Percent Composition

Law of Definite Proportions

The **law of definite proportions** states that a given chemical compound ALWAYS contains the same elements in the exact same proportions by mass. For example, water is always made of 11.19% hydrogen, and 88.81% oxygen by mass, regardless of where the water came from. This can also be written an 8:1 O:H.

**Mass Percent**: the mass of an element in a compound expressed as a percent of the total mass of the compound.

It is possible to have different compounds made up of different amounts of the same element. The **law of multiple proportions** states that when 2 elements combine with each other to form more than one compound (for example, H2O, and H2O2), the mass of 1 element combines with a fixed mass of the other element, and the ratios will always be whole numbers. This just means that different compounds made up of the same elements differ in the number of atoms that combine.

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| --- | --- |
| **H2O** | **H2O2**- hydrogen peroxide- used to treat minor cuts or bleach hair |
| **C6H6**-benzene-cancer causing agent | **C8H18**- octane- major component of fuel |
| **CO**-carbon monoxide-deadly gas formed through incomplete combustion of hydrocarbons | **CO2**-carbon dioxide-product of cellular respiration-product of combustion of hydrocarbons |

Real World Example of the Law of Definite Proportions

Say you wanted to make your grandmother's famous chocolate cake. It calls for proportions such as 1 cup of flour to ½ cup of water, and 3 cups of sugar to 2 cups of chocolate chips.

a) How does this recipe demonstrate the law of definite proportions?

b) If you wanted to make a bigger or smaller cake, how would you maintain the taste?

c)If you added only more flour or sugar, would you still have the same cake? Why or why not?

Percent Composition

In order to determine what elements are present in a compound and in what percentage, we can perform a calculation. The **percent composition by mass** is the percent by mass of each element of a compound. We can find the percent composition from the formula, or from mass data. Examples of both are provided below.

% by mass= $\frac{ mass of element}{ mass of compound}$ $×$ 100%

**Percent Composition by Formula**

One way we can calculate the percent composition is with information provided by a chemical formula. Because of the **law of definite proportions**, we can choose any sample size to determine the composition.

To begin, always assume that you have 1 mole of a compound. You will then need to calculate the molar mass of the compound using the Periodic Table. You will also need to make note of the masses of each of the elements that make up the compound. From this information you can find the percent composition of each element.

**Example 1**: Find the percentage composition of the elements in Lead (IV) Sulfide, PbS2.

Step 1: Assume that we have one mole of PbS2.

Step 2: Calculate the molar mass of PbS2:

From the Periodic Table:

Molar Mass Pb= 207.2 g/mol

Molar Mass S= 32.065 g/mol

Molar Mass PbS2= 207.2 + (2x 32.065) = 271.34g/mol

Step 3: Find the mass percent of Pb in PbS2 = mass of 1 mol of Pb x 100%

 mass of 1 mol PbS2

 = 207.2 X 100%

 271.34

 = 76.4%

Step 4: Find the mass percent of S in PbS2 = mass of 1 mol S2 x 100%

 mass of 1 mol PbS2

 = 64.14 x 100%

 271.34

 = 23.6%

Step 5: Check to ensure the total is 100%.

76.4% + 23.6%= 100%

**Example 2**: Find the percent composition by mass of each of the elements in Glucose, C6H12O6.

Step 1: Assume 1 mole of compound

Step 2: Determine the mass of one mole of glucose.

From the Periodic Table:

Molar Mass C= 12.01 g/mol

Molar Mass H= 1.008 g/mol

Molar Mass O= 16.00 g/mol

Molar Mass C6H12O6= 180.16 g

Step 3:

Find the mass percent of C in C6H12O6 = mass of 1 mol of C x 100%

 mass of 1 mol C6H12O6

 = 6x 12.01 X 100%

 180.16

 = 40.0%

Step 4:

Find the mass percent of H in C6H12O6 = mass of 1 mol of H x 100%

 mass of 1 mol C6H12O6

 = 12x 1.008 X 100%

 180.16

 = 6.71%

Step 5:

Find the mass percent of O in C6H12O6 = mass of 1 mol of O x 100%

 mass of 1 mol C6H12O6

 = 6x 16.00 X 100%

 180.16

 = 53.29%

Alternatively, to find the % composition of oxygen, we could have subtracted the sum of the % compositions of hydrogen and carbon, since we know our total is 100%.

Ie: Oxygen's percentage: 100 - (40.00 + 6.71) = 53.29 %

**Example 3**: Water, H2O. Please complete this as you watch the video lesson.

One mole of water is \_\_\_\_\_\_\_\_\_\_\_\_\_\_ grams.

How many mole(s) of H atoms are there in one mole of water? \_\_\_\_\_\_\_\_\_\_

How many grams of H is this equivalent to? \_\_\_\_\_\_\_\_\_\_\_\_\_

How many moles of O atoms are there in one mole of water? \_\_\_\_\_\_\_\_\_\_

How many grams of O is this equivalent to? \_\_\_\_\_\_\_\_\_\_\_\_\_

What is the percentage of hydrogen (by mass) in water?\_\_\_\_\_\_\_\_\_\_\_\_

What is the percentage of oxygen (by mass) in water? \_\_\_\_\_\_\_\_\_\_\_\_\_

**Percent Composition from Mass Data**

Example 1: A compound with a mass of 48.72 g is found to contain 32.69 g of zinc and 16.03 g of sulfur. What is the percentage composition of the compound?

Mass percent of Zn = Mass of Zn x 100 %

 Mass of Compound

 = 32.69 g x 100 %

 48.72 g

 = 67.10 %

Mass percent of S = Mass of S x 100 %

 Mass of Compound

 = 16.03 g x 100 %

 48.72 g

 = 32.90 %

To check our answer:

Mass percent of S = 100 % - 67.10 % = 32.90 %

The percent composition of the compound is 67.10 % Zn and 32.90 % sulfur.