Chemistry 112

Learning Opportunities

June 1 – 5

Net Ionic Equations

Much of our world is water based. Therefore, many chemical reactions take place in water. These reactions take place in what is referred to as *aqueous solution*. If you look at the example below, you will see the subscript (aq). This indicates the substance has dissolved in the water of the solution. The subscript (s) indicates the substance is a solid and has not dissolved. Solid substances will be seen on the bottom of the container or may make the solution appear cloudy.

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

Substances that dissolve in aqueous solutions (subscript aq) dissociate in water to their ionic forms. The *complete ionic equation* below represents this dissociation. Solid substances do not dissociate.

$$Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + Cl^-(aq) \rightarrow AgCl(s) + Na^+(aq) + NO_3^-(aq)$$

Any ions that occur on both the reactants side and the products side can be eliminated to simplify the equation. These ions do not take part in the reaction.

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

The ions that do not take place in the reaction (the ones that are crossed out) are referred to as *spectator ions*. When you rewrite the equation without the spectator ions, the final equation is called the *net ionic equation*.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

These are the particles directly involved in the chemical change.

See Net ionic equations – Sample problems

Practice problems

Write net ionic equations for the following equations:

1. $BaBr_{2\,(aq)} + Na_2SO_{4\,(aq)} \rightarrow BaSO_{4\,(s)} + NaBr_{\,(aq)}$
2. $Na_3PO_{4(aq)} + FeCl_{3(aq)} \rightarrow NaCl_{(aq)} + FePO_{4(s)}$
3. $(NH_4)_2S_{(aq)} + Co(NO_3)_{2(aq)} \rightarrow CoS_{(s)} + NH_4NO_{3(aq)}$
4. $AgNO_{3(aq)} + Na_2CO_{3(aq)} \rightarrow NaNO_{3(aq)} + Ag_2CO_{3(s)}$
5. $CaCl_{2(aq)} + Na_2CO_{3(aq)} \rightarrow CaCO_{3(s)} + NaCl_{(aq)}$

Predicting Precipitates

When mixing two ionic compounds it is common to have a precipitate (a solid) form. The solubility of the products formed by the reaction is used to determine whether a precipitate can form.

The products are looked up in a table to determine their solubility.

See the document – Solubility Table

SOLUBILITY OF IONIC COMPOUNDS AT SATP – GENERALIZATIONS

Anion	Cl^-, Br^-, I^-	S^{2-}	OH^-	SO_4^{2-}	CO_3^{2-}, PO_4^{3-}, SO_3^{2-}	CH_3COO^-	NO_3^-
High Solubility (aq) ≥ 0.1 mol/L (at SATP)	most	Group 1, NH_4^+ Group 2	Group 1, NH_4^+ Sr^{2+}, Ba^{2+}, Tl^+	most	Group 1, NH_4^+	most	all
Low Solubility (s) < 0.1 mol/L (at SATP)	Ag^+, Pb^{2+}, Tl^+, Hg_2^{2+} (Hg^+), Cu^+	most	most	Ag^+, Pb^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, Ra^{2+}	most	Ag^+	none

All Group 1 compounds, including acids, and all ammonium compounds, are assumed to have high solubility in water.

Find anion column

Cations for high solubility compounds (aq)

Cations for low solubility compounds (s)

Steps to solve these questions:

1. Predict the products formed (most will be double replacement reactions).
2. For the first product:
   a. Determine the anion and use it to find the correct column on the table
   b. In this column, find the location of the cation
      i. If this corresponds to the "high solubility" row, give the product the subscript (aq)
      ii. If this corresponds to the "low solubility" row, give the product the subscript (s) – this is the precipitate
3. Repeat step 2 for the second product

See Predicting precipitates – Samples

Practice Problems

Identify the precipitates formed when the following ionic compounds are mixed:

a. $AgNO_{3(aq)} + Na_3PO_{4(aq)} \rightarrow$
b. $AgNO_{3(aq)} + NaOH_{(aq)} \rightarrow$
c. $Pb(NO_3)_{2(aq)} + Na_2CO_{3(aq)} \rightarrow$
d. $CaCl_{2(aq)} + Na_3PO_{4(aq)} \rightarrow$
e. $KI_{(aq)} + Pb(NO_3)_{2(aq)} \rightarrow$