

Chapter 16 Thermal Energy and Heat

Section 16.1 Thermal Energy and Matter

(pages 474–478)

This section defines heat and describes how work, temperature, and thermal energy are related to heat. Thermal expansion and contraction of materials is discussed, and uses of a calorimeter are explained.

Reading Strategy (page 474)

Previewing Before you read, preview the figures in this section and add two more questions in the table. As you read, write answers to your questions. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.

Thermal Energy and Matter	
Questions About Thermal Energy and Matter	Answers
Which has more thermal energy, a cup of tea or a pitcher of juice?	

Work and Heat (page 474)

- Heat is the transfer of thermal energy from one object to another as the result of a difference in _____.
- Circle the letter of each sentence that is true about heat.
 - Heat is a fluid that flows between particles of matter.
 - Heat flows spontaneously from hot objects to cold objects.
 - Friction produces heat.
 - The transfer of thermal energy from one object to another is heat.

Temperature (page 475)

- What is temperature? _____

- Is the following sentence true or false? On the Celsius scale, the reference points for temperature are the freezing and boiling points of water. _____

Chapter 16 Thermal Energy and Heat

5. Circle the letter of each sentence that explains what happens when an object heats up.
 - a. Its particles move faster, on average.
 - b. The average kinetic energy of its particles decreases.
 - c. Its mass increases.
 - d. Its temperature increases.

Thermal Energy (page 475)

6. What is thermal energy? _____

7. Thermal energy depends upon the _____,
_____, and _____ of an object.
8. Is the following sentence true or false? Two substances can be the same temperature and have different thermal energies.

Thermal Expansion and Contraction (page 476)

9. Is the following sentence true or false? Thermal contraction occurs when matter is heated, because particles of matter tend to move closer together as temperature increases. _____
10. Describe thermal expansion and contraction by completing the table below.

Thermal Expansion and Contraction			
Condition	Temperature	Space Between Particles	Volume
	Increases		
			Decreases

Specific Heat (pages 476–477)

11. The amount of heat needed to raise the temperature of one gram of material by one degree Celsius is called _____.
12. Why are you more likely to burn yourself on a metal toy than on a plastic toy if both have been sitting in the sun? _____

Measuring Heat Changes (page 478)

13. What device is used to measure changes in thermal energy?

14. Is the following sentence true or false? A calorimeter uses the principle that heat flows from a hotter object to a colder object until both reach the same temperature. _____

Chapter 16 Thermal Energy and Heat

Section 16.2 Heat and Thermodynamics

(pages 479–483)

This section discusses three kinds of thermal energy transfer and introduces the first, second, and third laws of thermodynamics.

Reading Strategy (page 479)

Build Vocabulary As you read this section, add definitions and examples to complete the table. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.

Transfer of Thermal Energy	
Definitions	Examples
Conduction: transfer of thermal energy with no net transfer of matter	Frying pan handle heats up
Convection:	
Radiation:	

Conduction (pages 479–480)

- The transfer of thermal energy with no overall transfer of matter is called _____.
- Why is conduction slower in gases than in liquids and solids? _____

- Is the following sentence true or false? Conduction is faster in metals than in other solids because metals have free electrons that transfer thermal energy. _____
- Circle the letter of each sentence that is true about conduction.
 - Thermal energy is transferred without transfer of matter.
 - Matter is transferred great distances during conduction.
 - Conduction can occur between materials that are not touching.
 - In most solids, conduction takes place as particles vibrate in place.
- Complete the table about conduction.

Conduction		
Type of Material	Quality of Conduction	Two Examples
	Conducts thermal energy well	Copper;
Thermal insulator		Wood;

Chapter 16 Thermal Energy and Heat

Convection (pages 480–481)

6. The transfer of thermal energy when particles of a fluid move from one place to another is called _____.
7. Why is temperature higher at the bottom of an oven? _____

8. When a fluid circulates in a loop as it alternately heats up and cools down, a(n) _____ occurs.
9. Give three examples of convection currents in nature. _____

Radiation (page 481)

10. The transfer of energy by waves moving through space is called _____.
11. Circle the letter of each sentence that is true about radiation.
 - a. Energy is transferred by waves.
 - b. All objects radiate energy.
 - c. The amount of energy radiated from an object decreases as its temperature increases.
 - d. The farther away you are from a radiating object, the less radiation you receive.

