Thermal energy

*Notes for Friday

Energy is the ability to do work or cause change.

*Every chemical or physical change in matter includes a change in energy.

Ex: bending a paperclip takes energy

When ice changes to liquid water, it absorbs energy from the surrounding matter.

When candle wax burns, it gives off energy.

Temperature is a measure of the average energy of random motion of particles of matter.

The particles of gas in the warm outside air have greater average energy of motion than the particles of air in a cool building.

Thermal energy is the total energy of all the particles in an object.

You experience thermal energy when you describe matter- like the air in a room- as feeling hot or cold.

Thermal energy always flows from warmer matter to cooler matter.

Ex: If you hold a cup of hot cocoa on a cold day it warms your hands.

The most common form of energy released or absorbed is thermal energy.

Ex: Ice absorbs thermal energy from its surroundings when it melts.

Endothermic change: energy is taken in

Exothermic change: energy is released.

→On another piece of paper:
Answer:

- Math - Analyzing Data P. 27 (1-4)
- P. 27 Section 3 Assessment (1a,b, 3a,b)

Physical Change

In what ways can matter change? A **physical change** is any change that alters the form or appearance of matter but does not make any substance in the matter into a different substance. For example, a sand artist may change a formless pile of sand into a work of art. However, the sculpture is still made of sand. **A substance that undergoes a physical change is still the same substance after the change.**

Changes of State As you may know, matter occurs in three familiar states—solid, liquid, and gas. Suppose you leave a small puddle of liquid water on the kitchen counter. When you come back two hours later, the puddle is gone. Has the liquid water disappeared? No, a physical change happened. The liquid water changed into water vapor (a gas) and mixed with the air. A change in state, such as from a solid to a liquid or from a liquid to a gas, is an example of a physical change.

Changes in Shape or Form Is there a physical change when you dissolve a teaspoon of sugar in water? To be sure, you would need to know whether or not the sugar has been changed to a different substance. For example, you know that a sugar solution tastes sweet, just like the undissolved sugar. If you pour the sugar solution into a pan and let the water dry out, the sugar will remain as a crust at the bottom of the pan. The crust may not look exactly like the sugar before you dissolved it, but it's still sugar. So, dissolving is also a physical change. Other examples of physical changes are bending, crushing, breaking, chopping, and anything else that changes only the shape or form of matter. The methods of separating mixtures—filtration and distillation—that you read about in Section 1 also involve physical changes.

Reading Checkpoint **Why is the melting of an ice cube called a physical change?**

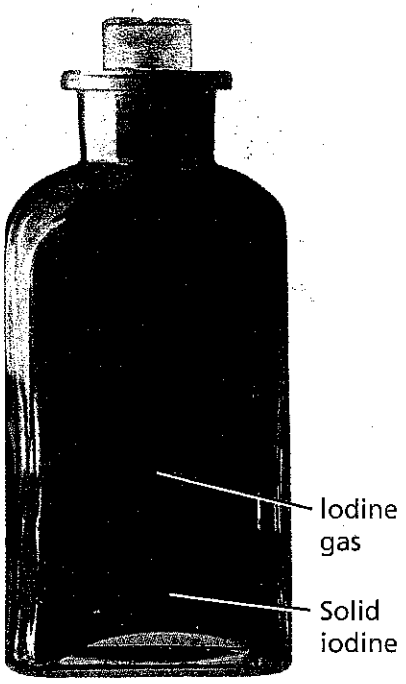


FIGURE 15
Change of State
At room temperature, the element iodine is a purple solid that easily becomes a gas.
Classifying *Why is the change in the iodine classified as a physical change?*

