CHEMISTRY IN YOUR WORLD

Connection to History

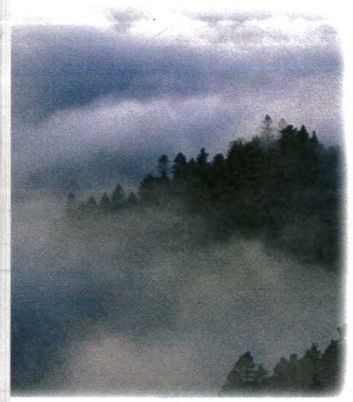
Alchemical Cymbals

Chemistry is an ancient science dating back to at least 1000 B.C., when early "chemists" discovered how to isolate metals from ores and how to preserve bodies by using embalming fluids. The Greeks were the first to try to figure out why chemical changes occur. By 400 B.C., they had proposed a system of four elements: fire, earth, water, and air. The next 2000 years of chemical history were dominated by a pseudoscience called *alchemy*. Although many alchemists were fakes and mystics, some were serious scientists who made important discoveries.

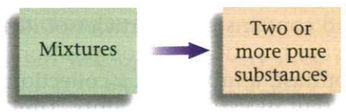
In fact, did you know that the cymbals used by more than 60% of the rock bands in the world were invented by an alchemist? The story begins 377 years ago in Constantinople, when an alchemist named Avedis discovered an alloy that produced better-sounding cymbals. This development was important because at that time cymbals were mainly used by armies to frighten their enemies. To honor his achievement, Avedis was given the name Zildjian, which meant "cymbal maker."

The descendants of that alchemist now run the Avedis Zildjian Company in Norwell, Massachusetts, which manufactures 2000 of the world's best cymbals every day. The musical world—from classical to rock—truly loves alchemical cymbals.

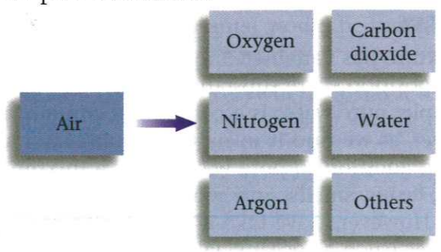
Worker at Avedis Zildjian Company making cymbals



Mixtures can be separated into pure substances: elements and/or compounds.



For example, we have seen that air can be separated into oxygen (element), nitrogen (element), water (compound), carbon dioxide (compound), argon (element), and other pure substances.



Active Reading Question

Give an example of a mixture and an example of a compound and explain how they are different.

Homogeneous and Heterogeneous Mixtures

Mixtures can be classified as either homogeneous or heterogeneous. A **homogeneous mixture** is *the same throughout*. For example, when we dissolve some salt in water and stir well, all regions of the resulting mixture have the same properties. A homogeneous mixture is also called a **solution**. Of course, different amounts of salt and water can be mixed to form various solutions, but a homogeneous mixture (a solution) does not vary in composition from one region of the solution to another (see **Figure 2.13**).

Homogeneous mixture
A mixture that is the same throughout

Solution
A homogeneous mixture

Heterogeneous mixture
A mixture containing regions with differing properties

The air around you is a solution—it is a homogeneous mixture of gases. Solid solutions also exist. Brass is a homogeneous mixture of the metals copper and zinc.

A **heterogeneous mixture** contains regions that have different properties from those of other regions. For example, when we pour sand into water, the resulting mixture has one region containing water and another, very different region containing mostly sand (see **Figure 2.14**).

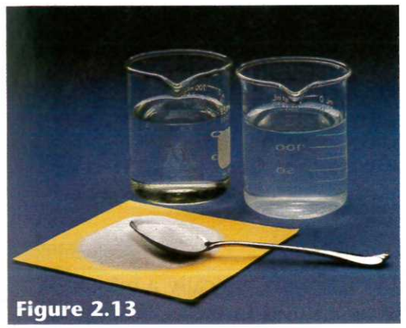


Figure 2.13

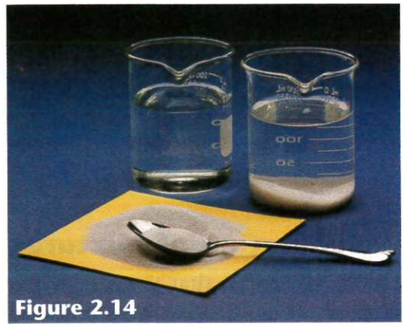


Figure 2.14

Figure 2.13
When table salt is stirred into water (left), a homogeneous mixture called a solution is formed (right).

Figure 2.14
Sand and water do not mix to form a uniform mixture. After the mixture is stirred, the sand settles back to the bottom.

HANDS-ON CHEMISTRY • MINI-LAB •

Mysterious Mixing

Materials

- clear plastic cup
- food coloring
- water

Procedure

1. Fill a clear plastic cup halfway with water.
2. Carefully place a drop of food coloring on the surface of the water.
3. Without disturbing the water, observe the food coloring for a few minutes.
4. How can you make the food coloring mix more quickly with the water? Design an experiment and discuss it with your teacher.
5. Test the experiment.

