Name_____ Date_____ Period_____

QUANTITATIVE ANALYSIS

PURPOSE

To determine the values for the coefficients used in a balanced chemical equation.

BACKGROUND

By now you are familiar with seeing and working with balanced chemical equations. But how do you know the coefficients in these equations are correct? Do the coefficients reflect how the chemical substances actually combine? In this experiment, you will determine the values for the coefficients used in the balanced chemical equation for the reaction of iron metal with a copper(II) chloride solution, which produces copper metal and an iron compound. You will use the fact that the coefficients of the substances in a chemical equation represent the relative number of moles of each substance involved in the reaction. You will determine the relative numbers of moles of each reactant and product in the reaction you observe. From the mole ratios, you will derive the appropriate coefficients to be used in the chemical equation. If your experiment is successful, you should be able to determine the mole ratio of the *iron used* to the *copper produced*.

MATERIALS (PER PAIR)

safety goggles
gloves (optional)
glass-marking pencil
50-mL graduated cylinder
100, 125 or 150 -mL beaker
centigram balance
crucible tongs
plastic wash bottle
paper towels
glass stirring rod
drying oven or heat lamp
0.5 moles/L copper(II) chloride, $CuCl_2$
1 iron nail, Fe
steel wool
distilled water

SAFETY FIRST!

In this lab, observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the Procedure, refer to the list below for its meaning.


Caution: Wear your safety goggles. (All steps.)


Caution: Copper(II) chloride solution is toxic. Avoid skin contact with this material.

PROCEDURE

As you perform the experiment, record your data in Data Table 2 and your observations in Data Table 1.

Day 1

1. Using a Sharpie, label a clean, dry beaker with your name. Determine the mass of the beaker to the nearest 0.01 g, and record the measurement in Data Table 2.

2. Add 50 mL of copper(II) chloride solution to the beaker.

3. Clean an iron nail with steel wool (if necessary) to remove any rust or protective coating. Determine the mass of the nail to the nearest 0.01 g and record the measurement.

4. Slide the nail carefully into the solution of copper(II) chloride. Let the beaker stand undisturbed for at least 20 minutes. Record any evidence of a chemical reaction in Data Table 1.

Day 2

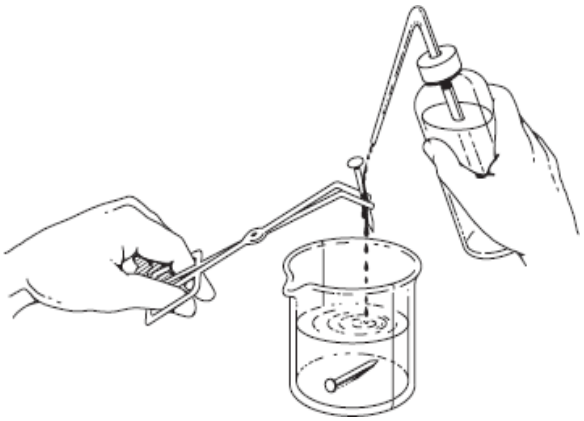
5. Using crucible tongs, remove the nail from the reaction solution. Hold the nail over the reaction beaker. Rinse the adherent reaction product off the nail and into the beaker, using a jet of water from a wash bottle, as shown in Figure 19.1.

6. Allow the nail to dry on a paper towel in a safe place. You will re-measure the mass later when dry.

7. Carefully decant the liquid portion of the reaction solution into another beaker, as shown in Figure 19.2. Leave the solid reaction product in the original beaker. Dispose of the decanted solution by pouring it into the sink.

8. Use 25 mL of water to wash the reaction product contained in the beaker. Decant the wash water into the collection container. Repeat the washing and decanting procedures two more times, being careful to avoid losing any reaction product. Pour the contents of the collection container into the sink when finished.

Figure 19.1



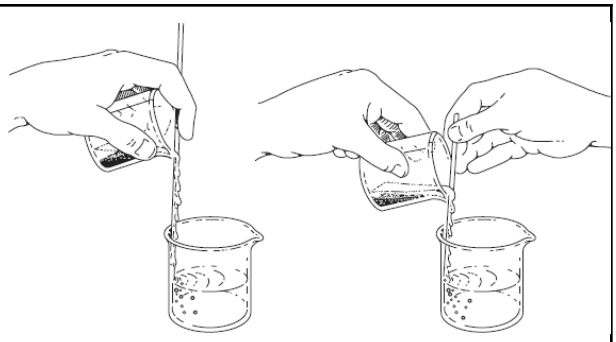


Figure 19.2

9. Place the reaction beaker containing the solid product in the appropriate place to be dried.

Day 3

10. Determine the mass of the dry nail to the nearest 0.01 g and record the measurement.

11. Determine the mass of the beaker and the dry reaction product to the nearest 0.01 g and record the measurement. When you are finished, dispose of the nail and the solid product in a waste container. Return the beaker clean and dry to the cupboard.

OBSERVATIONS *Watch this video of the lab and write your observations here!*

DATA TABLE 1: VISUAL EVIDENCE OF CHEMICAL REACTION

	Observations
Day 1 Original appearance of reactants	
Day 2 Appearance after sitting overnight	

Day 3 Appearance of dried substances	

DATA *Use the information I've provided for you to complete the calculations!*

DATA TABLE 2: MASS DETERMINATIONS	
Items	Mass (g)
empty dry beaker	**97.48**
iron nail (before reaction)	**17.07**
iron nail (after reaction)	**14.42**
beaker and dry product	**100.60**

ANALYSES AND CONCLUSIONS

Show all of your work on the calculations. Don't forget units!

1. Determine the mass of iron lost by the nail.

2. Calculate the number of moles of iron used.

3. Determine the mass of the product (assume the product is copper metal).

4. Calculate the number of moles of copper produced.

5. Using the mole quantities you have just calculated, determine the mole ratio of iron used to copper produced in this lab. Express your answer as **a number rounded to the thousandth, not a fraction**.

6. Calculate percent yield using your value for the mole ratio (#5).
(Your teacher will give you the theoretical yield; ***which will = 1 mole)***

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

7. Assuming that one product is iron(II) chloride, *write a balanced equation for the reaction*.

8. What type of reaction is this (#7)?

9. Copper could be lost in this experiment during the washing and decanting steps. How would this affect the iron: copper mole ratio? Would it make it higher or lower? Explain.

10. What other factors might account for any error in your mole ratio?

11. Does the mole ratio of a substance in a chemical equation depend on the amounts of reactants used? Explain your answer!

Extra credit (+2)
Must answer both questions correctly to receive credit.
15. What was the limiting reactant for this chemical reaction? How did you come to this conclusion?