XVI. Acids and Bases (Chapter 8)

A. The Bronsted-Lowery Definition

1. There are many definitions for acids.

   a) The Bronsted-Lowery definition is useful for us:

   Acids- H^+ donor. (Note: The hydrogen ion H^+ is referred to as a "proton" since this ion consists of a single proton. Therefore, acids are also referred to as "proton donors". This is not to be confused with thinking that the ion comes from a nucleus of an atom.)

   Bases- H^+ acceptors.

2. Some common acids:

   a) HCl- muriatic acid, hydrochloric acid; found in the stomach.

   b) H_2SO_4- sulfuric acid; found in car batteries.

   c) $HC_2H_3O_2$- acetic acid; found in vinegar.

   d) H_3PO_4- phosphoric acid; found in soft drinks.

   e) HNO_3- nitric acid; used in industry.

3. Acids give off H^+

   a) Strong acids such as HCl give off H^+ simply by adding it to water:

   $HCl(aq) + H_2O \longrightarrow H_3O^+ + Cl^-$

   b) Weak acids such as $HC_2H_3O_2$ do not give off H^+ as easily when added to water.

4. Some common bases:

   a) NaOH- sodium hydroxide, lye; found in drain cleaners.

   b) KOH- potassium hydroxide.

   c) $Mg(OH)_2$- magnesium hydroxide, milk of magnesia.

B. Acid/Base Reactions.

1. General reaction:

   $HA + MOH \text{ --> } H_2O + MA$

   a) Example:

      $HCl + NaOH \text{ ---> } H_2O + NaCl$

2. Reactions between acids and bases: neutralization.

   a) The formation of water drives the reaction towards completion.

   b) Complete the following molecular equations, then write the net-ionic equations:

      i) $HCl(aq) + NaOH(aq) \text{ --->}$

      ii) $HC_2H_3O_2(aq) + NaOH(aq) \text{ --->}$

      iii) $HNO_3(aq) + KOH(aq) \text{ --->}$

      iv) $Ba(OH)_2(aq) + HNO_2(aq) \text{ --->}$

3. For the following reactions identify the conjugate acid/base pairs.

a) $HCl + H_2O \text{ ---> } H_3O^+ + Cl^-$

b) $HSO_4^- + HCO_3^- \text{ ----> } SO_4^{2-} + H_2CO_3$

c) $HSO_4^- + HClO_4 \text{ ----> } H_2SO_4 + ClO_4^-$

d) $NH_3 + CH_3^- \text{ ----> } CH_4 + NH_2^-$

4. a) What is the conjugate base for the HCO_3^- ion? (What does the hydrogen carbonate ion turn into upon acting as an acid?

b) What is the conjugate acid of water? (What does water turn into when it acts as a base?)

c) What is the conjugate base of water?

d) What is the conjugate acid of NH_3?

e) What is the conjugate base of NH_3?

C. The pH of Strong Acids

1. Evaluate the following:

a) log 1 =	$10^x = 1$	x =
b) log 10 =	$10^x = 10$	x =
c) log 100 =	$10^x = 100$	x =
d) log 1000 =	$10^x = 1000$	x =
e) log .1 =	$10^x = .1$	x =
f) log .01 =	$10^x = .01$	x =

g) log 4.71 =

h) log (4.71×10^1) =

i) log (4.71×10^2) =

j) log (3.74×10^{-4}) =

k) log .0000571 =

2. Evaluate the following:

a) antilog 1 =

b) antilog 2 =

c) antilog -3 =

d) antilog 12.7 =

e) antilog -11.24 =

f) antilog -4.55 =

3. pH is defined as: **$pH = -\log [H_3O^+]$** where [ ] represent concentration in molarity.

a) Memorize the pH equation.

b) Calculate the pH for solutions containing the following $[H_3O^+]$.

$[H_3O^+] = .1M$ $\qquad$ $pH = -\log [H_3O^+] =$

$[H_3O^+] = .01M$

$[H_3O^+] = .001M$

$[H_3O^+] = .0001M$

c) A solution of pH 1 contains ___ times (more/less) H_3O^+ than a solution of pH 2.

d) A solution of pH 1 contains ___ times (more/less) H_3O^+ than a solution of pH 3.

4. pH calculations for strong acids (HNO_3, HCl) are easy since strong acids ionize 100% into hydronium ion. Calculate the pH for the following solutions:

a) 9.7×10^{-3}M HCl

b) .015M HCl.

c) 5.78×10^{-5}M HNO_3.

D. The pH of Strong Bases

1. pH calculations of strong bases take more work since the strong base dissociates into OH^-, not H_3O^+.

2. The strong bases we will consider are Group IA metallic hydroxides (LiOH, NaOH, KOH) and $Ba(OH)_2$.

3. $[H_3O^+]$ is related to $[OH^-]$ for aqueous solutions by the equation:

$$\mathbf{[H_3O^+]\,[OH^-] = 1.00 \times 10^{-14}}$$

   a) Memorize this equation

   b) Calculate the pH for the following solutions:

      i) 7.88×10^{-5}M NaOH

      ii) 8.95×10^{-3}M KOH

      iii) .0029M $Ba(OH)_2$

E. Calculating $[H_3O^+]$ and $[OH^-]$ from pH.

1. $\mathbf{[H_3O^+] = 10^{-pH}}$ ($[H_3O^+]$ = antilog -pH)

   a) Memorize this equation.

2. Calculate $[H_3O^+]$ given the following information:

   a) pH = 7.00

   b) pH = 11.00

   c) pH = 3.31

   d) pH = 9.65

3. Once $[H_3O^+]$ is calculated, $[OH^-]$ can be calculated using the equation

$$\mathbf{[H_3O^+][OH^-] = 1.00 \times 10^{-14}}.$$

4. A solution has a pH of 2.90. Calculate $[H_3O^+]$ and $[OH^-]$.

F. Titration

1. It is found that 14.5 mL of .687M NaOH neutralizes 23.7 mL of HCl. Calculate the molarity of the HCl solution.

2. In a laboratory titration 15.0 mL of .275M H_2SO_4 neutralizes 20.0 mL of NaOH. What is the molarity of the NaOH solution?

3. 89.5 mL of .027M $Ba(OH)_2$ neutralizes 32.3 mL of a solution of HNO_3. Calculate the molarity of the acid.