Skills to Develop

• Define a solution.
• Identify the solute and solvent in a solution.
• Explain the differences among solutions and heterogeneous mixtures, such as colloids and suspensions.

In Chapter 4, we distinguished between pure substances and mixtures. Remember, a mixture contains two or more pure substances that are not bonded together. These substances remain unbounded to each other, but are mixed within the same container. They also retain their own properties, such as color, boiling point, etc. There are two types of mixtures: mixtures in which the substances are evenly mixed together (called a solution) and a mixture in which the substances are not evenly mixed (called a heterogeneous mixture).

In this chapter we begin our study of solution chemistry. We all probably think we know what a solution is. We might be holding a can of soda or a cup of tea while reading this book and think . . . hey this is a solution. Well, you are right. But you might not realize that alloys, such as brass, are also classified as solutions, or that air is a solution. Why are these classified as solution? Why wouldn't milk be classified as a solution? To answer these questions, we have to learn some specific properties of solutions. Let’s begin with the definition of a solution and view some of the different types of mixtures.

Homogeneous Mixtures

A solution is an even (or homogeneous) mixture of substances. When you consider that the prefix “homo” means “same”, this definition makes perfectly good sense. Solutions carry the same properties throughout. Take, for example, vinegar that is used in cooking is approximately \( (5\%) \) acetic acid in water. This means that every teaspoon of vinegar that is removed from the container contains \( (5\%) \) acetic acid and \( (95\%) \) water. This ratio of mixing is carried out throughout the entire container of vinegar.

A point should be made here that when a solution is said to have uniform properties throughout, the definition is referring to properties at the particle level. Well, what does this mean? Let’s consider brass as an example. The brass is an alloy made from copper and zinc. To the naked eye a brass coin seems like it is just one substance but at a particle level two substances are present (copper and zinc) and the copper and zinc atoms are evenly mixed at the atomic level. So the brass represents a homogeneous mixture. Now, consider a handful of zinc filings and copper pieces. Is this now a homogeneous solution? The properties of any scoop of the “mixture” you are holding would not be consistent with any other scoop you removed from the mixture. The ratio of copper and zinc may be different. Additionally, you would see differences in the color at different places in the mixture (there are visible places in which there are more copper atoms and visible places in which there are more zinc atoms). Thus the combination of zinc filings and copper pieces in a pile does not represent a homogeneous mixture, but is, instead, a heterogeneous mixture. In a solution, the particles are so small that they cannot be distinguished by the naked eye. In a solution, the mixture would have the same appearance and properties in all places throughout the mixture.

The point should be made that because solutions have the same composition throughout does not mean you cannot vary the composition. If you were to take one cup of water and dissolve \( \left( \frac{1}{4} \right) \) teaspoon of table salt in it, a
solution would form. The solution would have the same properties throughout, the particles of salt would be so small that they would not be seen, and the composition of every milliliter of the solution would be the same. But you can vary the composition of this solution to a point. If you were to add another \(\frac{1}{2}\) teaspoon of salt to the cup of water, you would make another solution, but this time there would be a different composition than the last. You still have a solution where the salt particles are so small that they would not be seen and the solution has the same properties throughout, thus it is homogeneous.

The solvent and solute are the two basic parts of a solution. The solvent is the substance present in the greatest amount, whichever substance there is more of in the mixture. The solvent is frequently, but not always, water. The solute, then, is the substance present in the least amount. Let's think for a minute that you are making a cup of hot chocolate. You take a teaspoon of cocoa powder and dissolve it in one cup of hot water. Since the cocoa powder is in the lesser amount it is said to be the solute; the water is the solvent since it is in the greater amount.

Example 6.1.1

Name the solute and solvent in each of the following solutions.

a) salt water  
b) air  

Solution:

a) Solute \(\equiv\) salt; Solvent \(\equiv\) water  
b) Solute \(\equiv\) oxygen; Solvent \(\equiv\) nitrogen

Colloids and Suspensions

Two other types of mixtures that we will compare to solutions include colloids and suspensions. These mixtures are frequently confused with solutions, but these are heterogeneous, not homogeneous, mixtures.

Recall that a solution is a mixture of substances in such a way that the final product has the same composition throughout. Remember the example of vinegar that is \(5\%\) by mass, acetic acid in water. This clear liquid is a solution since light easily passes through and it never separates. All liquid solutions have this shared property, in which the particles are so small that light goes straight through. In other words, the mixture is clear or see-through. It is important to note, however, that clear does not necessarily mean colorless.

On the other hand, colloids are mixtures in which the size of the particles is between \(1 \times 10^{-3}\) to \(1 \times 10^{-9}\) meters. In meters, these sizes translate to \(10^{-10}\) to \(10^{-6}\) nanometers. These particles, although sounding small, are still much bigger than the particles in a solution.
A common example of a colloid is milk. One way to tell that milk is a colloid is by the Tyndall effect. The Tyndall effect is the scattering of light by particles. This involves shining a light through the mixture: when the light is shined through a colloid, the light does not go straight through, but has a cloudy appearance. Because light is not allowed to pass through the mixture, the mixture is considered a colloid. When light is passed through a solution, the particles are so small that they do not obstruct the light. However, when light is passed through a colloid, since the particles are larger, they will act as an obstruction to the light and the light is scattered. The particles in a colloid, while able to scatter light, are still small enough so that they do not settle out of solution.

It is amazing just how common colloids are to use in our everyday lives. Some common colloids you may have seen include milk of magnesia, mayonnaise, Jell-O, and marshmallows.

Suspensions are mixtures which contain even bigger particles than solutions or colloids do. In suspensions, particles settle into layers within a container if they are left standing. This means that the particles in a suspension are large enough so that gravity pulls them out of solution. With suspensions, filtration can usually be used to separate the excess particles from the solution. If a suspension is passed through a piece of filter paper (or a coffee filter) some particles will go through and others will be stopped in the filter paper. A common example of a suspension is muddy water. If you had a beaker of water and added a handful of fine dirt, even if you stirred it, when you let it stand, dirt would settle to the bottom.

Neither colloids nor suspensions are classified as solutions, but are special types of heterogeneous mixtures instead. In order to be a solution, a mixture must have very small particles evenly distributed, so that the mixture has the same properties throughout. Colloids and suspensions have particles that are too big to be considered a solution.

Example 6.1.2

Label each of the following mixtures as a solution, colloid, or suspension.

a) Italian salad dressing
b) Mustard
c) Apple juice

Solution:

a) Suspension - when left to sit, it separates into layers.

b) Colloid - although it does not separate into layers like suspensions do, mustard does not let light go through.

c) Solution - apple juice doesn't separate into layers like suspensions do, but apple juice will let light through so it is a solution and not a colloid.

Lesson Summary

- Generally speaking, in a solution, a solute is present in the least amount (less than \(\frac{1}{2}\) of the solution) whereas the solvent is present in the greater amount (more than \(\frac{1}{2}\) of the solution).
- A solution is a mixture that has the same properties throughout.
• Common examples of colloids include milk, butter, Jell-O, and clouds.
• Suspensions are mixtures in which the particles are large enough so that they settle to the bottom of the container and can be filtered using filter paper.

Vocabulary

• Solution: A homogeneous mixture of substances.
• Solvent: The substance in a solution present in the greatest amount.
• Solute: The substance in a solution present in the least amount.
• Colloid: Type of mixture in which the size of the particles is between $1 \times 10^3 \text{ pm}$ and $1 \times 10^6 \text{ pm}$.
• Suspension: Type of mixture in which the particles settle to the bottom of the container and can be separated by filtration.

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