Chapter 1
Chemistry: Methods and Measurement
Solutions to the Even-Numbered Questions and Problems

In-Chapter Questions and Problems

1.2 Heterogeneous mixture.

1.4
a. Physical property
b. Physical property
c. Physical property

1.6
a. Intensive property. The shape of leaves is independent of the quantity.
b. Extensive property. The number of leaves depends on the quantity.

1.8
a. Two (leading zeros are not significant)
b. Three (trailing zero significant due to decimal)
c. Three (trailing zero significant due to decimal)
d. Two (trailing zero insignificant without decimal)
e. Three (zeros between non-zero digits are significant)
f. Three (zeros between non-zero digits are significant)

1.10
a. 4.820×10^{1}
b. 4.800×10^{2}
c. 1.26×10^{-1}
d. 9.2×10^{3}
e. 5.20×10^{-2}
f. 8.22×10^{2}

1.12
a. 6.2262 rounds to 6.2
b. 3895 rounds to 3.9×10^{3}
c. 6.885 rounds to 6.9
d. 2.2247 rounds to 2.2
e. 0.0004109 rounds to 0.00041 (or 4.1×10^{-4})

1.14
a. 14.20 (four significant figures)
b. –5.9 (two significant figures)
c. 3.60 (three significant figures)

1.16 4.80×10^{8} (three significant figures due to the position of the decimal)

1.18 a. 231 (three significant figures)
b. 4.7×10^{-1} (two significant figures)
c. 6.05×10^{5} (three significant figures)
d. 14 (two significant figures)
e. 9.0×10^{-1} (two significant figures)
f. 2.5×10^{-3} (two significant figures)

1.20 $2.00 \times 10^{2}\ \text{J} \times \dfrac{1\ \text{cal}}{4.18\ \text{J}} = 47.8\ \text{cal}$ (3 significant figures)

End-of-Chapter Questions and Problems

1.22 Energy is the ability to do work to accomplish some change. Energy is important because it is part of all change involving all life forms, from one-celled organisms to humans.

1.24 Observation is the starting point for all scientific inquiry because it gives rise to questions that can only be answered by generating and testing hypotheses.

1.26 To estimate the mass of Earth, you need the estimated density of the earth and the estimated radius of the earth (to calculate the volume of the earth).

1.28 Atoms do not really look like balls and bonds do not really look like sticks. Carbon atoms aren't black and hydrogen atoms aren't gray.

1.30 A scientific law is a summary of large quantities of information and, for which, no exceptions have been found. It is, in effect, a "final product". Theories, on the other hand, are subject to revision as more information becomes available.

1.32 Many examples exist. One might involve the observation that your television does not work. A hypothesis or "educated guess" is made: The television is not connected to the electrical outlet. The experiment involves following the power cord to the outlet and observing its position. If you observe that it is not in the outlet (data), you may insert the plug into the electrical outlet and turn on the television. The television becomes alive (result) and the hypothesis is substantiated by the result of the experiment. On the other hand, if the plug was originally in the outlet, a new hypothesis would be needed and the methodology repeated until the results supported the hypothesis.

1.34 The statement "observed increases in global temperature are caused by elevated levels of carbon dioxide" should be classified as a theory because experiments conducted by many research groups demonstrate that carbon dioxide can convert light to heat. However, other processes also contribute to global warming and potentially, are more major causes. Remember, theories are subject to constant refinement.

1.36 To do this experiment, one must first measure the mass of a piece of filter paper. This will be the mass $_{initial}$. Then, pour 1-L of the seawater solution through the filter paper. The solid suspensions in the seawater can be removed by filtration and the filter paper will retain the solid. Next, dry the filter paper to remove any retained water. Reweigh the filter paper. This is the mass $_{final}$. The difference between the initial and final masses is the mass of solid that was suspended in the seawater sample.

$$[\text{mass}_{\text{initial}} - \text{mass}_{\text{final}}] = \text{mass difference (amount of solids)}$$

1.38 A gas has no definite shape or volume. A liquid has a definite volume but no definite shape. A solid has both fixed volume and fixed shape.

1.40 Examples of pure substances include water, ammonia, table sugar, oxygen, and silver. Examples of mixtures include air, soft drinks, cement, and milk.

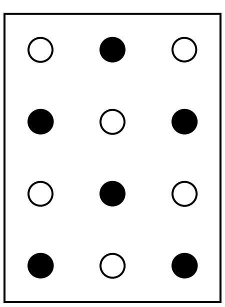
1.42 An extensive property depends on the quantity of a substance. Mass is an example of an extensive property.

