Everyday Examples Identification by physical properties is a subject in science that is easy to observe in the real world. Suppose you volunteer to help your friend choose a family pet. While visiting the local animal shelter, you spot a cute dog. The dog looks like the one in **Figure 11.** You look at the sign on the cage. It says that the dog is male, one to two years old, and its breed is unknown. You and your friend wonder what breed of dog he is. What kind of information do you and your friend need to figure out the dog's breed? First, you need a thorough description of the physical properties of the dog. What does the dog look like? Second, you need to know the descriptions of various breeds of dogs. Then you can match up the description of the dog with the correct breed. The dog you found is a white, medium-sized dog with large black spots on his back. He also has black ears and a black mask around his eyes. The manager of the shelter tells you that the dog is close to full-grown. What breed is the dog?

Narrowing the Options To find out, you may need to research the various breeds of dogs and their descriptions. Often, determining the identity of something that is unknown is easiest by using the process of elimination. You figure out all of the breeds the dog can't be. Then your list of possible breeds is smaller. Upon looking at the descriptions of various breeds, you eliminate small dog and large dog breeds. You also eliminate breeds that do not contain white dogs. With the remaining breeds, you might look at photos to see which ones most resemble your dog. Scientists use similar methods to determine the identities of living and nonliving things.

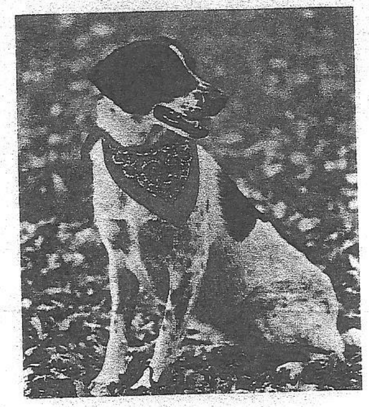


Figure 11 Physical descriptions are used to determine the identities of unknown things.
Observe *What physical properties can be used to describe this dog?*

section 1 review

Summary

Physical Properties

- Physical properties include color, shape, length, mass, volume, and density.

States of Matter

- There are four states of matter.
- Matter can change from one state of matter to another.
- State of matter is determined by how much energy the particles have.

Using Physical Properties

- Substances can be classified according to their physical properties.

Self Check

1. **Identify** the physical properties of this textbook.
2. **List** the four states of matter. Describe each and give an example.
3. **Explain** how water might have two different densities.
4. **Think Critically** Which evaporates more quickly—rubbing alcohol that has been refrigerated or unrefrigerated?

Applying Math

5. **Solve One-Step Equations** Nickel has a density of 9.8 g/cm^3. Lead has a density of 11.3 g/cm^3. If both samples have a volume of 4 cm^3, what are the masses of each?

section 2

Chemical Properties and Changes

as you read

What You'll Learn

- **Recognize** chemical properties.
- **Identify** chemical changes.
- **Classify** matter according to chemical properties
- **Describe** the law of conservation of mass.

Why It's Important

Knowing the chemical properties will allow you to distinguish differences in matter.

Review Vocabulary
heat: a form of energy that flows from a warmer object to a cooler object

New Vocabulary
- chemical property
- chemical change
- law of conservation of mass

