

Atomic Theory of Matter

- **Democritus** (Greek, 5th cent. B.C.E.) proposed that matter is not continuous, but rather cannot be divided beyond a certain point, called the **atom**.
 - ☞ Philosophical concept, not a scientific theory.
- Scientific concept of the atom is credited to the English school teacher **John Dalton** (1766-1844), who first applied the concept to a periodic table of elements in 1803.
 - ☞ Dalton's atomic theory was suggested by the quantitative work of a number of scientists who preceded him, especially Joseph Louis Proust.

Joseph Louis Proust
(1754 - 1826)

“We must recognize an invisible hand which holds the balance in the formation of compounds. A compound is a substance to which Nature assigns fixed ratios; it is, in short, a being which Nature never creates other than balance in hand, *pondere et mensurâ*.”

– Proust, 1799

**Law of Definite Proportions
or
Law of Constant Composition**

A compound is always composed of the same elements in a fixed ratio by weight.

Example: When 200.59 g of mercury reacts completely with 32.066 g sulfur, 232.66 g of red mercury sulfide is produced. What is the **percent composition by weight** of red mercury sulfide?

$$\% \text{Hg} = \frac{200.59 \text{ g}}{232.66 \text{ g}} \times 100\% = 86.216\% \text{Hg}$$

$$\% \text{S} = \frac{32.066 \text{ g}}{232.66 \text{ g}} \times 100\% = 13.782\% \text{S}$$

For every sample of red mercury sulfide the same percent composition by weight is found. (The mineral cinnabarite is this compound.) It follows from this that a compound of mercury and sulfur with any other percent composition by weight must be a different substance.

Dalton's Atomic Theory (1803)

- ① All matter is composed of atoms.
- ② All atoms of an element have the same mass (*atomic weight*).
- ③ All atoms of different elements have different masses (i.e., different atomic weights).
- ④ Atoms are indestructible and indivisible.
- ⑤ Compounds are formed when atoms of two or more elements combine.
- ⑥ In a compound the relative numbers and kinds of atoms are constant.

Modern Corrections to Dalton's Theory

- ② Many elements are composed of a mixture of *isotopes*, atoms of the same element with different masses.
- ③ Some atoms of two different elements may have virtually the same mass; these are called *isobars*.
- ④ Atoms can be split (*fission*) or merged (*fusion*) in *nuclear reactions*. Some of the mass of atoms is converted to energy in nuclear reactions, according to $E = mc^2$.

Law of Multiple Proportions

If two elements can form more than one compound, then the ratios of the weights of one element in the compounds to a fixed weight of the other element in the compounds are small whole numbers.

—John Dalton, 1803

Example: In addition to red cinnabarite, mercury and sulfur form a black compound. When 32.066 g of sulfur reacts completely with 401.18 g of mercury, 433.25 g of black mercury sulfide are produced. Show that the red and black forms of mercury sulfide obey the Law of Multiple Proportions.

Ratio Hg/S (black) =

$$401.18 \text{ g Hg} / 32.066 \text{ g S} = 12.511 \text{ g Hg/g S}$$

Ratio Hg/S (red) =

$$200.59 \text{ g Hg} / 32.066 \text{ g S} = 6.2555 \text{ g Hg/g S}$$

{Ratio Hg/S (black)}/{Ratio Hg/S (red)} =

$$12.511 / 6.2555 = 2$$