REVIEW QUESTIONS
Chapter 16

1. For each reaction below, identify the Brønsted-Lowry acid and base and their conjugates:

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

_____ _____ _____ _____

B) $(CH_3)_3N (aq) + H_2O (l) \rightleftharpoons (CH_3)_3NH^+ (aq) + OH^- (aq)$

_____ _____ _____ _____

C) $HCHO_2 (aq) + PO_4^{3-} (aq) \rightleftharpoons CH_2O^- (aq) + HPO_4^{2-} (aq)$

_____ _____ _____ _____

2. Identify the Lewis acid and base in each of the following reactions:

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

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

C) $HIO (lq) + NH_2^- (lq) \rightleftharpoons NH_3 (l) + IO^- (lq)$
(lq denotes liquid ammonia as solvent)

3. For each of the following descriptive statements, provide an interpretation in terms of the Bronsted-Lowry, the Lewis theory, or both, as appropriate.

   a) Hydrogen bromide, HBr, dissolves in water to form an acidic solution.

   b) Sodium hydride, NaH, reacts with water to form a basic solution.

   c) Sulfur dioxide, SO_2, dissolves in water to form an acidic solution.

4. Complete the table below by calculating the missing entries and indicating whether each solution is acidic or basic:

$[H^+]$	**$[OH^-]$**	**pH**	**pOH**	**acidic or basic?**
2.5×10^{-4} M				
	6.9×10^{-8} M			
		3.20		
			5.75	

5. For each pair shown below, choose the stronger base:

   a) F^- or Cl^-

   b) Cl^- or H_2O

   c) ClO_4^- or ClO_2^-

6. Calculate the $[H^+]$ and $[OH^-]$ for each of the following strong acid or base solution:

   a) 1.8×10^{-4} M HBr

   b) 0.0895 M $HClO_4$

   c) 3.2×10^{-3} M KOH

   d) 0.0075 M $Ca(OH)_2$

7. People often take milk of magnesia to reduce the discomfort associated with acid stomach or heartburn. The recommended dose is 1 teaspoon, which contains 400 mg of $Mg(OH)_2$. What volume of HCl solution with a pH of 1.3 can be neutralized by one dose of milk of magnesia? (Calculate answer to 2 sig figs).

8. Calculate the $[H_3O^+]$ and $[OH^-]$ for solutions with the following pH values:

   a) 2.63

   b) 14.25

9. Using values of K_a in your textbook, arrange the following acids in order of **(a)** increasing acid strength, and **(b)** decreasing percent ionization:

   C_6H_5OH HNO_2 CH_3CO_2H HOCl

10. A 0.10 M solution of lactic acid ($HC_3H_5O_3$) has a pH of 2.44. Calculate K_a for lactic acid.

11. A 0.200 M solution of a weak acid HX is 9.4% ionized. Calculate the pH and K_a for this acid.

12. Calculate the pH of a 0.050 M solution of ethylamine ($C_2H_5NH_2$, $K_b = 6.4 \times 10^{-4}$).

13. The K_a for hydrocyanic acid, HCN, is 5.0×10^{-10}. What is the K_b for CN^-?

14. Hydrosulfuric acid is a polyprotic acid with the following equilibria:

$$H_2S\,(aq) \rightleftharpoons H^+\,(aq) + HS^-\,(aq) \qquad Ka_1 = 1.1 \times 10^{-7}$$
$$HS^-\,(aq) \rightleftharpoons H^+\,(aq) + S^{2-}\,(aq) \qquad Ka_2 = 1.2 \times 10^{-13}$$

a) Calculate the pH of a 0.100 M H_2S solution.

b) Calculate the $[S^{2-}]$ for the solution above.

15. Sodium benzoate, $C_6H_5CO_2Na$, is the salt of the weak acid, benzoic acid ($C_6H_5CO_2H$). A 0.10 M solution of sodium benzoate has a pH of 8.60 at room temperature.

a) Calculate the K_b value for benzoate ion ($C_6H_5CO_2^-$).

b) Calculate the K_a value for benzoic acid.

16. Potassium sorbate ($KC_6H_7O_2$) is the salt of the weak acid, sorbic acid ($HC_6H_7O_2$) with Ka = $1.7x10^{-5}$, and is commonly added to cheese to prevent mold. What is the pH of a solution containing 4.93 g of potassium sorbate in 500 mL of solution?

17. Calculate the pH of solutions prepared by:

    a) Diluting 75 mL of 0.10 M $HClO_4$ to a volume of 350 mL.

    b) Dissolving 4.8 g of $Ca(OH)_2$ in 250 mL of solution.

    c) Dissolving 3.25 g of NH_4Cl in 125 mL of solution.

