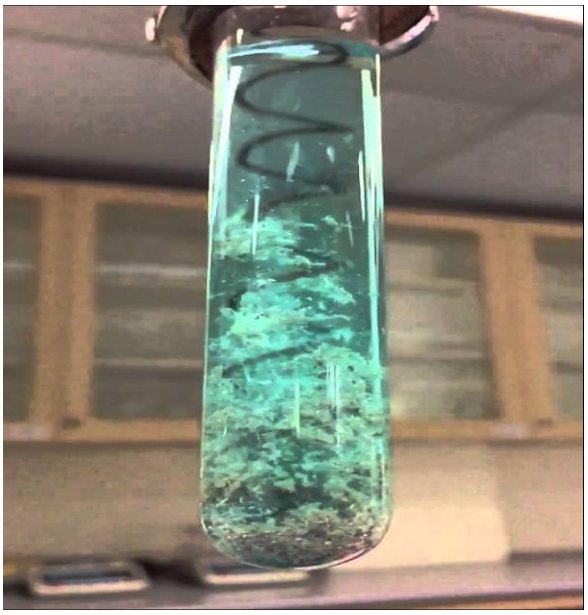
Chemistry Lecture #47: Predicting the Outcome of Single-replacement Reactions

In a single-replacement reaction, one element will replace another element in a compound. For example,

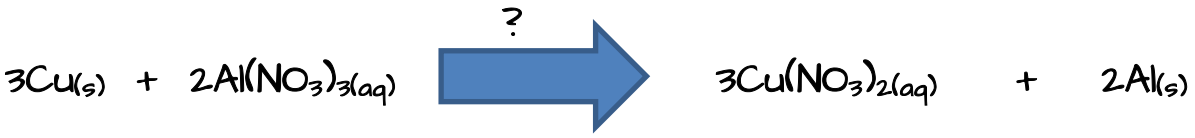
$$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$$

In the above reaction, Cu will replace Ag in the compound $AgNO_3$ to create $Cu(NO_3)_2$. In fact, if you take a copper wire and stick it into a clear solution of $AgNO_3$, the copper will dissolve into the solution and give it a blue color (which is the color of $Cu(NO_3)_2$.). The silver that is dissolved in solution as $AgNO_3$ will precipitate, and solid Ag crystals will appear. Below is a picture of the reaction.



This picture is taken from a youtube video made by Cindy Qiu. Her video can be seen at https://youtu.be/svQtn44RJ6Y

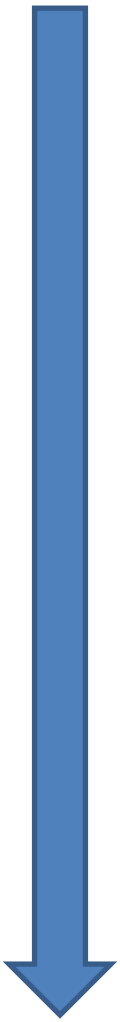
If I take a copper wire and put it in an aluminum nitrate solution, will aluminum precipitate out of solution? The reaction would be



Actually, the above reaction *does not* occur. If you were to put a copper wire into the aluminum nitrate solution, nothing would happen.

We can predict if a single-replacement reaction will occur. If an element in a single-replacement reaction is more reactive than another element, the reaction will occur. An *activity series* is a list of elements ordered from most reactive to least reactive.

ACTIVITY SERIES

Metals	*decreasing activity*	*halogens*
Lithium		fluorine
Potassium		chlorine
Calcium		bromine
Sodium		iodine
Magnesium		
Aluminum		
Zinc		
Chromium		
Iron		
Nickel		
Tin		
Lead		
HYDROGEN		
Copper		
Mercury		
Silver		
Platinum		
Gold		

Let's use the activity series to predict whether a reaction will occur.

If the element on the left side of a single-replacement reaction is listed above the element on the right side of the equation, the reaction will occur.

If the element on the left side of the reaction is listed below the element on the right side, the reaction will not occur.

Predict whether the following reaction will occur:

$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$

Cu (copper) is the element on the left hand side of the equation and Ag (silver) is on the right hand side. If you look at the activity series, copper is listed above silver in the metals column.

So, since copper is listed above silver (or is more reactive), the above reaction occurs.

Predict whether the following reaction will occur:

$3Cu_{(s)} + 2Al(NO_3)_{3(aq)} \rightarrow 3Cu(NO_3)_{2(aq)} + 2Al_{(s)}$

Cu is on the left and Al is on the right. Copper is listed *below* aluminum in the metals column on the activity chart. Therefore, the reaction will not occur.

Predict whether the following reaction will occur:

$Br_{2(g)} + 2NaF_{(aq)} \rightarrow 2NaBr_{(aq)} + F_{2(g)}$

Bromine is below fluorine on the activity chart, so the reaction will not occur.

Predict whether the following reaction will occur:

$Cl_{2(g)} + 2KI_{(aq)} \rightarrow 2KCl_{(aq)} + I_{2(g)}$

Chlorine is above iodine in the activity chart, so the reaction will occur.