Reactions in Aqueous Solution

Net Ionic Equations

The way we have been writing ionic compounds look like

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

This equation does not show that like most ionic compounds, the reactants and one of the products dissociate, or separate, into cations and anions when they dissolve in water.

For example, when sodium chloride dissolves in water, it separates into sodium ($Na^+_{(aq)}$) and chloride ions ($Cl^-_{(aq)}$). Similarly, silver nitrate dissociates into silver ions ($Ag^+_{(aq)}$) and nitrate ions ($NO_3^-{}_{(aq)}$).

A complete ionic equation is an equation that shows dissolved ionic compounds as dissociated free ions.

$$Ag^{+}_{(aq)} + NO_{3}^{-}{}_{(aq)} + Na^{+}_{(aq)} + Cl^{-}_{(aq)} \longrightarrow AgCl_{(s)} + Na^{+}_{(aq)} + NO_{3}^{-}{}_{(aq)}$$

Notice that there are some ions are on both the reactants and products side. They can be cancelled out because they don't participate in the reaction.

$$Ag^{+}_{(aq)} + \cancel{NO_{3}^{-}}{}_{(aq)} + \cancel{Na^{+}}_{(aq)} + Cl^{-}_{(aq)} \longrightarrow AgCl_{(s)} + \cancel{Na^{+}}_{(aq)} + \cancel{NO_{3}^{-}}{}_{(aq)}$$

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

An ion that appears on both sides of the table and is not directly involved in the reaction is a **spectator ion.**

The **net ionic equation** is when the equation is written *without* including the spectator ions. It shows only those particles that are directly involved in the chemical change.

In writing balanced net ionic equations, the ionic charged must be balanced.

Consider the following equation

$$Pb_{(s)} + AgNO_{3(aq)} \longrightarrow Ag_{(s)} + Pb(NO_3)_{2(aq)}$$

What would this look like as a complete ionic equation? What ions would cancel out?

$$Pb_{(s)} + Ag^{+}_{(s)} + NO_3^{-}{}_{(aq)}$$
$$\longrightarrow Ag_{(s)} + Pb^{2+}{}_{(s)} + NO_3^{-}{}_{(aq)}$$

$$Pb_{(s)} + Ag^{+}{}_{(s)} \longrightarrow Ag_{(s)} + Pb^{2+}{}_{(s)}$$

Is the equation above balanced?

$$Pb_{(s)} + 2Ag^{+}{}_{(s)} \longrightarrow 2Ag_{(s)} + Pb^{2+}{}_{(s)}$$

A net ionic equation shows only those particles involved in the reaction and is balanced with respect to both mass and charge.

Example

An aqueous solution of iron(III) chloride and potassium hydroxide are mixed. A precipitate of iron(III) hydroxide forms.

Identify the spectator ions and write a balanced net ionic equation for the reaction.

Predicting the Formation of a Precipitate

You can predict the formation of a precipitate by using the general rules for solubility of ionic compounds.

Will a precipitate form when aqueous solutions of $Na_2CO_3(aq)$ and $Ba(NO_3)_2(aq)$ are mixed?

Lets look at Table 11.3 on the top of page 344 to see what is soluble and what isn't.

Solubility Rules from Table 11.3 on p. 344 of textbook

1. All group 1, and ammonium (NH_4^+) compounds are soluble.

2. All nitrate (NO_3^-), chlorate (ClO_3^-), and acetate ($CH3COO^-$, except Ag+) compounds are soluble.

3. Most sulfate (SO_4^{2-}) compounds are soluble, except Pb^{2+}, Ag^+, Hg_2^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}

4. Most halide (F^-, Cl^-, Br^-, I^-) compounds are soluble, except some heavy metal compounds (Pb^{2+}, Ag^+, Hg_2^{2+})

5. Most CO_3^{2-}, PO_4^{3-}, CrO_4^{2-}, S^{2-}, O^{2-}, OH^- are insoluble.

Try questions #28-35 on pages 343-344