Percent Composition and Empirical Formulas

Percent Composition

Percent composition is the percent by mass of each element in a chemical compound. While this may sound difficult it is just like any other percent calculation such as your test scores. To find percent composition use the following formula and steps:

$$\frac{part}{whole}(100\%) = \frac{mass\ of\ element}{total\ mass\ of\ compound}(100\%) = percent\ by\ mass$$

1. Find the individual mass of each element. Make sure to account for multiple atoms of the same element (e.g. H_2O has 2 hydrogens so the mass of hydrogen is 2.016 g/mol).
2. Find the total mass of the compound by adding together the mass of each element.
3. Divide the mass of each element by the total mass and multiply by 100% to find the percent by mass for each element. Use correct significant figures!

Example 1

Determine the percent composition of sodium bicarbonate, $NaHCO_3$.

1. Find the individual mass of each element.

   Na **C**

   H **3 O**

2. Find the total mass of the compound.

   $NaHCO_3$

3. Find the percent composition. Use correct significant figures.

$$\frac{mass\ of\ element}{total\ mass\ of\ compound}(100\%) =$$

Example 2

Find the percent composition of sodium sulfate.

Empirical Formula

Empirical formulas represent the smallest whole number ratio of elements in a compound. Finding the empirical formula is essentially a reverse process of finding the percent composition. When chemists analyze a new compound they often know the percent of each element in that compound. From that information you must be able to obtain the ratio of each element to one another. To do this we will be utilize the mole concept that you have already learned. To find the empirical formula

1. Find the mass of each element. If you are given percent composition, then assume that you have total sample of 100.0 g.
2. Convert grams to moles for each element.
3. Divide all elements by the one with the smallest number of moles. This is to help obtain a whole number ratio between each element.
4. If not whole numbers, then multiply by the smallest factor that will obtain a whole number.

Example 1

A sample is found to contain 48.64% carbon, 8.16% hydrogen, and 43.20% oxygen. Determine the empirical formula of this compound.

Example 2

A solid contains 36.84% nitrogen and 63.16% oxygen. What is the empirical formula of this compound?

Molecular Formula

While the empirical formula represents the simplest ratio of elements in a compound, it is sometimes not the correct formula. Consider acetylene and benzene which have the same empirical formula, CH. Acetylene, however, is a gas and benzene is a liquid. They two chemicals have the same empirical formula, but they must have a higher ratio of elements so we must find the molecular formula. To do so use the following steps:

1. Find the empirical formula.
2. Find the molar mass of the empirical formula.
3. Divide the molar mass of the compound by the empirical formula. The result will show you how many times larger the molar mass is.
4. Multiply the empirical formula subscripts by the ratio of molar masses from step 3 to find the molecular formula.

Example 1

The empirical formula of acetylene and benzene is CH. If the molar mass of acetylene is 26.04 g/mol and the molar mass of benzene is 78.12 g/mol, find the molecular formulas for each of these compounds.

Acetylene

Benzene

Problems

1. What is the percent composition of phosphoric acid, H_3PO_4?

2. Propane is composed of 81.82% carbon and 18.18% hydrogen. What is the empirical formula?

3. Aspirin is comprised of 60.00% carbon, 4.44% hydrogen, and 35.56% oxygen. What is the empirical formula?

4. An oxide of aluminum contains 0.545 g of Al and 0.485 g of O. Find the empirical formula.

5. A compound is composed of 65.45% carbon, 5.45% hydrogen, and 29.09% oxygen. If the molar mass of this compound is 110.0 g/mol, what is the molecular formula?