Practice Exercises

2.1 $V = \frac{4}{3}\pi r^3$, 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.

2.2 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}

2.3 $$t_F = \left(\frac{9\ °\text{F}}{5\ °\text{C}}\right)t_C + 32\ °\text{F} = \left(\frac{9\ °\text{F}}{5\ °\text{C}}\right)(86\ °\text{F}) + 32\ °\text{F} = 187\ °\text{F}$$

2.4 $$t_C = (t_F - 32\ °\text{F})\left(\frac{5\ °\text{C}}{9\ °\text{F}}\right) = (50\ °\text{F} - 32\ °\text{F})\left(\frac{5\ °\text{C}}{9\ °\text{F}}\right) = 10\ °\text{C}$$

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

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

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

2.5
(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) $\frac{14.24\ \text{cm} \times 12.334\ \text{cm}}{(2.223\ \text{cm} - 1.04\ \text{cm})}$ = 148.57 cm: rounded correctly to 149 cm

2.6
(a) 32.02 mL – 2.0 mL = 30. mL
(b) 54.183 g – 0.0278 g = 54.155 g
(c) 10.0 g + 1.03 g + 0.243 g = 11.3 g
(d) 43.4 in × $\left(\frac{1\ \text{ft}}{12\ \text{in.}}\right)$ = 3.62 ft (1 and 12 are exact numbers)

(e) $\dfrac{1.03\text{ m} \times 2.074\text{ m} \times 3.9\text{ m} \times}{12.46\text{ m} + 4.778\text{ m}} = 0.48\text{ m}^2$

2.7 $\text{m}^2 = \left(124\text{ ft}^2\right)\left(\dfrac{30.48\text{ cm}}{1\text{ ft}}\right)^2\left(\dfrac{1\text{ m}}{100\text{ cm}}\right)^2 = 11.5\text{ m}^2$

2.8 (a) $\text{in.} = \left(3.00\text{ yd}\right)\left(\dfrac{3\text{ ft}}{1\text{ yd}}\right)\left(\dfrac{12\text{ in.}}{1\text{ ft}}\right) = 108\text{ in.}$

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

(c) $\text{ft} = \left(3.27\text{ mm}\right)\left(\dfrac{1\text{ m}}{1000\text{ mm}}\right)\left(\dfrac{100\text{ cm}}{1\text{ m}}\right)\left(\dfrac{1\text{ in.}}{2.54\text{ cm}}\right)\left(\dfrac{1\text{ ft}}{12\text{ in.}}\right) = 0.0107\text{ ft}$

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

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

Density of the object = $\dfrac{365\text{ g}}{22.12\text{ cm}^3} = 16.5\text{ g/cm}^3$
The object is not composed of pure gold since the density of gold is 19.3 g/cm^3.

2.10 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.

Density in lb/ft^3 = $\dfrac{12.6\text{ g}}{\text{cm}^3}\left(\dfrac{1\text{ lb}}{453.6\text{ g}}\right)\left(\dfrac{30.48\text{ cm}}{1\text{ ft}}\right)^3 = 787\text{ lb/ft}^3$
Mass of sample alloy = (0.822 ft^3) (787 lb/ft^3) = 647 lb

2.11 density = mass/volume = $(1.24 \times 10^6\text{ g})/(1.38 \times 10^6\text{ cm}^3) = 0.899\text{ g/cm}^3$
.

2.12 volume of one-carat diamond = 225 mg $\left(\dfrac{1\text{ g}}{1000\text{ mg}}\right)\left(\dfrac{1\text{ cm}^3}{3.52\text{ g}}\right) = 0.0639\text{ cm}^3$

Review Questions

2.1 Physical properties include boiling point, melting point, density, color, refractive index, mass and volume.

2.2 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.

2.3 (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.

2.4 (a) 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.

(b) 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. An example is when iron and carbon are mixed together to make steel. During this process compounds of iron and carbon such as cementite, Fe_3C , are produced.