Thermodynamics (pages 482–483)

12. Thermodynamics is the study of conversions between _____ and other forms of energy.
13. Is the following sentence true or false? Energy cannot be created or destroyed, but it can be converted into different forms.

14. Thermal energy flows spontaneously from _____ objects to _____ ones.
15. According to the second law of thermodynamics, what must happen for thermal energy to flow from a colder object to a hotter object? _____

16. Thermal energy that is not converted into work is called _____.
17. Is the following sentence true or false? Scientists have created a heat engine with 100 percent efficiency by reducing the temperature of the outside environment to absolute zero.

18. Is the following sentence true or false? Matter can be cooled to absolute zero. _____

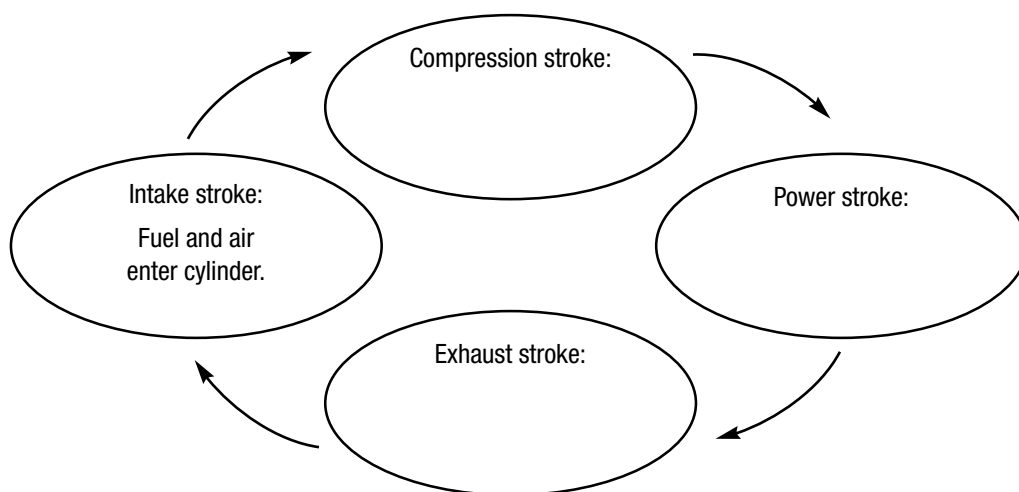
Chapter 16 Thermal Energy and Heat

Section 16.3 Using Heat**(pages 486–492)**

This section describes ways in which humans benefit from heat engines, heating systems, and cooling systems. It also discusses how each of these systems works.

Reading Strategy (page 486)

Sequencing As you read, complete the cycle diagram to show the sequence of events in a gasoline engine. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.

Sequence of Events in a Gasoline Engine**Heat Engines (pages 486–487)**

- The two main types of heat engines are the _____ and the _____.
- A steam engine is an external combustion engine because it burns fuel _____ the engine.
- Who developed the first practical steam engine?
 - James Prescott Joule
 - Thomas Newcomen
 - James Watt
 - Benjamin Thompson
- How is heat converted into work in a steam engine? _____

- A heat engine used by most cars in which fuel burns inside the engine is called a(n) _____.
- Each upward or downward motion of a piston in an internal combustion engine is called a(n) _____.

Chapter 16 Thermal Energy and Heat

7. Is the following sentence true or false? In a typical car, the crankshaft produces a linear motion that turns the wheels.

8. Why is it important for an internal combustion engine to have a cooling system? _____

9. Is the following sentence true or false? Gasoline engines operate very efficiently in converting fuel energy to work.

Heating Systems (pages 489–490)

10. What is a central heating system? _____

11. List four energy sources used for central heating systems.
 - a. _____
 - b. _____
 - c. _____
 - d. _____
12. Is the following sentence true or false? In most heating systems, conduction is used to distribute most of the thermal energy.