Ability to Change

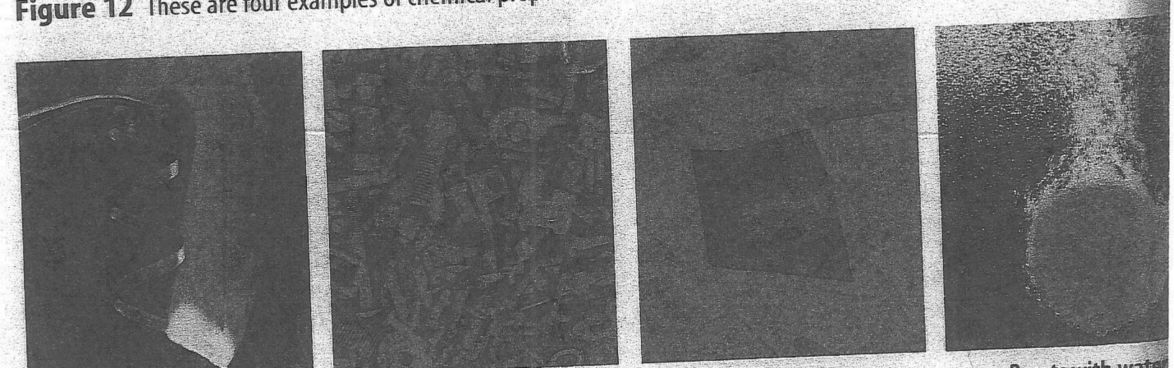
It is time to celebrate. You and your coworkers have cooperated in classifying all of the products and setting up the shelves in the new grocery store. The store manager agrees to a celebration party and campfire at the nearby park. Several large pieces of firewood and some small pieces of kindling are needed to start the campfire. After the campfire, all that remains of the wood is a small pile of ash. Where did the wood go? What property of the wood is responsible for this change?

All of the properties that you observed and used for classification in the first section were physical properties that you could observe easily. In addition, even when those properties changed, the identity of the object remained the same. Something different seems to have happened in the bonfire example.

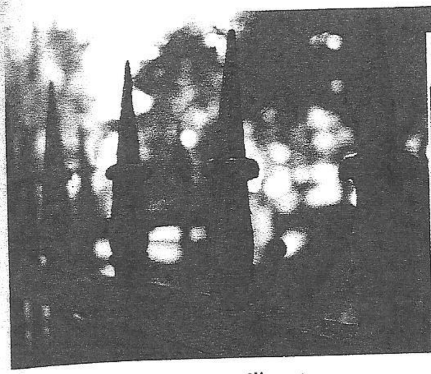
Some properties do indicate a change of identity for the substances involved. A **chemical property** is any characteristic that gives a substance the ability to undergo a change that results in a new substance. **Figure 12** shows some properties of substances that can be observed only as they undergo a chemical change.

Reading Check *What does a chemical property give a substance the ability to do?*

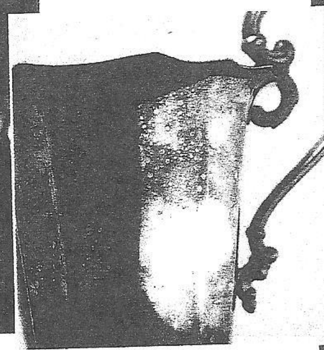
Figure 12 These are four examples of chemical properties.



Flammability | Reacts with oxygen | Reacts with light | Reacts with wate



An untreated iron gate will rust.



Silver dishes develop tarnish.

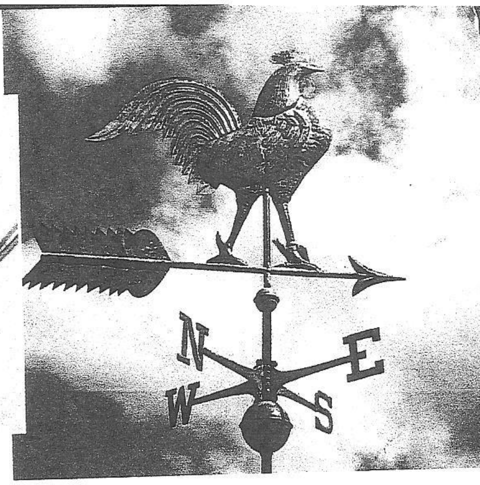


Figure 13 Many kinds of interactions with oxygen can occur. Copper sculptures develop a green patina, which is a mixture of copper compounds.

Common Chemical Properties

You don't have to be in a laboratory to see the changes that take place because of chemical properties. These are called chemical changes. A **chemical change** is a change in the identity of a substance due to the chemical properties of that substance. A new substance or substances are formed as a result of such a change.

