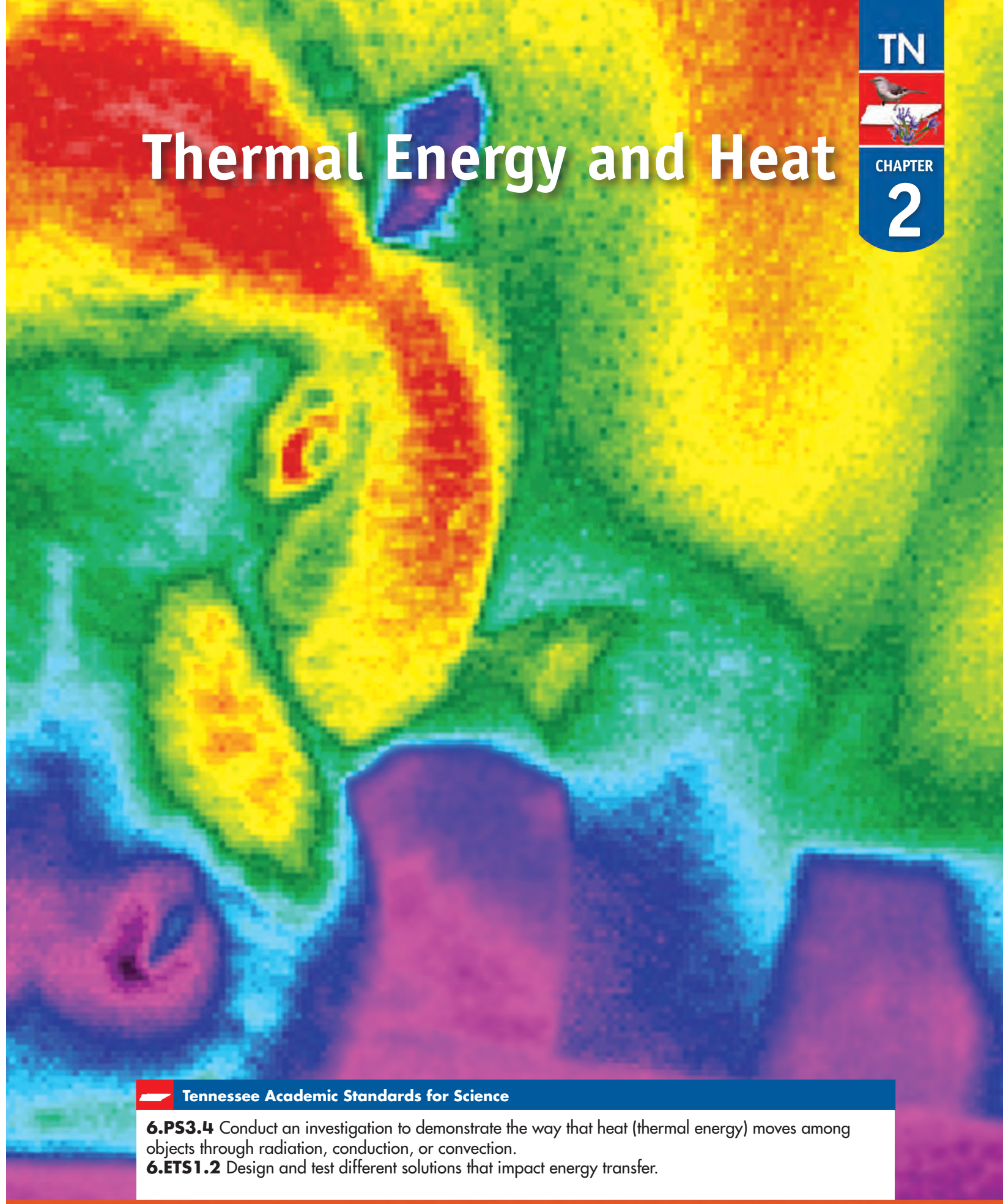
WHAT MIGHT THESE COLORS MEAN?

How does heat flow from one object to another?

This brightly colored image is called a thermogram. A special camera measures the electromagnetic radiation of an object and creates a temperature "map." A thermographic camera can be used to find people in a fire, detect when a racehorse might be injured, and spot tumors in humans. By noticing excessive heat in motors, transformers, and pumps, the camera can detect equipment problems before they fail, saving millions of dollars.

Infer Since a thermogram shows temperature, what might the colors you see indicate?

Watch the **Untamed Science** video to learn more about heat.



TN

CHAPTER 2

Thermal Energy and Heat

Tennessee Academic Standards for Science

6.PS3.4 Conduct an investigation to demonstrate the way that heat (thermal energy) moves among objects through radiation, conduction, or convection.
6.ETS1.2 Design and test different solutions that impact energy transfer.

CHAPTER 2

Getting Started

Check Your Understanding

1. **Background** Read the paragraph below and then answer the question.

Kiera is swimming in the ocean. Since she is moving, she has **kinetic energy.** Energy is measured in **joules.** Her brother, who swims at the same speed but has more mass, has more kinetic energy. If he slows down, he will have the same amount of kinetic energy as Kiera. While swimming, she notices that it is easier to float in salt water because it has a higher **density** than fresh water.

Kinetic energy is energy an object has due to its motion.

A **joule** is a unit of work equal to one newton-meter.

Density is the ratio of the mass of a substance to its volume.

- What are the two ways you can increase kinetic energy?

