1.6 Homogeneous and Heterogeneous Mixture

How do you like your coffee?

Many people enjoy a cup of coffee at some point during the day. Some may drink it black, while others may put cream (or some dairy substitute) and sugar in their coffee. You can buy high-end coffee drinks at espresso stands (either sit-down or drive-through). Whatever your preference, you want the coffee to be the same at the beginning and the end of your drink. You don't want the components to separate out, but you want your drink to be uniform from top to bottom.

Mixtures

Ordinary table salt is called sodium chloride. It is considered a compound, or a pure substance, because it has a uniform and definite composition. All samples of sodium chloride are chemically identical. Water is also a compound, a pure substance. Salt easily dissolves in water, but salt water cannot be classified as a substance because its composition can vary. You may dissolve a small amount of salt or a large amount into a given amount of water. A mixture is a physical blend of two or more components, each of which retains its own identity and properties in the mixture. Only the form of the salt is changed when it is dissolved into water. It retains its composition and properties.

Homogeneous Mixtures

A homogeneous mixture is a mixture in which the composition is uniform throughout the mixture. The salt water described above is homogeneous because the dissolved salt is evenly distributed throughout the entire salt water sample. Often it is easy to confuse a homogeneous mixture with a pure substance because they are both uniform. The difference is that the composition of the substance is always the same. The amount of salt in the salt water can vary from one sample to another. All solutions would be considered homogeneous because the dissolved material is present in the same amount throughout the solution.

One characteristic of mixtures is that they can be separated into their components. Since each part of the mixture has not reacted with another part of the mixture, the identities of the different materials is unchanged.
Heterogeneous Mixtures

A heterogeneous mixture is a mixture in which the composition is not uniform throughout the mixture. Vegetable soup is a heterogeneous mixture. Any given spoonful of soup will contain varying amounts of the different vegetables and other components of the soup.

A phase is any part of a sample that has a uniform composition and properties. By definition, a pure substance or a homogeneous mixture consists of a single phase. A heterogeneous mixture consists of two or more phases. When oil and water are combined, they do not mix evenly, but instead form two separate layers. Each of the layers is called a phase. The oil phase is less dense than the water phase and so the oil floats on top of the water.

In the vegetable soup example, one phase would be the liquid soup itself. This phase has vitamins, minerals, and other components dissolved in the water. This phase would be homogeneous. The carrots, peas, corn, or other vegetables represent other phases of the soup. The various vegetables are not mixed evenly in the soup, but are spread around at random. This is the heterogeneous portion.

There are a large number of heterogeneous mixtures around us. Soil is composed of a variety of substances and is often of different composition depending on the sample taken. One shovel may come up with dirt and grass while the next shovel could contain an earthworm. A cookie with peanuts, chocolate chips, and M & M candy would be a heterogeneous mixture. Any bite of the cookie may result in a variety of components.

Smog is another example of a heterogeneous mixture. This murky collection of pollutants can be a mixture of water and contaminants from burning gasoline or plastics mixed with nitric oxide derivatives and ozone. You can see that the smog distribution in the air (New York City to the left) is not evenly spread out, but varies from one part of the atmosphere to another.
Why is the state of water different in each picture?

Water can take many forms. At low temperatures (below 0°C), it is a solid. When at "normal" temperatures (between 0°C and 100°C), it is a liquid. While at temperatures above 100°C, water is a gas (steam). The state the water is in depends upon the temperature. Each state (solid, liquid, and gas) has its own unique set of physical properties.

Matter and Its States

Matter typically exists in one of three states: solid, liquid, or gas. The state a given substance exhibits is also a physical property. Some substances exist as gases at room temperature (oxygen and carbon dioxide), while others, like water and mercury metal, exist as liquids. Most metals exist as solids at room temperature. All substances can exist in any of these three states.

Note: Technically speaking a fourth state of matter called plasma exists, but it does not naturally occur on earth, so we will omit it from our study here.

Liquids have the following characteristics:

- no definite shape (takes the shape of its container)
- has definite volume
- particles are free to move over each other, but are still attracted to each other.

A familiar liquid is mercury metal. Mercury is an anomaly. It is the only metal we know of that is liquid at room temperature. Mercury also has an ability to stick to itself (surface tension) - a property all liquids exhibit. Mercury has a relatively high surface tension, which makes it very unique. Here you see mercury in its common liquid form.

If we were to heat liquid mercury to its boiling point of 357°C, and under the right pressure conditions, we would notice all particles in the liquid state go into the gas state.
Gases have the following characteristics:

- no definite shape (takes the shape of its container)
- no definite volume
- particles move in random motion with little or no attraction to each other
- highly compressible

Solids are defined by the following characteristics:

- definite shape (rigid)
- definite volume
- particles vibrate around fixed axes

If we were to cool liquid mercury to its freezing point of -39°C, and under the right pressure conditions, we would notice all of the liquid particles would go into the solid state.

- The video below from http://www.youtube.com/watch?v=zKUl6gJhFZY shows this process.

As you can see in the video, mercury can be solidified when its temperature is brought to its freezing point. However, when returned to room temperature conditions, mercury does not exist in solid state for long, and returns back to its more common liquid form.

How did goldminers search for gold?

Beginning in the late 1840s, thousands of prospectors rushed to California to search for gold. One of the approaches taken to isolate the gold from the soil was called "panning." Dirt would be placed in the pan and covered with water. After thorough mixing, the pan is gently swirled to remove dissolved material while the heavier gold settles to the bottom of the pan. The gold is then separated from the mixture of soil and water.

