Neutralization Reactions

When an acidic solution and a basic solution are mixed, they quickly react with each other. If the proper amounts of acid and base are used, the result is a solution that is neither acidic nor basic.

The reaction between an acid and a base is called an acid-base **neutralization reaction**. In such a reaction, the acid neutralizes the base and the base neutralizes the acid.

As a rule, one of the compounds that forms during a neutralization reaction is an ionic compound. This compound is called a **salt**. The other compound that forms is usually (but not always) water.

As an example, consider the neutralization reaction between hydrochloric acid and sodium hydroxide.

$$\underbrace{HCl(aq)}_{acid} + \underbrace{NaOH(aq)}_{base} \rightarrow \underbrace{H_2O(l)}_{water} + \underbrace{NaCl(aq)}_{salt}$$

If we write the complete ionic and net ionic equations for this reaction, it becomes clear why the resulting solution is neutralized.

$$H^+(aq) + Cl^-(aq) + Na^+(aq) + OH^-(aq) \rightarrow Na^+(aq) + Cl^-(aq) + H_2O(l)$$

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

The net ionic equation clearly shows that a hydrogen ion and a hydroxide ion combine to form a molecule of water. Since water does not have acidic or basic properties, the resulting solution is neutralized.

Example 1
Write the formula, complete ionic, and net ionic equations for the neutralization reaction that occurs when sulfuric acid and sodium hydroxide are mixed.

Calculating Unknown Concentrations

Using stoichiometry, it is possible to determine the concentration of an acid (or base) by determining the amount of a base (or acid) with a known concentration that is required to neutralize it.

In order to do this it is necessary to understand that, in order for neutralization to occur, the number of hydrogen ions and the number of hydroxide ions in the final solution must be equal. In other words,

$$moles\ of\ H^+\ ions = moles\ of\ OH^-\ ions$$

Example 2
Calculate the concentration of hydrochloric acid, if 25 mL is just neutralized by 40 mL of a $0.15\ mol/L$ sodium hydroxide solution.

It is also possible to determine the volume of acid (or base) required to neutralize a given amount of base (or acid).

Example 3
What volume of a $0.25\ mol/L$ solution of carbonic acid is needed to neutralize $30\ g$ of sodium hydroxide?

Worksheet

1. Complete the following neutralization reactions.

   a) $HCl + LiOH \rightarrow$

   b) $HNO_3 + CsOH \rightarrow$

   c) $HBr + KOH \rightarrow$

2. 100 mL of $NaOH$ was required to neutralize 20 mL of 5.0 $mol/L\ HClO_4$. What is the concentration of the sodium hydroxide?

3. 60 mL of 0.02$mol/L\ NaOH$ was required to neutralize 15 mL of HNO_3. What is the concentration of the nitric acid?

4. If 10 mL of 0.3 $mol/L\ KOH$ are required to neutralize 30 mL of stomach acid (HCl), what is the concentration of the stomach acid?

5. How many milliliters of 0.22 $mol/L\ CsOH$ solution is needed to neutralize 26.4 mL of 0.25 $mol/L\ HBr$?

6. How many milliliters of 0.16 $mol/L\ HClO_4$ solution is needed to neutralize 35 mL of 0.215 $mol/L\ LiOH$?

7. 25 mL of 1.0 $mol/L\ HCl$ are required to neutralize a Drano solution ($NaOH$). How many moles of $NaOH$ are present in the solution?