1.44 An intensive property is a characteristic of a substance that is independent of the quantity of the substance. An extensive property depends on the quantity of the substance.

1.46 A physical change involves a change in the form of a substance, but not in its chemical composition. A chemical change is synonymous with a chemical reaction. A chemical reaction is a process in which atoms are rearranged, replaced, or added to produce new combinations.

1.48 a. Liquid
b. Solid
c. Gas

1.50 The drawing represents a homogeneous mixture of two compounds. As you can see in the drawing, the compounds are thoroughly intermingled.



1.52 a. physical change
b. chemical change
c. chemical change

1.54 a. chemical property
b. physical property

1.56 a. pure substance
b. mixture
c. mixture
d. mixture

1.58 a. homogeneous
b. heterogeneous
c. heterogeneous
d. homogeneous

1.60 The particles in the diagram are close together, and they have a regular and predictable pattern of particle arrangement. Therefore, the state of matter represented in the diagram is the solid state. Since there is only one atom represented in the diagram, the composition is an element, which is one of the two types of pure substances.

1.62 Intensive properties; they are characteristic of the variety of plants. Extensive properties would best distinguish between young and mature plants.

1.64 Weight is the force of gravity on an object. Mass is independent of gravity.

Weight = mass x acceleration due to gravity

1.66 A meter (m) is close in length to the English yard (yd).

1.68 The English quart (qt) is similar in size to the liter (L).

1.70 $\mu g < cg < Mg$

1.72 The temperature reading is made by determining the thermometer mark nearest the end of the red bar. That value is 25.27. Then, one additional digit is estimated by subdividing the marks into ten equal divisions. Therefore, the temperature reading to the correct number of significant figures is 25.275.

1.74 a. Error is the difference between the true value and our estimation, or measurement, of the value.
b. Uncertainty is the degree of doubt in a single measurement.

1.76 a. two
b. three
c. three
d. two
e. two
f. three

1.78 a. 1.24×10^5
d. 53.3

b. 2.86×10^{-3} e. 17.0
c. 1.42×10^{-3} f. 508

1.80 a. $\dfrac{(16.0)(0.1879)}{45.3} = 6.64 \times 10^{-2}$

b. $\dfrac{(76.32)(1.53)}{0.052} = 2.2 \times 10^{3}$

c. $(0.0063)(57.8) = 0.36$

d. $18 + 52.1 = 7.0 \times 10^{1}$

e. $58.17 - 57.79 = 0.38$

1.82 a. 3,240
b. 0.000150
c. 0.4579
d. –683,000
e. –0.0821
f. 299,790,000
g. 1.50
h. 602,000,000,000,000,000,000,000

1.84 Accuracy is the degree of agreement between the true value and the measured value. These measurements represent low accuracy. Precision is a measure of the agreement of replicate measurements. These measurements have a high level of precision.

1.86 Measurements require the determination of an amount followed by a unit because the unit defines the basic quantity being measured.

1.88 a. M, mega
b. m, milli
c. n, nano

1.90 Since 2.54 centimeters (cm) equals 1 inch (in), the conversion factors are:

$$\frac{2.54\,\text{cm}}{1\,\text{in}} \quad \text{and} \quad \frac{1\,\text{in}}{2.54\,\text{cm}}$$

1.92 a. $5.0 \text{ qt} \times \dfrac{1 \text{ gal}}{4 \text{ qt}} = 1.3 \text{ gal}$

b. $5.0 \text{ qt} \times \dfrac{2 \text{ pt}}{1 \text{ qt}} = 1.0 \times 10^1 \text{ pt}$

c. $5.0 \text{ qt} \times \dfrac{0.946 \text{ L}}{1 \text{ qt}} = 4.7 \text{ L}$

d. $5.0 \text{ qt} \times \dfrac{0.946 \text{ L}}{1 \text{ qt}} \times \dfrac{1 \text{ mL}}{10^{-3} \text{ L}} = 4.7 \times 10^3 \text{ mL}$

e. $5.0 \text{ qt} \times \dfrac{0.946 \text{ L}}{1 \text{ qt}} \times \dfrac{1 \mu\text{L}}{10^{-6} \text{ L}} = 4.7 \times 10^6 \mu\text{L}$

