Section 3
Chemical Properties

Key Concept A chemical property describes the ability of a substance to change into a new substance.

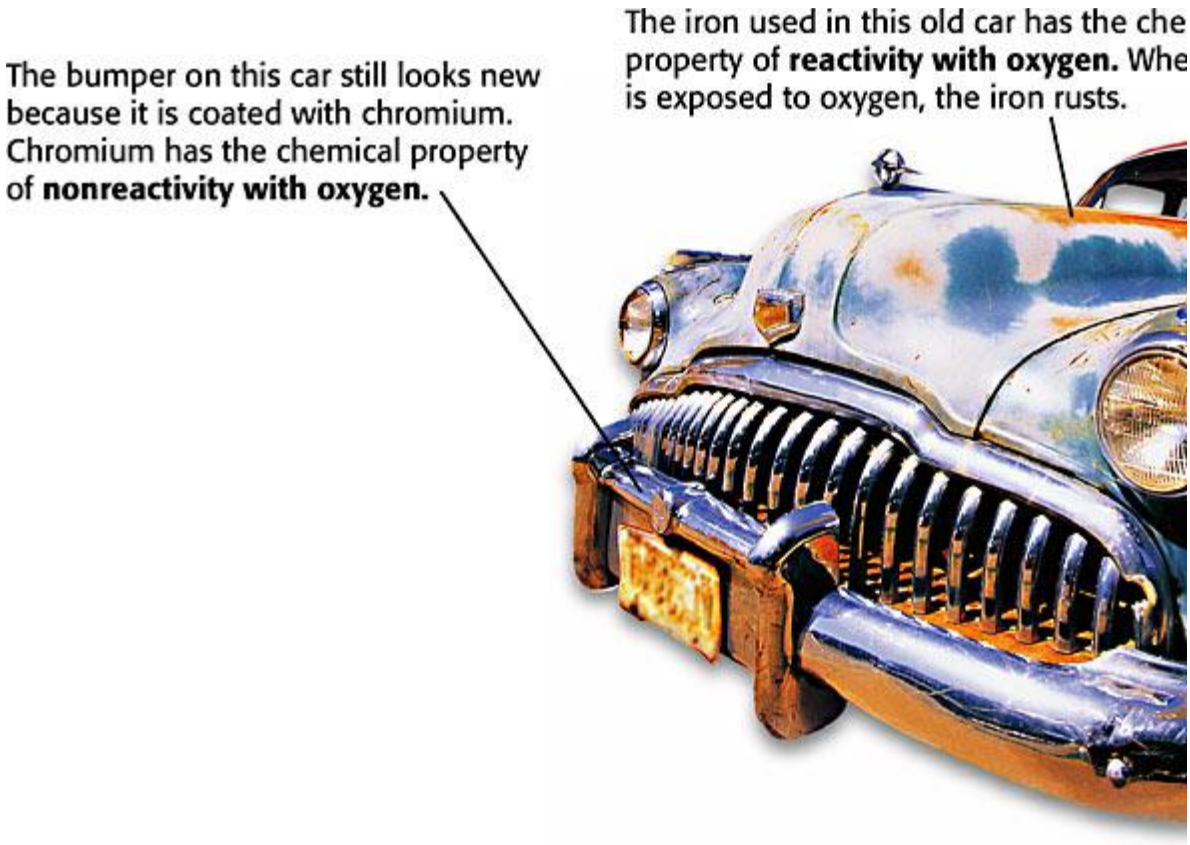
What You Will Learn
- Examples of chemical properties are reactivity and flammability.
- A chemical change is the process by which a substance changes into a new substance.
- Chemical changes usually liberate or absorb heat.

Why It Matters
Understanding the chemical properties of matter can help you understand how new substances form from other substances.

How would you describe a piece of wood before and after it is burned? Did burning change the wood's color? Did burning change the wood's texture? The piece of wood changed, and physical changes alone do not account for all of the ways in which the wood changed.

Identifying Chemical Properties
Physical properties are not the only properties that describe matter. **Chemical properties** describe matter based on its ability to change into new matter, or matter whose identity differs from the identity of the original matter. One chemical property is reactivity. *Reactivity* is the ability of a substance to change into one or more new substances. The photo of the old car in **Figure 1** shows reactivity and nonreactivity.

Figure 1 Reactivity with Oxygen



A kind of reactivity is flammability. *Flammability* is the ability of a substance to burn. Wood has the chemical property of flammability. When wood is burned, it becomes ash, smoke, and other substances. The properties of these new substances differ from the properties of the wood. Ash and smoke cannot burn, so they have the chemical property of nonflammability.

