chapter 6

Thermal Energy

section 2 Heat

Before You Read

Write down two things you do to make yourself feel warmer.

_____

_____

What You'll Learn

- compare thermal energy and heat
- three ways heat moves
- what insulators and conductors are

Read to Learn

Mark the Text

Identify Main Ideas As you read this section, highlight the main ideas about conduction, radiation, and convection.

Heat and Thermal Energy

It's cold, turn up the heat. Heat the oven to 375°F. A heat wave has hit the Midwest. You've often heard the word *heat*, but what exactly is it? **Heat** is thermal energy that moves from one object to another when the objects are at different temperatures. Heat moves, or is transferred, when two objects are in contact with each other. More heat is transferred when the difference in temperature between the objects is large. Less heat is transferred when the temperature difference is small.

For example, no heat moves between two pots of boiling water that are touching. The water in both pots is the same temperature. Suppose a pot of boiling water touches a pot of cold water. Heat is transferred from the hot pot to the cold pot. The hot water loses heat and the cold water gains heat. Heat will transfer until both objects are the same temperature.

Thermal Energy is the sum of the potential and kinetic energy of all the molecules in an object.

Thermal Energy = potential + kinetic energy energy

Reading Check: Is more heat transferred when:

a) a box that is 95°C touches a ball that is 5°C

or

b) a box that is 95°C touches a ball that is 80°C?

How does heat move?

Heat always is transferred from warmer objects to cooler objects. It never transfers from a cooler object to a warmer one. The warmer object loses thermal energy. It becomes cooler. The cooler object gains thermal energy. It becomes warmer. Heat can be transferred in three ways—by conduction, radiation, or convection.

Reading Check: Heat only moves from a _____ object to a _____ object.

Conduction

When you eat something hot, conduction occurs. As the hot food touches your mouth, heat moves from the food to your mouth. **Conduction** is the movement of heat between objects that are touching.

When you hold an ice cube in your hand, conduction is occurring. The ice cube starts to melt and your hand starts to feel cold. The fast-moving molecules in your warm hand bump into the slow-moving molecules in the cold ice. When the faster-moving molecules touch the slower-moving molecules, energy passes from molecule to molecule. As a result, heat moves from your warm hand to the cold ice. The slow-moving molecules in the ice start moving faster. With more energy, the ice warms and its temperature rises. The ice begins to melt. The fast-moving molecules in your hand move more slowly. They lose thermal energy and your hand becomes cooler.

Reading Check: Rate of Heat Transfer by Conduction is fastest in:
a) solid
b) liquid
c) gas

When does conduction work best?

Conduction works best in solids and liquids. That's because the molecules and atoms are closer together in a solid or a liquid than in a gas. The molecules and atoms have to move only a short distance before they bump into each other and transfer energy to another molecule or atom. So, heat is transferred by conduction faster in liquids and solids than in gases.

Think it Over

1. **Describe** Give an example of heat being transferred by conduction.

Radiation

On a beautiful, clear day, you walk outside and notice the warmth of the Sun. How does the Sun heat Earth? The Sun transfers thermal energy to Earth, but not by conduction. The Sun and Earth do not touch. Instead, the Sun transfers heat to Earth by radiation. **Radiation** is the transter of energy by electro-magnetic waves. Electromagnetic waves can carry energy through empty space, like the space between Earth and the Sun. These waves can also carry energy through solids, liquids, and gases.

The Sun is not the only object that transfers heat by radiation. Sit next to a fire in a fireplace. You feel heat transferred by radiation from the fire to your skin. All objects give off electromagnetic radiation. Warm objects give off more radiation than cool objects.

Reading Check

2. **Explain** What transfers thermal energy when objects are heated by radiation?

Convection

When you heat a pot of water, heat transfers by conduction from the stove to the pot. Heat can be transferred in another way, too. As gas and liquid molecules move, they carry energy with them. **Convection** is the transfer of thermal energy through the movement of molecules from one part of a material to another.

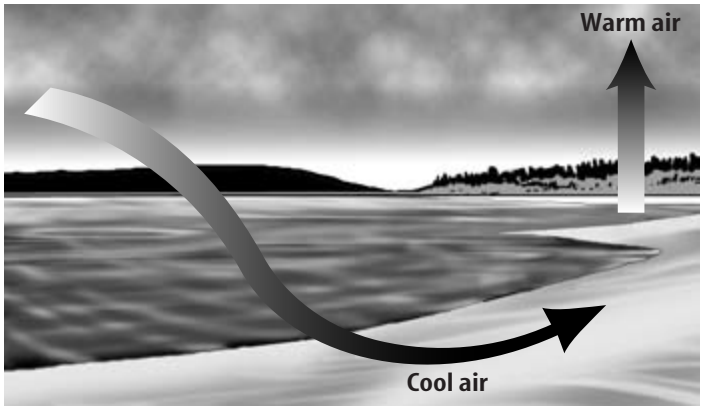
How is heat transferred by convection?

