

3.1: What is Matter?

Learning Objectives

- Define matter and explain how it is composed of building blocks known as "atoms."

We are all familiar with matter. **Matter** is anything that has mass and volume (takes up space). Matter includes atoms and anything made up of atoms, but not other energy phenomena or waves such as light or sound. While this simple definition is easily applied, the way people view matter is often broken down into two characteristic scales: the macroscopic and the microscopic.



Figure 3.1.1: Moseley Hall Chemistry Lab. (Mbrickn via Wikimedia Commons)

The **macroscopic scale** is the scale on which objects or phenomena are large enough to be visible practically with the naked eye, without magnifying optical instruments. Everything that one can see, touch, and handle in the chemistry laboratory in Figure 3.1.1 is within the macroscopic scale. To describe each of these objects, only a few macroscopic properties are required. However, each of these items can be decomposed into smaller microscopic scale properties.

The **microscopic scale** is the scale of objects and events smaller than those that can easily be seen by the naked eye, requiring a lens or microscope to see them clearly. All of the everyday objects that we can bump into, touch, or squeeze are ultimately composed of atoms. This ordinary atomic matter is in turn made up of interacting subatomic particles – usually a nucleus of protons and neutrons, and a cloud of orbiting electrons. Because of this, a large number of variables are needed to describe such a system which complicates the characterization.

Matter vs. Mass

Matter should not be confused with mass as the two are not the same in modern physics. Matter is a physical substance of which systems may be composed; while mass is not a substance, but rather a quantitative property of matter and other substances or systems.

For most common objects that we encounter, it is fairly simple to demonstrate that they have mass and take up space. You might be able to imagine, however, the difficulty for people several hundred years ago to demonstrate that air had mass and volume. Air (and all other gases) are invisible to the eye, have very small masses compared to equal volumes of solids and liquids, and are quite easy to compress (change volume). Without sensitive equipment, it would have been difficult to convince people that gases are matter. Today, we can measure the mass of a small balloon when it is deflated and then blow it up, tie it off, and measure its mass again to detect the additional mass due to the air inside. The mass of air, under room conditions, that occupies a one quart jar is approximately 0.0002 pounds. This small amount of mass would have been difficult to measure in times before balances were designed to accurately measure very small masses. Later, scientists were able to compress gases into such a small volume that the

gases turned into liquids, which made it clear that gases are matter.



Figure 3.1.2: Everything from an ant, to a truck, to the earth, and even the entire galaxy is composed of matter.

Even though the universe consists of "things" as wildly different as ants and galaxies, the matter that makes up all of these "things" is composed of a very limited number of building blocks. These building blocks are known as **atoms**, and so far, scientists have discovered or created a grand total of 118 different types of atoms. Scientists have given a name to each different type of atom. A substance that is composed of only one type of atom is called an element. At this point, what should amaze us is that all forms of matter in our universe are made with only 118 different building blocks. In some ways, it's sort of like cooking a gourmet, five-course meal using only three ingredients! How is it possible? To answer that question, you have to understand the ways in which different elements are put together to form matter.

The most important method that nature uses to organize atoms into matter is the formation of **molecules**. Molecules are groups of two or more atoms that have been bonded together. There are millions of different ways to bond atoms together, which means that there are millions of different possible molecules. Each of these molecules has its own set of chemical properties, and it's these properties with which chemists are most concerned. You will learn a lot more about atoms and molecules, including how they were discovered, in a later part of the textbook.

Summary

- All matter has mass and occupies space. All physical objects are made of matter.
- Matter itself is composed of tiny building blocks known as "atoms". There are only 118 different types of atoms known to man.
- Frequently, atoms are bonded together to form "molecules".

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