(c) Physical change. During the whipping process air is mixed with cream to increase its volume.

(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 aluminum is not chemically altered during recycling.

2.5 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.

2.6 (a) Extensive — Obviously, 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) Intensive — The physical state, gas, liquid, or solid, depends on temperature and pressure but not on the mass of the substance.

2.7 (a) Intensive — The melting point of 1.0 g of water is that same as 100.0 thus melting point is not mass Dependent.

(b) 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.

(c) Extensive — The volume occupied by a substance is dependent on the mass 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.

2.8 (a) Gas — Temperature, density, volume, viscosity

(b) Liquid — Temperature, density, volume, viscosity

(c) Solid — Temperature, density, volume

2.9 (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

2.10 (a) Potassium chloride is a solid at room temperature.

(b) Carbon dioxide is a gas at room temperature.

(c) Ethyl alcohol is a liquid at room temperature.

(d) Methane is a gas at room temperature.

(e) Sucrose is a solid at room temperature.

2.11 (a) Sodium chloride is a solid at room temperature.

(b) Ozone is a gas at room temperature.

(c) Teflon is a solid at room temperature.

(d) Cholesterol is a solid at room temperature.

(e) Silicon dioxide is a solid at room temperature.

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

2.13 Kilogram

2.14

2.14	(a)	0.01	10^{-2}
	(b)	0.001	10^{-3}
	(c)	1000	10^{3}
	(d)	0.000001	10^{-6}
	(e)	0.000000001	10^{-9}
	(f)	0.000000000001	10^{-12}
	(g)	1,000,000	10^{6}

2.15 (a) c (b) m (c) k (d) μ
(e) n (f) p (g) M

2.16 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.

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

2.18 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.

2.19 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.

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

2.21 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.

2.22 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:

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

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

2.24 $d = \frac{\text{m}}{\text{v}}$: d = density; m = mass; v = volume

2.25 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

2.26	(a) 0.01 m	(b) 1000 m	(c) 10^{12} pm
	(d) 0.1 m	(e) 0.001 kg	(f) 0.01 g
2.27	(a) 10^{-9}	(b) 10^{-6}	(c) 10^{3}
	(d) 10^{6}	(e) 10^{-3}	(f) 0.1

2.28 (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) $T_F = \left(\frac{9\ °F}{5\ °C}\right)(t_C) + 32\ °F = \left(\frac{9\ °F}{5\ °C}\right)(16\ °C) + 32\ °F = 61\ °F$

(c) $T_C = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F) = \left(\frac{5\ °C}{9\ °F}\right)(25.5\ °F - 32\ °F) = -3.61\ °C$

(d) $T_C = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F) = \left(\frac{5\ °C}{9\ °F}\right)(49\ °F - 32\ °F) = 9.4\ °C$

(e) $T_K = (t_C + 273\ °C) = 62 + 273 = 335\ K$

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

2.29 (a) $t_C = \left(\frac{5\ °C}{9\ °F}\right) t_F - 32\ °F) = \left(\frac{5\ °C}{9\ °F}\right)(96\ °F - 32\ °F) = 36\ °C$

(b) $t_C = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F) = \left(\frac{5\ °C}{9\ °F}\right)(-6\ °F - 32\ °F) = -21\ °C$

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

(d) $t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (273\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = 0\ °C$

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

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

2.30 $t_C = (t_F - 32\ °F)\left(\frac{5\ °C}{9\ °F}\right) = (103.5\ °F - 32\ °F)\left(\frac{5\ °C}{9\ °F}\right) = 39.7\ °C$

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

2.31 Convert –96 °F to t_c:

$t_C = \left(\frac{5\ °C}{9\ °F}\right)(t_F - 32\ °F) = \left(\frac{5\ °C}{9\ °F}\right)(-96\ °F - 32\ °F) = -71\ °C$

