Preparing Solutions, Reagents, and Buffers

SOLUTIONS, reagents, and buffers are significant to daily life, even though we usually do not think about them. Almost any beverage you drink is a solution. In addition, reagents are used almost any time anything is tested. If your doctor requires a blood test to be performed, many reagents are used. But what about buffers? They are absolutely necessary for life.

Objective:

Describe the nature, components, preparation, and uses of various types of solutions.

Key Terms:

acid
aqueous solution
balance
base
buffer
concentration
conjugate acid
conjugate base
graduated cylinder
hydrogen ion
neutral
pH
reagent
solute
solution
solvent
volumetric flask
weak acid
weak base

Solutions

A **solution** is a uniform combination of two types of material—solute and solvent. The **solute** is the dissolved part; the **solvent** is the material in which the solute is dissolved. If sugar is dissolved in water, the sugar is the solute and the water is the solvent. This is a solution. Solutions can be more complicated. First, there could be two or more solutes dissolved in

the solvent. Consider a bottle of 7-Up™, which contains a large majority of water (solvent). The solution has three solutes: sugar, flavoring, and a gas called carbon dioxide.

The solute and solvent can have various forms. All material exists as solid, liquid, or gas. It is easy to see solutions in which the solvent is a liquid (water), because there are so many of them. A solution in which the solvent is water is called an **aqueous solution**. Some special solutions use alcohol as the solvent. These frequently have medical uses. What if the solvent is a solid or a gas? Could you still have a solution? Of course. When you put on a ring or some other piece of gold jewelry, is it really gold? There is gold in the ring, but it is not all gold. The ring is probably a solution in which the gold is dissolved (solute) in another metal called copper (the solvent).

FIGURE 1. Soda is a type of solution that contains several solutes.

PURPOSES OF SOLUTIONS

Solutions have various purposes. The purpose of 7-Up™ is to be a good-tasting and refreshing drink. Other beverages (e.g., coffee and tea) need to be sweet for some people, so the consumers add sugar. Do you just put the sugar into the drink and let it land wherever it does? No. You stir it to get it to dissolve and spread evenly throughout the cup.

Assume that you and your friend both have a cup of tea. However, you like it much sweeter than your friend does. Therefore, you add more sugar. This reveals something important about solutions: They do not all contain the same amount of solute in the solvent. This amount of solute is the **concentration** (amount of solute in a solution, which may be very specific or may vary widely). The more solute that dissolves, the greater the concentration.

Reagents

Some solutions have very specific purposes. A **reagent**, for example, is a solution used to test for some specific situation. If someone in your family has diabetes, your doctor will want to test to see if you have it. This is done by taking a small sample of your urine and adding a reagent to it. If you have diabetes, the reagent will cause a color change. In fact, the degree of color change can estimate the severity of your diabetes. Almost any medical facility has a laboratory for such tests. The labs use many reagents because each reagent can test for only one thing.

If you have ever seen swimming pool water tested, you have seen a reagent at work. A little of the water is taken into a small container. A few drops of one reagent are added to the water,

FIGURE 2. Reagents are commonly used with pool water test kits.

and the shade of yellow shows the amount of chlorine in the water. A different reagent is used with a second water sample to test the acidity. Here you would look for shades of orange.

Buffers

Buffers are solutions with which you have had a lot of involvement but probably do not realize it. A **buffer** is a combination of a weak acid and its conjugate base or a weak base and its conjugate acid. An **acid** is a substance with one or more atoms of the element hydrogen. The **hydrogen ion** is an atom of the element hydrogen that has become electrically charged. The amount of acid is measured by the amount of hydrogen ions, called the **pH**. Numerically, pH ranges from 0 through 14. If the pH is 7, the solution is **neutral**. A pH below 7 is an acid; a pH above 7 is a base.

A **base** is the opposite of an acid. It will accept the hydrogen ion from the acid. However, all acids are not equal. A **weak acid** has only a few hydrogen ions. The same is true of a base. A **weak base** will accept only a few hydrogen ions. Now you can see how the buffer exists. It will be a weak acid and its conjugate base or a weak base and its conjugate acid. When an acid releases its hydrogen ion, the remaining part is the **conjugate base**. When a base accepts a hydrogen ion, it is the **conjugate acid**.

Buffers are not something with which you would work. They are also not something you would eat or drink. Buffers are part of your body. Without them, your body could not exist. The main buffer in your body is in your blood. Your blood must stay at a certain level of acidity for you to stay alive. Let's say you eat an orange. An orange is fairly acidic. Without buffer in your blood, the acidity of the orange would make your blood more acidic, resulting in unconsciousness or death. To prevent this tragedy, the buffer "controls" the acidity of your blood by absorbing the acidity of the orange.