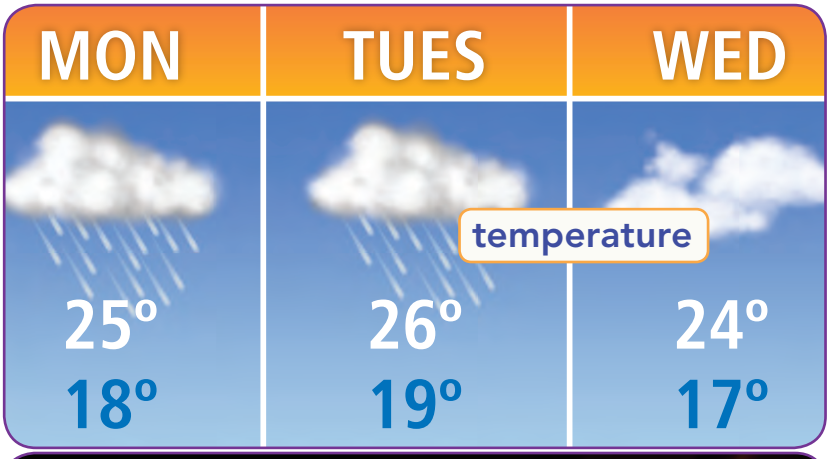
Vocabulary Skill

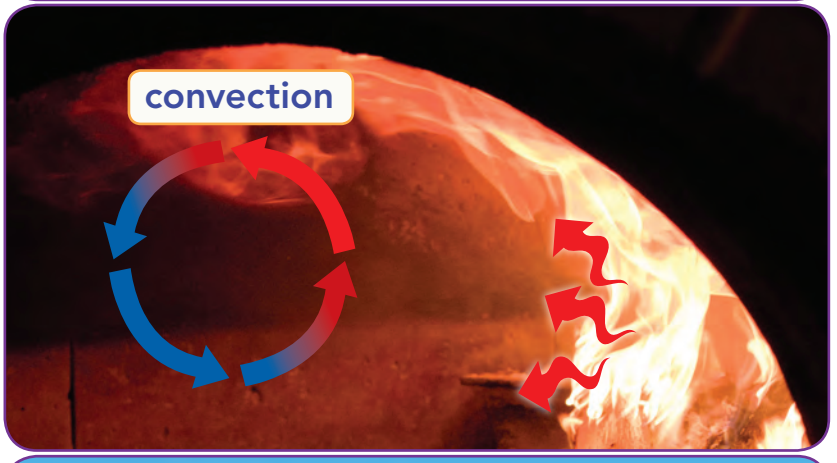
Identify Multiple Meanings Some words have several meanings. Words you use every day may have different meanings in science.

Word	Everyday Meaning	Scientific Meaning
conductor	*n.* the director of an orchestra **Example:** The *conductor* signaled to the musicians to begin playing.	*n.* a material that conducts heat well **Example:** Metal is a good *conductor.*
heat	*v.* to make warm or hot **Example:** The fireplace began to *heat* the room.	*n.* thermal energy moving from a warmer object to a cooler object **Example:** When the door was left open, *heat* transferred from the warm room to the cool air outside.

2. **Quick Check** **Circle the sentence below that uses the scientific meaning of the word *conductor.***

- The *conductor* got a standing ovation after the concert.
- It is easier to cook eggs in a pan that is a good *conductor.*





Chapter Preview

LESSON 1

- temperature
- Fahrenheit scale
- Celsius scale
- Kelvin scale
- absolute zero
- heat

Identify Supporting Evidence
Communicate

LESSON 2

- convection
- convection current
- radiation
- conduction

Compare and Contrast
Infer

LESSON 3

- conductor
- insulator
- specific heat
- thermal expansion

Identify the Main Idea
Calculate

CCC: Energy and Matter

Scenario Investigation

Where Is the Battery?

SEP: Constructing Explanations (for Science) and Designing Solutions (for Engineering)

Purpose To investigate thermal energy transfer in the bathroom

Materials
- ceramic tile
- carpet square
- 2 thermometers
- duct tape

Scenario

On your local radio station, you are known as *"The Science Answer Person."* Your show has a simple format. The audience sends questions to you, and you answer them on the air. That sounds easy, doesn't it?

Most of the questions you receive are easy to answer, but some questions are hard to answer in words that young children will understand. This is one of those questions. Today the father of a second-grader sent the following question:

> Hi, Science Answer Person,
>
> My 7-year-old son came out of the bathroom today carrying the bathroom rug. He was looking at the bottom of it very closely, so I asked him what he was looking for. He said, "Where's the battery?"
>
> "Why do you think it has a battery?" I asked.
>
> "Because the floor is so cold, but the rug is warm."
>
> I know the rug doesn't have a battery, but I do not know why it feels so much warmer than the tile floor. Aren't they the same temperature? Please help.
>
> Signed, Mr. Cold Feet

Of course, Mr. Cold Feet is right. The rug and the tile are the same temperature. How can you prove it and explain to a second-grader what is really happening?

Procedure

☑ **1. Colder Than I Thought** Your teacher will give you a tile and a piece of carpet that sat in a cool place for the same length of time. Touch each of them. Which one feels colder? Does it feel a lot colder or just a little bit colder?

_____

☑ **2. Keep It Standard** In this investigation, you will use two thermometers to measure and compare the temperatures of the tile and the carpet square. If the thermometers do not report the same temperature under the same conditions, you must correct for the error. Read the thermometers as they sit on your desk. Do they both show the same temperature? If they show different temperatures, calculate the difference between the two readings. Record which thermometer has a lower reading and the difference in the two temperatures. This number will be called the Correction Factor. Add this number to all readings of the lower thermometer as you complete the investigation.

Lower thermometer (*A* or *B*) _____ Correction Factor _____

Procedure *(continued)*

☑ **3. Taking Their Temperatures** Use duct tape to attach the bulb of one thermometer to the tile and the other to the carpet. After three minutes, record the temperature of each. (Be sure to add the Correction Factor if needed.)

Tile: _____ Carpet: _____

☑ **4. The Readings** What is the temperature difference between the tile and the carpet? Would you consider the tile and carpet the same temperature? Explain.

_____

☑ **5. Why Does the Tile Feel Colder?** This did not come as a surprise to you, The Science Answer Person, but the temperatures are the same (or very close). Why does the tile feel colder? (*Hint:* Before you answer, read about conductors and insulators in your textbook.)

_____

_____

Conclusion

Let's see what you learned about the transfer of thermal energy.

☑ **1.** When you touch a cold object, in which direction does thermal energy flow?

_____

☑ **2.** Is temperature the same as heat? Explain.

_____

_____

☑ **3.** When a hot object is placed in cold water, the temperature of the hot object will decrease and the temperature of the cold water will increase. When will the flow of heat stop?

_____

☑ **4.** If you place an object that is room temperature in room-temperature water, what energy transfer will happen? Explain.

_____

_____

It's time to prepare the script for tomorrow's show. In the script, you must explain why the tile feels colder than the carpet even though they are the same temperature. Remember that your answer is for a child, so keep your explanation simple. If you use scientific terms, explain what they mean.

