Pearson

Exercises

Review Questions

1. What are the standard SI base units of length, mass, time, and temperature?
2. What are the three common temperature scales? Does the size of a degree differ among them?
3. What are prefix multipliers? List some examples.
4. What is a derived unit? List an example.
5. Explain the relationship between the reliability of a measurement and the instrument used to make the measurement.
6. What is the significance of the number of digits reported in a measured quantity?
7. Explain the difference between precision and accuracy.
8. Explain the difference between random error and systematic error.
9. When multiplying or dividing measured quantities, what determines the number of significant figures in the result?
10. When adding or subtracting measured quantities, what determines the number of significant figures in the result?
11. Explain the difference between density and mass.
12. Explain the difference between *intensive* and *extensive* properties.
13. What is energy? Explain the difference between kinetic energy and potential energy.
14. State the law of conservation of energy, and explain its significance.
15. What kind of energy is chemical energy? In what way is an elevated weight similar to a tank of gasoline?
16. Explain the difference between an exothermic and an endothermic process.
17. What is dimensional analysis?
18. How should units be treated in calculations?

Problems by Topic

Note: Answers to all odd-numbered Problems can be found in Appendix III. Exercises in the Problems by Topic section are paired, with each odd-numbered problem followed by a similar even-numbered problem. Exercises in the Cumulative Problems section are also paired but more loosely. Because of their nature, Challenge Problems and Conceptual Problems are unpaired.

The Units of Measurement

19. Convert each temperature.

a. 32 °F to °C (temperature at which water freezes)

b. 77 K to °F (temperature of liquid nitrogen)

c. –109 °F to °C (temperature of dry ice)

d. 98.6 °F to K (body temperature)

20. Convert each temperature.

a. 212 °F to °C (temperature of boiling water at sea level)

b. 22 °C to K (approximate room temperature)

c. 0.00 K to °F (coldest temperature possible, also known as absolute zero)

d. 2.735 K to °C (average temperature of the universe as measured from background black body radiation)

21. The coldest temperature ever measured in the United States is –80 °F on January 23, 1971, in Prospect Creek, Alaska**.** Convert that temperature to °C and K. (Assume that –80 °F is accurate to two significant figures.)

22. The warmest temperature ever measured in the United States is 134 °F on July 10, 1913, in Death Valley, California. Convert that temperature to °C and K.

23. Use the prefix multipliers to express each measurement without any exponents.

a. 1.2×10^{-9} m

b. 22×10^{-15} s

c. 1.5×10^{9} g

d. 3.5×10^{6} L

24. Use prefix multipliers to express each measurement without any exponents.

a. 38.8×10^{5} g

b. 55.2×10^{-10} s

c. 23.4×10^{-11} m

d. 87.9×10^{-7} L

25. Use scientific notation to express each quantity with only the base units (no prefix multipliers).

a. 4.5 ns

b. 18 fs

c. 128 pm

d. 35 μm

26. Use scientific notation to express each quantity with only the base units (no prefix multipliers).

a. 35 μL

b. 225 Mm

c. 133 Tg

d. 1.5 cg

27. Complete the table.

a. 1245 kg	1.245×10^{6} g	1.245×10^{9} mg
b. 515 km	_____ dm	_____ cm
c. 122.355 s	_____ ms	_____ ks
d. 3.345 kJ	_____ J	_____ mJ

28. Complete the table.

a. 355 km/s	_____ cm/s	_____ m/ms
b. 1228 g/L	_____ g/mL	_____ kg/ML
c. 554 mK/s	_____ K/s	_____ μK/ms
d. 2.554 mg/mL	_____ g/L	_____ μg/mL

29. Express the quantity 254,998 m in each unit.

a. km

b. Mm

c. mm

d. cm

30. Express the quantity 556.2×10^{-12} s in each unit.

a. ms

b. ns

c. ps

d. fs

31. How many 1-cm squares does it take to construct a square that is 1 m on each side?

32. How many 1-cm cubes does it take to construct a cube that is 4 cm on edge?

33. Convert 15.0 L to each unit.

a. mL

b. cm^3

c. gal

d. qt

34. Convert 4.58×10^3 cm^3 to each unit.

a. L

b. mL

c. gal

d. qt

The m in the equation for density is in italic type, meaning that it stands for mass rather than for meters. In general, the symbols for units such as meters (m), seconds (s), or kelvins (K) appear in regular type, while those for variables such as mass (m), volume (V), and time (t) appear in italics.

