

# Chapter 1

## Chemistry: The Central Science

### Practice Problems C

- 1.1 (iii)
- 1.2 (i) and (i)
- 1.3 pink liquid = grey solid < blue solid < yellow liquid < blue liquid < green solid
- 1.4 physical: (iii), chemical: (i), (ii) is neither
- 1.5 12 blue cubes, infinite number of significant figures;  
 $2 \times 10^1$  red spheres, one significant figure
- 1.6  $2.4 \times 10^2$  lbs.
- 1.7  $2.67 \text{ g/cm}^3$
- 1.8 (a) 4 red blocks/1 object  
(b) 1 object/1 yellow block  
(c) 2 white blocks/1 yellow block  
(d) 1 yellow block/6 grey connectors
- 1.9 375 red bars; 3500 yellow balls

### Questions and Problems

- 1.1 **Chemistry is the study of matter and the changes that matter undergoes.**  
**Matter is anything that has mass and occupies space.**
- 1.2 **The scientific method is a set of guidelines used by scientists to add their experimental results to the larger body of knowledge in a given field. The process involves observation, hypothesis, experimentation, theory development, and further experimentation.**
- 1.3 **A hypothesis explains observations. A theory explains data from accumulated experiments and**

**predicts related phenomena.**

- 1.4    a. **Hypothesis** – This statement is an opinion.
- b. **Law** – Newton’s Law of Gravitation.
- c. **Theory** – Atomic Theory.
- 1.5    a. **Law** – Newton’s 2nd Law of Motion.
- b. **Theory** – Big Bang Theory.
- c. **Hypothesis** – It may be possible but we have no data to support this statement.
- 1.6    a. **O and H**                      b. **C and H**                      c. **H and Cl**                      d. **N**
- 1.7    a. **C and O**                      b. **F and H**                      c. **N and H**                      d. **O**
- 1.8    a. Matter is anything that has mass and occupies space. Examples include **air, seawater, concrete, an automobile, or a dog.**
- b. A substance is a form of matter that has definite (constant) composition and distinct properties. Examples include **iron, silver, water, or sugar.**
- c. A mixture is a combination of two or more substances in which the substances retain their distinct identities. Examples include **milk, salt water, air, or steel.**
- 1.9    Examples of homogeneous mixtures: **apple juice or root beer.**
- Examples of heterogeneous mixtures: **chocolate chip cookie or vinaigrette salad dressing.**
- 1.10   Examples of elements (see the front cover for a complete list): **oxygen, platinum, sodium, cobalt.**
- Examples of compounds: **sugar, salt, hemoglobin, citric acid.**

An element cannot be separated into simpler substances by chemical means. A compound can be separated into its constituent elements by a chemical reaction.

1.11 There are **118** known elements.

1.12 Li: **Lithium**

F: **Fluorine**

P: **Phosphorus**

Cu: **Copper**

As: **Arsenic**

Zn: **Zinc**

Cl: **Chlorine**

Pt: **Platinum**

Mg: **Magnesium**

U: **Uranium**

Al: **Aluminum**

Si: **Silicon**

Ne: **Neon**

1.13 a. **K** (potassium)

d. **B** (boron)

g. **S** (sulfur)

b. **Sn** (tin)

e. **Ba** (barium)

h. **Ar** (argon)

c. **Cr** (chromium)

f. **Pu** (plutonium)

i. **Hg** (mercury)

1.14 a. hydrogen: **element**

c. gold: **element**

b. water: **compound**

d. sugar: **compound**

1.15 a. The sea is a heterogeneous mixture of seawater and biological matter, but seawater, with the biomass

filtered out, is a **homogeneous mixture**.

b. **element**

c. **compound**

d. **homogeneous mixture**

e. **heterogeneous mixture**

f. **homogeneous mixture**

g. **heterogeneous mixture**

1.16 a. **liquid**                      b. **gas**                      c. **mixture**                      d. **solid**

1.17 a. **element**                      b. **compound**                      c. **compound**                      d. **element**

1.18 a. Chemistry Units: **meter (m), centimeter (cm), millimeter (mm)**

SI Base Unit: **meter (m)**

b. Chemistry Units: **cubic decimeter (dm<sup>3</sup>) or liter (L), milliliter (mL), cubic centimeter (cm<sup>3</sup>)**

SI Base Unit: **cubic meter (m<sup>3</sup>)**

c. Chemistry Units: **gram (g)**

SI Base Unit: **kilogram (kg)**

d. Chemistry Units: **second (s)**

SI Base Unit: **second (s)**

e. Chemistry Units: **kelvin (K) or degrees Celsius (°C)**

SI Base Unit: **kelvin (K)**

- 1.19    a.  $1 \times 10^6$                       c.  $1 \times 10^{-1}$                       e.  $1 \times 10^{-3}$                       g.  $1 \times 10^{-9}$
- b.  $1 \times 10^3$                       d.  $1 \times 10^{-2}$                       f.  $1 \times 10^{-6}$                       h.  $1 \times 10^{-12}$

- 1.20    For liquids and solids, chemists normally use **g/mL or g/cm<sup>3</sup>** as units for density.

For gases, chemists normally use **g/L** as units for density. Gas densities are generally very low, so the smaller unit of g/L is typically used. 1 g/L = 0.001 g/mL.

- 1.21    Weight is the force exerted by an object or sample due to gravity. It depends on the gravitational force where the weight is measured.

Mass is a measure of the amount of matter in an object or sample. It remains constant regardless of where it is measured.

Since gravity on the moon is about one sixth that on Earth,

$$\text{weight on the moon} = (168 \text{ lbs on Earth}) \left( \frac{1}{6} \right) = \mathbf{28 \text{ lbs}}$$

- 1.22    Kelvin is known as the absolute temperature scale, meaning the lowest possible temperature is 0 K.

The units of the Celsius and Kelvin scales are the same, so conversion between units is a matter of addition:

$$\mathbf{K = ^\circ C + 273.15}$$

The freezing point of water is defined as 0°C. The boiling point of water is defined as 100°C.

In the Fahrenheit scale, the freezing point of water is 32°F and the boiling point of water is 212°F. Since the difference is 180°F, compared to 100°C between the freezing and boiling points of water, one degree Fahrenheit represents a smaller change in temperature than one degree Celsius. To convert between these two temperature scales, use:

$$\text{temperature in Celsius} = (\text{temperature in F} - 32^\circ\text{F}) \times \frac{5^\circ\text{C}}{9^\circ\text{F}}$$

- 1.23    **Strategy:** Use the density equation:

$$d = \frac{m}{V}$$

**Solution:**

$$d = \frac{m}{V} = \frac{586 \text{ g}}{188 \text{ mL}} = \mathbf{3.12 \text{ g/mL}}$$

1.24

$$\text{mass of ethanol} = \frac{0.798 \text{ g}}{1 \text{ mL}} \times 17.4 \text{ mL} = \mathbf{13.9 \text{ g}}$$

- 1.25 **Strategy:** Find the appropriate equations for converting between Fahrenheit and Celsius and between Celsius and Fahrenheit given in Section 1.3 of the text. Substitute the temperature values given in the problem into the appropriate equation.

**Setup:** Conversion from Fahrenheit to Celsius:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32^{\circ}\text{F}) \times \frac{5^{\circ}\text{C}}{9^{\circ}\text{F}}$$

Conversion from Celsius to Fahrenheit:

$$^{\circ}\text{F} = \left( ^{\circ}\text{C} \times \frac{9^{\circ}\text{F}}{5^{\circ}\text{C}} \right) + 32^{\circ}\text{F}$$

- Solution:**
- a.  $^{\circ}\text{C} = (95^{\circ}\text{F} - 32^{\circ}\text{F}) \times \frac{5^{\circ}\text{C}}{9^{\circ}\text{F}} = \mathbf{35^{\circ}\text{C}}$
- b.  $^{\circ}\text{C} = (12^{\circ}\text{F} - 32^{\circ}\text{F}) \times \frac{5^{\circ}\text{C}}{9^{\circ}\text{F}} = \mathbf{-11^{\circ}\text{C}}$
- c.  $^{\circ}\text{C} = (102^{\circ}\text{F} - 32^{\circ}\text{F}) \times \frac{5^{\circ}\text{C}}{9^{\circ}\text{F}} = \mathbf{39^{\circ}\text{C}}$
- d.  $^{\circ}\text{C} = (1852^{\circ}\text{F} - 32^{\circ}\text{F}) \times \frac{5^{\circ}\text{C}}{9^{\circ}\text{F}} = \mathbf{1011^{\circ}\text{C}}$
- e.  $^{\circ}\text{F} = \left( -273.15^{\circ}\text{C} \times \frac{9^{\circ}\text{F}}{5^{\circ}\text{C}} \right) + 32^{\circ}\text{F} = \mathbf{-459.67^{\circ}\text{F}}$

1.26 a.  $^{\circ}\text{C} = (105^{\circ}\text{F} - 32^{\circ}\text{F}) \times \frac{5^{\circ}\text{C}}{9^{\circ}\text{F}} = \mathbf{41^{\circ}\text{C}}$

b.  $^{\circ}\text{F} = \left( -11.5^{\circ}\text{C} \times \frac{9^{\circ}\text{F}}{5^{\circ}\text{C}} \right) + 32^{\circ}\text{F} = \mathbf{11.3^{\circ}\text{F}}$

c.  $^{\circ}\text{F} = \left( 6.3 \times 10^3^{\circ}\text{C} \times \frac{9^{\circ}\text{F}}{5^{\circ}\text{C}} \right) + 32^{\circ}\text{F} = \mathbf{1.1 \times 10^4^{\circ}\text{F}}$

1.27 **Strategy:** Use the density equation.

**Solution:**

$$\text{volume of water} = V = \frac{m}{d} = \frac{2.50 \text{ g}}{0.992 \text{ g/mL}} = \mathbf{2.52 \text{ mL}}$$

1.28

$$\text{volume of platinum} = \frac{87.6 \text{ g}}{21.5 \text{ g/cm}^3} = \mathbf{4.07 \text{ cm}^3}$$

1.29 **Strategy:** Use the equation for converting  $^{\circ}\text{C}$  to K.

