QUESTIONS AND PROBLEMS

Energy

2.1 Discuss the changes in the potential and kinetic energy of a roller-coaster ride as the roller coaster climbs up a ramp and goes down the other side.

2.2 Discuss the changes in the potential and kinetic energy of a ski jumper taking the elevator to the top of the jump and skiing down the ramp.

2.3 Indicate whether each statement describes potential or kinetic energy:

a. water at the top of a waterfall
b. kicking a ball
c. the energy in a lump of coal
d. a skier at the top of a hill

2.4 Indicate whether each statement describes potential or kinetic energy:

a. the energy in your food
b. a tightly wound spring
c. an earthquake
d. a car speeding down the freeway

2.5 A burning match releases 1.1×10^3 J. Convert the energy released by 20 matches to the following energy units:

a. kilojoules **b.** calories **c.** kilocalories

2.6 A person uses 750 kcal to run a race. Convert the energy used for the race to the following energy units:

a. calories **b.** joules **c.** kilojoules

2.2 Temperature

Temperature is a measure of how hot or cold a substance is compared to another substance. The temperature is an indication of the kinetic energy of the particles in a substance. Heat flows from a substance with a higher temperature to a substance with a lower temperature until the temperatures of both are the same. When you drink hot coffee or touch a hot pan, heat flows to your mouth or hand, which is at a lower temperature. When you touch an ice cube, it feels cold because heat flows from your hand to the colder ice cube.

LEARNING GOAL

Given a temperature, calculate a corresponding temperature on another temperature scale.

SAMPLE PROBLEM 2.4

■ Converting from Celsius to Kelvin Temperature

A dermatologist may use cryogenic liquid nitrogen at −196 °C to remove skin lesions and some skin cancers. What is the temperature of the liquid nitrogen in K?

SOLUTION

To find the Kelvin temperature, we use the equation:

$$T_K = T_C + 273$$
$$T_K = -196 + 273$$
$$= 77 \text{ K}$$

STUDY CHECK

On the planet Mercury, the average night temperature is 13 K, and the average day temperature is 683 K. What are these temperatures in Celsius degrees?

QUESTIONS AND PROBLEMS

Temperature

2.7 Your friend who is visiting from Canada just took her temperature. When she reads 99.8, she becomes concerned that she is quite ill. How would you explain this temperature to your friend?

2.8 You have a friend who is using a recipe for flan from a Mexican cookbook. You notice that he set your oven temperature at 175 °F. What would you advise him to do?

2.9 Solve the following temperature conversions:

a. 37.0 °C = ____ °F **b.** 65.3 °F = ____ °C

c. −27 °C = ____ K **d.** 62 °C = ____ K

e. 114 °F = ____ °C **f.** 72 °F = ____ K

2.10 Solve the following temperature conversions:

a. 25 °C = ____ °F **b.** 155 °C = ____ °F

c. −25 °F = ____ °C **d.** 224 K = ____ °C

e. 545 K = ____ °C **f.** 875 K = ____ °F

2.11 a. A patient with heat stroke has a temperature of 106 °F. What does this read on a Celsius thermometer?

b. Because high fevers can cause convulsions in children, the doctor wants to be called if the child's temperature goes over 40. °C. Should the doctor be called if a child has a temperature of 103 °F?

2.12 a. Hot water is heated to 145 °F. What is the temperature of the hot water in °C?

b. During extreme hypothermia, a young woman's temperature dropped to 20.6 °C. What was her temperature on the Fahrenheit scale?

2.3 Specific Heat

QUESTIONS AND PROBLEMS

Specific Heat

2.13 If the same amount of heat is supplied to samples of 10.0 g each of aluminum, iron, and copper, all at 15 °C, which sample would reach the highest temperature? (See Table 2.2.)

2.14 Substances A and B are the same mass and at the same initial temperature. When the same amount of heat is added to each, the final temperature of A is 55 °C higher than the temperature of B. What does this tell you about the specific heats of A and B?

