knowledge of metric prefixes, however, we have 1 km = 10^3 m and we can use this relationship between lengths to write the desired conversion factor between volumes:

$$\left(\frac{10^3\ \text{m}}{1\ \text{km}}\right)^3 = \frac{10^9\ \text{m}^3}{1\ \text{km}^3}$$

Thus, converting from km^3 to m^3 to L, we have

$$\text{Volume in liters} = (1.36 \times 10^9\ \text{km}^3)\left(\frac{10^9\ \text{m}^3}{1\ \text{km}^3}\right)\left(\frac{1\ \text{L}}{10^{-3}\ \text{m}^3}\right) = 1.36 \times 10^{21}\ \text{L}$$

PRACTICE EXERCISE

If the volume of an object is reported as 5.0 ft^3, what is the volume in cubic meters?
Answer: 0.14 m^3

Strategies in Chemistry THE IMPORTANCE OF PRACTICE

If you have ever played a musical instrument or participated in athletics, you know that the keys to success are practice and discipline. You cannot learn to play a piano merely by listening to music, and you cannot learn how to play basketball merely by watching games on television. Likewise, you cannot learn chemistry by merely watching your instructor do it. Simply reading this book, listening to lectures, or reviewing notes will not usually be sufficient when exam time comes around. Your task is not merely to understand how someone else uses chemistry, but to be able to do it yourself. That takes practice on a regular basis, and anything that you have to do on a regular basis requires self-discipline until it becomes a habit.

Throughout the book, we have provided sample exercises in which the solutions are shown in detail. A practice exercise, for which only the answer is given, accompanies each sample exercise. It is important that you use these exercises as learning aids. End-of-chapter exercises provide additional questions to help you understand the material in the chapter. Red numbers indicate exercises for which answers are given at the back of the book. A review of basic mathematics is given in Appendix A.

The practice exercises in this text and the homework assignments given by your instructor provide the minimal practice that you will need to succeed in your chemistry course. Only by working all the assigned problems will you face the full range of difficulty and coverage that your instructor expects you to master for exams. There is no substitute for a determined and perhaps lengthy effort to work problems on your own. If you are stuck on a problem, however, ask for help from your instructor, a teaching assistant, a tutor, or a fellow student. Spending an inordinate amount of time on a single exercise is rarely effective unless you know that it is particularly challenging and requires extensive thought and effort.

SAMPLE EXERCISE 1.12 | Conversions Involving Density

What is the mass in grams of 1.00 gal of water? The density of water is 1.00 g/mL.

SOLUTION

Before we begin solving this exercise, we note the following:

1. We are given 1.00 gal of water (the known, or given, quantity) and asked to calculate its mass in grams (the unknown).
2. We have the following conversion factors either given, commonly known, or available on the back inside cover of the text:

$$\frac{1.00\ \text{g water}}{1\ \text{mL water}} \quad \frac{1\ \text{L}}{1000\ \text{mL}} \quad \frac{1\ \text{L}}{1.057\ \text{qt}} \quad \frac{1\ \text{gal}}{4\ \text{qt}}$$

The first of these conversion factors must be used as written (with grams in the numerator) to give the desired result, whereas the last conversion factor must be inverted in order to cancel gallons:

$$\text{Mass in grams} = (1.00\ \text{gal})\left(\frac{4\ \text{qt}}{1\ \text{gal}}\right)\left(\frac{1\ \text{L}}{1.057\ \text{qt}}\right)\left(\frac{1000\ \text{mL}}{1\ \text{L}}\right)\left(\frac{1.00\ \text{g}}{1\ \text{mL}}\right)$$
$$= 3.78 \times 10^3\ \text{g water}$$

The units of our final answer are appropriate, and we've also taken care of our significant figures. We can further check our calculation by the estimation procedure. We can round 1.057 off to 1. Focusing on the numbers that do not equal 1 then gives merely 4 × 1000 = 4000 g, in agreement with the detailed calculation.

In cases such as this you may also be able to use common sense to assess the reasonableness of your answer. In this case we know that most people can lift a gallon of milk with one hand, although it would be tiring to carry it around all day. Milk is mostly water and will have a density that is not too different than water. Therefore, we might estimate that in familiar units a gallon of water would have mass that was more than 5 lbs but less than 50 lbs. The mass we have calculated is 3.78 kg × 2.2 lb/kg = 8.3 lbs—an answer that is reasonable at least as an order of magnitude estimate.

PRACTICE EXERCISE

The density of benzene is 0.879 g/mL. Calculate the mass in grams of 1.00 qt of benzene.
Answer: 832 g

CHAPTER REVIEW

Following each chapter you will find a summary that highlights important content of the chapter. The summary contains all the key terms from the chapter in their contexts. A list of key skills and key equations follows the summary. These review materials are important tools to help you prepare for exams.

