Unit 5 Physical Science: Part II

Chapter 18 Heat, Light, and Sound
Chapter 19 Electricity and Magnetism
Chapter 20 Energy Resources

Different forms of energy make this video game exciting and fun to play.

A video game is powered by electricity. The machine uses the electricity to produce flashing colors of light and the sounds of voices.

Use the chart to answer the following questions.

1. How does light travel from the video screen to the player's eyes?
2. How does electricity move through the wires of a video machine?
3. What kind of energy is produced by the video game's voices?

Form of Energy	How It Travels
Light	In waves
Sound	In waves
Electricity	Through wires as a flow of electrons

Chapter 18 Heat, Light, and Sound

You can feel the heat from a campfire. You can see the light of its orange-yellow flames. You can hear the sound of the crackling wood. What do you think heat, light, and sound all have in common?

Learning Objectives

- Describe how heat and temperature are related.
- Identify ways that heat moves.
- Identify the features of a wave.
- List four things that light may do when it strikes an object.
- Explain where colors come from.
- Explain how sounds are produced.
- LAB ACTIVITY: Show how different colors of light can be combined.
- ON-THE-JOB SCIENCE: Interpret codes that are scanned by lasers.

Words to Know

conduction	the way heat is passed along by molecules of matter that bump into one another
insulator	matter that does not conduct heat well
convection	the transfer of heat within a gas or a liquid by the movement of warmer particles
vacuum	any place where there is no matter
radiation	energy that travels in waves
wavelength	the distance from the crest, or top, of one wave to the crest of the next wave
amplitude	the height of a wave
frequency	the number of wave cycles that pass through a point in one second
reflection	the bouncing of light off an object
refraction	the bending of light rays as they pass from one substance into another
spectrum	the band of colors that make up white light
prism	a triangular-shaped, three-dimensional object made of clear glass that breaks up white light into its different colors

18-1 Heat and Matter

Words to Know

conduction	the way heat is passed along by molecules of matter that bump into one another
insulator	matter that does not conduct heat well
convection	the transfer of heat within a gas or a liquid by the movement of warmer particles
vacuum	any place where there is no matter
radiation	energy that travels in waves

Heat and Temperature

Science Fact

Heat is measured in calories. A calorie is the amount of heat needed to raise the temperature of 1 gram of water 1°C.

Heat and temperature are related, but they are not the same. You feel heat energy while you are standing in sunlight. You feel it next to a fire. You feel your own heat energy when you sleep under blankets. There is heat energy in everything, even in the oceans.

Heat is a form of kinetic energy. Remember that all matter is made up of moving atoms and molecules. The moving particles all have kinetic energy.

However, no two particles in a substance have exactly the same amount of kinetic energy. Heat is the *total* kinetic energy of the particles in a substance. Temperature is the measure of the *average* kinetic energy of the particles in a substance.

If you add heat energy to a substance, its particles move faster. They become hotter. You raise the average kinetic energy and temperature of the substance. If you remove heat from a substance, the particles in the substance move slower. You lower its temperature.

A small cup of hot soup and a large pot of hot soup have the same temperature. This is because the *average* kinetic energy of the particles in both containers of soup is the same. However, remember that heat is the *total* kinetic energy of the particles in a substance. There are many more particles of soup in the large pot than in the small cup. Therefore, the large pot of soup has a higher total kinetic energy, or more heat, than the smaller cup.

Safety Alert

Use heatproof mitts or potholders when handling hot objects.

The difference between heat and temperature explains why the Pacific Ocean has more heat than a cup of hot soup. The soup has a higher temperature, or average kinetic energy. However, the ocean is so huge that it has a tremendous number of particles. Its total kinetic energy, or heat, is much greater than that of the cup of hot soup.

