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Chapter One
Scientific Measurements

Practice Exercises

1.1 The scientific method is an iterative process of gathering information through making observations and collecting data and then formulating explanations that lead to a conclusion.

1.2 (a) element (b) mixture, homogeneous (c) compound
(d) mixture, heterogeneous (e) element

1.3 (a) chemical change (b) physical change
(c) physical change (d) physical change

1.4 (a) intensive (b) extensive
(c) intensive (d) extensive

1.5 $V = \frac{4}{3}\pi r^3$, the SI unit for radius, r, is meters, the numbers $\frac{4}{3}$ and π do not have units. Therefore, the SI unit for volume is meter^3 or m^3.

1.6 Force equals mass × acceleration ($F = ma$), and acceleration equals change in velocity divided by change in time ($a = \frac{\text{change in } v}{\text{change in } t}$), and velocity equals distance divided by time ($v = \frac{d}{t}$). Put the equations together:

$$F = m\left(\frac{\text{change in } v}{\text{change in } t}\right)$$

$$F = m\left(\frac{\text{change in } \frac{d}{t}}{\text{change in } t}\right) = m\left(\frac{\text{change in } d}{\text{change in } t^2}\right)$$

The unit for mass is kilogram (kg); the unit for distance is meter (m) and the unit for time is second (s). Substitute the units into the equation above:

Unit for force in SI base units = $\text{kg}\left(\frac{\text{m}}{\text{s}^2}\right)$ or kg m s^{-2}

1.7 $$t_F = \left(\frac{9\ °F}{5\ °C}\right) t_C + 32\ °F = \left(\frac{9\ °F}{5\ °C}\right)(355\ °C) + 32\ °F = 671\ °F$$

1.8 $$t_C = (t_F - 32\ °F)\left(\frac{5\ °C}{9\ °F}\right) = (55\ °F - 32\ °F)\left(\frac{5\ °C}{9\ °F}\right) = 13\ °C$$

To convert from °F to K we first convert to °C.

$$t_C = (t_F - 32\ °F)\left(\frac{5\ °C}{9\ °F}\right) = (68\ °F - 32\ °F)\left(\frac{5\ °C}{9\ °F}\right) = 20\ °C$$

$$T_K = (273\ °C + t_C)\left(\frac{1\ K}{1\ °C}\right) = (273\ °C + 20\ °C)\left(\frac{1\ K}{1\ °C}\right) = 293\ K$$

1.9 (a) 21.0233 g + 21.0 g = 42.0233 g: rounded correctly to 42.0 g

(b) 10.0324 g / 11.7 mL = 0.8574 g / mL: rounded correctly to 0.857 g/mL

(c) $\dfrac{14.25\ \text{cm} \times 12.334\ \text{cm}}{(2.223\ \text{cm} - 1.04\ \text{cm})}$ = 148.57 cm: rounded correctly to 149 cm

1.10 (a) 54.183 g – 0.0278 g = 54.155 g

(b) 10.0 g + 1.03 g + 0.243 g = 11.3 g (rounded after adding)

(c) $43.4\ \text{in} \times \left(\dfrac{1\ \text{ft}}{12\ \text{in.}}\right) = 3.62\ \text{ft}$ (1 and 12 are exact numbers)

(d) $\dfrac{1.03\ \text{m} \times 2.074\ \text{m} \times 2.9\ \text{m}}{12.46\ \text{m} + 4.778\ \text{m}} = 0.36\ \text{m}^2$

1.11 $\text{m}^2 = (124\ \text{ft}^2)\left(\dfrac{30.48\ \text{cm}}{1\ \text{ft}}\right)^2\left(\dfrac{1\ \text{m}}{100\ \text{cm}}\right)^2 = 11.5\ \text{m}^2$

1.12 (a) $\text{in.}^3 = (3.00\ \text{yd}^3)\left(\dfrac{3\ \text{ft}}{1\ \text{yd}}\right)^3\left(\dfrac{12\ \text{in.}}{1\ \text{ft}}\right)^3 = 140{,}000\ \text{in.}^3 = 1.40 \times 10^5\ \text{in}^3$

(b) $\text{cm} = (1.25\ \text{km})\left(\dfrac{1000\ \text{m}}{1\ \text{km}}\right)\left(\dfrac{100\ \text{cm}}{1\ \text{m}}\right) = 1.25 \times 10^5\ \text{cm}$

(c) $\text{g} = (3.27\ \text{oz})\left(\dfrac{28.35\ \text{g}}{1\ \text{oz}}\right) = 92.7\ \text{g}$

(d) $\dfrac{\text{km}}{\text{L}} = \left(\dfrac{20.2\ \text{mile}}{1\ \text{gal}}\right)\left(\dfrac{1.609\ \text{km}}{1\ \text{mile}}\right)\left(\dfrac{1\ \text{gal}}{3.785\ \text{L}}\right) = 8.59\ \dfrac{\text{km}}{\text{L}}$

1.13 Density = $\dfrac{\text{mass}}{\text{volume}} = \dfrac{0.244\ \text{g}}{15.0\ \text{mL}}$ = 0.0163 g/mL = 0.0163 g cm^{-3}

1.14 Density = $\dfrac{\text{mass}}{\text{volume}} = \dfrac{\text{mass}}{V_f - V_i} = \dfrac{0.547\ \text{g}}{(5.95\ \text{mL} - 5.70\ \text{mL})}$ = 2.2 g mL^{-1} = 2.2 g cm^{-3}

1.15 Density = $\dfrac{\text{mass}}{\text{volume}}$

Density of the object = $\dfrac{365\ \text{g}}{22.12\ \text{cm}^3}$ = 16.5 g/cm^3

The object is not composed of pure gold since the density of gold is 19.3 g/cm^3.