The Reliability of a Measurement and Significant Figures

35. A ruler used to measure a penny has markings every 1 mm. Which measurement for the size of the penny is correctly reported for this ruler?

a. 19.05 mm

b. 19 mm

c. 19.1 mm

36. A scale used to weigh produce at a market has markings every 0.1 kg. Which measurement for the mass of a dozen apples is correctly reported for this scale?

a. 1.87 kg

b. 1.9 kg

c. 1.875 kg

37. Read each measurement to the correct number of significant figures. Laboratory glassware should always be read from the bottom of the meniscus.

a.

b.

c.

38. Read each measurement to the correct number of significant figures. Laboratory glassware should always be read from the bottom of the meniscus. Digital balances normally display mass to the correct number of significant figures for that particular balance.

a.

b.

c.

39. For each number, underline the zeroes that are significant and draw an x through the zeroes that are not.

a. 1,050,501 km

b. 0.0020 m

c. 0.000000000000002 s

d. 0.001090 cm

40. For each number, underline the zeroes that are significant and draw an x through the zeroes that are not.

a. 180,701 mi

b. 0.001040 m

c. 0.005710 km

d. 90,201 m

41. How many significant figures are in each number?

a. 0.000312 m

b. 312,000 s

c. 3.12×10^5 km

d. 13,127 s

e. 2000

42. How many significant figures are in each number?

a. 0.1111 s

b. 0.007 m

c. 108,700 km

d. 1.563300×10^{11} m

e. 30,800

43. Which numbers are exact (and therefore have an unlimited number of significant figures)?

a. $\pi = 3.14$

b. 12 inches = 1 foot

c. EPA gas mileage rating of 26 miles per gallon

d. 1 gross = 144

44. Indicate the number of significant figures in each number. If the number is an exact number, indicate that it has an unlimited number of significant figures.

a. 305,435,087 (2008 U.S. population)

b. 2.54 cm = 1 in

c. 11.4 g/cm^3 (density of lead)

d. 12 = 1 dozen

45. Round each number to four significant figures.

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a. 156.852

b. 156.842

c. 156.849

d. 156.899

46. Round each number to three significant figures.

a. 79,845.82

b. 1.548937×10^7

c. 2.3499999995

d. 0.000045389

47. Calculate to the correct number of significant figures.

a. $915 \div 4.970$

b. $1.54 \times 0.03060 \times 0.69$

c. $27.5 \times 1.82 \div 100.04$

d. $\left(2.290 \times 10^6\right) \div \left(6.7 \times 10^4\right)$

48. Calculate to the correct number of significant figures.

a. $89.3 \times 77.0 \times 0.08$

b. $\left(5.01 \times 10^5\right) \div \left(7.8 \times 10^2\right)$

c. $4.005 \times 74 \times 0.007$

d. $453 \div 2.031$

49. Calculate to the correct number of significant figures.

a. $43.7 - 2.341$

b. $17.6 + 2.838 + 2.3 + 110.77$

c. $19.6 + 58.33 - 4.974$

d. $5.99 - 5.572$

50. Calculate to the correct number of significant figures.

a. $0.004 + 0.09879$

b. $1239.3 + 9.73 + 3.42$

c. $2.4 - 1.777$

d. $532 + 7.3 - 48.523$

51. Calculate to the correct number of significant figures.

a. $(24.6681 \times 2.38) + 332.58$

b. $(85.3 - 21.489) \div 0.0059$

c. $(512 \div 986.7) + 5.44$

d. $\left[\left(28.7 \times 10^5\right) \div 48.533\right] + 144.99$

52. Calculate to the correct number of significant figures.

a. $\left[\left(1.7 \times 10^6\right) \div \left(2.63 \times 10^5\right)\right] + 7.33$

b. $(568.99 - 232.1) \div 5.3$

c. $(9443 + 45 - 9.9) \times 8.1 \times 10^6$

d. $(3.14 \times 2.4367) - 2.34$

Density

53. A new penny has a mass of 2.49 g and a volume of $0.349\ \mathrm{cm}^3$. Is the penny made of pure copper? Explain.

54. A titanium bicycle frame displaces 0.314 L of water and has a mass of 1.41 kg. What is the density of the titanium in $\mathrm{g/cm}^3$?

55. Glycerol is a syrupy liquid used in cosmetics and soaps. A 3.25-L sample of pure glycerol has a mass of 4.10×10^3 g. What is the density of glycerol in $\mathrm{g/cm}^3$?