Match each description with the heating system it describes.

Description	Heating System
_____ 13. Water heated by a boiler circulates through radiators in each room, transferring thermal energy.	a. hot-water heating b. steam heating c. electric baseboard heating d. forced-air heating
_____ 14. Fans are used to circulate warm air through ducts to the rooms in a building.	
_____ 15. A hot coil heats air by conduction and radiation.	
_____ 16. This system is often used in older buildings or to heat many buildings from a single location.	

Cooling Systems (pages 490–492)

17. Is the following sentence true or false? Most cooling systems, such as air conditioners and refrigerators, are heat pumps.

18. A fluid that vaporizes and condenses inside the tubing of a heat pump is called a(n) _____.
19. How does a heat pump reverse the normal flow of thermal energy? _____

Chapter 16 Thermal Energy and Heat

Calculating with Specific Heat

How much heat is required to raise the temperature of a gold earring from 25.0°C to 30.0°C? The earring weighs 25 grams, and the specific heat of gold is 0.128 J/g•°C.

1. Read and Understand

What information are you given?

$$\text{Specific heat} = c = 0.128 \text{ J/g}\cdot\text{°C}$$

$$\text{Mass} = m = 25.0 \text{ grams}$$

$$\text{Change in Temperature} = \Delta T = (30.0\text{°C} - 25.0\text{°C}) = 5.0\text{°C}$$

2. Plan and Solve

What unknown are you trying to calculate?

$$\text{Amount of heat needed} = Q = ?$$

What formula contains the given quantities and the unknown?

$$Q = \text{Mass} \times \text{Specific heat} \times \text{Change in Temperature}$$

$$Q = m \times c \times \Delta T$$

Replace each variable with its known value.

$$Q = 25.0 \text{ g} \times 0.128 \text{ J/g}\cdot\text{°C} \times 5.0\text{°C} = 16 \text{ J}$$

3. Look Back and Check

Is your answer reasonable?

$$\frac{\text{Heat absorbed}}{(m \times c)} = 16 \text{ J} / (25.0 \text{ g} \times 0.128 \text{ J/g}\cdot\text{°C}) = 5.0\text{°C}$$

This is a reasonable answer for the heat required to raise the temperature of the earring.

Math Practice

On a separate sheet of paper, solve the following problems.

- How much heat is required to raise the temperature of 25 grams of water from 25.0°C to 30.0°C? The specific heat of water is 4.18 J/g•°C.
- Determine the mass of a sample of silver if 705 J of heat are required to raise its temperature from 25°C to 35°C. The specific heat of silver is 0.235 J/g•°C.
- An iron skillet has a mass of 500.0 g. The specific heat of iron is 0.449 J/g•°C. The pan is heated by adding 19,082.5 J of heat. How much does the temperature of the pan increase?

**Math Skill:
Formulas and
Equations**

You may want to read more about this **Math Skill** in the **Skills and Reference Handbook** at the end of your textbook.

Chapter 16 Thermal Energy and Heat

WordWise

Answer the questions by writing the correct vocabulary term in the blanks. Use the circled letter(s) in each term to find the hidden vocabulary word. Then, write a definition for the hidden word.

Clues

This flows spontaneously from hot objects to cold objects.

Any device that converts heat into work

A heat pump does work on this so you can keep your veggies cold.

The Kelvin scale is used to measure this.

A device used to determine the specific heat of a material

The transfer of thermal energy when particles of a fluid move from place to place

The amount of heat needed to raise the temperature of one gram of a material by one degree Celsius

The transfer of thermal energy with no overall transfer of matter

The total potential and kinetic energy of all the particles in an object

The transfer of energy by waves moving through space

According to the first law of thermodynamics, this is conserved.

Vocabulary Terms

___ _ _ Q

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___ Q _ _ _ _ Q _ Q _

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Hidden words: _____

Definition: _____