1.94 a. $3.0 \text{ m} \times \dfrac{1 \text{ yd}}{0.91 \text{ m}} = 3.3 \text{ yd}$

b. $3.0 \text{ m} \times \dfrac{1 \text{ yd}}{0.91 \text{ m}} \times \dfrac{36 \text{ in}}{1 \text{ yd}} = 1.2 \times 10^2 \text{ in.}$

c. $3.0 \text{ m} \times \dfrac{1 \text{ yd}}{0.91 \text{ m}} \times \dfrac{3 \text{ ft}}{1 \text{ yd}} = 9.9 \text{ ft}$

d. $3.0 \text{ m} \times \dfrac{1 \text{ cm}}{10^{-2} \text{ m}} = 3.0 \times 10^2 \text{ cm}$

e. $3.0 \text{ m} \times \dfrac{1 \text{ mm}}{10^{-3} \text{ m}} = 3.0 \times 10^3 \text{ mm}$

1.96 $7.5 \times 10^{-3} \text{ cm} \times \dfrac{10^{-2} \text{ m}}{1 \text{ cm}} \times \dfrac{1 \text{ mm}}{10^{-3} \text{ m}} = 7.5 \times 10^{-2} \text{ mm}$

1.98 To solve this problem, we will first look at weight. Pounds (lb) can be converted to grams. One pound is equal to 454 grams. Then, the area of in^2 can be converted to cm^2, because 1 inch is equal to 2.54 cm.

$$\frac{32 \text{ lb}}{\text{in}^2} \times \frac{454 \text{ g}}{1 \text{ lb}} \times \left(\frac{1 \text{ in}}{2.54 \text{ cm}}\right) =$$

$$\frac{32 \cancel{\text{lb}}}{\cancel{\text{in}^2}} \times \frac{454 \text{ g}}{1 \cancel{\text{lb}}} \times \frac{1 \cancel{\text{in}^2}}{6.45 \text{ cm}^2} = 2252 \ \frac{\text{g}}{\text{cm}^2}$$

The answer should have 2 significant figures, so it is rounded and converted to scientific notation to give the answer: $2.3 \times 10^3\ \dfrac{\text{g}}{\text{cm}^2}$

1.100 $9 \text{ pt} \times \dfrac{1\,\text{qt}}{2\,\text{pt}} \times \dfrac{0.946\,\text{L}}{1\,\text{qt}} \times \dfrac{1\,\text{mL}}{10^{-3}\,\text{L}} \times \dfrac{1\,\text{drop}}{0.05\,\text{mL}} = 8.5 \times 10^4 \text{ drops}$

8.5×10^4 drops $\approx 9 \times 10^4$ drops (1 significant figure)

1.102 length: $21 \text{ in.} \times \dfrac{2.54\,\text{cm}}{1\,\text{in.}} = 53 \text{ cm}$

weight: $\left(6\,\text{lb} \times \dfrac{16\,\text{oz}}{1\,\text{lb}}\right) + 9 \text{ oz} = 105 \text{ oz}$

$105 \text{ oz} \times \dfrac{1 \text{ lb}}{16 \text{ oz}} \times \dfrac{454 \text{ g}}{1 \text{ lb}} = 2.98 \times 10^3 \text{ g}$

1.104 In order to compare the magnitude of two volumes, we must convert them to a common unit:

$$50 \text{ mL} \times \frac{1\,\text{L}}{1000\,\text{mL}} = 5.00 \times 10^{-2} \text{ L}$$

and 5.00×10^{-2} L is smaller than 0.500 L (5.00×10^{-1}L).

1.106 In order to compare the magnitude of two volumes, we must convert them to a common unit:
by definition 0.946 L = 1 qt so,

$$1.0 \text{ qt} \times \frac{0.946\,\text{L}}{1\text{qt}} = 0.946 \text{ L}$$

and 1.0 qt is smaller than 1.0 L.

1.108 Sally lost more weight.

a. In order to calculate the amount of weight that was lost, the final weight should be subtracted from the initial weight. After the amount of weight that was lost is determined, the weight lost by Sally should be converted from pounds to kilograms. Comparisons should be made only between weights that have the same units. A conversion factor relating pounds to kilograms can be used to complete this calculation.

b. Sally's weight loss: 193 lbs – 145 lbs = 48 lbs

$$48 \text{ lbs x } \frac{1\,\text{kg}}{2.2\,\text{lbs}} = 22 \text{ kg (2 significant figures)}$$

Gertrude's weight loss: 80 kg – 65 kg = 15 kg

1.110 0 K < 0˚F < 0˚C

1.112 a. False. Energy cannot be created or destroyed.
b. True.
c. False. Conversion of energy from one form to another cannot occur with 100% efficiency.
d. True.

