20.3 Conservation of Mass

Have you ever been to a campfire? What happens to the pile of wood after it is finished burning? Of course, it is reduced to a pile of ashes. What happened to the wood? Did it just disappear into the atmosphere? The burning of wood is a chemical reaction. So far, you have learned that every atom in a chemical reaction is accounted for. If this is so, what happened to the mass of the wood in that pile? In this section, you will learn why the mass of the reactants is equal to the mass of the products in any chemical reaction.

Conservation of Mass

What is the law of conservation of mass?

In the eighteenth century, chemical reactions were still a bit of a mystery. A French scientist, Antoine Laurent Lavoisier (1743-94), established an important principal based on his experiments with chemical reactions. He stated that the total mass of the products of a reaction is equal to the total mass of the reactants. This statement is known as the **law of conservation of mass**. Lavoisier's law of conservation was not obvious to many other scientists of the time.

How can you prove the law of conservation of mass?

You already know that when wood is burned, a chemical reaction is taking place, but do you know what happens to the mass of the wood after it has burned? By now, you also know that much of the mass of the burning wood is converted into a gas such as carbon dioxide. This gas then escapes into the atmosphere. How can you prove that the mass of the reactants is equal to the mass of the products in the reaction of burning wood? Lavoisier showed that a *closed system* must be used when studying chemical reactions. When chemicals are reacted in a closed container, you can show that the mass before and after the reaction is the same.

An example of how mass is conserved in a reaction

In one of his experiments, Lavoisier placed 10.0 grams of mercury (II) oxide into a sealed container. He heated the container so that the mercury (II) oxide reacted to produce oxygen and mercury. As he observed the reaction, the white, powdery mercury (II) oxide bubbled, and turned into a smaller amount of a silvery liquid. In the reaction, 10.0 grams of mercury (II) oxide reacted in the presence of heat to produce 0.7 grams of oxygen gas and 9.3 grams of mercury. How does this data prove the law of conservation of mass?

Antoine Lavoisier

Born in 1743, Antoine Lavoisier was one of the best known French scientists of his time, and an important government official. As a student he stated "I am young and avid for glory." He demonstrated with careful measurements that it was not possible to change water into soil, but that the sediment observed from boiling water came from the container. He also burned sulfur in air and proved that the products of the reaction weighed more than the reactants and that the weight gained came from the air. Despite his contributions to chemistry, he believed that the existence of atoms was philosophically impossible. He became suspicious to leaders of the French Revolution and was beheaded in 1794.

Conservation and petroleum

Why are we in danger of running out of natural resources like petroleum?

In a chemical reaction, *atoms* are conserved, not necessarily molecules. Petroleum is a mixture of many different molecules. Furthermore, the rate of production of these molecules in nature is very small compared to the rate at which we use them. The United States uses many millions of barrels of petroleum each day in a variety of different chemical reactions. Since the mass of petroleum on earth is limited, how long do you think it will take before we run out?

What is petroleum?

Petroleum is our most important *nonrenewable* resource. From it we obtain fuels to burn in our cars, homes and power plants. It also provides us with the chemicals used to manufacture many different products we use every day. Petroleum is a mixture containing hundreds of different compounds, called *hydrocarbons*, that have two important chemical properties. First, when these compounds burn in oxygen, they release large amounts of energy. Second, molecules of these compounds can be modified in a variety of ways to produce useful materials such as plastics, drugs, explosives and even perfumes! It is no wonder that petroleum is often called "black gold."

What are hydrocarbons?

Hydrocarbons are compounds that consist of many carbon atoms bonded together to form a backbone know as a *carbon chain*. Hydrogen atoms are attached to this chain (figure 20.17). Do you see where the name "hydrocarbon" comes from? The chemical formulas for some of the hydrocarbons found in petroleum are given in figure 20.18.

How was petroleum formed?

The formation of petroleum is a chemical reaction that takes millions of years to complete. Many scientists believe that the petroleum we use today originated from animals and plants that lived in the ocean millions of years ago. As these organisms died, they settled to the bottom and were covered with sediments. The plant and animal material was digested by micrscopic organisms and, as more sediments piled up on top of them, pressure and heat converted the organic material into petroleum that is now trapped in porous rocks, deep under the earth. While it is likely that petroleum is continuously being formed, its rate of formation is too slow for it to be considered a *renewable* resource.

A short list of petroleum products...

- Aspirin
- Make-up
- Synthetic rubber
- Chewing gum
- Saccharin
- Fibers for clothing
- Artificial flavors
- Fertilizers
- Plastics

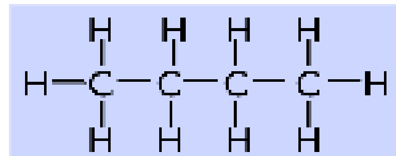

Figure 20.17: *A hydrocarbon*

name	formula
methane	CH_4
ethane	C_2H_6
propane	C_3H_8
butane	C_4H_{10}
pentane	C_5H_{12}
hexane	C_6H_{14}
heptane	C_7H_{16}
octane	C_8H_{18}

Figure 20.18: *Some of the hydrocarbons found in petroleum.*