2.15 Calculate the specific heat (J/g °C) for each of the following:

a. a 13.5-g sample of zinc heated from 24.2 °C to 83.6 °C that absorbs 312 J of heat

b. a 48.2-g sample of a metal that absorbs 345 J when temperature increases from 35.0 °C to 57.9 °C

2.16 Calculate the specific heat (J/g °C) for each of the following:

a. an 18.5-g sample of tin that absorbs 183 J when its temperature increases from 35.0 °C to 78.6 °C

b. a 22.5-g sample of a metal that absorbs 645 J when its temperature changes from 36.2 °C to 92.0 °C

2.17 What is the amount of heat required in each of the following?

a. calories to heat 25 g of water from 15 °C to 25 °C

b. calories to heat 150 g of water from 0 °C to 75 °C

c. kilocalories to heat 150 g of water in a kettle from 15 °C to 77 °C

2.18 What is the amount of heat involved in each of the following?

a. calories given off when 85 g of water cools from 45 °C to 25 °C

b. calories given off when 25 g of water cools from 86 °C to 61 °C

c. kilocalories absorbed when 5.0 kg of water warms from 22 °C to 28 °C

2.19 Calculate the energy in joules and calories

a. required to heat 25.0 g of water from 12.5 °C to 25.7 °C

b. required to heat 38.0 g of copper (Cu) from 122 °C to 246 °C

c. lost when 15.0 g of ethanol, C_2H_5OH, cools from 60.5 °C to −42.0 °C

d. lost when 112 g of iron, Fe, cools from 118 °C to 55 °C

2.20 Calculate the energy in joules and calories

a. required to heat 5.25 g of water, H_2O, from 5.5 °C to 64.8 °C

b. lost when 75.0 g of water, H_2O, cools from 86.4 °C to 2.1 °C

c. required to heat 10.0 g of silver (Ag) from 112 °C to 275 °C

d. lost when 18.0 g of gold (Au) cools from 224 °C to 118 °C

2.21 Calculate the mass in grams for each of the following:

a. a gold sample that absorbs 225 J to change its temperature from 15.0 °C to 47.0 °C

b. an iron object that loses 8.40 kJ when its temperature drops from 168.0 °C to 82.0 °C

c. a sample of aluminum that absorbs 8.80 kJ when heated from 12.5 °C to 26.8 °C

d. a sample of titanium that loses 14 200 J when it cools from 185 °C to 42 °C

2.22 Calculate the mass in grams for each of the following:

a. a sample of water that absorbs 8250 J when its temperature rises from 18.4 °C to 92.6 °C

b. a pure silver sample that loses 3.22 kJ when its temperature drops from 145 °C to 24 °C

c. a sample of aluminum that absorbs 1.65 kJ when its temperature rises from 65 °C to 187 °C

d. an iron bar that loses 2.52 kJ when its temperature drops from 252 °C to 75 °C

Because muscular exercise is an important way to expend energy, an increase in daily exercise aids weight loss. Table 2.6 lists some activities and the amount of energy they require.

Swimming	2100	500
Running	3100	750

QUESTIONS AND PROBLEMS

Energy and Nutrition

2.23 Using the following data, determine the kilojoules and kilocalories for each food burned in a calorimeter:

a. one stalk of celery that produces energy to heat 505 g of water from 25.2 °C to 35.7 °C

b. a waffle that produces energy to heat 4980 g of water from 20.6 °C to 62.4 °C

2.24 Calculate the kilojoules and kilocalories each food provides when burned in a calorimeter:

a. 1 cup of popcorn that produces energy to change the temperature of 1250 g of water from 25.5 °C to 50.8 °C

b. a sample of butter that produces energy to increase the temperature of 357 g water from 22.7 °C to 38.8 °C

2.25 Using the energy values for foods, determine each of the following (round final Cal answers to the tens place):

a. the total Calories for 1 cup of orange juice that contains 26 g of carbohydrate, no fat, and 2 g of protein

b. the grams of carbohydrate in one apple if the apple has no fat and no protein and provides 72 kcal of energy

c. the Calories in 1 tablespoon of vegetable oil, which contains 14 g of fat and no carbohydrate or protein

d. the total Calories in one breakfast roll that has 30.0 g of carbohydrate, 15 g of fat, and 5 g of protein

2.26 Using the energy values for food, determine each of the following (round final Cal answers to tens place):

a. the total Calories for 2 tablespoons of crunchy peanut butter that contains 6 g of carbohydrate, 16 g of fat, and 7 g of protein

b. the grams of protein in 1 cup of soup that has 110 Cal with 7 g of fat and 9 g of carbohydrate

c. the grams of sugar (carbohydrate) in one can of cola if it has 140 Cal and no fat and no protein

d. the grams of fat in one avocado if it has 405 Calories, 13 g of carbohydrate, and 5 g of protein

2.27 One cup of clam chowder contains 9 g of protein, 12 g of fat, and 16 g of carbohydrate. How many kilocalories are in the clam chowder? How many kilojoules are in the clam chowder? (Round the final answers to the tens place.)