The campfire you enjoyed to celebrate the opening of the grocery store resulted in chemical changes. The oxygen in the air reacted with the wood to form a new substance called ash. Wood can burn. This chemical property is called flammability. Some products have warnings on their labels about keeping them away from heat and flame because of the flammability of the materials. Sometimes after a campfire you see stones that didn't burn around the edge of the ashes. These stones have the chemical property of being incombustible.

Common Reactions An unpainted iron gate, such as the one shown in **Figure 13,** will rust in time. The rust is a result of oxygen in the air reacting with the iron and causing corrosion. The corrosion produces a new substance called iron oxide, also known as rust. Other chemical reactions occur when metals interact with other elements. The middle photo shows tarnish, the grayish-brown film that develops on silver when it reacts with sulfur in the air. The ability to react with oxygen or sulfur is a chemical property. The photo on the right shows another example of this chemical property.

Have you ever sliced an apple or banana and left it sitting on the table? The brownish coloring that you notice is a chemical change that occurs between the fruit and the oxygen in the air. Those who work in the produce department at the grocery store must be careful with any fruit they slice to use as samples. Although nothing is wrong with brown apples, they don't look appetizing.

INTEGRATE Health

Enzyme Research Researchers have discovered an enzyme in fruit that is involved in the browning process. They are doing experiments to try to grow grapevines in which the level of this enzyme, polyphenol oxidase (PPO), is reduced. This could result in grapes that do not brown as quickly. Write a paragraph in your Science Journal about why this would be helpful to fruit growers, store owners, and customers.

water

Heat and Light Vitamins often are dispensed in dark-brown bottles. Do you know why? Many vitamins will change when exposed to light. This is a chemical property. They are protected in those colored bottles from undergoing a chemical change with light.

Some substances are sensitive to heat and will undergo a chemical change only when heated or cooled. One example is limestone. Limestone is generally thought of as unreactive. Some limestone formations have been around for centuries without changing. However, if limestone is heated, it goes through a chemical change and produces carbon dioxide and lime, a chemical used in many industrial processes. The chemical property in this case is the ability to change when heated.

Another chemical property is the ability to change with electrical contact. Electricity can cause a change in some substances and decompose some compounds. Water is one of those compounds that can be broken down with electricity.

Something New

The important difference in a chemical change is that a new substance is formed. Because of chemical changes, you can enjoy many things in life that you would not have experienced without them. What about that perfect, browned marshmallow you roasted at the campfire? A chemical change occurred as a result of the fire to make the taste and the appearance different.

Sugar is normally a white, crystalline substance, but after you heat it over a flame, it turns to a dark-brown caramel. A new substance has been formed. Sugar also can undergo a chemical change when sulfuric acid is added to it. The new substance has obviously different properties from the original, as shown in **Figure 14.**

If eggs, sugar, flour, and other ingredients didn't change chemically through baking, you couldn't enjoy birthday cake. Cake begins as liquid and ends as solid. The baked cake clearly has different properties.