TN

LESSON 1

6.PS3.4

Temperature, Thermal Energy, and Heat

UNLOCK THE BIG QUESTION

- What Determines the Temperature of an Object?
- What Is Thermal Energy?

MY PLANET DIARY

Nature's Bathtub

Could you take a hot bath outside, with no ceramic bathtub or running water? This is possible in hot springs all over the world. Hot springs occur when underground water heated by Earth bubbles up and collects in pools on Earth's surface. The water in a hot spring can reach above 50°C (122°F). By contrast, a hot shower is about 43°C (110°F). Visitors use these hot springs to relax.

FUN FACT

Answer the question below.

What other daily household functions could be done without running water or electricity?

Lab zone® Do the Inquiry Warm-Up *How Cold Is the Water?*

What Determines the Temperature of an Object?

You may have used a thermometer to take your temperature when you were sick. **Temperature** is a measure of how hot or cold something is compared to a reference point. (One reference point is the freezing point of water.) What makes an object hot or cold?

Vocabulary

- temperature
- Celsius scale
- absolute zero
- Fahrenheit scale
- Kelvin scale
- heat

Skills

Reading: Identify Supporting Evidence

Inquiry: Communicate

Recall that all moving objects have kinetic energy. Matter is made up of tiny particles that are always moving, so these particles have kinetic energy. **Temperature is a measure of the average kinetic energy of the particles in an object.** As an object heats up, its particles move faster. As a result, both the average kinetic energy of the particles and the temperature increase.

The United States uses the **Fahrenheit scale** to measure temperature. Most countries use the **Celsius scale.** You can use an equation to convert between scales, but it's simpler to estimate using thermometers like the one in **Figure 1.** Temperatures that line up, like 32°F and 0°C, are equivalent. Many scientists use the **Kelvin scale.** Celsius and Fahrenheit scales are divided into degrees. The Kelvin scale is divided into kelvins (K). A temperature change of 1 K is the same temperature change as 1°C. Zero kelvins, or **absolute zero,** is the lowest temperature possible. At absolute zero, particles have no kinetic energy. Zero K is equal to −273°C.

did you know?

When Anders Celsius invented the Celsius scale, he had 100°C as the *freezing* point of water and 0°C as its *boiling* point.

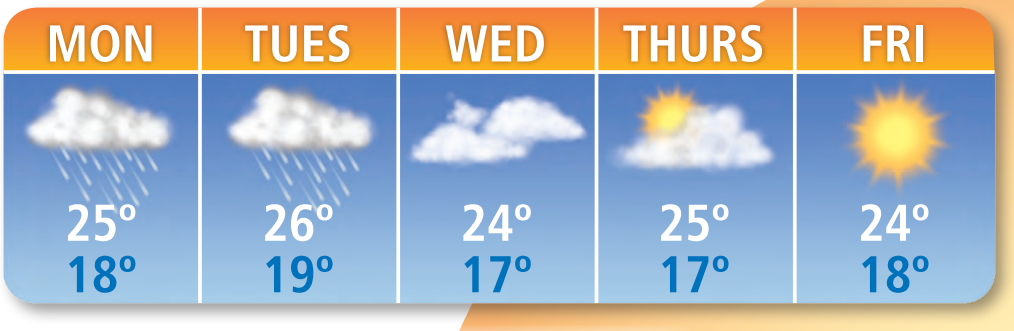


FIGURE 1

Temperature Scales

The chart above shows a weather report, but it does not identify the temperature scale.

Interpret Diagrams **Explain why this report would mean something different in Japan than it would in the United States. Fill in the thermometer to show one of the temperatures in Celsius. What is this equivalent to in Fahrenheit?**

Lab zone® Do the Lab Investigation *Build Your Own Thermometer.*

Assess Your Understanding

got it?

- I get it! Now I know that temperature is related to _____
- I need extra help with _____

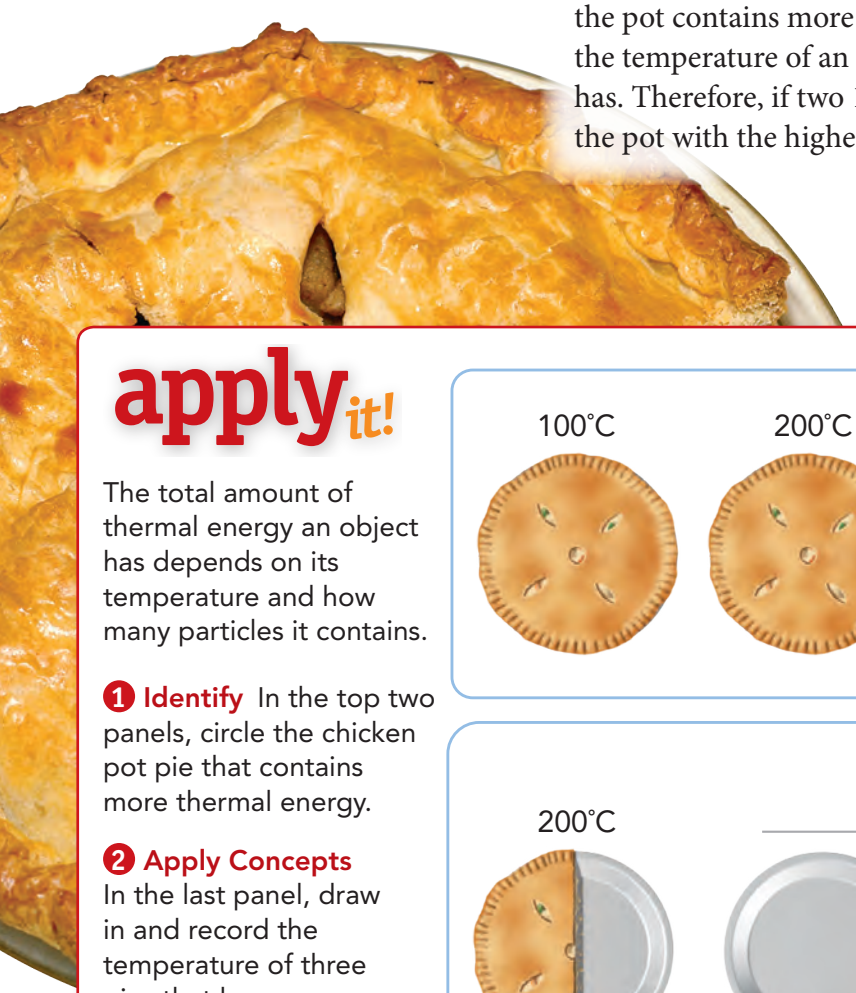
What Is Thermal Energy?