PREPARATION OF SOLUTIONS, REAGENTS, AND BUFFERS

To prepare a solution, you would mix a solute and solvent until they are uniform. If the solute dissolves easily in the solvent, you can just stir the combination until it is uniform. If the solute is difficult to dissolve, it needs help. To help the solute dissolve, the combination is often stirred by a special unit that magnetically rotates the solution.

To make a solution of sugar in coffee, you do not carefully measure the amount of each. Many solutions, however, must have exact amounts of solvent and solute. For these, the amount of solvent can be measured in a **graduated cylinder**, which is a measuring device for liquids. The amount of solute would be measured on a device called a **balance**, which is a weighing device for solids. Some solutions must be precise. Most reagents must be precise, so the measurements are important.

A buffer is usually made using a purchased buffer capsule. The capsule is placed in a **volumetric flask** (a container to measure liquid volumes very carefully). Water is added, and the mixture is stirred magnetically until all of the solid is dissolved. Then more water is added to the flask to bring the volume to the marked line that shows you have the correct volume.

ON THE JOB...

CAREER CONNECTION: Laboratory Technician

A laboratory technician is a person who works in a laboratory to determine properties of materials. Many manufacturing plants have one or more "lab techs" to ensure that products are correct. Medical lab techs regularly work with reagents and buffers. People like this work in hospitals, medical clinics, etc. You would certainly need at least a Bachelor of Science degree for such a job. The job is usually stable and highly respected with a decent salary.

COMPARING SOLUTIONS, REAGENTS, AND BUFFERS

Various similarities and differences exist in solutions, reagents, and buffers.

Similarities

All are varieties of solutions, so all three involve a solvent and one or more solutes.

Solutions, reagents, and buffers should all be clear (no cloudiness and no settling). Sometimes the color can be so intense that it is impossible to observe that it is clear.

Solutions, reagents, and buffers will be uniform throughout.

Differences

While a lot of solutions, reagents, and buffers are colorless, there can be differences in their color. For instance, some will be colored by the solute. If the solute is green, the solution will be green. Yet buffers are almost always colorless.

The purpose or function of solutions, reagents, and buffers varies. The purpose of the solvent in a solution is usually to act as a carrier for the solute. As an example, the sodium chloride in eye drops is usually the active ingredient. Since this substance, which is solid, cannot be put directly into the eye, the water solvent carries and distributes the solute. Reagents are intended to identify or quantify some particular component, so they usually function by means of color changes or color intensi-

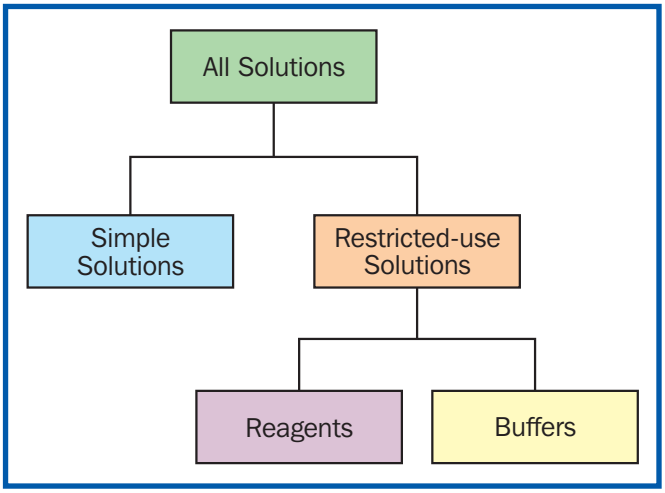

FIGURE 3. The relationship among solutions, reagents, and buffers.

ties. Buffers have no color involvement since they are intended to simply maintain the pH of a solution.

Summary:

A solution is a combination of a solvent with one or more solutes. It is uniform, so the solute is uniformly distributed. A simple solution usually acts as a carrier of the solute and distributes it evenly. When the solution has the purpose of testing some other material, it is a reagent. A reagent typically tests by changing colors to indicate the presence or amount of something. Further, a solution can be specialized by being a buffer, which prevents the acidity of the solution from changing greatly.

Checking Your Knowledge:

1. What are the components of a solution?
2. How can a solution be something other than liquid?
3. Why must the solute be evenly spread throughout the solution?
4. Why would it be necessary to use the correct reagent?
5. Why are buffers so important?

Expanding Your Knowledge:

Use the Internet to help you explain how air is a solution. Then research and explain what Benedict Solution is and how it is used. Next, research and explain what a condition known as acidosis is and what effects it could have.

Web Links:

Alloy
http://en.wikipedia.org/wiki/Alloy

Alkalosis
https://health.google.com/health/ref/Alkalosis

Alkalosis
http://health.nytimes.com/health/guides/disease/alkalosis/overview.html

Solutions
http://chemtutor.com/solution.htm

Agricultural Career Profiles
http://www.mycaert.com/career-profiles