CHAPTER 1
CHEMISTRY: THE STUDY OF CHANGE

PROBLEM-SOLVING STRATEGIES AND TUTORIAL SOLUTIONS

TYPES OF PROBLEMS

Problem Type 1: Density Calculations.

Problem Type 2: Temperature Conversions.
(a) °C → °F
(b) °F → °C

Problem Type 3: Scientific Notation.
(a) Expressing a number in scientific notation.
(b) Addition and subtraction.
(c) Multiplication and division.

Problem Type 4: Significant Figures.
(a) Addition and subtraction.
(b) Multiplication and division.

Problem Type 5: The Dimensional Analysis Method of Solving Problems.

PROBLEM TYPE 1: DENSITY CALCULATIONS

Density is the mass of an object divided by its volume.

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

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

Densities of solids and liquids are typically expressed in units of grams per cubic centimeter (g/cm^3) or equivalently grams per milliliter (g/mL). Because gases are much less dense than solids and liquids, typical units are grams per liter (g/L).

EXAMPLE 1.1
A lead brick with dimensions of 5.08 cm by 10.2 cm by 20.3 cm has a mass of 11,950 g. What is the density of lead in g/cm^3?

Strategy: You are given the mass of the lead brick in the problem. You need to calculate the volume of the lead brick to solve for the density. The volume of a rectangular object is equal to the length × width × height.

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

Solution:

Volume = length × width × height
Volume = 5.08 cm × 10.2 cm × 20.3 cm = **1052 cm^3**

Calculate the density by substituting the mass and the volume into the equation.

$$d = \frac{m}{V} = \frac{11{,}950\ \text{g}}{1052\ \text{cm}^3} = \mathbf{11.4\ g/cm^3}$$

PRACTICE EXERCISE

1. Platinum has a density of 21.4 g/cm^3. What is the mass of a small piece of platinum that has a volume of 7.50 cm^3?

Text Problem: 1.22

PROBLEM TYPE 2: TEMPERATURE CONVERSIONS

To convert between the Fahrenheit scale and the Celsius scale, you must account for two differences between the two scales.

(1) The Fahrenheit scale defines the normal freezing point of water to be exactly 32°F, whereas the Celsius scale defines it to be exactly 0°C.

(2) A Fahrenheit degree is 5/9 the size of a Celsius degree.

A. Converting degrees Fahrenheit to degrees Celsius

The equation needed to complete a conversion from degrees Fahrenheit to degrees Celsius is:

$$\mathbf{?\ °C = (°F - 32°F) \times \frac{5°C}{9°F}}$$

32°F is subtracted to compensate for the normal freezing point of water being 32°F, compared to 0° on the Celsius scale. We multiply by (5/9) because a Fahrenheit degree is 5/9 the size of a Celsius degree.

EXAMPLE 1.2
Convert 20°F to degrees Celsius.

$$?\ °C = (°F - 32°F) \times \frac{5°C}{9°F}$$

$$?\ °C = (20°F - 32°F) \times \frac{5°C}{9°F} = \mathbf{-6.7°C}$$

B. Converting degrees Celsius to degrees Fahrenheit

The equation needed to complete a conversion from degrees Celsius to degrees Fahrenheit is:

$$\mathbf{?\ °F = \left(°C \times \frac{9°F}{5°C}\right) + 32°F}$$

°C is multiplied by (9/5) because a Celsius degree is 9/5 the size of a Fahrenheit degree. 32°F is then added to compensate for the normal freezing point of water being 32°F, compared to 0° on the Celsius scale.

EXAMPLE 1.3
Normal human body temperature on the Celsius scale is 37.0°C. Convert this to the Fahrenheit scale.

$$?\ °F = \left(°C \times \frac{9°F}{5°C}\right) + 32°F$$

$$? \text{°F} = \left(37.0\text{°C} \times \frac{9\text{°F}}{5\text{°C}}\right) + 32\text{°F} = \mathbf{98.6°F}$$

PRACTICE EXERCISE

2. Convert –40°F to degrees Celsius.

Text Problems: 1.24, 1.26

PROBLEM TYPE 3: SCIENTIFIC NOTATION

Scientific notation is typically used when working with small or large numbers. All numbers can be expressed in the form

$$N \times 10^n$$

where N is a number between 1 and 10 and n is an exponent that can be a positive or negative integer, or zero.

A. Expressing a number in scientific notation

Strategy: Writing scientific notation as $N \times 10^n$, we determine n by counting the number of places that the decimal point must be moved to give N, a number between 1 and 10.