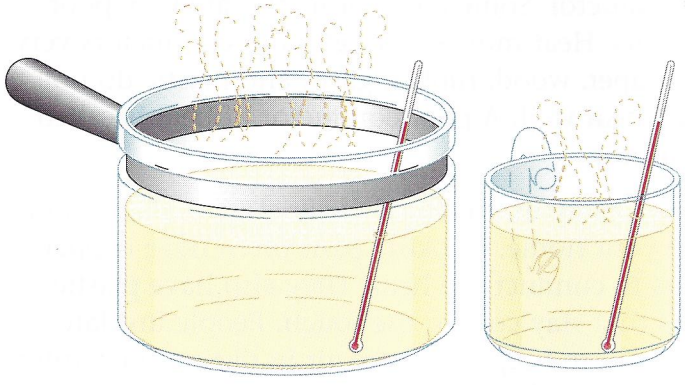


Figure 18-1 ***The temperatures of the pot and cup are the same. The pot has twice as much soup. So, there is twice as much heat energy in the pot as in the cup.***

Heat always moves from a warmer place to a cooler place. That is why you become cold when you step outdoors on a cold day. The heat moves out from your body into the cold air. That is also why you can warm up a piece of cold pizza in the oven. The oven's heat moves into the cold pizza.

✓ **How is heat different from temperature?**

Heat and Solids

Remember
The particles in a solid are closer together than those in a liquid or a gas.

Suppose you put a spoon into a cup of hot soup. The top of the spoon does not touch the soup at all. Yet it will soon be hot. This is because of a process that moves the heat along. This process is called **conduction.**

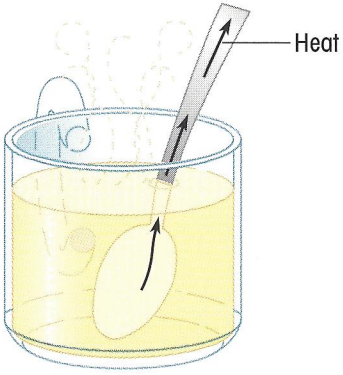


Figure 18-2 *Heat from the cup of soup moves up the spoon by conduction.*

In conduction, heat is passed along by molecules of matter that bump into one another. The soup heats the bottom of the spoon. The hot molecules on the bottom of the spoon bump into other molecules in the spoon. This warms them up. In turn, these molecules warm up the next closest molecules up the spoon. The heat moves up to the handle of the spoon.

Some kinds of matter are good conductors. Heat moves quickly through these substances. Metals are good conductors. Copper, for example, is a very good conductor. Some kinds of matter are very poor conductors. Heat moves through poor conductors very slowly. Paper, wood, rubber, glass, and plastic do not conduct heat well. A poor conductor of heat is called an **insulator.**

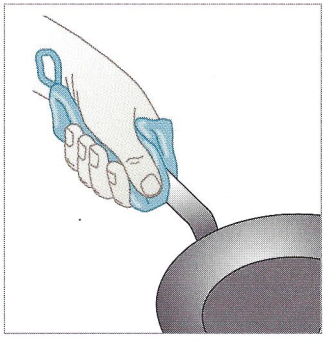


Figure 18-3 *A potholder is an insulator.*

There are many examples of conductors and insulators around your home. Cooking pans often have copper bottoms to conduct the heat. They also have plastic handles that stay cool to the touch. People insulate their homes to keep the warm air in during the winter and hot air out during the summer.

✓ **What is the difference between a good conductor and a poor conductor?**

Heating Liquids and Gases

In conduction, heat moves through solids when molecules bump into one another. In liquids and gases, the heat is usually moved along by a process called **convection.** Convection is the passing of heat within a gas or a liquid by the movement of warmer particles.

Think of a space heater in a room. The heater warms the air around it. This causes the kinetic energy of the molecules in the air to increase. As the molecules move faster, they spread out. The air becomes less dense. This less dense, warm air then rises to the ceiling. The warm air pushes the cooler air down toward the heater. In turn, this cooler air gets heated and rises. This circular movement of air is called a *convection current.*

Most weather is caused by convection currents in the air around the Earth. There are also convection currents in the oceans called density currents. These are caused by warm water rising and pushing down cool water.

