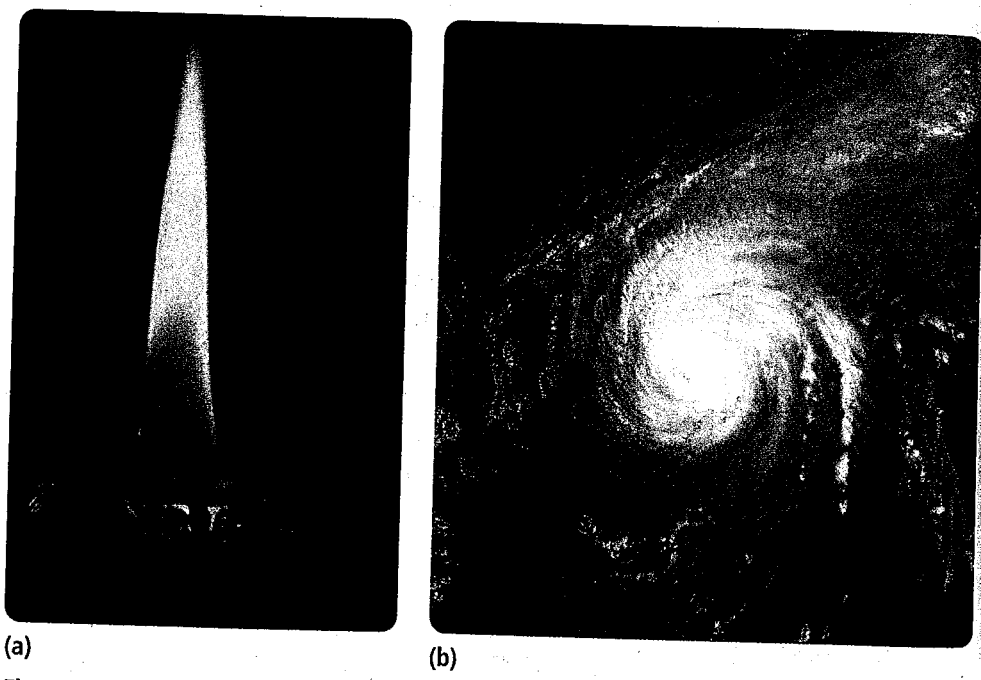
5.3 Changes in Matter

LEARNING TIP

Read the first two paragraphs on this page. Write a one sentence summary to remember important information. For the rest of Section 5.3, read each part and pause to think about what you read. Then write a one sentence summary or brief point-form notes to help you remember the important information.

Change is as much a part of your world as the substances that it is made of. You know that erosion is constantly changing the surface of Earth, and that your skin cells are constantly being replaced with new ones. You have seen juice crystals dissolve, condensation appear on a bathroom mirror after a hot shower, wood burn in a fire, and rust appear on metal. Change does not surprise you. Realizing that change happens all the time is the first step to understanding chemistry. Chemistry is the study of matter, so it is also the study of changes of matter (Figure 1).



(a) (b)

Figure 1 Although the processes of change are difficult to see, the changes are not. Some can be as small as a single flame (a), while others can be as large as weather systems on Earth (b).

How is melting an ice cube different from burning a marshmallow? Both involve heating, but somehow the changes are different. Can you identify what the difference is? The ice cube was water before and after heating, while the marshmallow was a marshmallow before and carbon crust after. In order to understand the many changes happening all around us, we must recognize two very different kinds of change. The two kinds of change that are important to chemistry are physical changes and chemical changes.

To learn more about physical and chemical changes, go to **www.science.nelson.com** GO

Physical Change

In a physical change, the substance remains the same before and after the change. A **physical change** may cause a change in form or state, but not in substance. For example, cutting a piece of paper into smaller and smaller pieces changes its form, but it is still paper with the same properties.

TRY THIS: Physical Change: A Thought Experiment

Skill Focus: questioning

Some experiments can be done in your head. Great scientists, such as Galileo Galilei and Albert Einstein, used "thought" experiments to help them develop their ideas. Now you can try an interesting thought experiment to demonstrate various examples of physical changes. All you need is your imagination.

1. Imagine an ordinary kitchen appliance, such as a toaster. Now imagine beating it with a hammer. Are the dents you make physical? Is it still a toaster?
2. Imagine taking a bottle of syrup from a cupboard and dropping it on the kitchen floor. The top comes off the bottle, and the syrup runs all over the floor. You leave the syrup where it is. When you come back, it has hardened and stuck to the floor. Is this a physical change? Why?

A. Make up your own thought experiment to show a physical change.

B. Create a rule for physical changes using the words "original substances."

When substances can exist in two or more states, changing from one state to another is a physical change. The substance is the same throughout the changes. Different terms are used to describe the different changes of state (Figure 2). Substances go from solid to liquid or liquid to gas when heat energy is added. They go from gas to liquid or liquid to solid when heat energy is removed. Notice in Figure 2 that some substances can go directly from solid to gas, or vice versa, without passing through the liquid state. Frost and snow, for example, are created through this unique process. Also notice that the common terms "freezing" and "boiling" are not used because they describe the changes of state of water.