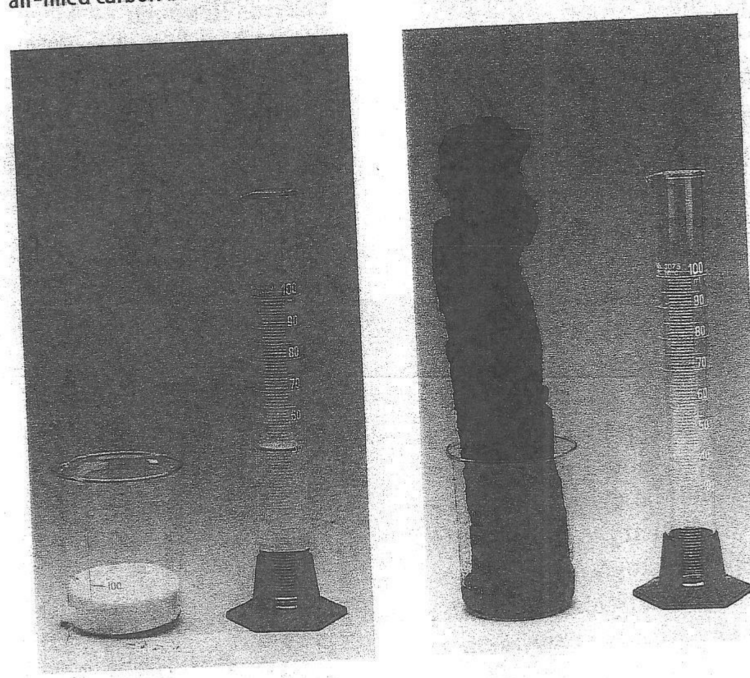


Figure 14 When sugar and sulfuric acid combine, a chemical change occurs and a new substance forms. During this reaction, the mixture foams and a toxic gas is released, leaving only water and air-filled carbon behind.

Signs of Change How do you know that you have a new substance? Is it just because it looks different? You could put a salad in a blender and it would look different, but a chemical change would not have occurred. You still would have lettuce, carrots, and any other vegetables that were there to begin with.

You can look for signs when evaluating whether you have a new substance as a result of a chemical change. Look at the piece of birthday cake in **Figure 15.** When a cake bakes, gas bubbles form and grow within the ingredients. Bubbles are a sign that a chemical change has taken place. When you look closely at a piece of cake, you can see the airholes left from the bubbles.

Other signs of change include the production of heat, light, smoke, change in color, and sound. Which of these signs of change would you have seen or heard during the campfire?

Is it reversible? One other way to determine whether a physical change or a chemical change has occurred is to decide whether or not you can reverse the change by simple physical means. Physical changes usually can be reversed easily. For example, melted butter can become solid again if it is placed in the refrigerator. A figure made of modeling clay, like the one in **Figure 16,** can be smashed to fit back into a container. However, chemical changes can't be reversed using physical means. For example, the ashes in a fireplace cannot be put back together to make the logs that you had to start with. Can you find the egg in a cake? Where is the white flour?

Reading Check *What kind of change can be reversed easily?*

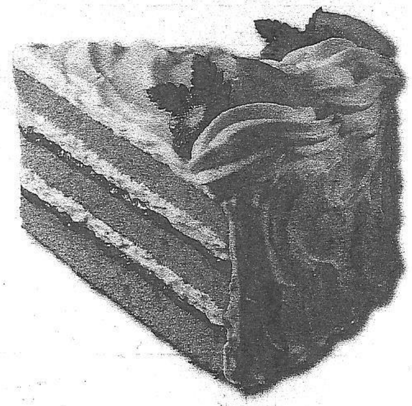


Figure 15 The evidence of a chemical change in the cake is the holes left by the air bubbles that were produced during baking. **Identify** *other examples of a chemical change.*

Figure 16 A change such as molding clay can be undone easily.