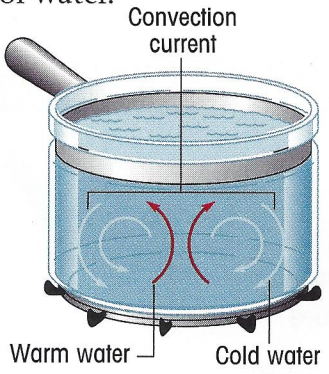


Figure 18-4 *In convection, warm water rises and pushes the cooler, denser water down.*

✓ **How does a convection current form in air?**

Heat and Space

Both conduction and convection move heat energy through matter. In some places, however, there is no matter. A **vacuum** is any place where there is no matter.

Conduction and convection cannot move heat through a vacuum. However, the energy from the sun can travel through a vacuum. It travels in waves. Energy that travels in waves is called **radiation.** When the light from the sun strikes the Earth, a lot of it changes to heat energy.

✓ **What kind of energy can travel through a vacuum?**

Lesson Review

1. What happens to a substance if heat is added to its particles?
2. What is the measure of the average kinetic energy of the particles in a substance called?
3. Why can conduction and convection not move energy through a vacuum?
4. **CRITICAL THINKING** A bathtub of water and a sink of water both have the same temperature. Which has more heat? Explain.

Great Moments in Science

THE MERCURY THERMOMETER

People have used thermometers since the 1500s. A thermometer measures the temperature of a substance. Early thermometers were sealed tubes that contained water and alcohol. The liquid in the tube rose as the temperature of the substance being measured rose.

The problem with these thermometers was that the water and the alcohol did not rise evenly. The thermometers were not very accurate. In 1714, the German scientist Gabriel Daniel Fahrenheit invented something much more accurate. It was the mercury thermometer. The mercury in the tube rises evenly as the temperature rises.

Fahrenheit also developed the Fahrenheit temperature scale. Most people in the United States use the Fahrenheit scale. On this scale, the freezing point of water is 32°. The boiling point of water is 212°.

CRITICAL THINKING How was Fahrenheit's invention important to science?

18-2 Light

Words to Know

wavelength	the distance from the crest, or top, of one wave to the crest of the next wave
amplitude	the height of a wave
frequency	the number of wave cycles that pass through a point in one second
reflection	the bouncing of light off an object
refraction	the bending of light rays as they pass from one substance into another
spectrum	the band of colors that make up white light
prism	a triangular-shaped, three-dimensional object made of clear glass that breaks up white light into its different colors

Energy in Waves

Waves carry energy from one place to another. These waves move in repeated patterns. If you could see waves of energy, they would look something like ocean waves. TV and radio signals move through space in waves. Light and sound move in waves, too.

The top of a wave is called the *crest*. The bottom of a wave is called the *trough*. Every wave has three features that can be used to describe the wave. These features are wavelength, amplitude, and frequency. A **wavelength** is the distance from the crest, or top, of one wave to the crest of the next wave. The height of a wave is called its **amplitude.**

The greater a wave's amplitude, or height, the more energy it has. So, a sound wave with a big amplitude will make a loud sound. A light wave with a big amplitude will make a bright light.

The **frequency** of a wave is the number of wave cycles that pass through a point in one second. Wave frequency is the rate of a wave's movement.

