Pearson

8.6: Representing Aqueous Reactions: Molecular, Ionic, and Complete Ionic Equations

Consider the following equation for a precipitation reaction:

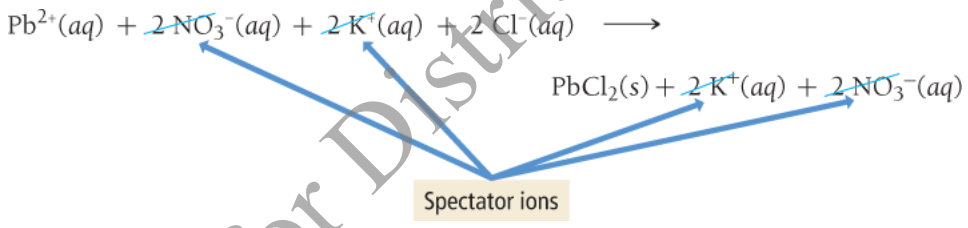
$$\mathrm{Pb(NO_3)_2\,(aq) + 2\,KCl\,(aq) \rightarrow PbCl_2\,(s) + 2\,KNO_3\,(aq)}$$

This equation is a **molecular equation**, an equation that shows the complete neutral formulas for each compound in the reaction as if they existed as molecules. In actual solutions of soluble ionic compounds, dissolved substances are present as ions. We can write equations for reactions occurring in aqueous solution in a way that better shows the dissociated nature of dissolved ionic compounds. For example, we can rewrite the above equation as:

$$\mathrm{Pb^{2+}\,(aq) + 2\,NO_3^-\,(aq) + 2\,K^+\,(aq) + 2\,Cl^-\,(aq) \rightarrow PbCl_2\,(s) + 2\,K^+\,(aq) + 2\,NO_3^-\,(aq)}$$

Equations such as this, which list all of the ions present as either reactants or products in a chemical reaction, are **complete ionic equations**.

Notice that in the complete ionic equation, some of the ions in solution appear unchanged on both sides of the equation. These ions are called **spectator ions** because they do not participate in the reaction.



To simplify the equation and to show more clearly what is happening, we can omit spectator ions:

$$\mathrm{Pb^{2+}\,(aq) + 2\,Cl^-\,(aq) \rightarrow PbCl_2\,(s)}$$

Equations that show only the species that actually change during the reaction are **net ionic equations**.

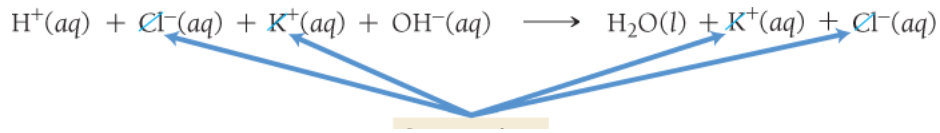
As another example, consider the reaction between HCl(aq) and KOH(aq):

$$\mathrm{HCl\,(aq) + KOH\,(aq) \rightarrow H_2O\,(l) + KCl\,(aq)}$$

Since HCl, KOH, and KCl all exist in solution primarily as independent ions, the complete ionic equation is:

$$\mathrm{H^+\,(aq) + Cl^-\,(aq) + K^+\,(aq) + OH^-\,(aq) \rightarrow H_2O\,(l) + K^+\,(aq) + Cl^-\,(aq)}$$

To write the net ionic equation, we remove the spectator ions, those that are unchanged on both sides of the equation:



Spectator ions

The net ionic equation is $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$.

Summarizing Aqueous Equations

- A **molecular equation** is a chemical equation showing the complete, neutral formulas for every compound in a reaction.
- A **complete ionic equation** is a chemical equation showing all of the species as they are actually present in solution.
- A **net ionic equation** is an equation showing only the species that actually change during the reaction.

Example 8.8 Writing Complete Ionic and Net Ionic Equations

Consider the following precipitation reaction occurring in aqueous solution:

$$3\ SrCl_2(aq) + 2\ Li_3PO_4(aq) \rightarrow Sr_3(PO_4)_2(s) + 6\ LiCl(aq)$$

Write the complete ionic equation and net ionic equation for this reaction.

SOLUTION Write the complete ionic equation by separating aqueous ionic compounds into their constituent ions. The $Sr_3(PO_4)_2(s)$, precipitating as a solid, remains as one unit.

Complete ionic equation:

$$3\ Sr^{2+}(aq) + 6\ Cl^-(aq) + 6\ Li^+(aq) + 2\ PO_4{}^{3-}(aq) \rightarrow Sr_3(PO_4)_2(s) + 6\ Li^+(aq) + 6\ Cl^-(aq)$$

Write the net ionic equation by eliminating the spectator ions, those that do not change from one side of the reaction to the other.

Net ionic equation:

$$3\ Sr^{2+}(aq) + 2\ PO_4{}^{3-}(aq) \rightarrow Sr_3(PO_4)_2(s)$$

FOR PRACTICE 8.8 Consider the following reaction occurring in aqueous solution:

$$2\ HI(aq) + Ba(OH)_2(aq) \rightarrow 2\ H_2O(l) + BaI_2(aq)$$

Write the complete ionic equation and net ionic equation for this reaction.

FOR MORE PRACTICE 8.8 Write complete ionic and net ionic equations for the following reaction occurring in aqueous solution:

$$2\ AgNO_3(aq) + MgCl_2(aq) \rightarrow 2\ AgCl(s) + Mg(NO_3)_2(aq)$$