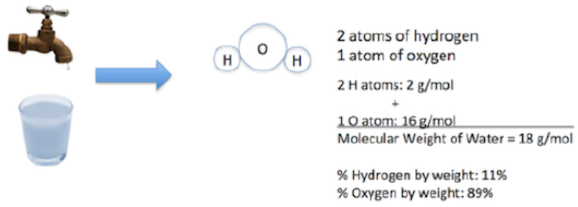
Atomic Theory

Skills to Develop

- Describe the law of conservation of mass, the law of definite proportions, and the law of multiple proportions
- Describe Dalton's atomic theory

The **law of conservation of mass** was established by Lavoisier, although others had used it before. It said that in any chemical reaction, the total mass of products is the same as the total mass of reactants. No matter is created or destroyed during the reaction.

There was a debate over whether elements always combine in exactly the same ratio, which is called **composition**. It was well known that the elemental ratios in many materials are approximately constant. Water is made by burning hydrogen in oxygen. The composition is about 11.1% hydrogen and 88.9% oxygen, by mass. The oxides of metals also generally have consistent compositions. For instance, mercuric oxide is 92.6% mercury, and mercurous oxide is 96.2% mercury; no bigger or smaller ratios were known. Berthollet, a respected scientist, argued that the consistent ratios observed arise from the conditions of the experiment; for instance, the most insoluble or volatile composition will be preferentially produced because it removes itself from the reaction. In the absence of such influences, he believed the ratios could vary continuously.

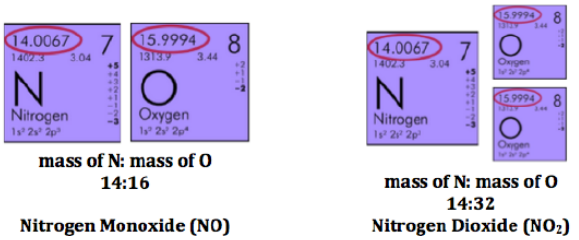


Law of Definite Proportions: % by Weight of Hydrogen and Oxygen in Water

The law of definite proportions illustrates how a specific compound has a constant mass ratio of elements, or a fixed composition.

Another scientist, Proust, said that the proportions were always the same, and eventually persuaded Berthollet of the **law of definite proportions**. Proust was more careful to study only pure compounds, and knew how precise his measurements were, so that even though the exact numbers didn't always come out the same, once he rounded to the correct number of significant figures, the ratios were the same, no matter how the material was prepared. Review the difference between accuracy and precision on the previous page (Lavoisier), and how to use the correct number of significant figures. (Some types of materials, like minerals or alloys, can have variable proportions; Berthollet was also right that in solution compositions might be possible that were not observed in the isolated substances. Berthollet's arguments on composition were inspired by his correct understanding of chemical equilibrium, but because he was wrong about definite proportions for pure compounds, this contribution to scientific knowledge was not recognized for a long time.)

Studying the data of people like Proust and Lavoisier, Dalton noticed a remarkable pattern. Carbon and nitrogen both combine with oxygen in several different definite ratios to form several different products. Likewise sulfur and phosphorus, which is why there are sulfates and sulfites. For example, carbon combines with oxygen in the ratios of 3:4 and 3:8 (3g carbon for each 4g of oxygen). Of course, 2 x 4 = 8. One compound had exactly twice as much oxygen as the other. Nitrogen combines with oxygen in ratios of 7:4, 7:8, and 7:16. In each case, the amount of oxygen doubles. This is called the **law of multiple proportions**.



The law of multiple proportions utilizes two or more compounds with the same elements in different proportions to show how the elements are combined in small whole-number ratios.

These laws all made good sense if each element has atoms that combine as whole atoms. An **atom** is a very small, distinct thing, like a ball. Now we know that atoms can be divided into smaller parts, but an atom is the smallest amount of an element you can have, because if you divide it into smaller parts, the properties will change.

The Atomic Theory

John Dalton's atomic theory:

- Matter is composed of atoms
- Atoms come in different types, called elements
- Atoms of each element have a distinct mass
- Each atom of a given element is identical to every other atom of that element
- Atoms are not created, destroyed or changed when chemical changes occur

In more modern terminology, we say that atoms of different elements are combined to make molecules. Chemical reactions change how the atoms are combined, but the number of each type of atom doesn't change.

Outside Link

- CrashCourse Chemistry: The Fundamental Law (11 min)

Contributors and Attributions

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