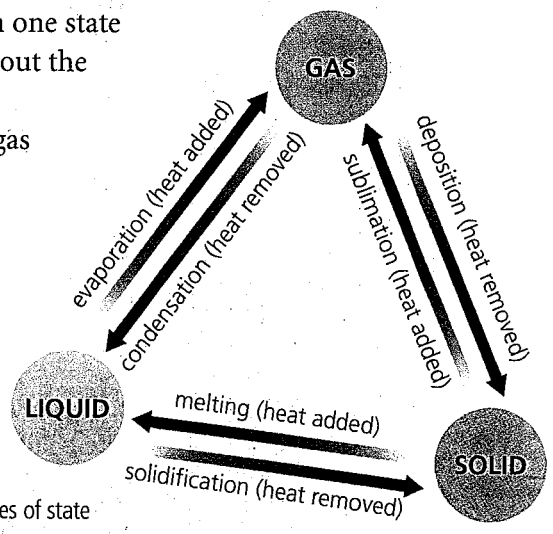


Figure 2 Changes of state

TRY THIS: Recycling Through Physical Change

Skills Focus: conducting, observing, analyzing, inferring

Materials: thermoplastic, safety goggles, hot plate, 400 mL beaker, water, tongs

When glass, paper, or plastic is recycled, what changes do they go through? Part of most recycling processes is the adding of heat. Find out what happens when plastic is heated.

1. Your teacher will provide you with a piece of thermoplastic. Examine it, and note its properties. Bend it slightly. What do you think might happen if it was bent in half?
2. Put on your safety goggles. On a hot plate, boil 200 mL of water in a 400 mL beaker. Using tongs, immerse the thermoplastic in the boiling water, and gently move it in the water. Observe any changes in properties.
3. When the thermoplastic seems quite flexible, carefully remove it from the water, and then roll it into a ball. Allow it to cool for a few minutes. Observe its new characteristics.
4. Unplug the hot plate, and clean up.

A. Do you think the thermoplastic is now a different material, or is it just a different form? Explain your thinking.

B. What would happen if you reheated the thermoplastic?

C. If the thermoplastic was recycled in this form, what would the new manufacturer have to do to use it?

To learn more about the changes of state, go to www.science.nelson.com GO

Dissolving is another physical change. When salt is dissolved in water, the crystals disappear but the salty taste of the water confirms that the salt is still present. The salt can be re-crystallized by evaporating the water. For many cultures, including British Columbia's Aboriginal cultures, the ocean was the main source of salt, an important part of their food preservation and nutrition. GO

Chemical Change

A **chemical change** occurs when a substance changes into one or more new substances with different properties. When you burn a candle, what happens to the wax? Scientists in the Middle Ages believed that the wax in the candle changed into energy. Later, however, scientists showed that some of the particles that make up the wax become vapour and react with oxygen in the air to form new substances—carbon dioxide and water. As gases, these new substances escape into the air.

A chemical change is more likely to be a permanent change since many chemical reactions are not reversible. You would not expect your blackened marshmallow to change into a fresh one, or the gases from a burning candle to suddenly form into wax. There are some reactions, however, in which substances change into new substances in one chemical reaction, and, in a different chemical reaction, the new substances can change back to the original substances. The chemical reactions that occur in rechargeable batteries during charging and use are good examples of this type of reaction.

Identifying Chemical and Physical Change

The challenge of distinguishing between physical and chemical changes is that you can only observe the large visible changes. What do you look for when trying to decide if a change is physical or chemical? If a new substance is made, you should see a different set of observable properties, such as a change in colour. In chemical reactions, you may also see bubbles, which indicate that a gas is forming, or you may notice a solid forming from liquids. Although a change in energy is often associated with chemical reactions, it does not provide proof that a chemical reaction has taken place. Some chemical reactions do give off heat and light energy, but others absorb energy. For example, cold packs work because of a chemical reaction that absorbs energy. Physical changes may also involve some change in energy. Changes in state involve a loss or gain in heat.

Table 1 summarizes the characteristics of physical and chemical changes. Table 2 provides examples of what you might observe when specific physical and chemical changes occur. 5A *Investigation*

5A *Investigation*

The Nature of a Burning Candle

To perform this investigation, turn to page 176.

In this investigation, you will observe and identify the physical and chemical changes that happen when a candle burns.

Table 1 Characteristics of Physical and Chemical Change

Physical change	Chemical change
reversible (usually)	irreversible (usually)
no new substance forms	new substance forms (for example, gas or solid)
properties do not change	new set of properties (for example, colour)
energy change may occur, but may not be noticed	energy change may occur (for example, heat or light is given off, or energy is absorbed)

LEARNING TIP

To check your understanding, use Table 1 to explain to a partner the differences between chemical and physical changes. Use examples from Table 2 in your explanation.

