

What are Atoms?

Elements are the simplest form of matter. They are the fundamental building blocks of all the substances that we see around us. That makes them pretty important, and we would do well to understand as much about them as we can. But what are elements made of?

Based on a knowledge of the way gasses behave, it is clear that matter is made of tiny submicroscopic particles. Of course, people have not always known this. In ancient times, when the Greek philosophers considered the question of what composed matter, the favored argument was that matter was continuous (there were no ultimately small fundamental particles). This line of reasoning was based on the idea that you could always cut something into smaller and smaller pieces. No matter how small the pieces get you can

always make them smaller if you have a sharp knife and good vision. Another differing view from the Greek philosopher Democritus of Abdera around 460 B.C., was that there was a limit to subdivision. This view held that there was a point where a tiniest indivisible particle was reached and that particle could not be further subdivided. The word atom comes to us from this viewpoint. It derives from the Greek word "*atomos*," meaning indivisible. Unfortunately, the atomic ideas of Democritus had no lasting effects. Aristotle dismissed the atomic idea as worthless. For more than 2000 years nobody did anything to continue the explorations that the Greeks had started into the nature of matter. By the 1700's, however, studies of gases had led most scientists to understand that matter was composed of particles, and careful measurements of mass changes during chemical reactions showed that matter was conserved and that compounds had definite compositions.

In 1803, British chemist John Dalton described atoms as the unique constituents of the chemical elements. Dalton drew upon the chemical laws of conservation of mass, definite proportions, and multiple proportions [see the box] to propose that the elements consisted of these smallest chemical units of combination. He revived the word atom to describe them because they were never split or subdivided during chemical changes and they never went away. These smallest units of chemical change seemed indivisible and indestructible just as the word atom implies. Dalton assumed that atoms must combine in simple whole number proportions. Using this idea and the laws of definite and multiple proportions, he created the first set of relative atomic weights and his first try at a table of the elements.

Dalton's 1803 Table of Weights

 Hydrogen, 1	 Sulfur, 13	 Strontian, 46	 Lead, 90
 Azote, 5	 Magnesia, 20	 Barytes, 68	 Silver, 190
 Carbon, 5 or 4	 Lime, 24	 Iron, 50	 Gold, 190
 Oxygen, 7	 Soda, 28	 Zinc, 56	 Platina, 190
 Phosphorus, 9	 Potash, 42	 Copper, 56	 Mercury, 167

at•om (at' əm) *n.* A unit of matter, the smallest unit of an element, consisting of a dense, central, positively charged nucleus surrounded by a system of electrons, equal in number to the number of nuclear protons, the entire structure having an approximate diameter of 10^{-8} centimeter and characteristically remaining undivided in chemical reactions except for limited removal, transfer, or exchange of certain electrons.

Conservation of Mass

20 g of $H_2(g)$ combine with 160 g of $O_2(g)$ to form 180 g of water. Mass is not created or destroyed.

Definite Proportions

450 g of water decomposes to form 50 g of $H_2(g)$ and 400 g of $O_2(g)$. 90 g of water decomposes to form 10 g of $H_2(g)$ and 80 g of $O_2(g)$. When water decomposes the ratio of the mass of $O_2(g)$ to $H_2(g)$ is always 8 to 1.

Multiple Proportions

When 1.00 g of carbon burns in an internal combustion engine where oxygen is in short supply, 2.33 g of carbon monoxide forms as the carbon combines with 1.33 g of oxygen. When 1.00 g of carbon burns in the open air, 3.67 g of carbon dioxide forms as the carbon combines with 2.67 g of oxygen. The masses of the oxygen in the two carbon-oxygen compounds are in whole number ratios.

Dalton's major contribution to chemistry was his formulation of a new atomic hypothesis which built upon the early ideas of Democritus with refinements. Dalton's postulates were:

- All elements are composed of discrete particles called atoms
- Each atoms of an element is identical to every other atom of that element. Elements are composed of atoms which are identical in mass.
- Atoms of one element are different than those of other elements. Elements differ from each other in that each element has atoms of a unique mass.
- Atoms are the unit of chemical combination. They are never created, destroyed, or subdivided during chemical changes. They are indivisible.
- When atoms combine, they do so in simple whole number proportions.
- Compounds are formed and chemical changes occur with the union or separation of atoms.

Dalton's ideas differed from those of Democritus because they were based on quantitative data. Dalton correctly described in general terms the fundamental particles that make up all the substances that we see around us, but many of his notions about atoms are incorrect. Atoms of an element are *NOT* indivisible, nor are they necessarily identical. Despite these errors, Dalton made a substantial contribution to the science of chemistry.

Answer the questions below based on the reading above.

1. What was Dalton's contribution to the science of chemistry? _____

2. What evidence did Dalton have that atoms actually exist? _____

3. What single, measurable characteristic of atoms did Dalton base his conclusions on? _____

4. What is the law of multiple proportions? What does it show? _____

5. What is the law of definite proportions? How can it be used to construct a table of relative masses? _____