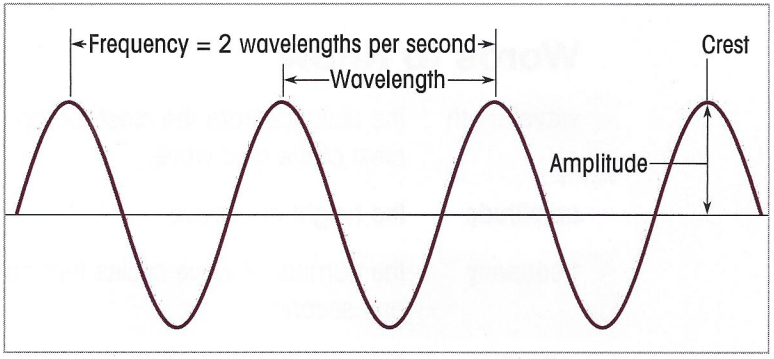


Figure 18-5 *The three basic features of a wave are its wavelength, amplitude, and frequency.*

✓ **What are three features of a wave?**

What Is Light?

Light energy travels in waves. Light waves always travel in straight lines. These straight lines of light are called *rays*. When a group of rays all travel in the same direction, they are called a *beam*.

Light travels through a vacuum at about 186,000 miles (almost 300,000 kilometers) per second. However, air slows down light waves. Liquids slow them down even more, and solids even more.

Light travels in many different wavelengths. Some wavelengths we can see. What we see is called *visible light*. Some wavelengths are too short for us to see. These wavelengths are called *ultraviolet light*. Some wavelengths are too long for us to see. These wavelengths are called *infrared light*.

✓ **What are three different kinds of light? What makes them different from each other?**

Science Fact

A laser produces a narrow, strong beam of light. Lasers have many uses. Doctors sometimes use laser light instead of scalpels to cut body tissues. Laser light is also used to send signals from telephones and televisions. The laser light travels through hairlike strands of glass called optical fibers.

Light and Objects

Light can do one of four things when it strikes an object.

1. It can pass straight through the object.
2. It can get absorbed into the object.
3. It can bounce off the object.
4. It can be bent by the object.

A substance or an object is *transparent* if light passes through it. Some things that are transparent are air, clear glass, clear plastic, and colorless liquids such as water. A *translucent* object allows some light to pass through it. Frosted glass, stained glass, and most paper are translucent. An object that blocks light completely is *opaque*. An opaque object makes a shadow where the light is being blocked.

Objects that are opaque absorb most of the light that hits them. The light does not pass through the objects. Light energy that is absorbed is changed into heat energy. Dark colors and rough surfaces absorb a lot of light.

When light bounces off an object, **reflection** occurs. All substances reflect some light. Mirrors and objects with shiny surfaces reflect almost all the light that strikes them. The light reflecting off objects sends images to your eyes. That is how you see the objects.

It you dip a pole into clear water, it appears to bend. The pole looks like it bends just at the point where it enters the water. Of course, the pole does not really bend. The water bends the light rays. This bending of light rays when they pass from one substance to another is called **refraction.**

Refraction is caused by a change in the speed of light as the light passes from one substance into another. When light strikes the water, the light slows down. Then it bends away from the surface of the water.

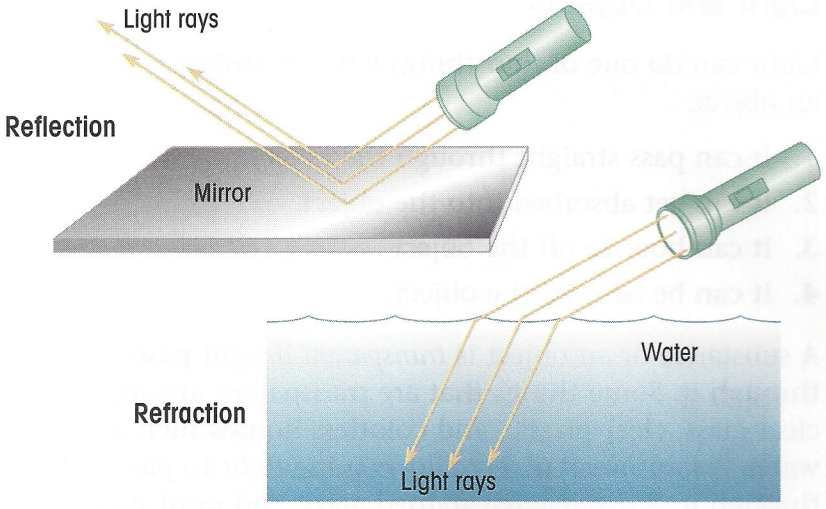


Figure 18-6 *This picture shows the reflection and refraction of light.*

What four things might light waves do when they strike an object?