2.32 Range in Kelvins:

$K = (10\ MK)\left(\frac{1 \times 10^6\ K}{1\ MK}\right) = 1.0 \times 10^7\ K$

$K = (25\ MK)\left(\frac{1 \times 10^6\ K}{1\ MK}\right) = 2.5 \times 10^7\ K$

Range in degrees Celsius:

$t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (1.0 \times 10^7\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) \approx 1.0 \times 10^7\ °C$

$t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (2.5 \times 10^7\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) \approx 2.5 \times 10^7\ °C$

Range in degrees Fahrenheit:

$t_F = \left(\frac{9\ °F}{5\ °C}\right)(°C) + 32\ °F = \left(\frac{9\ °F}{5\ °C}\right)(1.0 \times 10^7\ °C) + 32\ °F \approx 1.8 \times 10^7\ °F$

$t_F = \left(\frac{9\ °F}{5\ °C}\right)(°C) + 32\ °F = \left(\frac{9\ °F}{5\ °C}\right)(2.5 \times 10^7\ °C) + 32\ °F \approx 4.5 \times 10^7\ °F$

2.33 Convert 111 K to t_C:

$t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (111\ K - 273K)\left(\frac{1\ °C}{1\ K}\right) = -162\ °C$

Convert –162 °C to t_F

$t_F = \left(\frac{9\ °F}{5\ °C}\right)(t_C) + 32\ °F = \left(\frac{9\ °F}{5\ °C}\right)(-162°C) + 32\ °F = -260\ °F$

2.34 $t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (4\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = -269\ °C$

2.35 Convert 6000 K to t_C:

$t_C = (T_K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = (6000\ K - 273\ K)\left(\frac{1\ °C}{1\ K}\right) = 5700\ °C$

This is hot enough to melt concrete, since it is hotter than 2000 °C.

2.36 (a) 4 significant figures; (b) 5 significant figures; (c) 4 significant figures; (d) 2 significant figures; (e) 4 significant figures; (f) 2 significant figures

2.37 (a) 3 significant figures; (b) 6 significant figures; (c) 1 significant figures; (d) 5 significant figures; (e) 1 significant figures; (f) 5 significant figures

2.38 (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

2.39 (a) 2.06 g/mL; (b) 4.02 mL; (c) 12.4 g/mL; (d) 0.276 g/mL; (e) 0.0006 m/s

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

(b) $\mu\text{g/L} = (8.2\ \text{mg/mL})\left(\frac{1\ \text{g}}{1000\ \text{mg}}\right)\left(\frac{1 \times 10^6\ \mu\text{g}}{1\ \text{g}}\right)\left(\frac{1000\ \text{mL}}{1\ \text{L}}\right) = 8.2 \times 10^6\ \mu\text{g/L}$

(c) $\text{kg} = (75.3\ \text{mg})\left(\frac{1\ \text{g}}{1000\ \text{mg}}\right)\left(\frac{1\ \text{kg}}{1000\ \text{g}}\right) = 7.53 \times 10^{-5}\ \text{kg}$

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

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

(f) $\text{dm} = (342\ \text{pm})^2\left(\frac{1\times10^{-12}\ \text{m}}{1\ \text{pm}}\right)^2\left(\frac{10\ \text{dm}}{1\ \text{m}}\right)^2 = 3.42 \times 10^{-20}\ \text{dm}$

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

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

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

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

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

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

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

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

(b) $\text{m} = (3.0\ \text{ft})\left(\frac{12\ \text{in.}}{1\ \text{ft}}\right)\left(\frac{2.54\ \text{cm}}{1\ \text{in.}}\right)\left(\frac{1\ \text{m}}{100\ \text{cm}}\right) = 0.91\ \text{m}$

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

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

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

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

2.46 $$\text{mL} = \left(4.2 \text{ qt}\right)\left(\frac{946.35 \text{ mL}}{1 \text{ qt}}\right) = 4.0 \times 10^3 \text{mL}$$ (stomach volume)

4.0×10^3 mL ÷ 0.9 mL = 4,000 pistachios (don't try this at home)

2.47 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:

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

$$2.8 \text{ qt} < 4.2 \text{ qt}$$

Luke can eat 50 eggs.