1.16 The density of the alloy is 12.6 g/cm^3. To determine the mass of the 0.822 ft^3 sample of the alloy, first convert the density from g/cm^3 to lb/ft^3, then find the weight.

$$\text{Density in lb/ft}^3 = \frac{12.6\text{ g}}{\text{cm}^3}\left(\frac{1\text{ lb}}{453.6\text{ g}}\right)\left(\frac{30.48\text{ cm}}{1\text{ ft}}\right)^3 = 787\text{ lb/ft}^3$$

Mass of sample alloy = (0.822 ft^3) (787 lb/ft^3) = 647 lb

1.17 $\text{specific gravity} = \dfrac{\text{density of substance}}{\text{density of water}}$

$$1.090 = \frac{\text{density of wine}}{62.4\text{ lb ft}^3}$$

density of wine = 1.090 × 62.4 lb ft^3 = 68.02 lb ft^3

$$\text{mass of wine} = 79 \text{ gallons} \times \text{density of wine} \times \frac{\text{ft}^3}{7.481 \text{ gallons}}$$

$$= 79 \text{ gallons} \times \frac{68.02 \text{ lb}}{1 \text{ ft}^3} \times \frac{\text{ft}^3}{7.481 \text{ gallons}} = 720 \text{ lb}$$

1.18 specific gravity = $\dfrac{\text{density of substance}}{\text{density of water}}$

$$\text{density of water} = \frac{1.00 \text{ g}}{1 \text{ mL}} \left(\frac{1 \text{ oz}}{28.3495 \text{ g}}\right)\left(\frac{29.574 \text{ mL}}{1 \text{ liquid oz}}\right) = 1.043 \text{ oz/liquid oz}$$

$$\text{specific gravity of urine} = \frac{1.008 \text{ oz/liquid oz}}{1.043 \text{ oz/liquid oz}} = 0.966$$

The specific gravity of urine is below the normal range.

Review Questions

1.1 This answer will be student dependent.

1.2 Observation, testing and explanation.

1.3 (a) A law is a description of behavior based on the results of many experiments which are true while a theory is a tested explanation of the results of many experiments.
(b) An observation is a statement that accurately describes something we see, hear, taste, feel or smell while a conclusion is a statement that is based on a series of observations.
(c) Data are the observations made while performing experiments.

1.4 A theory is valid as long as there is no experimental evidence to disprove it. Any experimental evidence that contradicts the theory, and therefore, disproves the theory.

1.5 Matter has mass and occupies space. All items, except (b) an idea, in the question are examples of matter.

1.6 (a) An element is a pure substance that cannot be decomposed into something simpler.
(b) A compound is a pure substance that is composed of two or more elements in some fixed or characteristic proportion.
(c) Mixtures result from combinations of pure substances in varying proportions.
(d) A homogeneous mixture has one phase. It has the same properties throughout the sample.
(e) A heterogeneous mixture has more than one phase. The different phases have different properties.
(f) A phase is a region of a mixture that has properties that are different from other regions of the mixture.
(g) A solution is a homogeneous mixture.

1.7 Changing a compound into its element is a chemical change.

1.8 (a) F (b) Se (c) Ni (d) Ar
(e) Li (f) P (g) I (h) Ga
(i) Hg (j) Mn

1.9 (a) sodium (b) zinc (c) silicon
(d) tin (e) magnesium (f) tungsten
(g) cobalt (h) aluminum (i) oxygen
(j) nitrogen

1.10 (a) This is a heterogeneous mixture.
(b) This is a pure substance and is an element, such as H_2, O_2, N_2 or a halogen.
(c) This is a homogeneous mixture.
(d) This is a pure substance and is a molecule such as H_2O.

1.11 (a) Diagrams (a) and (d) contain pure elements
(b) Diagram (c) contains a compound
(c) Diagram (a) and (b) contain diatomic molecules

1.12 A physical change does not change the chemical composition of matter. Melting, boiling, change of shape, or mass, and the formation of a mixture are examples of physical changes to matter.
A chemical change changes the chemical composition of matter. Formation of new compounds from the reaction of other substances is an example.
A chemical changes involves the change in composition while a physical change does not change in the composition of matter.

1.13 The reaction of calcium metal with water is a chemical change resulting in the formation of new compounds, hydrogen gas and calcium hydroxide. It is not stated in the problem, but the water also increases in temperature, which is a physical change.

1.14 These are all physical changes.

1.15 A chemical property describes a property that changes the chemical nature of a substance while physical properties describe properties that do not change the chemical nature of a substance. For example, boiling water does not change the chemical composition of water.

1.16 Extensive properties, such as volume, and size, are properties that depend on the amount of substance or mass of substance while intensive properties, such as density, are not dependent on the amount of substance. The density of a milliliter of water is the same as the density of a liter of water at the same temperature.

1.17 (a) Extensive Mass is a mass dependent property.
(b) Intensive The boiling point of a substance is the same for a mL as it is for a L of the compound so it is mass independent.
(c) Intensive The color of a substance does not change when you change the amount of substance.
(d) Extensive Surface area depends on the amount of substance. It also depends on the nature of the substance. A bar of metal has a smaller surface area than that of the same bar ground into fine particles.
(e) Intensive The physical state, gas, liquid, or solid, depends on temperature and pressure but not on the mass of the substance.
(f) Intensive The density of 1.0 g of water is the same as 100.0 g if both samples are at the same temperature. Thus, density is not dependent on the mass of substance.
(g) Extensive The volume occupied by a substance is dependent on the mass of substance.

1.18 (a) Gas Temperature, density, volume, viscosity
(b) Liquid Temperature, density, volume, viscosity
(c) Solid Temperature, density, volume

1.19 Measurements involve a comparison. The unit gives the number meaning.

1.20 Kilogram

1.21 Kilogram, meter, second, kelvin

1.22 Derived units are a result of multiplying or dividing a unit by 1, by a multiplier, or by another unit. Examples include m^2 for area, m/s for velocity, kg m/s^2 for energy.