Heat is transferred by convection as a pot of water is heated. First, thermal energy is transferred to the water molecules near the bottom of the pot. These water molecules begin to move faster as their thermal energy increases. The faster the molecules move, the farther apart they get. Now the molecules in the warm water are farther apart than the molecules in the cooler water near the top of the pot. So, the warm water is less dense than the cool water. The warm, less dense water rises to the top of the pot. The cool, more dense water moves down to the bottom of the pot. As the cool water is heated, it rises to the top. This repeats until all the water in the pot is the same temperature.

What is natural convection?

Natural: Not man-made

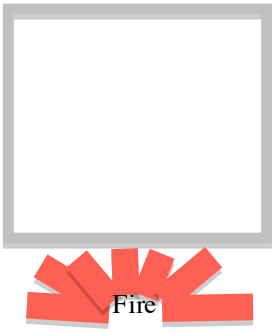
Natural convection takes place when a cool, dense fluid, pushes away a warm, less dense fluid. Think of the shore of a lake. The water is cooler than the land during the day. The warm land heats the air above it by conduction. As the air gets hotter, its particles move faster and farther away from each other. The hot air is less dense and it rises. The cooler, denser air from above the lake moves toward the land. You feel this movement of cool air as wind. The figure shows that as cool air moves over the land, it pushes the warm, less dense air up. The land heats the cool air and the cycle repeats.



Think it Over

3. **Explain** Why is a warm fluid less dense than a cool fluid?

Draw a diagram of Convection in a Pot of Water:



Picture This

4. **Describe** Using a highlighter, make one long line stroke that follows the arrows in the figure to show the path of the air flow. Describe the movement of the air.

Can only one type of heat trasnfer happen in any situation?
Circle: Yes or No

What is forced convection?

Forced convection takes place when an outside force pushes a fluid to make the fluid move and transfer heat. A fan is an example of an outside force. Computers use fans to keep their electronic parts from getting too hot. The fan blows cool air onto the hot parts.

Heat from the computer parts is transferred to the air around them by conduction. Warm air is pushed up and away from the hot parts and cool air moves in. The hot parts keep transferring heat to the cool air around them.

Thermal Conductors

*This section talks about conduction

Why are most cooking pans made of metal? Why does a metal spoon in a bowl of hot soup feel warm? Metal is a good conductor of heat. A **conductor** is any material that transfers heat easily. Some materials are good conductors because of the types of atoms or chemical compounds they are made up of.

chemical compounds: molecules

Remember that an atom has a nucleus surrounded by one or more electrons. In some materials, like metals, these electrons are not held tightly in place. They can move around freely. These electrons can transfer thermal energy by bumping into other atoms. Metals such as gold and copper are the best conductors of heat.

Thermal Insulators

insulator: heat does not transfer easily. It is the opposite of a conductor.

When you cook food in a pan, you want the pan to conduct heat from the hot burner to your food. But you do not want heat to move easily to the pan's handle. An insulator is a material that heat does not flow through easily. Most cooking pans have handles made from insulators.

Liquids and gases are usually better insulators than solids are. Air is a good insulator. Many insulating materials have spaces filled with air. The air prevents heat from moving through the material by conduction. Metals and other good conductors of heat are poor insulators. Air and other good insulators are poor heat conductors.

Houses and other buildings contain insulating materials. These materials reduce the heat conduction between the inside and outside. Insulating windows are made of two layers of glass. There is a layer of air or other gas in between the layers of glass. The layer of air reduces heat conduction. It keeps heat from going outside in the winter and from coming inside in the summer.

Think it Over

5. **Determine** Would a container made of a conductor or of an insulator be better for keeping hot food from getting cold?

Heat Absorption

On a hot day, you can walk barefoot across the lawn. But the pavement of the street is too hot to walk on. Why is the pavement hotter than the grass? The change in temperature of an object as it absorbs heat depends on the material it is made of.

What is specific heat?

