Study Guide – Acids and Bases (Chapters 23 and 24) Name: _____
Chemistry II
2 or 6 points **DUE ON WED., 3/17/10** Date: _____

Topics to be covered on the February 17, 2010 test:

acid	base	Arrhenius theory
Brønsted-Lowry theory	hydronium ion	proton = H^+ = H_3O^+
conjugate acid	conjugate base	conjugate acid-base pair
dissociation (ionization)	acid strength	four strong acids
monoprotic acid	diprotic acid	polyprotic acid
acidic organic acids	amphoteric	autoionization (especially of water)
K_w	pH	concentrations based on pH
K_a	pH of weak acid solutions	pH of mixed weak acids
percent dissociation (ionization)	K_b	strong bases
pH of weak bases	pH of polyprotic acids	salts
pH of salt solutions	Lewis theory	Lewis acids and bases

Practice problems (do at least 10 for 2 points, all of them for 6 points):

1) (a) What is the difference between the Arrhenius and Brønsted-Lowry definition of acid?

(b) NH_3 (g) and HCl (g) react to form the ionic solid NH_4Cl. Which substance is the Brønsted-Lowry acid? Which substance is the Brønsted-Lowry base?

2) Write the equation for the following acids dissolving in water. Identify the acid (A), base (B), conjugate acid (CA), and conjugate base (CB).

(a) HIO_3

(b) NH_4^+

(c) $HC_7H_5O_2$

3) Write the equation for the following bases dissolving in water. Identify the acid (A), base (B), conjugate acid (CA), and conjugate base (CB).

(a) CN^-

(b) O^{2-}

(c) HPO_4^{2-}

4) Identify the acid (A), base (B), conjugate acid (CA), and conjugate base (CB) in the following reactions:

(a) $NH_4^+ (aq) + CN^- (aq) \rightleftharpoons HCN (aq) + NH_3 (aq)$

(b) $(CH_3)_3N (aq) + H_2O (\ell) \rightleftharpoons (CH_3)_3NH^+ (aq) + OH^-$

(c) $HCHO_2 (aq) + PO_4^{3-} (aq) \rightleftharpoons CHO_2^- (aq) + HPO_4^{2-}$

5) Label the following as a strong acid, weak acid, or species of negligible acidity.

HNO_2 H_2SO_4 HPO_4^{2-} CH_4 $CH_3NH_3^+$

6) The hydrogen oxalate ion, $HC_2O_4^-$, is amphoteric. Write a balanced chemical equation showing how it acts as an acid toward water and another equation showing how it acids as a base toward water. In each equation, identify the acid (A), base (B), conjugate acid (CA), and conjugate base (CB).

7) (a) Write a chemical equation that illustrates the autoionization of water.

(b) Write the equilibrium expression for the autoionization of water:

(c) Why is H_2O absent from the above expression?

(d) If a solution is described as basic, what is meant by that statement in terms of the above expression?

8) Calculate $[H^+]$ for each of the following solutions, and indicate whether the solution is acidic, basic, or neutral.

(a) $[OH^-] = 0.00045$ M [$H^+ = 2.2 \times 10^{-11}$, basic]

(b) $[OH^-] = 8.8 \times 10^{-9}$ M

(c) a solution where the $[OH^-]$ is 100 times greater than $[H^+]$

9) Complete the following table:

$[H^+]$	$[OH^-]$	pH	pOH	Acidic, basic, or neutral?
7.5×10^{-3} M				
	3.6×10^{-10} M			
		8.25		
			5.70	

10) The average pH of normal blood is 7.40. At normal body temperature (37 °C), $K_w = 2.4 \times 10^{-14}$. Calculate the $[H^+]$, $[OH^-]$, and pOH for blood at this temperature. [$H^+ = 4.0 \times 10^{-8}$]

11) Carbon dioxide in the atmosphere dissolves in raindrops to produce carbonic acid, causing the pH of clean, unpolluted rain to range from about 5.2 to 5.6. What are the ranges of $[H^+]$ and $[OH^-]$ in the raindrops?

12) (a) What is a strong acid?

(b) A solution is labeled 0.500 M HCl. What is the $[H^+]$ for the solution?

13) Calculate the pH of each of the following strong acid solutions:

(a) 8.5×10^{-3} M HCl [pH = 2.1]

(b) 1.52 g of HNO_3 in 575 mL of solution

(c) 5.00 mL of 0.250 M $HClO_4$ diluted to 50.0 mL

14) Calculate the $[OH^-]$ and pH for the following strong base solutions:

(a) 0.012 M KOH

(b) 1.565 g of KOH in 500.0 mL of solution

(c) 10.0 mL of 0.0105 M $Ca(OH)_2$ diluted to 500.0 mL

15) Write the chemical equation and K_a expression for the ionization of each of the following acids in water:

(a) $HBrO_2$

(b) $HC_3H_5O_2$

16) Lactic acid ($HC_3H_5O_3$) is monoprotic. A 0.10 M solution of lactic acid has a pH of 2.44. Calculate K_a. [$K_a = 1.4 \times 10^{-4}$]