1.23

(a)	0.01	10^{-2}	c
(b)	0.001	10^{-3}	m
(c)	1000	10^{3}	k
(d)	0.000001	10^{-6}	μ (the Greek letter mu)
(e)	0.000000001	10^{-9}	n
(f)	0.000000000001	10^{-12}	p
(g)	1,000,000	10^{6}	M

1.24 The melting points and boiling points of water at 1 atmosphere pressure. On the Celsius scale these points correspond to 0 °C and 100 °C respectively.

1.25 (a) 1 Fahrenheit degree < 1 Celsius degree
(b) 1 Celsius degree = 1 Kelvin
(c) 1 Fahrenheit degree < 1 Kelvin

1.26 The digits that are significant figures in a quantity are those that are known (measured) with certainty plus the last digit, which contains some uncertainty.

1.27 Rounding numbers: if the number after the significant figure is less than 5, keep the number. If the number after the significant figure is 5 or more, and if it is 5 and the 5 is followed by nonzero digits, raise the number by 1. If the number after the significant figure is 5, and followed by a zero, drop the 5 if the preceding digit is even, add 1 if it is odd.

1.28 The *accuracy* of a measured value is the closeness of that value to the true value of the quantity. The *precision* of a number of repeated measurements of the same quantity is the closeness of the measurements to one another.

1.29 The minimum uncertainty that is implied in this measurement is ± 0.01 cm.

1.30 In addition, the significant figures are the least precise number. In multiplication, the number of significant figures in the answer depends on smallest number of significant figures.

1.31 The unit that you start with is the denominator and the desired unit is the numerator.

1.32 The problem with using the fraction 3 yd/1 ft as a conversion factor is that there are 3 feet in one yard. The conversion factor should be 1 yd/3 ft. For the second part of the question, it is not possible to construct a valid conversion factor relating centimeters to meters from the equation 1 cm = 1000 m, since 100 cm = 1 m.

1.33 To convert 250 seconds to hours multiply 250 by:

$$\frac{1\ \text{h}}{3600\ \text{s}}$$

To convert 3.84 hours to seconds multiply 3.84 hours by:

$$\frac{3600\ \text{s}}{1\ \text{h}}$$

1.34 Four significant figures would be correct because the conversion factor contains exact values. The measured value determines the number of significant figures.

1.35 $d = \frac{m}{V}$: d = density; m = mass; V = volume

1.36 Density is the ratio of the mass of a substance divided by its volume and is an intensive property. Specific gravity is the ratio of the density of a substance divided by the density of water using the same units. Specific gravity does not have any units. Specific gravity is useful since it avoids units, and only the density of water with the desired units needs to be tabulated.

1.37 The answer will be student dependent, but some answers might be g/mL, lb/ gallon, kg/L, ft^3/lb. These would have to be divided by the density of water with the same units: 1.00 g/mL, 8.34 lb/gallon, 1.00 kg/L, 62.4 lb/ft^3 at 25 °C.

1.38 10.5 g silver = 1 cm^3 silver

$$\frac{10.5\ \text{g Ag}}{1\ \text{cm}^3} \text{ and } \frac{1\ \text{cm}^3}{10.5\ \text{g Ag}}$$

Review Problems

1.39 (a) Physical change. Copper does not change chemically when electricity flows through it: It remains copper.
(b) Physical change. Gallium is changes its state, not its chemical composition when it melts.
(c) Chemical change. This is an example of the Maillard reaction describing the chemical reaction of sugar molecules and amino acids.
(d) Chemical change. Wine contains ethanol which can be converted to acetic acid.
(e) Chemical change. Concrete is composed of many different substances that undergo a chemical process called hydration when water is added to it.

1.40 (a) Chemical change. Iron reacts with oxygen to form the rust.
(b) Physical change. When corn is popped water is turned into steam by heating the corn. The pressure of the steam caused the kernel to pop open resulting in popped corn.
(c) Physical change. Generally alloys are mixtures of substances and no chemical change occurs. On occasion, a chemical change can occur during the production of an alloy.
(d) Physical change. During the production of butter fat molecules aggregate, due to the agitation of whipping, and separate from the water.
(e) Physical change. The water vapor becomes the liquid and does not change its chemical composition.

1.41 (a) Hydrogen is a gas at room temperature.
(b) Aluminum is a solid at room temperature.
(c) Nitrogen is a gas at room temperature.

(d) Mercury is a liquid at room temperature.

1.42 (a) Potassium chloride is a solid at room temperature.
(b) Carbon dioxide is a gas at room temperature.
(c) Methane is a gas at room temperature.
(d) Sucrose is a solid at room temperature.

1.43 (a) 0.01 (b) 1000 (c) 10^{12}
(d) 0.1 (e) 0.001 (f) 0.01

1.44 (a) 10^{-9} (b) 10^{-6} (c) 10^{3}
(d) 10^{6} (e) 10^{-3} (f) 0.1

1.45 (a) $t_F = \left(\frac{9\ °F}{5\ °C}\right)(t_C) + 32\ °F = \left(\frac{9\ °F}{5\ °C}\right)(57\ °C) + 32\ °F = 135\ °F$ when rounded to the proper number of significant figures.

(b) $t_C = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F) = \left(\frac{5\ °C}{9\ °F}\right)(-25.5\ °F - 32\ °F) = -31.9\ °C$

(c) $t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (378\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = 105\ °C$

(d) $T_K = (t_C + 273\ °C)\left(\frac{1\ K}{1\ °C}\right) = (-31 + 273)\left(\frac{1\ K}{1\ °C}\right) = 242\ K$

1.46 (a) $t_C = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F) = \left(\frac{5\ °C}{9\ °F}\right)(98\ °F - 32\ °F) = 37\ °C$

(b) $t_F = \left(\frac{9\ °F}{5\ °C}\right)(t_C) + 32\ °F = \left(\frac{9\ °F}{5\ °C}\right)(-55\ °C) + 32\ °F = -67\ °F$

(c) $t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (299\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = 26\ °C$

(d) $T_K = (t_C + 273\ °C)\left(\frac{1\ K}{1\ °C}\right) = (40\ °C + 273\ °C)\left(\frac{1\ K}{1\ °C}\right) = 313\ K$