2.28 A high-protein diet contains 70.0 g of carbohydrate, 150 g of protein, and 5.0 g of fat. How many kilocalories does this diet provide? How many kilojoules does this diet provide? (Round the final answers to the tens place.)

SAMPLE PROBLEM 2.10

■ Classifying Pure Substances and Mixtures

Classify each of the following as a pure substance (element or compound) or a mixture (homogeneous or heterogeneous):

a. ice cream float
b. coffee with cream and sugar
c. copper wire
d. carbon dioxide (CO_2)

SOLUTION

a. mixture; heterogeneous with a nonuniform composition
b. mixture; homogeneous with uniform composition of coffee, cream, and sugar
c. pure substance; element
d. pure substance; compound with a definite ratio of two elements

STUDY CHECK

A salad dressing is prepared with oil, vinegar, and chunks of blue cheese. Is this a homogeneous or heterogeneous mixture?

QUESTIONS AND PROBLEMS

Classification of Matter

2.29 Classify each of the following pure substances as an element or compound. Give a reason for your answer.

a. baking soda ($NaHCO_3$)
b. oxygen (O_2)
c. ice (H_2O)
d. aluminum foil (Al)

2.30 Classify each of the following pure substances as an element or compound. Give a reason for your answer.

a. platinum (Pt) in a catalytic converter
b. vitamin C ($C_6H_8O_6$)
c. mercury in a thermometer (Hg)
d. carbon monoxide (CO)

2.31 Classify each of the following mixtures as homogeneous or heterogeneous:

a. vegetable soup
b. saltwater
c. tea
d. tea with ice and a lemon slice
e. water and sand in an aquarium
f. fruit salad

2.32 Classify each of the following mixtures as homogeneous or heterogeneous:

a. homogenized milk
b. chocolate chip ice cream
c. gasoline
d. ham and cheese sandwich
e. chicken noodle soup
f. hot tea with sweetener

b. Chemical change; a change occurs in the composition of the stain.
c. Chemical change; a change occurs in the composition of lactose.
d. Physical change; a change of size does not change composition.

STUDY CHECK

Which of the following are chemical changes?

a. Water freezes on a pond.
b. Gas bubbles form when baking powder is placed in vinegar.
c. A log is chopped for firewood.
d. A log is burned in a fireplace.

QUESTIONS AND PROBLEMS

States and Properties of Matter

2.33 Indicate whether each of the following describes a gas, a liquid, or a solid:
a. This substance has no definite volume or shape.
b. The particles in a substance do not interact strongly with each other.
c. The particles in a substance are held in a definite structure.

2.34 Indicate whether each of the following describes a gas, a liquid, or a solid:
a. The substance has a definite volume but takes the shape of the container.
b. The particles in this substance are very far apart.
c. This substance occupies the entire volume of the container.

2.35 Describe each of the following as a physical or chemical property:
a. Chromium is a steel-gray solid.
b. Hydrogen reacts readily with oxygen.
c. Nitrogen freezes at –210 °C.
d. Milk will sour when left in a warm room.

2.36 Describe each of the following as a physical or chemical property:
a. Neon is a colorless gas at room temperature.
b. Apple slices turn brown when exposed to air.
c. Phosphorus will ignite when exposed to air.
d. At room temperature, mercury is a liquid.

2.37 What type of change, physical or chemical, takes place in each of the following?
a. Water vapor condenses to form rain.
b. Cesium metal reacts explosively with water.
c. Gold melts at 1064 °C.
d. A puzzle is cut into 1000 pieces.
e. Sugar dissolves in water.

2.38 What type of change, physical or chemical, takes place in each of the following?
a. Gold is hammered into thin sheets.
b. A silver pin tarnishes in the air.
c. A tree is cut into boards at a sawmill.
d. Food is digested.
e. A chocolate bar melts.

