Lesson 4 - Use of solubility tables to predict and identify precipitation reactions between ions in solution. Ionic reactions show only the ions that react and the products that form.

Lets take the reaction between solutions of silver nitrate and sodium chloride. A white precipitate of silver chloride forms.
The overall equation for this reaction is shown below.

$$AgNO_{3(aq)} + NaCl_{(aq)} => AgCl_{(s)} + NaNO_{3(aq)}$$

But the Na^+ and NO_3^- ions do not take part in the reaction to form the precipitate. There are free sodium and nitrate ions floating in solution before and after the reaction. The ions that do not take part in the reaction are called ***spectator ions.***

The only ions reacting to form a new product are the Ag^+ and Cl^- ions. The new product formed is solid silver chloride (AgCl).

So the balanced ionic equation for this reaction is given below

$$Ag^+_{(aq)} + Cl^-_{(aq)} => AgCl_{(s)}$$

Ionic equations:

- show the charge on each ion.
- show the states of each species present in the equation.
- Are balanced for charge and elements.

Writing ionic balanced chemical and ionic equations for precipitation reactions involves few basic steps, as outlined below. We will cover this topic by introducing two examples.
Refresh yourself with naming precipitates by visiting this link.

Example 1. Write the balanced chemical and ionic equations for the reaction between Copper(II) nitrate and sodium carbonate.
Step 1 Write the balanced chemical equation, with states, for this reaction with reference to a solubility table.

$$Cu(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow CuCO_3(s) + 2NaNO_3(aq)$$

Step 2 Write the ionic equation for this reaction

i. Separate out all the aqueous species into there component ions.

$$Cu^{2+}(aq) + 2NO_3^-(aq) + 2Na^+(aq) + CO_3^{2-}(aq) \rightarrow CuCO_3(s) + 2Na^+(aq) + 2NO_3^-(aq)$$

ii. Cancel out the number of any species that is found on both sides in the same state.

$$Cu^{2+}(aq) + 2NO_3^-(aq) + 2Na^+(aq) + CO_3^{2-}(aq) \rightarrow CuCO_3(s) + 2Na^+(aq) + 2NO_3^-(aq)$$

iii. Rewrite the equation checking to see that the equation is balanced for elements and for charge.

$$Cu^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CuCO_3(s)$$

Example 2. Write the balanced chemical and ionic equations for the reaction between chlorine gas and sodium bromide to produce liquid bromine(Br_2) and sodium chloride.
Step 1 Write the balanced chemical equation, with states, for this reaction with reference to a solubility table.

$$Cl_2(g) + 2NaBr(aq) \rightarrow Br_2(l) + 2NaCl(aq)$$

Step 2 Write the ionic equation for this reaction

i. Separate out all the aqueous species into there component ions.

$$Cl_2(g) + 2Na^+(aq) + 2Br^-(aq) \rightarrow Br_2(l) + 2Na^+(aq) + Cl^-(aq)$$

ii. Cancel out the number of any species that is found on both sides in the same state.

$$Cl_2(g) + 2Na^+(aq) + 2Br^-(aq) \rightarrow Br_2(l) + 2Na^+(aq) + 2Cl^-(aq)$$

iii. Rewrite the equation checking to see that the equation is balanced for elements and for charge.

$$Cl_2(g) + 2Br^-(aq) \rightarrow Br_2(l) + 2Cl^-(aq)$$

Example 3. Write the balanced chemical and ionic equations for the reaction between magnesium hydroxide powder and hydrochloric acid(HCl) solution where one of the products is liquid water.
Step 1 Write the balanced chemical equation, with states, for this reaction with reference to a solubility table.

$$Mg(OH)_2(s) + 2HCl(aq) \rightarrow 2H_2O(l) + MgCl_2(aq)$$

Step 2 Write the ionic equation for this reaction

i. Separate out all the aqueous species into there component ions.

$$Mg(OH)_2(s) + 2H^+(aq) + 2Cl^-(aq) \rightarrow 2H_2O(l) + Mg^{2+}(aq) + 2Cl^-(aq)$$

ii. Cancel out the number of any species that is found on both sides in the same state.

$$Mg(OH)_2(s) + 2H^+(aq) + 2Cl^-(aq) \rightarrow 2H_2O(l) + Mg^{2+}(aq) + 2Cl^-(aq)$$

iii. Rewrite the equation checking to see that the equation is balanced for elements and for charge.

$$Mg(OH)_2(s) + 2H^+(aq) \rightarrow 2H_2O(l) + Mg^{2+}(aq)$$

Visit this link to refresh yourself with the writing of chemical and ionic equations of precipitate reactions.

Consider the solubility table shown on the right when answering the questions below.

1. Complete the table below. The first one is done for you.

Solubility of some common ionic compounds

Soluble Ionic Compounds		Important Exceptions
Compounds containing	NO_3^-	None
	$C_2H_3O_2^-$	None
	Cl^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	Br^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	I^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	SO_4^{2-}	Compounds of Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Ionic Compounds		**Important Exceptions**
Compounds containing	S^{2-}	Compounds of NH_4^+, the alkali metal cations, and Ca^{2+}, Sr^{2+}, and Ba^{2+}
	CO_3^{2-}	Compounds of NH_4^+ and the alkali metal cations
	PO_4^{3-}	Compounds of NH_4^+ and the alkali metal cations
	OH^-	Compounds of the alkali metal cations, and Ca^{2+}, Sr^{2+}, and Ba^{2+}

Activity	Precipitate	Spectator ions	Chemical equation	Ionic equation
Silver nitrate solution is mixed with an equal volume of sodium chloride	AgCl Silver chloride	Na^+, NO_3^-	$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
Sodium sulfate solution is mixed with an lead nitrate solution				
Ammonium carbonate solution is mixed with a solution of calcium nitrate				
Ammonium chloride solution is mixed with a solution of sodium carbonate				
Solid calcium nitrate is placed in a sodium sulfate solution.				
Ammonium sulfide solution is mixed with an iron(iii) nitrate solution.				
Ammonium phosphate solution is mixed with a solution of calcium nitrate				