If the decimal point is moved to the left, n is a positive integer, the number you are working with is larger than 10. If the decimal point is moved to the right, n is a negative integer. The number you are working with is smaller than 1.

EXAMPLE 1.4
Express 0.000105 in scientific notation.

Solution: The decimal point must be moved four places to the right to give N, a number between 1 and 10. In this case,

$$N = \mathbf{1.05}$$

Since 0.000105 is a number less than one, n is a negative integer. In this case, $n = -4$ (The decimal point was moved four places to the right to give $N = 1.05$).

Combining the above two steps:

$$0.000105 = \mathbf{1.05 \times 10^{-4}}$$

Tip: The notation 1.05×10^{-4} means the following: Take 1.05 and multiply by 10^{-4} (0.0001).

$$1.05 \times 0.0001 = 0.000105$$

EXAMPLE 1.5
Express 4224 in scientific notation.

Solution: The decimal point must be moved three places to the left to give N, a number between 1 and 10. In this case,

$$N = \mathbf{4.224}$$

Since 4,224 is a number greater than one, n is a positive integer. In this case, $n = 3$ (the decimal point was moved three places to the left to give $N = 4.224$).

Combining the above two steps:

$$4224 = \mathbf{4.224 \times 10^3}$$

Tip: The notation 4.224×10^3 means the following: Take 4.224 and multiply by 10^3 (1000).

$$4.224 \times 1000 = 4{,}224$$

PRACTICE EXERCISE

3. Express the following numbers in scientific notation:

(a) 45,781 **(b)** 0.0000430

Text Problem: 1.30

B. Addition and subtraction using scientific notation

Strategy: Let's express scientific notation as $N \times 10^n$. When adding or subtracting numbers using scientific notation, we must write each quantity with the same exponent, *n*. We can then add or subtract the *N* parts of the numbers, keeping the exponent, *n*, the same.

EXAMPLE 1.6

Express the answer to the following calculation in scientific notation. $(2.43 \times 10^1) + (5.955 \times 10^2) = ?$

Solution: Write each quantity with the same exponent, *n*. Let's write 2.43×10^1 in such a way that $n = 2$.

Tip: We are *increasing* 10^n by a factor of 10, so we must *decrease* *N* by a factor of 10. We move the decimal point one place to the left.

$$2.43 \times 10^1 = \mathbf{0.243 \times 10^2}$$

(*n* was increased by 1. Move the decimal point one place to the left.)

Add or subtract, as required, the *N* parts of the numbers, keeping the exponent, *n*, the same. In this example, the process is addition.

$$\begin{array}{r} 0.243 \times 10^2 \\ +\ 5.955 \times 10^2 \\ \hline \mathbf{6.198 \times 10^2} \end{array}$$

C. Multiplication and division using scientific notation

Strategy: Let's express scientific notation as $N \times 10^n$. Multiply or divide the *N* parts of the numbers in the usual way. To come up with the correct exponent *n*, when multiplying, *add* the exponents, when dividing, *subtract* the exponents.

EXAMPLE 1.7

Divide 4.2×10^{-7} by 5.0×10^{-5}.

Solution: Divide the *N* parts of the numbers in the usual way.

$$4.2 \div 5.0 = 0.84$$

When dividing the 10^n parts, *subtract* the exponents.

$$0.84 \times 10^{-7-(-5)} = 0.84 \times 10^{-7+5} = \mathbf{0.84 \times 10^{-2}}$$

The usual practice is to express *N* as a number between 1 and 10. Therefore, it is more appropriate to move the decimal point of the above number one place to the right, decreasing the exponent by 1.

$$0.84 \times 10^{-2} = \mathbf{8.4 \times 10^{-3}}$$

Tip: In the answer, we moved the decimal point to the right, *increasing N* by a factor of 10. Therefore, we must *decrease* 10^n by a factor of 10. The exponent, *n*, is changed from −2 to −3.

EXAMPLE 1.8

Multiply 2.2×10^{-3} by 1.4×10^6.

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

$$2.2 \times 1.4 = 3.1$$

When multiplying the 10^n parts, *add* the exponents.

$$3.1 \times 10^{-3+6} = \mathbf{3.1 \times 10^3}$$

PRACTICE EXERCISE

4. Express the answer to the following calculations in scientific notation. Try these without using a calculator.

   (a) $2.20 \times 10^3 - 4.54 \times 10^2 =$

   (b) $4.78 \times 10^5 \div 6.332 \times 10^{-7} =$

Text Problem: 1.32

PROBLEM TYPE 4: SIGNIFICANT FIGURES

See Section 1.8 of the text for guidelines for using significant figures.