1.47 Temperature in °C:

$$t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (15.7 \times 10^6\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = 15.7 \times 10^6\ °C$$

Temperature in °F:

$$t_F = \left(\frac{9\ °F}{5\ °C}\right)(°C) + 32\ °F = \left(\frac{9\ °F}{5\ °C}\right)(15.7 \times 10^6\ °C) + 32\ °F = 2.83 \times 10^7\ °F$$

1.48 Temperature in °C:

$$t_C = (T_K - 273\text{ K})\left(\frac{1\ ^\circ\text{C}}{1\text{ K}}\right) = (109\text{ K} - 273\text{ K})\left(\frac{1\ ^\circ\text{C}}{1\text{ K}}\right) = -164\ ^\circ\text{C}$$

Temperature in °F:

$$t_F = \left(\frac{9\ ^\circ\text{F}}{5\ ^\circ\text{C}}\right)(^\circ\text{C}) + 32\ ^\circ\text{F} = \left(\frac{9\ ^\circ\text{F}}{5\ ^\circ\text{C}}\right)(-164\ ^\circ\text{C}) + 32\ ^\circ\text{F} = -263.2\ ^\circ\text{F}$$

1.49 $t_C = (t_F - 32\ ^\circ\text{F})\left(\dfrac{5\ ^\circ\text{C}}{9\ ^\circ\text{F}}\right) = (103.5\ ^\circ\text{F} - 32\ ^\circ\text{F})\left(\dfrac{5\ ^\circ\text{C}}{9\ ^\circ\text{F}}\right) = 39.7\ ^\circ\text{C}$

This dog has a fever; the temperature above is out of normal canine range.

1.50 $t_C = (t_F - 32\ ^\circ\text{F})\left(\dfrac{5\ ^\circ\text{C}}{9\ ^\circ\text{F}}\right) = (120.0\ ^\circ\text{F} - 32\ ^\circ\text{F})\left(\dfrac{5\ ^\circ\text{C}}{9\ ^\circ\text{F}}\right) = 48.89\ ^\circ\text{C}$

The temperature in Death Valley, 56.7 °C, was warmer.

1.51 9.2 cm, 2 significant figures; 9.15 cm, 3 significant figures

1.52 24.25 °C, 4 significant figures; 18.9 °C, 3 significant figures

1.53 (a) 4 significant figures (b) 5 significant figures
(c) 4 significant figures (d) 2 significant figures
(e) 2 significant figures

1.54 (a) 3 significant figures (b) 6 significant figures
(c) 1 significant figures (d) 5 significant figures
(e) 1 significant figure

1.55 (a) 0.72 m^2 (b) 84.24 kg
(c) 4.19 g/cm^3 (dividing a number with 4 sig. figs by one with 3 sig. figs)
(d) 19.42 g/mL (e) 858.0 cm^2

1.56 (a) 2.06 g/mL (b) 4.02 mL
(c) 12.4 g/mL (d) 0.276 g/mL
(e) 0.0006 m/s^2

1.57 (a) finite number of significant figures
(b) exact number
(c) finite number of significant figures
(d) finite number of significant figures

1.58 (a) finite number of significant figures
(b) finite number of significant figures
(c) finite number of significant figures
(d) exact number

1.59 (a) $\text{km/hr} = (32.0\ \text{dm/s})\left(\dfrac{1\ \text{m}}{10\ \text{dm}}\right)\left(\dfrac{1\ \text{km}}{1000\ \text{m}}\right)\left(\dfrac{3600\ \text{s}}{1\ \text{h}}\right) = 11.5\ \text{km/h}$

(b) $\text{mg/L} = (8.2\ \text{mg/mL})\left(\dfrac{1\ \text{g}}{1000\ \text{mg}}\right)\left(\dfrac{1\times10^{6}\ \text{mg}}{1\ \text{g}}\right)\left(\dfrac{1000\ \text{mL}}{1\ \text{L}}\right) = 8.2\times10^{6}\ \text{mg/L}$

$(\quad)\left(\dfrac{1\ \text{g}}{\quad}\right)\left(\dfrac{1\ \text{kg}}{\quad}\right)\ \ ^{-5}$

(c) $kg = 75.3\ mg \left(\frac{}{1000\ mg}\right)\left(\frac{}{1000\ g}\right) = 7.53 \times 10\ \ kg$

(d) $L = (137.5\ mL)\left(\frac{1\ L}{1000\ mL}\right) = 0.1375\ L$

(e) $mL = (0.025\ L)\left(\frac{1000\ mL}{1\ L}\right) = 25\ mL$

(f) $\text{dm} = \left(342\ \text{pm}^2\right)\left(\frac{1\times 10^{-12}\ \text{m}}{1\ \text{pm}}\right)^2\left(\frac{10\ \text{dm}}{1\ \text{m}}\right)^2 = 3.42\times 10^{-20}\ \text{dm}$

1.60 (a) $\mu\text{m}^3 = (92\ \text{dL})\left(\frac{1\ \text{L}}{10\ \text{dL}}\right)\left(\frac{1000\ \text{cm}^3}{1\ \text{L}}\right)\left(\frac{1\ \text{m}}{100\ \text{cm}}\right)^3\left(\frac{10^6\ \mu\text{m}}{1\ \text{m}}\right)^3 = 9.2\times 10^{15}\ \mu\text{m}^3$

(b) $\mu\text{g} = (22\ \text{ng})\left(\frac{1\ \text{g}}{10^9\ \text{ng}}\right)\left(\frac{10^6\ \mu\text{g}}{1\ \text{g}}\right) = 0.022\ \mu\text{g}$

(c) $\text{nL} = (83\ \text{pL})\left(\frac{1\ \text{L}}{10^{12}\ \text{pL}}\right)\left(\frac{10^9\ \text{nL}}{1\ \text{L}}\right) = 0.083\ \text{nL}$