2.48 $$\frac{\text{m}}{\text{s}} = \left(\frac{200 \text{ mi}}{1 \text{ hr}}\right)\left(\frac{5280 \text{ ft}}{1 \text{ mi}}\right)\left(\frac{30.48 \text{ cm}}{1 \text{ ft}}\right)\left(\frac{1\times10^{-2}\text{m}}{1 \text{ cm}}\right)\left(\frac{1 \text{ hr}}{60 \text{ min}}\right)\left(\frac{1 \text{ min}}{60 \text{ s}}\right) = 90 \frac{\text{m}}{\text{s}}$$

2.49 $$\text{km/h} = \left(\frac{2435 \text{ ft}}{\text{s}}\right)\left(\frac{1 \text{ yd}}{3 \text{ ft}}\right)\left(\frac{0.9144 \text{ m}}{1 \text{ yd}}\right)\left(\frac{1 \text{ km}}{1000 \text{ m}}\right)\left(\frac{3600 \text{ s}}{1 \text{ h}}\right) = 2672 \text{ km/h}$$

2.50 $$\frac{\text{mi}}{\text{h}} = \left(\frac{2230 \text{ ft}}{1 \text{ s}}\right)\left(\frac{1 \text{ mi}}{5280 \text{ ft}}\right)\left(\frac{60 \text{ s}}{1 \text{ min}}\right)\left(\frac{60 \text{ min}}{1 \text{ hr}}\right) = 1520 \frac{\text{mi}}{\text{hr}}$$

2.51 $$\text{tons/day} = 2.05\times10^5 \frac{\text{ft}^3}{\text{s}}\left(\frac{62.4 \text{ lb}}{1 \text{ ft}^3}\right)\left(\frac{1 \text{ ton}}{2000 \text{ lb}}\right)\left(\frac{3600 \text{ s}}{1 \text{ h}}\right)\left(\frac{24 \text{ h}}{1 \text{ d}}\right) = 5.53 \times 10^8 \text{ tons/day}$$

2.52 $$\text{1 light year} = 1 \text{ y}\left(\frac{365.25 \text{ d}}{1 \text{ y}}\right)\left(\frac{24 \text{ h}}{1 \text{ d}}\right)\left(\frac{3600 \text{ s}}{1 \text{ h}}\right)\left(\frac{3.00\times10^8 \text{ m}}{1 \text{ s}}\right) = 9.47 \times 10^{15} \text{ m}$$

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

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

statute miles = $360 \text{ degree latitude}\left(\frac{60 \text{ nautical miles}}{1 \text{ degree latitude}}\right)\left(\frac{1.151 \text{ statute miles}}{1 \text{ nautical mile}}\right)$ = 2.49×10^4 statute miles

2.54 meters = $6033.5 \text{ fathoms}\left(\frac{6 \text{ ft}}{1 \text{ fathom}}\right)\left(\frac{1 \text{ yd}}{3 \text{ ft}}\right)\left(\frac{0.9144 \text{ m}}{1 \text{ yd}}\right)$ = 11,034 m

2.55 pounds/in^2 = $11{,}034 \text{ m}\left(\frac{14.7 \text{ lb/in}^2}{10 \text{ m}}\right)$ = 16,200 lb/in^2

tons/in^2 = $162{,}000 \text{ lb/in}^2\left(\frac{1 \text{ ton}}{2000 \text{ lb}}\right)$ = 8.10 ton/in^2

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

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

2.58 $\text{mL} = 25.0\text{g}\left(\frac{1 \text{ mL}}{0.791 \text{ g}}\right) = 31.6 \text{ mL}$