A. Addition and 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.

EXAMPLE 1.9

Carry out the following operations and express the answer to the correct number of significant figures.

$$\mathbf{102.226 + 2.51 + 736.0 =}$$

Solution:

$$\begin{array}{r} 102.226 \\ 2.51 \\ +\ \underline{736.0} \\ 840.736 \end{array} \quad \leftarrow \text{fewest digits to the right of the decimal point}$$

The 3 and 6 are nonsignificant digits, since 736.0 only has one digit to the right of the decimal point. The answer should only have one digit to the right of the decimal point.

The correct answer rounded off to the correct number of significant figures is **840.7**

Tip: To round off a number at a certain point, simply drop the digits that follow if the first of them is less than 5. If the first digit following the point of rounding off is equal to or greater than 5, add 1 to the preceding digit.

B. Multiplying and dividing

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

EXAMPLE 1.10

Carry out the following operations and express the answer to the correct number of significant figures.

$$12 \times 2143.1 \div 3.11 = ?$$

Solution:

$$12 \times 2143.1 \div 3.11 = 8269.2 = 8.2\mathbf{692} \times 10^3$$

The 6, 9, and 2 (bolded) are nonsignificant digits because the original number 12 only has two significant figures. Therefore, the answer has only two significant figures.

The correct answer rounded off to the correct number of significant figures is $\mathbf{8.3 \times 10^3}$

PRACTICE EXERCISE

5. Carry out the following operations and express the answer to the correct number of significant figures.

   (a) $90.25 - 83 + 1.0015 =$
   (b) $55.6 \times 3.482 \div 505.34 =$

Text Problem: 1.36

PROBLEM TYPE 5: THE DIMENSIONAL ANALYSIS METHOD OF SOLVING PROBLEMS

In order to convert from one unit to another, you need to be proficient at applying dimensional analysis. See Section 1.9 of the text. Conversion factors can seem daunting, but if you keep track of the units, making sure that the appropriate units cancel, your effort will be rewarded.

Step 1: Map out a strategy to proceed from initial units to final units based on available conversion factors.

Step 2: Use the following method as many times as is necessary to ensure that you obtain the desired unit.

$$\text{Given}\cancel{\text{ unit}} \times \left(\frac{\text{desired unit}}{\text{given}\cancel{\text{ unit}}}\right) = \text{desired unit}$$

EXAMPLE 1.11

How long will it take to fly from Denver to New York, a distance of 1631 miles, at a speed of 815 km/hr?

Strategy: One conversion factor is given in the problem, 815 km/hr. This conversion factor can be used to convert from distance (in km) to time (in hr). If you can convert the distance of 1631 miles to km, then you can use the conversion factor (815 km/hr) to convert to time in hours. Another conversion factor that you can look up is

$$1 \text{ mi} = 1.61 \text{ km}$$

You should come up with the following strategy.

$$\text{miles} \rightarrow \text{km} \rightarrow \text{hours}$$

Solution: Carry out the necessary conversions, making sure that units cancel.

$$\textbf{? hours} = 1631\ \cancel{\text{mi}}\ (\text{given}) \times \frac{1.61\ \cancel{\text{km}}\ (\text{desired})}{1\ \cancel{\text{mi}}\ (\text{given})} \times \frac{1\ \text{h (desired)}}{815\ \cancel{\text{km}}\ (\text{given})} = \mathbf{3.22\ h}$$

Tip: In the first conversion factor (km/mi), km is the desired unit. When moving on to the next conversion factor (h/km), km is now given, and the desired unit is h.

EXAMPLE 1.12

The *Voyager II* mission to the outer planets of our solar system transmitted by radio signals many spectacular photographs of Neptune. Radio waves, like light waves, travel at a speed of 3.00×10^8 m/s. If Neptune was 2.75 billion miles from Earth during these transmissions, how many hours were required for radio signals to travel from Neptune to Earth?

Strategy: One conversion factor is given in the problem, 3.00×10^8 m/s. This conversion factor will allow you to convert from distance (in m) to time (in seconds). If you can convert the distance of 2.75 billion miles to meters, then the speed of light (3.00×10^8 m/s) can be used to convert to time in seconds. Other conversion factors that you can look up are:

1 billion = 1×10^9	60 s = 1 min
1 mi = 1.61 km	60 min = 1 h
1 km = 1000 m	

You should come up with the following strategy.

miles → km → meters → seconds → min → hours

Solution: Carry out the necessary conversions, making sure that units cancel.

$$? \textbf{h} = (2.75 \times 10^9 \text{ mi}) \times \frac{1.61 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ s}}{3.00 \times 10^8 \text{ m}} \times \frac{1 \text{ min}}{60 \text{ s}} \times \frac{1 \text{ h}}{60 \text{ min}} = \textbf{4.10 h}$$

PRACTICE EXERCISES

6. On a certain day, the concentration of carbon monoxide, CO, in the air over Denver reached 1.8×10^{-5} g/L. Convert this concentration to mg/m^3.

7. Copper (Cu) is a trace element that is essential for nutrition. Newborn infants require 80 μg of Cu per kilogram of body mass per day. The Cu content of a popular baby formula is 0.48 μg of Cu per milliliter. How many milliliters should a 7.0 lb baby consume per day to obtain the minimum daily Cu requirement?

Text Problems: 1.38, 1.40, 1.42, 1.44, 1.46, 1.48, 1.50

ANSWERS TO PRACTICE EXERCISES

1. 161 g Pt
2. –40°C
3. **(a)** 4.5781×10^4
   (b) 4.30×10^{-5}
4. **(a)** 1.75×10^3
   (b) 7.55×10^{11}
5. **(a)** 8
   (b) 0.383
6. 18 mg/m^3
7. 530 mL/day

SOLUTIONS TO SELECTED TEXT PROBLEMS

1.4 **(a)** hypothesis **(b)** law **(c)** theory

1.12
(a) Physical change. The helium isn't changed in any way by leaking out of 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.

1.14 **(a)** K **(b)** Sn **(c)** Cr **(d)** B **(e)** Ba
(f) Pu **(g)** S **(h)** Ar **(i)** Hg

1.16 **(a)** homogeneous mixture **(b)** element **(c)** compound
(d) homogeneous mixture **(e)** heterogeneous mixture **(f)** homogeneous mixture
(g) heterogeneous mixture

1.22 Density Calculation, Problem Type 1.

Strategy: We are given the density and volume of a liquid and asked to calculate the mass of the liquid. Rearrange the density equation, Equation (1.1) of the text, to solve for mass.

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

Solution:

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

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

1.24 Temperature Conversion, Problem Type 2.

Strategy: Find the appropriate equations for converting between Fahrenheit and Celsius and between Celsius and Fahrenheit given in Section 1.7 of the text. Substitute the temperature values given in the problem into the appropriate equation.

(a) Conversion from Fahrenheit to Celsius.

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

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

(b) Conversion from Celsius to Fahrenheit.

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

$$? \ °\mathbf{F} = \left(-11.5°\cancel{C} \times \frac{9°F}{5°\cancel{C}}\right) + 32°F = \mathbf{11.3°F}$$

(c) Conversion from Celsius to Fahrenheit.

$$? \ °F = \left(°C \times \frac{9°F}{5°C}\right) + 32°F$$

$$? \ °\mathbf{F} = \left(6.3 \times 10^3 \ °\cancel{C} \times \frac{9°F}{5°\cancel{C}}\right) + 32°F = \mathbf{1.1 \times 10^4 \ °F}$$

(d) Conversion from Fahrenheit to Celsius.

$$? \ °C = (°F - 32°F) \times \frac{5°C}{9°F}$$

$$? \ °\mathbf{C} = (451°F - 32°F) \times \frac{5°C}{9°F} = \mathbf{233°C}$$

1.26 **(a)** $K = (°C + 273°C)\frac{1\ K}{1°C}$

$°C = K - 273 = 77\ K - 273 = \mathbf{-196°C}$

(b) $°C = 4.2\ K - 273 = \mathbf{-269°C}$

(c) $°C = 601\ K - 273 = \mathbf{328°C}$

1.30 **(a)** 10^{-2} indicates that the decimal point must be moved two places to the left.

$$1.52 \times 10^{-2} = \mathbf{0.0152}$$

(b) 10^{-8} indicates that the decimal point must be moved 8 places to the left.

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

1.32 Scientific Notation, Problem Types 3B and 3C

(a) Addition using scientific notation.

Strategy: Let's express scientific notation as $N \times 10^n$. When adding numbers using scientific notation, we must write each quantity with the same exponent, n. We can then add the N parts of the numbers, keeping the exponent, n, the same.

Solution: Write each quantity with the same exponent, n.

Let's write 0.0095 in such a way that $n = -3$. We have decreased 10^n by 10^3, so we must increase N by 10^3. Move the decimal point 3 places to the right.

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

Add the N parts of the numbers, keeping the exponent, n, the same.

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

The usual practice is to express N as a number between 1 and 10. Since we must *decrease* N by a factor of 10 to express N between 1 and 10 (1.8), we must *increase* 10^n by a factor of 10. The exponent, n, is increased by 1 from –3 to –2.

