BEFORE, you learned
• Matter can change from one state to another
• Changes in state require energy changes

NOW, you will learn
• How properties can help you identify substances
• How properties of substances can be used to separate substances

KEY CONCEPT
Properties are used to identify substances.

Sunshine State STANDARDS
SC.A.1.3.1: The student identifies various ways in which substances differ (e.g., mass, volume, shape, density, texture, and reaction to temperature and light).
SC.A.1.3.5: The student knows the difference between a physical change in a substance (e.g., altering the shape, form, volume, or density) and a chemical change (i.e., producing new substances with different characteristics).

EXPLORE Identifying Substances
How can properties help you identify a substance?

PROCEDURE
1. Place some of substance A into one cup and some of substance B into the other cup. Label the cups.
2. Carefully add some water to each cup. Observe and record what happens.

WHAT DO YOU THINK?
• Which result was a physical change? a chemical change? Explain.
• The substances are baking soda and baking powder. Baking powder and water produce carbon dioxide gas. Which substance is baking powder?

MATERIALS
• substance A
• substance B
• 2 cups
• water

Substances have characteristic properties.
You often use the properties of a substance to identify it. For example, when you reach into your pocket, you can tell the difference between a ticket stub and a folded piece of tissue because one is stiff and smooth and the other is soft. You can identify nickels, dimes, and quarters without looking at them by feeling their shapes and comparing their sizes. To tell the difference between a nickel and a subway token, however, you might have to use another property, such as color. Texture, shape, and color are physical properties that you use all the time to identify and sort objects.

Check Your Reading How can physical properties be used to identify a substance?
Identifying Unknown Substances

Suppose you have a glass of an unknown liquid that you want to identify. It looks like milk, but you cannot be sure. How could you determine what it is? Of course, you would not taste an unknown substance, but there are many properties other than taste that you could use to identify the substance safely.

To proceed scientifically, you could measure several properties of the unknown liquid and compare them with the properties of known substances. You might observe and measure such properties as color, odor, texture, density, boiling point, and freezing point. A few of these properties might be enough to tell you that your white liquid is glue rather than milk.

To determine the difference among several colorless liquids, scientists would use additional tests. Their tests, however, would rely on the same idea of measuring and comparing the properties of an unknown with something that is already known.

Properties Used for Identifying Substances

You are already familiar with the most common physical properties of matter. Some of these properties, such as mass and volume, depend upon the specific object in question. You cannot use mass to tell one substance from another because two very different objects can have the same mass—a kilogram of feathers has the same mass as a kilogram of peanut butter, for example.

Other properties, such as density, can be used to identify substances. They do not vary from one sample of the same substance to another. For example, you could see a difference between a kilogram of liquid soap and a kilogram of honey by measuring their densities.

The physical properties described below can be used to identify a substance.

**Density** The densities of wood, plastic, and steel are all different. Scientists already have determined the densities of many substances. As a result, you can conveniently compare the density of an unknown substance with the densities of known substances. Finding any matching densities will give you information about the possible identity of the unknown substance. However, it is possible for two different substances to have the same density. In that case, in order to identify the substance positively, you would need additional data.

**Why can’t you identify a substance on the basis of density alone?**
Substances respond to heating in different ways. Some warm up very quickly, and others take a long while to increase in temperature. This property is important in selecting materials for different uses. Aluminum and iron are good materials for making pots and pans because they conduct heat well. Various materials used in household insulation are poor heat conductors. Therefore, these insulators are used to keep warm air inside a home on a cold day. You can measure the rate at which a substance conducts heat and compare that rate with the heat conduction rates of other substances.

**Solubility** Solubility is a measure of how much of a substance dissolves in a given volume of a liquid. Sugar and dirt, for instance, have very different solubilities in water. If you put a spoonful of sugar into a cup of water and stir, the sugar dissolves in the water very rapidly. If you put a spoonful of dirt into water and stir, most of the dirt settles to the bottom as soon as you stop stirring.

**Electric Properties** Some substances conduct electricity better than others. This means that they allow electric charge to move through them easily. Copper wire is used to carry electricity because it is a good conductor. Materials that do not conduct easily, such as rubber and plastics, are used to block the flow of charge. With the proper equipment, scientists can test the electric conductivity of an unknown substance.

**Magnetic Properties** Some substances are attracted to magnets, but others are not. You can use a magnet to pick up a paper clip but not a plastic button or a wooden match. The elements iron, cobalt, and nickel are magnetic—meaning they respond to magnets—but copper, aluminum, and zinc are not. Steel, which contains iron, is also magnetic.
Mixtures can be separated by using the properties of the substances in them.

Suppose you have a bag of cans that you want to recycle. The recycling center accepts only aluminum cans. You know that some of your cans contain steel. You would probably find it difficult to tell aluminum cans from steel ones just by looking at them. How could you separate the cans? Aluminum and steel may look similar, but they have different magnetic properties. You could use a magnet to test each can. If the magnet sticks to the can, the can contains steel. Recycling centers often use magnets to separate aluminum cans from steel cans.

Some mixtures contain solids mixed with liquids. A filter can be used to separate the solid from the liquid. One example of this is a tea bag. The paper filter allows the liquid water to mix with the tea, because water molecules are small enough to pass through the filter. The large pieces of tea, however, cannot pass through the filter and remain inside the tea bag.

How can a mixture of sand, salt, and pepper be separated?

Scientists often have to isolate a single substance from a mixture. Use your knowledge of the properties of sand, salt, and pepper to design a method for separating each of these substances from the mixture.

**PROCEDURE**

1. Examine the mixture and the materials provided. Design a procedure for separating the different substances in your mixture. Carefully consider the order in which you will try each step.

2. Write up your procedure. Explain why you chose the steps you did for each substance.

3. Carry out your procedure.

**WHAT DO YOU THINK?**

- Was your procedure successful? How would you modify your procedure if you were to perform the separation again?
- How does knowing the properties of matter help you separate the substances in mixtures?
Some mixtures are more difficult to separate than others. For example, if you stir sugar into water, the sugar dissolves and breaks up into individual molecules that are too tiny to filter out. In this case, you can take advantage of the fact that water is a liquid and will evaporate from an open dish. Sugar, however, does not evaporate. The mixture can be heated to speed the evaporation of the water, leaving the sugar behind.

There are many important reasons for separating substances. One reason is to make a substance safe to consume, such as drinking water. In order to produce drinking water, workers at a water-treatment plant must separate many of the substances that are mixed in with the water.

The process in water-treatment plants generally includes these steps:

- First, a chemical is added to the water that causes the larger particles to stick together. They settle to the bottom of the water, where they can be removed.
- Next, the water is run through a series of special molecular filters. Each filter removes smaller particles than the one before.
- Finally, another chemical, chlorine, is added to disinfect the water and make it safe to drink.

Water-treatment plants use the properties of the substances found in water to produce the clean water that flows from your tap.

**Check your reading**

What are two situations in which separating substances is useful?