Different objects at the same temperature can have different amounts of energy. To understand this, you need to know about thermal energy and about heat. Temperature, thermal energy, and heat are closely related, but they are not the same thing.

Thermal Energy Temperature is a measure of the average kinetic energy of the individual particles in an object. However, it is not a measure of the total amount of energy in an object. **Thermal energy is the total energy of all the particles in an object.** It depends on the temperature of an object, the number of particles in it, and how those particles are arranged. This lesson will focus on the first two factors.

The more particles an object has at a given temperature, the more thermal energy it has. For example, a 1-liter pot of tea at 75°C has more thermal energy than a 0.2-liter mug of tea at 75°C because the pot contains more tea particles. On the other hand, the higher the temperature of an object, the more thermal energy the object has. Therefore, if two 1-liter pots of tea have different temperatures, the pot with the higher temperature has more thermal energy.

Identify Supporting Evidence Since thermal energy is the total energy of all the particles in an object, it depends on multiple factors. Underline sentences that support this idea.

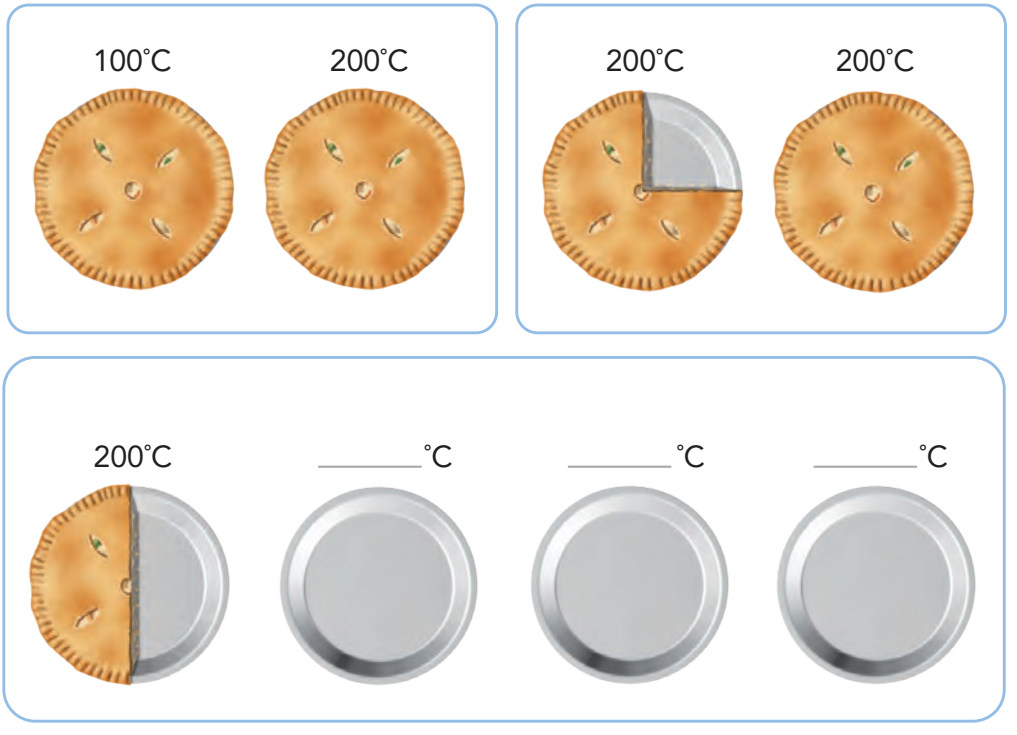


apply it!

The total amount of thermal energy an object has depends on its temperature and how many particles it contains.

1 Identify In the top two panels, circle the chicken pot pie that contains more thermal energy.

2 Apply Concepts In the last panel, draw in and record the temperature of three pies that have more thermal energy than the one on the left.



Heat You might say that an object contains heat, but, strictly speaking, it does not. Objects contain thermal energy. **Heat** is the *transfer* of thermal energy from a warmer object to a cooler object. The warmer object will cool down, and the cooler object will warm up until they are the same temperature. When this happens, heat stops transferring. Heat is measured in the units of energy—joules.

Vocabulary Write a sentence that uses the scientific meaning of *heat*.

FIGURE 2

Heat

When you hold your hand over a plate of food, you will feel warmth if heat transfers into you and cold if heat transfers out of you.

Communicate **In the photo, draw arrows to show the direction of heat transfer for at least two foods. Would your hand feel warmer over some foods than over others? What characteristics of the food might affect how warm or cold your hand feels? Discuss your ideas with a partner.**

Lab zone® Do the Quick Lab *Temperature and Thermal Energy.*

Assess Your Understanding

1a. **List** What are two factors that determine an object's thermal energy?

b. CHALLENGE Object A has less thermal energy than Object B, but heat flows from Object A to Object B. What conditions would make this possible?

got it?

- ○ **I get it!** Now I know that the thermal energy in an object is defined as _____
- ○ I need extra help with _____

TN

LESSON 2

6.PS3.4, 6.ETS1.2

The Transfer of Heat

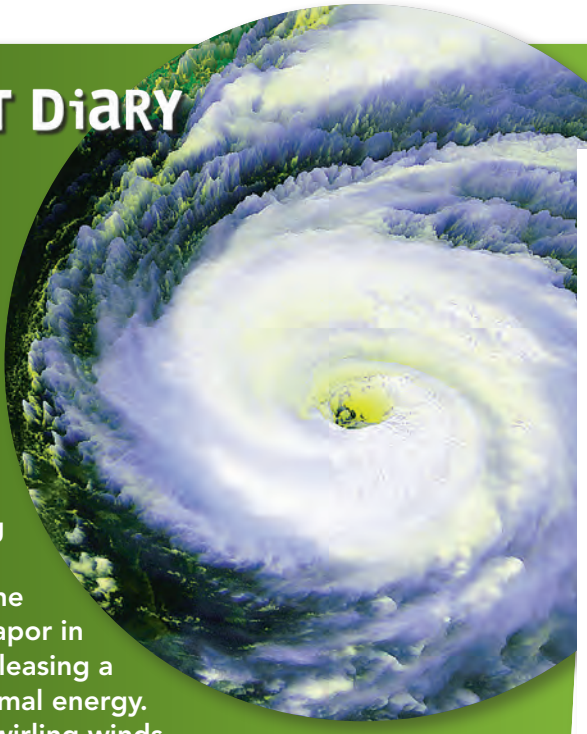
UNLOCK THE BIG ?