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

(b) Division using scientific notation.

Strategy: Let's express scientific notation as $N \times 10^n$. When dividing numbers using scientific notation, divide the N parts of the numbers in the usual way. To come up with the correct exponent, n, we *subtract* the exponents.

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, n.

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

(c) Subtraction using scientific notation.

Strategy: Let's express scientific notation as $N \times 10^n$. When subtracting numbers using scientific notation, we must write each quantity with the same exponent, n. We can then subtract the N parts of the numbers, keeping the exponent, n, the same.

Solution: Write each quantity with the same exponent, n.

Let's write 850,000 in such a way that $n = 5$. This means to move the decimal point five places to the left.

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

Subtract the N parts of the numbers, keeping the exponent, n, the same.

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

The usual practice is to express N as a number between 1 and 10. Since we must *increase* N by a factor of 10 to express N between 1 and 10 (5), we must *decrease* 10^n by a factor of 10. The exponent, n, is decreased by 1 from 5 to 4.

$$-0.5 \times 10^5 = \mathbf{-5 \times 10^4}$$

(d) Multiplication using scientific notation.

Strategy: Let's express scientific notation as $N \times 10^n$. When multiplying numbers using scientific notation, multiply the N parts of the numbers in the usual way. To come up with the correct exponent, n, we *add* the exponents.

Solution: Multiply the N parts of the numbers in the usual way.

$$3.6 \times 3.6 = 13$$

Add the exponents, *n*.

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

The usual practice is to express *N* as a number between 1 and 10. Since we must *decrease N* by a factor of 10 to express *N* between 1 and 10 (1.3), we must *increase* 10^n by a factor of 10. The exponent, *n*, is increased by 1 from 2 to 3.

$$\mathbf{13 \times 10^2 = 1.3 \times 10^3}$$

1.34 **(a)** one **(b)** three **(c)** three **(d)** four
(e) two or three **(f)** one **(g)** one or two

1.36 Significant Figures, Problem Types 4B and 4C

(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:

$$\frac{7.310\text{ km}}{5.70\text{ km}} = 1.28\mathbf{3}$$

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 (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 decimal notation, we have

$$\begin{array}{r} 0.00326\text{ mg} \\ -\ 0.0000788\text{ mg} \\ \hline 0.00318\mathbf{12}\text{ mg} \end{array}$$

The bolded 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:

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

(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 7.74×10^7 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.

1.38 Factor-Label Method, Problem Type 5.

(a)
Strategy: The problem may be stated as

$$? \text{ mg} = 242 \text{ lb}$$

A relationship between pounds and grams is given on the end sheet of your text (1 lb = 453.6 g). This relationship will allow conversion from pounds to grams. A metric conversion is then needed to convert grams to milligrams ($1 \text{ mg} = 1 \times 10^{-3}$ g). Arrange the appropriate conversion factors so that pounds and grams cancel, and the unit milligrams is obtained in your answer.

Solution: The sequence of conversions is

$$\text{lb} \rightarrow \text{grams} \rightarrow \text{mg}$$

Using the following conversion factors,

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

we obtain the answer in one step:

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

Check: Does your answer seem reasonable? Should 242 lb be equivalent to 110 million mg? How many mg are in 1 lb? There are 453,600 mg in 1 lb.

(b)
Strategy: The problem may be stated as

$$? \text{ m}^3 = 68.3 \text{ cm}^3$$

Recall that $1 \text{ cm} = 1 \times 10^{-2}$ m. We need to set up a conversion factor to convert from cm^3 to m^3.

Solution: We need the following conversion factor so that centimeters cancel and we end up with meters.

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

Since this conversion factor deals with length and we want volume, it must therefore be cubed to give

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

We can write

$$? \text{ m}^3 = 68.3 \cancel{\text{cm}^3} \times \left(\frac{1 \times 10^{-2} \text{ m}}{1 \cancel{\text{cm}}}\right)^3 = \mathbf{6.83 \times 10^{-5} \text{ m}^3}$$

Check: We know that 1 $cm^3 = 1 \times 10^{-6}$ m^3. We started with 6.83×10^1 cm^3. Multiplying this quantity by 1×10^{-6} gives 6.83×10^{-5}.

(c)
Strategy: The problem may be stated as

$$? \text{ L} = 7.2 \text{ m}^3$$

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

Solution: The sequence of conversions is

$$\text{m}^3 \rightarrow \text{cm}^3 \rightarrow \text{L}$$

Using the following conversion factors,

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

the answer is obtained in one step:

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

Check: From the above conversion factors you can show that 1 $m^3 = 1 \times 10^3$ L. Therefore, 7 m^3 would equal 7×10^3 L, which is close to the answer.