Separation of Mixtures

Not everyone is out searching for gold (and not many of those searchers is going to get much gold, either). In a chemical reaction, it is important to isolate the component(s) of interest from all the other materials so they can be further characterized. Studies of biochemical systems, environmental analysis, pharmaceutical research - these and many other areas of research require reliable separation methods.

Here are a number of common separation techniques:
**Chromatography** is the separation of a mixture by passing it in solution or suspension or as a vapor (as in gas chromatography) through a medium in which the components move at different rates. Thin-layer chromatography is a special type of chromatography used for separating and identifying mixtures that are or can be colored, especially pigments. Paper chromatography is often used to separate photopigments found in plant cells.

**Evaporation** is a technique used to separate out homogenous mixtures where there is one or more dissolved solids. This method drives off the liquid components from the solid components. The process typically involves heating the mixture until no more liquid remains. Prior to using this method, the mixture should only contain one liquid component, unless it is not important to isolate the liquid components. This is because all liquid components will evaporate over time. This method is suitable to separate a soluble solid from a liquid.

In many parts of the world, table salt is obtained from the evaporation of sea water. The heat for the process comes from the sun. Once the sea water in these evaporation ponds has evaporated, the salt can be harvested.

**Distillation** is an effective method to separate mixtures comprised of two or more pure liquids. Distillation is a purification process where the components of a liquid mixture are vaporized and then condensed and isolated. In simple distillation, a mixture is heated and the most volatile component vaporizes at the lowest temperature. The vapor passes through a cooled tube (a condenser), where it condenses back into its liquid state. The condensate that is collected is called distillate.

**Filtration** is a separation method used to separate out pure substances in mixtures comprised of particles some of which are large enough in size to be captured with a porous material. Particle size can vary considerably, given the type of mixture. For instance, stream water is a mixture that contains naturally occurring biological organisms like bacteria, viruses, and protozoans. Some water filters can filter out bacteria, the length of which is on the order of 1 micron. Other mixtures, like soil, have relatively large particle sizes, which can be filtered through something like a coffee filter.
Summary

- A mixture is a physical blend of two or more components, each of which retains its own identity and properties in the mixture.
- A homogeneous mixture is a mixture in which the composition is uniform throughout the mixture.
- All solutions would be considered homogeneous.
- A heterogeneous mixture is a mixture in which the composition is not uniform throughout the mixture.
- A phase is a separate layer in a heterogeneous mixture.
- Three states of matter exist – solid, liquid, and gas.
- Solids have a definite shape and volume.
- Liquids have a definite volume, but take the shape of the container.
- Gases have no definite shape or volume.
- Mixtures can be separated using a variety of techniques.
- Chromatography involves solvent separation on a solid medium.
- Distillation takes advantage of differences in boiling points.
- Evaporation removes a liquid from a solution to leave a solid material.
- Filtration separates solids of different sizes.

Review

1. What is a mixture?
2. What is a homogeneous mixture?
3. Are all solutions homogeneous mixtures?
4. Can homogeneous mixtures be separated into their components?
5. Define a heterogeneous mixture.
6. Why is vegetable soup a heterogeneous mixture?
7. How many phases are in a heterogeneous mixture?
8. How many states of matter are there?
9. What are properties of a solid?
10. What are properties of a liquid?
11. What are properties of a gas?
12. What processes can be used to separate a mixture?
13. What technique would you use to separate sand from water? There are two possibilities.
14. What technique would you use to separate alcohol from water?
Answers

1. 2 or more components physically blended
2. Uniform mixture
3. All solutions are homogeneous mixtures.
4. Yes. By filtration, evaporation, distillation, etc.
5. Non-uniform mixture.
6. Any vegetables, meat, noodles are randomly spread throughout the soup. A spoonful may contain a variety of components.
7. A heterogeneous mixture has 2 or more phases.
8. 3 states of matter. Gas, Liquid, and Solid
9. Solids have a definite shape and volume. They are not compressible.
10. Liquids have a definite volume and take the shape of the container.
11. Gases have no definite shape or volume.
12. Components of a mixture can be separated by processes such as chromatography, filtration, or distillation.
13. Sand and water can be separated by filtration, or by evaporating the water.
14. Both water and alcohol are in the liquid phase. Different boiling points would allow separation through distillation.
Practice

Use the link below to answer the following questions:

http://www.buzzle.com/articles/homogeneous-mixture-examples.html

1. What is the composition of gunpowder?
2. Why would vinegar be considered a homogeneous mixture?
3. Name three alloys and list what they are composed of.

Use the website to answer the following questions:

http://www.miamisci.org/af/sln/phases/nitrogensolid.html

1. Which material is a gas at room temperature (25°C)?
2. Which material is a solid at room temperature?
3. Which material is a liquid at room temperature?
4. What happens to the motion of the particles as you increase the temperature?
5. What happens to the motion of the particles as you decrease the temperature?

Use the link below to answer the following questions:

http://antoine.frostburg.edu/chem/senese/101/matter/faq/what-is-heterogeneous.shtml

1. Why is a mixture of sand and sugar a heterogeneous mixture?
2. What are the phases in a glass of iced tea?
3. How is blood a heterogeneous mixture?

Use this resource to answer the following questions:


1. Where is salt produced in the Hawaiian Islands?
2. What does “paakai” mean?
3. How long does it take for salt to form by evaporation?