(d) $\text{m}^3 = (230\ \text{km}^3)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)^3 = 2.3\times 10^{11}\ \text{m}^3$

(e) $\text{km hr}^{-2} = (87.3\ \text{cm s}^{-2})\left(\frac{1\ \text{m}}{100\ \text{cm}}\right)\left(\frac{1\ \text{km}}{1000\ \text{m}}\right)\left(\frac{3600\ \text{s}}{1\ \text{hr}}\right)^2 = 1.13\times 10^4\ \text{km hr}^{-2}$

(f) $\text{nm}^2 = (238\ \text{mm}^2)\left(\frac{1\ \text{m}}{1000\ \text{mm}}\right)^2\left(\frac{1\ \text{nm}}{10^{-9}\ \text{m}}\right)^2 = 2.38\times 10^{14}\ \text{nm}^2$

1.61 (a) $\text{cm} = \left(36\ \text{in.}\right)\left(\frac{2.54\ \text{cm}}{1\ \text{in.}}\right) = 91\ \text{cm}$

(b) $\text{kg} = \left(5.0\ \text{lb}\right)\left(\frac{1\ \text{kg}}{2.205\ \text{lb}}\right) = 2.3\ \text{kg}$

(c) $\text{mL} = \left(3.0\ \text{qt}\right)\left(\frac{946.4\ \text{mL}}{1\ \text{qt}}\right) = 2800\ \text{mL}$

(d) $\text{mL} = \left(8\ \text{oz}\right)\left(\frac{29.6\ \text{mL}}{1\ \text{oz}}\right) = 200\ \text{mL}$

(e) $\text{km/hr} = \left(55\ \text{mi/hr}\right)\left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right) = 88\ \text{km/hr}$

(f) $\text{km} = \left(50.0\ \text{mi}\right)\left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right) = 80.4\ \text{km}$

1.62 (a) $\text{qt} = \left(250\ \text{mL}\right)\left(\frac{1\ \text{qt}}{946.4\ \text{mL}}\right) = 0.26\ \text{qt}$

(b) $\text{m} = \left(3.0\ \text{ft}\right)\left(\frac{12\ \text{in.}}{\ }\right)\left(\frac{2.54}{\ }\right)\left(\frac{1\ \text{m}}{\ }\right) = 0.91\ \text{m}$

$$\left.\begin{matrix}\;\\ 1\ \text{ft}\end{matrix}\right)\left(\begin{matrix}\;\\ 1\ \text{in.}\end{matrix}\right)\left(\begin{matrix}\;\\ 100\ \text{cm}\end{matrix}\right)$$

(c) $\text{lb} = (1.62\ \text{kg})\left(\frac{2.205\ \text{lb}}{1\ \text{kg}}\right) = 3.57\ \text{lb}$

(d) $\text{oz} = (1.75\ \text{L})\left(\frac{1000\ \text{mL}}{1\ \text{L}}\right)\left(\frac{1\ \text{oz}}{29.6\ \text{mL}}\right) = 59.1\ \text{oz}$

(e) $\text{mi/hr} = (35\ \text{km/hr})\left(\frac{1\ \text{mi}}{1.609\ \text{km}}\right) = 22\ \text{mi/hr}$

(f) $\text{mi} = (80.0\text{ km})\left(\frac{1\text{ mi}}{1.609\text{ km}}\right) = 49.7\text{ mi}$

1.63 (a) $\text{cm}^2 = (8.4\text{ ft}^2)\left(\frac{30.48\text{ cm}}{1\text{ ft}}\right)^2 = 7{,}800\text{ cm}^2$

(b) $\text{km}^2 = (223\text{ mi}^2)\left(\frac{1.609\text{ km}}{1\text{ mi}}\right)^2 = 577\text{ km}^2$

(c) $\text{cm}^3 = (231\text{ ft}^3)\left(\frac{30.48\text{ cm}}{1\text{ ft}}\right)^3 = 6.54\times10^6\text{ cm}^3$

1.64 (a) $\text{m}^2 = (2.4\text{ yd}^2)\left(\frac{0.9144\text{ m}}{1\text{ yd}}\right)^2 = 2.0\text{ m}^2$

(b) $\text{mm}^2 = (8.3\text{ in}^2)\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)^2\left(\frac{10\text{ mm}}{1\text{ cm}}\right)^2 = 5400\text{ mm}^2$

(c) $\text{L} = (9.1\text{ ft}^3)\left(\frac{1\text{ yd}}{3\text{ft}}\right)^3\left(\frac{0.9144\text{ m}}{1\text{ yd}}\right)^3\left(\frac{100\text{ cm}}{1\text{ m}}\right)^3\left(\frac{1\text{ mL}}{1\text{ cm}^3}\right)\left(\frac{1\text{ L}}{1000\text{ mL}}\right) = 260\text{ L}$

1.65 $\text{mL} = (4.2\text{ qt})\left(\frac{946.35\text{ mL}}{1\text{ qt}}\right) = 4.0\times10^3\text{ mL}$ (stomach volume)

$4.0\times10^3\text{ mL} \div 0.9\text{ mL} = 4{,}000$ pistachios (don’t try this at home)

1.66 To determine if 50 eggs will fit into 4.2 quarts, calculate the volume of fifty eggs, then compare the answer to the volume of the stomach:

Volume of 50 eggs = $(50\text{ eggs})\left(\frac{53\text{ mL}}{1\text{egg}}\right)\left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{1.057\text{ qt}}{1\text{ L}}\right) = 2.8\text{ qt}$

2.8 qt < 4.2 qt

Luke can eat 50 eggs.

