Atoms, Elements, Molecules, & Compounds

Teacher's Guide

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The smallest unit of matter is the **atom.** Atoms are sometimes referred to as the "building blocks of matter." They are the smallest units that an element can be separated into and still remain the same substance. Atoms make up elements and combine to form molecules and compounds.

Atomic theory has evolved throughout history and is still being researched and modified. Notable atomic discoveries occurred in the 1800s with the publication of John Dalton's atomic theory and J. J. Thomson's discovery of small particles inside of atoms. These theories were later modified by Ernest Rutherford's experimentation and discovery of the nucleus of the atom. One of the most common atomic models was developed in the early 1900s by Niels Bohr, who suggested that electrons travel in paths around the nucleus. Bohr further proposed that electrons can "jump" between levels, and his proposed structure of an atom served as a valuable model for understanding the behavior of electrons and atoms. The modern atomic theory builds on Bohr's model and states that electrons don't necessarily travel in definite paths. Rather, there are areas inside each atom where the electrons are most likely to occur. These areas are referred to as electron clouds, which orbit the nucleus of the atom.

Atoms make up all elements. **Elements** are pure substances that cannot be separated into a simpler substance by physical or chemical changes. All elements have unique characteristics, such as boiling point or density, and are grouped into categories based on these common properties. The three major categories of elements are metals, nonmetals, and metalloids. **Metals** are shiny, malleable, ductile, and good thermal and electrical conductors. **Nonmetals** are dull, brittle, unmalleable, and poor thermal and electrical conductors. **Metalloids** are substances that have properties of both metals and nonmetals.

In the late 1800s, Dmitri Mendeleev discovered a repeating pattern existed with the properties of the known elements when they were arranged in order of increasing atomic mass. The known elements were "periodic," which means they had a repeating and regular pattern. Mendeleev's arrangement of the known elements became the first periodic table of the elements, where every eighth element has similar physical and chemical characteristics. Each square on the periodic table includes information about the element, including a chemical abbreviation, atomic mass, and atomic number. (You may wish to explain to students that the atomic masses shown are the masses of naturally occurring isotopes of the elements.) The periodic table is arranged in rows, called **periods,** and columns, called **groups** or **families.** Elements in the periodic families share similar properties because the atoms of those elements have the same number of electrons in the outer valence shell.

The behavior of the electrons in an atom determines how the atom combines to form molecules and compounds. Atoms will bond by gaining, losing, or sharing electrons to fill the outermost energy level with eight electrons. Compounds can be formed by ionic bonds, covalent bonds, or a combination of both. **Ionic bonds** are formed when oppositely charged ions are attracted, while **covalent bonds** are formed when atoms share electrons.

Compounds and molecules are created when atoms combine, but they represent different kinds of combinations. That is, **molecules** are created when two or more atoms join together. The atoms can be the same element, such as two oxygen atoms joining to form an oxygen molecule, or two different elements, such as two hydrogen atoms combining with one oxygen atom to form a water molecule. **Compounds,** on the other hand, are created when two or more different elements chemically combine. All compounds are molecules, but not all molecules are compounds. For instance, a substance created with two atoms of the same element cannot be a compound, but it can be a molecule. Compounds cannot be broken down by physical changes, only by chemical means. Therefore, in order for elements to combine and form a compound, they must react with one another. This process requires a great deal of energy and cannot be undone by physical means. Elements join together to form compounds in a specific ratio based on their masses, not in random combinations. When elements react to form a compound, the compound has different properties than the elements that formed it. The compound does not retain the properties of the components that formed it. Compounds and molecules are found everywhere and make up all living and nonliving things.