Aluminum

Table sugar

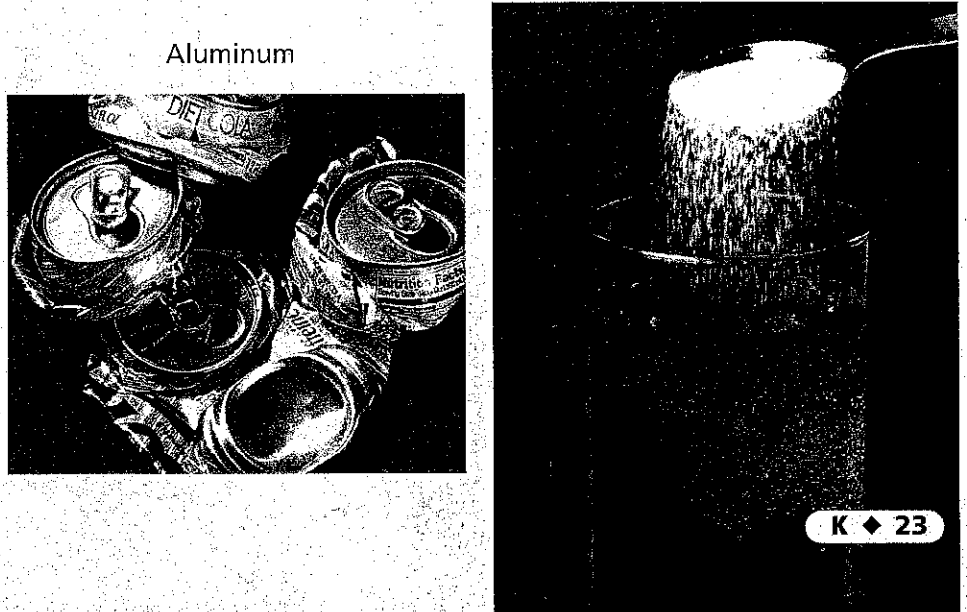


FIGURE 16
Change in Form
Crushing aluminum soda cans doesn't change the aluminum into another metal (left). When table sugar dissolves in a glass of water, it is still sugar (right).

Lab zone Skills Activity

Inferring

Make a list of changes in matter that you observe during a single day. These changes may occur in your environment (such as changes in the weather), as a result of people's activities (such as cooking or driving a car), or in other situations. Try to classify each change on your list as a physical change or a chemical change. Then briefly explain your choice.

Chemical Change

A second kind of change occurs when a substance is transformed into a different substance. A change in matter that produces one or more new substances is a **chemical change,** or a chemical reaction. In some chemical changes, a single substance simply changes to one or more other substances. For example, when hydrogen peroxide is poured on a cut on your skin, it breaks down into water and oxygen gas.

In other chemical changes, two or more substances combine to form different substances. For example, iron metal combines with oxygen from the air to form the substance iron oxide, which you call rust. **Unlike a physical change, a chemical change produces new substances with properties different from those of the original substances.**

Examples of Chemical Change One familiar chemical change is the burning of natural gas on a gas stove. Natural gas is mostly the compound methane, CH_4. When it burns, methane combines with oxygen in the air and forms new substances. These new substances include carbon dioxide gas, CO_2, and water vapor, H_2O, which mix with air and are carried away. Both of these new substances can be identified by their properties, which are different from those of the methane. The chemical change that occurs when fuels such as natural gas, wood, candle wax, and gasoline burn in air is called combustion. Other processes that result in chemical change include electrolysis, oxidation, and tarnishing. The table in Figure 17 describes each of these kinds of chemical changes.

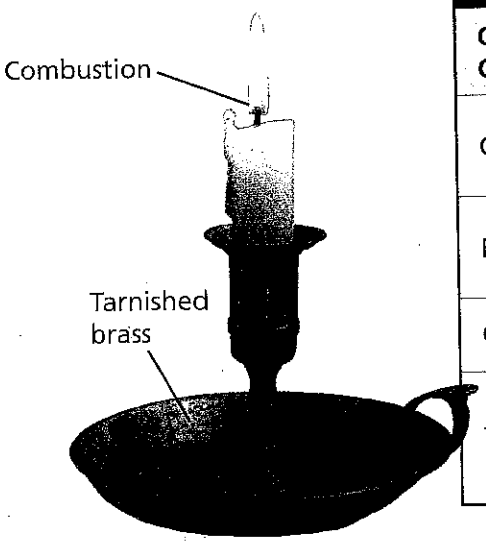
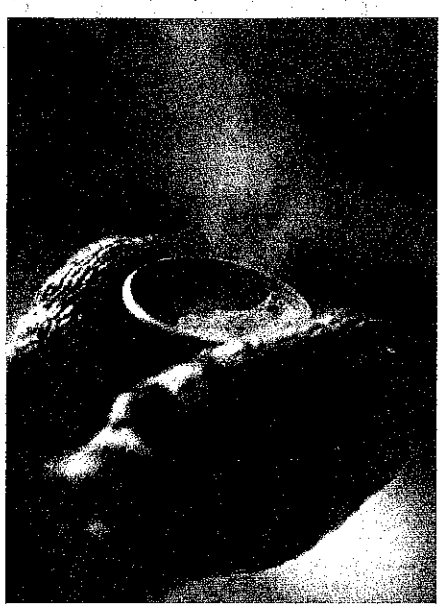