The **specific heat** of a material is the amount of heat needed to raise 1 kilogram of that material by 1°C. More heat is needed to change the temperature of a material with a high specific heat than a material with a low specific heat. ☑

For example, the sand on a beach has a lower specific heat than water in a lake. On a hot summer day, the sand feels warmer than the water. Both are warmed by radiation from the Sun. But, the sand heats up faster than the water because it has a lower specific heat than the water. At night, the sand feels cool and the water feels warmer. They both lose thermal energy to the cooler night air. However, the temperature of the sand decreases faster than the temperature of the water.

Thermal Pollution

Some power plants and factories use water to cool hot equipment. The cooling water becomes hot. This hot water may be released into lakes, rivers, or the ocean. The hot water increases the temperature of the nearby water. **Thermal pollution** is the increase in the temperature of a body of water caused by warmer water being added to it. Rainwater falling on warm roads and parking lots can also cause thermal pollution.

Why is thermal pollution harmful?

Warmer water has less dissolved oxygen than cooler water. Warm water causes fish and other animals to use more oxygen. Some animals may die because there is not enough oxygen in the water. Also, in warmer water, parasites and diseases are a bigger problem for many organisms. Factories and power plants can reduce thermal pollution by cooling hot water in cooling towers before it's released.

Reading Check

6. **Explain** Which kind of material needs more heat to raise its temperature, one with a high specific heat or one with a low specific heat?

_____

So, does the above material heat up more quickly or more slowly?

_____

Dissolved oxygen: oxgyen that becomes a part of water. Without dissolved oxygen animals in the water cannot breathe.

Think it Over

7. **Identify** Name one harmful result of thermal pollution.

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After You Read

Mini Glossary

conduction: the movement of heat between objects that are touching

conductor: any material that transfers heat easily

convection: the transfer of thermal energy through the movement of molecules from one part of a material to another

heat: thermal energy that moves from one object to another when the objects are at different temperatures

radiation: the transfer of energy by electromagnetic waves

specific heat: the amount of heat needed to raise 1 kilogram of a material by 1°C

thermal pollution: the increase in the temperature of a body of water caused by adding warmer water

1. Review the terms and definitions in the Mini Glossary. Chose one of the terms that describes how heat can be moved and use it in a sentence.

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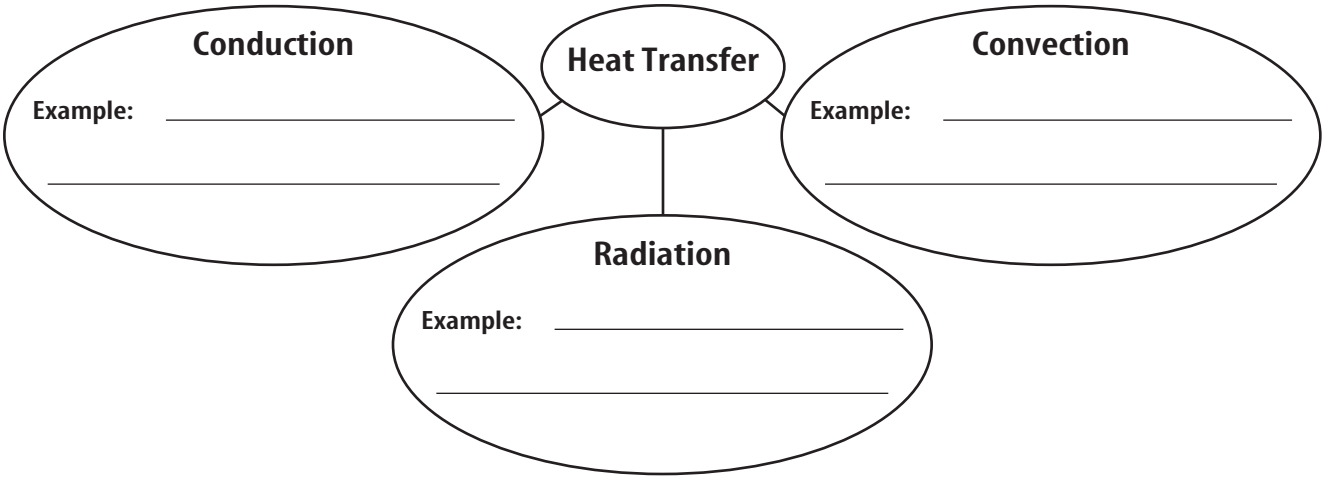
_____

2. Fill in the blanks on the web diagram below with examples of the different methods of heat transfer.



3. You were asked to highlight the main ideas about conduction, radiation, and convection. What would be another way to learn about these three methods of heat movement?

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End of Section

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