AMPS Solution C

**Setup:** Conversion from Celsius to Kelvin:

$$\text{K} = ^{\circ}\text{C} + 273.15$$

**Solution:** a.  $\text{K} = 115.21^{\circ}\text{C} + 273.15 = \mathbf{388.36 \text{ K}}$

b.  $\text{K} = 37^{\circ}\text{C} + 273 = \mathbf{3.10 \times 10^2 \text{ K}}$

c.  $\text{K} = 357^{\circ}\text{C} + 273 = \mathbf{6.30 \times 10^2 \text{ K}}$

Note that when there are no digits to the right of the decimal point in the original temperature, we use 273 instead of 273.15.

1.30 a.  $^{\circ}\text{C} = \text{K} - 273 = 77 \text{ K} - 273 = \mathbf{-196^{\circ}\text{C}}$

AMPS Solution C

b.  $^{\circ}\text{C} = 4.22 \text{ K} - 273.15 = -268.93^{\circ}\text{C}$

$$\text{c. } ^\circ\text{C} = 600.61 \text{ K} - 273.15 = \mathbf{327.46^\circ\text{C}}$$

- 1.31 **Qualitative data does not require explicit measurement. Quantitative data requires measurement and is expressed with a number.**

- 1.32 **Physical properties can be observed and measured without changing the identity of a substance.** For example, the boiling point of water can be determined by heating a container of water and measuring the temperature at which the liquid water turns to steam. The water vapor (steam) is still  $\text{H}_2\text{O}$ , so the identity of the substance has not changed. Liquid water can be recovered by allowing the water vapor to contact a cool surface, on which it condenses to liquid water.

**Chemical properties can only be observed by carrying out a chemical change.** During the measurement, the identity of the substance changes. The original substance cannot be recovered by any physical means. For example, when iron is exposed to water and oxygen, it undergoes a chemical change to produce rust. The iron cannot be recovered by any physical means.

- 1.33 An extensive property depends on the amount of substance present. An intensive property is independent of the amount of substance present.

- 1.34      a. extensive                                  c. intensive
- b. extensive                                  d. extensive

- 1.35
- Quantitative.** This statement involves a measurable distance.
  - Qualitative.** This is a value judgment. There is no numerical scale of measurement for artistic excellence.
  - Qualitative.** If the numerical values for the densities of ice and water were given, it would be a quantitative statement.
  - Qualitative.** The statement is a value judgment.
  - Qualitative.** Even though numbers are involved, they are not the result of measurement.



- 1.36
- a. **Chemical property.** Oxygen gas is consumed in a combustion reaction; its composition and identity are changed.
  - b. **Chemical property.** The fertilizer is consumed by the growing plants; it is turned into vegetable matter (different composition).
  - c. **Physical property.** The measurement of the boiling point of water does not change its identity or composition.
  - d. **Physical property.** The measurement of the densities of lead and aluminum does not change their composition.
  - e. **Chemical property.** When uranium undergoes nuclear decay, the products are chemically different substances.
- 1.37
- a. **Physical Change.** The material is helium regardless of whether it is located inside or outside the balloon.
  - b. **Chemical change** in the battery.
  - c. **Physical Change.** The orange juice concentrate can be regenerated by evaporation of the water.
  - d. **Chemical Change.** Photosynthesis changes water, carbon dioxide, etc., into complex organic matter.
  - e. **Physical Change.** The salt can be recovered unchanged by evaporation.
- 1.38
- Mass is extensive and additive:  $44.3 + 115.2 = \mathbf{159.5\text{ g}}$
- Temperature is intensive:  $\mathbf{10^{\circ}\text{C}}$
- Density is intensive:  $\mathbf{1.00\text{ g/mL}}$
- 1.39
- Mass is extensive and additive:  $37.2 + 62.7 = \mathbf{99.9\text{ g}}$
- Temperature is intensive:  $\mathbf{20^{\circ}\text{C}}$
- Density is intensive:  $\mathbf{11.35\text{ g/cm}^3}$

1.40 a. **Exact.** The number of tickets is determined by counting.

b. **Inexact.** The volume must be measured.

c. **Exact.** The number of eggs is determined by counting.

d. **Inexact.** The mass of oxygen must be measured.

e. **Exact.** The number of days is a defined value.

1.41 **Using scientific notation avoids the ambiguity associated with trailing zeros.**

1.42 **Significant figures are the meaningful digits in a reported number. They indicate the level of uncertainty in a measurement. Using too many significant figures implies a greater certainty in a measured or calculated number than is realistic.**

1.43 **Accuracy tells us how close a measurement is to the true value. Precision tells us how close multiple measurements are to one another. Having precise measurements does not always guarantee an accurate result, because there may be an error made that is common to all the measurements.**

1.44 a. The decimal point must be moved eight places to the right, making the exponent  $-8$ .

$$0.000000027 = 2.7 \times 10^{-8}$$

b. The decimal point must be moved two places to the left, making the exponent 2.

$$356 = 3.56 \times 10^2$$

c. The decimal point must be moved four places to the left, making the exponent 4.

$$47,764 = 4.7764 \times 10^4$$

d. The decimal point must be moved two places to the right, making the exponent  $-2$ .

$$0.096 = 9.6 \times 10^{-2}$$

1.45 **Strategy:** To convert an exponential number  $N \times 10^n$  to a decimal number, move the decimal  $n$  places to the left if  $n < 0$ , or move it  $n$  places to the right if  $n > 0$ . While shifting the decimal, add place-

holding zeros as needed.

**Solution:** a.  $1.52 \times 10^{-2} = \mathbf{0.0152}$

b.  $7.78 \times 10^{-8} = \mathbf{0.0000000778}$

c.  $1 \times 10^{-6} = \mathbf{0.000001}$

d.  $1.6001 \times 10^3 = \mathbf{1600.1}$

1.46 a.  $145.75 + (2.3 \times 10^{-1}) = 145.75 + 0.23 = \mathbf{1.4598 \times 10^2}$

b.  $\frac{79500}{2.5 \times 10^2} = \frac{7.95 \times 10^4}{2.5 \times 10^2} = \mathbf{3.2 \times 10^2}$

c.  $(7.0 \times 10^{-3}) - (8.0 \times 10^{-4}) = (7.0 \times 10^{-3}) - (0.80 \times 10^{-3}) = \mathbf{6.2 \times 10^{-3}}$

d.  $(1.0 \times 10^4) \times (9.9 \times 10^6) = \mathbf{9.9 \times 10^{10}}$

1.47 a. Addition using scientific notation.

**Strategy:** A measurement is in *scientific notation* when it is written in the form  $N \times 10^n$ , where  $0 \leq N < 10$  and  $n$  is an integer. When adding measurements that are written in scientific notation, rewrite the quantities so that they share a common exponent. To get the “ $N$  part” of the result, we simply add the “ $N$  parts” of the rewritten numbers. To get the exponent of the result, we simply set it equal to the common exponent. Finally, if need be, we rewrite the result so that its value of  $N$  satisfies  $0 \leq N < 10$ .

**Solution:** Rewrite the quantities so that they have a common exponent. In this case, choose the common exponent  $n = -3$ .

$$0.0095 = 9.5 \times 10^{-3}$$

Add the “ $N$  parts” of the rewritten numbers and set the exponent of the result equal to the

common exponent.

$$\begin{array}{r} 9.5 \times 10^{-3} \\ + 8.5 \times 10^{-3} \\ \hline 18.0 \times 10^{-3} \end{array}$$

Rewrite the number so that it is in scientific notation (so that  $0 \leq N < 10$ ).

$$18.0 \times 10^{-3} = \mathbf{1.8 \times 10^{-2}}$$

b. Division using scientific notation.

**Strategy:** When dividing two numbers using scientific notation, divide the “ $N$  parts” of the numbers in the usual way. To find the exponent of the result, *subtract* the exponent of the divisor from that of the dividend.

**Solution:** Make sure that all numbers are expressed in scientific notation.

$$653 = 6.53 \times 10^2$$

Divide the “ $N$  parts” of the numbers in the usual way.

$$6.53 \div 5.75 = 1.14$$

*Subtract* the exponents.

$$1.14 \times 10^{+2 - (-8)} = 1.14 \times 10^{+2 + 8} = \mathbf{1.14 \times 10^{10}}$$

c. Subtraction using scientific notation.

**Strategy:** When subtracting two measurements that are written in scientific notation, rewrite the quantities so that they share a common exponent. To get the “ $N$  part” of the result, we simply subtract the “ $N$  parts” of the rewritten numbers. To get the exponent of the result, we simply set it equal to the common exponent. Finally, if need be, we rewrite the result so that its value of  $N$  satisfies  $0 \leq N < 10$ .

**Solution:** Rewrite the quantities so that they have a common exponent. Rewrite 850,000 in such a way that  $n = 5$ .

$$850,000 = 8.5 \times 10^5$$

Subtract the “ $N$  parts” of the numbers and set the exponent of the result equal to the common

exponent.

$$\begin{array}{r} 8.5 \times 10^5 \\ - 9.0 \times 10^5 \\ \hline -0.5 \times 10^5 \end{array}$$

Rewrite the number so that  $0 \leq N < 10$  (ignore the sign of  $N$  when it is negative).

$$-0.5 \times 10^5 = -5 \times 10^4$$

d. Multiplication using scientific notation.

**Strategy:** When multiplying two numbers using scientific notation, multiply the “ $N$  parts” of the numbers in the usual way. To find the exponent of the result, *add* the exponents of the two measurements.

**Solution:** Multiply the “ $N$  parts” of the numbers in the usual way.

$$3.6 \times 3.6 = 13$$

Add the exponents.

$$13 \times 10^{-4 + (+6)} = 13 \times 10^2$$

Rewrite the number so that it is in scientific notation (so that  $0 \leq N < 10$ ).

$$13 \times 10^2 = 1.3 \times 10^3$$

1.48 a. **four**

d. **two, three, or four**

g. **one**

b. **two**

e. **three**

h. **two**

c. **five**

f. **one**

1.49 a. **one**

d. **four**

g. **one or two**

b. **three**

e. **three**

c. **three**f. **one**1.50 a. **10.6 m**b. **0.79 g**c. **16.5 cm**

1.51 a. Division

**Strategy:** The number of significant figures in the answer is determined by the original number having the smallest number of significant figures.

**Solution:**

$$\frac{7.310 \text{ km}}{5.70 \text{ km}} = \mathbf{1.283}$$

The 3 (bolded) is a nonsignificant digit because the original number 5.70 only has three significant digits. Therefore, the answer has only three significant digits.

The correct answer rounded off to the correct number of significant figures is:

**1.28**

**Think  
About It:**

Why are there no units?

b. Subtraction

**Strategy:** The number of significant figures to the right of the decimal point in the answer is determined by the lowest number of digits to the right of the decimal point in any of the original numbers.

