Activity 22: Covellite or Chalcocite???

Maine Geological Survey

Objectives:

To have the students exposed to the concept of mineral stoichiometrics, although you may not wish to use this term with them. Additionally, to have the students realize that mineral formation is a very complex process where any number of variables can have an impact, not only upon how the mineral forms, but even upon the combination of elements that will combine to form a compound.

Time:

This activity is designed to last at least two class periods.

Background:

The mineral covellite, one of the major ores of copper, has the formula CuS and is a simple cupric sulfide. The mineral chalcocite, also a major ore of copper, has the formula Cu_2S. Chalcocite was mined in Roman times in the area of England now known as Cornwall. The equations for the formation of these minerals are as follows:

$$\text{Chalcocite } 2Cu + S \rightarrow Cu_2S$$

$$\text{Covellite } Cu + S \rightarrow CuS$$

Both reactions are endothermic, requiring considerable heat. While a number of more complex models for the laboratory production of these minerals exist, the basic technique is to heat a given amount of copper, in combination with excess sulfur in a closed crucible under a fume hood. After heating to constant weight, one can calculate the formula of the newly formed compound on the basis of stoichiometric data. In any given class, due to many complex and interlocking variables, you will almost always get BOTH types of minerals forming. This fascinates students as they begin to see that seemingly innocuous factors can change the outcome, and hence the chemical formula, of the resulting compound. Mixed results can be obtained by using both Fisher and regular Bunsen burners for the heat sources.

One of the results of this activity is that students start to see, especially with respect to this idea of "manufactured" resources, that there are any number of little variables which can cause a big change in the results of an experiment or process.

Materials:

Students should work in groups of two; each group will need the following:

- A .5 gram coil of 18 gauge uninsulated copper wire
- At least 2 grams of powdered sulfur
- A 30 ml Coors porcelain crucible with matching cover
- A pair of crucible tongs
- A pipe stem triangle
- A ring stand with attached adjustable ring
- A Bunsen burner (regular or Fisher) and a burner lighter
- A wire gauze pad
- A calculator

Each individual student will need safety goggles, pens and notebook. The class as a whole will need a balance sensitive to 0.01 grams and access to a fume hood.

Procedure:

The students weigh the crucible, cover, and copper before heating. They then add sulfur and heat the copper and sulfur until constant weight is achieved. Constant weight has been reached when there is no significant change in final weight when the materials are heated again with addition of a small amount of one of the reactants, in this case sulfur.

Additional sulfur, 0.5 grams of it, is added between the first and second heating. Most students will achieve constant weight after two heatings. By subtraction of the initial weight of crucible and cover from the final weight of the crucible, cover, and contents, the weight of the product (covellite or chalcocite) is calculated. Then using the starting weight of copper in THEIR sample, they calculate the theoretical weight of both CuS and Cu2S that they could have produced during the heating. Simple comparison of the actual yield to these two theoretical values lets you determine the formula. You assume that it is the value that you are closest to. It is a very rare occasion when the experimental value turns out to be exactly between the two. See sample calculations below, and student data table.

It should be noted that the student calculations, both sets of which should be shown in the student write up, will use their EXACT MASS of copper as a starting value; it will probably be near, but not exactly 0.50 grams.

By comparing the experimental yield of the copper sulfide produced (whichever one it is) to the theoretical yield; students can predict which mineral they have formed. The value closest to the experimental yield is assumed to be the correct formula for the compound.

Special Safety Procedures:

Students must wear safety goggles during all portions of this experiment; ALL HEATINGS MUST BE DONE under a fully operational fume hood. Make certain the hood is running BEFORE students start the Bunsen burner. Using the Fisher burners, heating time should average 2 minutes per group.

Even students with little or no chemistry background can perform this activity and get a great deal out of it provided adequate discussion of the theoretical and mathematical aspects is done with the class before the activity is started.

References:

Activity developed by Duane Leavitt.

Sample calculations based on exactly 0.50 grams of Cu used as a starting weight. These should be on board the day of the activity for student reference.