56. An allegedly gold nugget is tested to determine its density. It is found to displace 19.3 mL of water and has a mass of 371 g. Could the nugget be made of gold?

57. Ethylene glycol (antifreeze) has a density of $1.11\ \mathrm{g/cm}^3$.

a. What is the mass in g of 417 mL of this liquid?

b. What is the volume in L of 4.1 kg of this liquid?

58. Acetone (nail polish remover) has a density of $0.7857\ \mathrm{g/cm}^3$.

a. What is the mass, in g, of 28.56 mL of acetone?

b. What is the volume, in mL, of 6.54 g of acetone?

59. A small airplane takes on 245 L of fuel. If the density of the fuel is 0.821 g/mL, what mass of fuel

59. A small airplane takes on 245 L of fuel. If the density of the fuel is 0.821 g/mL, what mass of fuel has the airplane taken on?

60. Human fat has a density of $0.918\ \text{g/cm}^3$. How much volume (in cm^3) is gained by a person who gains 10.0 lb of pure fat?

Unit Conversions

61. Perform each unit conversion.

a. 27.8 L to cm^3

b. 1898 mg to kg

c. 198 km to cm

62. Perform each unit conversion.

a. 28.9 nm to μm

b. 1432 cm^3 to L

c. 1211 Tm to Gm

63. Perform each unit conversion.

a. 154 cm to in

b. 3.14 kg to g

c. 3.5 L to qt

d. 109 mm to in

64. Perform each unit conversion.

a. 1.4 in to mm

b. 116 ft to cm

c. 1845 kg to lb

d. 815 yd to km

65. A runner wants to run 10.0 km. She knows that her running pace is 7.5 miles per hour. How many minutes must she run?

66. A cyclist rides at an average speed of 18 miles per hour. If she wants to bike 212 km, how long (in hours) must she ride?

67. A European automobile has a gas mileage of 17 km/L. What is the car's gas mileage in miles per gallon?

68. A gas can holds 5.0 gallons of gasoline. Express this quantity in cm^3.

69. A house has an area of 195 m^2. What is its area in:

a. km^2

b. dm^2

c. cm^2

70. A bedroom has a volume of 115 m^3. What is its volume in:

a. km^3

b. dm^3

c. cm^3

71. The average U.S. farm occupies 435 acres. How many square miles is this?
$(1\ \text{acre} = 43{,}560\ \text{ft}^2,\ 1\ \text{mile} = 5280\ \text{ft})$

72. Total U.S. farmland occupies 954 million acres. How many square miles is this?
$(1\ \text{acre} = 43{,}560\ \text{ft}^2,\ 1\ \text{mile} = 5280\ \text{ft})$. Total U.S. land area is 3.537 million square miles. What percentage of U.S. land is farmland?

73. An acetaminophen suspension for infants contains 80 mg/0.80 mL suspension. The recommended dose is 15 mg/kg body weight. How many mL of this suspension should be given to an infant weighing 14 lb? (Assume two significant figures.)

74. An ibuprofen suspension for infants contains 100 mg/5.0 mL suspension. The recommended dose is 10 mg/kg body weight. How many mL of this suspension should be given to an infant weighing 18 lb? (Assume two significant figures.)

75. Convert between energy units.

a. 534 kWh to J

b. 215 kJ to Cal

c. 567 Cal to J

d. 2.85×10^3 J to cal

76. Convert between energy units.

a. 231 cal to kJ

b. 132×10^4 kJ to kcal

c. 4.99×10^3 kJ to kWh

d. 2.88×10^4 J to Cal

77. Suppose that a person eats 2387 Calories per day. Convert this amount of energy into each unit.

a. J

b. kJ

c. kWh

78. A particular frost-free refrigerator uses about 745 kWh of electrical energy per year. Express this amount of energy in each unit.

a. J

b. kJ

c. Cal

79. A household receives a $145 electricity bill. The cost of electricity is $0.120/kWh. How much energy, in joules, did the household use?

80. A 150-lb person burns about 2700 Calories to run a marathon. How much energy is burned in kJ? Assume two significant figures.

Cumulative Problems

81. A solid gold cylinder sits on a weight-sensitive alarm. A thief uses a can of sand to replace the solid gold cylinder. The can of sand and the gold cylinder have exactly the same dimensions $(\text{length} = 22 \text{ cm and radius} = 3.8 \text{ cm})$.

a. Calculate the mass of the gold cylinder and can of sand (ignore the mass of the can itself). $\left(\text{density of gold} = 19.3 \text{ g/cm}^3, \text{density of sand} = 3.00 \text{ g/cm}^3\right)$

b. Did the thief set off the alarm? Explain.

