PHYS 251 Determining a Chemical Formula Experimentally

Partner(s) _____

_____ Date _____ Time _____

**Objective**: The object of this experiment is to determine the empirical formula of a compound. An empirical formula of a compound is the simplest whole number ratio of the various atoms in a compound. In this experiment, you will determine the empirical formula of the compound that results when copper and sulfur react.

**Apparatus**: Electronic balance, crucible with lid, Bunsen burner, ring stand, burner starter, and crucible tongs.

**Chemicals**: Small gauge copper wire and sulfur.

**Procedure**: Determine the mass of a piece of copper wire and the mass of a crucible. Cover the copper wire with sulfur. With a lid on the crucible, heat over an intense heat for several minutes under exhaust hood. Check to see that the sulfur is completely burned off. Add more sulfur to cover the wire and heat again. Determine the mass of the product. Subtract the mass of the copper from the mass of the product to determine the mass of sulfur that reacted with the copper. Divide the mass of copper by its atomic mass. This is the number of moles of copper used. Divide the mass of sulfur by its atomic mass to determine the moles of sulfur that reacted. To get the moles of each element divide each number of moles by the smaller number of moles. This gives the subscripts for the equation. Examine the product and compare properties to those of copper.

http://elearning.classof1.com/demo/labs.html

**Example 1 - Determining the empirical formula of a compound from mass.**

$$Cu\ (s) + S\ (s) + O_2\ (g) \rightarrow \text{copper sulfide} + SO_2\ (g)$$

**Data**:

| | |
|---|---|
| Mass of copper | 1.27 g (3 sig figs) |
| Mass of crucible | 25.83g (4 sig figs) |
| Mass of crucible and product | 27.42g (4 sig figs) |
| Mass of product | 27.42-25.83= 1.59 g |
| Mass of sulfur in compound | 1.59-1.27 = |
| Atomic mass of Cu | 63.546 |
| Atomic mass of S | 32.066 |
| Moles of Cu | |
| Moles of S | |
| Subscript for Cu | |
| Subscript for S | |
| Formula | |

## I. Determining the empirical formula of a compound from mass.

1. Determine the empirical formula of methane given that 6.0 g of methane can be produced from 4.5 g of carbon and 1.5 g of hydrogen.
   carbon + hydrogen → Methane  Formula _____
   4.5 g  1.5 g  6.0 g

2. Greigite is also a color- and flavor-imparting trace constituent of certain types of rock salt, most notably Indian black salt, which has been long used as a condiment in South Asian cuisine and Ayurvedic therapeutics. Determine the empirical formula of the compound made when 32.39 g of iron combines with 24.80 g of sulfur.
   Iron + Sulfur → $Fe_xS_y$  Formula _____
   Fe (s) + S (s)

**Example 2 - Determining empirical formula from percentage composition. Determine the empirical formula of a compound that contains 36.5% sodium, 25.4% sulfur, and 38.1% oxygen.**

(This type of problem is essentially the same as the problems described above, with one slight difference. In these problems you start with a percentage composition instead of mass. However, if you assume that you are studying a 100g sample, you can easily change percentages to grams. Then solve the problems exactly as shown above.)

Solution:

By **assuming that we can study a 100g sample** of the compound, we can change % to grams. So rewrite the problem as: Determine the empirical formula of a compound that contains 36.5g sodium, 25.4g sulfur, and 38.1g oxygen.

| | % composition | g of element | molar mass (g/mol) | # Moles of element | Molar ratio |
|---|---|---|---|---|---|
| Sodium (Na) | 36.5 | 36.5 | 23.0 | 1.59 | 1.59/0.791 = 2.01 |
| Sulfur (S) | 25.4 | 25.4 | 32.1 | 0.791 | 0.791/0.791 = 1.00 |
| Oxygen (O) | 38.1 | 38.1 | 16.0 | 2.38 | 2.38/0.791 = 3.01 |
| Formula | **$Na_2SO_3$** | | | | |

# of moles of an element = mass of that element in the sample/ molar mass of the element

Now, find the simplest whole number ratio by dividing the smallest number of moles into all three values.

3. Determine the empirical formula of a compound that is 29.0% sodium, 40.5% sulfur, and 30.4 % oxygen by weight.

29.0% sodium + 40.5% sulfur + 30.4 % oxygen Formula _____

29.0 g Na + 40.5 g S + 30.4 g O