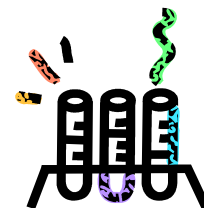


## Mini-Lab 1-03: Foiled Again...Again!

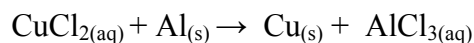


### **Purpose:**

In this activity, you will relate mass, moles, stoichiometric coefficients and limiting reactants to one another by observation of the reaction between copper(II) chloride and aluminum foil.

### **Think about this:**

The UNbalanced equation between copper(II) chloride and aluminum is:



### **Safety**

- 1) Don't eat or drink anything in the lab.
- 2) Always wear eye protection.
- 3) Wear protective clothing (lab coats, etc.).
- 4) Don't play around – treat the lab with respect.

### **Questions**

Place 20 mL of 0.37M copper(II) chloride into a beaker. Weigh 0.05 g of Al foil, tear it into small pieces, and add it to the beaker. Mix the reactants with a glass or steel rod.

- 1) What is the BALANCED equation for this reaction?
- 2) What do you observe when you mix the aluminum into the solution?
- 3) What is the chemical identity of the brown solid?
- 4) Which one of the reactants is the limiting reactant? How do you know?

**WAIT! Do not write down an answer to the Final question until your Instructor tells you to.**

- 5) What minimum mass of aluminum would you need to add to 20 mL of 0.37 M copper(II) chloride solution to make the solution turn clear?



## Instructor's Page

### 1-03: Foiled Again...Again!

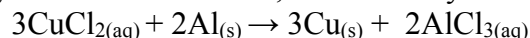
Source: idea from Wood and Breyfogle, JCE, v. 83, Num. 5, May 2006, developed by Captain Joshua Kittle, USAF Academy

Concepts: balancing equations, stoichiometry, limiting reagents

Materials: Aluminum foil, graduated cylinders, rulers, balances, prepared 0.37 Molar solution of copper chloride

(Alternatively, make a solution that is 0.37 M copper sulfate and 0.37 M NaCl. This is, effectively a solution of copper chloride, with some sulfate ions and sodium ions that you don't need to mention, since they don't participate in this reaction. Root Killer for pouring down your drains is 99% copper sulfate and can be purchased at any hardware store.)

Hints: This reaction is quite astonishing because the dark red pure copper "grows" on the aluminum foil rapidly. They should know how to balance the reaction without any observations or data, which is why this is asked first. The balanced reaction is:



They should realize that the aluminum is the limiting reactant because the solution is still blue when the aluminum is all gone, indicating that there is still aqueous copper chloride present.

To make the solution clear, they just need for copper chloride to be the limiting reagent. In 20 mL of solution, there are  $7.4 \times 10^{-3}$  moles of copper chloride. To obtain an exact stoichiometric balance of aluminum, they would need:

$$7.4 \times 10^{-3} \text{CuCl}_2 \left( \frac{2 \text{Al}}{3 \text{CuCl}_2} \right) \left( \frac{27.0 \text{gAl}}{\text{molAl}} \right) = 0.13 \text{gAl}$$

So, anything more than 0.13 grams of Aluminum will cause the solution to become clear after the reaction is completed.

#### **For More Information:**

Reference the J. Chem Ed publication listed above for a good discussion of this. Also, the reason that you cannot use copper nitrate or sulfate is that the chloride ion is necessary to disrupt the aluminum oxide surface on the foil and expose the bare metal. Aluminum oxide ( $\text{Al}_2\text{O}_3$ ) forms spontaneously and immediately on any aluminum surface exposed to air. Aluminum oxide is very hard and chemically resistant material. In fact, you may know it by its common name: sapphire! In order for this reaction to take place, the chloride ions must coordinate with the aluminum in the aluminum oxide layer and allow the copper to come into contact with actual aluminum.