Where Does Color Come From?

White light, such as sunlight, is made up of several different wavelengths. These different wavelengths are the different colors we see. Red, orange, yellow, green, blue, indigo (violet-blue), and violet are the seven visible colors in white light.

These are the same colors in a rainbow. Rainbows are caused by sunlight passing through drops of water. The drops of water refract the white light. The different wavelengths of the white light bend different amounts, so they separate into a band of seven different colors. This band is called a **spectrum.** It is made up of red, orange, yellow, green, blue, indigo, and violet. All these colors together make up white light.

You can create a spectrum yourself by letting sunlight shine through a prism. A **prism** is a triangular-shaped, three-dimensional object made of clear glass that breaks up white light into its different colors.

Science Fact

To help you remember the colors in a spectrum, think of the name Roy G. Biv. This name is made up of the first letter of each color of the spectrum.

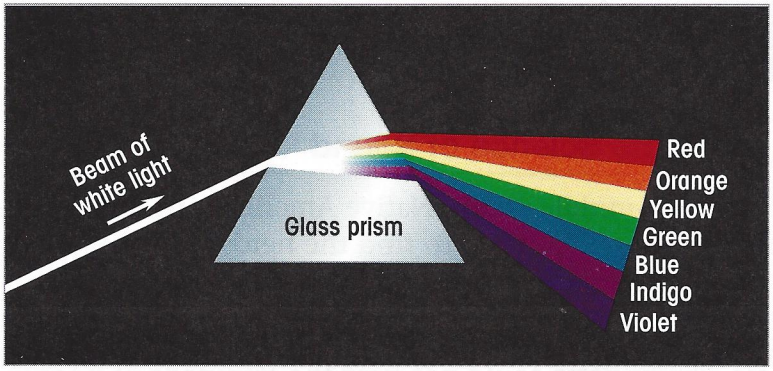


Figure 18-7 *A prism refracts white light and separates it into a spectrum.*

You know that objects absorb light, reflect light, refract light, or let light pass straight through them. The color of an object is determined by the color of light that the object reflects.

Suppose you were looking at a red sweater. Light strikes the sweater. The sweater absorbs all the colors in white light except red. It absorbs orange, yellow, green, blue, indigo, and violet. Only the red band of light bounces off the sweater and enters your eyes. You see red.

A pure black object absorbs all the light striking it. A pure white object reflects all the light striking it.

✓ **What is white light made up of?**

Lesson Review

1. What are three forms of energy that move in waves?
2. What happens when light strikes an object?
3. What happens to light when it passes through a prism?
4. **CRITICAL THINKING** What colors of light are absorbed by a yellow hat?

18-3 Sound

Using the Science of Sound

Until the middle 1800s, Native Americans of the Great Plains hunted buffalo. To find the herds, a hunter would press his ear to the ground. Why?

Sound travels better through solids than through the air. The hunters could not hear the stampede of hooves in the air. However, they could sometimes hear it in the ground. Using the science of sound, Native Americans found buffalo for food and clothing.

✓ **Does sound travel better through solids or through the air?**

Science Fact

Sound travels well underwater. Whales can hear one another from hundreds of miles away.

What Is Sound?

Sound is another form of energy that moves in waves. Sound waves travel about a million times slower than light waves.

Remember
Vibrations are quick back-and-forth movements of air.

Sounds are made by matter that vibrates. When you shout across a room to a friend, the folds of tissue in your throat, called vocal cords, vibrate.