1.67 $\frac{\text{m}}{\text{s}} = \left(\frac{200\text{ mi}}{1\text{ hr}}\right)\left(\frac{5280\text{ ft}}{1\text{ mi}}\right)\left(\frac{30.48\text{ cm}}{1\text{ ft}}\right)\left(\frac{1\times10^{-2}\text{ m}}{1\text{ cm}}\right)\left(\frac{1\text{ hr}}{60\text{ min}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right) = 89.4\ \frac{\text{m}}{\text{s}}$

1.68 $\text{km/h} = \left(\frac{2435\text{ ft}}{\text{s}}\right)\left(\frac{1\text{ yd}}{3\text{ ft}}\right)\left(0.9144\text{ m}\right)\left(1\text{ km}\right)\left(3600\text{ s}\right) = 2672\text{ km/h}$

1 yd $\left(\frac{1000\ \text{m}}{\ }\right)\left(\frac{1\ \text{h}}{\ }\right)$

1.69 $$\frac{\text{mi}}{\text{hr}} = \left(\frac{2230\ \text{ft}}{1\ \text{s}}\right)\left(\frac{1\ \text{mi}}{5280\ \text{ft}}\right)\left(\frac{60\ \text{s}}{1\ \text{min}}\right)\left(\frac{60\ \text{min}}{1\ \text{hr}}\right) = 1520\ \frac{\text{mi}}{\text{hr}}$$

1.70 $$\text{tons/day} = 2.05\times10^{5}\ \frac{\text{ft}^3}{\text{s}}\left(\frac{62.4\ \text{lb}}{1\ \text{ft}^3}\right)\left(\frac{1\ \text{ton}}{2000\ \text{lb}}\right)\left(\frac{3600\ \text{s}}{1\ \text{h}}\right)\left(\frac{24\ \text{h}}{1\ \text{d}}\right) = 5.53\times10^{8}\ \text{tons/day}$$

1.71 $$1\ \text{light year} = 1\ \text{y}\left(\frac{365.25\ \text{d}}{1\ \text{y}}\right)\left(\frac{24\ \text{h}}{1\ \text{d}}\right)\left(\frac{3600\ \text{s}}{1\ \text{h}}\right)\left(\frac{3.00\times10^{8}\ \text{m}}{1\ \text{s}}\right) = 9.47\times10^{15}\ \text{m}$$

$$\text{miles} = 8.7\text{ light years}\left(\frac{9.47\times 10^{15}\text{ m}}{1\text{ light year}}\right)\left(\frac{1\text{ km}}{1000\text{ m}}\right)\left(\frac{1\text{ mi}}{1.609\text{ km}}\right) = 5.1\times 10^{13}\text{ mi}$$

1.72 There are 360 degrees of latitude around the circumference of the earth.

$$\text{statute miles} = 360\text{ degree latitude}\left(\frac{60\text{ nautical miles}}{1\text{ degree latitude}}\right)\left(\frac{1.151\text{ statute miles}}{1\text{ nautical mile}}\right)$$

$$= 2.49\times 10^{4}\text{ statute miles}$$

1.73 density = mass/ volume = 36.4 g/45.6 mL = 0.798 g/mL

1.74 $\text{density} = \frac{\text{mass}}{\text{volume}}$ $\quad d = \frac{14.3\text{ g}}{8.46\text{ cm}^3} = 1.69\text{ g/cm}^3$

1.75 $\text{mL} = 25.0\text{ g}\left(\frac{1\text{ mL}}{0.791\text{ g}}\right) = 31.6\text{ mL}$

1.76 $\text{mL} = (26.223\text{ g})\left(\frac{1\text{ mL}}{0.99704\text{ g}}\right) = 26.301\text{ mL}$

1.77 $\text{g} = 185\text{ mL}\left(\frac{1.492\text{ g}}{1\text{ mL}}\right) = 276\text{ g}$

1.78 $\text{kg} = (34\text{ L})\left(\frac{1000\text{ mL}}{1\text{ L}}\right)\left(\frac{0.65\text{ g}}{1\text{ mL}}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right) = 22.1\text{ kg}$

$$\text{lbs} = (22.1\text{ kg})\left(\frac{2.2\text{ lbs}}{1\text{ kg}}\right) = 49\text{ lbs}$$

1.79 mass of silver = 62.00 g – 27.35 g = 34.65 g
volume of silver = 18.3 mL –15 mL = 3.3 mL or 3.3 cm^3
density of silver = (mass of silver)/(volume of silver) = (34.65 g)/(3.3 cm^3) = 11 g/cm^3

1.80 volume of titanium = (1.84 cm)(2.24 cm)(2.44 cm) = 10.1 cm^3
density of titanium = 45.7 g/10.1 cm^3 = 4.54 g/cm^3

1.81 $\text{density} = \left(\frac{227{,}641\text{ lb}}{385{,}265\text{ gal}}\right) = 0.591\text{ lb gal}^{-1}$

$$\text{density} = 0.591\text{ lb gal}^{-1}\left(\frac{453.6\text{ g}}{1\text{ lb}}\right)\left(\frac{3785\text{ mL}}{1\text{ gal}}\right)^{-1} = 0.0708\text{ g mL}^{-1}$$

1.82 $10.1\text{ ft}\times 32.3\text{ ft}\times 4.00\text{ in}\times\frac{1\text{ ft}}{12\text{ in}}\times\left[\frac{0.3048\text{ m}}{\text{ft}}\right]^3 = 3.08\text{ m}^3$

$$3.08\text{ m}^3\times 0.686\ \frac{\text{kg}}{\text{L}^3}\times\frac{1000\text{ L}}{\text{m}^3} = 2112\text{ kg}$$

Additional Exercises

1.83 $\quad 1.299\ \frac{\text{CN\$}}{\text{L}} \times \frac{1\ \text{US\$}}{1.001\ \text{CN\$}} \times \frac{3.785\ \text{L}}{\text{gal}} = 4.912\ \text{US\$/gal}$

1.84 $\quad 28.5\ \frac{\text{km}}{\text{L}} \times \left(\frac{0.6214\ \text{mi}}{1.00\ \text{km}}\right) \times \left(\frac{3.785\ \text{L}}{1.00\ \text{gal}}\right) = 67.0\ \text{mi gal}^{-1}$

The first car has a mileage of 67.0 mi gal^{-1} and is more efficient than 31 mi gal^{-1}.