SUMMARY AND KEY TERMS

Introduction and Section 1.1 **Chemistry** is the study of the composition, structure, properties, and changes of matter. The composition of matter relates to the kinds of **elements** it contains. The structure of matter relates to the ways the **atoms** of these elements are arranged. A **property** is any characteristic that gives a sample of matter its unique identity. A **molecule** is an entity composed of two or more atoms with the atoms attached to one another in a specific way.

Section 1.2 Matter exists in three physical states, **gas, liquid**, and **solid**, which are known as the **states of matter**. There are two kinds of **pure substances**: **elements** and **compounds**. Each element has a single kind of atom and is represented by a chemical symbol consisting of one or two letters, with the first letter capitalized. Compounds are composed of two or more elements joined chemically. The **law of constant composition**, also called the **law of definite proportions**, states that the elemental composition of a pure compound is always the same. Most matter consists of a mixture of substances. **Mixtures** have variable compositions and can be either homogeneous or heterogeneous; homogeneous mixtures are called **solutions**.

Section 1.3 Each substance has a unique set of **physical properties** and **chemical properties** that can be used to identify it. During a **physical change**, matter does not change its composition. **Changes of state** are physical changes. In a **chemical change (chemical reaction)** a substance is transformed into a chemically different substance. **Intensive properties** are independent of the amount of matter examined and are used to identify substances. **Extensive properties** relate to the amount of substance present. Differences in physical and chemical properties are used to separate substances.

The **scientific method** is a dynamic process used to answer questions about our physical world. Observations and experiments lead to **scientific laws**, general rules that summarize how nature behaves. Observations also lead to tentative explanations or **hypotheses**. As a hypothesis is tested and refined, a **theory** may be developed.

Section 1.4 Measurements in chemistry are made using the **metric system**. Special emphasis is placed on a particular set of metric units called **SI units**, which are based on the meter, the kilogram, and the second as the basic units of length, **mass**, and time, respectively. The metric system employs a set of prefixes to indicate decimal fractions or multiples of the base units. The SI temperature scale is the **Kelvin scale**, although the **Celsius scale** is frequently used as well. **Density** is an important property that equals mass divided by volume.

Section 1.5 All measured quantities are inexact to some extent. The **precision** of a measurement indicates how closely different measurements of a quantity agree with one another. The **accuracy** of a measurement indicates how well a measurement agrees with the accepted or "true" value. The **significant figures** in a measured quantity include one estimated digit, the last digit of the measurement. The significant figures indicate the extent of the uncertainty of the measurement. Certain rules must be followed so that a calculation involving measured quantities is reported with the appropriate number of significant figures.

Section 1.6 In the **dimensional analysis** approach to problem solving, we keep track of units as we carry measurements through calculations. The units are multiplied together, divided into each other, or canceled like algebraic quantities. Obtaining the proper units for the final result is an important means of checking the method of calculation. When converting units and when carrying out several other types of problems, **conversion factors** can be used. These factors are ratios constructed from valid relations between equivalent quantities.

KEY SKILLS

- Distinguish among elements, compounds, and mixtures.
- Memorize symbols of common elements and common metric prefixes.
- Use significant figures, scientific notation, metric units, and dimensional analysis in calculations.

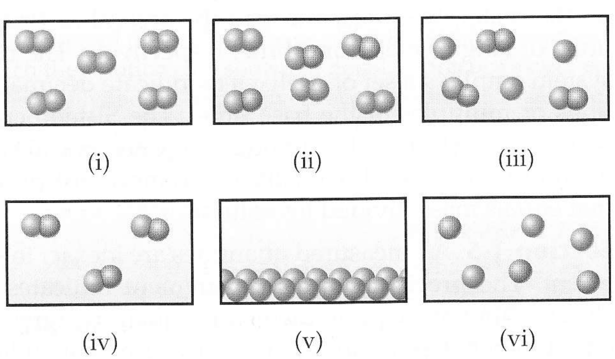
KEY EQUATIONS

- $K = {}^\circ C + 273.15$ [1.1] — Interconverting between Celsius (°C) and Kelvin (K) temperatures scales
- $^\circ C = \frac{5}{9}(^\circ F - 32)$ or $^\circ F = \frac{9}{5}(^\circ C) + 32$ [1.2] — Interconverting between Celsius (°C) and Fahrenheit (°F) temperature scales
- $\text{Density} = \frac{\text{mass}}{\text{volume}}$ [1.3] — Definition of density

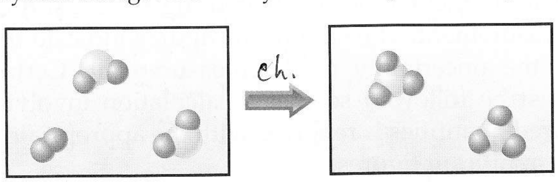
VISUALIZING CONCEPTS

The exercises in this section are intended to probe your understanding of key concepts rather than your ability to utilize formulas and perform calculations. Those exercises with red exercise numbers have answers in the back of the book.