17) A 0.100 M solution of chloroacetic acid, $ClCH_2COOH$, is 11.0% ionized (dissociated). Using this information, calculate $[ClCH_2COO^-]$, $[H^+]$, $[ClCH_2COOH]$, and the K_a for chloroacetic acid. [$K_a = 1.4 \times 10^{-3}$]

18) A particular sample of vinegar has a pH of 2.90. Assuming that acetic acid (K_a =1.8 x 10^{-5}) is the only acid in vinegar, calculate the concentration of acetic acid ($HC_2H_3O_2$) in vinegar. [0.089 M]

19) The acid-dissociation constant of benzoic acid ($HC_7H_5O_2$) is 6.3 x 10^{-5}. Calculate the equilibrium concentrations of H_3O^+, $C_7H_5O_2^-$, and $HC_7H_5O_2$ in the solution if the initial concentration of $HC_7H_5O_2$ was 0.050 M. [H_3O^+ = 1.8 x 10^{-3} M]

20) Determine the pH of each of the following solutions:

(a) 0.095 M propionic acid ($HC_3H_5O_2$, K_a = 1.3 x 10^{-5}) [pH = 3.0]

(b) 0.0100 M hydrogen chromate ion ($HCrO_4^-$, K_a = 3.0 x 10^{-7}) [pH = 3.8]

(c) 0.120 M pyridine (C_5H_5N, K_b = 1.7 x 10^{-9}) [pH = 9.1]

21) Citric acid ($H_3C_6H_5O_7$), present in citrus fruits, is a triprotic acid. Calculate the pH and citrate ion concentration ($C_6H_5O_7^{3-}$) for a 0.050 M solution of citric acid. Explain any approximations or assumptions that you make in your calculations. [pH = 2.24, citrate ion = 1.2 x 10^{-9} M]

22) Ephedrine, a central nervous system stimulant, is used in nasal sprays as a decongestant. This compound is a weak organic base:

$$C_{10}H_{15}ON\ (aq) + H_2O\ (\ell) \rightleftharpoons C_{10}H_{15}ONH^+\ (aq) + OH^-\ (aq)$$

A 0.035 M solution of ephedrine has a pH of 11.33.

(a) What are the equilibrium concentrations of $C_{10}H_{15}ON$, $C_{10}H_{15}ONH^+$, and OH^-?

(b) Calculate K_b for ephedrine. [1.4×10^{-4}]

23) (a) Explain why, if the acid-dissociation constant for phenol, C_6H_5OH, is listed as 1.3×10^{-10} in a textbook, it is not necessary to also list the K_b for the phenolate ion ($C_6H_5O^-$).

(b) Calculate the K_b for the phenolate ion. [$K_b = 7.7 \times 10^{-5}$]

24) (a) Given that the K_a for acetic acid is 1.8×10^{-5} and that for the hypochlorous acid is 3.0×10^{-8}. which is the stronger acid?

(b) Which is a stronger base, then, the acetate ion or the hypochlorite ion?

(c) Calculate K_b values for $C_2H_3O_2^-$ and ClO^-.

25) Calculate $[OH^-]$ and pH for the following solutions:

(a) 0.10 M NaCN (HCN $K_a = 4.9 \times 10^{-10}$)

(b) 0.080 M Na_2CO_3 (H_2CO_3 $K_a = 4.3 \times 10^{-7}$, HCO_3^- $K_a = 5.6 \times 10^{-11}$)

26) Identify the Lewis acid and Lewis base in the following reactions:

(a) $Fe(ClO_4)_3\ (s) + 6\ H_2O\ (\ell) \rightleftharpoons Fe(H_2O)_6^{3+}\ (aq) + 3\ ClO_4^-\ (aq)$

(b) CN^- (aq) + H_2O (ℓ) $\rightleftharpoons$ HCN (aq) + OH^- (aq)

(c) $(CH_3)_3N$ (g) + BF_3 (g) $\rightleftharpoons$ $(CH_3)_3NBF_3$ (s)

(d) HIO (soln) + NH_2^- (soln) $\rightleftharpoons$ NH_3 (soln) + IO^- (soln) [solvent = liquid ammonia]

27) What mass of KOH is necessary to prepare 800.0 mL of an aqueous solution with a pH of 11.56?

[0.16 g]

28) Write out the stepwise K_a reactions for the diprotic acid H_2SO_3.

29) Using the K_a tables attached and only the first dissociation step, calculate the pH of 0.10 M solutions of each of the following polyprotic acids:

(a) H_3PO_4 (b) H_2CO_3

30) Determine if the following solutions would be acidic, basic, or neutral:

(a) $NaNO_3$ (b) $NaNO_2$

(c) NH_4NO_2 (d) KClO

(e) NH_4ClO (f) KF

31) (a) What are the major species present in a 0.150 M solution of NH_3?

(b) Calculate the $[OH^-]$ and the pH of the solution.