82. The proton has a radius of approximately 1.0×10^{-13} cm and a mass of 1.7×10^{-24} g. Determine the density of a proton. For a sphere $V = (4/3)\pi r^3$.

83. The density of titanium is 4.51 g/cm^3. What is the volume (in cubic inches) of 3.5 lb of titanium?

84. The density of iron is 7.86 g/cm^3. What is its density in pounds per cubic inch $\left(\text{lb/in}^3\right)$?

85. A steel cylinder has a length of 2.16 in, a radius of 0.22 in, and a mass of 41 g. What is the density of the steel in g/cm^3?

86. A solid aluminum sphere has a mass of 85 g. Use the density of aluminum to find the radius of the sphere in inches.

87. A backyard swimming pool holds 185 cu yd $\left(\text{yd}^3\right)$ of water. What is the mass of the water in pounds?

88. An iceberg has a volume of 7655 cu ft. What is the mass of the ice (in kg) composing the iceberg (at 0 °C)?

89. The Toyota Prius, a hybrid electric vehicle, has a U.S. Environmental Protection Agency (EPA) gas mileage rating of 52 mi/gal in the city. How many kilometers can the Prius travel on 15 L of gasoline?

90. The Honda Insight, a hybrid electric vehicle, has a U.S. Environmental Protection Agency (EPA) gas mileage rating of 57 mi/gal in the city. How many kilometers can the Insight travel on the amount of gasoline that would fit in a soda can? The volume of a soda can is 355 mL.

91. The single proton that forms the nucleus of the hydrogen atom has a radius of approximately 1.0×10^{-13} cm. The hydrogen atom itself has a radius of approximately 52.9 pm. What fraction of the space within the atom is occupied by the nucleus? (*Hint*: Start by calculating the volume of the nucleus and the volume of the atom.)

92. A sample of gaseous neon atoms at atmospheric pressure and 0 °C contains 2.69×10^{22} atoms per liter. The atomic radius of neon is 69 pm. What fraction of the space is occupied by the atoms themselves? What does this reveal about the separation between atoms in the gaseous phase? (*Hint*: Start by calculating the volume occupied by one atom and then multiply that by the number of atoms in 1 liter to get the volume occupied by the atoms themselves.)

93. The diameter of a hydrogen atom is 212 pm. Find the length in kilometers of a row of 6.02×10^{23} hydrogen atoms. The diameter of a ping pong ball is 4.0 cm. Find the length in kilometers of a row of 6.02×10^{23} ping pong balls.

94. The world's record in the 100-m dash is 9.58 s, and in the 100-yd dash it is 9.07 s. Find the speed in

mi/hr of the runners who set these records.

95. Table salt contains 39.33 g of sodium per 100 g of salt. The U.S. Food and Drug Administration (FDA) recommends that adults consume less than 2.40 g of sodium per day. A particular snack mix contains 1.25 g of salt per 100 g of the mix. What mass of the snack mix can an adult consume and not exceed the FDA limit?

96. Lead metal can be extracted from a mineral called galena, which contains 86.6% lead by mass. A particular ore contains 68.5% galena by mass. If the lead can be extracted with 92.5% efficiency, what mass of ore is required to make a lead sphere with a 5.00-cm radius?

97. A length of #8 copper wire ($\text{radius} = 1.63\ \text{mm}$) has a mass of 24.0 kg and a resistance of 2.061 ohm per km (Ω/km). What is the overall resistance of the wire? (*Hint*: Begin by using the mass and the density of copper to determine the volume of the wire and then use $\text{V} = \pi \cdot r^2 \cdot l$ to determine the length of the wire.)

98. Rolls of aluminum foil are 304 mm wide and 0.016 mm thick. What maximum length of aluminum foil can be made from 1.10 kg of aluminum?

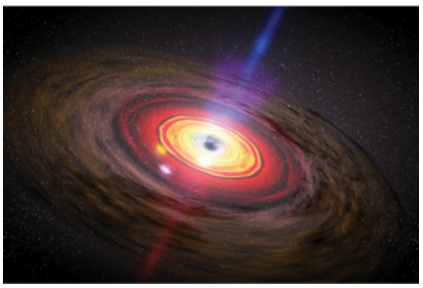
99. Liquid nitrogen has a density of 0.808 g/mL and boils at 77 K. Researchers often purchase liquid nitrogen in insulated 175-L tanks. The liquid vaporizes quickly to gaseous nitrogen (which has a density of 1.15 g/L at room temperature and atmospheric pressure) when the liquid is removed from the tank. Suppose that all 175 L of liquid nitrogen in a tank accidentally vaporized in a lab that measured $10.00\ \text{m} \times 10.00\ \text{m} \times 2.50\ \text{m}$. What maximum fraction of the air in the room could be displaced by the gaseous nitrogen?