**Solution:** Writing both numbers in the decimal notation, we have

$$\begin{array}{r} 0.00326 \text{ mg} \\ - 0.0000788 \text{ mg} \\ \hline \mathbf{0.0031812 \text{ mg}} \end{array}$$

The bold numbers are nonsignificant digits because the number 0.00326 has five digits to the right of the decimal point. Therefore, we carry five digits to the right of the decimal point in our answer.

The correct answer rounded off to the correct number of significant figures is:

$$0.00318 \text{ mg} = 3.18 \times 10^{-3} \text{ mg}$$

c. Addition

**Strategy:** The number of significant figures to the right of the decimal point in the answer is determined by the lowest number of digits to the right of the decimal point in any of the original numbers.

**Solution:** Writing both numbers with exponents = +7, we have

$$(0.402 \times 10^7 \text{ dm}) + (7.74 \times 10^7 \text{ dm}) = \mathbf{8.14 \times 10^7 \text{ dm}}$$

Since  $7.74 \times 10^7$  has only two digits to the right of the decimal point, two digits are carried to the right of the decimal point in the final answer.

- 1.52 **Student A's results are neither precise nor accurate. Student B's results are both precise and accurate. Student C's results are precise but not accurate.**
- 1.53 **Tailor Z's measurements are the most accurate. Tailor Y's measurements are the least accurate. Tailor X's measurements are the most precise. Tailor Y's measurements are the least precise.**
- 1.54 a.  $22.6 \text{ m} \times \frac{1 \text{ dm}}{0.1 \text{ m}} = \mathbf{226 \text{ dm}}$
- b.  $25.4 \text{ mg} \times \frac{1 \times 10^{-3} \text{ g}}{1 \text{ mg}} \times \frac{1 \times 10^{-3} \text{ kg}}{1 \text{ g}} = \mathbf{2.54 \times 10^{-5} \text{ kg}}$
- c.  $556 \text{ mL} \times \frac{1 \times 10^{-3} \text{ L}}{1 \text{ mL}} = \mathbf{0.556 \text{ L}}$
- d.  $\frac{10.6 \text{ kg}}{1 \text{ m}^3} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \left( \frac{1 \times 10^{-2} \text{ m}}{1 \text{ cm}} \right)^3 = 0.0106 \text{ g/cm}^3$
- 1.55 a. **Strategy:** The solution requires a two-step dimensional analysis because we must first convert pounds

to grams and then grams to milligrams.

**Setup:** The necessary conversion factors as derived from the equalities:  $1 \text{ g} = 1000 \text{ mg}$  and  $1 \text{ lb} = 453.6 \text{ g}$ .

$$\frac{453.6 \text{ g}}{1 \text{ lb}} \text{ and } \frac{1 \text{ mg}}{1 \times 10^{-3} \text{ g}}$$

**Solution:**

$$242 \text{ lb} \times \frac{453.6 \text{ g}}{1 \text{ lb}} \times \frac{1 \text{ mg}}{1 \times 10^{-3} \text{ g}} = \mathbf{1.10 \times 10^8 \text{ mg}}$$

b. **Strategy:** We need to convert from cubic centimeters to cubic meters.

**Setup:**  $1 \text{ m} = 100 \text{ cm}$ . When a unit is raised to a power, the corresponding conversion factor must also be raised to that power in order for the units to cancel.

**Solution:**

$$68.3 \text{ cm}^3 \times \left( \frac{1 \text{ m}}{100 \text{ cm}} \right)^3 = \mathbf{6.83 \times 10^{-5} \text{ m}^3}$$

c. **Strategy:** In Chapter 1 of the text, a conversion is given between liters and  $\text{cm}^3$  ( $1 \text{ L} = 1000 \text{ cm}^3$ ). If we can convert  $\text{m}^3$  to  $\text{cm}^3$ , we can then convert to liters. Recall that  $1 \text{ cm} = 1 \times 10^{-2} \text{ m}$ . We need to set up two conversion factors to convert from  $\text{m}^3$  to L. Arrange the appropriate conversion factors so that  $\text{m}^3$  and  $\text{cm}^3$  cancel, and the unit liters is obtained in your answer.

**Setup:** The sequence of conversions is  $\text{m}^3 \rightarrow \text{cm}^3 \rightarrow \text{L}$ . Use the following conversion factors:

$$\left( \frac{1 \text{ cm}}{1 \times 10^{-2} \text{ m}} \right)^3 \text{ and } \frac{1 \text{ L}}{1000 \text{ cm}^3}$$

**Solution:**

$$7.2 \text{ m}^3 \times \left( \frac{1 \text{ cm}}{1 \times 10^{-2} \text{ m}} \right)^3 \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = \mathbf{7.2 \times 10^3 \text{ L}}$$

**Think** From the above conversion factors you can show that  $1 \text{ m}^3 = 1 \times 10^3 \text{ L}$ . Therefore,  $7 \text{ m}^3$   
**About It:** would equal  $7 \times 10^3 \text{ L}$ , which is close to the answer.



- d. **Strategy:** A relationship between pounds and grams is given on the end sheet of your text ( $1 \text{ lb} = 453.6 \text{ g}$ ). This relationship will allow conversion from grams to pounds. If we can convert from  $\mu\text{g}$  to grams, we can then convert from grams to pounds. Recall that  $1 \mu\text{g} = 1 \times 10^{-6} \text{ g}$ . Arrange the appropriate conversion factors so that  $\mu\text{g}$  and grams cancel, and the unit pounds is obtained in your answer.

**Setup:** The sequence of conversions is  $\mu\text{g} \rightarrow \text{g} \rightarrow \text{lb}$ . Use the following conversion factors:

$$\frac{1 \times 10^{-6} \text{ g}}{1 \mu\text{g}} \text{ and } \frac{1 \text{ lb}}{453.6 \text{ g}}$$

**Solution:**

$$28.3 \mu\text{g} \times \frac{1 \times 10^{-6} \text{ g}}{1 \mu\text{g}} \times \frac{1 \text{ lb}}{453.6 \text{ g}} = \mathbf{6.24 \times 10^{-8} \text{ lb}}$$

**Think** Does the answer seem reasonable? What number does the prefix  $\mu$  represent? Should 28.3  
**About It:**  $\mu\text{g}$  be a very small mass?

$$1.56 \quad \frac{1255 \text{ m}}{1 \text{ s}} \times \frac{1 \text{ mi}}{1609 \text{ m}} \times \frac{3600 \text{ s}}{1 \text{ h}} = \mathbf{2808 \text{ mi/h}}$$

- 1.57 **Strategy:** You should know conversion factors that will allow you to convert between days and hours, between hours and minutes, and between minutes and seconds. Make sure to arrange the conversion factors so that days, hours, and minutes cancel, leaving units of seconds for the answer.

**Setup:** The sequence of conversions is days  $\rightarrow$  hours  $\rightarrow$  minutes  $\rightarrow$  seconds. Use the following conversion factors:

$$\frac{24 \text{ h}}{1 \text{ day}}, \frac{60 \text{ min}}{1 \text{ h}}, \text{ and } \frac{60 \text{ s}}{1 \text{ min}}$$

**Solution:**

$$365.24 \text{ day} \times \frac{24 \text{ h}}{1 \text{ day}} \times \frac{60 \text{ min}}{1 \text{ h}} \times \frac{60 \text{ s}}{1 \text{ min}} = \mathbf{3.1557 \times 10^7 \text{ s}}$$

**Think** Does your answer seem reasonable? Should there be a very large number of seconds in 1 year?  
**About It:**

$$1.58 \quad (93 \times 10^6 \text{ mi}) \times \frac{1.609 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ s}}{3.00 \times 10^8 \text{ m}} \times \frac{1 \text{ min}}{60 \text{ s}} = \mathbf{8.3 \text{ min}}$$

- 1.59 a. **Strategy:** The measurement is given in mi/min. We are asked to convert this rate to in/s. Use conversion factors to convert mi  $\rightarrow$  ft  $\rightarrow$  in and to convert min  $\rightarrow$  s.

**Setup:** Use the conversion factors:

$$\frac{5280 \text{ ft}}{1 \text{ mi}}, \frac{12 \text{ in}}{1 \text{ ft}}, \text{ and } \frac{1 \text{ min}}{60 \text{ s}}$$

Be sure to set the conversion factors up so that the appropriate units cancel.

**Solution:**

$$\frac{1 \text{ mi}}{13 \text{ min}} \times \frac{5280 \text{ ft}}{1 \text{ mi}} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{1 \text{ min}}{60 \text{ s}} = \mathbf{81 \text{ in/s}}$$

- b. **Strategy:** The measurement is given in mi/min. We are asked to convert this rate to m/min. Use a conversion factor convert mi  $\rightarrow$  m.

**Setup:** Use the conversion factor:

$$\frac{1609 \text{ m}}{1 \text{ mi}}$$

**Solution:**

$$\frac{1 \text{ mi}}{13 \text{ min}} \times \frac{1609 \text{ m}}{1 \text{ mi}} = \mathbf{1.2 \times 10^2 \text{ m/min}}$$

- c. **Strategy:** The measurement is given in mi/min. We are asked to convert this rate to km/h. Use conversion factors to convert mi  $\rightarrow$  m  $\rightarrow$  km and convert min  $\rightarrow$  h.

**Setup:** Use the conversion factors:

$$\frac{1609 \text{ m}}{1 \text{ mi}}, \frac{1 \text{ km}}{1000 \text{ m}}, \text{ and } \frac{60 \text{ min}}{1 \text{ h}}$$

**Solution:**

$$\frac{1 \text{ mi}}{13 \text{ min}} \times \frac{1609 \text{ m}}{1 \text{ mi}} \times \frac{1 \text{ km}}{1000 \text{ m}} \times \frac{60 \text{ min}}{1 \text{ h}} = \mathbf{7.4 \text{ km/h}}$$

1.60

$$6.0 \text{ ft} \times \frac{1 \text{ m}}{3.28 \text{ ft}} = \mathbf{1.8 \text{ m}}$$

$$168 \text{ lb} \times \frac{453.6 \text{ g}}{1 \text{ lb}} \times \frac{1 \text{ kg}}{1000 \text{ g}} = \mathbf{76.2 \text{ kg}}$$

1.61 **Strategy:** The rate is given in the units mi/h. The desired units are km/h. Use conversion factors to convert mi  $\rightarrow$  m  $\rightarrow$  km.