When your vocal cords vibrate, they cause surrounding air molecules to vibrate. The vibrating air forms sound waves. Eventually, the sound waves reach your friend's ear. They cause tiny bones in the ear to vibrate. As a result, your friend hears your voice.

Try humming while holding your fingers at your throat. You can feel your vocal cords vibrate. Musical instruments also make sounds by vibrating.

Unlike light, sound cannot travel in a vacuum. Sound travels fastest through solids. It moves slowest through gases.

The loudness of sound is determined by the amplitude of the sound waves. If you hit a drum hard, you will cause it to vibrate in big waves. You will make a loud sound. If you just tap the drum, you will cause only tiny waves. You will make a quiet sound.

✓ **How are sounds made?**

Lesson Review

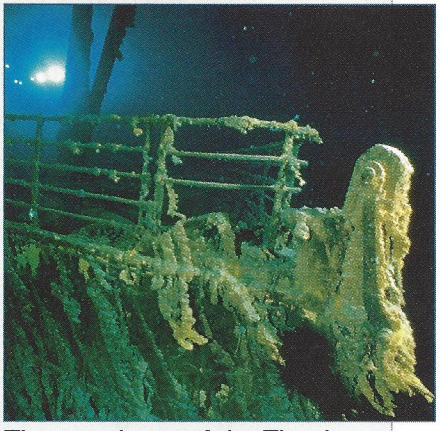
1. What can sound waves not travel through?
2. What happens when the amplitude of a sound wave is increased?
3. **CRITICAL THINKING** What produces sound when you pluck a guitar string?

On the Cutting Edge

SONAR

Like light waves, sound waves can reflect off objects. Scientists use reflected sound waves to locate objects underwater, using sonar. A short sound wave is sent out from the bottom of a ship by using a device called a transducer.

In 1985, scientists used sonar to locate the wreckage of the ship *Titanic*. The *Titanic* sank in the Atlantic Ocean in 1912 after hitting an iceberg. To find the *Titanic*, the scientists sent sound waves into the ocean. They measured how long it took the sound waves to strike the wreckage and then return. Because sound waves travel in water at a certain speed, the scientists could figure out how far down the *Titanic* was located.

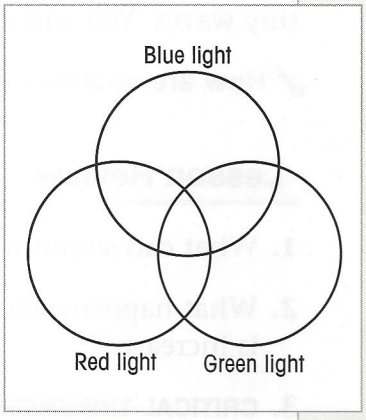


The wreckage of the Titanic *was found by using sonar.*

CRITICAL THINKING How can scientists use sonar to map the ocean floor?

LAB ACTIVITY
Combining Colors of Light

BACKGROUND
White light is made up of seven colors: red, orange, yellow, green, blue, indigo, and violet. You can combine red light, green light, and blue light to produce other colors of light.



PURPOSE
You will combine different colors of light and observe the colors that are produced.

MATERIALS
paper; pencil; 3 flashlights; red, green, and blue cellophane; transparent tape; white wall

WHAT TO DO
1. Copy the chart to the right.
2. Work in groups of three. Cover the front of each flashlight with one of the cellophane sheets. Use tape to hold the cellophane in place. Darken the room.
3. Each member of the group turns on one of the flashlights and shines the light near the same spot on a white wall. The lights should form three overlapping circles on the wall, as shown in the picture.
4. In the chart, record the color of light that is produced where the red light and green light overlap. Then do the same for red light and blue light and for blue light and green light. Finally, record the color that is produced where all three colors of light overlap.

Color Used	Color Produced
Red and green	
Red and blue	
Blue and green	
Red, blue, and green	

DRAW CONCLUSIONS
- How many different colors of light must be combined to produce white light?
- What can you conclude about these three colors?