2.47 Calculate the heat change at 100 °C in each of the following problems. Indicate whether heat was absorbed or released.

a. calories to vaporize 10.0 g of water
b. kilocalories to vaporize 50.0 g of water
c. kilocalories to condense 8.0 kg of steam

2.48 Calculate the heat change at 100 °C in each of the following problems. Indicate whether heat was absorbed or released.

a. calories to condense 10.0 g of steam
b. kilocalories to condense 75 g of steam
c. kilocalories to vaporize 44 g of water

2.49 Draw a heating curve for a sample of ice that is heated from −20 °C to 140 °C. Indicate the segment of the graph that corresponds to each of the following:

a. solid **b.** melting point **c.** liquid
d. boiling point **e.** gas

2.50 Draw a cooling curve for a sample of steam that cools from 110 °C to −10 °C. Indicate the segment of the graph that corresponds to each of the following:

a. solid **b.** freezing point **c.** liquid
d. condensation point (boiling point) **e.** gas

2.51 Using the values for the heat of fusion, specific heat of water, or heat of vaporization, calculate the amount of heat energy in each of the following:

a. calories needed to warm 20.0 g of water at 15 °C to 72 °C (one step)
b. calories need to melt 50.0 g of ice at 0 °C and to warm the liquid to 65 °C (two steps)
c. kilojoules given off when 15 g of steam condenses at 100 °C and the liquid cools to 0 °C (two steps)
d. kilocalories needed to melt 24 g of ice at 0 °C, to warm the liquid to 100 °C, and to vaporize it at 100 °C (three steps)

2.52 Using the values for the heat of fusion, specific heat of water, or heat of vaporization, calculate the amount of heat energy in each of the following:

a. calories removed to condense 125 g of steam at 100 °C and to cool the liquid to 15 °C (two steps)
b. joules needed to melt a 525-g ice cube at 0 °C and to warm the liquid to 15 °C (two steps)
c. kilocalories removed to condense 85 g of steam at 100 °C, cool the liquid to 0 °C, and freeze it at 0 °C (three steps)
d. calories to warm 55 mL of water (density = 1.0 g/mL) from 10 °C to 100 °C and vaporize it at 100 °C (two steps)

CONCEPT MAP

ENERGY AND MATTER

2.8 4.0 kcal/g of sucrose; 17 kJ/g of sucrose

2.9 380 kcal

2.10 Salad dressing is a heterogeneous mixture with a nonuniform composition.

2.11 b. and d. are chemical changes

2.12 50.1 kJ

2.13 14 kcal; 24 kcal

2.14 75.4 kJ

ANSWERS TO SELECTED QUESTIONS AND PROBLEMS

2.1 As the car goes up the ramp, kinetic energy changes to potential energy. As the car descends, potential energy changes to kinetic energy. At the bottom, all the energy is kinetic.

2.3 **a.** potential **b.** kinetic **c.** potential **d.** potential

2.5 **a.** 22 kJ **b.** 5300 cal **c.** 5.3 kcal

2.7 In the United States, the Fahrenheit scale is in common use. On a Fahrenheit thermometer, normal body temperature is 98.6 °F. A temperature of 99.8 °F would indicate a mild fever. On the Celsius scale, her temperature is 37.7 °C.

2.9 **a.** 98.6 °F **b.** 18.5 °C **c.** 246 K
d. 335 K **e.** 46 °C **f.** 295 K

2.11 **a.** 41 °C
b. No. The temperature is equivalent to 39 °C.

2.13 Copper has the lowest specific heat of the samples and will reach the highest temperature.

2.15 **a.** 0.389 J/g °C **b.** 0.313 J/g °C

2.17 **a.** 250 cal **b.** 11 000 cal **c.** 9.3 kcal

2.19 **a.** 1380 J; 330. cal **b.** 1810 J; 434 cal
c. 3780 J; 904 cal **d.** 3200 J; 760 cal

2.21 **a.** 54.5 g of gold **b.** 216 g of iron
c. 686 g of aluminum **d.** 190. g of titanium

2.23 **a.** 5.30 kcal; 22.2 kJ **b.** 208 kcal; 870. kJ

2.25 **a.** 110 Cal **b.** 18 g **c.** 130 Cal **d.** 280 Cal

2.27 210 kcal; 870 kJ

2.29 **a.** compound; contains four elements in definite composition
b. element; consists of one type of pure substance
c. compound; consists of two elements in a definite composition
d. element; consists of one type of pure substance