Results/Analysis

1. Make a list of your observations from step 3.
2. The water does not appear to be moving. What do your observations tell you about the water molecules? Explain your answer.
3. Draw molecular-level pictures that explain your observations.
4. Explain the results of your experiment to make the food coloring mix more quickly with the water.

EXAMPLE 2.3

Distinguishing Between Mixtures and Pure Substances

Identify each of the following as a pure substance, a homogeneous mixture, or a heterogeneous mixture.

a. gasoline
b. a stream with gravel at the bottom
c. air
d. copper metal

Solution

a. Gasoline is a homogeneous mixture containing many compounds.
b. A stream with gravel on the bottom is a heterogeneous mixture.
c. Air is a homogeneous mixture of elements and compounds.
d. Copper metal is a pure substance (an element).

Practice Problem • Exercise 2.3

Classify each of the following as a pure substance, a homogeneous mixture, or a heterogeneous mixture.

a. maple syrup
b. the oxygen and helium in a scuba tank
c. oil and vinegar salad dressing
d. common salt (sodium chloride)

B. Separation of Mixtures

We have seen that the matter found in nature is typically a mixture of pure substances. For example, seawater is water containing dissolved minerals. We can separate the water from the minerals by boiling, which changes the water to steam (gaseous water) and leaves the minerals behind as solids. If we collect and cool the steam, it condenses to pure water. This separation process, called **distillation**, is shown in **Figure 2.15.**

Distillation
A separation process that depends on the different boiling points of the substances

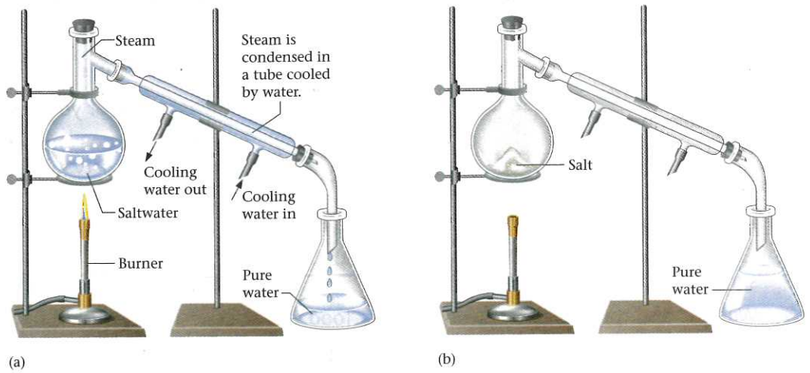


Figure 2.15
Distillation of a solution consisting of salt dissolved in water. (a) When the solution is boiled, steam is driven off. If this steam is collected and cooled, it condenses to form pure water, which drips into the collection flask. (b) After all of the water has been boiled off, the salt remains in the original flask and the water is in the collection flask.

When we carry out the distillation of saltwater, water is changed from the liquid state to the gaseous state and then back to the liquid state. These changes of state are examples of physical changes. We are separating a mixture of substances, but we are not changing the composition of the individual substances. We can represent this as shown in **Figure 2.16.**

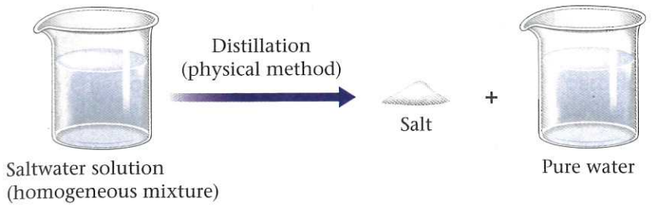


Figure 2.16
No chemical change occurs when salt water is distilled.

Suppose that we scooped up some sand with our sample of seawater. This sample is a heterogeneous mixture, because it contains an undissolved solid as well as the saltwater solution. We can separate out the sand by simple **filtration**. We pour the mixture onto a mesh, such as a filter paper, which allows the liquid to pass through and leaves the solid behind (see **Figure 2.17**). The salt can then be separated from the water by distillation. The total separation process is represented in **Figure 2.18.** All the changes involved are physical changes.

