

EQUILIBRIUM SYLLABUS

Chemical Equilibrium ⇌ Acid Base Equilibrium ⇌ Solubility & Aqueous Equilibrium

I. MAJOR TOPICS

Chemical Equilibrium:

- A. The Equilibrium Expression
- B. What is K_{eq} ? ICE Diagrams
- C. Le Chatelier's Principal

Acid Base Equilibrium:

- D. Bronsted Acids & Bases
- E. Strong Acids and Bases
- F. Weak Acids and Bases (K_a & K_b)
- G. Diprotic & Polyprotic Acids
- H. Molecular Structure and Acid Strength
- I. Hydrolysis
- J. Lewis Acids and Bases

Solubility & Aqueous Equilibrium:

- K. Common Ion Effect/ Henderson Hasselbach Eq
- L. Buffers
- M. Titration Curves
- N. Acid-Base Indicators
- O. Solubility Equilibria, K_{sp}
- P. Common Ion Effect & Solubility
- Q. pH & Solubility
- R. Complex Ions

II. OBJECTIVES/GUIDELINES:

Chemical Equilibrium:

1. What is equilibrium? How is equilibrium dynamic?
2. Be able to provide an example of physical and chemical equilibrium.
3. What does K represent? What information does K provide about the favorability of a reaction's progress?
4. Be able to write K expressions.
5. What is the Law of Mass Action and what does it tell us about K?
6. Realize that equilibrium expressions can be either expressed in terms of molarity or partial pressures. Know how K_p and K_c relate. This equation will be provided.
7. What is the difference between K and k?
8. What is Q? How is Q different than K?
9. Be very comfortable manipulating ICE tables in terms of K_p and K_c expressions.
10. Know when to use x as a simplification in the quadratic equation.
11. Understand Le Chatelier's Principal and how changes in temperature, pressure/volume and concentration affect equilibrium concentrations or K.
12. Be careful of the ubiquitous tricks. What happens when you add an inert gas? What happens when you add a catalyst?

Acid Base Equilibrium:

13. What is the definition of a Bronsted acid/base? How does this compare/contrast with a Lewis acid/base?
14. Be able to identify Bronsted acid/bases and their conjugate pairs.
15. How is it that water can act as an acid or a base?
16. What is the formulaic expression for K_w ? What are ion concentrations for pure water?
17. What is the purpose of the pH and the pOH scales? Know how to calculate and convert from pH, pOH, $[H^+]$ and $[OH^-]$.
18. Review the "big six" acids and the qualifications that determine the strong bases.
19. Be able to predict the direction of a reaction by comparing the strength of the acid and the conjugate base (K_a vs K_b).
20. Be able to determine relative concentrations of different species in an acid or base solution.
21. Be able to determine $[H^+]$ and $[OH^-]$ given the initial molarity of a strong acid or base.
22. Use ICE tables and K_a/K_b values to determine equilibrium $[H^+]$ and $[OH^-]$ of weak acids/bases. Know when and how to use an approximation (assuming one species contributions are negligible).
23. What is the difference between a K_a and a K_b value?
24. What is the % ionization and how do we calculate it?
25. Be able to handle Diprotic and Polyprotic acids. Are the contributions of the second acidic proton significant or negligible?
26. Be able to comment on the relative strength of oxyacids based on their structures. What makes a strong acid? A weakly bonded H!
27. What is hydrolysis? Be familiar with the ions that hydrolyze and those that do not. Remember our lab and its data!
28. Be able to represent Eq concentrations and pH calculations with salts that hydrolyze. When do you use K_a ? . . . K_b ?

29. Be able to define and identify Lewis acids and bases.
30. Know your basic, acidic, and amphoteric oxides and what these compounds do in water.