1.85 Hausberg Tarn $\quad 4350\ \text{m}\left(\frac{1\ \text{yd}}{0.9144\ \text{m}}\right) = 4760\ \text{yd}$

Mount Kenya $\quad 4600\ \text{m}\left(\frac{1\ \text{yd}}{0.9144\ \text{m}}\right) = 5000\ \text{yd} \qquad 4700\ \text{m}\left(\frac{1\ \text{yd}}{0.9144\ \text{m}}\right) = 5100\ \text{yd}$

Temperature

$$\Delta t_F = \left[\left(\frac{9\ ^\circ\text{F}}{5\ ^\circ\text{C}}\right)t_{C_1} + 32\ ^\circ\text{C}\right] - \left[\left(\frac{9\ ^\circ\text{F}}{5\ ^\circ\text{C}}\right)t_{C_2} + 32\ ^\circ\text{C}\right]$$

$$= \left(\frac{9\ ^\circ\text{F}}{5\ ^\circ\text{C}}\right)t_{C_1} - \left(\frac{9\ ^\circ\text{F}}{5\ ^\circ\text{C}}\right)t_{C_2} + 32\ ^\circ\text{C} - 32\ ^\circ\text{C}$$

$$= \left(\frac{9\ ^\circ\text{F}}{5\ ^\circ\text{C}}\right)\left(t_{C_1} - t_{C_2}\right)$$

$$= \left(\frac{9\ ^\circ\text{F}}{5\ ^\circ\text{C}}\right)4.0\ ^\circ\text{C} = 7.2\ ^\circ\text{F}$$

1.86 If the density is in metric tons…

$$\text{g} = 1\ \text{teaspoon}\left(\frac{5.00\ \text{mL}}{1\ \text{tsp}}\right)\left(\frac{1\ \text{cm}^3}{1\ \text{mL}}\right)\left(\frac{1\times10^8\ \text{tons}}{1\ \text{cm}^3}\right)\left(\frac{1000\ \text{kg}}{1\ \text{ton}}\right)\left(\frac{1\times10^3\ \text{g}}{1\ \text{kg}}\right) = 5.00\times10^{14}\ \text{g}$$

If the density is in English tons…

$$\text{g} = 1\ \text{teaspoon}\left(\frac{5.00\ \text{mL}}{1\ \text{tsp}}\right)\left(\frac{1\ \text{cm}^3}{1\ \text{mL}}\right)\left(\frac{1\times10^8\ \text{tons}}{1\ \text{cm}^3}\right)\left(\frac{2000\ \text{lbs}}{1\ \text{ton}}\right)\left(\frac{453.59\ \text{g}}{1\ \text{lb}}\right) = 4.54\times10^{14}\ \text{g}$$

1.87 $\quad \text{days} = 3.50\times10^{14}\ \text{km}\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{s}}{\_\_\_\_\_\_\_\_\_\_\_}\right)\left(\frac{1\ \text{h}}{\_\_\_\_\_}\right)\left(\frac{1\ \text{d}}{\_\_\_}\right) = 1.35\times10^4\ \text{d}$

$$1 \text{ light year} = 3.00 \times 10^{8} \text{ m/s} \left(\frac{3600 \text{ s}}{1 \text{ h}}\right)\left(\frac{24 \text{ h}}{1 \text{ d}}\right)\left(\frac{365 \text{ d}}{1 \text{ y}}\right) = 9.46 \times 10^{15} \text{ m/yr}$$

$$\text{light years} = 3.50 \times 10^{14} \text{ km}\left(\frac{1000 \text{ m}}{1 \text{ km}}\right)\left(\frac{1 \text{ light year}}{9.46 \times 10^{15} \text{ m}}\right) = 37.0 \text{ light years}$$

1.88 (a) In order to determine the volume of the pycnometer, we need to determine the volume of the water that fills it. We will do this using the mass of the water and its density.

mass of water = mass of filled pycnometer – mass of empty pycnometer

= 36.842 g – 27.314 g = 9.528 g

$$\text{volume} = (9.528 \text{ g})\left(\frac{1 \text{ mL}}{0.99704 \text{ g}}\right) = 9.556 \text{ mL}$$

(b) We know the volume of chloroform from part (a). The mass of chloroform is determined in the same way that we determined the mass of water.
mass of chloroform = mass of filled pycnometer – mass of empty pycnometer
= 41.428 g – 27.314 g = 14.114 g

$$\text{Density of chloroform} = \left(\frac{14.114\ \text{g}}{9.556\ \text{mL}}\right) = 1.477\ \text{g/mL}$$

1.89 For the message to get to Mars:

$$\text{time} = (225{,}000{,}000\ \text{miles})\left(\frac{1.609\ \text{km}}{1\ \text{mile}}\right)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{s}}{3.00 \times 10^{8}\ \text{m}}\right) = 1210\ \text{s}$$

The reply would take the same amount of time, so the minimum time would be:
1210 s × 2 = 2420 s

1.90 (a) $\$7.35 = 30\ \text{min}$ $\qquad \dfrac{\$7.35}{30\ \text{min}} = \dfrac{\$0.245}{\text{min}} \qquad \dfrac{30\ \text{min}}{\$7.35} = \dfrac{1\ \text{min}}{\$0.245}$

(b) $$\$ = \left(\left(1\ \text{hr} \times \frac{60\ \text{min}}{\text{hr}}\right) + 45\ \text{min}\right)\left(\frac{\$0.245}{\text{min}}\right) = \$25.73$$

(c) $$\text{min} = (\$333.50)\left(\frac{1\ \text{min}}{\$0.245}\right) = 1360\ \text{min}$$

