QUICK QUIZ

Choose the best answer to each of the following questions. Explain your reasoning with one or more complete sentences.

1. One kilometer is
   a. 10 meters.
   b. 100 meters.
   c. 1000 meters.
2. A megaton is
   a. 100 tons.
   b. 1000 tons.
   c. 1 million tons.
3. A millimeter is approximately the size of
   a. the ball point in a pen.
   b. a golf ball.
   c. a basketball.
4. You are buying apples while traveling in Europe. The price is most likely to be quoted in
   a. euros per kilogram.
   b. euros per milliliter.
   c. euros per kilometer.
5. A liter is approximately equivalent to
   a. a mile.
   b. a pound.
   c. a quart.
6. A temperature of 105°C is
   a. typical of Phoenix in the summer.
   b. typical of Antarctica in the winter.
   c. hot enough to boil water.
7. Which of the following is *not* a unit of energy?
   a. joules
   b. watts
   c. kilowatt-hours
8. You want to know how much total energy is required to operate a 100-watt light bulb. Do you need any more information?
   a. No.
   b. Yes; you need to know the temperature of the light bulb when it is on.
   c. Yes; you need to know how long the light bulb is on.
9. New Mexico has a population density of about 12 people per square mile and an area of about 120,000 square miles. To find its actual population, you should
   a. multiply the population density by the area.
   b. divide the population density by the area.
   c. divide the area by the population density.
10. The concentration of carbon dioxide in Earth's atmosphere might be stated in
    a. grams per meter.
    b. parts per million.
    c. joules per watt.

Exercises 2B

REVIEW QUESTIONS

1. Briefly describe the origin and use of common units in the U.S. customary system.
2. Briefly describe the origin and use of metric units.
3. What are the basic metric units of length, mass, time, and volume? How are the metric prefixes used?
4. Using examples, show how to convert among the Fahrenheit, Celsius, and Kelvin temperature scales.
5. What is *energy*? List at least three common units of energy. Under what circumstances do the different units tend to be used?
6. What is the difference between *energy* and *power*? What are the standard units for power?
7. What do we mean by *density*? What do we mean by *concentration*? Describe common units of density and concentration, including blood alcohol content, with examples.

DOES IT MAKE SENSE?

Decide whether each of the following statements makes sense (or is clearly true) or does not make sense (or is clearly false). Explain your reasoning. Hint: Be sure to consider whether the units are appropriate to the statement, as well as whether the stated amount makes any sense. For example, a statement that someone is 15 feet tall uses the units (feet) appropriately, but does not make sense because no one is that tall.

8. I drank 2 liters of water today.
9. I know a professional bicyclist who weighs 300 kilograms.
10. I drove along the highway at 100 kilometers per hour.
11. I know someone who can run 35 liters per second.
12. A guy on our track team can high-jump 7 meters.
13. My friend ran 10,000 meters in less than an hour.
14. The book I sent you weighs 3 milligrams.
15. My car's gas tank holds 12 meters of gasoline.

16. My daily food intake gives me about 10 million joules of energy.
17. Our utility company charges 10¢ per watt for the electricity we use.
18. The beach ball we played with had a density of 10 grams per cubic centimeter.

BASIC SKILLS & CONCEPTS

19–22: Powers of 10. Evaluate the following expressions using skills covered in the Brief Review on p. 100.

19. a. $10^4 \times 10^7$ b. $10^5 \times 10^{-3}$ c. $\frac{10^6}{10^2}$ d. $\frac{10^8}{10^{-4}}$
20. a. $10^{-2} \times 10^{-6}$ b. $\frac{10^{-6}}{10^{-8}}$ c. $10^{12} \times 10^{23}$ d. $\frac{10^{-4}}{10^5}$
21. a. $\frac{10^{25}}{10^{15}}$ b. $10^1 + 10^0$ c. $10^2 + 10^{-1}$ d. $10^2 - 10^1$
22. a. $\frac{10^{12}}{10^{-4}}$ b. $10^{23} \times 10^{-23}$ c. $10^4 + 10^2$ d. $\frac{10^{15}}{10^{-5}}$

23–30: USCS Units. Answer the following questions involving conversions within the USCS system.

23. What is the height in inches of a 6'10" basketball player?
24. What is the weight in tons of a 345-pound lineman?
25. One cubic foot holds 7.48 gallons of water, and one gallon of water weighs 8.33 pounds. How much does a cubic foot of water weigh in pounds? in ounces (avoirdupois)?
26. Suppose you bought 10 six-packs of soda, each six-pack containing six 12-ounce cans. How many gallons of soda did you buy?
27. A speed boat has a top speed of 46 knots (nautical miles per hour). What is this speed in miles per hour?
28. How many quarts does an 18-gallon gasoline tank hold? How many pints? How many ounces?
29. How many cords of wood could you fit in a room that is 4 yards long, 4 yards wide, and 2 yards high? (See Table 2.4.)
30. A small city produces 500,000 cubic feet of garbage per week. If all of this garbage were stacked neatly (in a nice vertical pile) on a 100-yard by 60-yard football field, how high would the pile be (in feet)?

31–36: Metric Prefixes. Complete the following sentences with a number. All answers should be greater than 1.

31. A meter is _____ times as large as a millimeter.
32. A kilogram is _____ times as large as a milligram.
33. A liter is _____ times as large as a milliliter.
34. A kilometer is _____ times as large as a micrometer.
35. A square meter is _____ times as large as a square centimeter.
36. A cubic meter is _____ times as large as a cubic millimeter.

37–46: USCS–Metric Conversions. Convert the following quantities to the indicated units.

37. 22 kilograms to pounds
38. 160 centimeters to inches
39. 16 quarts to liters
40. 2 square kilometers to square miles
41. 55 miles per hour to kilometers per hour
42. 120 kilometers per hour to miles per hour
43. 18 meters per second to miles per hour
44. 20 square meters to square feet
45. 300 cubic inches to cubic centimeters
46. 18 grams per cubic centimeter to pounds per cubic inch

47–48: Celsius–Fahrenheit Conversions. Convert the following temperatures from Fahrenheit to Celsius or vice versa.

47. a. 45°F b. 20°C c. −15°C d. −30°C e. 70°F
48. a. −8°C b. 15°F c. 15°C d. 75°F e. 20°F

49–50: Celsius–Kelvin Conversions. Convert the following temperatures from Kelvin to Celsius or vice versa.

49. a. 50 K b. 240 K c. 10°C
50. a. −40°C b. 400 K c. 125°C

51. **Running Power.** Assume that running consumes 100 Calories per mile. If you run 10-minute miles, what is your average power output, in watts, during a 1-hour run?
52. **Bicycle Power.** A 1-hour bike ride at a pace of 15 miles per hour consumes about 750 Calories. What is your average power output, in watts, during a 45-minute bike ride?

53–54: Electric Bills. Consider the following electric bills.
a. Calculate the total electrical energy use in joules.
b. Calculate your average power use in watts.
c. Assume that your power supplier generates electricity by burning oil. Note that 1 liter of oil releases 12 million joules of energy. How much oil is needed to generate the electricity you use? Give your answer in both liters and gallons.

53. In May you used 900 kilowatt-hours of energy for electricity.
54. In October you used 1050 kilowatt-hours of energy for electricity.

55–60: Densities. Compute the following densities using the appropriate units.

55. A cube of wood measures 3 centimeters on a side and it weighs 20 grams. What is its density? Will it float in water?
56. At room temperature, a 0.1-cubic-centimeter sample of plutonium weighs 1.98 grams. What is its density? Will it float in water?
57. The land area of the United States is about 3.5 million square miles, and the population is about 306 million people. What is the average population density?
58. The country with the greatest population density is Monaco, where approximately 32,500 people live in an area of

1.95 square kilometers. What is the population density of Monaco in people per square kilometer? Compare this density to that of the United States, which is approximately 31 people per square kilometer.

59. New Jersey and Alaska have populations of 8.7 million and 680,000, respectively (U.S. Census Bureau, 2008). Their areas are 7417 and 571,951 square miles, respectively. Compute the population densities of both states.

60. A standard DVD has a surface area of 134 square centimeters. Depending on formatting, it holds either 4.7 or 8.5 gigabytes. Find the data density in both cases.

61. **Blood Alcohol Content: Wine.** A typical glass of wine contains about 20 grams of alcohol. Consider a 110-pound woman, with approximately 4 liters (4000 milliliters) of blood, who drinks two glasses of wine.

    a. If all the alcohol were immediately absorbed into her bloodstream, what would her blood alcohol content be? Explain why it is fortunate that, in reality, the alcohol is not absorbed immediately.

    b. Again assume that all the alcohol is absorbed immediately, but now assume that her body eliminates the alcohol (through metabolism) at a rate of 10 grams per hour. What is her blood alcohol content 3 hours after drinking the wine? Is it safe for her to drive at this time? Explain.

62. **Blood Alcohol Content: Hard Liquor.** Eight ounces of a hard liquor (such as whiskey) typically contain about 70 grams of alcohol. Consider a 200-pound man, with approximately 6 liters (6000 milliliters) of blood, who quickly drinks 8 ounces of hard liquor.

    a. If all the alcohol were immediately absorbed into his bloodstream, what would his blood alcohol content be? Explain why it is fortunate that, in reality, the alcohol is not absorbed immediately.

    b. Again assume that all the alcohol is absorbed immediately, but now assume that his body eliminates the alcohol (through metabolism) at a rate of 15 grams per hour. What is his blood alcohol content 4 hours after drinking the liquor? Is it safe for him to drive at this time? Explain.

FURTHER APPLICATIONS

63–68: Currency Conversions. Use the currency exchange rates in Table 2.1 in Unit 2A to answer the following questions. State all of the conversion factors that you use.

63. Apples in a French market cost 2.50 euros per kilogram. What is the price in dollars per pound?

64. Gasoline at a Belgian gas station costs 1.40 euros per liter. What is the price in dollars per gallon?

65. Suppose that a new fuel-efficient German car travels an average of 26 kilometers on 1 liter of gasoline. If gasoline costs 1.50 euros per liter, how much will it cost to drive 300 kilometers?

66. Carpet at a British home supply store sells for 16 pounds (currency) per square meter. What is the price in dollars per square yard?

67. An 0.8-liter bottle of Mexican wine costs 100 pesos. What is the price in dollars per ounce?

68. The monthly rent on an 80-square-meter apartment in Nice, France, is 1040 euros. The monthly rent on a 500-square-foot apartment in Santa Fe, New Mexico, is $800. In terms of price per area, which apartment is less expensive?

69. **The Metric Mile.** Two historic races in track and field are the mile (1 USCS mile) and the metric mile (1500 meters).

    a. Complete the sentence: The metric mile is _____% of the USCS mile in length.

    b. Consider the following world records in the two events (as of 2009).

	Men	Women
Mile	3:43:13	4:12:56
Metric mile	3:26:00	3:50:46

    Compute and compare the average speed in the men's mile and metric mile races.

    c. Compute and compare the average speed in the women's mile and metric mile races.

    d. If the average speed for the metric mile were run for the entire length of a mile race, would it result in a world record? Answer for both men and women.

70. **Supertankers.** An oil supertanker of the Very Large Crude Carrier (VLCC) class has a deadweight tonnage (the total amount that it can carry in crew, supplies, and cargo) of 300,000 long tons.

    a. How many kilograms can the tanker carry?

    b. Assume that the tonnage consists entirely of oil. If the density of oil is 850 kilograms per cubic meter, how many cubic meters of oil can the tanker carry?

    c. Assume that 1000 liters of oil has a volume of 1 cubic meter. How many barrels of oil can the tanker carry? (See Tables 2.4 and 2.6.)

    d. Find the current price of oil in dollars per barrel. What is the value of the oil carried by a full tanker?

71. **Lake Victoria.** Lake Victoria is Africa's largest lake and the second largest fresh-water lake in the world in terms of surface area. Its volume is approximately 2750 cubic kilometers and its surface area is 68,800 square kilometers.

    a. What is the average depth of the lake (the depth of a box with the volume and surface area of the lake)?

    b. In the last six years, the water level of the lake has dropped 10 feet (from the depth computed in part a). Approximately how much water has the lake lost?

    c. What percentage of the volume (2750 cubic kilometers) has been lost?

72. **The Cullinan Diamond and the Star of Africa.** The largest single rough diamond ever found, the Cullinan diamond, weighed 3106 carats. It was used to cut the world's largest diamond gem, the Star of Africa (530.2 carats), which is part of the British crown jewels collection. How much did the Cullinan diamond weigh in milligrams? in (avoirdupois) pounds? How much does the Star of Africa weigh in milligrams? in (avoirdupois) pounds?

73–76: Gems and Gold. Use carats and karats, as discussed in the Practical Matters box on p. 98, to answer the following questions.

73. What is the weight of the 45.52-carat Hope diamond in grams and ounces?

74. What is the purity (as a percentage) of a 14-karat gold ring?

75. How many ounces of gold are in a 16-karat gold chain that weighs 2.2 ounces?

76. What is the weight in carats of a diamond that weighs 0.15 ounce?

77. **Power Spa.** An outdoor spa (hot tub) draws 1500 watts to keep the water warm. If the utility company charges \$0.10 per kilowatt-hour, how much does it cost to operate the spa for 4 months during the winter (24 hours per day)?

78. **Hair Dryer Cost.** You have an 1800-watt hair dryer that you use for an average of 10 minutes per day. Your utility company charges 12¢ per kilowatt-hour of energy (including taxes and fees). How much does it cost to run the hair dryer each day? each year?

79. **Compact Fluorescent Light Bulbs.** You replace a 100-watt standard light bulb with a 25-watt compact fluorescent bulb that supplies the same light. Over a 10,000-hour life (typical for a compact fluorescent bulb), how much energy, in kilowatt-hours, do you save? If electricity costs 12¢ per kilowatt-hour, how much money do you save?

80. **Human Wattage.** Suppose you require 2500 food Calories per day.

    a. What is your average power, in watts? Compare your answer to the wattage of some familiar appliance.

    b. How much energy, in joules, do you require from food in a year? Counting all forms of energy (such as gasoline, electricity, and energy for heating), the average U.S. citizen consumes about 400 billion joules of energy each year. Compare this value to the energy needed from food alone.

81. **Coal Power Plant.** A new coal-burning power plant can generate 1.5 gigawatts (billion watts) of power. Burning 1 kilogram of coal yields about 450 kilowatt-hours of energy. How much energy, in kilowatt-hours, can the plant generate each month? How much coal, in kilograms, is needed by this power plant each month? If a typical home uses 1000 kilowatt-hours per month, how many homes can this power plant supply with energy?

82. **Nuclear Power Plant.** Operating at full capacity, the Columbia Generating Station, a nuclear power plant near Richland, Washington, can generate 1190 megawatts of power. Nuclear fission of 1 kilogram of uranium (in the form of uranium-235) releases 16 million kilowatt-hours of energy. How much energy, in kilowatt-hours, can the plant generate each month? How much uranium, in kilograms, is needed by this power plant each month? If a typical home uses 1000 kilowatt-hours per month, how many homes can this power plant supply with energy?

83–84: Solar Energy. Use these facts in the following exercises: Solar (photovoltaic) cells convert sunlight directly into electricity. If solar cells were 100% efficient, they would generate about 1000 watts of power per square meter of surface area when exposed to direct sunlight. With lower efficiency, they generate proportionally less power. For example, 10% efficient cells generate 100 watts of power in direct sunlight.

83. Suppose a 1-square-meter panel of solar cells has an efficiency of 20% and receives the equivalent of 6 hours of direct sunlight per day. How much energy, in joules, can it produce each day? What average power, in watts, does the panel produce?

84. Suppose you want to supply 1 kilowatt of power to a house (the average household power requirement) by putting solar panels on its roof. For the solar cells described in Exercise 83, how many square meters of solar panels would you need? Assume that you can make use of the average power from the solar cells (by, for example, storing the energy in batteries until it is needed).

85. **Wind Power: One Turbine.** Modern wind energy "farms" use large wind turbines to generate electricity from the wind. At a typical installation, a single modern turbine can produce an average power of about 200 kilowatts. (This average takes wind variations into account.) How much energy, in kilowatt-hours, can such a turbine generate in a year? Given that the average household uses about 10,000 kilowatt-hours of energy each year, how many households can be powered by a single wind turbine?

