Name Date

Section 10.1 Summary

Temperature, Thermal Energy, and Heat

Textbook pages 424–435

Before You Read

We often use the terms heat and temperature interchangeably. Do you think they mean the same thing? Explain your reasoning in the lines below.

How is energy associated with moving particles?

The **kinetic molecular theory** explains that particles in matter are in constant motion. **Kinetic energy** is the energy of a particle or an object due to its motion. When particles collide, kinetic energy is transferred between them. The particles of a substance move at different speeds depending on the state of the substance. The particles of a gas have more kinetic energy than those of a liquid and move more quickly. The particles of a liquid have more kinetic energy than those of a solid.

Kinetic energy is not the only energy associated with moving particles. **Potential energy** is stored energy that has the *potential* to be transformed into another form of energy, such as kinetic energy. A good example is the gravitational attraction between Earth and the textbook you are holding. As you lift the textbook, its gravitational potential energy increases. The book has a greater distance to fall, so more energy will be transformed into kinetic energy if it does. On the other hand, the lower you hold the book, the less gravitational potential energy it has. At a lower height, less energy will be transformed into kinetic energy if the book falls. Similarly, there are attractive electrical forces between atoms and molecules. The pull of these attractive forces also gives particles potential energy. ✔

How is kinetic energy measured?

Kinetic energy is measured in terms of temperature, thermal energy, and heat.

1. **Temperature** is a measure of the *average kinetic energy* of all the particles in a sample of matter. As the particles'

Mark the Text

Check for Understanding

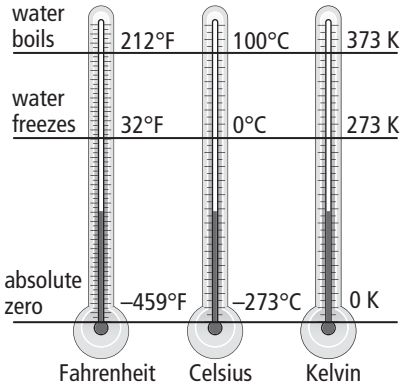
As you read this section, be sure to reread any parts you do not understand. Highlight any sentences that help make concepts clearer for you.

✔ *Reading Check*

What two types of energy are associated with moving particles?

average kinetic energy increases, the temperature of the sample also increases, and vice versa. For example, particles in a glass of cold water move more slowly than, and therefore have less kinetic energy than, particles in a cup of hot water.

Three different scales are used to measure temperature: Fahrenheit, Celsius, and Kelvin.



2. Thermal energy is the *total energy* of all the particles in a solid, liquid, or gas. A hot bowl of soup has more thermal energy when it is first served than after it cools. So far this is similar to temperature. However, since thermal energy includes the energy of all of the particles in a sample of matter, a large bowl of soup has more thermal energy than a small bowl of soup at the same temperature. In fact, a swimming pool of lukewarm water has more thermal energy than a small cup of hot tea.

3. Heat is the amount of *thermal energy* that transfers from an area or object of higher temperature to an area or object of lower temperature. Heat can be transferred in three ways:

1. Conduction: **Conduction** describes heat transfer that occurs when faster moving particles collide with slower moving particles. During conduction, heat is transferred from matter with a higher temperature and greater kinetic energy to matter with a lower temperature and less kinetic energy. For example, if a metal spoon that is at room temperature is placed in a pot of boiling water, heat will be transferred to the spoon by conduction and it will become hot. Materials often conduct heat at different rates. Metals, for example, are good thermal conductors, while wood and air are not.

2. Convection: **Convection** is the transfer of heat within a fluid, where the fluid actually moves from one place to another. Unlike conduction, convection transfers matter as well as heat. A boiling pot of water provides a good example of how convection works. As the water at the bottom of the pot heats up, the molecules begin to move faster and their kinetic energy increases, causing them to spread apart. The water expands and becomes less dense than the surrounding water. As a result, it rises to the surface, where it cools, contracts, and sinks— only to be reheated and circulated again. This movement of a fluid due to differences in density is called a **convection current**.
3. Radiation: **Radiation** is the transfer of heat by electromagnetic waves that carry radiant energy. One type of radiation associated with heat transfer is called **infrared radiation**, or heat radiation. This is the heat transfer you experience when you stand close to a campfire. The campfire is emitting electromagnetic waves toward your body, causing you to feel warmth. Similarly, everything around you experiences heat transfer as a result of **solar radiation** from the Sun, which includes many different types of electromagnetic waves. ✔

Reading Check

What is the difference between convection and radiation?