How Is Heat Transferred?

MY PLANET DIARY

DISASTER

Wild Weather



Hurricanes are intense storms that can cause billions of dollars in damage. These storms form when very warm, moist air rises quickly, creating an area of lower air pressure below. As the air rises, the water vapor in the air condenses, releasing a huge amount of thermal energy. This energy causes swirling winds, which draw in more warm water, feeding the storm. If a hurricane's path takes it over land, the storm can cause massive destruction. However, as the storm moves over land, its energy source—the warm ocean water—is depleted, and the storm eventually fizzles out.

Answer the question below.

Why do hurricanes tend to form in warmer climates?

Lab zone® Do the Inquiry Warm-Up *What Does It Mean to Heat Up?*

How Is Heat Transferred?

Heat is transferring around you all the time. If it wasn't, nothing would ever change temperature. Heat doesn't transfer randomly. It travels only in one direction and by three different methods.

Heat is transferred from warmer areas to cooler areas by conduction, convection, and radiation.

Vocabulary

- convection
- convection current
- radiation
- conduction

Skills

Reading: Compare and Contrast

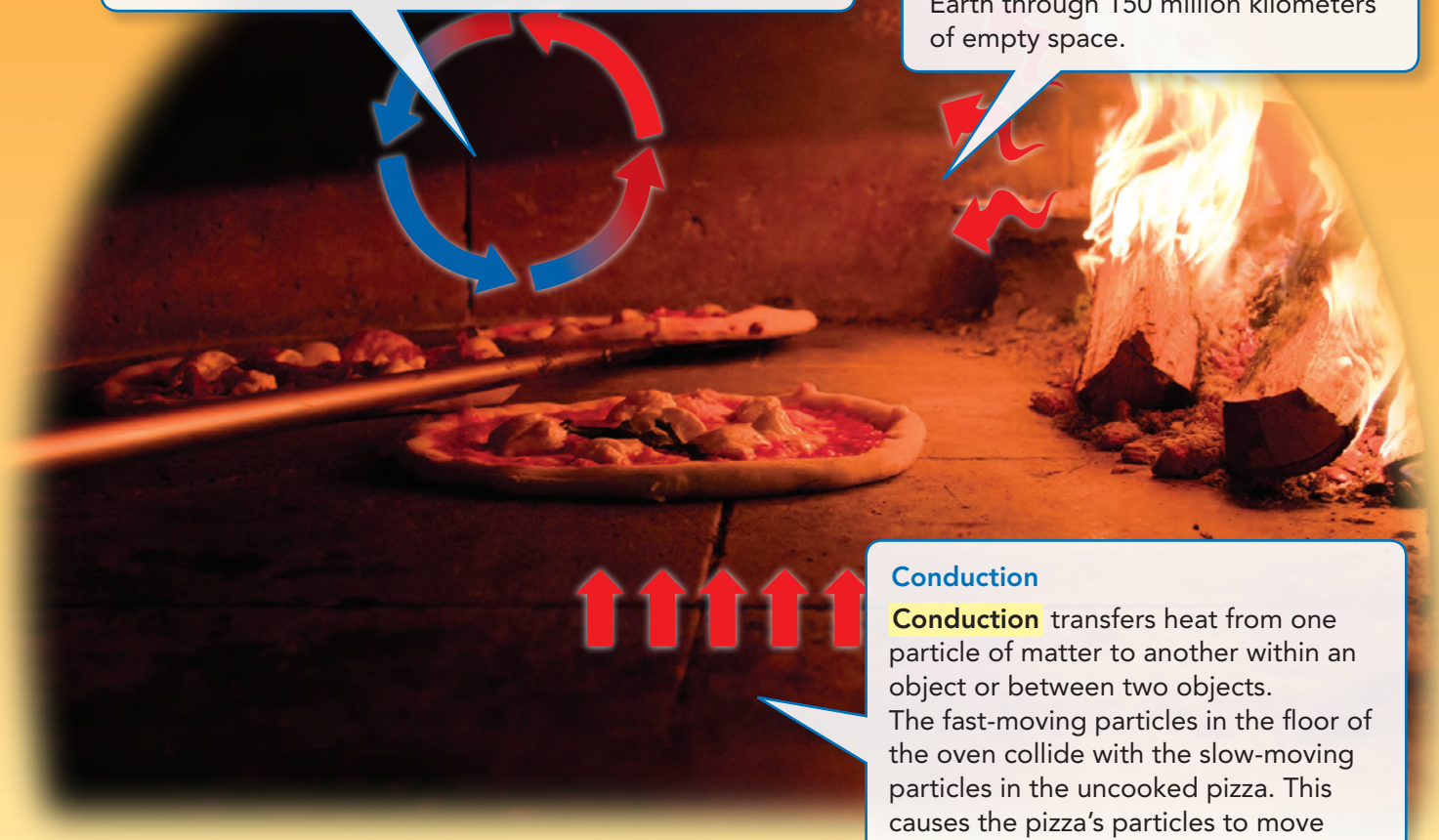
Inquiry: Infer

Convection

Convection is a type of heat transfer that occurs only in fluids, such as water and air. When air is heated, its particles speed up and move farther apart. This makes the heated air less dense. The heated air rises to float on top of the denser, cooler air. Cooler air flows into its place, heats up, and rises. Previously heated air cools down, sinks, and the cycle repeats. This flow creates a circular motion known as a **convection current.** Convection currents in air cause wind and weather changes.

Radiation

Radiation is the transfer of energy by electromagnetic waves. Radiation is the only form of heat transfer that does not require matter. You can feel the radiation from a fire without touching the flames. The sun's energy travels to Earth through 150 million kilometers of empty space.



Conduction

Conduction transfers heat from one particle of matter to another within an object or between two objects. The fast-moving particles in the floor of the oven collide with the slow-moving particles in the uncooked pizza. This causes the pizza's particles to move faster, making the pizza hotter.