Filtration
Separation of a solid from a liquid by using filter paper

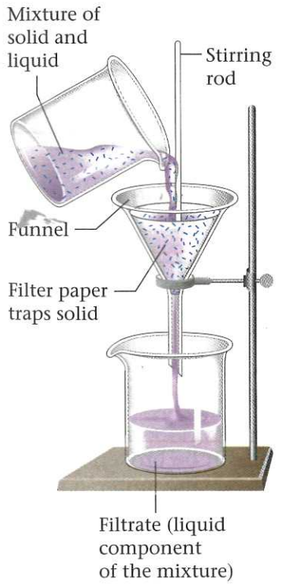
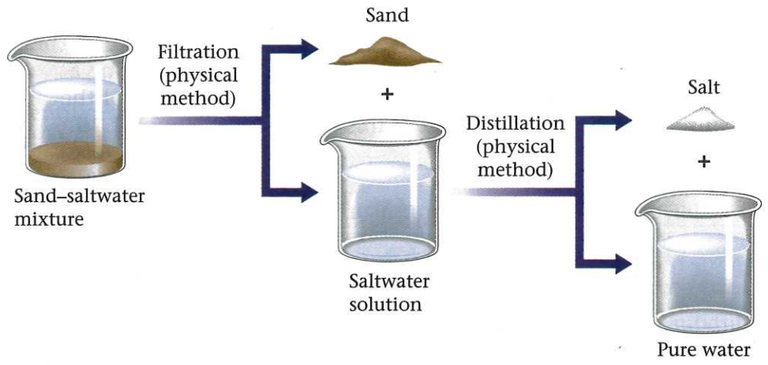


Figure 2.17
Filtration separates a liquid from a solid. The liquid passes through the filter paper, but the solid particles are trapped.

Figure 2.18
Separation of a sand-saltwater mixture



We can summarize the description of matter given in this chapter with the diagram shown in **Figure 2.19.** Note that a given sample of matter can be a pure substance (either an element or a compound) or, more commonly, a mixture (homogeneous or heterogeneous).

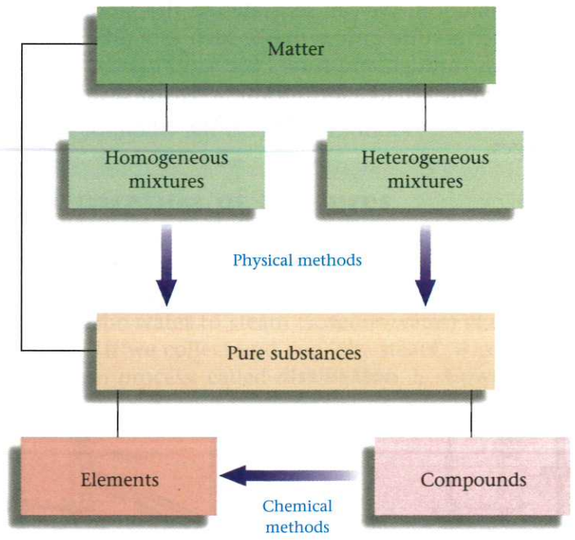
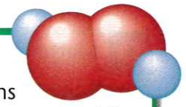


Figure 2.19
The organization of matter

We have seen that all matter exists as elements or can be broken down into elements, the most fundamental substances we have encountered up to this point. We will have more to say about the nature of elements in the next chapter.

CELEBRITY CHEMICAL Hydrogen Peroxide (H_2O_2)



Hydrogen and oxygen atoms combine to form two different molecules: the very familiar water molecule (H_2O) and the hydrogen peroxide molecule (H_2O_2). Because these molecules have very similar compositions, you might think they should behave in very similar ways. In fact, the properties of water and hydrogen peroxide are very different.

You are already very familiar with water. We drink it, we swim in it, we cook vegetables in it, we wash with it, and so on. Water is essential for life. A few days without it and we die.

Hydrogen peroxide is very different from water. This corrosive liquid would poison us if we were foolish enough to drink it. It is most commonly used as a bleaching agent. For example, hydrogen peroxide bleaches hair by reacting with melanin, the substance responsible for the color of brown and black hair. Hydrogen peroxide changes the composition of melanin in a way that causes it to lose its color—it turns brown hair blonde. In addition, hydrogen peroxide is used to bleach fibers, such as silk, and to bleach flour, producing the ultra-white powder that consumers demand. Small amounts of hydrogen peroxide are also added to some toothpastes as whitening agents.

One of the most common uses of hydrogen peroxide is to prevent infections in cuts. Sometime in your life when you have cut or scraped yourself, a parent or a nurse probably has applied a liquid to the wound that foamed and burned. That substance was hydrogen peroxide—a powerful *antiseptic* (killer of microorganisms).

Although it looks deceptively similar to water, hydrogen peroxide behaves very differently from water. A small change in the make-up of a molecule can produce big changes in behavior.

SECTION 2.3 REVIEW QUESTIONS

1. What is meant by the term *mixture*? Provide two examples of a mixture.
2. Why can't mixtures be classified as pure substances?
3. Explain the difference between a *heterogeneous mixture* and a *homogeneous mixture*. Provide two examples of each.
4. Identify the following as *mixtures* or as *pure substances*.
   - **a.** milk
   - **b.** the paper this book is printed on
   - **c.** a teaspoon of sugar
   - **d.** a teaspoon of sugar dissolved in a glass of water
   - **e.** steel
5. What is another name for a homogeneous mixture?
6. Classify the following mixtures as *homogeneous* or *heterogeneous*.
   - **a.** vanilla yogurt
   - **b.** vanilla and strawberry swirl yogurt
   - **c.** Italian salad dressing
   - **d.** kitty litter
7. Explain how you would separate a sugar water solution into sugar (solid) and water. Is this process a distillation or filtration?

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