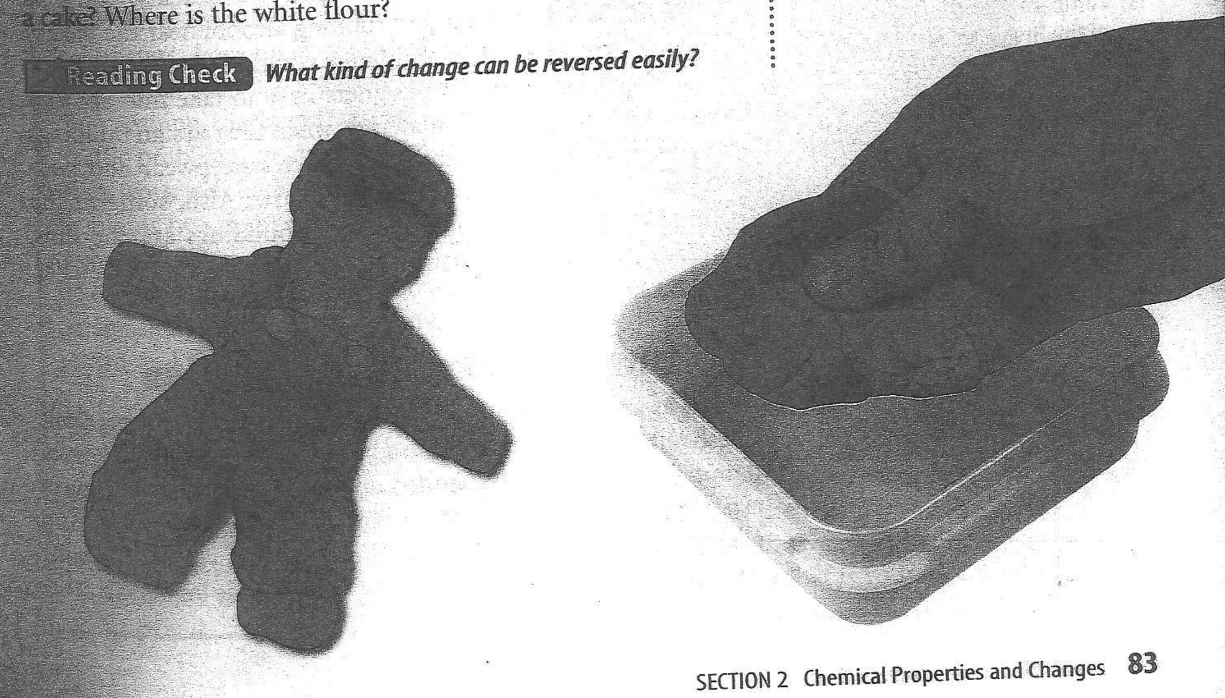


Table 1 Comparing Properties	
Physical Properties	color, shape, length, mass, volume, density, state, ability to attract a magnet, melting point, boiling point, malleability, ductility
Chemical Properties	flammability; reacts with: oxygen, water, vinegar, etc.; reacts in the presence of electricity, light, heat, etc.

Mini LAB

Observing Yeast

Procedure

1. Observe a tablespoon of dry yeast with a magnifying lens. Draw and describe what you observe.
2. Put the yeast in 50 mL of warm, not hot, water.
3. Compare your observations of the dry yeast with those of the wet yeast.
4. Put a pinch of sugar in the water and observe for 15 minutes.
5. Record your observations.

Analysis

1. Are new substances formed when sugar is added to the water and yeast? Explain.
2. Do you think this is a chemical change or a physical change? Explain.

Try at Home

Classifying According to Chemical Properties

Classifying according to physical properties is often easier than classifying according to chemical properties. **Table 1** summarizes the two kinds of properties. The physical properties of a substance are easily observed, but the chemical properties can't be observed without changing the substance. However, once you know the chemical properties, you can classify and identify matter based on those properties. For example, if you try to burn what looks like a piece of wood but find that it won't burn, you can rule out the possibility that it is wood.

In a grocery store, the products sometimes are separated according to their flammability or sensitivity to light or heat. You don't often see the produce section in front of big windows where heat and light come in. The fruit and vegetables would undergo a chemical change and ripen too quickly. You also won't find the lighter fluid and rubbing alcohol near the bakery or other places where heat and flame could be present.

Architects and product designers have to take into account the chemical properties of materials when they design buildings and merchandise. For example, children's sleepwear and bedding can't be made of a flammable fabric. Also, some of the architects designing the most modern buildings are choosing materials like titanium because it does not react with oxygen like many other metals do.

The Law of Conservation of Mass

It was so convenient to turn the firewood into the small pile of ash left after the campfire. You began with many kilograms of flammable substances but ended up with just a few kilograms of ash. Could this be a solution to the problems with landfills and garbage dumps? Why not burn all the trash? If you could make such a reduction without creating undesirable materials, this would be a great solution.