(d)
Strategy: The problem may be stated as

$$? \text{ lb} = 28.3 \ \mu\text{g}$$

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

Solution: The sequence of conversions is

$$\mu\text{g} \rightarrow \text{g} \rightarrow \text{lb}$$

Using the following conversion factors,

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

we can write

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

Check: Does the answer seem reasonable? What number does the prefix μ represent? Should 28.3 μg be a very small mass?

1.40 Factor-Label Method, Problem Type 5.

Strategy: The problem may be stated as

$$? \text{ s} = 365.24 \text{ days}$$

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.

Solution: The sequence of conversions is

$$\text{days} \rightarrow \text{hours} \rightarrow \text{minutes} \rightarrow \text{seconds}$$

Using the following conversion factors,

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

we can write

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

Check: Does your answer seem reasonable? Should there be a very large number of seconds in 1 year?

1.42 (a) $$? \text{ in/s} = \frac{1 \cancel{\text{mi}}}{13 \cancel{\text{min}}} \times \frac{5280 \cancel{\text{ft}}}{1 \cancel{\text{mi}}} \times \frac{12 \text{ in}}{1 \cancel{\text{ft}}} \times \frac{1 \cancel{\text{min}}}{60 \text{ s}} = \mathbf{81 \text{ in/s}}$$

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

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

1.44 $$? \text{ km/h} = \frac{55 \cancel{\text{mi}}}{1 \text{ h}} \times \frac{1.609 \text{ km}}{1 \cancel{\text{mi}}} = \mathbf{88 \text{ km/h}}$$

1.46 $$0.62 \text{ ppm Pb} = \frac{0.62 \text{ g Pb}}{1 \times 10^6 \text{ g blood}}$$

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

1.48 (a) $$? \text{ m} = 185 \cancel{\text{nm}} \times \frac{1 \times 10^{-9} \text{ m}}{1 \cancel{\text{nm}}} = \mathbf{1.85 \times 10^{-7} \text{ m}}$$

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

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

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

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

1.52 See Section 1.6 of your text for a discussion of these terms.

(a) Chemical property. Iron has changed its composition and identity by chemically combining with oxygen and water.

(b) Chemical property. The water reacts with chemicals in the air (such as sulfur dioxide) to produce acids, thus changing the composition and identity of the water.

(c) Physical property. The color of the hemoglobin can be observed and measured without changing its composition or identity.

(d) Physical property. The evaporation of water does not change its chemical properties. Evaporation is a change in matter from the liquid state to the gaseous state.

(e) Chemical property. The carbon dioxide is chemically converted into other molecules.

1.54 Volume of rectangular bar = length × width × height

$$\textbf{density} = \frac{m}{V} = \frac{52.7064 \text{ g}}{(8.53 \text{ cm})(2.4 \text{ cm})(1.0 \text{ cm})} = \mathbf{2.6 \text{ g/cm}^3}$$

1.56 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 $2r$.

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

$$\text{volume of Hg filling cylinder} = \frac{105.5 \text{ g}}{13.6 \text{ g/cm}^3} = 7.76 \text{ cm}^3$$

Next, solve for the radius of the cylinder.

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

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

$$r = \sqrt{\frac{7.76 \text{ cm}^3}{\pi \times 12.7 \text{ cm}}} = 0.441 \text{ cm}$$

The cylinder diameter equals $2r$.

$$\textbf{Cylinder diameter} = 2r = 2(0.441 \text{ cm}) = \mathbf{0.882 \text{ cm}}$$

1.58 $$\frac{343\ \text{m}}{1\ \text{s}} \times \frac{1\ \text{mi}}{1609\ \text{m}} \times \frac{3600\ \text{s}}{1\ \text{h}} = \mathbf{767\ mph}$$

1.60 In order to work this problem, you need to understand the physical principles involved in the experiment in Problem 1.59. The volume of the water displaced must equal the volume of the piece of silver. If the silver did not sink, would you have been able to determine the volume of the piece of silver?

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°C* to prevent the ice from melting.

1.62 $$\text{Volume} = \frac{\text{mass}}{\text{density}}$$

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

1.64 To work this problem, we need to convert from cubic feet to L. Some tables will have a conversion factor of 28.3 L = 1 ft^3, but we can also calculate it using the dimensional analysis method described in Section 1.9 of the text.

