Name: _____Period: _____Date: _____

Chemistry 30 – Acid Equilibrium – Unit Homework

Topic	Textbook Reading	Textbook Questions
Properties of Acids and Bases Conjugate Acid/Base Pairs	Section 19.1 (595-601)	#2, 3
Strength of Acids and Bases Dissociation Constants	Section 19.2 (602-607)	#10, 11
pH and pOH	Section 19.3 (608-616)	#18-23
Neutralization and Titration	Section 19.4 (617-621)	19.1 #1 19.4 #29-32

Properties of Acids and Bases

1. List four characteristic properties of acids and of bases.
2. Classify each of the following as either an acid or a base:
   a. The substance has a bitter taste
   b. H_2SO_4
   c. litmus paper dipped in this turns red
   d. reacts with active metals to produce hydrogen gas
   e. KOH
   f. NH_3
   g. has a slippery feel
   h. has a sour taste
   i. a proton donor
   j. a proton acceptor
3. Copy the chart and fill it in with definitions.

	Acid	Base
Arrhenius		
Brønsted-Lowry		

4. Which of the following could be considered Brønsted-Lowry bases?
   a. Br^-
   b. Li^+
   c. H_3PO_4
   d. NH_4^+
   e. H_2O
   f. NH_2^-

Conjugate Acid-Base Pairs

5. Identify the acid, base, conjugate acid and conjugate base for each of the following.
   a. $HClO_4(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + ClO_4^-(aq)$
   b. $H_2SO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HSO_3^-(aq)$
   c. $HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_2H_3O_2^-(aq)$
   d. $H_2S(g) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HS^-(aq)$
   e. $HSO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + SO_3^{2-}(aq)$
   f. $NH_3(g) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
   g. $HF(aq) + HSO_3^-(aq) \rightleftharpoons F^-(aq) + H_2SO_3(aq)$
   h. $HNO_2(aq) + HS^-(aq) \rightleftharpoons NO_2^-(aq) + H_2S(aq)$
6. Complete the equation for the reaction of each of the following with water. Then:
   i. Indicate whether the ion or molecule is an acid or base; and,
   ii. Indicate whether each reaction is explained by Arrhenius, Brønsted-Lowry, or both.
      a. $HI(aq) + H_2O(l) \rightleftharpoons$
      b. $HF(aq) + H_2O(l) \rightleftharpoons$
      c. $C_2H_3O_2^-(aq) + H_2O(l) \rightleftharpoons$
      d. $CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons$
      e. $O^{2-}(aq) + H_2O(l) \rightleftharpoons$

7. Define the term **amphoteric**. Give an example of an amphoteric compound.
8. Write the formula for the conjugate base of:
   a. H_2SO_3
   b. HCO_3^-
   c. NH_4^+
9. What are the conjugate bases of these acids?

original acid	conjugate base
HNO_3	
H_2O	
H_3O^+	
H_2SO_4	
HBr	
HCO_3^-	

10. What are the conjugate acids of these bases?

original base	conjugate acid
OH^-	
H_2O	
HCO_3^-	
SO_4^{2-}	
ClO_4^-	

11. Write the formula for the conjugate acid of:
    a. H_2O
    b. CO_3^{2-}
    c. PH_3
12. Which of the following represent conjugate acid-base pairs?
    a. H_2O, H_3O^+
    b. OH^-, HNO_3
    c. H_2SO_4, SO_4^{-2}
    d. $HC_2H_3O_2$, $C_2H_3O_2^-$

Strength of Acids and Bases

13. What is the difference between a strong acid and a weak acid? Give an example of both.
14. Explain the difference between the terms "concentrated" and "dilute" with respect to both strong and weak acids.
15. Write a dissociation equation for each acid or base in an aqueous solution. Remember to use a single arrow (→) for strong acids and bases and a double arrow (⇌) for weak acids and bases.
    a. HCl
    b. NaOH
    c. $Ca(OH)_2$
    d. HCN
    e. H_2SO_4
    f. $HC_2H_3O_2$
    g. NH_3
16. Write balanced equations for:
    a. The dissociation of calcium hydroxide
    b. The ionization of nitric acid
    c. The ionization of propionic acid
    d. The ionization of pyridine

K_a and K_b

17. Given the following balanced ionization reactions for the following weak acids and bases, write the K_a or K_b expressions for each.
    a. ascorbic acid: $HC_6H_7O_6\ (aq) \rightleftharpoons H^+\ (aq) + C_6H_7O_6^-\ (aq)$
    b. boric acid: $H_3BO_3\ (aq) \rightleftharpoons H^+\ (aq) + H_2BO_3^-\ (aq)$
    c. methylamine: $CH_3NH_2\ (aq) + H_2O\ (l) \rightleftharpoons CH_3NH_3^+\ (aq) + OH^-\ (aq)$
18. Calculate $[H^+]$ for a 1.0×10^{-3} M solution of hydrochloric acid.
19. Calculate $[H^+]$ in a 0.20 M solution of formic acid. $K_a = 1.8 \times 10^{-4}$

$$HCOOH \rightleftharpoons H^+ + HCOO^-$$

20. Ethylamine ($C_2H_5NH_2$) is a weak base. Calculate $[OH^-]$ in a 2.32×10^{-3} M solution if $K_b = 5.6 \times 10^{-4}$.
21. Calculate $[OH^-]$ is a solution containing 100.0 g of potassium hydroxide in 2.50 L solution. Potassium hydroxide is a strong base.
22. A solution is prepared that contains 0.0445 mole of sulfuric acid in a total solution volume of 12.1 L. Sulfuric acid typically undergoes complete ionization according to the equation:

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

    Calculate $[H^+]$. Sulfuric acid is a strong acid.
23. Calculate the hydroxide ion concentration in a 0.045M solution of ammonia, NH_3, a weak base with $K_b = 1.8 \times 10^{-5}$.

pH and pOH

24. Determine pH and pOH for each concentration.
    a. $[H^+] = 0.023$ M
    b. $[H^+] = 6.6 \times 10^{-6}$ M
    c. $[OH^-] = 0.0334$ M
    d. $[OH^-] = 9.01 \times 10^{-4}$ M
    e. $[H^+] = 8.96 \times 10^{-3}$ M
25. Determine $[H^+]$ and $[OH^-]$ for each pH value.
    a. pH = 2.5
    b. pH = 11.3
    c. pOH = 4.6
    d. pOH = 8.7
    e. pH = 7.65
26. 4.52 g of calcium hydroxide, a strong base, is dissolved in 1.00 L of water. What is the pH of the resulting solution?
27. Methanoic acid ($HCHO_2$) is a weak acid that undergoes the following ionization reaction:

$$HCHO_2 \rightleftharpoons H^+ + CHO_2^-$$

    If 25.0 g of methanoic acid is dissolved to make 0.500 L of solution, what is the pH?
28. A weak base, methylamine, is dissolved in water according to the following dissociation reaction:

$$CH_3NH_2\ (aq) + H_2O\ (l) \rightleftharpoons CH_3NH_3^+\ (aq) + OH^-\ (aq)$$

    If 0.00355 moles of methylamine is present in 1.25 L of solution, what is the pH?
29. Phosphoric acid is a **weak** acid that undergoes the following ionization reaction:

$$H_3PO_4(aq) \rightleftharpoons H^+(aq) + H_2PO_4^-(aq)$$

If there is 1.32×10^{-2} mol of phosphoric acid present in 875 mL of solution, calculate the concentration of hydrogen ions, H^+, in solution. K_a for phosphoric acid is 7.0×10^{-3}.

30. A solution of acetic acid contains 12.0 g of $HC_2H_3O_2$ in 500 mL of solution. Calculate $[H^+]$.
31. Why would the pH be different for a 0.05 M solution of HCl and a 0.05 M solution of acetic acid? What is the difference in pH?
32. Calculate the pH of a 0.00345 M solution of analine, $C_6H_5NH_2$, a weak base.
33. Calculate the $[H^+]$ in a solution in which $[OH^-] = 2.0\times10^{-2}$ M. Is this solution acidic, neutral, or basic?
34. Find pH of each of the following. Identify each as an acidic, neutral, or basic.
    a. $[H^+] = 0.0015$ M
    b. $[H^+] = 5.0\times10^{-9}$ M
    c. $[OH^-] = 3.27\times10^{-4}$ M
    d. $[OH^-] = 1.00\times10^{-12}$ M
35. What is the pH, pOH, $[H^+]$, and $[OH^-]$ for a 3.2×10^{-4} M solution of sodium hydroxide?
36. What is the pH, pOH, $[H^+]$, and $[OH^-]$ for a 9.20×10^{-3} M solution of sulfuric acid?

Neutralization

37. How many moles of NaOH are needed to completely neutralize 0.432 mol of H_2SO_4?
38. How many moles of $Ca(OH)_2$ are needed to completely neutralize 0.530 mol of H_3PO_4?
39. It takes 38 mL of 0.75 M NaOH solution to completely neutralize 155 mL of a sulfuric acid solution (H_2SO_4). What is the concentration of the H_2SO_4 solution?
40. It takes 12.5 mL of a 0.30 M CH_3COOH solution to completely neutralize 285 mL of NaOH solution. What is the concentration of the NaOH solution?
41. It takes 50 mL of 0.500 M KOH solution to completely neutralize 125 mL of sulfuric acid solution. What is the pH of the sulfuric acid solution?
42. What is the pH of a NaOH solution if it takes 100.0 mL to neutralize 150.0 mL of 3.00 M H_2CO_3 solution?
43. Titration reveals that 11.6 mL of 3.0 M sulfuric acid are required to neutralize the sodium hydroxide in 25.00 mL of NaOH solution. What is the molarity of the NaOH solution?
44. When 34.2 mL of a 1.02 M NaOH solution is added from a buret to 25.00 mL of a phosphoric acid solution that contains phenolphthalein, the solution changes from colorless to pink. What is the molarity of the phosphoric acid?