100. Mercury is often used in thermometers. The mercury sits in a bulb on the bottom of the thermometer and rises up a thin capillary as the temperature rises. Suppose a mercury thermometer contains 3.380 g of mercury and has a capillary that is 0.200 mm in diameter. How far does the mercury rise in the capillary when the temperature changes from 0.0 °C to 25.0 °C? The density of mercury at these temperatures is $13.596\ \text{g/cm}^3$ and $13.534\ \text{g/cm}^3$, respectively.

101. Carbon-12 contains 6 protons and 6 neutrons. The radius of the nucleus is approximately 2.7 fm (femtometers), and the radius of the atom is approximately 70 pm (picometers). Calculate the volume of the nucleus and the volume of the atom. What percentage of the carbon atom's volume is occupied by the nucleus? (Assume two significant figures.)

Challenge Problems

102. In 1999, scientists discovered a new class of black holes with masses 100 to 10,000 times the mass of our sun that occupy less space than our moon. Suppose that one of these black holes has a mass of 1×10^3 suns and a radius equal to one-half the radius of our moon. What is the density of the black hole in g/cm^3? The radius of our sun is $7.0 \times 10^5\ \text{km}$, and it has an average density of $1.4 \times 10^3\ \text{kg/m}^3$. The diameter of the moon is 2.16×10^3 miles.



103. Polluted air can have carbon monoxide (CO) levels of 15.0 ppm. An average human inhales about 0.50 L of air per breath and takes about 20 breaths per minute. How many milligrams of carbon monoxide does the average person inhale in an 8-hour period in this level of carbon monoxide pollution? Assume that the carbon monoxide has a density of 1.2 g/L. (*Hint*: 15.0 ppm CO means 15.0 L CO per 10^6 L air.)

104. Nanotechnology, the field of building ultrasmall structures one atom at a time, has progressed in recent years. One potential application of nanotechnology is the construction of artificial cells. The simplest cells would probably mimic red blood cells, the body's oxygen transporters. Nanocontainers, perhaps constructed of carbon, could be pumped full of oxygen and injected into a person's

perhaps constructed of carbon, could be pumped full of oxygen and injected into a person's bloodstream. If the person needed additional oxygen—due to a heart attack or for the purpose of space travel, for example—these containers could slowly release oxygen into the blood, allowing tissues that would otherwise die to remain alive. Suppose that the nanocontainers were cubic and had an edge length of 25 nanometers.

a. What is the volume of one nanocontainer? (Ignore the thickness of the nanocontainer's wall.)

b. Suppose that each nanocontainer could contain pure oxygen pressurized to a density of 85g/L. How many grams of oxygen could be contained by each nanocontainer?

c. Air typically contains about 0.28 g of oxygen per liter. An average human inhales about 0.50 L of air per breath and takes about 20 breaths per minute. How many grams of oxygen does a human inhale per hour? (Assume two significant figures.)

d. What is the minimum number of nanocontainers that a person would need in his bloodstream to provide 1 hour's worth of oxygen?

e. What is the minimum volume occupied by the number of nanocontainers calculated in part d? Is such a volume feasible, given that total blood volume in an adult is about 5 L?

105. Determine the approximate percent increase in waist size that occurs when a 155-lb person gains 40.0 lb of fat. Assume that the volume of the person can be modeled by a cylinder that is 4.0 ft tall. The average density of a human is about $1.0\ \mathrm{g/cm^3}$, and the density of fat is $0.918\ \mathrm{g/cm^3}$.

106. A box contains a mixture of small copper spheres and small lead spheres. The total volume of both metals is measured by the displacement of water to be $427\ \mathrm{cm^3}$, and the total mass is 4.36 kg. What percentage of the spheres is copper?

Conceptual Problems

107. A cube has an edge length of 7 cm. If it is divided up into 1-cm cubes, how many 1-cm cubes are there?

108. Substance A has a density of $1.7\ \mathrm{g/cm^3}$. Substance B has a density of $1.7\ \mathrm{kg/m^3}$. Without doing any calculations, determine which substance is more dense.