Mass Is Not Destroyed Before you celebrate your discovery, think this through. Did mass really disappear during the fire? It appears that way when you compare the mass of the pile of ashes to the mass of the firewood you started with. The **law of conservation of mass** states that the mass of what you end with is always the same as the mass of what you start with.

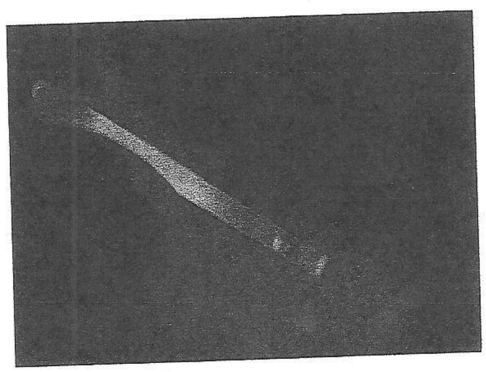
This law was first investigated about 200 years ago, and many investigations since then have proven it to be true. One experiment done by French scientist Antoine Lavoisier was a small version of a campfire. He determined that a fire does not make mass disappear or truly get rid of anything. The question, however, remains. Where did the mass go? The ashes aren't heavy enough to account for the mass of all of the pieces of firewood.

Where did the mass go? If you look at the campfire example more closely, you see that the law of conservation of mass is true. When flammable materials burn, they combine with oxygen. Ash, smoke, and gases are produced. The smoke and gases escape into the air. If you could measure the mass of the oxygen and all of the original firewood that was burned and compare it to the remaining mass of the ash, smoke, and gas, they would be equal.

Applying Science

Do light sticks conserve mass?

Light sticks often are used on Halloween to light the way for trick-or-treaters. They make children visible to drivers. They also are used as toys, for camping, marking trails, emergency traffic problems, by the military, and they work well underwater. A light stick contains two chemicals in separate tubes. When you break the inner tube, the two chemicals react producing a greenish light. The chemicals are not toxic, and they will not catch fire.



Identifying the Problem

In all reactions that occur in the world, mass is never lost or gained. This is the law of conservation of mass. An example of this phenomenon is the light stick. How can you prove this?

Solving the Problem

Describe how you could show that a light stick does not gain or lose mass when you allow the reaction to take place. Is this reaction a chemical or physical change? What is your evidence?

Figure 17 This reaction demonstrates the law of conservation of mass. Although a chemical change has occurred and new substances were made, the mass remained constant.

Before and After Mass is not destroyed or created during any chemical change. The law of conservation of mass is demonstrated in **Figure 17.** In the first photo, you see one substance in the flask and a different substance contained in a test tube inside the flask. The total mass is 16.150 g. In the second photo, the flask is turned upside down. This allows the two substances to mix and react. Because the flask is sealed, nothing is allowed to escape. In the third photo, the flask is placed on the balance again and the total mass is determined to be 16.150 g. If no mass is lost or gained, what happens in a reaction? Instead of disappearing or appearing, the particles in the substances rearrange into different combinations with different properties.

section 2 review

Summary

Common Chemical Properties

- A new substance, or substances, form(s) as a result of a chemical change.
- Exposure to oxygen, heat, and light can cause chemical reactions.

Something New

- Physical changes can be reversed. Chemical changes cannot be reversed.
- Substances can be classified according to their chemical properties.

The Law of Conservation of Mass

- Mass is not gained or lost during a chemical reaction.

Self Check

1. **Define** What is a chemical property? Give four examples.
2. **Identify** some of the signs that a chemical change has occurred.
3. **Think Critically** You see a bright flash and then flames during a class demonstration. Is this an example of a physical change or a chemical change? Explain.

Applying Math

4. **Solving One-Step Equations** A student heats 4.00 g of a blue compound, which reacts completely to produce 2.56 g of a white compound and an unknown amount of colorless gas. What is the mass of this gas?

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