18. For each pair, determine which is the stronger acid, and provide a brief explanation for your choice.

a) H_2SO_4 and H_2SeO_4

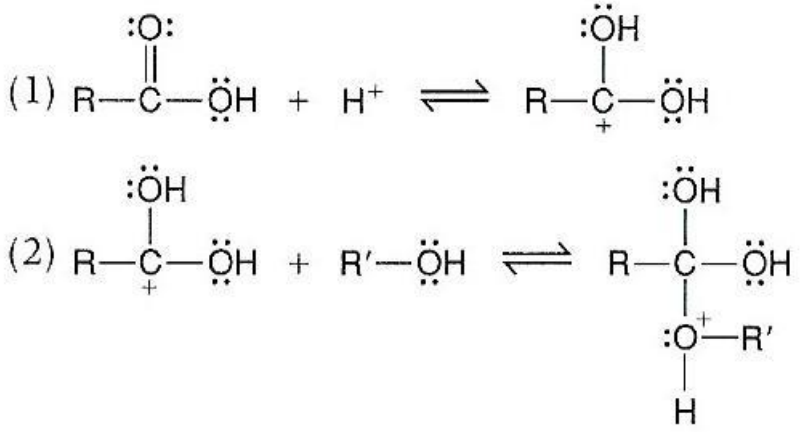
b) CH_3CO_2H and CCl_3CO_2H

c) HPO_4^{2-} and $H_2PO_4^-$

19. Arrange the solutions below in order of increasing basicity (assume concentrations to be the same):

CH_3NH_3Br KOH KBr KCN $C_5H_5NHNO_2$

20. Esters, RCOOR', are important organic compounds that are active ingredients in the odors of fruits, and have important uses in the food and cosmetics industries. Shown below are the first two steps in the mechanism for synthesis of these compounds. Identify the Lewis acids and bases in these two steps:



21. For each list below, rank in order of decreasing acid strength (highest to lowest):

a) $CCl_3CH_2O–H$ $CH_2ClCH_2O–H$ $CHCl_2CH_2O–H$

b) $CH_3CH_2CH_2COOH$ $CH_3CH_2CHCOOH$ (Cl) $ClCH_2CH_2CH_2COOH$ CH_3CHCH_2COOH (Cl)

c) CH_3CH_2OH $CH_3CH_2NH_2$ CH_3CH_2SH $CH_3CH_2CH_3$

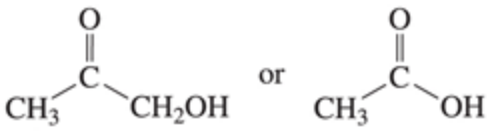
22. In each pair shown below, determine which is the stronger base:

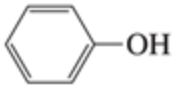
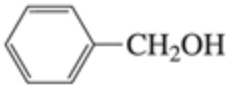
a) CH_3O^- or CH_3S^-

b) Br^- or I^-

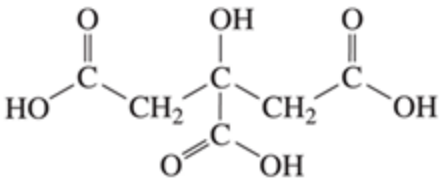
c) $ClCH_2CH_2O^-$ or $Cl_2CHCH_2O^-$

23. For each pair shown below, determine which is the stronger acid:

a)  or

b)  or 

24. Citrus fruits are rich in citric acid, a compound with four acidic hydrogens:



a) Identify the acidic hydrogen in this molecule. Which is the weakest? Why?

b) Explain why the pK_a for the COOH group in the center of the molecule is lower than the pK_a of acetic acid.

25. Using the information given, determine if reactants or products are favored in each equilibrium below:

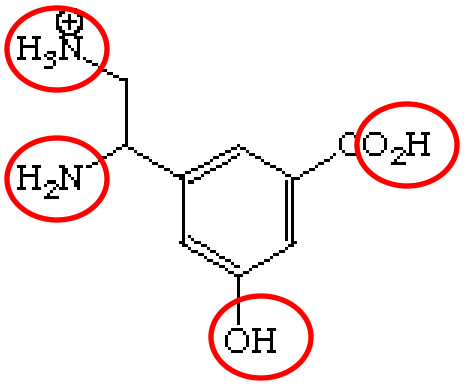
a) $CH_3CO_2H + NH_3 \rightleftharpoons CH_3O^- + NH_4^+$

$pK_a = 4.8$ $pK_a = 9.4$

b) $CH_3CH_2OH + CH_3NH_2 \rightleftharpoons CH_3O^- + CH_3NH_3^+$

$pK_a = 15.9$ $pK_a = 10.7$

26. Identify the highest and lowest pK_a values for the hydrogens circled below:



27. Identify the more acidic hydrogen in each pair shown below:

(a) $(CH_3)_2P-H$ CH_3S-H

(b) $CH_3CH_2N(H)H$ $CH_3C(=O)N(H)H$

(c)