

Section 10.1.

Temperature, Thermal Energy, and Heat.

Textbook pages 424 to 435.

Before You Read.

We often use the terms heat and temperature interchangeably. Do you think they mean the same thing?

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'

Next page.

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:
 - a. 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.

Next page.

- b. 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**.
- c. 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.

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.

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