Table 2 Examples of Physical and Chemical Changes

Physical change	Chemical change
When cream is whipped, air puffs up the cream. The substances are still cream and air.	Baking powder reacts when heated to create carbon dioxide, which makes bread rise. The reaction creates a new gas that takes up more space.
Boiling water creates water vapour that escapes as a gas, but it is still water. The water can condense to become liquid water again.	Gasoline burns explosively to create great heat, carbon dioxide, and water. New gases are created.
Sugar dissolves in tea. The sugar "disappears," but it can still be identified by its sweetness.	Sunlight causes the body to create vitamin D and melanin in the skin.
Tattoo ink is injected under the skin to create graphic tattoos. The properties of the ink are permanent and unchanged.	Hydrogen peroxide is used to bleach hair to a much lighter colour. Darker hair pigments are changed chemically into other substances that have less or no colour.

TRY THIS: Recognizing Chemical Change

Skills Focus: conducting, observing, recording, analyzing

Sodium hydroxide is corrosive. Clean any spills, especially on skin or clothing, with cold water. Some metal solutions are extremely toxic. Wash your hands after the activity and clean up any spills.

Materials: safety goggles, spot plates, small dropping bottles of the following solutions: 0.5 mol/L sodium hydroxide, 0.2 mol/L copper(II) nitrate, 0.2 mol/L nickel(II) nitrate, 0.2 mol/L magnesium nitrate, 0.2 mol/L iron(III) nitrate, 0.5 mol/L sodium iodide, 0.2 mol/L lead(II) nitrate, 0.2 mol/L silver nitrate, 0.5 mol/L sodium carbonate, 0.2 mol/L calcium nitrate, disposal container

1. Put on your safety goggles. In one row of your spot plate, add five drops of the sodium hydroxide solution to each of four depressions. Then add two drops of copper(II) nitrate to the first depression, two drops of nickel(II) nitrate to the second depression, two drops of magnesium nitrate to the third, and two drops of iron(III) nitrate to the fourth. Record your observations.
2. In a second row, add five drops of the sodium iodide solution to each of three depressions. Then add two drops of lead(II) nitrate to the first depression, two drops of copper(II) nitrate to the second, and two drops of silver nitrate to the third. Record your observations.
3. In a third row, add five drops of sodium carbonate to each of three depressions. Then add two drops of calcium nitrate to the first depression, two drops of nickel(II) nitrate to the second depression, and two drops of lead(II) nitrate to the third. Record your observations.

A. Identify the combinations of chemicals in which chemical changes occurred.

B. What evidence showed that chemical changes had occurred?

5.3 CHECK YOUR Understanding

1. Describe the difference between a physical change and a chemical change.
2. Which of the following kitchen activities are physical changes, and which are chemical changes?
   (a) cooking bacon
   (b) making icing
   (c) baking a cake
   (d) using oven cleaner
   (e) making whipped cream
3. Which of the following everyday activities are physical changes, and which are chemical changes?
   (a) salting ice on a driveway
   (b) burning leaves
   (c) mixing sand with soil
   (d) composting cut vegetation
   (e) using a glue gun
4. Which of the following geological changes are physical changes and which are chemical changes?
   (a) formation of a limestone cave
   (b) creation of a canyon by a river
   (c) wearing of rocks by wave action
   (d) destruction of lakes by acid rain
   (e) heaving of the ground by ice formation
5. Which of the following are examples of a physical change?
   (a) change in physical state
   (b) change in size or shape
   (c) change in properties
   (d) change in texture
   (e) change in physical quantities
   (f) change in substances
6. Which of the following are examples of a chemical change?
   (a) corrosion reactions
   (b) combustion reactions
   (c) dissolving of sugar
   (d) evaporation of water
   (e) decaying reactions
   (f) digestion of food
7. What observations indicate that a physical change is occuring?
8. What observations indicate that a chemical change is occuring?
9. Make a list of five physical changes and five chemical changes that you see in your daily life.
10. Give two examples of geological changes that take place over millions of years. Are they physical or chemical changes? Explain.
11. What is the difference between dew and frost? What is different about their formation?
12. Starting with the water in an ocean, use the terms for physical changes of state to trace the path of the water into the atmosphere, to the land, and back to the ocean.
13. All over Europe there is growing concern about the rapid weathering of the statues and architecture over the last 50 years. Some Roman statues have aged more over the last few years than in the previous 2000 years. If most statues are made of calcium carbonate (marble), do you think the process of weathering the statues is physical or chemical? Explain your answer.
14. If you cut a piece of paper in two, do the properties of the paper change? If you cut these two pieces in half, do the properties change? If you repeat this process indefinitely, would there come a time when the properties could change? Explain your thinking.