# 2.13 Investigation

## The Percentage Yield of a Chemical Reaction

Aluminum metal reacts with aqueous copper(II) chloride dihydrate to produce aqueous aluminum chloride, copper metal, and water.

**Inquiry Skills**

| | | |
|---|---|---|
| ○ Questioning | ○ Planning | ● Analyzing |
| ○ Hypothesizing | ● Conducting | ● Evaluating |
| ● Predicting | ● Recording | ○ Communicating |

### Question

What mass of copper is formed when excess aluminum reacts with a given mass of copper(II) chloride dihydrate?

### Prediction

(a) Use the following balanced chemical equation to calculate the theoretical yield of copper:

$$3\ CuCl_2{\cdot}2H_2O_{(aq)} + 2\ Al_{(s)} \rightarrow 3\ Cu_{(s)} + 2\ AlCl_{3(aq)} + 6\ H_2O_{(l)}$$

Based on your calculation, predict the actual yield of copper.

### Materials

eye protection
8-cm by 8-cm piece of aluminum foil
2.00 g copper(II) chloride dihydrate, $CuCl_2{\cdot}2H_2O_{(aq)}$

| | |
|---|---|
| two 150-mL beakers | 50-mL graduated cylinder |
| stirring rod | ruler |
| forceps | hot plate |
| ring stand | iron ring |
| wire gauze | watch glass |
| crucible tongs | electronic balance |

### Procedure

1. Measure and record the mass of an empty beaker.
2. Measure out 2.00 g of the copper salt, and dissolve it in 50 mL of water in a second beaker.

Copper chloride dihydrate is toxic and must not be ingested.

3. Fold the aluminum foil lengthwise twice to make a 2-cm by 8-cm strip. Coil the strip loosely to fit into the copper chloride solution in the beaker. Ensure that the strip is entirely immersed.
4. Heat the beaker gently on the hot plate until the blue colour in the solution has disappeared completely (approximately 5 min). Continue to heat gently for an additional 5 min. Allow the beaker and its contents to cool.

Care must be taken when handling hot equipment. Eye protection and lab aprons must be worn.

5. Use the forceps to shake loose all the copper that formed on the aluminum foil. Carefully transfer the copper to the beaker from step 1. Rinse the copper with water.
6. Pour off as much of the rinse water as possible. Spread the copper on the bottom of the beaker.
7. Cover the beaker containing the wet copper with a watch glass. Gently heat the beaker to drive off the water. Reduce the heat if the copper begins to turn black.
8. When the copper is dry, determine the mass of the copper.

### Analysis

(b) Identify the limiting reagent and the excess reagent in this reaction. What visible evidence is there to confirm your identification?

(c) Answer the Question.

(d) Determine the percentage yield of copper in this experiment.

### Evaluation

(e) If the percentage yield is less than 100%, identify some sources of experimental error. If the percentage yield is greater than 100%, suggest specific factors that may account for this high yield.

(f) What steps did you take to ensure that the reaction went to completion?

(g) If you wanted to use the other reactant as the limiting reagent, what changes in the Procedure would you need to make? What visible evidence would you look for to ensure that the reaction had gone to completion?