Name _____

Period ____ Date ___/___/___

17 • The Chemistry of Acids & Bases

STUDY QUESTIONS & PROBLEMS

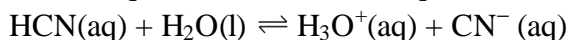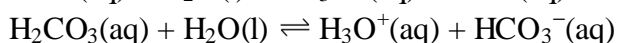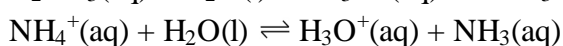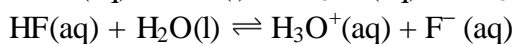1. For the following aqueous equilibria, designate the Brønsted-Lowry conjugate acid-base pairs and establish the weaker side:
   a. $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
   b. $HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$
   c. $NH_4^+(aq) + CO_3^{2-}(aq) \rightleftharpoons NH_3(aq) + HCO_3^-(aq)$

2. Write the name and formula for the conjugate bases of the following:
   a. HNO_2
   b. H_2SO_4
   c. $H_2PO_4^-$
   d. HF
   e. CH_3CO_2H

3. Complete the Brønsted-Lowry equilibria, label the components acid or base, and pair up the conjugate acid-base pairs:
   a. $HSO_4^- + H_2O \rightleftharpoons$
   b. $NH_3 + H_2O \rightleftharpoons$
   c. $CN^- + H_2O \rightleftharpoons$
   d. $H^- + H_2O \rightleftharpoons$
   e. $HClO_4 + H_2O \rightleftharpoons$

4. Is the monohydrogenphosphate ion HPO_4^{2-} amphiprotic?
   If so, write the formulas of its conjugate acid and its conjugate base.

5. Of the following acids, determine
   a. The strongest acid
   b. The acid that produces the lowest concentration of hydronium ions per mole of acid
   c. The acid with the strongest conjugate base
   d. The diprotic acid
   e. The strong acid
   f. The acid with the weakest conjugate base
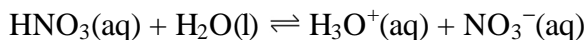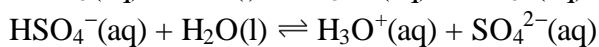
$HNO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_3^-(aq)$	K_a = very large
$HSO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + SO_4^{2-}(aq)$	$K_a = 1.2 \times 10^{-2}$
$HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$	$K_a = 4.0 \times 10^{-10}$
$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$	$K_a = 4.2 \times 10^{-7}$
$NH_4^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NH_3(aq)$	$K_a = 5.6 \times 10^{-10}$
$HF(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + F^-(aq)$	$K_a = 7.2 \times 10^{-4}$

6. Write net ionic acid-base reactions for:
   a. The reaction of acetic acid with aqueous ammonia solution
   b. The reaction of hydrofluoric acid with sodium hydroxide
   c. The reaction of ammonium chloride with potassium hydroxide
   d. The reaction of sodium bicarbonate with sulfuric acid
   e. The reaction of chlorous acid with aqueous ammonia solution
   f. The reaction of disodium hydrogen phosphate with acetic acid

7. What is the pH of
   a. 0.0010 M HCl solution?
   b. 0.15 M KOH solution?
   c. 10^{-8} M HNO_3 solution?

8. List the following substances in order of increasing acid strength: (*Look up the K_a's – pg 799*)
   H_2O, H_2SO_3, HCN, $H_2PO_4^-$, NH_4^+, $[Cu(H_2O)_6]^{2+}$, NH_3, H_3O^+, HCO_2H, HCl.

9. Complete the table for each aqueous solution at 25°C.
   State whether the solutions are acidic or basic.

$[H_3O^+]$	$[OH^-]$	pH	pOH	acidic or basic
2.0×10^{-5}				
		6.25		
	5.6×10^{-2}			
			9.20	
8.7×10^{-10}				

10. What is the pH of a solution that contains 2.60 grams of NaOH in 250 mL of aqueous solution?

11. If the pH of a sample of rainwater is 4.62, what is the hydronium ion concentration $[H_3O^+]$ and the hydroxide ion concentration $[OH^-]$ in the rainwater?

12. A 0.12 M solution of an unknown weak acid has a pH of 4.26 at 25°C. What is the hydronium ion concentration in the solution and what is the value of its K_a?

13. Hydroxylamine is a weak base with a $K_b = 6.6 \times 10^{-9}$. What is the pH of a 0.36 M solution of hydroxylamine in water at 25°C?

14. Suppose you dissolved benzoic acid in water to make a 0.15 M solution.
    What is:
    a. the concentration of benzoic acid?
    b. the concentration of hydronium ion?
    c. the concentration of benzoate anion?
    d. the pH of the solution?
    K_a for benzoic acid = 6.3×10^{-5} at 25°C

15. Which of the following salts, when dissolved in water to produce 0.10 M solutions, would have the lowest pH?
    a. sodium acetate
    b. potassium chloride
    c. sodium bisulfate
    d. magnesium nitrate
    e. potassium cyanide

16. For each of the following salts, predict whether an aqueous solution would be acidic, basic, or neutral.
    a. sodium nitrate $NaNO_3$
    b. ammonium iodide NH_4I
    c. sodium bicarbonate $NaHCO_3$
    d. ammonium cyanide NH_4CN
    e. sodium hypochlorite $NaOCl$
    f. potassium acetate KCH_3CO_2

17. a. Cyanic acid HOCN has a $K_a = 3.5 \times 10^{-4}$, what is the K_b for the cyanate ion OCN^-?

    b. Phenol is a relatively weak acid, $K_a = 1.3 \times 10^{-10}$. How does the strength of its conjugate base compare with the strength of ammonia, the acetate ion, and sodium hydroxide?

18. a. What is the pH of a 0.80 M solution of sulfurous acid?
    b. What is the concentration of sulfite ion in a 0.80 M solution of sulfurous acid?
    c. What happens to the concentration of sulfite ion SO_3^{2-} if the concentration of sulfurous acid is halved?

19. Identify the Lewis acid and the Lewis base in the following reactions:
    a. Boron trichloride reacts with chloride ion to produce $[BCl_4]^-$
    b. Nickel reacts with carbon monoxide to produce nickel tetracarbonyl $[Ni(CO)_4]$.
    c. Ammonia reacts with acetic acid to produce ammonium acetate.
    d. Sodium ions are solvated by water to produce $Na^+(aq)$

20. Calculate the pH of a 0.35 M solution of potassium cyanide. K_a for $HCN = 4.0 \times 10^{-10}$.

Note: Question #20.
   In the answers, the authors forgot to change the K_a into the K_b.
   The K_b should be 2.5×10^{-5}. The "x" = $[OH^-]$ = .002958; pOH = 2.53; pH = 11.47