2.31 **a.** heterogeneous **b.** homogeneous
c. homogeneous **d.** heterogeneous
e. heterogeneous **f.** heterogeneous

2.29 **a.** gas **b.** gas **c.** solid

2.33 **a.** gas **b.** gas **c.** solid

2.35 **a.** physical **b.** chemical **c.** physical **d.** chemical

2.37 **a.** physical **b.** chemical **c.** physical
d. physical **e.** physical

2.39 **a.** chemical **b.** physical **c.** physical
d. chemical **e.** physical

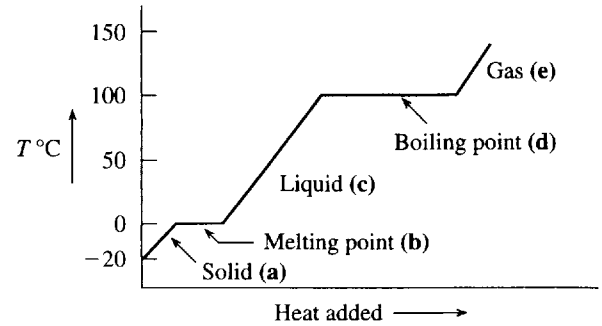
2.41 **a.** melting **b.** sublimation
c. freezing **d.** deposition

2.43 **a.** 5200 cal absorbed **b.** 1400 cal absorbed
c. 18 kcal released

2.45 **a.** condensation **b.** evaporation
c. boiling **d.** condensation

2.47 **a.** 5400 cal absorbed **b.** 27 kcal absorbed
c. 4300 kcal released

2.49



2.51 **a.** 1100 cal **b.** 7300 cal **c.** 40. kJ **d.** 17 kcal

2.53 **a.** 10 °C **b.** 30 °C **c.** 32 °F **d.** 200 °C

2.55 113 °F; 318 K

2.57 **a.** 15 h sleeping **b.** 1.2 h running

2.59 Mixtures b. and c. are not the same throughout and are heterogeneous. Mixture a. is the same throughout and is homogeneous.

2.61 **a.** The heat from the skin is used to evaporate the water (perspiration). Therefore, the skin is cooled.
b. On a hot day, there are more molecules with sufficient energy to become water vapor.

2.63 **a.** −60 °C **b.** 60 °C
c. A is solid. B is melting. C is liquid. D is boiling. E is gas.
d. At −80 °C, it is solid; at −40 °C, it is liquid; at 25 °C, it is liquid; at 80 °C, it is gas.

2.65 Sand must have a lower specific heat than water. When both substances absorb the same amount of heat, the final temperature of the sand will be higher than that of water.

2.67 When water vapor condenses or liquid water freezes, heat is released, which warms the air.

2.69 **a.** 136 °F **b.** −129 °F

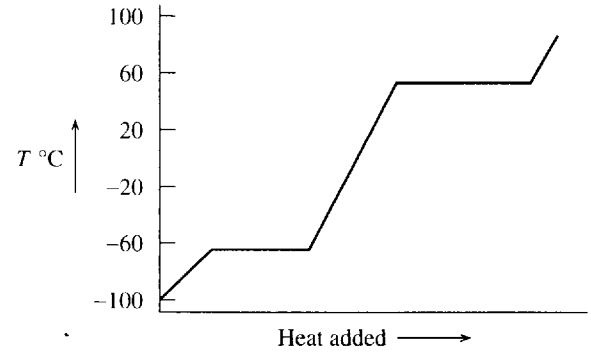
2.71 85 kJ

2.73 **a.** 45 g of protein, 140 g of carbohydrate, 53 g of fat
b. 71 g of protein, 210 g of carbohydrate, 84 g of fat
c. 98 g of protein, 290 g of carbohydrate, 120 g of fat

2.75 3500 kcal

2.77 **a.** solid **b.** liquid **c.** solid
d. gas **e.** liquid

2.79 **a.** solid **b.** solid chloroform melts
c. liquid **d.** gas **e.** −64 °C



2.81 20. kcal

2.83 28 kcal

2.85 $\frac{0.34 \text{ cal}}{\text{g °C}}$

2.87 105.4 kJ

2.89 **a.** 26.5 g **b.** 54.5 g of gold **c.** 175 °C **d.** $\frac{0.27 \text{ cal}}{\text{g °C}}$

2.91 350 g of ice