First, converting from cubic feet to liters:

$$(5.0 \times 10^7\ \text{ft}^3) \times \left(\frac{12\ \text{in}}{1\ \text{ft}}\right)^3 \times \left(\frac{2.54\ \text{cm}}{1\ \text{in}}\right)^3 \times \frac{1\ \text{mL}}{1\ \text{cm}^3} \times \frac{1 \times 10^{-3}\ \text{L}}{1\ \text{mL}} = 1.4 \times 10^9\ \text{L}$$

The mass of vanillin (in g) is:

$$\frac{2.0 \times 10^{-11}\ \text{g vanillin}}{1\ \text{L}} \times (1.4 \times 10^9\ \text{L}) = 2.8 \times 10^{-2}\ \text{g vanillin}$$

The cost is:

$$(2.8 \times 10^{-2}\ \text{g vanillin}) \times \frac{\$112}{50\ \text{g vanillin}} = \mathbf{\$0.063} = \mathbf{6.3¢}$$

1.66 There are 78.3 + 117.3 = 195.6 Celsius degrees between 0°S and 100°S. We can write this as a unit factor.

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

Set up the equation like a Celsius to Fahrenheit conversion. We need to subtract 117.3°C, because the zero point on the new scale is 117.3°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 ? °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°C we have: $$\mathbf{?\ ^\circ S} = (25^\circ\text{C} + 117.3^\circ\text{C})\left(\frac{100^\circ\text{S}}{195.6^\circ\text{C}}\right) = \mathbf{73^\circ S}$$

1.68 (a) $\dfrac{6000\ \text{mL of inhaled air}}{1\ \text{min}} \times \dfrac{0.001\ \text{L}}{1\ \text{mL}} \times \dfrac{60\ \text{min}}{1\ \text{h}} \times \dfrac{24\ \text{h}}{1\ \text{day}} = \mathbf{8.6 \times 10^3\ L\ of\ air/day}$

(b) $\dfrac{8.6 \times 10^3\ \text{L of air}}{1\ \text{day}} \times \dfrac{2.1 \times 10^{-6}\ \text{L CO}}{1\ \text{L of air}} = \mathbf{0.018\ L\ CO/day}$

1.70 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 1.69.

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

$$\text{volume of 1 kg of seawater} = \frac{1000\ \text{g}}{1.03\ \text{g/mL}} = 971\ \text{mL} = 0.971\ \text{L}$$

In other words, there are 1.3 g of Mg in every 0.971 L of seawater.

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

$$(8.0 \times 10^4\ \text{tons Mg}) \times \frac{2000\ \text{lb}}{1\ \text{ton}} \times \frac{453.6\ \text{g}}{1\ \text{lb}} = 7.3 \times 10^{10}\ \text{g Mg}$$

Volume of seawater needed to extract 8.0 × 10⁴ ton Mg =

$$(7.3 \times 10^{10}\ \text{g Mg}) \times \frac{0.971\ \text{L seawater}}{1.3\ \text{g Mg}} = \mathbf{5.5 \times 10^{10}\ L\ of\ seawater}$$

1.72 Volume = surface area × depth

Recall that 1 L = 1 dm^3. Let's convert the surface area to units of dm^2 and the depth to units of dm.

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

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

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

1.74 Volume of sphere $= \dfrac{4}{3}\pi r^3$

$$\text{Volume} = \frac{4}{3}\pi\left(\frac{15\ \text{cm}}{2}\right)^3 = 1.8 \times 10^3\ \text{cm}^3$$

$$\text{mass} = \text{volume} \times \text{density} = (1.8 \times 10^3\ \text{cm}^3) \times \frac{22.57\ \text{g Os}}{1\ \text{cm}^3} \times \frac{1\ \text{kg}}{1000\ \text{g}} = \mathbf{41\ kg\ Os}$$

$$41\ \text{kg Os} \times \frac{2.205\ \text{lb}}{1\ \text{kg}} = \mathbf{9.0 \times 10^1\ lb\ Os}$$

1.76 $62\text{ kg} = 6.2 \times 10^4\text{ g}$

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

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

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

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

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

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

1.78 $\textbf{? °C} = (7.3 \times 10^2 - 273)\text{ K} = \mathbf{4.6 \times 10^2\text{ °C}}$

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

1.80 $$(8.0 \times 10^4\text{ tons Au}) \times \frac{2000\text{ lb Au}}{1\text{ ton Au}} \times \frac{16\text{ oz Au}}{1\text{ lb Au}} \times \frac{\$350}{1\text{ oz Au}} = \mathbf{\$9.0 \times 10^{11}}\text{ or } \textbf{900 billion dollars}$$

