Honors Chemistry Lab #26: Percent Composition Investigation

Introduction:

In previous lab investigations, we discussed the relationship between the bulk mass of a substance and the number of atoms or molecules it contains (i.e., the mole). Given the chemical formula of the substance, we were able to determine molar mass and, thus, the amount of the substance from its mass. But what if the chemical formula of a substance is unknown? In this lab, we will explore how to apply these very same principles in order to derive the chemical formulas of unknown substances from experimental mass measurements. The elemental makeup of a compound defines its chemical identity, and chemical formulas are the most succinct way of representing this elemental makeup. When a compound's formula is unknown, measuring the mass of each of its constituent elements is often the first step in the process of determining the formula experimentally. The results of these measurements permit the calculation of the compound's percent composition, defined as the percentage by mass of each element in the compound. Percent composition is also useful for evaluating the relative abundance of a given element in different compounds of known formulas. As one example, consider the common nitrogen-containing fertilizers ammonia (NH_3), ammonium nitrate (NH_4NO_3), and urea (CH_4N_2O). The element nitrogen is the active ingredient for agricultural purposes, so the mass percentage of nitrogen in the compound is a practical and economic concern for consumers choosing among these fertilizers. For these sorts of applications, the percent composition of a compound is easily derived from its formula mass and the atomic masses of its constituent elements. A molecule of NH_3 contains one N atom weighing 14.01 amu and three H atoms weighing a total of (3 × 1.008 amu) = 3.024 amu. The formula mass of ammonia is therefore (14.01 amu + 3.024 amu) = 17.03 amu, and its percent composition would be calculated as shown in the box to the right.

$$\%\mathrm{N} = \frac{14.01\ \text{amu N}}{17.03\ \text{amu NH}_3} \times 100\% = 82.27\%$$

$$\%\mathrm{H} = \frac{3.024\ \text{amu N}}{17.03\ \text{amu NH}_3} \times 100\% = 17.76\%$$

In this lab you will explore the concept of percent composition using various types of gum. Most gum contains one or two different types of saps harvested from trees along with sugars and other dyes. Most sugar in gum is sucrose ($C_{12}H_{22}O_{11}$), but there are also many others forms of sugars that are often added. You will need to check the nutrition label for the ingredients for each gum you use in this lab. Using your knowledge of percent composition, you will need to design an experiment to determine the percentage of sugar in at least three different types of gum. In your experimental design, be sure to devise a way to collect quantitative data that can also be represented graphically. You will need to organize your data in a table that is suitable for your experimental design and includes multiple replicates. Thoroughly describe your experimental methodology. Show all relevant calculations and analyze your results for accuracy.

Materials: You will need chewing gum and everything else depends on your experimental design.

Methods: This is completely your choice. Thoroughly describe your experimental methodology.

Data Collection: Devise a way to collect quantitative data that can also be represented graphically. You will need to organize your data in a table that is suitable for your experimental design and includes multiple replicates. Show all relevant calculations

Data Analysis: Represent your data graphically and analyze all data for accuracy.

Extensions: Design and conduct a new experiment that builds upon and extends concepts covered in this lab. Be creative and put some effort into your new design.

Post-Lab Questions: You tell me.

Please self-assess your lab report using the checklist/rubric.