**Setup:** Use the conversion factors:

$$\frac{1609 \text{ m}}{1 \text{ mi}} \text{ and } \frac{1 \text{ km}}{1000 \text{ m}}$$

**Solution:**

$$\frac{55 \text{ mi}}{1 \text{ h}} \times \frac{1609 \text{ m}}{1 \text{ mi}} \times \frac{1 \text{ km}}{1000 \text{ m}} = \mathbf{88 \text{ km/h}}$$

$$1.62 \quad \frac{62 \text{ m}}{1 \text{ s}} \times \frac{1 \text{ mi}}{1609 \text{ m}} \times \frac{3600 \text{ s}}{1 \text{ h}} = \mathbf{1.4 \times 10^2 \text{ mph}}$$

1.63 **Strategy:** We seek to calculate the mass of Pb in a  $6.0 \times 10^3 \text{ g}$  sample of blood. Lead is present in the blood at the rate of  $0.62 \text{ ppm} = \frac{0.62 \text{ g Pb}}{1 \times 10^6 \text{ g blood}}$ . Use the rate to convert g blood  $\rightarrow$  g Pb.

**Setup:** Be sure to set the conversion factor up so that g blood cancels.

**Solution:**

$$6.0 \times 10^3 \text{ g of blood} \times \frac{0.62 \text{ g Pb}}{1 \times 10^6 \text{ g blood}} = \mathbf{3.7 \times 10^{-3} \text{ g Pb}}$$

- 1.64 a.  $32.4 \text{ yd} \times \frac{36 \text{ in}}{1 \text{ yd}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = \mathbf{2.96 \times 10^3 \text{ cm}}$
- b.  $\frac{3.0 \times 10^{10} \text{ cm}}{1 \text{ s}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{1 \text{ ft}}{12 \text{ in}} = \mathbf{9.8 \times 10^8 \text{ ft/s}}$
- c.  $1.42 \text{ yr} \times \frac{365 \text{ day}}{1 \text{ yr}} \times \frac{24 \text{ h}}{1 \text{ day}} \times \frac{3600 \text{ s}}{1 \text{ h}} \times \frac{3.00 \times 10^8 \text{ m}}{1 \text{ s}} \times \frac{1 \text{ mi}}{1609 \text{ m}} = \mathbf{8.35 \times 10^{12} \text{ mi}}$

- 1.65 a. **Strategy:** The given unit is nm and the desired unit is m. Use a conversion factor to convert nm  $\rightarrow$  m.

**Setup:** Use the conversion factor:

$$\frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}}$$

**Solution:**

$$185 \text{ nm} \times \frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}} = \mathbf{1.85 \times 10^{-7} \text{ m}}$$

- b. **Strategy:** The given unit is yr and the desired unit is s. Use conversion factors to convert yr  $\rightarrow$  d  $\rightarrow$  h  $\rightarrow$  s.

**Setup:** Use the conversion factors:

$$\frac{365 \text{ d}}{1 \text{ yr}}, \frac{24 \text{ h}}{1 \text{ d}}, \text{ and } \frac{3600 \text{ s}}{1 \text{ h}}$$

**Solution:**

$$(4.5 \times 10^9 \text{ yr}) \times \frac{365 \text{ day}}{1 \text{ yr}} \times \frac{24 \text{ h}}{1 \text{ day}} \times \frac{3600 \text{ s}}{1 \text{ h}} = \mathbf{1.4 \times 10^{17} \text{ s}}$$

- c. **Strategy:** The given unit is  $\text{cm}^3$  and the desired unit is  $\text{m}^3$ . Use a conversion factor to convert  $\text{cm}^3 \rightarrow \text{m}^3$ .

**Setup:** Use the conversion factor:

$$\left( \frac{0.01 \text{ m}}{1 \text{ cm}} \right)^3$$

**Solution:**

$$71.2 \text{ cm}^3 \times \left( \frac{0.01 \text{ m}}{1 \text{ cm}} \right)^3 = 7.12 \times 10^{-5} \text{ m}^3$$

- d. **Strategy:** The given unit is  $\text{m}^3$  and the desired unit is L. Use conversion factors to convert  $\text{m}^3 \rightarrow \text{cm}^3 \rightarrow \text{L}$ .

**Setup:** Use the conversion factors:

$$\left( \frac{1 \text{ cm}}{1 \times 10^{-2} \text{ m}} \right)^3 \text{ and } \frac{1 \text{ L}}{1000 \text{ cm}^3}$$

**Solution:**

$$88.6 \text{ m}^3 \times \left( \frac{1 \text{ cm}}{1 \times 10^{-2} \text{ m}} \right)^3 \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 8.86 \times 10^4 \text{ L}$$

$$1.66 \quad \text{density} = \frac{2.70 \text{ g}}{1 \text{ cm}^3} \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \left( \frac{1 \text{ cm}}{0.01 \text{ m}} \right)^3 = 2.70 \times 10^3 \text{ kg/m}^3$$

- 1.67 **Strategy:** The given rate has units  $\text{g/L}$  and the desired units are  $\text{g/cm}^3$ . Use a conversion factor to convert  $\text{L} \rightarrow \text{cm}^3$ .

**Setup:** Use the conversion factor:

$$\frac{1 \text{ L}}{1000 \text{ cm}^3}$$

**Solution:**

$$\frac{0.625 \text{ g}}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 6.25 \times 10^{-4} \text{ g/cm}^3$$

- 1.68 a. Convert the dimensions of the room to dm:

$$17.6 \text{ m} \times \frac{10 \text{ dm}}{\text{m}} = 176 \text{ dm} ; 8.80 \text{ m} \times \frac{10 \text{ dm}}{\text{m}} = 88.0 \text{ dm} ; 2.64 \text{ m} \times \frac{10 \text{ dm}}{\text{m}} = 26.4 \text{ dm}$$

Multiply the room dimensions to get the volume of the room:

$$176 \text{ dm} \times 88.0 \text{ dm} \times 26.4 \text{ dm} = 4.089 \times 10^5 \text{ dm}^3 = 4.089 \times 10^5 \text{ L}$$

Because the concentration of CO in the room is  $8.00 \times 10^2$  ppm, the volume that would be occupied under the same conditions by the CO alone is

$$4.089 \times 10^5 \text{ L} \times \frac{8.00 \times 10^2 \text{ L CO}}{1.00 \times 10^6 \text{ L total}} = \mathbf{327 \text{ L}}$$

$$\text{b. } \frac{0.050 \text{ mg}}{\text{m}^3} \times \frac{1 \text{ g}}{1 \times 10^3 \text{ mg}} \times \left( \frac{1 \text{ m}}{10 \text{ dm}} \right)^3 = 5.0 \times 10^{-8} \text{ g/dm}^3 = \mathbf{5.0 \times 10^{-8} \text{ g/L}}$$

$$\text{c. } \frac{120 \text{ mg}}{1 \text{ dL}} \times \frac{1 \times 10^3 \mu\text{g}}{1 \text{ mg}} \times \frac{10 \text{ dL}}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} = \mathbf{1.20 \times 10^3 \mu\text{g/mL}}$$

- 1.69 **Strategy:** Use the equation  $t = \frac{x^2}{2D}$  to convert the given distance ( $x = 10 \mu\text{m}$ ) to time  $t$  in seconds. Notice that both  $x$  and  $D$  contain distance units. But, for the given values,  $x = 10 \mu\text{m}$  and  $D = 5.7 \times 10^{-7} \text{ cm}^2/\text{s}$ , the distance units are dissimilar and will not cancel. So, before calculating, convert the units of  $x$  from  $\mu\text{m}$  to cm.

**Setup:** Use the conversion factors:

$$\frac{1 \times 10^{-2} \text{ m}}{1 \text{ cm}} \text{ and } \frac{1 \mu\text{m}}{1 \times 10^{-6} \text{ m}}$$

**Solution:**

$$10 \mu\text{m} \times \frac{1 \times 10^{-6} \text{ m}}{1 \mu\text{m}} \times \frac{1 \text{ cm}}{1 \times 10^{-2} \text{ m}} = 1 \times 10^{-3} \text{ cm} = x \text{ in the equation.}$$

$$t = \left[ \frac{(10^{-3} \text{ cm})^2}{2 \times 5.7 \times 10^{-7} \text{ cm}^2/\text{s}} \right] = \mathbf{0.88 \text{ s}}$$

- 1.70 Determine the volume occupied by the brain:

$$1 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mL}}{1 \text{ g}} = 1000 \text{ mL}$$

Next determine the volume occupied by a single cell:

$$\frac{1000 \text{ mL}}{1 \times 10^{11} \text{ cells}} = 1 \times 10^{-8} \text{ mL per cell}$$

Remember that  $1 \text{ mL} = 1 \text{ cm}^3$ . The cube root of the volume per cell, expressed in  $\text{cm}^3$ , gives the length of a cubic cell side:

$$\sqrt[3]{1 \times 10^{-8} \text{ cm}^3} = 2.2 \times 10^{-3} \text{ cm}$$

Therefore, the length of the edge of each cube is  $2 \times 10^{-3} \text{ cm}$ .

The surface area of a single cell is  $(2.2 \times 10^{-3} \text{ cm})^2 = 4.8 \times 10^{-6} \text{ cm}^2$ .

The total surface area of  $1 \times 10^{11}$  cells in a single layer is

$$1 \times 10^{11} \text{ cells} \times \frac{4.8 \times 10^{-6} \text{ cm}^2}{1 \text{ cell}} = 5 \times 10^5 \text{ cm}^2 \times \left( \frac{1 \text{ m}}{100 \text{ cm}} \right)^2 = 50 \text{ m}^2$$

- 1.71 a. **Upper ruler: 2.5 cm**

- b. **Lower ruler: 2.55 cm**

- 1.72 Volume of sample:  $V = 18.45 \text{ mL} - 17.00 \text{ mL} = 1.45 \text{ mL}$

$$\text{Density: } d = \frac{m}{V} = \frac{13.2 \text{ g}}{1.45 \text{ mL}} = 9.10 \text{ g/mL}$$

- 1.73 a. **chemical**      b. **chemical**      c. **physical**      d. **physical**      e. **chemical**

- 1.74 Volume of rectangular solid =  $l \times w \times h$

$$\text{Volume} = (8.53 \text{ cm})(2.4 \text{ cm})(1.0 \text{ cm}) = 2.0 \times 10^1 \text{ cm}^3$$

$$d = \frac{m}{V} = \frac{52.7064 \text{ g}}{2.0 \times 10^1 \text{ cm}^3} = 2.6 \text{ g/cm}^3$$

- 1.75 a. **Strategy:** Calculate the volume of the sphere using:

$$V = \frac{4}{3}\pi r^3$$

Then use the density equation,  $d = \frac{m}{V}$ , to find the mass.

**Setup:** Solve the density equation for  $m$  to get  $m = dV$ . Find the volume and substitute in into the equation for  $m$ .

**Solution:**

$$V = \left(\frac{4}{3}\right)(3.14159)(10.0 \text{ cm})^3 = 4189 \text{ cm}^3$$

$$m = dV = \frac{19.3 \text{ g}}{1 \text{ cm}^3} \times 4189 \text{ cm}^3 = \mathbf{8.08 \times 10^4 \text{ g}}$$

- b. **Strategy:** Compute the volume of the cube using:

$$V = s^3$$

Then, find the mass using the density equation:

$$d = \frac{m}{V}$$

**Setup:** Solve the density equation for  $m$  to get  $m = dV$ . Find the volume and substitute in into the equation for  $m$ .

**Solution:** The edge of the cube is  $s = 0.040 \text{ mm} = 0.0040 \text{ cm}$ , and  $V = (0.0040 \text{ cm})^3 = 6.4 \times 10^{-8} \text{ cm}^3$ .

$$m = dV = \frac{21.4 \text{ g}}{1 \text{ cm}^3} \times (6.4 \times 10^{-8} \text{ cm}^3) = \mathbf{1.4 \times 10^{-6} \text{ g}}$$

- c. **Strategy:** Use the density equation:

$$d = \frac{m}{V}$$



**Setup:** Solve the density equation for  $m$  to get  $m = dV$ .

**Solution:**

$$50.0 \text{ mL} \times \frac{0.798 \text{ g}}{1 \text{ mL}} = \mathbf{39.9 \text{ g}}$$

- 1.76 You are asked to solve for the inner diameter of the tube. If you can calculate the volume that the mercury occupies, you can calculate the radius of the cylinder,  $V_{\text{cylinder}} = \pi r^2 h$  ( $r$  is the inner radius of the cylinder, and  $h$  is the height of the cylinder). The cylinder diameter is  $2r$ .

$$\text{volume of Hg filling cylinder} = \frac{\text{mass of Hg}}{\text{density of Hg}}$$

$$\text{volume of Hg filling cylinder} = \frac{105.5 \text{ g}}{13.6 \text{ g/cm}^3} = 7.757 \text{ cm}^3$$

Next, solve for the radius of the cylinder.

$$\text{Volume of cylinder} = \pi r^2 h$$

$$r = \sqrt{\frac{\text{volume}}{\pi \times h}}$$

$$r = \sqrt{\frac{7.757 \text{ cm}^3}{\pi \times 12.7 \text{ cm}}} = 0.4409 \text{ cm}$$

The cylinder diameter equals  $2r$ .

$$\mathbf{\text{Cylinder diameter} = 2r = 2(0.4409 \text{ cm}) = \mathbf{0.882 \text{ cm}}}$$

- 1.77 **Strategy:** The difference between the masses of the empty and filled flasks is the mass of the water in the flask. The volume of the water (and the flask) can be found using the density equation.

**Setup:** Solve the density equation for  $V$ :

$$V = \frac{m}{d}$$

**Solution:**

$$87.39 - 56.12 = 31.27 \text{ g water}$$

$$V = \frac{m}{d} = \frac{31.27 \text{ g}}{0.9976 \text{ g/cm}^3} = \mathbf{31.35 \text{ cm}^3}$$

$$1.78 \quad \frac{343 \text{ m}}{1 \text{ s}} \times \frac{1 \text{ mi}}{1609 \text{ m}} \times \frac{3600 \text{ s}}{1 \text{ h}} = \mathbf{767 \text{ mph}}$$

- 1.79 **Strategy:** The volume of the piece of silver is the same as the volume of water it displaces. Once the volume is found, use the density equation to compute the density.

**Setup:**  $V = 260.5 - 242.0 = 18.50 \text{ mL}$

**Solution:** 
$$d = \left( \frac{194.3 \text{ g}}{18.50 \text{ mL}} \right) = \mathbf{10.50 \text{ g/mL}}$$

The density of a solid is generally reported in  $\text{g/cm}^3$ . ( $1 \text{ mL} = 1 \text{ cm}^3$ ) Therefore, the density is reported as  $\mathbf{10.50 \text{ g/cm}^3}$ .

**Think** The volume of the water displaced must equal the volume of the piece of silver. If the silver did  
**About It:** not sink, would you have been able to determine the volume of the piece of silver?

- 1.80 **The liquid must be *less dense* than the ice in order for the ice to sink. The temperature of the experiment must be maintained at or below  $0^\circ\text{C}$  to prevent the ice from melting.**

- 1.81 **Strategy:** Use the density equation.

**Setup:** 
$$d = \frac{m}{V}$$

**Solution:** 
$$d = \frac{m}{V} = \frac{1.20 \times 10^4 \text{ g}}{1.05 \times 10^3 \text{ cm}^3} = \mathbf{11.4 \text{ g/cm}^3}$$

1.82 
$$\text{Volume} = \frac{\text{mass}}{\text{density}}$$

$$\text{Volume occupied by Li} = \frac{1.20 \times 10^3 \text{ g}}{0.53 \text{ g/cm}^3} = 2.3 \times 10^3 \text{ cm}^3$$

- 1.83 **Strategy:** Use the conversion equation  $^{\circ}\text{F} \rightarrow ^{\circ}\text{C}$  or the conversion equation  $^{\circ}\text{C} \rightarrow ^{\circ}\text{F}$ . The solution below uses the conversion equation  $^{\circ}\text{C} \rightarrow ^{\circ}\text{F}$ .

**Setup:** Let  $t$  represent the common temperature. Substitute  $t$  into the conversion equation

$$^{\circ}\text{F} = \left( ^{\circ}\text{C} \times \frac{9^{\circ}\text{F}}{5^{\circ}\text{C}} \right) + 32^{\circ}\text{F} \text{ and solve for } t.$$

**Solution:**

$$t = \frac{9}{5}t + 32^{\circ}\text{F}$$

$$t - \frac{9}{5}t = 32^{\circ}\text{F}$$

$$-\frac{4}{5}t = 32^{\circ}\text{F}$$

$$t = -40^{\circ}\text{F} = -40^{\circ}\text{C}$$

- 1.84 There are  $78.3 + 117.3 = 195.6$  Celsius degrees between  $0^{\circ}\text{S}$  and  $100^{\circ}\text{S}$ . We can write this as a conversion factor.

$$\frac{195.6^{\circ}\text{C}}{100^{\circ}\text{S}}$$

Set up the equation like a Celsius to Fahrenheit conversion. We need to subtract  $117.3^{\circ}\text{C}$ , because the zero point on the new scale is  $117.3^{\circ}\text{C}$  lower than the zero point on the Celsius scale.

$$?^{\circ}\text{C} = \left( \frac{195.6^{\circ}\text{C}}{100^{\circ}\text{S}} \right) (?^{\circ}\text{S}) - 117.3^{\circ}\text{C}$$

Solving for  $?^{\circ}\text{S}$  gives:

$$?^{\circ}\text{S} = (?^{\circ}\text{C} + 117.3^{\circ}\text{C}) \left( \frac{100^{\circ}\text{S}}{195.6^{\circ}\text{C}} \right)$$

For  $25^{\circ}\text{C}$  we have:

$$?^{\circ}\text{S} = (25^{\circ}\text{C} + 117.3^{\circ}\text{C}) \left( \frac{100^{\circ}\text{S}}{195.6^{\circ}\text{C}} \right) = 72.8^{\circ}\text{S}$$

- 1.85 **Strategy:** The volume of seawater is given. The strategy is to use the given conversion factors to convert L seawater  $\rightarrow$  g seawater  $\rightarrow$  g NaCl. This result can then be converted to kg NaCl and to tons

NaCl. Note that 3.1% NaCl by weight means 100 g seawater = 3.1 g NaCl.

**Setup:** Use the conversion factors:

$$\frac{1000 \text{ mL seawater}}{1 \text{ L seawater}}, \frac{1.03 \text{ g seawater}}{1 \text{ mL seawater}}, \text{ and } \frac{3.1 \text{ g NaCl}}{100 \text{ g seawater}}$$

**Solution:**

$$1.5 \times 10^{21} \text{ L seawater} \times \frac{1000 \text{ mL seawater}}{1 \text{ L seawater}} \times \frac{1.03 \text{ g seawater}}{1 \text{ mL seawater}} \times \frac{3.1 \text{ g NaCl}}{100 \text{ g seawater}} = 4.8 \times 10^{22} \text{ g NaCl}$$

$$\text{mass NaCl (kg)} = 4.8 \times 10^{22} \text{ g NaCl} \times \frac{1 \text{ kg}}{1000 \text{ g}} = \mathbf{4.8 \times 10^{19} \text{ kg NaCl}}$$

$$\text{mass NaCl (tons)} = 4.8 \times 10^{22} \text{ g NaCl} \times \frac{1 \text{ lb}}{453.6 \text{ g}} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = \mathbf{5.3 \times 10^{16} \text{ tons NaCl}}$$

1.86

Volume = area  $\times$  thickness.

From the density, we can calculate the volume of the Al foil.

$$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{3.636 \text{ g}}{2.699 \text{ g/cm}^3} = 1.3472 \text{ cm}^3$$

Convert the unit of area from ft<sup>2</sup> to cm<sup>2</sup>.

$$1.000 \text{ ft}^2 \times \left( \frac{12 \text{ in}}{1 \text{ ft}} \right)^2 \times \left( \frac{2.54 \text{ cm}}{1 \text{ in}} \right)^2 = 929.03 \text{ cm}^2$$

$$\text{thickness} = \frac{\text{volume}}{\text{area}} = \frac{1.3472 \text{ cm}^3}{929.03 \text{ cm}^2} = 1.450 \times 10^{-3} \text{ cm} = \mathbf{1.450 \times 10^{-2} \text{ mm}}$$

1.87 **Strategy:** Assume that the crucible is platinum. Calculate the volume of the crucible and then compare that to the volume of water that the crucible displaces.

**Setup:**

$$\text{volume} = \frac{\text{mass}}{\text{density}}$$

**Solution:**

$$\text{Volume of crucible} = \frac{860.2 \text{ g}}{21.45 \text{ g/cm}^3} = \mathbf{40.10 \text{ cm}^3}$$

$$\text{Volume of water displaced} = \frac{(860.2 - 820.2)\text{g}}{0.9986 \text{ g/cm}^3} = \mathbf{40.1 \text{ cm}^3}$$

The volumes are the same (within experimental error), so **the density of the crucible is equal to the density of pure platinum**. Therefore, the crucible is probably made of platinum

1.88

$$\text{Volume} = \text{surface area} \times \text{depth}$$

Recall that  $1 \text{ L} = 1 \text{ dm}^3$ . Convert the surface area to units of  $\text{dm}^2$  and the depth to units of dm.

$$\text{surface area} = (1.8 \times 10^8 \text{ km}^2) \times \left( \frac{1000 \text{ m}}{1 \text{ km}} \right)^2 \times \left( \frac{1 \text{ dm}}{0.1 \text{ m}} \right)^2 = 1.8 \times 10^{16} \text{ dm}^2$$

$$\text{depth} = (3.9 \times 10^3 \text{ m}) \times \frac{1 \text{ dm}}{0.1 \text{ m}} = 3.9 \times 10^4 \text{ dm}$$

$$\mathbf{Volume} = \text{surface area} \times \text{depth} = (1.8 \times 10^{16} \text{ dm}^2)(3.9 \times 10^4 \text{ dm}) = 7.0 \times 10^{20} \text{ dm}^3 = \mathbf{7.0 \times 10^{20} \text{ L}}$$

1.89 a. **Strategy:** Use the given conversion factor to convert troy oz  $\rightarrow$  g.

**Setup:** Conversion factor:

$$\frac{31.103 \text{ g Au}}{1 \text{ troy oz Au}}$$

**Solution:**

$$2.41 \text{ troy oz Au} \times \frac{31.103 \text{ g Au}}{1 \text{ troy oz Au}} = \mathbf{75.0 \text{ g Au}}$$

b. **Strategy:** Use the given conversion factors to convert 1 troy oz  $\rightarrow$  g  $\rightarrow$  lb  $\rightarrow$  oz.

**Setup:** Conversion factors:

$$\frac{31.103 \text{ g}}{1 \text{ troy oz}}, \frac{1 \text{ lb}}{453.6 \text{ g}}, \text{ and } \frac{16 \text{ oz}}{1 \text{ lb}}$$

**Solution:**

$$1 \text{ troy oz} \times \frac{31.103 \text{ g}}{1 \text{ troy oz}} \times \frac{1 \text{ lb}}{453.6 \text{ g}} \times \frac{16 \text{ oz}}{1 \text{ lb}} = 1.097 \text{ oz}$$

$$1 \text{ troy oz} = 1.097 \text{ oz}$$

A troy ounce is heavier than an ounce.

1.90

$$\text{Volume of sphere} = \frac{4}{3}\pi r^3$$

$$\text{Volume} = \frac{4}{3}\pi \left(\frac{15 \text{ cm}}{2}\right)^3 = 1.77 \times 10^3 \text{ cm}^3$$

$$\text{mass} = \text{volume} \times \text{density} = (1.77 \times 10^3 \text{ cm}^3) \times \frac{22.57 \text{ g Os}}{1 \text{ cm}^3} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 4.0 \times 10^1 \text{ kg Os}$$

$$4.0 \times 10^1 \text{ kg Os} \times \frac{2.205 \text{ lb}}{1 \text{ kg}} = 88 \text{ lb Os}$$

1.91 a. **Strategy:** Use the percent error equation.

**Setup:** The percent error of a measurement is given by:

$$\frac{|\text{true value} - \text{experimental value}|}{\text{true value}} \times 100\%$$

**Solution:**

$$\frac{|0.798 \text{ g/mL} - 0.802 \text{ g/mL}|}{0.798 \text{ g/mL}} \times 100\% = 0.5\%$$

b. **Strategy:** Use the percent error equation.

**Setup:** The percent error of a measurement is given by:

$$\frac{|\text{true value} - \text{experimental value}|}{\text{true value}} \times 100\%$$

**Solution:**

$$\frac{|0.864 \text{ g} - 0.837 \text{ g}|}{0.864 \text{ g}} \times 100\% = 3.1\%$$

- 1.92 We assume that the thickness of the oil layer is equivalent to the length of one oil molecule. We can calculate the thickness of the oil layer from the volume and surface area.

$$40 \text{ m}^2 \times \left( \frac{1 \text{ cm}}{0.01 \text{ m}} \right)^2 = 4.0 \times 10^5 \text{ cm}^2$$

$$0.10 \text{ mL} = 0.10 \text{ cm}^3$$

$$\text{Volume} = \text{surface area} \times \text{thickness}$$

$$\text{thickness} = \frac{\text{volume}}{\text{surface area}} = \frac{0.10 \text{ cm}^3}{4.0 \times 10^5 \text{ cm}^2} = 2.5 \times 10^{-7} \text{ cm}$$

Converting to nm:

$$(2.5 \times 10^{-7} \text{ cm}) \times \frac{0.01 \text{ m}}{1 \text{ cm}} \times \frac{1 \text{ nm}}{1 \times 10^{-9} \text{ m}} = \mathbf{2.5 \text{ nm}}$$

- 1.93 **Gently heat the liquid to see if any solid remains after the liquid evaporates. Also, collect the vapor and then compare the densities of the condensed liquid with the original liquid. The composition of a mixed liquid frequently changes with evaporation along with its density.**

1.94 a. 
$$\frac{\$1.30}{15.0 \text{ ft}^3} \times \left( \frac{1 \text{ ft}}{12 \text{ in}} \right)^3 \times \left( \frac{1 \text{ in}}{2.54 \text{ cm}} \right)^3 \times \frac{1 \text{ cm}^3}{1 \text{ mL}} \times \frac{1 \text{ mL}}{0.001 \text{ L}} = \mathbf{\$3.06 \times 10^{-3} / L}$$

b. 
$$2.1 \text{ L water} \times \frac{0.304 \text{ ft}^3 \text{ gas}}{1 \text{ L water}} \times \frac{\$1.30}{15.0 \text{ ft}^3} = \mathbf{\$0.055 = 5.5\text{¢}}$$

- 1.95 **Strategy:** As water freezes, it expands. First, calculate the mass of the water at 20°C. Then, determine the volume that this mass of water would occupy at -5°C.

**Solution:**

$$\text{Mass of water} = 242 \text{ mL} \times \frac{0.998 \text{ g}}{1 \text{ mL}} = 241.5 \text{ g}$$

$$\text{Volume of ice at } -5^\circ\text{C} = 241.5 \text{ g} \times \frac{1 \text{ mL}}{0.916 \text{ g}} = 264 \text{ mL}$$

**The volume occupied by the ice is larger than the volume of the glass bottle. The glass bottle would break.**

- 1.96 This problem is similar in concept to a limiting reactant problem. We need sets of coins with 3 quarters, 1 nickel, and 2 dimes. First, we need to find the total number of each type of coin.

$$\text{Number of quarters} = (33.871 \times 10^3 \text{ g}) \times \frac{1 \text{ quarter}}{5.645 \text{ g}} = 6000 \text{ quarters}$$

$$\text{Number of nickels} = (10.432 \times 10^3 \text{ g}) \times \frac{1 \text{ nickel}}{4.967 \text{ g}} = 2100 \text{ nickels}$$

$$\text{Number of dimes} = (7.990 \times 10^3 \text{ g}) \times \frac{1 \text{ dime}}{2.316 \text{ g}} = 3450 \text{ dimes}$$

Next, we need to find which coin limits the number of sets that can be assembled. For each set of coins, we need 2 dimes for every 1 nickel.

$$2100 \text{ nickels} \times \frac{2 \text{ dimes}}{1 \text{ nickel}} = 4200 \text{ dimes}$$

We do not have enough dimes.

For each set of coins, we need 2 dimes for every 3 quarters.

$$6000 \text{ quarters} \times \frac{2 \text{ dimes}}{3 \text{ quarters}} = 4000 \text{ dimes}$$

Again, we do not have enough dimes, and therefore the number of dimes is our “limiting reactant”.

If we need 2 dimes per set, the number of sets that can be assembled is:

$$3450 \text{ dimes} \times \frac{1 \text{ set}}{2 \text{ dimes}} = 1725 \text{ sets}$$

The mass of each set is:

$$\left( 3 \text{ quarters} \times \frac{5.645 \text{ g}}{1 \text{ quarter}} \right) + \left( 1 \text{ nickel} \times \frac{4.967 \text{ g}}{1 \text{ nickel}} \right) + \left( 2 \text{ dimes} \times \frac{2.316 \text{ g}}{1 \text{ dime}} \right) = 26.534 \text{ g/set}$$

Finally, the total mass of 1725 sets of coins is:

$$1725 \text{ sets} \times \frac{26.534 \text{ g}}{1 \text{ set}} = 4.577 \times 10^4 \text{ g}$$

- 1.97 **Strategy:** We are given a distance (1500 m) and a rate (3 minutes 43.13 seconds per mile). Use the rate as a conversion factor to convert  $\text{m} \rightarrow \text{mi} \rightarrow \text{s}$ .



**Setup:** Convert the time to run 1 mile to seconds:

$$3 \text{ min } 43.13 \text{ s} = 180 \text{ s} + 43.13 \text{ s} = 223.13 \text{ s}$$

Use the conversion factors:  $\frac{1 \text{ mi}}{1609 \text{ m}} \quad \frac{223.13 \text{ s}}{1 \text{ mi}}$

**Solution:**

$$1500 \text{ m} \times \frac{1 \text{ mi}}{1609 \text{ m}} \times \frac{223.13 \text{ s}}{1 \text{ mi}} = \mathbf{208.0 \text{ s} = 3 \text{ min } 28.0 \text{ s}}$$

1.98  $(7.3 \times 10^2 - 273) \text{ K} = \mathbf{4.6 \times 10^2 \text{ } ^\circ\text{C}}$

$$\left( (4.6 \times 10^2 \text{ } ^\circ\text{C}) \times \frac{9^\circ\text{F}}{5^\circ\text{C}} \right) + 32^\circ\text{F} = \mathbf{8.6 \times 10^2 \text{ } ^\circ\text{F}}$$

1.99 a. **homogeneous**

b. **heterogeneous.** The air will contain particulate matter, clouds, etc. This mixture is not homogeneous.

