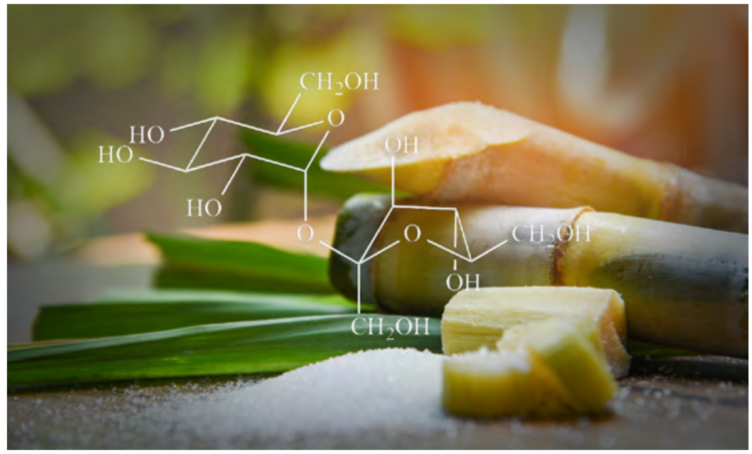
Chapter 2

The Chemistry of Life



2.3 Mixtures

Within each covalent bond, electrons are being shared between two atoms. We find, however, that some atoms are "greedy" for electrons. Relative to the periodic table we find that the closer the element is positioned to the upper right side, the greater its affinity for electrons. Consider the covalent bond between a hydrogen atom and an oxygen atom, as shown in Figure 2.12. Because oxygen is positioned closer to the upper right side of the periodic table, we can predict it has a greater affinity for electrons than does hydrogen, which is does. The result is a covalent bond where the bonding electrons spend more time closer to the oxygen atom than the hydrogen atom. Of course, electrons are negatively charged. This means that the oxygen side of the bond becomes somewhat negative in character. At the same time, the hydrogen side of the bond becomes slightly positive in character (it's positively charged nucleus becomes more exposed). The result is what we call a *polar covalent bond*.

FIGURE 2.12

The sharing of the two bonding electrons between a hydrogen and oxygen atom is less than even because the oxygen atom has a greater affinity for these electrons. As a result, the bonding electrons spend the majority of their time closer to the oxygen side of the bond. This makes the oxygen side of the bond slightly negative in charge, indicated by the δ- symbol, and the hydrogen side slightly positive, indicated by the δ+ symbol.

A water molecule has two such polar covalent bonds. And as a result, the oxygen side of the water molecule is slightly negative in character while the hydrogen side of the molecule is slightly positive. We can say that the molecule as a whole is **polar**, which means that the distribution of electrons within that molecule is not even. Another term that you might hear is the *dipole* (pronounced die-pole). "Di" is Latin for two, thus the word is saying that there are two poles, one negative and one positive.

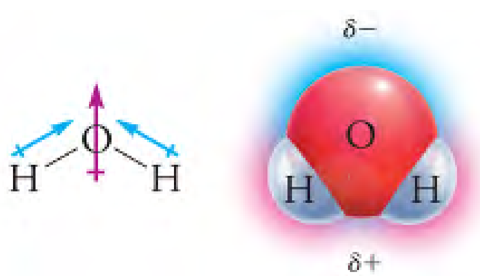


FIGURE 2.13

Water is a polar molecule. The orientation of this polarity can be represented using a crossed arrow shown in the structure to the left. As shown in the structure to the right, one side of the water molecule is thus slighty negative while the opposite side is slightly positive.

A dipole is sometimes represented using a crossed arrow where the arrow points to the negative side of the dipole. The greater the strength of the dipole, the larger the crossed arrow, as shown in Figure 2.13.

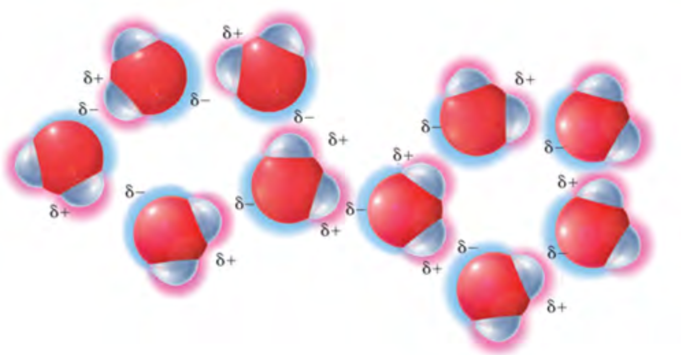


FIGURE 2.14

Water molecules attract one another because each contains a slightly positive side and a slightly negative side. The molecules position themselves such that the positive side of one faces the negative side of a neighbor. Because of these attractions, water molecules are "sticky."

Now, how do you suppose two water molecules might feel about each other? Bring them together and they'll be attracted to each other such that each positive side becomes aligned to each negative side, as shown in Figure 2.14. In this sense, water molecules are said to be "sticky". They stick to one another quite well. This explains why water has such a high boiling point—it takes a lot of thermal energy to pull them away from each other, which is what happens when going from a liquid to gaseous phase.

Now what do you suppose happens when the ionic compound sodium chloride, NaCl, is added to water? Each sodium ion is positively charged, which means they'll be surrounded by the negative sides of the water molecules. Meanwhile, each chloride ion is negatively charged, which means they'll be surrounded by the positive sides of the water molecules. Stir up the mixture and soon you'll find the solid sodium chloride (commonly known as table salt) has *dissolved* in the liquid water. You have made a *solution* of salt water. You were able to do this because of the affinity between polar water molecules and the electrically charged sodium and chloride ions, as shown in Figure 2.15.

