CHEM 142 Exam 3 Study Guide
Chapter 15: Acid-Base Equilibria

A. Terminologies and Concepts

1. Bronsted-Lowry definitions - acids vs. bases; give examples
2. Amphoteric substances - define and give examples
3. Salts - define and give examples
4. Conjugate acid-base pairs - define and give examples
5. Acid-base indicators - define and give examples
6. Strong vs. weak acids - define and give examples
7. Strong vs. weak bases - define and give examples
8. Polyprotic acids - define and give examples
9. Acid ionization vs. base dissociation equations
10. Autoprotolysis (or autoionization) of water
11. pH, pOH, $[H^+]$, $[OH^-]$, K_w
12. Explain the importance of pH control in:
    (a) Blood (circulatory system)
    (b) Agriculture (soil pH)
    (c) Environment (e.g. lakes and rivers)
    (d) Stomach
13. Discuss two ways of controlling pH
14. Define neutralization. What are the products of neutralization?
15. Given the reactants of a neutralization reaction, write the formulas of the products formed.
16. What are buffers?
17. Identify species that can act as buffers.
18. Explain what happens to the pH of a buffer solution if a small amount of HI is added.
19. Explain what happens to the pH of a buffer solution if a small amount of $Ca(OH)_2$ is added.
20. Calculate the pH of buffer solutions using the Henderson-Hasselbalch equation
21. Write the ionic species produced when an insoluble salt is in equilibrium with its ions.
22. Write the solubility product constant expression for a given salt.

B. Problem-Solving

1. For each of the following reactions, indicate the Bronsted-Lowry acids and bases, as well as the conjugate acid-base pairs. (For simplicity, the subscript (aq) has been omitted, but all species are aqueous.)

a) $SO_4^{2-} + HClO \Leftrightarrow HSO_4^- + ClO^-$

b) $Fe(H_2O)_6^{2+} + H_2O \Leftrightarrow Fe(H_2O)_5(OH)^+ + H_3O^+$

c) $HNO_2 + H_2O \Leftrightarrow NO_2^- + H_3O^+$

d) $CH_3NH_3^+ + HSO_4^- \Leftrightarrow CH_3NH_2 + H_2SO_4$

2. According to the Bronsted-Lowry theory, which of the following would you expect to act as an acid? Which as a base? Which is ampotheric?

a) NH_4^+ b) CN^- c) O^{2-} d) HNO_2 e) HPO_3^{2-} f) CHO_2^-

3. Complete the table below by writing the formula of the conjugate acid or conjugate base of each of the following species. You must provide the correct ionic charge, if applicable.

Conjugate acid	*Conjugate base*	*Conjugate acid*	*Conjugate base*
H_2CO_3			PO_4^{-3}
	Br^-	NH_4^+	
	ClO^-		$C_2H_3O_2^-$
$HBrO_2$		H_2SO_4	
$CH_3NH_3^+$			$C_2H_5NH_2$

4. Consider the following weak acids and their corresponding pKa's.

Weak acid (WA):	HCO_3^-	NH_4^+	HPO_4^{2-}	HCNO
K_a:	2.3×10^{-8}	5.6×10^{-10}	4.2×10^{-13}	3.5×10^{-4}
pK_a:	_____	_____	_____	_____
Conjugate base:	_____	_____	_____	_____
K_b:	_____	_____	_____	_____
pK_b:	_____	_____	_____	_____

a) For each acid, write the formula of its conjugate base at the space provided.

b) For each acid, calculate the pK_a as well as K_b and pK_b of its conjugate base. Write your answer at the space provided.

c) Which of the weak acids above is the strongest acid? Which is the weakest? Justify your answer.

d) Which of the conjugate bases above is the strongest base? Which is the weakest? Justify your answer.

e) Write the chemical equation for the reaction between ammonia, NH_3, and the weak acid cyanic acid, HCNO. Using the K_a's provided or given in the text, calculate the value of the equilibrium constant for this reaction.

5. Write the ionization equation and the K_a expression for each of the following acids:

a) HSO_3^-

b) $HBrO_2$

c) $C_2H_5NH_3^+$

6. Write the ionization (also called hydrolysis) equation and K_b expression for each of the following bases:

a) S^{2-}

b) ClO^-

c) $H_2PO_4^-$

7. Calculate the $[H^+]$, $[OH^-]$, pH and % ionization of a 0.250 M acetic acid ($HC_2H_3O_2$). K_a for acetic acid at 25 ^{0}C is 1.8×10^{-5}.

8. (Adapted from Brown et al., 2009) Niacin, one of the B vitamins, has the molecular formula $HC_5H_4NCO_2$. A 0.020 M solution of niacin has a pH of 3.26. What is the acid dissociation constant, K_a, for niacin?

9. (a) Write the base ionization of and the K_b expression for trimethylamine, $(CH_3)_3N$, a gas with a fishy, ammonia-like odor.

   (b) An aqueous solution that is 0.25 M $(CH_3)_3N$ has a pH of 11.63. What is the K_b for $(CH_3)_3N$? Show your work and include the correct unit in your answers.

10. Note whether aqueous solutions of each of the following salts will be acidic, basic or neutral. Explain your answer.

    (a) NaI

    (b) $NaCHO_2$

    (c) KIO

    (d) Na_2CO_3

    (e) NH_4ClO_4

11. Calculate the pH of each of the following aqueous solutions.

a) 0.175 g KOH dissolved in enough water to make 750 mL of solution

b) 0.350 M solution of $HClO_4$

c) 0.175 M solution of NH_3 (K_b for $NH_3 = 1.8 \times 10^{-5}$)

d) 0.33 M solution of $Ca(ClO)_2$ (K_b for $ClO^- = 3.3 \times 10^{-7}$)

11. Calculate the pH – *Cont.*

e) 0.555 M NH_4ClO_4 (K_b for NH_3 = 1.8 x 10^{-5})

f) 1.55 M solution of KCl

12. For each of the following acid-base pairs, indicate the pair that will function as buffer. Explain your answer.

a) $NaHSO_4^-$ and Na_2SO_4

b) HCl and KCl

c) NaOH and H_2O

d) $HC_2H_3O_2$ and $NaC_2H_3O_2$

e) HClO and KClO

f) CH_3NH_3Cl and CH_3NH_2

13. Calculate the pH of a buffer solution prepared by mixing 20.0 g NH_4Cl (FW 53.56 g/mol) and 0.50 mol NH_3 to make a 100 mL solution. (K_b NH_3 = 1.8 x 10^{-5})

14. Calculating pH during titration: Work on Chapter 16 Problems 68, 72 and 74 (Tro, p. 764)

15. Write the equation for the dissociation of each of the following sparingly soluble salts and the corresponding solubility product constant expression.

a) Ag_2CrO_4

b) $Ca_3(PO_4)_2$