FIGURE 17
Four examples of chemical change are listed in the table.
Interpreting Photographs *What fuel is undergoing combustion in the photograph?*

Examples of Chemical Change

Chemical Change	Description	Example
Combustion	Rapid combination of a fuel with oxygen; produces heat, light, and new substances	Gas, oil, or coal burning in a furnace
Electrolysis	Use of electricity to break a compound into elements or simpler compounds	Breaking down water into hydrogen and oxygen
Oxidation	Slow combination of a substance with oxygen	Rusting of an iron fence
Tarnishing	Slow combination of a bright metal with sulfur or another substance, producing a dark coating on the metal	Tarnishing of brass

FIGURE 20
Flow of Thermal Energy
Thermal energy from a hot cup of cocoa can warm cold hands on a chilly day.
Developing Hypotheses *How will the flow of thermal energy affect the cocoa?*



Matter and Thermal Energy

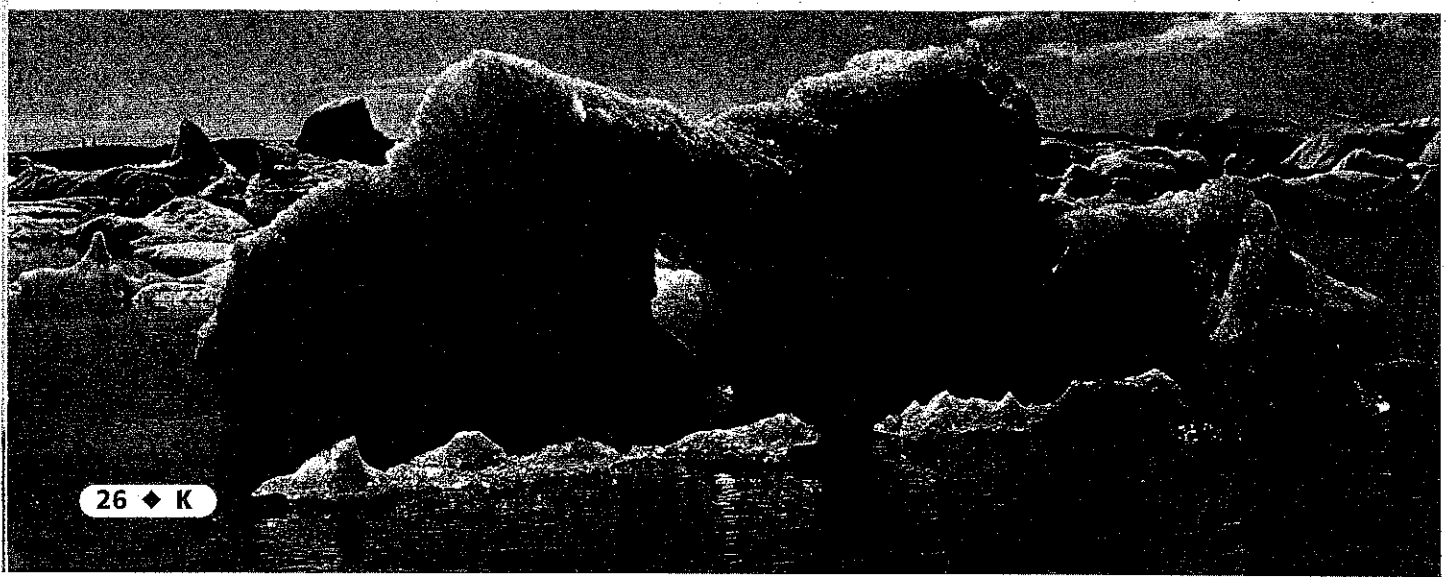
Do you feel as if you are full of energy today? **Energy** is the ability to do work or cause change. **Every chemical or physical change in matter includes a change in energy.** A change as simple as bending a paper clip takes energy. When ice changes to liquid water, it absorbs energy from the surrounding matter. When candle wax burns, it gives off energy.