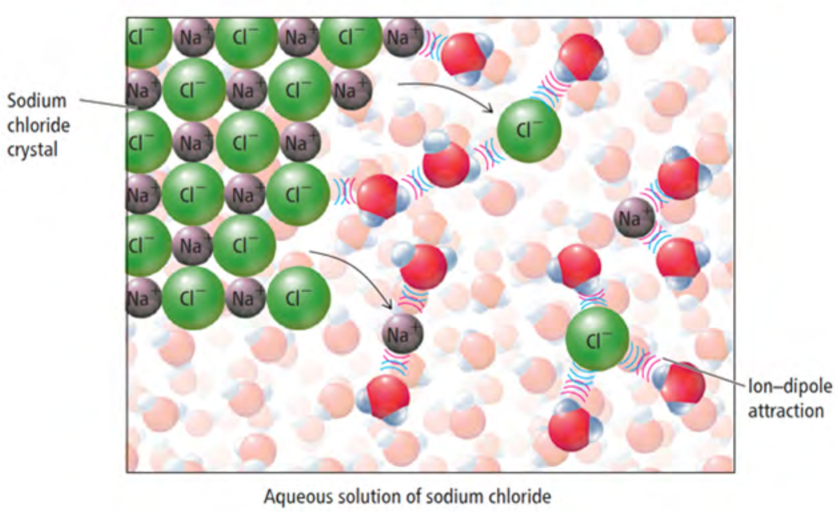


FIGURE 2.15

Water molecules Sodium and chloride ions tightly bound in a crystal lattice are separated from one another by the collective attraction exerted by many water molecules to form a solution of sodium chloride.

Let's summarize this process by spelling out related definitions. If a material is **pure**, it consists on only a single element or a single chemical compound. Pure gold, for example, contains nothing but gold atoms. Pure table salt contains nothing but the chemical compound sodium chloride. A **mixture** is a collection of two or more pure substances that are physically mixed. Within a mixture, each pure substance retains its own properties.

Figure 2.16

Examples of solutions.

A **solution** is a type of mixture where all the components are of the same phase, as shown in Figure 2.16. Salt water is a liquid solution because both the water and the dissolved sodium chloride are found in a single liquid phase. The atmosphere is a gaseous solution consisting of the gaseous elements nitrogen and oxygen as well as minor amounts of other gaseous materials, such as carbon dioxide. An example of a solid solution is the alloy white gold, which is a mixture of the elements gold and palladium or sometimes platinum.

FIGURE 2.17

The path of light becomes visible when the light passes through a suspension.

A **suspension** is a homogeneous mixture in which the different components are in different phases, such as solids in liquids or liquids in gases. In a suspension, the mixing is so thorough that the different phases cannot be readily distinguished. Milk is a suspension because it is a homogeneous mixture of solid proteins and fats finely dispersed in liquid water. Blood is a suspension composed of finely dispersed blood cells in water. Another example of a suspension is clouds, which are mixtures of tiny water droplets suspended in air. Shining a light through a suspension, as in Figure 2.17, results in a visible cone as the light is reflected by the suspended components.

In describing solutions, the component present in the largest amount is the **solvent**, and any other components are **solutes**. For example, when a teaspoon of table sugar is mixed with 1 L of water, we identify the sugar as the solute and the water as the solvent.

The process of mixing a solute with a solvent is called **dissolving**. To make a solution, a solute must dissolve in a solvent—that is, the solute and solvent must form a homogeneous mixture. Whether one material dissolves in another is a function of their electrical attractions for each other. Generally speaking, the stronger the attractions, the better the mixing.

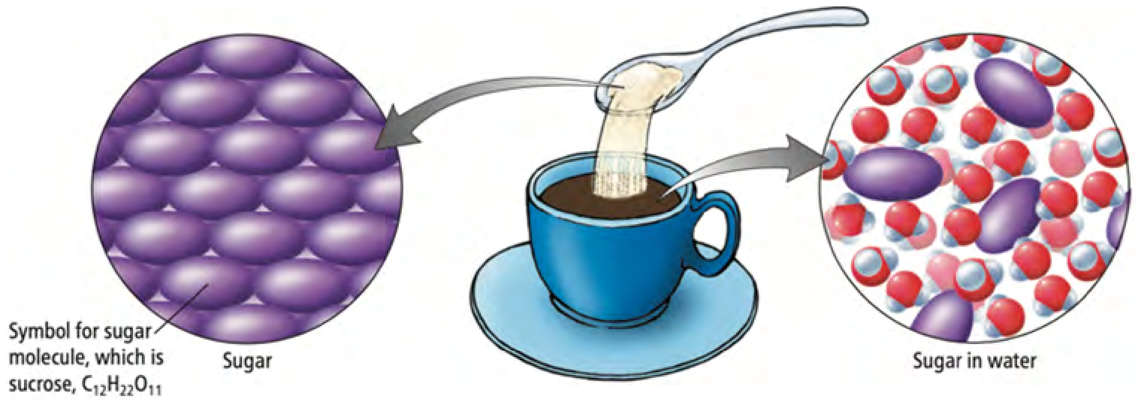


FIGURE 2.18

Water molecules pull the sucrose molecules in a sucrose crystal away from one another. This pulling away does not, however, affect the covalent bonds within each sucrose molecule, which is why each dissolved sucrose molecule remains intact as a single molecule.

Figure 2.18 shows at a molecular level how sugar dissolves in water.

READING CHECK

Impure water can be purified by

a. removing the impure water molecules.

b. removing everything that is not water.

c. breaking down the water into its simplest components.

d. adding some disinfectant such as chlorine.

CHECK YOUR ANSWER

The answer is (b.) when something other than water molecules is found in the water, we say that the water is impure.