FIGURE 1

Heat Transfer

A wood-fire pizza oven demonstrates three types of heat transfer.

Apply Concepts **Describe a heat transfer that occurs after the pizza comes out of the oven. What kind of transfer is it?**

Compare and Contrast

Circle statements on the previous page that describe what the different types of heat transfer have in common. Underline their differences on this page.

EXPLORE THE BIG ?

Where Does Heat Transfer on This Beach?

How does heat flow from one object to another?

FIGURE 2

Heat transfer goes on all around you all the time, even on the beach. **Apply Concepts** **Fill in the chart below to review the different types of heat transfer. Then, in the illustration, label at least one example of each type of heat transfer. Draw arrows to show how heat is being transferred in each example.**

Type of Heat Transfer	Explanation
Conduction	
Convection	
Radiation	

apply it!

Cooking pots come in a variety of shapes and sizes, but you're much more likely to see a wide, squat pot like this

than a tall, narrow pot like this.

Infer **Use conduction to explain why this is the case.**

Lab zone® Do the Quick Lab *Visualizing Convection Currents.*

Assess Your Understanding

1a. Classify What type of heat transfer occurs when eggs cook in a hot pan? Before toasters, people toasted bread by holding it over a fire. What type of heat transfer occurred then? Name the third type of heat transfer and an example of a food cooked by it.

b. ANSWER THE BIG ? How does heat flow from one object to another?

got it?

- ○ **I get it!** Now I know that the three methods of heat transfer are _____
- ○ I need extra help with _____

TN

LESSON 3

6.ETS1.2

Thermal Properties

UNLOCK THE BIG QUESTION

How Do Different Materials Respond to Heat?

MY PLANET DIARY

CAREER

Suiting Up

Comic book superheroes often wear special suits that allow them to fly or protect them from enemies. But there are some everyday heroes who wear suits that give them similar super-powers: astronauts! Whenever astronauts go outside a space station or ship, they put on suits that weigh hundreds of pounds. The suits enable them to survive in the wide temperature swings that occur in space. The suits are designed with a flexible insulating material to protect astronauts from extreme temperature swings, radiation, and low pressure in space. They also provide air to breathe, radio communication, and protection from micrometeoroids.

Communicate Answer the question below. Then discuss your answer with a partner.

You also use special clothing to stay warm. What materials do you use to stay warm?

Lab zone® Do the Inquiry Warm-Up *Thermal Properties.*

How Do Different Materials Respond to Heat?

When you bake something in the oven, you use dishes made of glass, ceramics, or metal instead of plastic. Some materials can stand up to the heat of an oven better than others. Materials respond to heat in different ways. The thermal properties of an object determine how it will respond to heat.

Vocabulary

- conductor
- insulator
- specific heat
- thermal expansion

Skills

- Reading: Identify the Main Idea
- Inquiry: Calculate

Conductors and Insulators

If you walk barefoot from your living room rug to the tile floor of your kitchen, you will notice that the tile feels colder than the rug. But the temperature of the rug and the tile are the same—room temperature! The difference has to do with how materials conduct heat. **Some materials conduct heat well, while other materials do not.**

Conductors

A material that conducts heat well is called a **conductor.** Metals such as silver are good conductors. Some materials are good conductors because of the particles they contain and how those particles are arranged. A good conductor, such as the tile floor, feels cold to the touch because heat easily transfers out of your skin and into the tile. However, heat also transfers out of conductors easily. A metal flagpole feels much hotter on a summer day than a wooden pole would in the same place because heat easily transfers out of the metal pole and into your hand.

Insulators

A wooden pole and your living room rug are good insulators. **Insulators** are materials that do not conduct heat well. Other good insulators include air and wool. For example, wool blankets slow the transfer of heat out of your body.

FIGURE 1

Conductors and Insulators

Both conductors and insulators are useful in a kitchen. Conductors easily transfer heat to cook your food. Insulators stay cool enough to be handled.

Classify **Circle the conductors in the photo. Below, list objects in a kitchen that can act as insulators.**

Specific Heat

Imagine running across hot sand toward the ocean. You run to the water's edge, but you don't go any farther—the water is too cold. How can the sand be so hot and the water so cold? After all, the sun heats both of them. The answer is that water requires more heat to raise its temperature than sand does.

When an object is heated, its temperature rises. But the temperature does not rise at the same rate for all objects. The amount of heat required to raise the temperature of an object depends on the object's chemical makeup. **To change the temperature of different objects by the same amount, different amounts of thermal energy are required.**

The amount of energy required to raise the temperature of 1 kilogram of a material by 1 kelvin is called its **specific heat.** It is measured in joules per kilogram-kelvin, or J/(kg·K). A material with a high specific heat can absorb a great deal of thermal energy without a great change in temperature.

You can calculate thermal energy changes with a formula.

Energy Change = Mass × Specific Heat × Temperature Change

Identify the Main Idea
Circle the main idea on this page. Underline the sentences that support the main idea.

do the math!

You can calculate the amount of thermal energy gained by 2 kg of water as its temperature increases by 3 K.

Energy Change = Mass × Specific Heat × Temp. Change

Energy Change = 2 kg × 4,180 J/(kg·K) × 3 K

Energy Change = 25,080 J

Material	Specific Heat (J/(kg·K))
Copper	385
Water	4,180
Glass	837
Silver	235
Iron	450

1 **Calculate** Use the formula and the table at the right to calculate how much energy is lost by 0.5 kg of silver that cools off by 2 K.

2 **Interpret Tables** How many times more energy must you transfer into a kilogram of glass than a kilogram of silver to raise their temperatures by the same amount?

3 **Draw Conclusions** The seawater at a beach heats up more slowly than the sand on the beach does. The specific heat of water must be (greater than/less than) the specific heat of sand.

Thermal Expansion

To loosen a jar lid, you can hold it under a stream of hot water. This works because the metal lid expands more than the glass does as it gets hotter. **As the thermal energy of matter increases, its particles usually spread out, causing the substance to expand.** This is true for almost all matter. The expanding of matter when it is heated is known as **thermal expansion.** When matter is cooled, the opposite happens. Thermal energy is released. This causes the particles to slow down and move closer together. As matter cools, it usually decreases in volume, or contracts. One exception is water. Water expands slightly when it freezes. This is why solid ice floats in a glass of liquid water.