1.82 $$\textbf{? Fe atoms} = 4.9\text{ g Fe} \times \frac{1.1 \times 10^{22}\text{ Fe atoms}}{1.0\text{ g Fe}} = \mathbf{5.4 \times 10^{22}\textbf{ Fe atoms}}$$

1.84 10 cm = 0.1 m. We need to find the number of times the 0.1 m wire must be cut in half until the piece left is 1.3×10^{-10} m long. Let n be the number of times we can cut the Cu wire in half. We can write:

$$\left(\frac{1}{2}\right)^n \times 0.1\text{ m} = 1.3 \times 10^{-10}\text{ m}$$

$$\left(\frac{1}{2}\right)^n = 1.3 \times 10^{-9}\text{ m}$$

Taking the log of both sides of the equation:

$$n \log\left(\frac{1}{2}\right) = \log(1.3 \times 10^{-9})$$

$$\boldsymbol{n} = \textbf{30 times}$$

1.86 Volume = area × thickness.

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

$$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{3.636\text{ g}}{2.699\text{ g/cm}^3} = 1.347\text{ cm}^3$$

Convert the unit of area from ft² to cm².

$$1.000\text{ ft}^2 \times \left(\frac{12\text{ in}}{1\text{ ft}}\right)^2 \times \left(\frac{2.54\text{ cm}}{1\text{ in}}\right)^2 = 929.0\text{ cm}^2$$

$$\textbf{thickness} = \frac{\text{volume}}{\text{area}} = \frac{1.347\text{ cm}^3}{929.0\text{ cm}^2} = 1.450 \times 10^{-3}\text{ cm} = \mathbf{1.450 \times 10^{-2}\text{ mm}}$$

1.88 First, let's 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.

$$(2.0 \times 10^4 \text{ gallons } H_2O) \times \frac{3.79 \text{ L}}{1 \text{ gallon}} \times \frac{1 \text{ mL}}{0.001 \text{ L}} \times \frac{1 \text{ g}}{1 \text{ mL}} = 7.6 \times 10^7 \text{ g } H_2O$$

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

$$(7.6 \times 10^7 \text{ g } H_2O) \times \frac{1 \text{ g chlorine}}{1 \times 10^6 \text{ g } H_2O} = 76 \text{ g chlorine}$$

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.

$$76 \text{ g chlorine} \times \frac{100\% \text{ soln}}{6\% \text{ chlorine}} \times \frac{1 \text{ mL soln}}{1 \text{ g soln}} = \mathbf{1.3 \times 10^3 \text{ mL of chlorine solution}}$$

1.90 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:

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

1.92 **(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) $$2.1 \text{ L water} \times \frac{0.304 \text{ ft}^3 \text{ gas}}{1 \text{ L water}} \times \frac{\$1.30}{15.0 \text{ ft}^3} = \mathbf{\$0.055} = \mathbf{5.5¢}$$

1.94 This problem is similar in concept to a limiting reagent 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 reagent".

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

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

The mass of each set is:

$$\left(3 \text{ quarters} \times \frac{5.645 \text{ g}}{1 \text{ quarter}}\right) + \left(1 \text{ nickel} \times \frac{4.967 \text{ g}}{1 \text{ nickel}}\right) + \left(2 \text{ dimes} \times \frac{2.316 \text{ g}}{1 \text{ dime}}\right) = 26.53 \text{ g/set}$$

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

$$1725 \text{ sets} \times \frac{26.53 \text{ g}}{1 \text{ set}} = \mathbf{4.576 \times 10^4\ g}$$

1.96 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:

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

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

$$V = 5.78 \times 10^3 \text{ cm}^3$$

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.

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

$$\textbf{mass} = (8.605 \text{ g/cm}^3)(5.78 \times 10^3 \text{ cm}^3) = \mathbf{4.97 \times 10^4\ g}$$

The assumption made in the calculation is that the alloy must be homogeneous in composition.

1.98 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:

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

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.

1.100 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.

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

$$\text{Mass of solution before reaction} = 45.60 \text{ g} + 1.328 \text{ g} = 46.93 \text{ g}$$

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

$$\text{Mass of } CO_2 \text{ released} = 46.93 \text{ g} - 46.699 \text{ g} = 0.23 \text{ g}$$

Finally, we use the density of carbon dioxide to convert to liters of CO_2 released.

$$\text{Volume of } CO_2 \text{ released} = 0.23 \cancel{\text{g}} \times \frac{1 \text{ L}}{1.81 \cancel{\text{g}}} = \mathbf{0.13 \text{ L}}$$