1.1 Which of the following figures represents **(a)** a pure element, **(b)** a mixture of two elements, **(c)** a pure compound, **(d)** a mixture of an element and a compound? (More than one picture might fit each description.) [Section 1.2]
CQ



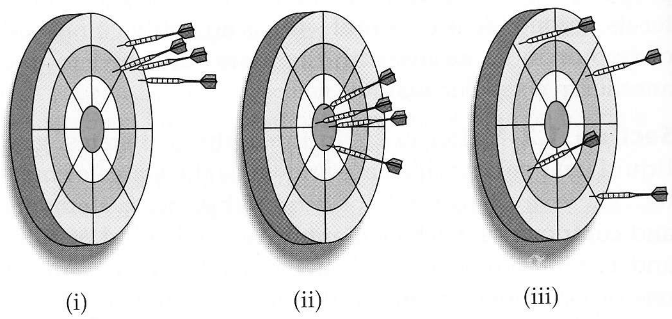
1.2 Does the following diagram represent a chemical or physical change? How do you know? [Section 1.3]
CQ



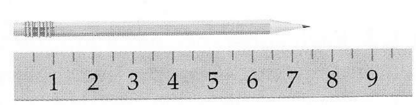
1.3 Identify each of the following as measurements of length, area, volume, mass, density, time, or temperature: **(a)** 5 ns, **(b)** 5.5 kg/m^3, **(c)** 0.88 pm, **(d)** 540 km^2, **(e)** 173 K, **(f)** 2 mm^3, **(g)** 23 °C. [Section 1.4]
CQ

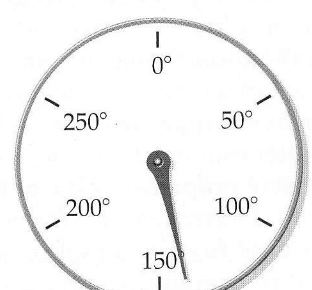
1.4 Three spheres of equal size are composed of aluminum (density = 2.70 g/cm^3), silver (density = 10.49 g/cm^3), and nickel (density = 8.90 g/cm^3). List the spheres from lightest to heaviest.

1.5 The following dartboards illustrate the types of errors often seen when one measurement is repeated several times. The bull's-eye represents the "true value," and the darts represent the experimental measurements. Which board best represents each of the following scenarios: **(a)** measurements both accurate and precise, **(b)** measurements precise but inaccurate, **(c)** measurements imprecise but yield an accurate average? [Section 1.5]
CQ



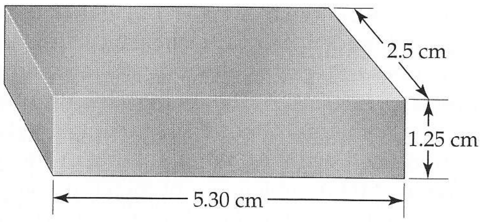
1.6 **(a)** What is the length of the pencil in the following figure if the scale reads in centimeters? How many significant figures are there in this measurement? **(b)** An oven thermometer with a circular scale reading degrees Fahrenheit is shown. What temperature does the scale indicate? How many significant figures are in the measurement? [Section 1.5]
CQ





1.7 What is wrong with the following statement? Twenty
CQ years ago an ancient artifact was determined to be 1900 years old. It must now be 1920 years old. [Section 1.5]

1.8 **(a)** How many significant figures should be reported for
CQ the volume of the metal bar shown below? **(b)** If the mass of the bar is 104.7 g, how many significant figures should be reported when its density is calculated using the calculated volume? [Section 1.5]



1.9 When you convert units, how do you decide which part
CQ of the conversion factor is in the numerator and which is in the denominator? [Section 1.6]

1.10 Draw a logic map indicating the steps you would take
CQ to convert miles per hour to kilometers per second. Write down the conversion factor for each step, as done in the diagram on page 26. [Section 1.6]

1.10 $\frac{mi}{hr} \cdot \frac{km}{0.62\,mi} \cdot \frac{hr}{60\,min} \cdot \frac{min}{60\,s} = \frac{km}{s}$

EXERCISES

Classification and Properties of Matter

The following exercises are divided into sections that deal with specific topics in the chapter. These exercises are grouped in pairs, with the answer given in the back of the book to the odd-numbered exercise, as indicated by the red exercise number. Those exercises whose number appears in brackets are more challenging than the nonbracketed exercises.

1.11 Classify each of the following as a pure substance or a mixture. If a mixture, indicate whether it is homogeneous or heterogeneous: **(a)** rice pudding, **(b)** seawater, **(c)** magnesium, **(d)** gasoline.

1.12 Classify each of the following as a pure substance or a mixture. If a mixture, indicate whether it is homogeneous or heterogeneous: **(a)** air, **(b)** tomato juice, **(c)** iodine crystals, **(d)** sand.

1.13 Give the chemical symbol or name for the following elements, as appropriate: **(a)** sulfur, **(b)** magnesium, **(c)** potassium, **(d)** chlorine, **(e)** copper, **(f)** F, **(g)** Ni, **(h)** Na, **(i)** Al, **(j)** Si.

1.14 Give the chemical symbol or name for each of the following elements, as appropriate: **(a)** carbon, **(b)** nitrogen, **(c)** bromine, **(d)** zinc, **(e)** iron, **(f)** P, **(g)** Ca, **(h)** He, **(i)** Pb, **(j)** Ag.

1.15 A solid white substance A is heated strongly in the ab-
CQ sence of air. It decomposes to form a new white substance B and a gas C. The gas has exactly the same properties as the product obtained when carbon is burned in an excess of oxygen. Based on these observations, can we determine whether solids A and B and the gas C are elements or compounds? Explain your conclusions for each substance.

1.16 In 1807 the English chemist Humphry Davy passed an
CQ electric current through molten potassium hydroxide and isolated a bright, shiny reactive substance. He claimed the discovery of a new element, which he named potassium. In those days, before the advent of modern instruments, what was the basis on which one could claim that a substance was an element?

1.17 In the process of attempting to characterize a substance,
CQ a chemist makes the following observations: The substance is a silvery white, lustrous metal. It melts at 649 °C and boils at 1105 °C. Its density at 20 °C is 1.738 g/cm^3. The substance burns in air, producing an intense white light. It reacts with chlorine to give a brittle white solid. The substance can be pounded into thin sheets or drawn into wires. It is a good conductor of electricity. Which of these characteristics are physical properties, and which are chemical properties?

1.18 Read the following description of the element zinc, and
CQ indicate which are physical properties and which are chemical properties. Zinc is a silver–gray-colored metal that melts at 420 °C. When zinc granules are added to dilute sulfuric acid, hydrogen is given off and the metal dissolves. Zinc has a hardness on the Mohs scale of 2.5 and a density of 7.13 g/cm^3 at 25 °C. It reacts slowly with oxygen gas at elevated temperatures to form zinc oxide, ZnO.

1.19 Label each of the following as either a physical process
CQ or a chemical process: **(a)** corrosion of aluminum metal, **(b)** melting of ice, **(c)** pulverizing an aspirin, **(d)** digesting a candy bar, **(e)** explosion of nitroglycerin.

1.20 A match is lit and held under a cold piece of metal. The
CQ following observations are made: **(a)** The match burns. **(b)** The metal gets warmer. **(c)** Water condenses on the metal. **(d)** Soot (carbon) is deposited on the metal. Which of these occurrences are due to physical changes, and which are due to chemical changes?

1.21 Suggest a method of separating each of the following
CQ mixtures into two components: **(a)** sugar and sand, **(b)** iron and sulfur.

1.22 A beaker contains a clear, colorless liquid. If it is water,
CQ how could you determine whether it contained dissolved table salt? Do *not* taste it!

Units and Measurement

1.23 What exponential notation do the following abbreviations represent: **(a)** d, **(b)** c, **(c)** f, **(d)** μ, **(e)** M, **(f)** k, **(g)** n, **(h)** m, **(i)** p?

1.24 Use appropriate metric prefixes to write the following measurements without use of exponents: **(a)** 6.35×10^{-2} L, **(b)** 6.5×10^{-6} s, **(c)** 9.5×10^{-4} m, **(d)** 4.23×10^{-9} m^3, **(e)** 12.5×10^{-8} kg, **(f)** 3.5×10^{-10} g, **(g)** 6.54×10^9 fs.

1.25 Make the following conversions: **(a)** 62 °F to °C, **(b)** 216.7 °C to °F, **(c)** 233 °C to K, **(d)** 315 K to °F, **(e)** 2500 °F to K.

1.26 **(a)** The temperature on a warm summer day is 87 °F. What is the temperature in °C? **(b)** Many scientific data are reported at 25 °C. What is this temperature in kelvins and in degrees Fahrenheit? **(c)** Suppose that a recipe calls for an oven temperature of 175 °F. Convert this temperature to degrees Celsius and to kelvins. **(d)** The melting point of sodium bromide (a salt) is 755 °C. Calculate this temperature in °F and in kelvins. **(e)** Neon, a gaseous element at room temperature, is used to make electronic signs. Neon has a melting point of −248.6 °C and a boiling point of −246.1 °C. Convert these temperatures to kelvins.

1.27 **(a)** A sample of carbon tetrachloride, a liquid once used in dry cleaning, has a mass of 39.73 g and a volume of 25.0 mL at 25 °C. What is its density at this temperature? Will carbon tetrachloride float on water? (Materials that are less dense than water will float.) **(b)** The density of platinum is 21.45 g/cm^3 at 20 °C. Calculate the mass of 75.00 cm^3 of platinum at this temperature. **(c)** The density of magnesium is 1.738 g/cm^3 at 20 °C. What is the volume of 87.50 g of this metal at this temperature?

1.28 **(a)** A cube of osmium metal 1.500 cm on a side has a mass of 76.31 g at 25 °C. What is its density in g/cm^3 at this temperature? **(b)** The density of titanium metal is 4.51 g/cm^3 at 25 °C. What mass of titanium displaces 125.0 mL of water at 25 °C? **(c)** The density of benzene at 15 °C is 0.8787 g/mL. Calculate the mass of 0.1500 L of benzene at this temperature.

1.29 **(a)** To identify a liquid substance, a student determined its density. Using a graduated cylinder, she measured out a 45-mL sample of the substance. She then measured the mass of the sample, finding that it weighed 38.5 g. She knew that the substance had to be either isopropyl alcohol (density 0.785 g/mL) or toluene (density 0.866 /mL). What are the calculated density and the probable identity of the substance? **(b)** An experiment requires 45.0 g of ethylene glycol, a liquid whose density is 1.114 g/mL. Rather than weigh the sample on a balance, a chemist chooses to dispense the liquid using a graduated cylinder. What volume of the liquid should he use? **(c)** A cubic piece of metal measures 5.00 cm on each edge. If the metal is nickel, whose density is 8.90 g/cm^3, what is the mass of the cube?

1.30 **(a)** After the label fell off a bottle containing a clear liquid believed to be benzene, a chemist measured the density of the liquid to verify its identity. A 25.0-mL portion of the liquid had a mass of 21.95 g. A chemistry handbook lists the density of benzene at 15 °C as 0.8787 g/mL. Is the calculated density in agreement with the tabulated value? **(b)** An experiment requires 15.0 g of cyclohexane, whose density at 25 °C is 0.7781 g/mL. What volume of cyclohexane should be used? **(c)** A spherical ball of lead has a diameter of 5.0 cm. What is the mass of the sphere if lead has a density of 11.34 g/cm^3? (The volume of a sphere is $(\frac{4}{3})\pi r^3$ where r is the radius.)

1.31 Gold can be hammered into extremely thin sheets called gold leaf. If a 200-mg piece of gold (density = 19.32 g/cm^3) is hammered into a sheet measuring 2.4 × 1.0 ft, what is the average thickness of the sheet in meters? How might the thickness be expressed without exponential notation, using an appropriate metric prefix?

1.32 A cylindrical rod formed from silicon is 16.8 cm long and has a mass of 2.17 kg. The density of silicon is 2.33 g/cm^3. What is the diameter of the cylinder? (The volume of a cylinder is given by $\pi r^2 h$, where r is the radius, and h is its length.)

Uncertainty in Measurement

1.33 Indicate which of the following are exact numbers:
CQ **(a)** the mass of a paper clip, **(b)** the surface area of a dime, **(c)** the number of inches in a mile, **(d)** the number of ounces in a pound, **(e)** the number of microseconds in a week, **(f)** the number of pages in this book.

1.34 Indicate which of the following are exact numbers:
CQ **(a)** the mass of a 32-oz can of coffee, **(b)** the number of students in your chemistry class, **(c)** the temperature of the surface of the sun, **(d)** the mass of a postage stamp, **(e)** the number of milliliters in a cubic meter of water, **(f)** the average height of students in your school.

1.35 What is the number of significant figures in each of the following measured quantities? **(a)** 358 kg, **(b)** 0.054 s, **(c)** 6.3050 cm, **(d)** 0.0105 L, **(e)** 7.0500×10^{-3} m^3.

1.36 Indicate the number of significant figures in each of the following measured quantities: **(a)** 3.774 km, **(b)** 205 m^2, **(c)** 1.700 cm, **(d)** 350.00 K, **(e)** 307.080 g.

1.37 Round each of the following numbers to four significant figures, and express the result in standard exponential notation: **(a)** 102.53070, **(b)** 656,980, **(c)** 0.008543210, **(d)** 0.000257870, **(e)** −0.0357202.

1.38 **(a)** The diameter of Earth at the equator is 7926.381 mi. Round this number to three significant figures, and express it in standard exponential notation. **(b)** The circumference of Earth through the poles is 40,008 km. Round this number to four significant figures, and express it in standard exponential notation.

1.39 Carry out the following operations, and express the answers with the appropriate number of significant figures.
(a) 12.0550 + 9.05
(b) 257.2 − 19.789
(c) (6.21×10^3) (0.1050)
(d) 0.0577/0.753

1.40 Carry out the following operations, and express the answer with the appropriate number of significant figures.
(a) 320.5 − (6104.5/2.3)
(b) $[(285.3 \times 10^5) - (1.200 \times 10^3)] \times 2.8954$
(c) $(0.0045 \times 20{,}000.0) + (2813 \times 12)$
(d) $863 \times [1255 - (3.45 \times 108)]$

Dimensional Analysis

1.41 Using your knowledge of metric units, English units, and the information on the back inside cover, write down the conversion factors needed to convert **(a)** mm to nm, **(b)** mg to kg, **(c)** km to ft, **(d)** in.^3 to cm^3.

1.42 Using your knowledge of metric units, English units, and the information on the back inside cover, write down the conversion factors needed to convert **(a)** μm to mm, **(b)** ms to ns, **(c)** mi to km, **(d)** ft^3 to L.