1.91 $$d_{\text{sea water}} = \left(\frac{1.025\ \text{g}}{\text{cm}^3}\right)\left(\frac{1\ \text{lb}}{453.59\ \text{g}}\right)\left(\frac{30.48\ \text{cm}}{1\ \text{ft}}\right)^3 = 64.0\ \text{lb ft}^{-3}$$

$$\text{ft}^3 = (4255\ \text{tons})\left(\frac{2000\ \text{lbs}}{1\ \text{ton}}\right)\left(\frac{1\ \text{ft}^3}{64.0\ \text{lb}}\right) = 1.330 \times 10^5\ \text{ft}^3$$

1.92 $$\text{g} = 2510\ \text{cm}^3\left(\frac{1\ \text{in}}{2.54\ \text{cm}}\right)^3\left(\frac{0.00011\ \text{lbs}}{1\ \text{in}^3}\right)\left(\frac{453.6\ \text{g}}{1\ \text{lb}}\right) = 7.6\ \text{g}$$

1.93 The experimental density most closely matches the known density of methanol (0.7914 g/mL). The density of ethanol is 0.7893 g/mL. Melting point and boiling point could also distinguish these two alcohols, but not color.

1.94 $$\text{g/mL} = 69.22\ \text{lb/ft}^3\left(\frac{453.59\ \text{g}}{1\ \text{lb}}\right)\left(\frac{1\ \text{ft}}{30.48\ \text{cm}}\right)^3\left(\frac{1\ \text{cm}^3}{1\ \text{mL}}\right) = 1.109\ \text{g/mL}$$

Since the density closely matches the known value, we conclude that this is an authentic sample of ethylene glycol.

1.95 We solve by combining two equations:

$t = \left(\dfrac{9\ °\text{F}}{\quad}\right)$

F 5 °C $(t_C) + 32$ °F

$t_F = t_C$

If $t_F = t_C$, we can use the same variable for both temperatures:

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

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

$$\frac{-4}{5}t_c = 32$$

$$t_c = 32\frac{-5}{4} = -40, \text{ therefore the answer is } -40\ °C.$$

1.96 Both the Rankine and the Kelvin scales have the same temperature at absolute zero: 0 R = 0 K.
For converting from t_F to T_R:

$$t_C = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F) \quad \text{and} \quad t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right)$$

therefore

$$(T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F)$$

at T_K = 0 K = 0 R

$$(0\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F)$$

$$-273\ °C = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F)$$

$-491\ °F = t_F - 32\ °F$

$t_F = -459\ °F$ at absolute zero

Also, T_R at absolute zero is 0 R and $T_R = (t_F + 459\ °F)\left(\frac{1\ R}{1\ °F}\right)$

So, the boiling point of water is 212 °F and in T_R:

$$T_R = (212\ °F + 459\ °F)\left(\frac{1\ R}{1\ °F}\right) = 671\ R$$

1.97 Sand d_{sand} = 2.84 g/mL
Gold d_{gold} = 19.3 g/mL
Mixture $d_{mixture}$ = 3.10 g/mL

$$1.00\ \text{kg mixture}\left(\frac{1000\ g}{1\ kg}\right) = 1.00 \times 10^3\ \text{g of mixture}$$

1.00×10^3 g of mixture = $m_{sand} + m_{gold}$
$m_{sand} = (d_{sand})(V_{sand})$
$m_{gold} = (d_{gold})(V_{gold})$
1.00×10^3 g of mixture = $(d_{sand})(V_{sand}) + (d_{gold})(V_{gold})$
1.00×10^3 g of mixture = $(2.84\ g/mL)(V_{sand}) + (19.3\ g/mL)(V_{gold})$
$V_{mixture} = V_{sand} + V_{gold}$

$$d = \left(\frac{m}{V}\right)$$

$$\left(\frac{1.00 \times 10^3\ g}{\ }\right) = 323\ mL$$

è$3.10\ \text{g mL}^{-1}$ ø

$V_{sand} + V_{gold} = 323\ \text{mL}$

$V_{sand} = 323\ \text{mL} - V_{gold}$

1.00×10^3 g of mixture = (2.84 g/mL)(323 mL – V_{gold}) + (19.3 g/mL)(V_{gold})
1.00×10^3 g of mixture = 917 g sand – (2.84 g/mL)(V_{gold}) + (19.3 g/mL)(V_{gold})
1.00×10^3 g of mixture – 917 g sand = (16.5 g/mL)(V_{gold})
5.0 mL = V_{gold}
1.00×10^3 g of mixture – 917 g sand = 83 g gold

$$\% \text{ mass of gold} = \frac{83 \text{ g gold}}{1000 \text{ g total}} \times 100\% = 8.3\% \text{ gold}$$

1.98 $$\text{Area of gold in cm}^2 = 14.6 \text{ ft}^2 \left(\frac{30.48 \text{ cm}}{1 \text{ ft}}\right)^2 = 1.36 \times 10^4 \text{ cm}^2$$

$$\text{Volume of gold in cm}^3 = 1.36 \times 10^4 \text{ cm}^2 \times 2.50\ \mu\text{m} \times \left(\frac{1 \text{ cm}}{1 \times 10^4\ \mu\text{m}}\right) = 3.39 \text{ cm}^3$$

$$\text{Cost of gold} = 3.39 \text{ cm}^3 \times \left(\frac{1 \text{ mL}}{1 \text{ cm}^3}\right) \times \left(\frac{19.3 \text{ g}}{1 \text{ mL}}\right) \times \left(\frac{1 \text{ troy ounce}}{31.1035 \text{ g}}\right) \times \left(\frac{\$1774.10}{\text{troy ounce}}\right) = \$3732$$

1.99 $$\text{Volume of diamond} = 3.45 \text{ carat}\left(\frac{200 \text{ mg}}{1 \text{ carat}}\right)\left(\frac{1 \text{ g}}{1000 \text{ mg}}\right)\left(\frac{1 \text{ cm}^3}{3.51 \text{ g}}\right) = 0.197 \text{ cm}^3$$

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

$$0.197 \text{ cm}^3 = \frac{4}{3}\pi r^3$$

r = 0.361 cm
$2r$ = 0.722 cm