Solubility & Aqueous Equilibrium:

31. Know what the common ion effect is and what causes it. Be able to relate common ion effect to Le Chatelier's Principle.
32. Be able to perform calculations with common ion effect. Understand such calculations both in terms of I.C.E. tables and the Henderson-Hasselbach equation.
33. What IS the Henderson-Hasselbach equation? When can you use it? How can you use it when calculating pOH or pKb??
34. How do you recognize a buffer system? What is a buffer's purpose? How does a buffer work in terms of Le Chatelier's Principle. Realize that a buffer is just an extension of the common ion effect.
35. Be able to carry out calculations with buffers. PRACTICE! Refer to examples in notes and in homework!!
36. How would you prepare a buffer solution to maintain a certain pH? What are the two factors?
37. Be able to sketch titration curves for the three different types of titrations. Be able to identify the following regions:
(1) Equivalence pt (2) pKa (1/2 neutralized point) (3) Buffer region (4) regions outside the buffer region (where $[HA] \ll [A^-]$ and $[HA] \gg [A^-]$) (5) place where excess strong acid or strong base is determining the pH.
38. What does the Equivalence point refer to? Be able to explain, IN DETAIL, the circumstances in which the pH at the equivalence point is ACIDIC, NEUTRAL, and BASIC. Be prepared to site examples of each of these situations.
39. Be able to perform titration calculations (mathematically analyzing any process of a titration). Remember, when tackling ANY titration problem, ALWAYS start off with a mole stoichiometry table (ICE table) and then decide what to do:
- If you are titrating a strong acid and strong base, calculate $[OH^-]$ or $[H^+]$ from the mole table.
- If you are titrating a weak acid or weak base, you have three courses of action.....
(1) If you are in the buffer region and have both acid and conj. base (or vice-versa) present in solution, use Henderson-Hasselbach Eq. to determine pH.
(2) If you are at the equivalence point, and only have conjugate base (or acid) in solution, do a HYDROLYSIS I.C.E. table.
(3) If you are past the equivalence point, and have excess strong base (or strong acid), determine the $[OH^-]$ (or $[H^+]$) from the mole table. Be able to explain why the hydrolysis of the conjugate base (or acid) is not significant at this point, past the equivalence point.
40. Just a note! When creating mole stoichiometry, ICE, tables - BALANCE your equations! For example: 1 mole of $Ba(OH)_2$ will neutralize 2 moles of HCl.....a 1 to 2 ratio!
41. If given a selection of pH indicators and their pH ranges, be able to choose the best indicator for a particular titration.
42. Be familiar with indicators, how they work, and what their purpose is. Where in the titration curve should you desire your indicator to change colors?
43. What is Ksp? What does a large Ksp value vs a small one represent?
44. What kind of solution do you have if it's demonstrating solubility equilibria?
45. What is Q and how do you use it to determine if a solution is unsaturated, saturated or supersaturated?
46. Know the different units for representing solubility and how to convert between them. There is molar solubility, solubility as mass, and ion concentrations.
47. Be able to set-up and complete calculations that make predictions concerning precipitation reactions. Basically, you will need to calculate Q. How does Q have to compare to Ksp in order to get a precipitate?
48. How does the common ion effect affect solubility? Be able to explain this in terms of Le Chatelier's Principle.
49. Be able to perform Ksp calculations with common ion effect.
50. How does pH affect solubility? Be able to pick out salts whose solubility would increase in an acidic medium and those salts whose solubility would NOT increase in an acidic medium. Be able to explain WHY.
51. Be able to predict if a chemical involved in a reaction will precipitate in the presence of H^+ or OH^- .
52. What are complex ions?
53. How are complex ions formed?
54. Be able to write complex ion formation reactions. The ones you need to know are summarized in the handout provided.
55. How does the formation of a complex ion affect the solubility of a salt? Explain in terms of Le Chatelier's Principle.

Complete the following problems from your Brown, LeMay & Bursten chemistry text. Show all of your work! (No Work = No Credit). The answers to the odd numbered problems are in the back of your text. It is your responsibility to get yourself in an academic position to answer ALL of these problems. **If needed – PLEASE ASK ME FOR HELP!**

Problem set #25: 15.7, 15.12, 15.22, 15.29, 15.34, 15.43, 15.48.

Due Date: _____

Problem set #26: 16.4, 16.5, 16.7, 16.13, 16.18, 16.28, 16.34, 16.43

Due Date: _____

Problem set #27: 16.48, 16.60, 16.68, 16.73, 16.76, 16.84, 16.88, 16.90

Due Date: _____

Problem set #28: 17.2, 17.4, 17.7, 17.15, 17.22, 17.28

Due Date: _____

Problem set #29: 17.34, 17.39, 17.44, 17.52, 17.60, 17.61

Due Date: _____