1.43 Perform the following conversions: **(a)** 0.076 L to mL, **(b)** 5.0×10^{-8} m to nm, **(c)** 6.88×10^5 ns to s, **(d)** 0.50 lb to g, **(e)** 1.55 kg/m^3 to g/L, **(f)** 5.850 gal/hr to L/s.

1.44 **(a)** The speed of light in a vacuum is 2.998×10^8 m/s. Calculate its speed in km/hr. **(b)** The Sears Tower in Chicago is 1454 ft tall. Calculate its height in meters. **(c)** The Vehicle Assembly Building at the Kennedy Space Center in Florida has a volume of 3,666,500 m^3. Convert this volume to liters, and express the result in standard exponential notation. **(d)** An individual suffering from a high cholesterol level in her blood has 232 mg of cholesterol per 100 mL of blood. If the total blood volume of the individual is 5.2 L, how many grams of total blood cholesterol does the individual's body contain?

1.45 Perform the following conversions: **(a)** 5.00 days to s, **(b)** 0.0550 mi to m, **(c)** \$1.89/gal to dollars per liter, **(d)** 0.510 in./ms to km/hr, **(e)** 22.50 gal/min to L/s, **(f)** 0.02500 ft^3 to cm^3.

1.46 Carry out the following conversions: **(a)** 0.105 in. to mm, **(b)** 0.650 qt to mL, **(c)** 8.75 μm/s to km/hr, **(d)** 1.955 m^3 to yd^3, **(e)** \$3.99/lb to dollars per kg, **(f)** 8.75 lb/ft^3 to g/mL.

1.47 **(a)** How many liters of wine can be held in a wine barrel whose capacity is 31 gal? **(b)** The recommended adult dose of Elixophyllin®, a drug used to treat asthma, is 6 mg/kg of body mass. Calculate the dose in milligrams for a 150-lb person. **(c)** If an automobile is able to travel 254 mi on 11.2 gal of gasoline, what is the gas mileage in km/L? **(d)** A pound of coffee beans yields 50 cups of coffee (4 cups = 1 qt). How many milliliters of coffee can be obtained from 1 g of coffee beans?

1.48 **(a)** If an electric car is capable of going 225 km on a single charge, how many charges will it need to travel from Boston, Massachusetts, to Miami, Florida, a distance of 1486 mi, assuming that the trip begins with a full charge? **(b)** If a migrating loon flies at an average speed of 14 m/s, what is its average speed in mi/hr? **(c)** What is the engine piston displacement in liters of an engine whose displacement is listed as 450 in.^3? **(d)** In March 1989 the *Exxon Valdez* ran aground and spilled 240,000 barrels of crude petroleum off the coast of Alaska. One barrel of petroleum is equal to 42 gal. How many liters of petroleum were spilled?

1.49 The density of air at ordinary atmospheric pressure and 25 °C is 1.19 g/L. What is the mass, in kilograms, of the air in a room that measures $12.5 \times 15.5 \times 8.0$ ft?

1.50 The concentration of carbon monoxide in an urban apartment is 48 $\mu\text{g/m}^3$. What mass of carbon monoxide in grams is present in a room measuring $9.0 \times 14.5 \times 18.8$ ft?

1.51 By using estimation techniques, arrange these items in order from shortest to longest: a 57-cm length of string, a 14-in. long shoe, and a 1.1-m length of pipe.

1.52 By using estimation techniques, determine which of the following is the heaviest and which is the lightest: a 5-lb bag of potatoes, a 5-kg bag of sugar, or 1 gal of water (density = 1.0 g/mL).

1.53 The Morgan silver dollar has a mass of 26.73 g. By law, it was required to contain 90% silver, with the remainder being copper. **(a)** When the coin was minted in the late 1800s, silver was worth \$1.18 per troy ounce (31.1 g). At this price, what is the value of the silver in the silver dollar? **(b)** Today, silver sells for about \$13.25 per troy ounce. How many Morgan silver dollars are required to obtain \$25.00 worth of pure silver?

1.54 A copper refinery produces a copper ingot weighing 150 lb. If the copper is drawn into wire whose diameter is 8.25 mm, how many feet of copper can be obtained from the ingot? The density of copper is 8.94 g/cm^3 (Assume that the wire is a cylinder whose volume is $V = \pi r^2 h$, where r is its radius and h is its height or length.)

ADDITIONAL EXERCISES

The exercises in this section are not divided by category, although they are roughly in the order of the topics in the chapter. They are not paired.

1.55 What is meant by the terms composition and structure when referring to matter?

1.56 **(a)** Classify each of the following as a pure substance, a
CQ solution, or a heterogeneous mixture: a gold coin, a cup of coffee, a wood plank. **(b)** What ambiguities are there in answering part (a) from the descriptions given?

1.57 **(a)** What is the difference between a hypothesis and a theory? **(b)** Explain the difference between a theory and a scientific law. Which addresses how matter behaves, and which addresses why it behaves that way?

1.58 A sample of ascorbic acid (vitamin C) is synthesized in
CQ the laboratory. It contains 1.50 g of carbon and 2.00 g of

oxygen. Another sample of ascorbic acid isolated from citrus fruits contains 6.35 g of carbon. How many grams of oxygen does it contain? Which law are you assuming in answering this question?

1.59 CQ Two students determine the percentage of lead in a sample as a laboratory exercise. The true percentage is 22.52%. The students' results for three determinations are as follows:

1. 22.52, 22.48, 22.54
2. 22.64, 22.58, 22.62

(a) Calculate the average percentage for each set of data, and tell which set is the more accurate based on the average. **(b)** Precision can be judged by examining the average of the deviations from the average value for that data set. (Calculate the average value for each data set, then calculate the average value of the absolute deviations of each measurement from the average.) Which set is more precise?

1.60 Is the use of significant figures in each of the following statements appropriate? Why or why not? **(a)** The 2005 circulation of *National Geographic* was 7,812,564. **(b)** On July 1, 2005, the population of Cook County, Illinois, was 5,303,683. **(c)** In the United States, 0.621% of the population has the surname Brown.

1.61 What type of quantity (for example, length, volume, density) do the following units indicate: **(a)** mL, **(b)** cm^2, **(c)** mm^3, **(d)** mg/L, **(e)** ps, **(f)** nm, **(g)** K?

1.62 CQ Give the derived SI units for each of the following quantities in base SI units: **(a)** acceleration = distance/time^2; **(b)** force = mass × acceleration; **(c)** work = force × distance; **(d)** pressure = force/area; **(e)** power = work/time.

1.63 The distance from Earth to the Moon is approximately 240,000 mi. **(a)** What is this distance in meters? **(b)** The peregrine falcon has been measured as traveling up to 350 km/hr in a dive. If this falcon could fly to the Moon at this speed, how many seconds would it take?

1.64 The US quarter has a mass of 5.67 g and is approximately 1.55 mm thick. **(a)** How many quarters would have to be stacked to reach 575 ft, the height of the Washington Monument? **(b)** How much would this stack weigh? **(c)** How much money would this stack contain? **(d)** At the beginning of 2007, the national debt was $8.7 trillion. How many stacks like the one described would be necessary to pay off this debt?

1.65 In the United States, water used for irrigation is measured in acre-feet. An acre-foot of water covers an acre to a depth of exactly 1 ft. An acre is 4840 yd^2. An acre-foot is enough water to supply two typical households for 1.00 yr. **(a)** If desalinated water costs $1950 per acre-foot, how much does desalinated water cost per liter? **(b)** How much would it cost one household per day if it were the only source of water?

1.66 CQ Suppose you decide to define your own temperature scale using the freezing point (−11.5 °C) and boiling point (197.6 °C) of ethylene glycol. If you set the freezing point as 0 °G and the boiling point as 100 °G, what is the freezing point of water on this new scale?

1.67 CQ The liquid substances mercury (density = 13.5 g/mL), water (1.00 g/mL), and cyclohexane (0.778 g/mL) do not form a solution when mixed, but separate in distinct layers. Sketch how the liquids would position themselves in a test tube.

1.68 CQ Small spheres of equal mass are made of lead (density = 11.3 g/cm^3), silver (10.5 g/cm^3), and aluminum (2.70 g/cm^3). Without doing a calculation, list the spheres in order from the smallest to the largest.

1.69 Water has a density of 0.997 g/cm^3 at 25 °C; ice has a density of 0.917 g/cm^3 at −10 °C. **(a)** If a soft-drink bottle whose volume is 1.50 L is completely filled with water and then frozen to −10 °C, what volume does the ice occupy? **(b)** Can the ice be contained within the bottle?

1.70 A 32.65-g sample of a solid is placed in a flask. Toluene, in which the solid is insoluble, is added to the flask so that the total volume of solid and liquid together is 50.00 mL. The solid and toluene together weigh 58.58 g. The density of toluene at the temperature of the experiment is 0.864 g/mL. What is the density of the solid?

1.71 **(a)** You are given a bottle that contains 4.59 cm^3 of a metallic solid. The total mass of the bottle and solid is 35.66 g. The empty bottle weighs 14.23 g. What is the density of the solid? **(b)** Mercury is traded by the "flask," a unit that has a mass of 34.5 kg. What is the volume of a flask of mercury if the density of mercury is 13.5 g/mL? **(c)** A thief plans to steal a gold sphere with a radius of 28.9 cm from a museum. If the gold has a density of 19.3 g/cm^3 what is the mass of the sphere? [The volume of a sphere is $V = (4/3)\pi r^3$.] Is he likely to be able to walk off with it unassisted?

1.72 Automobile batteries contain sulfuric acid, which is commonly referred to as "battery acid." Calculate the number of grams of sulfuric acid in 0.500 L of battery acid if the solution has a density of 1.28 g/mL and is 38.1% sulfuric acid by mass.

