Problems, Chapter 16 (without solutions) NOTE: Unless otherwise stated, assume T = 25.°C in all problems)

1) What is the Arrhenius definition of an acid? Of a base?

2) What is the Bronsted-Lowry definition of an acid? Of a base?

3) What is the Lewis definition of an acid? Of a base?

4) (16.2) Identify the acid-conjugate base and base-conjugate acid pairs in each of the following reactions in aqueous solution.

a) $CH_3COO^- + HCN \leftrightarrows CH_3COOH + CN^-$
b) $HCO_3^- + HCO_3^- \leftrightarrows H_2CO_3 + CO_3^{2-}$
c) $H_2PO_4^- + NH_3 \leftrightarrows HPO_4^{2-} + NH_4^+$
d) $HClO + CH_3NH_2 \leftrightarrows CH_3NH_3^+ + ClO^-$
e) $CO_3^{2-} + H_2O \leftrightarrows HCO_3^- + OH^-$

5) Identify each of the following species as a strong acid, weak acid, strong soluble base, insoluble base, or weak base: a) HCN; b) $Cu(OH)_2$; c) HNO_2; d) NaOH; e) HClO; f) HClO; g) NH_3

6) What is meant by the term amphoteric. Show by giving an appropriate set of reactions how the HSO_3^- anion exhibits amphoteric properties.

7) Complete the table (all solutions are at 25. °C)

$[H_3O^+]$	$[OH^-]$	pH	Acid or base
3.5×10^{-3}			
	3.8×10^{-7}		
1.8×10^{-9}			
		7.15	

8) The value for the autoionization constant for water at T = 40.0 °C is $K_w = 2.92 \times 10^{-14}$. What are the values for $[H_3O^+]$, $[OH^-]$, and pH for a neutral aqueous solution at this temperature?

9) (16.26) Find the pH of each of the following solutions:

a) 2.8×10^{-4} M $Ba(OH)_2$.
b) 5.2×10^{-4} M HNO_3.

10) How many grams of NaOH would be needed to prepare 500.0 mL of a solution with pH = 12.50?

11) What are the pH and the percent dissociation for a 0.0800 M aqueous solution of hypochlorous acid (HOCl), a weak acid, at T =25. °C. At this temperature the acid equilibrium constant is $K_a = 3.5 \times 10^{-8}$.

12) (16.52) Find the pH of an aqueous solution at 25. °C that is 0.34 M in phenol (C_6H_5OH, $K_a = 1.3 \times 10^{-10}$).

13) The pH of an aqueous solution of an unknown monoprotic acid is pH = 5.20 at T = 25. °C. The concentration of the acid is 0.010 M. What is K_a for the acid?

14) (16.70) Find the pH for each of the following solutions at T = 25. °C.

a) 0.10 M NH_3 ($K_b = 1.8 \times 10^{-5}$)

b) 0.050 M pyradine (C_5H_5N, $K_b = 1.7 \times 10^{-9}$)

15) Determine the pH and percent ionization of a 0.220 M solution of benzoic acid (C_6H_5COOH, $K_a = 6.5 \times 10^{-5}$).

16) The acid dissociation constant for acetic acid (CH_3COOH) is $K_a = 1.8 \times 10^{-5}$ at T = 25. °C.

a) What is pK_a for acetic acid?

b) What is K_b for the acetate ion, CH_3COO^-?

c) Which of the following acids is a stronger acid than acetic acid: HNO_2, C_6H_5COOH, HCN?

d) Which of the following anions is a stronger base than the acetate anion: NO_2^-, $C_6H_5COO^-$, CN^-?

There is a table of acid ionization constants in Burge (Table 16.5) that may be of use in doing parts c and d of this problem.

17) (16.10) Predict the relative acid strength of the following compounds: H_2O, H_2S, H_2Se.

18) Based on molecular structure arrange the compounds in order of increasing acid strength. Explain your reasoning.

a) H_2Te, HI, H_2S

b) HClO, $HClO_2$, HBrO

19) Determine whether each salt will form a solution that is acidic, basic, or neutral.
a) $C_2H_5NH_3NO_3$; b) K_2CO_3; c) RbI; d) NH_4ClO

20) (16.96) Find the pH of a 0.082 M solution of NaF (K_a for HF is 7.1×10^{-4}).

21) Identify the Lewis acid and Lewis base from among the reactants in each equation.

a) $Ag^+(aq) + 2\ NH_3(aq) \leftrightarrows Ag(NH_3)_2^+(aq)$

b) $AlBr_3 + NH_3 \leftrightarrows H_3NAlBr_3$

c) $F^-(aq) + BF_3(aq) \leftrightarrows BF_4^-(aq)$