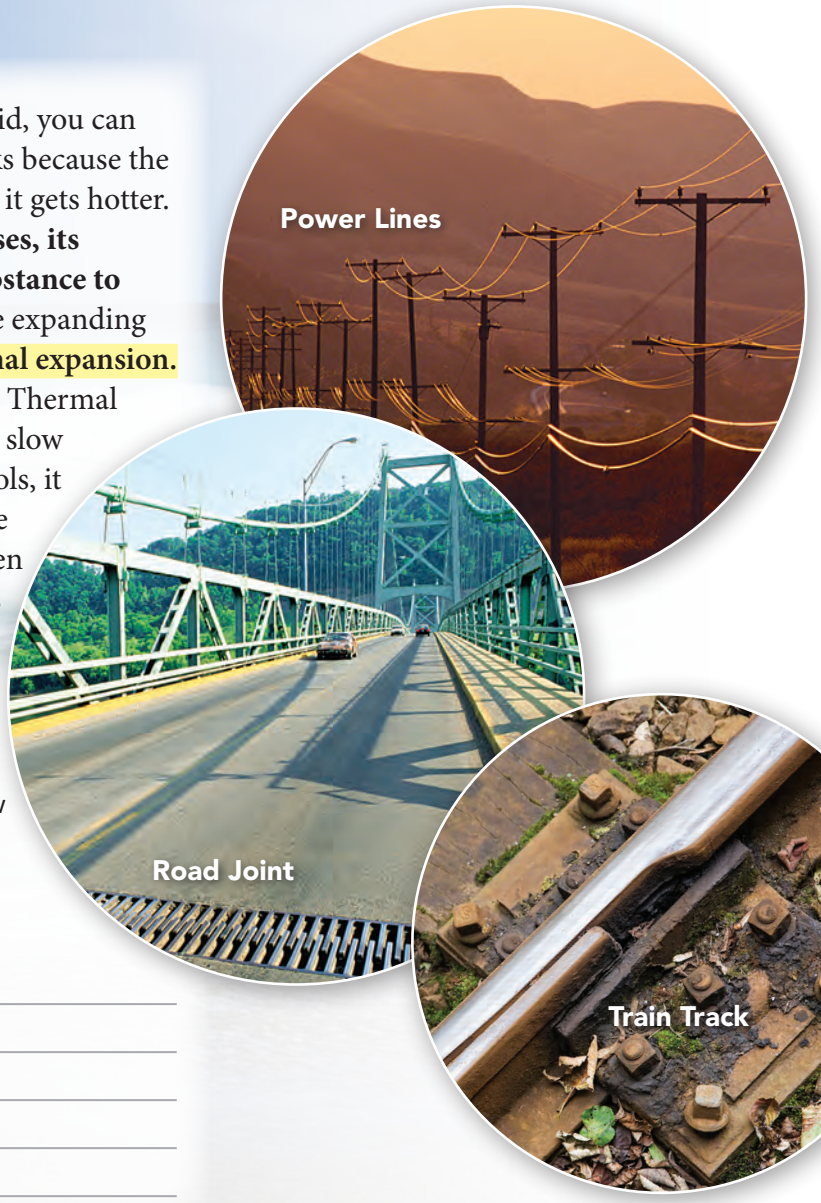


FIGURE 2

Thermal Expansion

Many objects are specifically designed to allow extra space for thermal expansion.

Predict **Pick one of the examples. What might happen if thermal expansion was not considered when this object was designed?**

Lab zone® Do the Quick Lab *Frosty Balloons.*

Assess Your Understanding

1a. Classify Foam picnic coolers keep food cold on a hot day. Is foam a conductor or an insulator? Explain.

b. Calculate The specific heat of foam is about 1,200 J/(kg·K). How much heat does it take to raise the temperature of 1 kg of foam by 2 K?

got it?

- ○ **I get it!** Now I know that the way a material responds to heat depends on
- ○ I need extra help with

CHAPTER 2

Study Guide

REVIEW THE BIG ?

Heat flows from _____ objects to _____ objects. The three methods of heat transfer are _____.

LESSON 1 Temperature, Thermal Energy, and Heat

- Temperature is a measure of the average kinetic energy of the particles in an object.
- Thermal energy is the total energy of all the particles in an object.

Vocabulary

- temperature
- Fahrenheit scale
- Celsius scale
- Kelvin scale
- absolute zero
- heat

LESSON 2 The Transfer of Heat

- Heat is transferred from warmer areas to cooler areas by conduction, convection, and radiation.

Vocabulary

- convection
- convection current
- radiation
- conduction

LESSON 3 Thermal Properties

- Some materials conduct heat well, while other materials do not.
- To change the temperature of different objects by the same amount, different amounts of thermal energy are required.
- As the thermal energy of matter increases, its particles usually spread out, causing the substance to expand.

Vocabulary

- conductor
- insulator
- specific heat
- thermal expansion

Review and Assessment

LESSON 1 Temperature, Thermal Energy, and Heat

1. What is the total energy of all the particles in an object called?

a. chemical energy **b.** thermal energy
c. potential energy **d.** mechanical energy

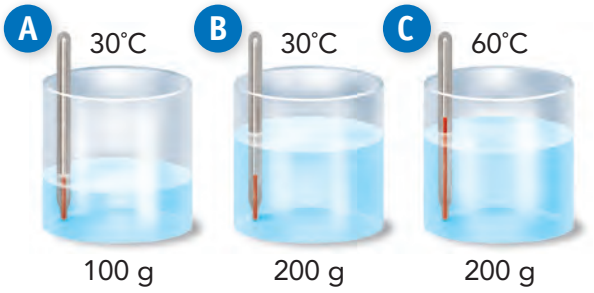
2. The temperature scale used in most of the world is the _____

3. Apply Concepts How does heat flow when you place an ice cube in your hand?

_____

_____

Use the illustration to answer the questions below.