1.73 A 40-lb container of peat moss measures 14 × 20 × 30 in. A 40-lb container of topsoil has a volume of 1.9 gal. **(a)** Calculate the average densities of peat moss and topsoil in units of g/cm^3. Would it be correct to say that peat moss is "lighter" than topsoil? Explain. **(b)** How many bags of the peat moss are needed to cover an area measuring 10. ft by 20. ft to a depth of 2.0 in.?

1.74 A coin dealer offers to sell you an ancient gold coin that is 2.2 cm in diameter and 3.0 mm in thickness. **(a)** The density of gold is 19.3 g/cm^3. How much should the coin weigh if it is pure gold? **(b)** If gold sells for $640 per troy ounce, how much is the gold content worth? (1 troy ounce = 31.1 g).

1.75 A package of aluminum foil contains 50 ft^2 of foil, which weighs approximately 8.0 oz. Aluminum has a density of 2.70 g/cm^3. What is the approximate thickness of the foil in millimeters?

1.76 A 15.0-cm long cylindrical glass tube, sealed at one end, is filled with ethanol. The mass of ethanol needed to fill the tube is found to be 11.86 g. The density of ethanol is 0.789 g/mL. Calculate the inner diameter of the tube in centimeters.

1.77 Gold is alloyed (mixed) with other metals to increase its hardness in making jewelry. **(a)** Consider a piece of gold jewelry that weighs 9.85 g and has a volume of

$0.675\ cm^3$. The jewelry contains only gold and silver, which have densities of $19.3\ g/cm^3$ and $10.5\ g/cm^3$, respectively. If the total volume of the jewelry is the sum of the volumes of the gold and silver that it contains, calculate the percentage of gold (by mass) in the jewelry. (b) The relative amount of gold in an alloy is commonly expressed in units of karats. Pure gold is 24-karat, and the percentage of gold in an alloy is given as a percentage of this value. For example, an alloy that is 50% gold is 12-karat. State the purity of the gold jewelry in karats.

1.78 CQ Suppose you are given a sample of a homogeneous liquid. What would you do to determine whether it is a solution or a pure substance?

1.79 CQ Chromatography (Figure 1.14) is a simple, but reliable, method for separating a mixture into its constituent substances. Suppose you are using chromatography to separate a mixture of two substances. How would you know whether the separation is successful? Can you propose a means of quantifying how good or how poor the separation is?

1.80 CQ You are assigned the task of separating a desired granular material, with a density of $3.62\ g/cm^3$, from an undesired granular material that has a density of $2.04\ g/cm^3$. You want to do this by shaking the mixture in a liquid in which the heavier material will fall to the bottom and the lighter material will float. A solid will float on any liquid that is more dense. Using the internet or a handbook of chemistry, find the densities of the following substances: carbon tetrachloride, hexane, benzene, and methylene iodide. Which of these liquids will serve your purpose, assuming no chemical interaction between the liquid and the solids?

1.81 In 2006, Professor Galen Suppes, from the University of Missouri-Columbia, was awarded a Presidential Green Challenge Award for his system of converting glycerin, $C_3H_5(OH)_3$, a by-product of biodiesel production, to propylene glycol, $C_3H_6(OH)_2$. Propylene glycol produced in this way will be cheap enough to replace the more toxic ethylene glycol that is the primary ingredient in automobile antifreeze. **(a)** If 50.0 mL of propylene glycol has a mass of 51.80 g, what is its density? **(b)** To obtain the same antifreeze protection requires 76 g of propylene glycol to replace each 62 g of ethylene glycol. Calculate the mass of propylene glycol required to replace 1.00 gal of ethylene glycol. The density of ethylene glycol is 1.12 g/mL. **(c)** Calculate the volume of propylene glycol, in gallons, needed to produce the same antifreeze protection as 1.00 gallon of ethylene glycol.

1.82 CQ The concepts of accuracy and precision are not always easy to grasp. Here are two sets of studies: **(a)** The mass of a secondary weight standard is determined by weighing it on a very precise balance under carefully controlled laboratory conditions. The average of 18 different weight measurements is taken as the weight of the standard. **(b)** A group of 10,000 males between the ages of 50 and 55 is surveyed to ascertain a relationship between calorie intake and blood cholesterol level. The survey questionnaire is quite detailed, asking the respondents about what they eat, smoking and drinking habits, and so on. The results are reported as showing that for men of comparable lifestyles, there is a 40% chance of the blood cholesterol level being above 230 for those who consume more than 40 calories per gram of body weight per day, as compared with those who consume fewer than 30 calories per gram of body weight per day.

Discuss and compare these two studies in terms of the precision and accuracy of the result in each case. How do the two studies differ in nature in ways that affect the accuracy and precision of the results? What makes for high precision and accuracy in any given study? In each of these studies, what factors might not be controlled that could affect the accuracy and precision? What steps can be taken generally to attain higher precision and accuracy?