1.100  $8 \times 10^4 \text{ tons Au} \times \frac{2000 \text{ lb Au}}{1 \text{ ton Au}} \times \frac{16 \text{ oz Au}}{1 \text{ lb Au}} \times \frac{28.35 \text{ g Au}}{1 \text{ oz Au}} \times \frac{\$1350}{31.103 \text{ g}} = \mathbf{\$3.2 \times 10^{12} \text{ or } \$3.2 \text{ trillion.}}$

1.101 **Strategy:** Step 1: Use conversion factors to convert L seawater  $\rightarrow$  mL seawater  $\rightarrow$  g Au.

Step 2: Use conversion factors to convert g Au  $\rightarrow$  dollars

**Setup:**

Step 1: Use the conversion factors:  $\frac{1 \text{ mL seawater}}{0.001 \text{ L seawater}} \quad \frac{4.0 \times 10^{-12} \text{ g Au}}{1 \text{ mL seawater}}$

Step 2: Use the conversion factor:  $\frac{\$1350}{31.103 \text{ g Au}}$

**Solution:**

$$(1.5 \times 10^{21} \text{ L seawater}) \times \frac{1 \text{ mL seawater}}{0.001 \text{ L seawater}} \times \frac{4.0 \times 10^{-12} \text{ g Au}}{1 \text{ mL seawater}} = \mathbf{6.0 \times 10^{12} \text{ g Au}}$$

$$\mathbf{\text{value of gold}} = 6.0 \times 10^{12} \text{ g Au} \times \frac{\$1350}{31.103 \text{ oz}} = \mathbf{\$2.6 \times 10^{14}}$$

**Think** No one has become rich mining gold from the ocean, because the cost of recovering the gold  
**About It:** would outweigh the price of the gold.

$$1.102 \quad 4.9 \text{ g Fe} \times \frac{1.1 \times 10^{22} \text{ Fe atoms}}{1.0 \text{ g Fe}} = \mathbf{5.4 \times 10^{22} \text{ Fe atoms}}$$

1.103 **Strategy:** Use conversion factors to convert tons of earth  $\rightarrow$  kg Si. Note that 0.50% crust by mass means 100 tons earth = 0.50 tons crust and that 27.2% Si by mass means 100 tons crust = 27.2 tons Si.

**Setup:** Conversion factors:

$$\frac{0.50 \text{ ton crust}}{100 \text{ ton earth}} \quad \frac{27.2 \text{ ton Si}}{100 \text{ ton crust}} \quad \frac{2000 \text{ lb Si}}{1 \text{ ton Si}} \quad \frac{453.6 \text{ g Si}}{1 \text{ lb Si}} \quad \frac{1 \text{ kg Si}}{1000 \text{ g Si}}$$

**Solution:**

$$5.9 \times 10^{21} \text{ ton earth} \times \frac{0.50 \text{ ton crust}}{100 \text{ ton earth}} \times \frac{27.2 \text{ ton Si}}{100 \text{ ton crust}} \times \frac{2000 \text{ lb Si}}{1 \text{ ton Si}} \times \frac{453.6 \text{ g Si}}{1 \text{ lb Si}} \times \frac{1 \text{ kg Si}}{1000 \text{ g Si}}$$

$$= 7.3 \times 10^{21} \text{ kg Si}$$

$$\mathbf{\text{mass of silicon in crust} = 7.3 \times 10^{21} \text{ kg Si}}$$

1.104 **Strategy:** The final cut results in two separate copper atoms. The length of a segment of wire consisting of a single copper atom is equal to the diameter (two times the radius) of a copper atom. We need to find the number of times the 0.1 m wire must be cut in half until the pieces that result from the final cut are each  $2.6 \times 10^{-10}$  m long.

**Setup:** Let  $n$  be the number of times we can cut the Cu wire in half. The original length is 10 cm or 0.1 m. We can write:

$$\left(\frac{1}{2}\right)^n \times 0.1 \text{ m} = 2.6 \times 10^{-10} \text{ m}$$

$$\left(\frac{1}{2}\right)^n = 2.6 \times 10^{-9} \text{ m}$$

**Solution:** Taking the log of both sides of the equation:

$$n \log\left(\frac{1}{2}\right) = \log(2.6 \times 10^{-9} \text{ m})$$

$$n = 29 \text{ times}$$

**1.105 Strategy:** We wish to calculate the density and radius of the ball bearing. For both calculations, we need the volume of the ball bearing. The data from the first experiment can be used to calculate the density of the mineral oil. In the second experiment, the density of the mineral oil can then be used to determine what part of the 40.00 mL volume is due to the mineral oil and what part is due to the ball bearing. Once the volume of the ball bearing is determined, we can calculate its density and radius.

**Solution:** From experiment one:

$$\text{Mass of oil} = 159.446 \text{ g} - 124.966 \text{ g} = 34.480 \text{ g}$$

$$\text{Density of oil} = \frac{34.480 \text{ g}}{40.00 \text{ mL}} = 0.8620 \text{ g/mL}$$

From the second experiment:

$$\text{Mass of oil} = 50.952 \text{ g} - 18.713 \text{ g} = 32.239 \text{ g}$$

$$\text{Volume of oil} = 32.239 \text{ g} \times \frac{1 \text{ mL}}{0.8620 \text{ g}} = 37.40 \text{ mL}$$

The volume of the ball bearing is obtained by difference.

$$\text{Volume of ball bearing} = 40.00 \text{ mL} - 37.40 \text{ mL} = 2.60 \text{ mL} = 2.60 \text{ cm}^3$$

Now that we have the volume of the ball bearing, we can calculate its density and radius.

$$\text{Density of ball bearing} = \frac{18.713 \text{ g}}{2.60 \text{ cm}^3} = 7.20 \text{ g/cm}^3$$

Using the formula for the volume of a sphere, we can solve for the radius of the ball bearing.

$$V = \frac{4}{3} \pi r^3$$

$$2.60 \text{ cm}^3 = \frac{4}{3} \pi r^3$$

$$r^3 = 0.621 \text{ cm}^3$$

$$r = 0.853 \text{ cm}$$

- 1.106 The density of the mixed solution should be based on the percentage of each liquid and its density. Because the solid object is suspended in the mixed solution, it should have the same density as this solution. The density of the mixed solution is:

$$(0.4137)(2.0514 \text{ g/mL}) + (0.5863)(2.6678 \text{ g/mL}) = \mathbf{2.413 \text{ g/mL}}$$

As discussed, the density of the object should have the same density as the mixed solution (**2.413 g/mL**).

**Yes**, this procedure can be used in general to determine the densities of solids. This procedure is called the flotation method. **It is based on the assumptions that the liquids are totally miscible and that the volumes of the liquids are additive.**

- 1.107 **It would be more difficult to prove that the unknown substance is an element. Most compounds would decompose on heating, making them easy to identify. On heating, the compound HgO decomposes to elemental mercury (Hg) and oxygen gas (O<sub>2</sub>).**
- 1.108 First, Calculate the mass (in g) of water in the pool. We perform this conversion because we know there is 1 g of chlorine needed per million grams of water.

$$(2.0 \times 10^4 \text{ gallons H}_2\text{O}) \times \frac{3.79 \text{ L}}{1 \text{ gallon}} \times \frac{1 \text{ mL}}{0.001 \text{ L}} \times \frac{1 \text{ g}}{1 \text{ mL}} = 7.58 \times 10^7 \text{ g H}_2\text{O}$$

Next, let's calculate the mass of chlorine that needs to be added to the pool.

$$(7.58 \times 10^7 \text{ g H}_2\text{O}) \times \frac{1 \text{ g chlorine}}{1 \times 10^6 \text{ g H}_2\text{O}} = 75.8 \text{ g chlorine}$$

The chlorine solution is only 6 percent chlorine by mass. We can now calculate the volume of chlorine solution that must be added to the pool.

$$75.8 \text{ g chlorine} \times \frac{100\% \text{ soln}}{6\% \text{ chlorine}} \times \frac{1 \text{ mL soln}}{1 \text{ g soln}} = \mathbf{1.3 \times 10^3 \text{ mL of chlorine solution}}$$

- 1.109 **Strategy:** Use the given rate to convert J  $\rightarrow$  yr.

**Setup:** Conversion factor:

$$\frac{1 \text{ yr}}{1.8 \times 10^{20} \text{ J}}$$

**Solution:**

$$(2.0 \times 10^{22} \text{ J}) \times \frac{1 \text{ yr}}{1.8 \times 10^{20} \text{ J}} = \mathbf{1.1 \times 10^2 \text{ yr}}$$

- 1.110 We want to calculate the mass of the cylinder, which can be calculated from its volume and density. The volume of a cylinder is  $\pi r^2 l$ . The density of the alloy can be calculated using the mass percentages of each element and the given densities of each element.

The volume of the cylinder is:

$$V = \pi r^2 l$$

$$V = \pi (6.44 \text{ cm})^2 (44.37 \text{ cm})$$

$$V = 5781 \text{ cm}^3$$

The density of the cylinder is:

$$\text{density} = (0.7942)(8.94 \text{ g/cm}^3) + (0.2058)(7.31 \text{ g/cm}^3) = 8.605 \text{ g/cm}^3$$

Now, we can calculate the mass of the cylinder.

$$\text{mass} = \text{density} \times \text{volume}$$

$$\text{mass} = (8.605 \text{ g/cm}^3)(5781 \text{ cm}^3) = \mathbf{4.97 \times 10^4 \text{ g}}$$

**The calculation assumes that the volumes of the two components are additive.** If the volumes are additive, then the density of the alloy is simply the weighted average of the densities of the components.

- 1.111 **Strategy:** Use the percent composition measurement to convert kg ore  $\rightarrow$  g Cu. Note that 34.63% Cu by mass means 100 g ore = 34.63 g Cu.

**Setup:** Use the conversion factors:

$$\frac{34.63 \text{ g Cu}}{100 \text{ g ore}} \quad \frac{1000 \text{ g}}{1 \text{ kg}}$$

**Solution:**

$$(5.11 \times 10^3 \text{ kg ore}) \times \frac{34.63 \text{ g Cu}}{100 \text{ g ore}} \times \frac{1000 \text{ g}}{1 \text{ kg}} = \mathbf{1.77 \times 10^6 \text{ g Cu}}$$

- 1.112 To work this problem, we need to convert from cubic feet to L. Some tables will have a conversion factor of  $28.3 \text{ L} = 1 \text{ ft}^3$ , but we can also calculate it using the dimensional analysis method described in Section 1.6 of the text.

