Name _____ Class _____ Date _____

Exercises

21.1 Temperature (pages 407–408)

1. Define temperature.
the quantity that tells how hot or cold something is compared with a standard

2. Explain how a common liquid thermometer works.
A common thermometer indicates the expansion and contraction of a liquid in a glass tube using a scale.

Match each number with the corresponding description.

	Temperature	Description
e	**3.** –273	a. Water freezes on the Celsius scale.
a	**4.** 0	b. Water freezes on the Fahrenheit scale.
b	**5.** 32	c. Water boils on the Celsius scale.
c	**6.** 100	d. Water boils on the Fahrenheit scale.
d	**7.** 212	e. Absolute zero on the Celsius scale.

8. Define absolute zero.
the lowest possible temperature, at which a substance has no kinetic energy to give up

9. Identify where each temperature scale is primarily used.
a. Celsius: most widely used by people worldwide
b. Fahrenheit: used commonly in the United States
c. Kelvin: used in scientific research

10. Divisions on the Celsius and Fahrenheit scales are called degrees, but divisions on the Kelvin scale are called kelvins.

11. For an ideal gas, temperature is proportional to the average kinetic energy of molecular translational motion.

12. Define translational motion.
motion along a straight or curved path

13. Is the following sentence true or false? For solids and liquids, temperature is unrelated to the average kinetic energy of molecular translational motion. false

14. What is the relationship between the temperature of a substance and the rate of motion of its molecules?
The faster the motion of the molecules, the higher the temperature of a substance

15. Suppose you have a 2-liter pot of boiling water, and you pour out 1 liter of the water. Explain whether the average kinetic energy and temperature of the water in the pot has changed.
The total kinetic energy is half the original value, but the average kinetic energy, and thus the temperature, is unchanged.

21.2 Heat (page 409)

16. Define heat.
the energy that transfers from one object to another because of a temperature difference between them

17. Describe the spontaneous energy transfer that occurs when you touch a cube of ice.
Because your hand is warmer, energy moves from your hand into the colder ice.

18. Is the following sentence true or false? A cup of hot water contains more heat than a cup of cold water. false

19. Explain the meanings of the terms *thermal energy* and *internal energy.*
The energy that results from heat flow is thermal energy. Scientists prefer to call the energy that results from heat flow internal energy.

20. Define thermal contact.
when objects or substances are in contact such that heat flows from one to the other

21. When two substances of different temperature are in thermal contact, heat flows from the higher-temperature substance into the lower-temperature substance.

22. Is the following sentence true or false? Heat always flows from a substance with more total molecular kinetic energy to a substance with less. false

23. Is the following sentence true or false? Heat never flows on its own from a cooler substance into a hotter substance. true

21.3 Thermal Equilibrium (page 410)

24. After objects in thermal contact with each other reach the same temperature, the objects are in thermal equilibrium.

25. When a thermometer is in contact with a substance, heat flows between them until they have the same temperature.

26. Why is it important for a thermometer to be small in comparison to the substance it is measuring?
It should not appreciably alter the temperature of the substance being measured.

21.4 Internal Energy (page 411)

27. Name four types of energy within substances.

a. translational kinetic energy

b. rotational kinetic energy

c. kinetic energy due to internal movements of atoms within molecules

d. potential energy due to the forces between molecules

28. Internal energy is the grand total of all energies inside a substance.

29. What are two ways the internal energy of a substance can change?

by taking in or giving off heat

30. Describe two ways a substance can change when it absorbs heat.

a. The molecules of the substance may jostle faster and the temperature of the substance will increase.

b. The substance can change phase, and its temperature will not increase.

21.5 Measurement of Heat (pages 411–412)

31. How can you determine the amount of heat transferred from one substance to another?

Measure the temperature change of a known mass of the substance that absorbs the heat.

32. In order to quantify heat, we must specify the mass and kind of substance affected.

33. Suppose you place a pot with 1 cup of water and an identical pot with 2 cups of water on a hot stove for the same amount of time. Circle the letters beside the sentences that correctly describe what happens.

a. More heat is added to the pot with 2 cups of water.

(b.) The same amount of heat is added to both pots.

(c.) The temperature of the pot with 1 cup of water increases more.

d. The temperature increase of both pots is the same.

34. Define calorie.

the amount of heat required to raise the temperature of 1 gram of water by 1°C

35. Circle the letter beside the number of kilocalories that equals 50,000 calories.

a. 5 (b.) 50

c. 500 d. 5000

36. A Calorie, used to describe the energy of _____food_____, is equivalent to one _____kilocalorie_____.

37. One calorie is equivalent to _____4.186_____ joules, the SI unit for all forms of energy.

21.6 Specific Heat Capacity (pages 413–414)

38. The capacity of a substance to store heat depends on its _____chemical composition_____.

39. What is specific heat capacity?

the quantity of heat required to raise the temperature of a unit mass of the material by 1 degree

Specific Heat Capacities		
Material	**(J/g°C)**	**(cal/g°C)**
Aluminum	0.900	0.215
Copper	0.386	0.092
Lead	0.128	0.031

40. Use the table above to complete these statements.

a. _____0.215_____ calorie(s) of heat are needed to raise the temperature of 1 gram of aluminum by 1 Celsius degree.

b. _____0.772_____ joule(s) of heat are needed to raise the temperature of 2 grams of copper by 1 Celsius degree.

c. _____0.256_____ joule(s) of heat are needed to raise the temperature of 1 gram of lead by 2 Celsius degrees.

