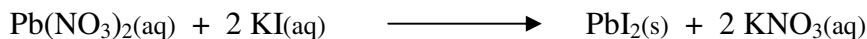


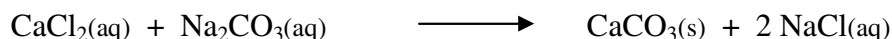
## Precipitation Reactions

Precipitation reactions involve mixing two solutions of Water soluble salts, Aqueous Solutions (denoted “aq”), to form a solid salt. An example is the reaction between soluble Lead Nitrate,  $\text{Pb}(\text{NO}_3)_2(\text{aq})$ , and Potassium Iodide,  $\text{KI}(\text{aq})$ , to form the insoluble salt Lead Iodide,  $\text{PbI}_2(\text{s})$ ; which precipitates out as a bright yellow solid. At the same time, the Water soluble salt Potassium Nitrate,  $\text{KNO}_3(\text{aq})$ , is also formed.

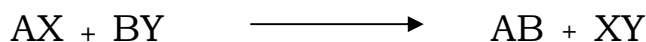


These reactions are Double Displacement reactions, otherwise known as Metathesis Reactions, because the cations effectively change places. Here, the  $\text{Pb}^{2+}$  cation displaces the  $\text{K}^+$  cation and combines with the Iodide ( $\text{I}^-$ ) to form  $\text{PbI}_2$ . Likewise, the  $\text{K}^+$  cation displaces the  $\text{Pb}^{2+}$  cation to combine with the Nitrate ( $\text{NO}_3^-$ ) to form  $\text{KNO}_3$ .

As another example, consider the following metathesis reaction in aqueous solution:



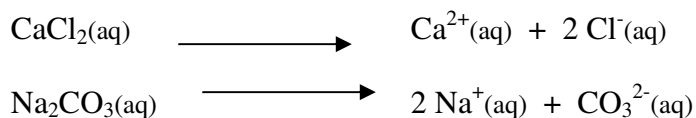
This is a type of reaction, in which two compounds exchange parts, takes the general form:



For our Calcium Chloride example, the exchange takes the following form:

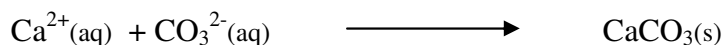


The reaction goes in a particular direction because one of the products is effectively removed from the reaction mixture. Here, one of the products,  $\text{CaCO}_3$ , is a solid that comes out of solution. Such reactions depend on the lack of solubility of one product. We can understand what is going on by considering what happens when we dissolve a salt in water. Each soluble salt will dissociate into its constituent ions.



When we mix together two solutions of soluble ionic compounds, we initially get a solution of four different ions, consisting of a cation and anion from each compound.

However, one of the pairs of the cations and anions produce a compound which is insoluble in water, and it precipitates.

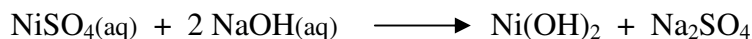


In the case of our example, NaCl remains in solution as  $\text{Na}^+(\text{aq})$  and  $\text{Cl}^-(\text{aq})$  ions because this ionic compound is soluble in water.

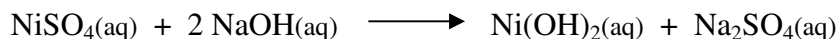
When predicting the products of a precipitation reaction, we first write the double displacement products, and then check the solubility of each to see if a precipitate forms. As an example, consider mixing solutions of Nickel Sulfate and Sodium Hydroxide:



Here the Nickel Ion ( $\text{Ni}^{2+}$ ) and Sodium Ion ( $\text{Na}^+$ ) will exchange places. Because the Nickel carries a +2 charge, and the Hydroxide Ion has a -1 charge ( $\text{OH}^-$ ), combining them will result in a compound of chemical formula  $\text{Ni}(\text{OH})_2$ . Likewise, combining the Sodium Ion ( $\text{Na}^+$ ) with the Sulfate Ion ( $\text{SO}_4^{2-}$ ) will result in the compound  $\text{Na}_2\text{SO}_4$ . Writing this in the chemical equation gives:



Note I have had to balance this equation with a stoichiometric coefficient of “2” for NaOH. Finally, we check our Solubility Rules to see that  $\text{Ni}(\text{OH})_2$ , as a Hydroxide, will be insoluble and that  $\text{Na}_2\text{SO}_4$  will be soluble. Hence, we can include these designations in the chemical equation:

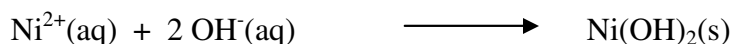


Hence, a precipitate,  $\text{Ni}(\text{OH})_2$ , does form.

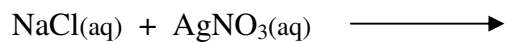
We should also notice that the  $\text{Na}^+$  and  $\text{SO}_4^{2-}$  don't undergo any chemical change. We can see this by writing this chemical equation in Total Ionic form; where each aqueous ionic species is written as the separate ions formed in solution:



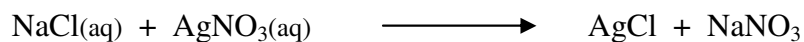
In this form, we see the Sodium ( $\text{Na}^+$ ) and Sulfate ( $\text{SO}_4^{2-}$ ) Ions do not change. They are thus referred to as Spectators. Only the Nickel ( $\text{Ni}^{2+}$ ) and Hydroxide ( $\text{OH}^-$ ) Ions react to form the precipitate. Thus, the Net Ionic Equation can be written so as to involve only those species undergoing a chemical change:



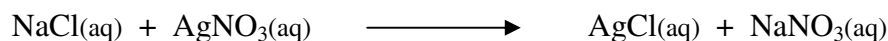
As a final example, consider what happens when an aqueous solution of Sodium Chloride is mixed with an aqueous solution of Silver Nitrate.



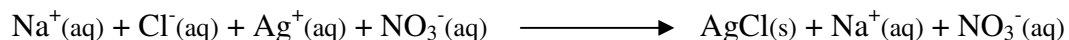
Our double-displacement products will be AgCl and NaNO<sub>3</sub>:



Checking our Solubility Rules tells us AgCl will be insoluble in Water, but NaNO<sub>3</sub> will dissolve. So, we have:



We can now write this reaction in its Total Ionic form:



Note, the Na<sup>+</sup> and NO<sub>3</sub><sup>-</sup> ions do not participate in the chemistry, and are therefore Spectator Ions. Hence, the Net Ionic Equation for this reaction is:

