

section ● Transferring Thermal Energy

● Before You Read

There is an old joke that says a sweater is something you put on when your mother is cold. On the lines below, write about a time when you felt warm, but someone else felt cold.

What You'll Learn

- three ways heat is transferred
- about thermal conductors and insulators
- how thermal insulators control the transfer of thermal energy

● Read to Learn

Ways to Transfer Thermal Energy

Thermal energy can be transferred from place to place in different ways. Particles can transfer heat either by colliding or moving to another part of a substance. Thermal energy also can be transferred without matter. There are three ways that thermal energy can be transferred—conduction, convection, and radiation.

Conduction

The kinetic theory states that particles in matter are always in random motion. When particles collide, energy is transferred from one particle to another. This process is called conduction. **Conduction** is the transfer of thermal energy by the collision of particles in matter.

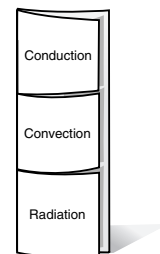
Imagine a metal frying pan heating on a stove. The metal atoms nearest the burner absorb the most thermal energy causing their kinetic energy to increase. These atoms start to move faster. Kinetic energy is transferred when these faster-moving atoms collide with slower-moving particles near them. As these collisions continue, thermal energy is transferred throughout the frying pan. In conduction, thermal energy is transferred by the collisions between particles in matter, not by the movement of matter.

Mark the Text

Identify Definitions As you read the section, highlight the definition of each word that appears in bold.

FOLDABLES™

● **Compare** Make the following Foldable to compare conduction, convection, and radiation.



Which materials are good thermal conductors?

Thermal energy can be transferred by conduction in all materials. The rate at which thermal energy is transferred depends upon the material. A thermal conductor is a material in which thermal energy is transferred easily. The conduction of thermal energy is faster in solids and liquids than in gases. Particles in gases are farther apart than in solids and liquids and collide less often. The best thermal conductors are metals.

Convection

A fluid is a substance that can flow. It can be a liquid or a gas. Thermal energy can be transferred in fluids by convection. **Convection** is the transfer of thermal energy in a fluid by the movement of fluid from place to place. During convection, particles with more energy transfer energy to other particles as they move from place to place.

As the particles move faster, they tend to get farther apart. As a result, a fluid expands when it is heated. Recall that density is mass divided by volume. The density of a liquid decreases when it is heated because the volume increases but the mass does not change. The warmer parts of a fluid are less dense than the cooler parts around them.

What causes convection currents?

Convection currents can occur because there is a difference in density between warm and cool fluids. When a beaker of water is heated from the bottom, convection currents form in the beaker. The warm water at the bottom of the beaker is less dense than the cooler water above it. The cooler, denser water sinks and the warmer, less dense water rises. As it rises, the warmer water transfers thermal energy to the cooler water around it. As the warm water cools, it becomes denser and sinks to the bottom of the beaker. The rising and sinking forms convection currents. In this way, convection currents transfer thermal energy by the movement of water from place to place.

Is there convection in the atmosphere?

Earth's atmosphere is made of gases and is a fluid. The atmosphere is warmer at the equator and cooler at the north and south poles. The atmosphere is warmer at the surface than at higher altitudes. Temperature differences cause convection currents in the atmosphere. Heat is carried to cooler regions by convection currents. Deserts and rainforests are caused by convection currents.

Reading Check

1. **Explain** What is convection?

Think it Over

2. **Infer** What do you think would happen to cooler regions if heat were not carried from warmer regions to cooler regions by convection currents?

Radiation

How does thermal energy travel through space? There is almost no matter between the Sun and Earth, so thermal energy does not travel by conduction or convection. Instead, energy is transferred from the Sun to Earth by radiation.

Radiation is the transfer of energy by electromagnetic waves. These waves transfer energy through solids, liquids, and gases. They also carry energy through empty space. Energy transferred by radiation is often called radiant energy. When you sit by a fireplace, you feel warm because thermal energy is transferred by radiation to your skin.


How does matter affect radiant energy?

When radiation strikes a material, three things happen: The material absorbs some of the energy, reflects some of the energy, and some of the energy may be transmitted, or passed through, the material. The amount of energy absorbed, reflected, and transmitted depends on the type of material. Light-colored materials reflect more radiant energy, while dark-colored materials absorb more radiant energy. When a material absorbs radiant energy, the thermal energy of the material increases.

The Flow of Thermal Energy

You control the flow of thermal energy in everyday activities. For example, you put on a coat when it's cool outside. You wear an oven mitt when you pull a hot pan out of the oven. In both cases, you use materials to help control the flow of thermal energy. Your coat reduces the flow of thermal energy from your body to the surrounding air. The oven mitt reduces the flow of thermal energy from the hot dish to your hand.

Thermal Insulators

A coat and oven mitt are thermal insulators. A **thermal insulator** is a material through which thermal energy flows slowly. Thermal insulators include wood, some plastics, fiberglass, and air. An insulator is the opposite of a conductor. Good conductors of thermal energy, such as metals, are poor thermal insulators. 

Gases such as air are much better thermal insulators than solids or liquids. Some kinds of insulating materials have many pockets of trapped air. These air pockets are poor conductors of thermal energy. They also keep convection currents from forming.



Think it Over

3. **Compare** How is energy transferred in radiation?

Reading Check

4. **Define** the meaning of the term *thermal insulator*.

● After You Read

Mini Glossary

conduction: the transfer of thermal energy by collisions between particles in matter

convection: transfer of thermal energy in a fluid by the movement of fluid from place to place.

thermal insulator: thermal material in which thermal energy moves slowly

radiation: the transfer of energy by electromagnetic waves

1. Review the terms in the Mini Glossary above. Write a sentence below that shows your understanding of the term thermal insulator.

2. Complete the table to organize information about how thermal energy is transferred.

How Thermal Energy Is Transferred	Definition	Example
Conduction		
Convection		
Radiation		

3. Think about what you have learned. How did identifying definitions help you as you read this section?



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