86. **California Wind Power.** California currently has wind farms capable of generating a total of 2500 megawatts (2.5 gigawatts) of power (roughly 2% of the state's total electricity).

    a. Assuming that wind farms typically generate 30% of their capacity, how much energy, in kilowatt-hours, can the California wind farms generate in one year? Given that the average household uses about 10,000 kilowatt-hours of energy each year, how many households can be powered by these wind farms?

    b. One of the great advantages of wind power is that it does not produce the carbon dioxide emissions that contribute to global warming. On average, energy produced from fossil fuels generates about 1.5 pounds of carbon dioxide for every kilowatt-hour of energy. Suppose California did not have its wind farms and the energy were instead produced from fossil fuels. How much more carbon dioxide would be entering the atmosphere each year?

WEB PROJECTS

87. **Energy Issues.** The question of how we will continue to meet our energy needs is one of the most important issues of our time. Research one aspect of this issue, such as the potential of various alternative energy resources, using information available at the Web site for the U.S. Energy Information Administration. Write a short report on your findings.

88. **Pollution Progress.** Investigate the average concentrations of various pollutants in a major city of your choice. Find the EPA standards for each pollutant, and find some of the hazards associated with exposure to each pollutant. Track how the levels of pollution in this city have changed over the past 20 years. Based on your findings, do you think it is likely that pollution in this city will get better or worse over the next decade? Summarize your findings and your conclusions in a one- or two-page report.

89. **Alcohol Poisoning.** Research some aspect of the dangers of alcohol, such as drunk driving or alcohol poisoning. Find statistics related to this issue, especially data that relate blood alcohol content to specific dangers. Summarize your findings in a short report about how society might combat the danger.

90. **Should the United States Go Metric?** Research the history of attempts to convert the United States to the metric system. Do you think it will ever happen? Do you think it would be a good idea?

IN YOUR WORLD

91. **Everyday Metric.** Describe three ways that you use metric units in your everyday life.

92. **Energy.** Look for a news article concerning energy or power. What units are used to describe energy or power? Summarize the article and explain the meaning of the units.

93. **Density and Concentration.** Look for a news article that uses units of density or concentration in any context. Summarize the article and explain the meaning of the units.

94. **Utility Bill.** Analyze a utility bill. Explain all the units shown, and determine the relative costs of different energy uses. What changes would you recommend if the recipient of the bill wanted to lower energy costs?

USING TECHNOLOGY

95. **Unit Conversions.** Given what you have learned in this chapter and the appropriate conversion factors, you can do any unit conversion problem. The following problems have somewhat obscure conversion factors. Use Google or Excel (or any other means) to make the following conversions.

    a. Convert 100 furlongs to kilometers.

    b. How fast does a snail crawl? Convert 23 inches per day to miles per hour.

    c. Convert 100 drams to ounces.

    d. Convert 1 hectare to acres.

    e. Convert 1000 pascals to pounds per square inch (units of pressure).

    f. Convert 1 hectoliter to gallons.

96. **Currency Conversions.** Use the Internet to convert $100 to the following currencies.

    a. Brazilian reals
    b. Israeli shekels
    c. Moroccan dirhams
    d. Russian rubles
    e. Turkish lira
    f. Chinese yuan
    g. Colombian pesos
    h. Indian rupees

UNIT 2C Problem-Solving Guidelines and Hints

If you look back through the examples we've studied, you'll see that we studied each problem in order to find a good strategy for solving it, and we carefully interpreted our results to make sure they had the correct units and made sense. In a few cases, we used pictures or diagrams to help us understand a problem. You may have noticed that while every problem is different, the *process* of problem solving has a few common features.

The four-step process on the next page provides a useful guide to problem solving. Study it carefully and look back to see how these steps were applied in earlier examples. Keep in mind that the four steps offer *general* advice, so they will not automatically lead to a solution. In this sense, problem solving is more of an art than a science, and the four steps are more like instructions for painting than a recipe for the Mona Lisa. Note also that while these steps apply to virtually all problem solving, it is not necessary (or particularly useful) to write them out step by step in solutions.