4. Interpret Data Compare the average motion of the particles in the three containers. Explain your answer.

_____

_____

_____

_____

_____

5. Draw Conclusions Compare the total amount of thermal energy in containers A and B. Explain your answer.

_____

_____

_____

_____

LESSON 2 The Transfer of Heat

6. What is the process by which heat transfers from one particle of matter to another when the particles collide?

a. conduction **b.** convection
c. expansion **d.** radiation

7. A convection current is _____

_____

_____

_____

8. Classify Identify each example of heat transfer as conduction, convection, or radiation: opening the windows in a hot room; a lizard basking in the sun; putting ice on a sprained ankle.

_____

_____

9. Infer How can heat be transferred across empty space? Explain your answer.

_____

_____

_____

10. Make Judgments Suppose you try to heat your home using a fireplace in one of the rooms. Would a fan be helpful? Explain.

_____

_____

_____

_____

11. Write About It Explain why a school might ask teachers to keep the windows closed and the shades down during a heat wave.

CHAPTER 2

Review and Assessment

LESSON 3 Thermal Properties

12. Suppose you want to know the amount of heat needed to raise the temperature of 2 kg of copper by 10°C. What property of the copper do you need to know?

a. the thermal energy of the copper

b. the temperature of the copper

c. the specific heat of copper

d. the melting point of copper

13. Wool is a good insulator, which means _____

_____

14. Apply Concepts When they are hung, telephone lines are allowed to sag. Explain why.

_____

_____

_____

15. Interpret Diagrams Why are two panes of glass used in the window shown below? (*Hint*: Air is an insulator.)

_____

_____

_____

16. math! Iron has a specific heat of 450 J/(kg·K). Design a set of three iron cooking pots. How much heat is required to increase the temperature of each pot by 100 K?

APPLY THE BIG IDEA How does heat flow from one object to another?

17. Suppose you were out camping and the weather turned cold. How would you keep warm? Explain each action you would take. Tell whether conduction, convection, or radiation is involved with each heat transfer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

TNReady Prep

6.PS3.4, 6.ETS1.2

Read each question and choose the best answer.

1. The temperatures of four pies are shown below.

A

80°C

B

40°C

C

40°C

D

80°C

Which statement is true?

A A and D have the same thermal energy.
B C and D have the same thermal energy.
C B has twice the thermal energy as C.
D D has twice the thermal energy as A.

2. What does a thermometer measure?

A the average kinetic energy of the particles in an object
B the movement of heat from one object to another
C the amount of thermal energy in an object
D the specific heat of an object

3. Which statement describes the direction of heat flow?

A Heat flows between two objects at the same temperature.
B Thermal energy can only be absorbed by cool objects.
C Heat flows from a warmer object to a cooler object.
D Heat flows from a cooler object to a warmer object.

4. The specific heat of iron is 450 J/(kg·K). How much thermal energy must be transferred to 15 kg of iron to raise its temperature by 4.0 K?

A 450 J
B 2,700 J
C 5,400 J
D 27,000 J

5. Which of the following can be classified as a good conductor of thermal energy?

A air
B wood
C silver
D wool

Constructed Response

Use your knowledge of science to help you answer Question 6. Write your answer on a separate sheet of paper.

6. Using the principles of conduction, convection, and radiation, explain how the water in the pot gets hot.

Aerogel Windows

Close the Window!

Even when they are shut tight, windows can let as much as half of a building's heat out. Scientists at the National Aeronautics and Space Administration (NASA) are working on a new material that may make glass windows a thing of the past.

Aerogel is a nearly transparent solid made from silicon dioxide—the same ingredient found in sand and glass.

Unlike glass, aerogel is 99.8 percent air. This makes it the world's least dense solid. Yet it insulates 39 times better than the best fiberglass insulation.

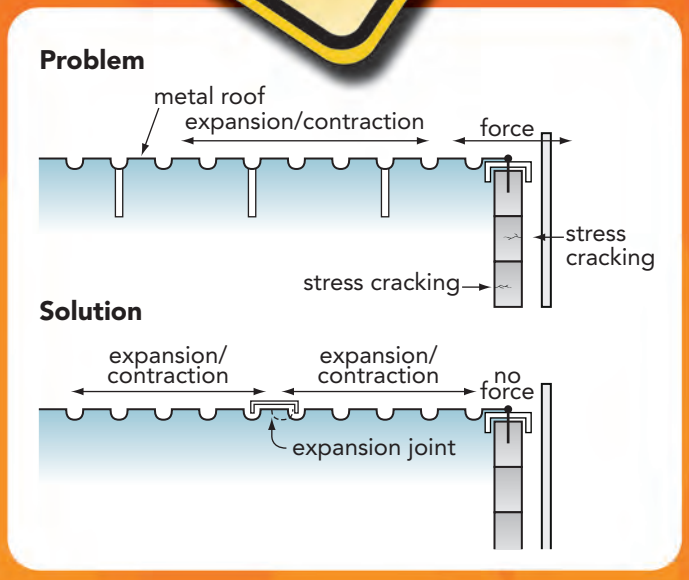
Aerogel absorbs infrared radiation, stopping most forms of energy transfer, including heat. This should make it an amazing material for windows! Unfortunately, tiny pores scatter some of the visible light, which gives aerogel a blue haze.

NASA is researching ways to make aerogel truly transparent. That could prove to be the future of windows!

▲ Aerogel, the world's least dense solid, is nonflammable and absorbs heat.

Write About It Write an advertisement for aerogel windows or insulation. Be creative! Promote the idea that the government would give homeowners a rebate for installing a cutting-edge energy solution.

THERMAL EXPANSION



When a metal roof expands from the sun's heat, the expanding metal pushes against the concrete wall. An expansion joint adds space for the metal to expand.

Make Way for Heat

Sometimes when things heat up, it's time to get out. School board officials stopped construction on a Florida school when cement blocks in the building cracked. The school hired an architecture firm to explore the problem. An engineer discovered that thermal expansion was responsible for the damage. But where was the heat coming from?

The school was designed with a metal roofing system. When metal warms up, it expands. Concrete blocks attached to the metal should have been installed with expansion joints. These joints slip sideways as the metal expands. Unfortunately, there was no slip room over one of the entrances to the building. Something had to give—and it was the concrete blocks! Engineers fixed the problem by adding expansion joints to the roof of the building.

Building in a warm climate? Don't forget to account for thermal expansion!

Design It Do some research about thermal expansion and expansion joints. Make sketches of your own design for a building or bridge. Your design should use expansion joints to account for thermal expansion.

Even concrete cracks under pressure from thermal expansion.