Heat is a flow of energy due to temperature differences.

**KEY CONCEPTS SUMMARY**

1. **Temperature depends on particle movement.**
   - All particles in matter have kinetic energy.
   - Temperature is the measurement of the average kinetic energy of particles in an object.
   - Temperature is commonly measured on the Fahrenheit or Celsius scales.
   - Particles in a warmer substance have a greater average kinetic energy than particles in a cooler substance.

2. **Energy flows from warmer to cooler objects.**
   - Heat is a transfer of energy from an object at a higher temperature to an object at a lower temperature.
   - Different materials require different amounts of energy to change temperature.
   - Energy is transferred from the warmer lemonade to the cold ice through heat.

3. **The transfer of energy as heat can be controlled.**
   - Energy can be transferred by conduction, convection, and radiation.
   - Different materials are used to control the transfer of energy.

<table>
<thead>
<tr>
<th>Types of Energy Transfer</th>
<th>Conduction</th>
<th>Convection</th>
<th>Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy transferred by direct contact</td>
<td>Energy flows directly from warmer object to cooler object</td>
<td>Movement of large number of particles in same direction</td>
<td>Energy transferred by electromagnetic waves such as light, microwaves, and infrared radiation</td>
</tr>
<tr>
<td>Energy flows directly from warmer object to cooler object</td>
<td>Can occur within one object</td>
<td>Occurs due to difference in density</td>
<td>All objects radiate energy</td>
</tr>
<tr>
<td>Continues until object temperatures are equal</td>
<td>Cycle occurs while temperature differences exist</td>
<td>Can transfer energy through empty space</td>
<td></td>
</tr>
</tbody>
</table>

**VOCABULARY**
- kinetic theory of matter p. 104
- temperature p. 105
- degree p. 106
- thermometer p. 107
- heat p. 110
- thermal energy p. 111
- calorie p. 112
- joule p. 112
- specific heat p. 113
- conduction p. 117
- conductor p. 117
- insulator p. 117
- convection p. 118
- radiation p. 119
11. The average kinetic energy of particles in an object can be measured by its
   a. heat          c. calories
   b. thermal energy d. temperature

12. How is energy transferred by convection?
   a. by direct contact between objects
   b. by electromagnetic waves
   c. by movement of groups of particles in gases or liquids
   d. by movement of groups of particles in solid objects

13. The total kinetic energy of particles in an object is
   a. heat          c. calories
   b. thermal energy d. temperature

14. Water requires more energy than an equal mass of iron for its temperature to increase by a given amount because water has a greater
   a. thermal energy c. temperature
   b. specific heat  d. kinetic energy

15. Energy from the Sun travels to Earth through which process?
   a. temperature  c. radiation
   b. conduction   d. convection

16. An insulator keeps a home warm by
   a. slowing the transfer of cold particles from outside to inside
   b. increasing the specific heat of the air inside
   c. slowing the transfer of energy from inside to outside
   d. increasing the thermal energy of the walls

17. Conduction is the transfer of energy from a warmer object to a cooler object through
   a. a vacuum        c. direct contact
   b. a gas           d. empty space

18. How are kinetic energy and temperature related to each other?

19. What is the difference between heat and temperature?
Thinking Critically

The illustrations below show particle movement in a substance at two different temperatures. Use the illustrations to answer the next four questions.

20. **OBSERVE** Which illustration represents the substance when it is at a higher temperature? Explain.

21. **PREDICT** What would happen to the particles in illustration A if the substance were chilled? What would happen if the particles in illustration B were warmed?

22. **PREDICT** If energy is transferred from one of the substances to the other through heat, in which direction would the energy flow (from A to B, or from B to A)? Why?

23. **COMMUNICATE** Suppose energy is transferred from one of the substances to the other through heat. Draw a sketch that shows what the particles of both substances would look like when the transfer of energy is complete. Explain.

24. **COMPARE AND CONTRAST** How are conduction and convection similar? How are they different?

25. **DRAW CONCLUSIONS** Suppose you are outdoors on a hot day and you move into the shade of a tree. Which form of energy transfer are you avoiding? Which type of energy transfer are you still feeling? Explain.

26. **COMMUNICATE** Draw a sketch that shows how convection occurs in a liquid. Label the sketch to indicate how the process occurs in a cycle.

Using Math Skills in Science

Use the illustrations of the two thermometers below to answer the next four questions.

27. How much of a change in temperature occurred between A and B in the Fahrenheit scale?

28. Suppose the temperatures were measured in 10 g of water. How much energy, in calories, would have been added to cause that increase in temperature? (Hint: 1 calorie raises the temperature of 1 g of water by 1°C.)

29. Again, suppose the temperatures shown above were measured in 10 g of water. How much energy, in joules, would have been added? (Hint: 1 calorie = 4.18 joules.)

30. Suppose that the temperatures were measured for 10 g of iron. How much energy, in joules, would have been added to cause the increase in temperature? (Hint: see graph on p. 113.)

31. **ANALYZE** Look back at the photograph and the question on pages 100 and 101. How has your understanding of temperature and heat changed after reading the chapter?

32. **COMMUNICATE** Explain the kinetic theory of matter in your own words. What, if anything, about the kinetic theory of matter surprised you?

UNIT PROJECTS

Evaluate all the data, results, and information from your project folder. Prepare to present your project.

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**Interpreting Diagrams**

The diagrams below illustrate the process that occurs in sea and land breezes.

![Diagram of sea breeze](image1)

**Afternoon**
- **Cool air**
- **Warm air**

![Diagram of land breeze](image2)

**Night**
- **Cool air**
- **Warm air**

50 km

Use the diagrams above to answer the next five questions.

1. What happens during the day?
   - a. Cool air from the land flows out to sea.
   - b. Warm air from the land flows out to sea close to sea level.
   - c. Cool air from the sea flows to the land.
   - d. Warm air from the sea flows to the land.

2. What characteristic of large bodies of water explains why the seawater is cooler than the land in the hot afternoon sun?
   - a. Water is liquid while the land is solid.
   - b. Water has a higher specific heat than land.
   - c. Land is a better insulator than water.
   - d. Land has a higher specific heat than water.

3. What process causes the warm air to move upward over the land during the day?
   - a. convection
   - b. condensation
   - c. evaporation
   - d. radiation

4. Warm air is pushed upwards by cooler air during convection because the warm air
   - a. is more dense
   - b. has more mass
   - c. is less dense
   - d. has less mass

5. About how far over water does this land breeze extend?
   - a. 1 kilometer
   - b. 10 kilometers
   - c. 25 kilometers
   - d. 50 kilometers

**Extended Response**

Answer the two questions below in detail. Include some of the terms from the word box on the right. Underline each term that you use in your answer.

6. What are the differences between the Fahrenheit and Celsius temperature scales? Which one is used in science? Why might this be the case?

7. Suppose you place three spoons—one metal, one plastic, and one wood—into a cup filled with hot water. The bowl end of the spoon is inside the cup and the handle is sticking up into the air. On each handle, you place a bead, held to the spoon by a dab of margarine. From which spoon will the bead fall first, and why?

boiling point  heat  specific heat
condensation  freezing point  zero point

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