ON-THE-JOB SCIENCE
Store Manager

Maurice is the manager of a grocery store. He has many responsibilities. He hires people and makes sure that they do their job well. He orders items, or merchandise, for the store. He also records the prices of the merchandise. To do this, Maurice uses light and the *bar codes* printed on the merchandise packages.

A bar code is a series of thick and thin lines with numbers printed below them. The manager inputs the information on the bar codes into a computer. Then a specific price is given to each bar code and recorded in the computer.

When a customer buys an item, the checkout person uses a *scanner* to find out the item's price. The scanner is a machine. It produces a beam of light that reads the patterns on the item's bar code. This beam of light is a laser. The scanner sends the information it reads to a computer. The computer then checks the item's price. The price is then sent to the cash register.

Maurice checks the computer for the price of bananas. The customer had seen a different price displayed.

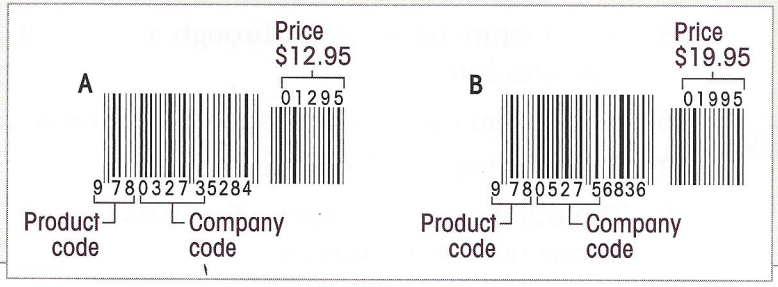
Critical Thinking

What must a store manager do to change the price of an item?

Compare bar codes A and B. Notice the numbers for the product, company, and price.

1. Are bar codes A and B for the same kind of product? How do you know?

2. Are bar codes A and B from the same company? How do you know?



Chapter 18 Review

Summary

Heat, light, and sound are all forms of energy. They travel by the movement of particles or in waves.

Lesson 18.1

In solids, heat moves by conduction. In liquids and gases, heat moves by convection. Heat cannot travel in a vacuum. Rays of sunlight can. They turn into heat energy when they strike the Earth.

Lesson 18.2

A wave has a certain wavelength, amplitude, and frequency. The color of visible light depends on its wavelength. The color of an object is determined by the wavelength of light that is reflected from the object.

Lesson 18.3

Sound is produced when matter vibrates. A person hears sound when sound waves enter the ears.

Vocabulary Review

prism
vacuum
insulator
frequency
spectrum
conduction
refraction
radiation

Complete each sentence with a term from the list.

1. Glass is an _____ because it does not conduct heat well.
2. The colors that make up white light form a _____.
3. There is no matter in a _____.
4. Heat moves through a spoon by _____.
5. When white light passes through a _____, it separates into colors.
6. Energy that can move through a vacuum is _____.
7. The bending of light rays is _____.
8. The number of wave cycles that pass through a point in one second is a wave's _____.

Chapter Quiz

Write your answers on a separate sheet of paper.

1. How are heat and temperature related?
2. How does heat move by conduction?
3. In convection, why does warm air rise?
4. What three features can be used to describe a wave?
5. What does increasing the amplitude of a light wave do?
6. What is the difference between reflection and refraction?
7. In what way does green light differ from red light?
8. What determines the color of an object?
9. What does the vibrating of matter produce?
10. What determines the loudness of a sound?

Test Tip
Make sure you understand what a test question is asking. Read a question twice before answering.

Research Project

One of the characteristics of sound is its strength, or intensity. Sound intensity is measured in units called *decibels*. Research the decibel levels of at least four different sounds, such as a whisper and a jet taking off. Find out which decibel levels are harmful to human hearing. Make a chart that shows what you learned.