41. Explain this statement: We can think of specific heat capacity as thermal inertia.

Inertia signifies the resistance of an object to a change in its state of motion. Specific heat capacity signifies the resistance of a substance to a change in its temperature.

42. Why does water have a higher specific heat capacity than iron?

Iron atoms primarily shake back and forth when they absorb energy, but water molecules soak up a lot of energy in rotations, internal vibrations, and bond stretching.

21.7 The High Specific Heat Capacity of Water (pages 415–416)

43. Is the following sentence true or false? Water takes longer to heat to a certain temperature than most substances, and it takes longer to cool. true

44. Explain why Europe is much warmer than northeastern Canada, even though they are at similar latitudes.

The Gulf Stream brings warm water from the Caribbean. The water holds its internal energy long enough to reach the coast of Europe. Here the water warms the air, and the winds warm Europe.

45. The high specific heat of ocean water near the west coast of North America causes the winters there to be warmer and the summers to be cooler than near the east coast.

21.8 Thermal Expansion (pages 416–419)

46. Why do most forms of matter expand when they are heated?

As the temperature of a substance is increased, its molecules jiggle faster and normally tend to move farther apart.

47. If concrete sidewalks and highway paving were laid down in one continuous piece, cracks would appear as the materials expanded on hot summer days and contracted on cold winter days.

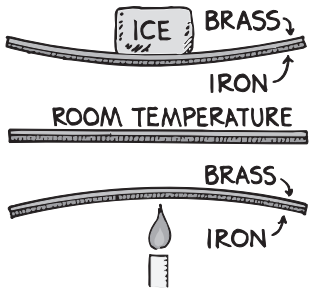
48. Describe one way that each of the following handles the different rates of thermal expansion in materials.

a. Dentist: uses filling material that has the same rate of expansion as teeth

b. Automobile engines: aluminum pistons are enough smaller in diameter than the steel cylinder to allow for the greater expansion rate of aluminum

c. Civil engineer: uses steel having the same expansion rate as concrete for reinforcing concrete

49. Roadways on bridges often have tongue-and-groove-type gaps called expansion joints to allow for thermal expansion.



50. Explain how the bimetallic strip in the figure above is affected in each case.

a. Heated by a flame:

The brass becomes longer than the iron, causing the strip to bend toward the iron.

b. Cooled by ice:

The brass becomes shorter than the iron, causing the strip to bend toward the brass.

51. Describe how a thermostat uses a bimetallic strip.

When the room becomes too cold, the bimetallic coil bends toward the brass side and closes an electric switch that turns on the heat. When the room becomes too warm, the coil bends toward the iron side and opens the electric switch, turning off the heat.

21.9 Expansion of Water (pages 419–422)

52. Water is most dense at a temperature of 4°C.

53. Complete the table by writing *increase* or *decrease* to describe how the volume and density of water changes during each temperature change.

Temperature Change	Change in Volume	Change in Density
0°C to 4°C	decrease	increase
4°C to 10°C	increase	decrease

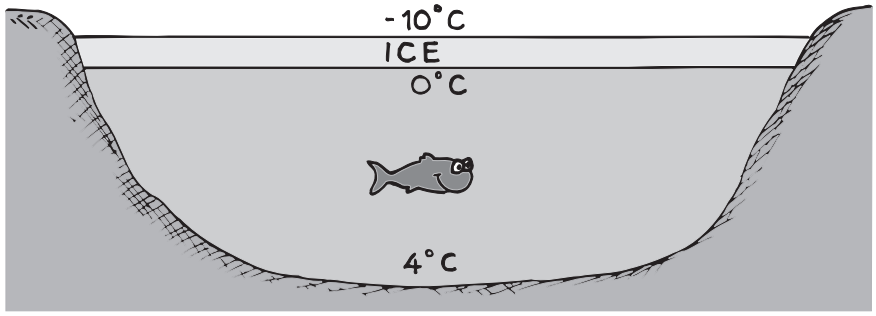
54. Describe how the thermal expansion and contraction of water is different from most other materials.

Almost all liquids expand when they are heated. Between the temperatures of 0°C and 4°C, water's volume decreases.

55. Explain why water has such an unusual thermal expansion and contraction behavior.

Water molecules in their crystal form have an unusual open structure. Water molecules in this open structure occupy a greater volume than they do in the liquid state.

Use the figure below to answer questions 56–60.



56. Where does most of the cooling in the pond take place?

at its surface

57. What determines whether the water will float at the surface?

The water will float only if it is as dense or less dense than the water below.

58. What must be true in order for water at 4°C to remain at the surface?

All the water below it must have at least an equal density, i.e., all the water below must be at 4°C.

59. What must be true in order for ice to begin forming at the surface of the pond?

All the water below it must be at 4°C.

60. If only some of the water in a deep pond is 4°C, where will it be?

on the bottom of the pond