8.4: Acids-Bases Reactions: Neutralization

In Chapter 5, we examined a special case of a double replacement reaction in which an acid reacted with a base to give water and a pair of ions in solution. In the context of the Brønsted Theory, a base can be thought of as an ionic compound that produces the hydroxide anion in solution. Thus, sodium hydroxide, NaOH, ionizes to form the sodium cation and the hydroxide anion ($\mathrm{OH^-}$).

$$\mathrm{NaOH(aq) \longrightarrow Na^+(aq) + OH^-(aq)}$$

We have written this equation using a single arrow because sodium hydroxide is a *strong base* and is essentially 100% ionized in solution. The hydroxide anion ($\mathrm{OH^-}$) reacts with the hydronium ion ($\mathrm{H_3O^+}$) to form two moles of water, as shown in the equation given below.

$$\mathrm{H_3O^+ + OH^- \longrightarrow 2\,H_2O}$$

Thus, if you have aqueous solutions of HCl and NaOH, the following process occur:

- HCl ionizes to form the hydronium ion:

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

- NaOH ionizes to form the hydroxide anion:

$$\mathrm{NaOH(aq) \longrightarrow Na^+(aq) + OH^-(aq)}$$

- $\mathrm{OH^-}$ reacts with $\mathrm{H_3O^+}$ to form *two* moles of water:

$$\mathrm{H_3O^+ + OH^- \longrightarrow 2\,H_2O}$$

If we add up the set of three equations, we see that hydronium and hydroxide ions appear on both sides of the arrow and cancel, leaving:

$$\mathrm{HCl(aq) + NaOH(aq) \longrightarrow H_2O + NaCl(aq)} \tag{8.4.1}$$

In Equation 8.4.1, we have not shown the additional water from the hydronium ion and we have grouped the sodium and chloride ions as NaCl *(aq)*, with the understanding that it will be fully ionized in aqueous solution. This is an example of a **neutralization reaction**; an *acid* and a *base* have reacted to form *water*. When we write neutralization equations we generally do not show hydronium or hydroxide ions and we generally show ionic species as distinct compounds. Neutralization equations therefore look very much like the other double replacements that we studied in Chapter 5.

? Exercise 8.4.1

For each of the following, write a balanced neutralization equation:

a. The reaction of calcium hydroxide with hydrochloric acid.
b. The reaction of sodium hydroxide with sulfuric acid (both ionizations).
c. The reaction of barium hydroxide with nitric acid.

? Exercise 8.4.2

Write a balanced neutralization equation for the reaction of calcium hydroxide with sulfuric acid