Chemistry Lecture #50: Reactions that Form Precipitates

When two soluble ionic compounds are mixed together, sometimes an insoluble precipitate is made through a double replacement reaction. For example, a clear solution of $CaCl_2$ mixed with a clear solution of $MgSO_4$ will produce white, solid precipitate.

We can predict the precipitate that will form when soluble compounds are mixed together. The steps we follow are as follows:

1. Write the compounds in their dissolved, ionic state.

2. Set up a double replacement reaction by pairing the outer ions and the inner ions. Rewrite the ions with their new pairings, and write the positive ion of the pair first.

3. Determine if the new ionic pairings will form soluble or insoluble ionic compounds (use the solubility rules we learned in lecture #48) Write the insoluble compound in non-ionic form.. If necessary, balance the equation.

Predict the insoluble precipitate in the reaction

$CaCl_{2(aq)} + MgSO_{4(aq)} \rightarrow$?

Answer:

$Ca^{2+} + 2Cl^- + Mg^{2+} + SO_4^{2-} \rightarrow Ca^{2+} + SO_4^{2-} + Mg^{2+} + 2Cl^-$

Ca^{2+} and SO_4^{2-} will form an insoluble compound, $CaSO_4$. Mg^{2+} and $2Cl^-$ will remain soluble. The finished reaction is

$Ca^{2+}_{(aq)} + 2Cl^-_{(aq)} + Mg^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow CaSO_{4(s)} + Mg^{2+}_{(aq)} + 2Cl^-_{(aq)}$

The above equation is called a *complete ionic equation*. It shows all the particles in the solution, and it shows their physical state (solid, dissolved in water, gas, etc).

Notice that Cl^- and Mg^{2+} are on both sides of the equation. These ions do not react. Ions that are not participants in the reaction, are called *spectator ions*. Since these ions undergo no change, we can cross them out and write the equation with only the ions that participate in the reaction.

$Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow CaSO_{4(s)}$

The above equation is called a *net ionic equation*. Net ionic equations only show the ions that participate in the reaction and omit spectator ions.

Write the complete ionic equation and net ionic equation for the reaction between an NaCl solution and an $AgNO_3$ solution.

Answer:

$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow$

$Na^+ + Cl^- + Ag^+ + NO_3^- \rightarrow Na^+ + NO_3^- + Ag^+ + Cl^-$

Na^+ and NO_3^- will be soluble. Ag^+ and Cl^- will form insoluble AgCl.

Complete ionic equation:

$Na^+_{(aq)} + Cl^-_{(aq)} + Ag^+_{(aq)} + NO_3^-{}_{(aq)} \rightarrow Na^+_{(aq)} + NO_3^-{}_{(aq)} + AgCl_{(s)}$

Net ionic equation:

$Cl^-_{(aq)} + Ag^+_{(aq)} \rightarrow AgCl_{(s)}$

Write complete ionic equation and net ionic equation for the reaction

$AlBr_{3(aq)} + 3NaOH_{(aq)} \rightarrow$

$Al^{3+} + 3Br^{-} + 3Na^{+} + 3OH^{-} \rightarrow Al^{3+} + 3OH^{-} + 3Na^{+} + 3Br^{-}$

Al^{3+} and OH^{-} will precipitate and form the ionic compound $Al(OH)_3$. Na^{+} and Br^{-} will remain soluble in water.

Complete ionic equation:

$Al^{3+}_{(aq)} + 3Br^{-}_{(aq)} + 3Na^{+}_{(aq)} + 3OH^{-}_{(aq)} \rightarrow Al(OH)_{3(s)} + 3Na^{+}_{(aq)} + 3Br^{-}_{(aq)}$

Net ionic equation: $Al^{3+}_{(aq)} + 3OH^{-}_{(aq)} \rightarrow Al(OH)_{3(s)}$