilibrium constant? There are NO units. Why?
- Calculations involving the equilibrium constant,  $K$
- Know how to calculate the equilibrium constant if given equilibrium amounts of reactants and products. This is where you are given the entire bottom row (final equilibrium concentrations) of the equilibrium table (ICE Table) that we use.
- Know how to calculate the equilibrium constant if given initial concentrations and ONE final concentration at equilibrium. This is where you are given only ONE of the bottom row concentrations of your equilibrium table.
- Know how to calculate final (equilibrium) concentrations if given initial concentrations and the value of  $K_c$ . This is the typical type problem where you must set up and solve the equilibrium expression for  $x$ . Your entire bottom row will be lots of concentration formulas containing  $x$ .
- Know how to predict the direction of a reaction if given concentrations and a value for  $K$ . (hint: compare  $Q$  to  $K$ )
- Know how to predict how equilibrium shifts (L, R, NC) when a system is stressed concentration changes, pressure changes, temperature changes ( $\Delta H$  is needed), and addition of a catalyst. This is all a complete understanding of **LeChâtelier's Principle !!!**
- What does a catalyst do for a given reaction?
- How does  $K$  change with temperature? Van't Hoff Equation!

## Acid/Base Theory and Aqueous Equilibria

- Know difference in a strong, weak, and non-electrolytes.
- Know your 3 Acid/Base Theories and their definitions.
- Know how to calculate concentrations of ions for strong electrolyte solutions (strong acids and bases fit this criteria).
- Memorize the 7 Strong Acids and 8 Strong Bases listed on my help sheet on our web site.
- Know the autoionization of water. How is it shown? What is the ion product for water?  
Memorize the value of  $K_w$  at 25°C —  $1.0 \times 10^{-14}$
- Know how to calculate ANY "p" function — **pH, pOH, pK<sub>a</sub>, pK<sub>b</sub>, pK<sub>w</sub>**, and in general, pX. Of course know how to do the opposite too. Given pH, what is the  $H^+$  or  $H_3O^+$  concentration?
- What's the definition of a neutral solution? What is an acidic pH? basic? neutral? How does the pH scale work? What's the relationship between pH and pOH?
- Know acid/base strength trends - that is know how a conjugate strength is related to the parent acid or base strength.
- Know how to write and use the mass action expressions for weak acids ( $K_a$ ) and weak bases ( $K_b$ ).  
This also includes the conjugates of each type which would be
  - salts of a weak acid/strong base (Generic: NaA)
  - salts of a weak base/strong acid (Generic: BHCl)
- Be able to calculate the pH of a solution if only given the percent ionization of the acid or base.
  - Also be able to then calculate what the value of  $K_a$  or  $K_b$  is from the percent ionization and concentration information.
- Be able to write the appropriate stepwise reactions for polyprotic acids and bases. Know how to calculate the concentrations of various deprotonated species for polyprotic acids and bases.
- Know what the dominant species are at various pH's for any acid or base (mono- or polyprotic). Yes, you do have to know the  $K_a$ 's or  $K_b$ 's, but those would be given. This task is much easier when you know about fraction of species and the plotting of it versus pH.

- Know about Fraction of Species and the way the plot looks and how you would use it to answer various questions about what species is the major species at a given pH. Below is a fraction of species plot for a diprotic acid.

### Fraction of Species



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- Know how to calculate the pH (and pOH) for any solution. You should refer to my Acid/Base pdf's that are available on our web page. There are a total of 6 versions of 2 Types of problems...  
 Chapter 7 problems are "Type 1" problems (EXAM 2) – ONE species put into solution.  
 Type 1 : only HA in solution (plain neutral acid)  
 Type 1 : only B in solution (plain neutral base)  
 Type 1 : only A<sup>-</sup> put in solution (the SALT of a weak acid - works the same as B in solution)  
 Type 1 : only BH<sup>+</sup> put in solution (the SALT of a weak base - works the same as HA in solution)

NOTE: Chapter 8 problems are "Type 2" problems (EXAM 3) – TWO species put into solution (Buffers). These are listed as a point of reference only. Buffers will be on Exam 3, not Exam 2.  
 Type 2 : both HA and A<sup>-</sup> put in solution (acidic buffer)  
 Type 2 : both B and BH<sup>+</sup> put in solution (basic buffer)  
 I talked about this mainly in understanding the "crossover" points on the fraction of species diagram. Those crossovers are the special points where the conjugates are equal in concentration and the pH must therefore equal pKa.

- Know when TO USE and when NOT TO USE the approximation for solving quadratics in acid/base equilibria. What is a reasonable concentration?
- Know what happens with salts that contain small, highly charged cations like Al<sup>3+</sup>.  
 Hint: treat these EXACTLY like you do any weak acid, HA. However, do know HOW/WHY these things behave this way.

**Remember** the numbering for polyprotic acids and their conjugates run in opposite directions. The first proton off a diprotic acid ( $K_{a1}$ ) is always the LAST proton going ON to the corresponding conjugate base ( $K_{b2}$ ).

For a triprotic acid:  $H_3A \rightleftharpoons H^+ + H_2A^-$  matches up with  $K_{a1}$

The conjugate reaction is  $H_2A^- + H_2O \rightleftharpoons H_3A + OH^-$  and matches up with  $K_{b3}$ .

The relationship between the two is  $K_{a1} \cdot K_{b3} = K_w$ .

### Now your turn

Now you start writing about all this stuff. Read your book. Over and over. Read other books if you need more help and insight. The more you expose yourself to the concepts the more things will make sense.

Remember, I didn't purposely leave anything out here to trick you on the exam. If I talked about it in class it is fair game on the exam. Practice working problems in the book and on the homework.