Three Types of Reaction Equations

1. The **Formula Equation**: All species in the equation are written as molecules or formula units. This type of equation gives a useful overall picture of the reaction, with the species written as they would appear on a reagent bottle.

2. The **Complete (Total) Ionic Equation**: All species in the equation are shown as they predominantly exist in the reaction mixture (see Table 1 below). This type of equation is useful as an actual representation of the species as they truly exist.

3. The **Net Ionic Equation**: Species are shown as they predominantly exist, like in the complete ionic equation, however, any **spectator ions** are omitted. This type of equation is useful because it only shows the species undergoing chemical change in the reaction.

**Spectator Ion**: Any ion that appears unchanged on both sides of the complete ionic equation. Spectator ions are present in the reaction mixture, but do not participate in the chemical reaction.

<table>
<thead>
<tr>
<th>Shown as Individual Ions (species that ionize/dissociate completely)</th>
<th>Shown as Molecules or Formula Units (species do not ionize or only partially ionize)</th>
</tr>
</thead>
<tbody>
<tr>
<td>soluble/aqueous ionic compounds</td>
<td>insoluble/solid ionic compounds</td>
</tr>
<tr>
<td>aqueous strong acids</td>
<td>aqueous weak acids</td>
</tr>
<tr>
<td>aqueous strong bases</td>
<td>aqueous weak bases</td>
</tr>
<tr>
<td></td>
<td>most molecular compounds</td>
</tr>
</tbody>
</table>

In each of the examples below, the type of species is indicated under the formula equation, and any spectator ions are circled in the complete ionic equation.

**Example #1:**

**Formula Equation:**

\[
2 \text{HClO}_4^{\text{(aq)}} + \text{Mg(OH)}_2^{\text{(aq)}} \rightarrow 2 \text{H}_2\text{O (l)} + \text{Mg(ClO}_4^{2-}^{\text{(aq)}}
\]

strong acid  strong base  molecular  sol. ionic

**Complete Ionic Equation:**

\[
2 \text{H}^+^{\text{(aq)}} + 2 \text{ClO}_4^{2-}^{\text{(aq)}} + \text{Mg}^{2+}^{\text{(aq)}} + 2 \text{OH}^-^{\text{(aq)}} \rightarrow 2 \text{H}_2\text{O (l)} + \text{Mg}^{2+}^{\text{(aq)}} + 2 \text{ClO}_4^{2-}^{\text{(aq)}}
\]

**Net Ionic Equation:**

\[
2 \text{H}^+^{\text{(aq)}} + 2 \text{OH}^-^{\text{(aq)}} \rightarrow 2 \text{H}_2\text{O (l)}
\]

Coefficients reduce to:

\[
\text{H}^+^{\text{(aq)}} + \text{OH}^-^{\text{(aq)}} \rightarrow \text{H}_2\text{O (l)}
\]
Example #2:

Formula Equation:

\[ 2 \text{HC}_2\text{H}_3\text{O}_2\text{(aq)} + \text{Ca}{}^{2+}\text{(aq)} \rightarrow 2 \text{H}_2\text{O} \text{ (l)} + \text{Ca(sptos)aq) } \]

Complete Ionic Equation:

\[ 2 \text{HC}_2\text{H}_3\text{O}_2\text{(aq)} + \text{Ca}{}^{2+}\text{(aq)} + 2 \text{OH}^-\text{(aq)} \rightarrow 2 \text{H}_2\text{O} \text{ (l)} + \text{Ca}{}^{2+}\text{(aq)} + 2 \text{C}_2\text{H}_3\text{O}_2^-\text{(aq)} \]

Net Ionic Equation:

\[ 2 \text{HC}_2\text{H}_3\text{O}_2\text{(aq)} + 2 \text{OH}^-\text{(aq)} \rightarrow 2 \text{H}_2\text{O} \text{ (l)} + 2 \text{C}_2\text{H}_3\text{O}_2^-\text{(aq)} \]

Coefficients reduce to:

\[ \text{HC}_2\text{H}_3\text{O}_2\text{(aq)} + \text{OH}^-\text{(aq)} \rightarrow \text{H}_2\text{O} \text{ (l)} + \text{C}_2\text{H}_3\text{O}_2^-\text{(aq)} \]

Example #3:

Formula Equation:

\[ \text{Pb(NO}_3\text{)}_2\text{(aq)} + 2 \text{KCl} \rightarrow \text{PbCl}_2 \text{ (s)} + 2 \text{KNO}_3 \text{(aq)} \]

Complete Ionic Equation:

\[ \text{Pb}{}^{2+}\text{(aq)} + 2 \text{NO}_3^-\text{(aq)} + 2 \text{K}^+\text{(aq)} + 2 \text{Cl}^-\text{(aq)} \rightarrow \text{PbCl}_2 \text{ (s)} + 2 \text{K}^+\text{(aq)} + 2 \text{NO}_3^-\text{(aq)} \]

Net Ionic Equation:

\[ \text{Pb}{}^{2+}\text{(aq)} + 2 \text{Cl}^-\text{(aq)} \rightarrow \text{PbCl}_2 \text{ (s)} \]

Example #4:

Formula Equation:

\[ \text{BaCl}_2\text{(aq)} + \text{Na}_2\text{SO}_4\text{(aq)} \rightarrow \text{BaSO}_4 \text{ (s)} + 2 \text{NaCl} \text{(aq)} \]

Complete Ionic Equation:

\[ \text{Ba}{}^{2+}\text{(aq)} + 2 \text{Cl}^-\text{(aq)} + 2 \text{Na}^+\text{(aq)} + \text{SO}_4^{2-}\text{(aq)} \rightarrow \text{BaSO}_4 \text{ (s)} + 2 \text{Na}^+\text{(aq)} + 2 \text{Cl}^-\text{(aq)} \]

Net Ionic Equation:

\[ \text{Ba}{}^{2+}\text{(aq)} + \text{SO}_4^{2-}\text{(aq)} \rightarrow \text{BaSO}_4 \text{ (s)} \]