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

2.60 $\text{g} = 185 \text{ mL}\left(\frac{1.492 \text{ g}}{1 \text{ mL}}\right) = 276 \text{ g}$

2.61 $\text{kg} = (34 \text{ L})\left(\frac{1000 \text{ mL}}{1 \text{ L}}\right)\left(\frac{0.65 \text{ g}}{1 \text{ mL}}\right)\left(\frac{1 \text{ kg}}{1000 \text{ g}}\right) = 22 \text{ kg}$

$\text{lbs} = (22 \text{ kg})\left(\frac{2.2 \text{ lbs}}{1 \text{ kg}}\right) = 48 \text{ lbs}$

2.62 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

2.63 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

2.64 density = $\left(\frac{227{,}641 \text{ lb}}{385{,}265 \text{ gal}}\right) = 0.591 \text{ lb/gal}$

sp. gr. of liquid hydrogen = $\frac{0.5909 \text{ lb/gal}}{8.34 \text{ lb/gal}} = 0.0708$

density = $0.07085\left(1.00\ ^{g}/_{mL}\right) = 0.0709\ ^{g}/_{mL}$

2.65 $$10.1\text{ ft x }32.3\text{ ft x }4.00\text{ in x}\frac{1\text{ ft}}{12\text{ in}}\text{ x}\left[\frac{0.3048\text{ m}}{\text{ft}}\right]^3 = 3.08\text{ m}^3$$

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

Additional Exercises

2.66 $$0.959\ \frac{\text{CN\$}}{\text{L}}\text{ x }\frac{1\text{ US\$}}{1.142\text{ CN\$}}\text{ x }\frac{3.785\text{ L}}{\text{gal}} = 3.178\text{ US\$}$$

2.67 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 $\quad \Delta t_F = \left(\frac{9\ °\text{F}}{5\ °\text{C}}\right)(t_C) = \left(\frac{9\ °\text{F}}{5\ °\text{C}}\right)(4.0\ °\text{C}) = 7.2\ °\text{F}$

2.68 If the density is in metric tons…

$$\text{g} = 1\text{ teaspoon}\left(\frac{4.93\text{ mL}}{1\text{ tsp}}\right)\left(\frac{1\text{ cm}^3}{1\text{ mL}}\right)\left(\frac{1\times10^8\text{ tons}}{1\text{ cm}^3}\right)\left(\frac{1000\text{ kg}}{1\text{ ton}}\right)\left(\frac{1\times10^3\text{ g}}{1\text{ kg}}\right)$$
$$= 4.93\times10^{14}\text{ g}$$

If the density is in English tons…

$$\text{g} = 1\text{ teaspoon}\left(\frac{4.93\text{ mL}}{1\text{ tsp}}\right)\left(\frac{1\text{ cm}^3}{1\text{ mL}}\right)\left(\frac{1\times10^8\text{ tons}}{1\text{ cm}^3}\right)\left(\frac{2000\text{ lbs}}{1\text{ ton}}\right)\left(\frac{453.59\text{ g}}{1\text{ lb}}\right)$$
$$= 4.47\times10^{14}\text{ g}$$

2.69 1 light year = $3.00\times10^8\text{ m/s}\left(\frac{3600\text{ s}}{1\text{ h}}\right)\left(\frac{24\text{ h}}{1\text{ d}}\right)\left(\frac{365\text{ d}}{1\text{ y}}\right) = 9.46\times10^{15}\text{ m}$

Distance to Arcturus:

days = $3.50\times10^{14}\text{ km}\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ s}}{3.00\times10^8\text{ m}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1\text{ d}}{24\text{ h}}\right) = 1.35\times10^4\text{ d}$

light years = $3.50\times10^{14}\text{ km}\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ light year}}{9.46\times10^{15}\text{ m}}\right) = 37.0\text{ light years}$

2.70 (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

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

2.71 For the message to get to the moon:

$$s = (239{,}000\text{ miles})\left(\frac{1.609\text{ km}}{1\text{ mile}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ s}}{3.00\times10^{8}\text{ m}}\right) = 1.28\text{ s}$$