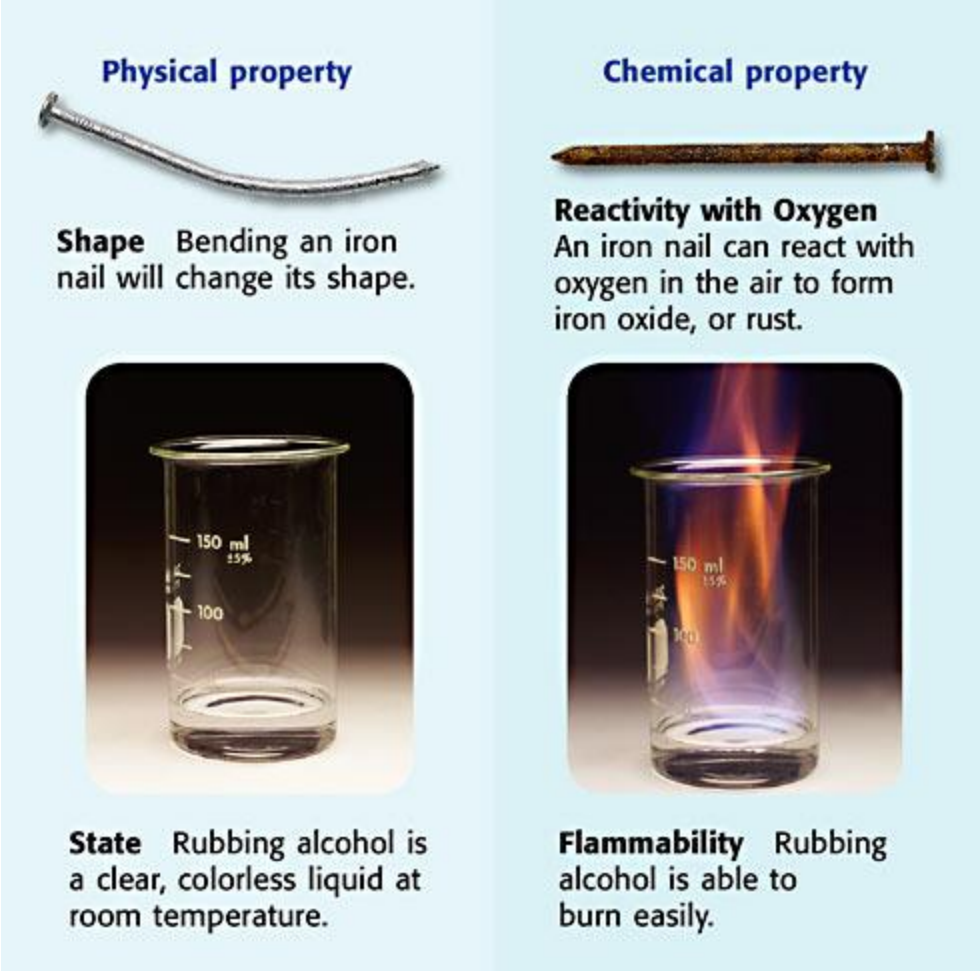
Standards Check Why is reactivity not a physical property?

Comparing Physical and Chemical Properties

How can you tell that a property is a physical property and not a chemical property? If the property is a physical property, you can observe that property of a substance without changing the identity of the substance. For example, you can find the density and hardness of wood without changing the wood into another substance.

Chemical properties, however, are not as easy to observe. For example, you can see that wood is flammable only while it is burning. And you can observe that gold is nonflammable only when you try to burn it and it does not burn. But a substance always has chemical properties. A piece of wood is flammable even when it is not burning. **Figure 2** shows kinds of physical properties and chemical properties.

Figure 2 Physical Properties Versus Chemical Properties



Characteristic Properties

Properties that are most useful in identifying a substance are called *characteristic properties.* Such properties are constant even if the sample size changes. Characteristic properties can be physical

properties, such as density, or chemical properties, such as reactivity. Scientists rely on characteristic properties to identify and classify substances.

Chemical Changes and New Substances

A **chemical change** happens when one or more substances change into new substances that have new and different properties. Chemical *changes* and chemical *properties* are not the same. The chemical properties of a substance describe which chemical changes can happen and which chemical changes cannot happen to that substance. But chemical changes are processes by which substances change into new substances. You can learn about a substance's chemical properties by observing which chemical changes that substance can undergo.

You see chemical changes more often than you may think. For example, a chemical change happens every time a battery is used. Chemical changes also take place within your body when the food you eat is digested. **Figure 3** describes other chemical changes.

Figure 3 Examples of Chemical Changes

Soured milk smells bad because bacteria have formed smelly new substances in it.

Hot gas that forms when hydrogen and oxygen join to make water helps blast the space shuttle into orbit.

The **Statue of Liberty** is made of copper, which is orange-brown. But this copper is green because of its interactions with moist air. These interactions are chemical changes that form copper compounds. Over time, the compounds turn the statue green.