Temperature and Thermal Energy Think of how it feels when you walk inside an air-conditioned building from the outdoors on a hot day. Whew! Did you exclaim about the change in temperature? **Temperature** is a measure of the average energy of random motion of particles of matter. The particles of gas in the warm outside air have greater average energy of motion than the particles of air in the cool building.

Thermal energy is the total energy of all of the particles in an object. Most often, you experience thermal energy when you describe matter—such as the air in a room—as feeling hot or cold. Temperature and thermal energy are not the same thing, but temperature is related to the amount of thermal energy an object has. Thermal energy always flows from warmer matter to cooler matter.

Thermal Energy and Changes in Matter When matter changes, the most common form of energy released or absorbed is thermal energy. For example, ice absorbs thermal energy from its surroundings when it melts. That's why you can pack food and drinks in an ice-filled picnic cooler to keep them cold. The melting of ice is an **endothermic change,** a change in which energy is taken in. Changes in matter can also occur when energy is given off. An **exothermic change** releases energy. Combustion is a chemical change that releases energy in the form of heat and light. You've taken advantage of an exothermic change if you've ever warmed your hands near a wood fire.

FIGURE 21
An Endothermic Change
An iceberg melting in the ocean absorbs thermal energy from the surrounding water.

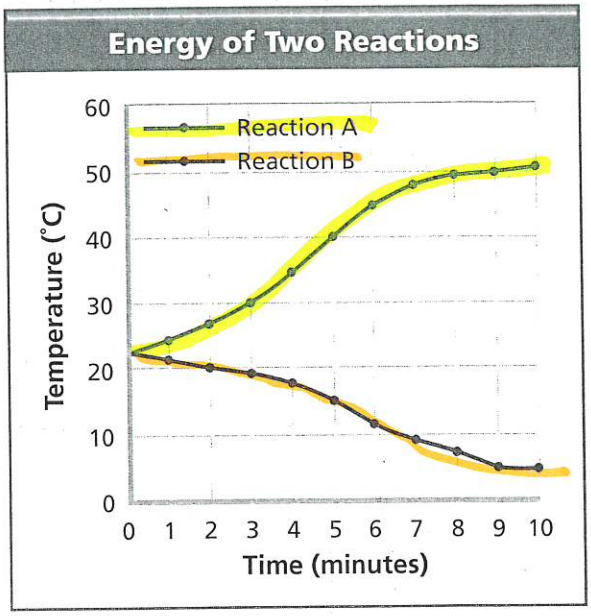


Math Analyzing Data

Comparing Energy Changes

A student observes two different chemical reactions, one in beaker A and the other in beaker B. The student measures the temperature of each reaction every minute. The student then plots the time and temperature data and creates the following graph.

1. **Reading Graphs** What do the numbers on the *x*-axis tell you about the length of the experiment?
2. **Comparing and Contrasting** How did the change in temperature in beaker B differ from that in beaker A?
3. **Interpreting Data** Which reaction is exothermic? Explain your reasoning.
4. **Calculating** Which reaction results in a greater change in temperature over time?



Section 3 Assessment

Target Reading Skill

Relating Cause and Effect Refer to your graphic organizer about chemical change to help you answer Question 2 below.

Reviewing Key Concepts

1. a. **Listing** Identify three different kinds of physical change that could happen to a plastic spoon.
   b. **Making Judgments** Which of the following processes is not a physical change: drying wet clothes, cutting snowflakes out of paper, lighting a match from a matchbook?
2. a. **Defining** What evidence would you look for to determine whether a chemical change has occurred?
   b. **Applying Concepts** Why is the electrolysis of water classified as a chemical change but the freezing of water is not?
   c. **Problem Solving** Explain why the mass of a rusted nail would be greater than the mass of the nail before it rusted. Assume that all the rust is still attached to the nail. (*Hint:* The nail rusts when exposed to the air.)
3. a. **Reviewing** What is thermal energy?
   b. **Explaining** How can you tell whether one glass of water has more thermal energy than another, identical glass of water?
   c. **Inferring** How might you cause an endothermic chemical change to begin and keep going?

Writing in Science

Persuasive Letter Write a letter to persuade a friend that a change in temperature does not necessarily mean that a chemical change has occurred.