The reply would take the same amount of time, so the total time would be:

1.28 s × 2 = 2.56 s

2.72 (a) $\$4.50 = 30\text{ min}$ $\qquad \frac{\$4.50}{30\text{ min}} = \frac{\$0.15}{\text{min}}$ $\qquad \frac{30\text{ min}}{\$4.\ 50} = \frac{1\text{ min}}{\$0.15}$

(b) $$\$ = \left(\left(1\text{ hr}\times\frac{60\text{ min}}{\text{hr}}\right) + 45\text{ min}\right)\left(\frac{\$0.15}{\text{min}}\right) = \$15.75$$

(c) $$\text{min} = (\$17.35)\left(\frac{1\text{ min}}{\$0.15}\right) = 116\text{ min}$$

2.73 $$d_{\text{sea water}} = \left(\frac{1.025\text{ g}}{\text{cm}^3}\right)\left(\frac{1\text{ lb}}{453.59\text{ g}}\right)\left(\frac{30.48\text{ cm}}{1\text{ ft}}\right)^3 = 64.0\ {}^{\text{lb}}\!/_{\text{ft}^3}$$

$$\text{ft}^3 = (4255\text{ tons})\left(\frac{2000\text{ lbs}}{1\text{ ton}}\right)\left(\frac{1\text{ ft}^3}{64.0\text{ lb}}\right) = 1.330\times10^{5}\text{ ft}^3$$

2.74 $$g = 2510\text{ cm}^3\left(\frac{1\text{ in}}{2.54\text{ cm}}\right)^3\left(\frac{0.00011\text{ lbs}}{1\text{ in}^3}\right)\left(\frac{453.59\text{ g}}{1\text{ lb}}\right) = 7.6\text{ g}$$

2.75 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.

2.76 $$\text{g/mL} = 69.22\text{ lb/ft}^3\left(\frac{453.59\text{ g}}{1\text{ lb}}\right)\left(\frac{1\text{ ft}}{30.48\text{ cm}}\right)^3\left(\frac{1\text{ cm}^3}{1\text{ mL}}\right) = 1.1088\text{g/mL}$$

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

2.77 $$t_c = (T_K - 273\text{ K})\left(\frac{1\ ^\circ\text{C}}{1\text{ K}}\right) = (5800\text{ K} - 273\text{ K})\left(\frac{1\ ^\circ\text{C}}{1\text{ K}}\right) = 5500\ ^\circ\text{C}$$

2.78 We solve by combining two equations:

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

$t_F = t_C$

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

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

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

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

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

2.79 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:

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

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:

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

2.80 Sand d = 2.84 g/mL
Gold d = 19.3 g/mL
Mixture d = 3.10 g/mL

$1.00\ \text{kg mixture}\left(\frac{1000\ g}{1\ kg}\right) = 1.00 \times 10^3$ 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 = $(2.84\ g/mL)(V_{sand}) + (19.3\ g/mL)(V_{gold})$

$V_{mixture} = V_{sand} + V_{gold}$

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

$$\left(\frac{1.00\times 10^3\ g}{3.10\ ^g/_{mL}}\right) = 323\ mL$$

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

$V_{sand} = 323$ 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

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

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

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

Cost of gold = $3.39\ cm^3 \times \left(\frac{1\ mL}{1\ cm^3}\right)\times\left(\frac{19.3\ g}{1\ mL}\right)\times\left(\frac{1\ \text{troy ounce}}{31.1035\ g}\right)\times\left(\frac{\$1125.10}{\text{troy ounce}}\right) = \$2367$

2.82 Volume of cylindrical metal bar = $\pi \times r^2 \times h = \pi \times \left(\left(\frac{1}{2}\right)(0.753\ cm)\right)^2 \times 2.33\ cm = 1.04\ cm^3$

