Percent Composition

Read from Percent Composition in **Lesson 2: Quantitative Analysis of Compounds** in the **Chemistry Tutorial Section, Chapter 7** of **The Physics Classroom**:

Part 1: Percent Composition

1. Percent composition is the percent breakdown of each element in a compound (by mass). Calculate the percent composition of the following compounds.

a. $C_6H_{12}O_6$ b. $(NH_4)_3PO_4$ c. tetraphosphorus pentaoxide

d. vanadium (IV) permanganate e. iron (III) sulfate f. acetic acid

2. The active compound in cocoa powder is theobromine, $C_7H_8N_4O_2$. What is the percentage (by mass) of nitrogen in theobromine?

3. 8.86 grams of magnesium metal were heated and reacted with oxygen. The resulting oxide had a mass of 14.7 grams. What is the percent composition of the compound?

Part 2: Hydrate problems

Hydrates are ionic compounds that contain water molecules as part of their crystal structure. When a hydrate is heated, the water molecules are released, and the anhydride (the dehydrated compound) is left. To solve hydrate problems, the mass of the anhydride and the mass of the water that was driven off must be found. Then the mole-to-mole ratio of the anhydride to water component needs to be calculated.

How to solve hydrate problems:

1. Convert the mass (or the percentage) of the anhydride (dehydrated ionic compound) to moles.
2. Convert the mass (or the percentage) of the water to moles.
3. Divide the number of moles of the water by the number of moles of the anhydride. The result should be close to a whole number – this will be the coefficient of the water in the hydrate formula.

The Mole and Its Applications

Example: A 15.0-gram sample of calcium chloride hydrate was heated for several minutes. After it was cooled, the mass of the anhydride was 11.2 grams.
The mass of the water driven off was 15.0 - 11.2 = 3.8 grams
The moles of anhydride are 11.2 g $CaCl_2$ x $\frac{1 \text{mol } CaCl_2}{110.98 \text{ g } CaCl_2}$ = 0.101 mol $CaCl_2$

The moles of water are 3.8 g H_2O x $\frac{1 \text{mol } H_2O}{18.02 \text{ g } H_2O}$ = 0.21 mol H_2O

Moles of H_2O to $CaCl_2$ is 0.21/0.101 ≈ 2

This means that the hydrate contains 2 moles of H_2O for every 1 mole of anhydrate.
The formula for the hydrate is $CaCl_2 \cdot \mathbf{2}\ H_2O$ and its name is calcium chloride dihydrate.

Show all work for the following hydrate problems.

1. A hydrate of sodium carbonate had a mass of 13.5 grams before heating. After heating, the mass of the anhydride was found to be 10.1 grams. What is the formula and name of the hydrate?

2. When 15.7 grams of an iron(III) chloride hydrate were heated, 6.28 grams of water were driven off. What is the formula and name of the hydrate?

3. Epsom salts are made of a hydrate that is 49% magnesium sulfate and 51% water, by mass. What is the formula and name of the hydrate? (This is tricky – assume that there is 100 grams of hydrate.)