Mole Lab #4:
QUANTITATIVE DETERMINATION OF AN EMPIRICAL FORMULA – TIN EXPERIMENT SC2 b, c, d

According to the atomic theory, in ordinary chemical reactions an atom cannot be divided into smaller parts. Therefore, when two elements combine they must do so in small whole number ratios. For example, when hydrogen and oxygen react to form the compound water the ratio of hydrogen atoms to oxygen atoms in a molecule of water is 2 to 1, never 2 ½ to 1 or 1 ¾ to 1.

It is important to note that one mole of a substance contains 6.02×10^{23} molecules, atoms, formula units, or ions (Avogadro's number). Therefore, 6.02×10^{23} molecules of water, H_20, contain $2 \times 6.02 \times 10^{23}$ atoms of hydrogen and $1 \times 6.02 \times 10^{23}$ atoms of oxygen, again a 2:1 ratio. Likewise, 1 mole of $CaCO_3$ has $1 \times 6.03 \times 10^{23}$ atoms of calcium, $1 \times 6.03 \times 10^{23}$ of calcium, $1 \times 6.03 \times 10^{23}$ atoms of carbon, and $3 \times 6.03 \times 10^{23}$ atoms of oxygen.

In order to determine experimentally an empirical formula you will oxidize tin by treating it with nitric acid. You will then calculate the mole ratio of the two elements (oxygen and tin) in one of the products and predict a formula for the resulting compound.

Objectives

In this experiment, you will:

1. React a carefully determined amount of tin with excess nitric acid;
2. Form a tin-oxygen crystalline product;
3. Calculate the mole ratio of tin and oxygen in the crystalline product;
4. Predict an empirical formula for the tin-oxygen product.

EQUIPMENT

Evaporating dish
Graduated Cylinder
Watch Glass
Glass Stirring Rod
Beaker
Ring Stand, Ring, and Wire Gauze
Laboratory Burner

PROCUEDURE

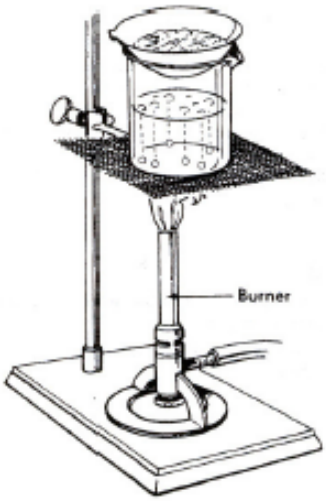
1. Prepare a table for recording data as directed in the Analysis section.

2. Clean and dry an evaporating dish and a watch glass cover. Determine the mass of the dish with watch glass cover to the nearest 0.01 g.

3. Place about 2 g of 30-mesh granulated tin in the dish, cover with the watch glass, and measure the mass to the nearest 0.01 g.

4. Add 5 mL of 8M nitric acid, HNO_3, and replace the watch glass. **CAUTION**: *Perform the reaction under a fume hood or in a well-ventilated room. HNO_3 causes burns; avoid skin contact.*

5. After the chemical action has nearly stopped, begin heating the dish over a hot water bath as shown in Figure 6-1. (An excessive amount of popping and spattering indicated you are heating too rapidly.) Continue to heat slowly until the contents are nearly dry.



6. When the popping and spattering no longer occur remove the evaporating from the water bath. Remove the watch glass taking care not to lose any of the substance. Do not clean the watch glass until all the measurements in Step 8 have been made.
7. Position the dish and its contents on a wire gauze supported by a ring stand as shown in Figure 6.2. Heat carefully with a hot flame until the solid becomes pale yellow. Brake up the solid with the stirring rod as the contents dry out. Once dry remove the dish from the heat source and allow to cool.

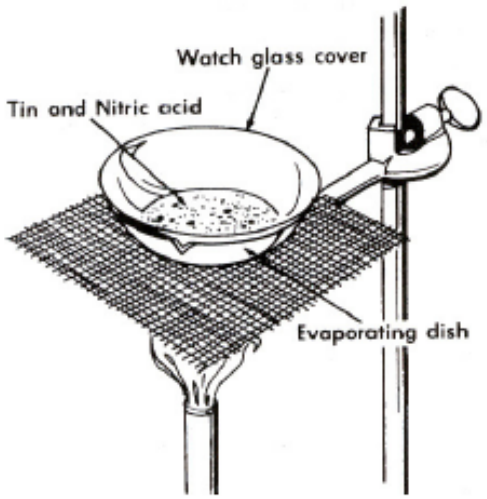


Figure 6-2. Apparatus set-up for evaporation by direct heating.

8. After the dish has cooled, replace the watch glass cover and measure the mass of the dish, contents, and cover to the nearest 0.01g.

ANALYSIS

1. Record your data in a table, which includes the following entries.
    a. Mass of evaporating dish and cover
    b. Mass of dish, cover, and tin
    c. Mass of tin
    d. Mass of dish, cover, and tin-oxygen product
    e. Mass of oxygen
2. Calculate the amount of moles of tin and oxygen in the container.
3. Calculate the estimated empirical formula of the tin-oxygen product.

DATA – RECORDED INFORMATION

Data Table	
Mass of Evaporating Dish / Cover	
Mass of Evaporating Dish / Cover & Tin	
Mass of Tin	
Mass of Evaporating Dish / Cover & Tin-Oxygen Product	
Mass of Oxygen	

CONCLUSION QUESTIONS

1. What are the possible oxidation numbers (charges) for tin and oxygen?
2. Write the two most probable empirical formulas for tin-oxygen compounds.
3. Does your predicted formula agree with either of these? If not, provide an explanation for the difference. Include any experimental errors that may have occurred.