First, convert from cubic feet to liters:

$$(5.0 \times 10^7 \text{ ft}^3) \times \left( \frac{12 \text{ in}}{1 \text{ ft}} \right)^3 \times \left( \frac{2.54 \text{ cm}}{1 \text{ in}} \right)^3 \times \frac{1 \text{ mL}}{1 \text{ cm}^3} \times \frac{1 \times 10^{-3} \text{ L}}{1 \text{ mL}} = 1.42 \times 10^9 \text{ L}$$

The mass of vanillin (in g) is:

$$\frac{2.0 \times 10^{-11} \text{ g vanillin}}{1 \text{ L}} \times (1.42 \times 10^9 \text{ L}) = 2.84 \times 10^{-2} \text{ g vanillin}$$

The cost is:

$$(2.84 \times 10^{-2} \text{ g vanillin}) \times \frac{\$112}{50 \text{ g vanillin}} = \$0.064 = \mathbf{6.4\text{¢}}$$

1.113 **Strategy:** Use the given rates to convert cars  $\rightarrow$  kg CO<sub>2</sub>.

**Setup:** Conversion factors:

$$\frac{5000 \text{ mi}}{1 \text{ car}}, \frac{1 \text{ gal gas}}{20 \text{ mi}}, \text{ and } \frac{9.5 \text{ kg CO}_2}{1 \text{ gal gas}}$$

**Solution:**

$$(40 \times 10^6 \text{ cars}) \times \frac{5000 \text{ mi}}{1 \text{ car}} \times \frac{1 \text{ gal gas}}{20 \text{ mi}} \times \frac{9.5 \text{ kg CO}_2}{1 \text{ gal gas}} = \mathbf{9.5 \times 10^{10} \text{ kg CO}_2}$$

1.114 First, calculate the volume of 1 kg of seawater from the density and the mass. We chose 1 kg of seawater, because the problem gives the amount of Mg in every kg of seawater. The density of seawater is given in Problem 1.89.

$$\text{volume} = \frac{\text{mass}}{\text{density}}$$

$$\text{volume of 1 kg of seawater} = \frac{1000 \text{ g}}{1.03 \text{ g/mL}} = 970.9 \text{ mL} = 0.9709 \text{ L}$$

In other words, there are 1.3 g of Mg in every 0.9709 L of seawater.

Next, let's convert tons of Mg to grams of Mg.

$$(8.0 \times 10^4 \text{ tons Mg}) \times \frac{2000 \text{ lb}}{1 \text{ ton}} \times \frac{453.6 \text{ g}}{1 \text{ lb}} = 7.26 \times 10^{10} \text{ g Mg}$$

Volume of seawater needed to extract  $8.0 \times 10^4$  ton Mg =

$$(7.26 \times 10^{10} \text{ g Mg}) \times \frac{0.9709 \text{ L seawater}}{1.3 \text{ g Mg}} = 5.4 \times 10^{10} \text{ L of seawater}$$

1.115 **Strategy:** Use dimensional analysis. The conversions should convert the units “people” to the units “kg NaF”. Since the number of conversion steps is large, divide the calculation into smaller steps.

**Setup:** Use the given conversion factors and also any others you may need from the inside back cover of the text.

**Solution:** The mass of water used by 50,000 people in 1 year is:

$$\begin{aligned} 50,000 \text{ people} \times \frac{150 \text{ gal water}}{1 \text{ person each day}} \times \frac{3.79 \text{ L}}{1 \text{ gal}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1.0 \text{ g H}_2\text{O}}{1 \text{ mL H}_2\text{O}} \times \frac{365 \text{ days}}{1 \text{ yr}} \\ = 1.04 \times 10^{13} \text{ g H}_2\text{O/yr} \end{aligned}$$

A concentration of 1 ppm of fluorine is needed. In other words, 1 g of fluorine is needed per million grams of water. NaF is 45.0% fluorine by mass. The amount of NaF needed per year in kg is:

$$(1.04 \times 10^{13} \text{ g H}_2\text{O}) \times \frac{1 \text{ g F}}{10^6 \text{ g H}_2\text{O}} \times \frac{100\% \text{ NaF}}{45\% \text{ F}} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 2.3 \times 10^4 \text{ kg NaF}$$

An average person uses 150 gallons of water per day. This is equal to 569 L of water. If only 6 L of water is used for drinking and cooking, 563 L of water is used for purposes in which NaF is not necessary. Therefore the amount of NaF wasted is:

$$\frac{563 \text{ L}}{569 \text{ L}} \times 100\% = 99\%$$

1.116  $62 \text{ kg} = 6.2 \times 10^4 \text{ g}$

**O:**  $(6.2 \times 10^4 \text{ g})(0.65) = 4.0 \times 10^4 \text{ g O}$

**N:**  $(6.2 \times 10^4 \text{ g})(0.03) = 2 \times 10^3 \text{ g N}$

**C:**  $(6.2 \times 10^4 \text{ g})(0.18) = 1.1 \times 10^4 \text{ g C}$

**Ca:**  $(6.2 \times 10^4 \text{ g})(0.016) = 9.9 \times 10^2 \text{ g Ca}$

**H:**  $(6.2 \times 10^4 \text{ g})(0.10) = 6.2 \times 10^3 \text{ g H}$

**P:**  $(6.2 \times 10^4 \text{ g})(0.012) = 7.4 \times 10^2 \text{ g P}$

1.117 **Strategy:** The key to solving this problem is to realize that all the oxygen needed must come from the 4% difference (20% – 16%) between inhaled and exhaled air. The 240 mL of pure oxygen/min requirement comes from the 4% of inhaled air that is oxygen.

**Setup:** 240 mL of pure oxygen/min = (0.04)(volume of inhaled air/min)

**Solution:** Volume of inhaled air/min =  $\frac{240 \text{ mL of oxygen/min}}{0.04} = 6000 \text{ mL of inhaled air/min}$

Since there are 12 breaths per min,

$$\text{volume of air / breath} = \frac{6000 \text{ mL of inhaled air}}{1 \text{ min}} \times \frac{1 \text{ min}}{12 \text{ breaths}} = 5 \times 10^2 \text{ mL / breath}$$

1.118 a. 
$$\frac{6000 \text{ mL of inhaled air}}{1 \text{ min}} \times \frac{0.001 \text{ L}}{1 \text{ mL}} \times \frac{60 \text{ min}}{1 \text{ h}} \times \frac{24 \text{ h}}{1 \text{ day}} = 8.6 \times 10^3 \text{ L of air / day}$$

b. 
$$\frac{8.6 \times 10^3 \text{ L of air}}{1 \text{ day}} \times \frac{2.1 \times 10^{-6} \text{ L CO}}{1 \text{ L of air}} = 0.018 \text{ L CO / day}$$

1.119 **Strategy:** For the Fahrenheit thermometer, we must convert the possible error of 0.1°F to °C. For each thermometer, use the percent error equation to find the percent error for the measurement.

**Setup:** 
$$0.1^\circ\text{F} \times \frac{5^\circ\text{C}}{9^\circ\text{F}} = 0.056^\circ\text{C}.$$

For the Fahrenheit thermometer, we expect:

$$|\text{true value} - \text{experimental value}| = 0.056^\circ\text{C}$$

For the Celsius thermometer, we expect:

$$|\text{true value} - \text{experimental value}| = 0.1^\circ\text{C}$$

$$\text{Percent error} = \frac{|\text{true value} - \text{experimental value}|}{\text{true value}} \times 100\%$$

**Solution:** For the Fahrenheit thermometer,  $\text{percent error} = \frac{0.056^\circ\text{C}}{38.9^\circ\text{C}} \times 100\% = 0.1\%$

For the Celsius thermometer,  $\text{percent error} = \frac{0.1^\circ\text{C}}{38.9^\circ\text{C}} \times 100\% = 0.3\%$



**Think** Which thermometer is more precise?  
**About It:**

- 1.120 When the carbon dioxide gas is released, the mass of the solution will decrease. If we know the starting mass of the solution and the mass of solution after the reaction is complete (given in the problem), we can calculate the mass of carbon dioxide produced. Then, using the density of carbon dioxide, we can calculate the volume of carbon dioxide released.

$$\text{Mass of hydrochloric acid} = 40.00 \text{ mL} \times \frac{1.140 \text{ g}}{1 \text{ mL}} = 45.60 \text{ g}$$

$$\text{Mass of solution before reaction} = 45.60 \text{ g} + 1.328 \text{ g} = 46.928 \text{ g}$$

We can now calculate the mass of carbon dioxide by difference.

$$\text{Mass of CO}_2 \text{ released} = 46.928 \text{ g} - 46.699 \text{ g} = 0.229 \text{ g}$$

Finally, we use the density of carbon dioxide to convert to liters of CO<sub>2</sub> released.

$$\text{Volume of CO}_2 \text{ released} = 0.229 \text{ g} \times \frac{1 \text{ L}}{1.81 \text{ g}} = \mathbf{0.127 \text{ L}}$$

- 1.121 **Strategy:** To calculate the density of the pheromone, you need the mass of the pheromone, and the volume that it occupies. The mass is given in the problem.

**Setup:** volume of a cylinder = area  $\times$  height =  $\pi r^2 \times h$

Converting the radius and height to cm gives:

$$0.50 \text{ mi} \times \frac{1609 \text{ m}}{1 \text{ mi}} \times \frac{1 \text{ cm}}{0.01 \text{ m}} = 8.05 \times 10^4 \text{ cm}$$

$$40 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 1.22 \times 10^3 \text{ cm}$$

**Solution:** volume =  $\pi(8.05 \times 10^4 \text{ cm})^2 \times (1.22 \times 10^3 \text{ cm}) = 2.48 \times 10^{13} \text{ cm}^3$

Density of gases is usually expressed in g/L. Let's convert the volume to liters.

$$(2.48 \times 10^{13} \text{ cm}^3) \times \frac{1 \text{ mL}}{1 \text{ cm}^3} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 2.48 \times 10^{10} \text{ L}$$

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{1.0 \times 10^{-8} \text{ g}}{2.48 \times 10^{10} \text{ L}} = 4.0 \times 10^{-19} \text{ g/L}$$