Conservation of Mass; Definite & Multiple Proportions

Unit: Atomic Structure

MA Curriculum Frameworks (2016): HS-PS1-1

Mastery Objective(s): (Students will be able to…)

- Explain the laws of conservation of mass, definite proportions, and multiple proportions.
- Solve problems relating to the conservation of mass.

Success Criteria:

- Explanations account for observations about the way atoms combine.
- Solutions account for all mass before and after some change.

Tier 2 Vocabulary: conservation

Language Objectives:

- Explain the laws of conservation of mass, definite proportions, and multiple proportions.

Notes:

conservation of mass: matter (mass) can neither be created nor destroyed, only changed in form. All of the mass that was present before a chemical or physical change took place is present after the change.

This law holds for the total mass, and also individually for the mass of each type of atom (element).

For example, in the chemical equation:

$$HCl + NaOH \rightarrow NaCl + H_2O$$

1. The combined mass of HCl and NaOH before the reaction is equal to the combined mass of NaCl and H_2O produced by the reaction.
2. The mass of each element before the reaction is equal to the mass of that same element after. For example, the number of grams of chlorine in the HCl that reacts is equal to the grams of chlorine in the NaCl produced.

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Law of Constant Composition (Law of Definite Proportions): the same compound always contains atoms of the same elements in the same proportions by mass. *E.g.,* water (H_2O) always contains 11 % hydrogen and 89 % oxygen by mass.

The Law of Constant Composition was part of Dalton's theory of atoms, first published in 1803.

Note also that the reverse is not necessarily true—very different compounds can have the same atoms in the same proportions, and even the exact same chemical formulas. For example, the compounds ethyl acetate and butyric acid both have the same chemical formula ($C_4H_8O_2$). However, ethyl acetate smells like nail polish, whereas butyric acid smells like a combination of rancid butter and vomit.

Law of Multiple Proportions: elements always combine in simple, whole-number ratios. (This works whether you're comparing atoms or masses.) For example, copper and chlorine can combine to form CuCl or $CuCl_2$, but they won't combine to form ratios like $Cu_{1.7}Cl_{4.83}$.

There is a joke whose punch line depends on the law of multiple proportions:

> A chemist and her friend walk into a bar. The chemist tells the bartender, "I'd like a glass of H_2O, please." Her friend says, "I'd like H_2O too." Both drink, and the friend dies.

The basis of the punch line is that "H_2O too" sounds like "H_2O_2," which is hydrogen peroxide.

The Law of Multiple Proportions was also first proposed by John Dalton in 1803 as part of his theory of atoms.

While the chemistry that we will study this year depends on the laws of constant composition and multiple proportions, there are a few unusual compounds whose elemental composition can vary from sample to sample. One example is the iron oxide wüstite, which can contain between 0.83 and 0.95 iron atoms for every oxygen atom, and thus contains anywhere between 23 % and 25 % oxygen.

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