What are Earth's energy sources?

Earth receives energy from three main sources:

1. Solar radiation, including visible light, infrared radiation, and other types of radiation, comes from the Sun.
2. Residual thermal energy from when Earth was formed is slowly released.
3. Decay of underground radioactive elements produces energy.

Use with textbook pages 424–431.

Kinetic molecular theory and temperature

1. Define the term kinetic energy.

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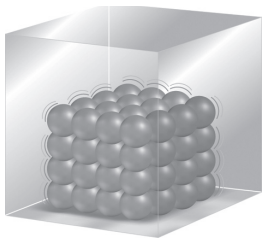
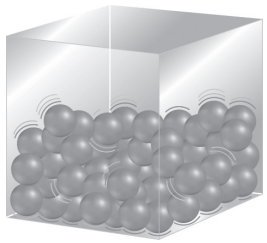
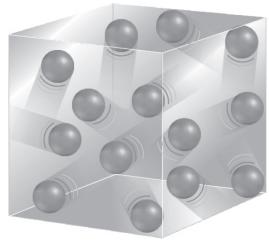
2. Complete the following table by describing the three states of matter in terms of the space between the particles, speed of movement of the particles, and relative amount of kinetic energy.

	 **Solid**	 **Liquid**	 **Gas**
spaces between particles			
movement of particles			
kinetic energy of particles			

3. Define the term temperature.

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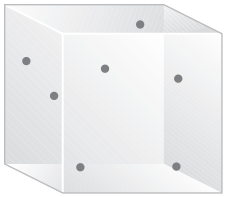
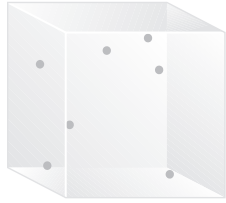
4. In the diagrams below, draw arrows to show how fast the water molecules are moving and in what direction they move in hot and cold water.

hot water



cold water



5. Three different scales are used to measure temperature. Complete the table below comparing the measurements for absolute zero, freezing of water, and boiling of water on the various scales.

	Fahrenheit	**Celsius**	**Kelvin**
absolute zero			
water freezes			
water boils			

Use with textbook pages 426–431.

Thermal energy, kinetic energy, potential energy

1. What is thermal energy?

2. What is kinetic energy?

3. What is potential energy?

4. What happens to the thermal energy of an object as its temperature rises?

5. What happens to molecules as their kinetic energy increase?

6. What happens to molecules as their potential energy increases?

7. What is heat?

8. Give an example that illustrates the above definition of heat.

9. State three ways in which thermal energy is transferred.

Use with textbook pages 427–431.

Thermal energy transfer

1. Using the illustrations, complete the following table.

	Type of thermal energy transfer	What is happening in the diagram
		
		
		

2. What materials are good thermal conductors?

3. Give three examples of materials that are considered to be insulators.

4. Explain what causes the movement of the liquid in a lava lamp.

5. What is radiant energy?

Temperature, thermal energy, and heat

Use with textbook pages 424–431.

Match each Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Term	Descriptor
1. conduction **2.** convection **3.** electromagnetic spectrum **4.** heat **5.** kinetic energy **6.** kinetic molecule theory **7.** temperature **8.** thermal energy	**A.** the transfer of thermal energy within a fluid and with the movement of fluid from one place to another **B.** the theory that all matter is composed of particles moving constantly in random directions **C.** the transfer of energy by waves travelling outward in all directions from a source **D.** the transfer of thermal energy from one substance to another or within a solid by direct contact of particles **E.** the total energy of all the particles in a solid, liquid, or gas **F.** a measure of the average kinetic energy of all the particles in a sample of matter **G.** the transfer of thermal energy from an area or object of high temperature to an area or object of low temperature **H.** the energy of a particle or object due to its motion.

Circle the letter of the best answer.

9. As the temperature of an object decreases, the kinetic energy of the object

A. decreases

B. increases

C. remains the same

D. fluctuates

10. Which of the following best describes heat?

A. stored energy of an object

B. transfer of thermal energy

C. energy of a particle due to its motion

D. total energy of all particles involved

11. A temperature reading of 273° Kelvin is equivalent to

A. 0°C

B. 100°C

C. 212°F

D. – 459°F

12. Which type of thermal energy accounts for the movement of clouds?

A. heat

B. conduction

C. convection

D. radiation

13. Which of the following are sources of thermal energy?

I.	Earth's formation
II.	radioactive decay
III.	humans

A. I only

B. II only

C. I and II only

D. I, II, and III