109. For each box, examine the blocks attached to the balances. Based on their positions and sizes, determine which block is more dense (the dark block or the lighter-colored block), or if the relative densities cannot be determined. (Think carefully about the information being shown.)

a.

b.

c.

Questions for Group Work

Active Classroom Learning

Discuss these questions with the group and record your consensus answer.

110. Look up the measurement of the approximate thickness of a human hair.

a. Convert the measurement to an SI unit (if it isn't already).

b. Write it in scientific notation.

c. Write it without scientific notation.

d. Write it with an appropriate prefix on a base unit.

Now repeat these steps using the distance from Earth to the sun.

111. The following statements are all true.

a. Jessica's house is 5 km from the grocery store.

b. Jessica's house is 4.73 km from the grocery store.

c. Jessica's house is 4.73297 km from the grocery store.

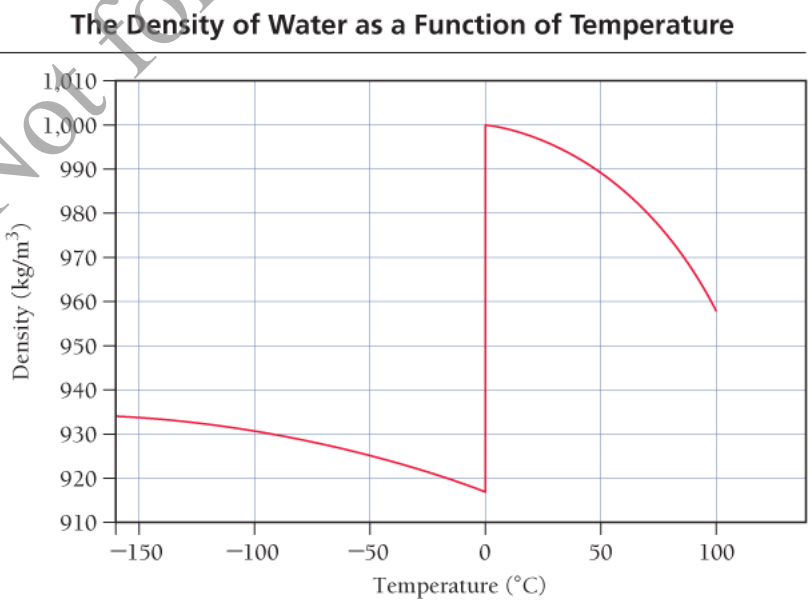
How can they all be true? What does the number of digits in each statement communicate? What sort of device would Jessica need to make the measurement in each statement?

112. One inch is equal to 2.54 cm. Draw a line that is 1 inch long, and mark the centimeters on the line. Draw a cube that is 1 inch on each side. Draw lines on each face of the cube that are 1 centimeter apart. How many cubic centimeters are there in 1 cubic inch?

113. Convert the height of each member in your group from feet and inches to meters. Once you have the heights in meters, calculate the sum of all the heights. Use appropriate rules for significant figures at each step.

Data Interpretation and Analysis

114. The density of a substance can change with temperature. The graph displays the density of water from –150 °C to 100 °C. Examine the graph and answer the questions.



a. Water undergoes a large change in density at 0 °C as it freezes to form ice. Calculate the percent change in density that occurs when liquid water freezes to ice at 0 °C.

(*Hint*: $\%\text{ change} = \frac{\text{final value} - \text{initial value}}{\text{initial value}} \times 100\%$)

b. Calculate the volume (in cm^3) of 54 g of water at 1 °C and the volume of the same mass of ice at –1 °C. What is the change in volume?

c. Antarctica contains 26.5 million cubic kilometers of ice. Assume the temperature of the ice is –20 °C. If all of this ice were heated to 1 °C and melted to form water, what volume of liquid water would form?

d. A 1.00-L sample of water is heated from 1 °C to 100 °C. What is the volume of the water after it is heated?

Answers to Conceptual Connections

Cc E.1 The prefix multiplier micro $\left(10^{-6}\right)$is appropriate. The measurement using this multiplier is 55.7 μm.

Cc E.2 **(c)** The sample expands. However, because its mass remains constant while its volume increases, its density decreases.

Cc E.3 Since burning natural gas gives off energy to the surroundings, the process is exothermic and the energy change is negative.

Cc E.4 **(b)** When we multiply a value in pound · second by $\frac{4.45\text{ newton} \cdot \text{second}}{1\text{ pound} \cdot \text{second}}$, the pound · second cancels and we get newton · second.