Density of cylindrical metal bar = $\left(\frac{\text{mass}}{\text{volume}}\right) = \left(\frac{8.423\ g}{1.04\ cm^3}\right) = 8.10\ g/mL$

Density in lb/ft^3 = $\left(\frac{8.10\ g}{1\ mL}\right)\left(\frac{1\ lb}{453.59\ g}\right)\left(\frac{1\ mL}{1\ cm^3}\right)\left(\frac{30.48\ cm}{1\ ft}\right)^3 = 506\ lb/ft^3$

2.83 Volume of diamond = $3.45\ \text{carat}\left(\frac{200\ mg}{1\ \text{carat}}\right)\left(\frac{1\ g}{1000\ mg}\right)\left(\frac{1\ mL}{3.51\ g}\right) = 0.197\ mL$

2.84 Concentration of lead in blood in μg/dL = $\left(\frac{2.5\times 10^{-4}\ g}{L}\right)\left(\frac{10^6\ \mu g}{1\ g}\right)\left(\frac{1\ L}{10\ dL}\right) = 25\ \mu g/dL$

This person is in danger of exhibiting the effects of lead poisoning since the 25 μg/dL is above the threshold of 10 μg of lead/dL.

2.85 Radius of ball bearing = 2.000 mm × (1/2) = 1.000 mm

Volume of ball bearing= $4/3 \times \pi \times r^3 = 4/3 \times \pi \times (1.000\ mm)^3 = 4.189\ mm^3$

Radius of ball bearing + gold = 1.000 mm + 0.500 mm = 1.500 mm

Volume of ball bearing + gold = $4/3 \times \pi \times r^3 = 4/3 \times \pi \times (1.500\ mm)^3 = 14.14\ mm^3$

Volume of gold = (volume of ball bearing + gold) – (volume of ball bearing) = 14.14 mm^3 – 4.189 mm^3 = 9.95 mm^3

$$\text{Mass of gold} = 9.95\ \text{mm}^3\left(\frac{1\ \text{cm}}{10\ \text{mm}}\right)^3\left(\frac{19.31\ \text{g}}{1\ \text{cm}}\right) = 0.192\ \text{g}$$

2.86 The question is asking to calculate the number of mile/gallon/person for a jet airliner and a car. The answer is:

$$\text{Rate of fuel consumption} = \frac{\left(\dfrac{1\ \text{mile}}{5.0\ \text{gallons of jet fuel}}\right)}{568\ \text{people}} = 3.5 \times 10^{-4}\ \text{mile/gallon/person}$$

$$\text{Rate of fuel consumption for car} = \frac{\left(\dfrac{21.5\ \text{miles}}{1\ \text{gallon}}\right)}{2\ \text{people}} = 11\ \text{mile/gallon/person}$$

But a more insightful answer would be to calculate the number of gallons/person/mile which would give the number of gallons each person uses per mile.

$$\text{Rate of fuel consumption} = \frac{\left(\dfrac{5.0\ \text{gallons of jet fuel}}{568\ \text{people}}\right)}{1\ \text{mile}} = 0.0088\ \text{gallon/person/mile}$$

$$\text{Rate of fuel consumption for car} = \frac{\left(\dfrac{1\ \text{gallon}}{2\ \text{people}}\right)}{21.5\ \text{miles}} = 0.75\ \text{gallon/person/mile}$$

This would indicate that the jet airliner has better fuel consumption.

$$\text{Pounds of jet fuel} = 3470\ \text{miles}\left(\frac{5.0\ \text{gallons}}{1\ \text{mile}}\right)\left(\frac{3.785\ \text{L}}{1\ \text{gallon}}\right)\left(\frac{1000\ \text{mL}}{1\ \text{L}}\right)\left(\frac{0.803\ \text{g}}{1\ \text{mL}}\right)\left(\frac{1\ \text{lb}}{453\ \text{g}}\right) = 1.16 \times 10^5\ \text{lb}$$