1.114 Specific gravity is the ratio of the density of the object in question to the density of a standard. The standard, a reference, is often the density of pure water at 4˚C. Specific gravity is a unitless term, whereas the unit for density can be g/mL, g/cm^3, or g/cc.

1.116 a. $T_{^\circ C} = \frac{T_{^\circ F} - 32}{1.8} = \frac{-10.0 - 32}{1.8} = -23.3^\circ\text{C}$

b. $T_K = T_{^\circ C} + 273.15 = (-23.3) + 273.15 = 249.9 \text{ K}$

1.118 a. If $T_K = T_{^\circ C} + 273.15$

then, $T_{^\circ C} = T_K - 273.15$

therefore $T_{^\circ C} = 300.0 - 273.15 = 26.9^\circ\text{C}$

b. From part (a), 300.0 K = 26.9˚C

If $T_{^\circ C} = \frac{T_{^\circ F} - 32}{1.8}$, then $1.8(T_{^\circ C}) = T_{^\circ F} - 32$

and $T_{^\circ F} = 1.8(T_{^\circ C}) + 32$

$T_{^\circ F} = [(1.8)(26.8)] + 32 = 80.2^\circ\text{F}$

1.120 First, the relationship 1 cal = 4.18 J can be used to create a conversion factor to convert from joules to calories. Then, calories are converted to kilocalories.

$$2.0 \text{ x } 10^{22} \text{ J x } \frac{1\,\text{cal}}{4.18\,\text{J}} \text{ x } \frac{1\,\text{kcal}}{10^3\,\text{cal}} = 4.8 \text{ x } 10^{18} \text{ kcal (two significant figures)}$$

1.122 $d = \frac{m}{V} = \frac{g}{mL} = \frac{50.0\,g}{63.6\,mL} = 0.786$ g/mL

1.124 Although the temperature changes the density and the volume of this sample, the mass remains constant. Therefore, the mass of air that was used for the previous calculation, 8.00 x 10^2 g. is used in this calculation with the new density of 1.50 g/mL. To calculate the new volume the density equation must be rearranged

$d = \frac{m}{V}$ to solve for volume.

Thus $V = \frac{m}{d} = \frac{8.00 \times 10^2\ g}{1.50\,g/\ mL} = 5.33 \times 10^2$ mL (3 significant figures)

$V = 533$ mL

1.126 $d = \frac{m}{V}$ Therefore, $m = Vd$

$118\ cm^3 \times \frac{1.8\ g}{1\ cm^3} = 2.1 \times 10^2\ g$

1.128 $d = \frac{m}{V} = \frac{98\,g}{1.00 \times 10^2\ cm^3} = 0.98\ g/cm^3$, therefore, teak

1.130 Measure the volume of each bar. Since the masses are identical, the bar that occupies the largest volume has the smallest density; the bar that occupies the smallest volume has the greatest density.

1.132 $d = \frac{m}{V}$

Thus $m = (d)(V) = (0.791$ g/mL)(50.0mL)

$m = 39.6$ g

1.134 Specific gravity of urine = $\frac{\text{density of urine}}{\text{density of water at } 4^\circ C}$

Multiplying both sides of the equation by the density of water at 4˚C,

(Specific gravity of urine) (density of water at 4˚C) = density of urine

(1.008) (1.000 g/mL) = density of urine = 1.008 g/mL

1.136 $d = \dfrac{m}{V}$ Therefore, $V = \dfrac{m}{d}$ or $V = m \text{ x } \dfrac{1}{d}$

Substituting, $272 \text{ g x } \dfrac{1 \text{ mL}}{13.6 \text{ g}} = 20.0 \text{ mL}$

1.138 $\text{BMI} = \dfrac{\text{weight (kg)}}{\text{height}^2 \text{ (m}^2\text{)}}$

Multiplying both sides of the equation by the height^2,

(BMI) (height^2) = weight

$$\left(\frac{38 \text{ kg}}{\text{m}^2}\right) (1.6 \text{ m})^2 = \frac{38 \text{ kg}}{\text{m}^2} \text{ x } 1.6 \text{ m x } 1.6 \text{ m} = 97 \text{ kg (2 significant figures)}$$

$$97 \text{ kg x} \frac{10^3 \text{ g}}{1 \text{ kg}} \text{x } \frac{1 \text{ lb}}{454 \text{ g}} = 214 \text{ lb} \approx 210 \text{ lb (2 significant figures)}$$