Standards Check How does a chemical change differ from a chemical property?

What Happens During a Chemical Change?

A fun way to see what happens during chemical changes is to bake a cake. You combine eggs, flour, sugar, and other ingredients, as shown in **Figure 4.** When you bake the batter, you end up with a substance that is very different from the batter. The heat of the oven and the interaction of the ingredients cause a chemical change. The result is a cake that has properties that differ from the properties of the raw ingredients.

Figure 4 Each of the original ingredients has different physical and chemical properties than the final product, the cake, does.

Signs of Chemical Changes

Look back at **Figure 3.** In each picture, at least one sign indicates a chemical change. These signs include a change in color or odor, fizzing and foaming, and sound or light being given off. Also, chemical changes usually liberate or absorb heat. *Liberate* means "to release." An increase in temperature takes place when a chemical change liberates heat. But a decrease in temperature occurs when a chemical change absorbs heat.

Standards Check Why do changes in temperature often happen during chemical changes?

Matter and Chemical Changes

When matter undergoes a chemical change, its identity changes. So, most chemical changes in ordinary tasks, such as baking a cake, are irreversible. Imagine *un*baking a cake! But some chemical changes can be reversed by other chemical changes. For example, when an electric current is applied to water formed from hydrogen and oxygen in a space shuttle's rockets, the water again splits into hydrogen and oxygen.

Physical Versus Chemical Changes

When trying to decide if an object has undergone a physical or chemical change, ask yourself, Did the object's composition change? *Composition* is the type of matter that makes up the object and the arrangement of the matter in the object. **Figure 5** shows a physical change and a chemical change.

Figure 5 Physical and Chemical Changes

Change in Texture
Grinding baking soda into a fine, powdery substance is a physical change.

Reactivity with Vinegar
A chemical change happens and gas bubbles are produced when vinegar is poured into baking soda.

Physical changes do not change matter's composition. Water is composed of two hydrogen atoms and one oxygen atom. When water freezes or boils, its composition does not change. So, freezing and boiling are physical changes. But chemical changes do alter the composition of a substance. A chemical change would change water into another substance.

Standards Check Explain why freezing and boiling are physical changes.

Reversing Changes

Can physical and chemical changes be reversed? Many physical changes are easily reversed. They do not change the composition of a substance. If an ice cube melts, you could freeze the liquid water to make another ice cube. But composition does change during a chemical change. So, most chemical changes are not easily reversed. Look at **Figure 6.** The chemical changes that happen when a firework explodes would be almost impossible to reverse, even if you collected all of the materials made in the chemical changes.

Figure 6 This display of fireworks represents many

chemical changes happening at the same time.

Section Summary

- Chemical properties describe the ability of a substance to change into a new substance.
- The chemical properties of a substance describe how the substance will behave under conditions that favor a chemical change.
- Reactivity and flammability are chemical properties.
- New substances form as a result of a chemical change.
- Chemical changes usually liberate or absorb heat.
- Chemical changes alter the composition of a substance.

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Chapter Summary

The Big Idea

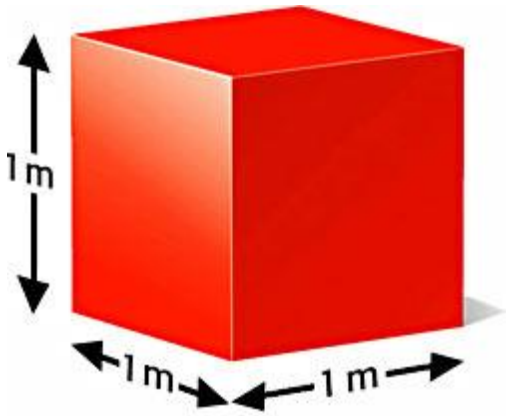
Matter is described by its properties and may undergo changes.

Section 1

What Is Matter?

Key Concept Matter is anything that has mass and takes up space. Matter can be described in terms of its volume, mass, and weight.

- All matter has volume and mass.
- Volume is the amount of space taken up by an object.
- Mass is a measure of the amount of matter in an object.
- Weight is a measure of the gravitational force exerted on an object.



A box whose sides are 1 m long has a volume of 1 m^3.

Section 2
Physical Properties

Key Concept Physical properties of matter can be observed or measured without changing the matter's identity.

- Examples of physical properties are melting temperature, density, hardness, thermal conductivity, and electrical conductivity.
- Density is the amount of matter in a given space or volume.
- A physical change does not change the identity of the matter that undergoes the change.
- Melting, freezing, cutting, bending, and dissolving are physical changes.

The physical property of density allows liquids to form layers.

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Rubbing alcohol is a clear liquid that has the chemical property of flammability.

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