Covellite – CuS **Cu + S → CuS**

0.50 g Cu x (1 mole Cu / 63.54 g/mole) = 0.008 moles Cu

0.008 moles Cu x (1 mole CuS / 1 mole Cu) x (95.54 g CuS / 1 mole CuS) = 0.76 g CuS

Chalcocite – Cu2S **2Cu + S → Cu_2S**

0.50 g Cu x (1 mole Cu / 63.54 g/mole) = 0.008 moles Cu

0.008 moles Cu x (1 mole Cu_2S / 2 mole Cu) x (159.08 g Cu_2S / 1 mole Cu_2S)=0.636 g Cu_2S

Name___________________________

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Student Sheet

Purpose:

To use a chemical reaction to demonstrate that a number of variables can influence what should be a single outcome. To gain practice in precise laboratory measurements and calculations.

Materials:

In this activity you will work in groups of two. Each group will need the following: a coil of 18 gauge, uninsulated copper wire about 6 cm long, at least 2 grams of powdered sulfur, a 30 ml Coors porcelain crucible with matching cover, a pair of crucible tongs, a pipestem triangle, a ring stand with attached adjustable ring, a Bunsen or Fisher burner, a burner lighter, a wire gauze pad, and a calculator. Each individual student will need safety goggles, pens, and notebook. The class as a whole will need access to a fume hood and a balance sensitive to 0.01 grams.

Procedure:

Very often, when chemical reactions take place in natural geologic systems, a relatively large number of factors can influence the product of the reaction. This activity involves a reaction with two possible outcomes. You will heat a mixture of copper and sulfur and the resulting compound will be **EITHER** chalcocite or covellite. Both of these minerals are found in ore deposits in nature and represent a major source of copper. You will use an analysis of the compound and some calculations to determine **WHICH** compound you have produced. It is important to follow directions exactly and to also measure the required weights as precisely as possible.

1. Weigh and record the weight of a clean, dry 30 ml Coors porcelain crucible and cover to the nearest 0.01 grams.
2. Measure out a piece of 18 gauge, uninsulated copper wire that is about 6 cm long; cut the wire off the roll and, using your pencil as a winder, make a spiral or spring shape of the copper. The copper must fit nicely in the bottom of the crucible.
3. Weigh the crucible, cover **AND** copper and find the weight of the copper by subtracting the weight obtained in Part 1. Record both of these weights in the table.
4. Add enough powdered sulfur to the crucible to **COVER** the copper coil. Place the crucible, cover, and contents in a pipestem triangle; place the triangle in the supporting ring on the ring stand so it rests about 2 inches above the top of your burner. Place this whole assembly under the fume hood and turn the fume hood on.
5. Heat the crucible vigorously until the bottom and sides of the crucible glow red; continue heating for another 30-60 seconds. **NOTE: THE FUME HOOD SHOULD BE RUNNING DURING ALL HEATINGS.**
6. Remove the crucible from the heating assembly with the crucible tongs and allow to cool. Do not touch the crucible with your hands. When you can hold your hand 2-3 cm ABOVE it and not feel any warmth, the crucible is cool.
7. When the crucible is cool, weigh it and record the weight.
8. Add 0.50 grams of additional sulfur to the crucible and repeat steps 6 and 7. Record the weight obtained this time as the second heating.
9. If there is not more than 0.05 grams difference between the first and second heatings you have achieved constant weight and are basically done. If you have not achieved constant weight, add another 0.50 grams of sulfur and repeat steps 6 and 7. Record the final weight of product produced in the data table.
10. Based on the calculations and equations put on the board by your teacher, calculate YOUR theoretical yields for both covellite (CuS), and chalcocite (Cu_2S). The theoretical value which is closest to your experimental value probably represents the compound you have created. Record the formula, CuS or Cu_2S, of the compound you have created. Observe the compound and write a brief description of it.
11. Clean up and dispose of materials as directed by your instructor.

	grams
Weight of empty crucible and cover	
Weight of copper, crucible and cover	
Weight of copper used	
Weight of crucible, cover, and contents after first heating	
Weight of crucible, cover, and contents after second heating at constant weight	
Weight of product produced	
Weight of sulfur combined	

Theoretical yield of chalcocite using your starting weight of copper (SHOW WORK):

Theoretical yield of covellite using your starting weight of copper (SHOW WORK):

Formula and name of product you produced:

Description of your product after heating to constant weight:

Did all members of your class produce the same compound? If not, what do you think caused the difference?

List several factors that could affect the outcome of this experiment: