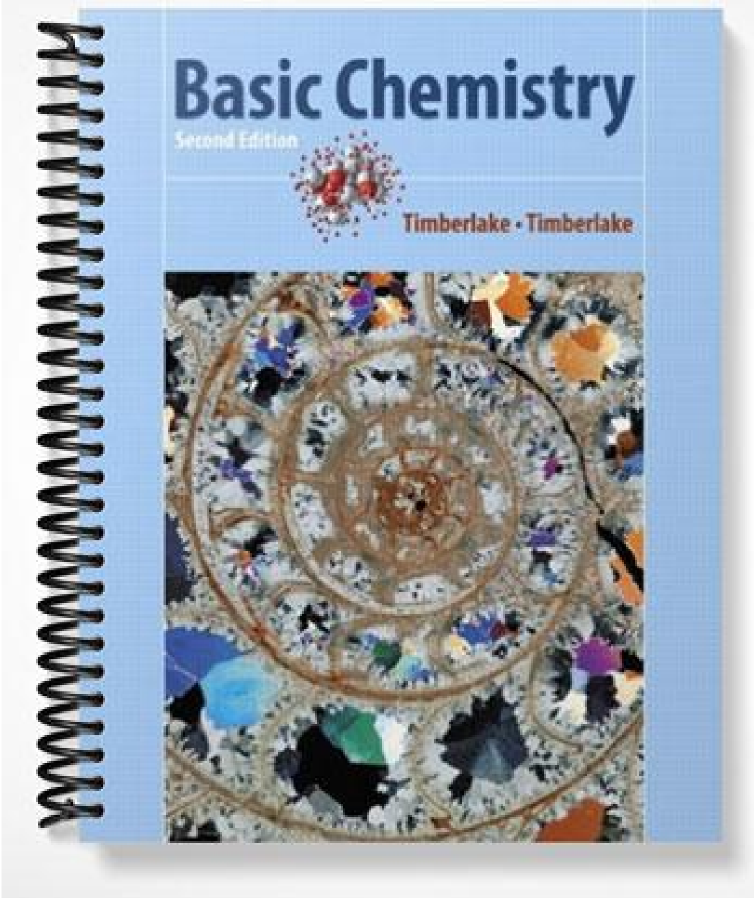
# SOLUTIONS MANUAL



# 2
# Measurements

**2.1** **a.** meter, length **b.** gram, mass **c.** liter, volume
**d.** second, time **e.** Celsius, temperature

**2.2** **a.** liter, volume **b.** meter, length **c.** kilogram, mass
**d.** gram, mass **e.** kelvin, temperature

**2.3** **a.** meter; both **b.** kilogram, both **c.** foot, neither
**d.** second, both **e.** Celsius, metric

**2.4** **a.** cubic meter, both **b.** kelvin, SI **c.** Fahrenheit; neither
**d.** liter, metric **e.** gram, metric

**2.5** **a.** gram; metric **b.** liter; metric **c.** Celsius; metric
**d.** meter; both **e.** second; both

**2.6** **a.** kelvin, SI **b.** kilogram, both **c.** liter, metric
**d.** meter, both **e.** cubic meter, both

**2.7** **a.** Move the decimal point left four places to give $5.5 \times 10^4$ m.
**b.** Move the decimal point left two places to give $4.8 \times 10^2$ g.
**c.** Move the decimal point right six places to give $5 \times 10^{-6}$ cm.
**d.** Move the decimal point right four places to give $1.4 \times 10^{-4}$ s.
**e.** Move the decimal point right three places to give $7.85 \times 10^{-3}$ L.
**f.** Move the decimal point left six places to give $6.7 \times 10^5$ kg.

**2.8** **a.** $1.8 \times 10^8$ g **b.** $6 \times 10^{-5}$ m **c.** $7.5 \times 10^5$ g **d.** $1.5 \times 10^{-1}$ m
**e.** $2.4 \times 10^{-2}$ s **f.** $1.5 \times 10^3$ $m^3$

**2.9** **a.** The value $7.2 \times 10^3$, which is also $72 \times 10^2$, is greater than $8.2 \times 10^2$.
**b.** The value $3.2 \times 10^{-2}$, which is also $320 \times 10^{-4}$, is greater than $4.5 \times 10^{-4}$.
**c.** The value $1 \times 10^4$ or 10 000 is greater than $1 \times 10^{-4}$, or 0.0001.
**d.** The value $6.8 \times 10^{-2}$ or 0.068 is greater than 0.00052.

**2.10** **a.** $5.5 \times 10^{-9}$ **b.** $3.4 \times 10^2$ **c.** $5 \times 10^{-8}$ **d.** $4 \times 10^{-10}$

**2.11** **a.** The standard number is 1.2 times the power of $10^4$, or 10 000, which gives 12 000.
**b.** The standard number is 8.25 times the power of $10^{-2}$, or 0.01, which gives 0.0825.
**c.** The standard number is 4 times the power of $10^6$, or 1 000 000, which gives 4 000 000.
**d.** The standard number is 5 times the power of $10^{-3}$, or 0.001, which gives 0.005.

**2.12** **a.** 0.000 036 **b.** 87 500 **c.** 0.03 **d.** 212 000

**2.13** **a.** The *estimated digit* is the last digit reported in a measurement. In 8.6 m, the 6 in the first decimal (tenths) place was estimated and has some uncertainty.
**b.** The *estimated digit* is the 5 in the second decimal (hundredths) place.
**c.** The *estimated digit* would be the 0 in the first decimal (tenths) place.

**2.14** **a.** The *estimated digit* is the last digit reported in a measurement. In 125.04 g, the 4 in the hundredths place is estimated and has some uncertainty.
**b.** The *estimated digit* is the 7 in the third decimal (thousandths) place.
**c.** The *estimated digit* would be the 8 in the first decimal (tenths) place.

**2.15** Measured numbers are obtained using some kind of measuring tool. Exact numbers are numbers obtained by counting or from a definition in the metric or the U.S measuring systems.
**a.** measured **b.** exact **c.** exact **d.** measured

**2.16** **a.** exact **b.** measured **c.** measured **d.** measured

**2.17** Measured numbers are obtained using some kind of measuring tool. Exact numbers are numbers obtained by counting or from a definition in the metric or the U.S. measuring systems.
**a.** The value 6 oz of meat is obtained by measurement, whereas 3 hamburgers is a counted/exact number.
**b.** None; both 1 table and 4 chairs are counted/exact numbers.
**c.** Both 0.75 lb and 350 g are obtained by measurements.
**d.** None; the values in a definition are exact numbers.

**2.18** **a.** 5 pizzas **b.** 6 nickels **c.** 3 onions **d.** 5 cars

**2.19** **a.** Zeros preceding significant digits are *not significant*.
**b.** Zeros between significant digits are *significant*.
**c.** Zeros after significant digits in a decimal number are *significant.*
**d.** Zeros in the coefficient of a number written in scientific notation are *significant.*
**e.** Zeros in a number with no decimal point are considered as placeholders only and *not significant.*

**2.20** **a.** significant **b.** significant **c.** not significant **d.** not significant
**e.** significant

**2.21** **a.** All five numbers are significant figures.
**b.** Only the two nonzero numbers are significant; the preceding zeros are placeholders.
**c.** Only the two nonzero numbers are significant; the zeros that follow are placeholders.
**d.** All three numbers in the coefficient of a number written in scientific notation are significant.
**e.** All four numbers including the last zero in a decimal number are significant.
**f.** All three numbers including the zeros that follow a nonzero digit in a decimal number are significant.

**2.22** **a.** 4 SF **b.** 6 SF **c.** 3 SF **d.** 3 SF
**e.** 3 SF **f.** 2 SF

**2.23** Both measurements in **c** have 2 significant figures and both measurements in **d** have 4 significant figures.

**2.24** In **a** and **b** both pairs have three significant figures. In **d** both pairs have two significant figures.

**2.25** **a.** 5 000 is the same as $5 \times 1000$, which is written in scientific notation as $5 \times 10^3$.
**b.** 30 000 is the same as $3 \times 10\,000$, which is written in scientific notation as $3 \times 10^4$.
**c.** 100 000 is the same as $1 \times 100\,000$, which is written in scientific notation as $1 \times 10^5$.
**d.** 0.000 25 is the same as $2.5 \times \frac{1}{10\,000}$, which is written in scientific notation as $2.5 \times 10^{-4}$.

**2.26** **a.** $5.1 \times 10^6$ g **b.** $2.6 \times 10^4$ s **c.** $4.0 \times 10^4$ m **d.** $8.2 \times 10^{-4}$ kg

**2.27** Calculators carry out mathematical computations and display without regard to significant figures. Our task is to round the calculator's answer to the number of significant figures or digits allowed by the values of the original data.

**2.28** The number in the calculator display does not show the correct number of significant figures. Thus, a significant zero must be added.

**2.29** To round a number, determine how many significant figures are kept and drop all remaining digits. There is no change in the retained figures if the first digit dropped is 0 to 4. However, if the first digit dropped is 5 to 9, raise the last retained digit by 1.

**a.** To round 1.854, drop the 4 and keep 1.85.
**b.** To round 184.2038, drop 2038 and keep 184.
**c.** To round 0.004 738 265, drop 8265 and increase the retained digits by 1, or 0.004 74.
**d.** To round 8807 to three significant figures, drop 7 and increase the retained digits to 8810, keeping a zero in the ones place as a placeholder. In scientific notation: $8.81 \times 10^3$.
**e.** To round 1.832 149, drop 2149 and keep 1.83 as the rounded value.

**2.30** **a.** 1.9 **b.** 180 **c.** 0.0047 **d.** 8800 **e.** 1.8

**2.31** **a.** Drop 55 and increase the last digit by 1, which gives 56.9 m.
**b.** Drop 25, and keep remaining digits as 0.00228 g.
**c.** Drop 27, keep remaining digits, and add two zeros as placeholders, 11 500 s ($1.15 \times 10^4$ s).
**d.** Add a significant zero to give three significant figures, 8.10 L.

**2.32** **a.** 3.3 m **b.** $1.9 \times 10^2$ g **c.** 0.0023 m **d.** 2.0 L

**2.33** **a.** Because the value of 0.034 has 2 SFs, the answer 1.6 can have only 2 SFs.
**b.** The measurement 5 has 1 SF, which allows 1 SF in the answer (0.01).
**c.** The measurement 1.25 has 3 SFs, which allows 3 SFs in the answer (27.6):
$$\frac{34.56}{1.25} = 27.6$$
**d.** The measurement 25 has 2 SFs, which allows 2 SFs in the answer (3.5):
$$\frac{(0.2465)(25)}{1.78} = 3.5$$
**e.** The measurement $2.8 \times 10^4$ has 2 SFs, which allows 2 SFs in the answer (0.14):
$(2.8 \times 10^4)(5.05 \times 10^{-6}) = 0.14\ (1.4 \times 10^{-1})$
**f.** The measurement $8 \times 10^3$ has 1 SF, which allows 1 SF in the answer (0.8):
$$\frac{(3.45 \times 10^{-2})(1.8 \times 10^5)}{(8 \times 10^3)} = 8 \times 10^{-1}\ (0.8)$$

**2.34** **a.** $7 \times 10^4$ **b.** 0.005 **c.** 15
**d.** 0.0055 **e.** $6 \times 10^6$ **f.** 8.58

**2.35** The answer of addition/subtraction problems has the same number of places as the measurement with the largest place.

**a.**

| | |
|---|---|
| 45.48 cm | **2 decimal places** |
| + 8.057 cm | 3 decimal places |
| 53.54 cm | **2 decimal places** |

**b.**

| | |
|---|---|
| 23.45 g | 2 decimal places |
| 104.1 g | **1 decimal place** |
| + 0.025 g | 3 decimal places |
| 127.6 g | **1 decimal place** |

**c.**

| | |
|---|---|
| 145.675 mL | 3 decimal places |
| − 24.2 mL | **1 decimal place** |
| 121.5 mL | **1 decimal place** |

**d.**

| | |
|---|---|
| 1.08 L | **2 decimal places** |
| − 0.585 L | 3 decimal places |
| 0.50 L | **2 decimal places** |

**2.36** **a.** 5.08 g + 25.1 g = 30.2 g
**b.** 85.66 cm + 104.10 cm + 0.025 cm = 189.79 cm
**c.** 24.568 mL − 14.25 mL = 10.32 mL
**d.** 0.2654 L − 0.2585 L = 0.0069 L

**2.37** The km/h markings indicate how many kilometers (how much distance) will be traversed in 1 hour's time if the speed is held constant. The mph markings indicate the same distance traversed *but measured in miles* during the 1 hour of travel.

**2.38** On the speedometer, 80 kph is about 50 mph. You are *not* exceeding the 55 mph speed limit if your speedometer reads 80 km/hr (kph).

**2.39** Because the prefix *kilo* means one thousand times, a *kilo*gram is equal to 1000 grams.

**2.40** Because the prefix *centi* means one hundredth, a *centi*meter is one hundredth of a meter.

**2.41** **a.** mg **b.** dL **c.** km **d.** kg
**e.** $\mu$L **f.** ns

**2.42** **a.** centimeter **b.** kilogram **c.** deciliter
**d.** gigameter **e.** microgram **f.** picogram

**2.43** **a.** 0.01 **b.** 1000 **c.** 0.001
**d.** 0.1 **e.** 1 000 000 **f.** $10^{-9}$

**2.44** **a.** 1 decigram **b.** 1 microgram **c.** 1 kilogram
**d.** 1 centigram **e.** 1 milligram **f.** 1 picogram

**2.45** **a.** 100 cm **b.** 1000 m **c.** 0.001 m **d.** 1000 mL

**2.46** **a.** 1 kg = 1000 g **b.** 1 mL = 0.001 L **c.** 1 g = 0.001 kg **d.** 1 g = 1000 mg

**2.47** **a.** A kilogram, which is 1000 g, is larger than a milligram (0.001 g).
**b.** A milliliter, which is $10^{-3}$ L, is larger than a microliter ($10^{-6}$ L).
**c.** A km, which is $10^3$ (1000) m, is larger than a cm ($10^{-2}$ m or 0.01 m).
**d.** A kL, which is $10^3$ (1000) L, is larger than a dL ($10^{-1}$ L or 0.1 L).

**2.48** **a.** mg **b.** mm **c.** $\mu$m **d.** mL

**2.49** Because a conversion factor can be inverted to give a second factor. $\frac{1\text{ m}}{100\text{ cm}}$ and $\frac{100\text{ cm}}{1\text{ m}}$.

**2.50** Verify that the units cancel when the conversion factors are applied.

**2.51** The numerator and denominator are from the equality: 1 kg = 1000 g

**2.52** 1 m = 100 cm

**2.53** **a.** 1 yd = 3 ft, $\frac{1\text{ yd}}{3\text{ ft}}$ and $\frac{3\text{ ft}}{1\text{ yd}}$

**b.** 1 L = 1000 mL, $\frac{1\text{ L}}{1000\text{ mL}}$ and $\frac{1000\text{ mL}}{1\text{ L}}$

**c.** 1 min = 60 s, $\frac{1\text{ min}}{60\text{ s}}$ and $\frac{60\text{ s}}{1\text{ min}}$

**d.** 1 dL = 100 mL, $\frac{1\text{ dL}}{100\text{ mL}}$ and $\frac{100\text{ mL}}{1\text{ dL}}$

**2.54** **a.** 1 gal = 4 qt, $\frac{1\text{ gal}}{4\text{ qt}}$ and $\frac{4\text{ qt}}{1\text{ gal}}$

**b.** 1 m = 1000 mm, $\frac{1\text{ m}}{1000\text{ mm}}$ and $\frac{1000}{1\text{ m}}$

**c.** 1 week = 7 days, $\frac{1\text{ week}}{7\text{ days}}$ and $\frac{7\text{ days}}{1\text{ week}}$

**d.** \$1 = 4 quarters, $\frac{\$1}{4\text{ quarters}}$ and $\frac{4\text{ quarters}}{\$1}$

**2.55** The equalities between the metric prefixes can be written as two conversion factors.

**a.** $1\text{ m} = 100\text{ cm}$, $\dfrac{1\text{ m}}{100\text{ cm}}$ and $\dfrac{100\text{ cm}}{1\text{ m}}$

**b.** $1\text{ g} = 1000\text{ mg}$, $\dfrac{1\text{ g}}{1000\text{ mg}}$ and $\dfrac{1000\text{ mg}}{1\text{ g}}$

**c.** $1\text{ L} = 1000\text{ mL}$, $\dfrac{1\text{ L}}{1000\text{ mL}}$ and $\dfrac{1000\text{ mL}}{1\text{ L}}$

**d.** $1\text{ kg} = 10^6\text{ mg}$, $\dfrac{10^6\text{ mg}}{1\text{ kg}}$ and $\dfrac{1\text{ kg}}{10^6\text{ mg}}$

**e.** $(1\text{ m})^3 = (100\text{ cm})^3$, $\dfrac{(100\text{ cm})^3}{(1\text{ m})^3}$ and $\dfrac{(1\text{ m})^3}{(100\text{ cm})^3}$

**2.56** **a.** $1\text{ in.} = 2.54\text{ cm}$, $\dfrac{1\text{ in.}}{2.54\text{ cm}}$ and $\dfrac{2.54\text{ cm}}{1\text{ in.}}$

**b.** $1\text{ kg} = 2.205\text{ lb}$, $\dfrac{1\text{ kg}}{2.205\text{ lb}}$ and $\dfrac{2.205\text{ lb}}{1\text{ kg}}$

**c.** $1\text{ lb} = 453.6\text{ g}$, $\dfrac{1\text{ lb}}{453.6\text{ g}}$ and $\dfrac{453.6\text{ g}}{1\text{ lb}}$

**d.** $1.057\text{ qt} = 1\text{ L}$, $\dfrac{1.057\text{ qt}}{1\text{ L}}$ and $\dfrac{1\text{ L}}{1.057\text{ qt}}$

**e.** $1\text{ in.}^2 = (2.54)^2\text{ cm}^2$, $\dfrac{(2.54)^2\text{ cm}^2}{1\text{ in.}^2}$ and $\dfrac{1\text{ in.}^2}{(2.54)^2\text{ cm}^2}$

**2.57** An equality stated in a problem can be written as two conversion factors, which are true only for that problem.

**a.** $3.5\text{ m} = 1\text{ s}$, $\dfrac{3.5\text{ m}}{1\text{ s}}$ and $\dfrac{1\text{ s}}{3.5\text{ m}}$

**b.** $1\text{ mL} = 0.65\text{ g}$, $\dfrac{0.65\text{ g}}{1\text{ mL}}$ and $\dfrac{1\text{ mL}}{0.65\text{ g}}$

**c.** $1.0\text{ gal} = 46.0\text{ km}$, $\dfrac{46.0\text{ km}}{1.0\text{ gal}}$ and $\dfrac{1.0\text{ gal}}{46.0\text{ km}}$

**d.** Percent means parts silver per 100 parts sterling silver. Using grams (g) as the mass unit,

$100\text{ g sterling} = 93\text{ g silver}$, $\dfrac{93\text{ g silver}}{100\text{ g sterling}}$ and $\dfrac{100\text{ g sterling}}{93\text{ g silver}}$

**e.** ppb indicates $\mu$g/kg, $\dfrac{29\ \mu\text{g}}{1\text{ kg}}$ and $\dfrac{1\text{ kg}}{29\ \mu\text{g}}$

**2.58** **a.** $32\text{ mi} = 1\text{ gal}$, $\dfrac{32\text{ mi}}{1\text{ gal}}$ and $\dfrac{1\text{ gal}}{32\text{ mi}}$

**b.** $20\text{ drops} = 1\text{ mL}$, $\dfrac{20\text{ drops}}{1\text{ mL}}$ and $\dfrac{1\text{ mL}}{20\text{ drops}}$

**c.** ppm indicates mg/kg, $\dfrac{32\text{ mg}}{1\text{ kg}}$ and $\dfrac{1\text{ kg}}{32\text{ mg}}$

**d.** $58\text{ g gold} = 100\text{ g jewelry}$, $\dfrac{58\text{ g gold}}{100\text{ g jewelry}}$ and $\dfrac{100\text{ g jewelry}}{58\text{ g gold}}$

**e.** $\$3.19 = 1\text{ gal}$, $\dfrac{\$3.19}{1\text{ gal}}$ and $\dfrac{1\text{ gal}}{\$3.19}$

**2.59** When using a conversion factor, you are trying to cancel existing units and arrive at a new (desired) unit. The conversion factor must be set up to give unit cancellation.

**2.60** The new (desired) unit should be in the numerator of the conversion factor.

**2.61** **a.** Plan: cm → m

$$175\ \cancel{\text{cm}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}} = 1.75\ \text{m}$$

**b.** Plan: mL → L

$$5500\ \cancel{\text{mL}} \times \frac{1\ \text{L}}{1000\ \cancel{\text{mL}}} = 5.5\ \text{L}$$

**c.** Plan: kg → g

$$0.0055\ \cancel{\text{kg}} \times \frac{1000\ \text{g}}{1\ \cancel{\text{kg}}} = 5.5\ \text{g}$$

**d.** Plan: $\text{cm}^3 \rightarrow \text{m}^3$

$$350\ \cancel{\text{cm}^3} \times \frac{1\ \text{m}^3}{(100)^3\ \cancel{\text{cm}^3}} = 3.5 \times 10^{-4}\ \text{m}^3$$

**2.62** **a.** Plan: mg → g

$$800\ \cancel{\text{mg}} \times \frac{1\ \text{g}}{1000\ \cancel{\text{mg}}} = 0.8\ \text{g}$$

**b.** Plan: dL → mL

$$0.85\ \cancel{\text{dL}} \times \frac{100\ \text{mL}}{1\ \cancel{\text{dL}}} = 85\ \text{mL}$$

**c.** Plan: mg → g

$$2840\ \cancel{\text{mg}} \times \frac{1\ \text{g}}{1000\ \cancel{\text{mg}}} = 2.84\ \text{g}$$

**d.** Plan: $\text{m}^2 \rightarrow \text{km}^2$

$$150\ 000\ \cancel{\text{m}^2} \times \frac{1\ \text{km}^2}{(1000)^2\ \cancel{\text{m}^2}} = 0.15\ \text{km}^2$$

**2.63** **a.** Plan: qt → mL

$$0.750\ \cancel{\text{qt}} \times \frac{1\ \cancel{\text{L}}}{1.057\ \cancel{\text{qt}}} \times \frac{1000\ \text{mL}}{1\ \cancel{\text{L}}} = 710.\ \text{mL}$$

**b.** Plan: stone → lb → kg

$$11.8\ \cancel{\text{stones}} \times \frac{14\ \cancel{\text{lb}}}{1\ \cancel{\text{stone}}} \times \frac{1\ \text{kg}}{2.205\ \cancel{\text{lb}}} = 74.9\ \text{kg}$$

**c.** Plan: in. → cm → mm

$$19.5\ \cancel{\text{in.}} \times \frac{2.54\ \cancel{\text{cm}}}{1\ \cancel{\text{in.}}} \times \frac{10\ \text{mm}}{1\ \cancel{\text{cm}}} = 495\ \text{mm}$$

**d.** Plan: $\mu$m → m → cm → in.

$$0.50\ \cancel{\mu\text{m}} \times \frac{1\ \cancel{\text{m}}}{10^6\ \cancel{\mu\text{m}}} \times \frac{100\ \cancel{\text{cm}}}{1\ \cancel{\text{m}}} \times \frac{1\ \text{in.}}{2.54\ \cancel{\text{cm}}} = 2.0 \times 10^{-5}\ \text{in.}$$

**2.64** **a.** $$4.0\ \cancel{\text{oz}} \times \frac{1\ \cancel{\text{lb}}}{16\ \cancel{\text{oz}}} \times \frac{453.6\ \text{g}}{1\ \cancel{\text{lb}}} = 110\ \text{g}$$

**b.** $$5.0\ \cancel{\text{pt}} \times \frac{1\ \cancel{\text{qt}}}{2\ \cancel{\text{pt}}} \times \frac{1\ \cancel{\text{L}}}{1.057\ \cancel{\text{qt}}} \times \frac{1000\ \text{mL}}{1\ \cancel{\text{L}}} = 2400\ \text{mL}$$

**c.** $$120\ 000\ \cancel{\text{mi}} \times \frac{1\ \text{km}}{0.6214\ \cancel{\text{mi}}} = 190\ 000\ \text{km}$$

**d.** $46.0\ \text{L} \times \dfrac{1.057\ \text{qt}}{1\ \text{L}} \times \dfrac{1\ \text{gal}}{4\ \text{qt}} = 12.2\ \text{gal}$

$18.5\ \text{gal} - 12.2\ \text{gal} = 6.3\ \text{gal}$

**2.65** **a.** Plan: ft → in. → cm → m

$78.0\ \text{ft} \times \dfrac{12\ \text{in.}}{1\ \text{ft}} \times \dfrac{2.54\ \text{cm}}{1\ \text{in.}} \times \dfrac{1\ \text{m}}{100\ \text{cm}} = 23.8\ \text{m (length)}$

**b.** Plan: ft → in. → cm → m → m²

$27.0\ \text{ft} \times \dfrac{12\ \text{in.}}{1\text{ft}} \times \dfrac{2.54\ \text{cm}}{1\ \text{in.}} \times \dfrac{1\ \text{m}}{100\ \text{cm}} = 8.23\ \text{m (width)}$

Area $= 23.8\ \text{m} \times 8.23\ \text{m} = 196\ \text{m}^2$

**c.** Plan: m → km → hr → min → s

$23.8\ \text{m} \times \dfrac{1\ \text{km}}{1000\ \text{m}} \times \dfrac{1\ \text{hr}}{185\ \text{km}} \times \dfrac{60\ \text{min}}{1\ \text{hr}} \times \dfrac{60\ \text{s}}{1\ \text{min}} = 0.463\ \text{s}$

**d.** Plan: $\text{m}^2 \rightarrow \text{cm}^2 \rightarrow \text{in.}^2 \rightarrow \text{ft}^2 \rightarrow \text{gal} \rightarrow \text{qt} \rightarrow \text{L}$

$196\ \text{m}^2 \times \dfrac{(100\ \text{cm})^2}{1\ \text{m}^2} \times \dfrac{(1\ \text{in.})^2}{(2.54\ \text{cm})^2} \times \dfrac{(1\ \text{ft})^2}{(12\ \text{in.})^2} \times \dfrac{1\ \text{gal}}{150\ \text{ft}^2} \times \dfrac{4\ \text{qt}}{1\ \text{gal}} \times \dfrac{1\ \text{L}}{1.057\ \text{qt}} = 53.2\ \text{L}$

**2.66** **a.** 91.4 m **b.** 41 m **c.** $4500\ \text{m}^2$ **d.** 2.7 s

**2.67** Each of the following require a percent factor from the problem information.

**a.** Plan: g crust → g oxygen (percent equality: 100.0 g crust = 46.7 g oxygen)

$325\ \text{g crust} \times \dfrac{46.7\ \text{g oxygen}}{100.0\ \text{g crust}} = 152\ \text{g oxygen}$

**b.** Plan: g crust → g magnesium (percent equality: 100.0 g crust = 2.1 g magnesium)

$1.25\ \text{g crust} \times \dfrac{2.1\ \text{g magnesium}}{100.0\ \text{g crust}} = 0.026\ \text{g magnesium}$

**c.** Plan: oz → lb → g → g nitrogen (percent equality: 100.0 g fertilizer = 15 g nitrogen)

$10.0\ \text{oz fertilizer} \times \dfrac{1\ \text{lb}}{16\ \text{oz}} \times \dfrac{453.6\ \text{g}}{1\ \text{lb}} \times \dfrac{15\ \text{g nitrogen}}{100.0\ \text{g fertilizer}} = 43\ \text{g nitrogen}$

**d.** Plan: kg pecans → kg choc. bars → lb (percent equality: 100.0 kg bars = 22.0 kg pecans)

$5.0\ \text{kg pecans} \times \dfrac{100\ \text{kg choc. bars}}{22.0\ \text{kg pecans}} \times \dfrac{2.205\ \text{lb}}{1\ \text{kg}} = 50.\ \text{lb of chocolate bars}$

**2.68** **a.** 0.045 kg **b.** 2530 g **c.** 29 g fiber/cake **d.** 4.0 oz

**2.69** Because the density of aluminum is $2.70\ \text{g/cm}^3$, silver is $10.5\ \text{g/cm}^3$, and lead is $11.3\ \text{g/cm}^3$, we can identify the unknown metal by calculating its density as follows:

$\dfrac{217\ \text{g metal}}{19.2\ \text{cm}^3\ \text{metal}} = 11.3\ \text{g/cm}^3$ The metal is lead.

**2.70** The volume of a cube, 2.0 cm on each edge, is calculated as follows:

$(2.0\ \text{cm})^3 \times 1\ \text{mL}/1\ \text{cm}^3 = 8.0\ \text{mL}$

A cube will displace its volume when submerged in water, so the final volume reading in each graduated cylinder is: 40.0 mL water + 8.0 mL metal = 48.0 mL total volume

**2.71** Density is the mass of a substance divided by its volume. The densities of solids and liquids are usually stated in g/mL or $\text{g/cm}^3$.

$$\text{Density} = \dfrac{\text{Mass (grams)}}{\text{Volume (mL)}}$$

**a.** $\dfrac{24.0\text{ g}}{20.0\text{ mL}} = 1.20\text{ g/mL}$

**b.** $\dfrac{0.250\ \cancel{\text{lb}}}{130.3\text{ mL}} \times \dfrac{453.6\text{ g}}{1\ \cancel{\text{lb}}} = \dfrac{0.870\text{ g}}{\text{mL}}$

**c.** Volume of gem: 34.5 mL total − 20.0 mL water = 14.5 mL

Density of gem: $\dfrac{45.0\text{ g}}{14.5\text{ mL}} = 3.10\text{ g/mL}$

**d.** $\dfrac{485.6\text{ g}}{114\text{ cm}^3} = 4.26\text{ g/cm}^3$

**e.** $0.100\ \cancel{\text{pt}} \times \dfrac{1\ \cancel{\text{qt}}}{2\ \cancel{\text{pt}}} \times \dfrac{1\ \cancel{\text{L}}}{1.057\ \cancel{\text{qt}}} \times \dfrac{1000\text{ mL}}{1\ \cancel{\text{L}}} = 47.3\text{ mL}$

Mass of syrup = 182.48 g − 115.25 g = 67.23 g

Density of syrup $= \dfrac{67.23\text{ g}}{47.3\text{ mL}} = 1.42\text{ g/mL}$

**2.72** **a.** 1220 g/3500 mL = 0.35 g/mL
**b.** 155 g/125 mL = 1.24 g/mL
**c.** 5.025 g/5.00 mL = 1.01 g/mL
**d.** 275 g/207 $\text{cm}^3$ = 1.33 g/$\text{cm}^3$
**e.** 140 g/10 000 mL = 0.014 g/mL

**2.73** **a.** $1.50\ \cancel{\text{kg alcohol}} \times \dfrac{1000\ \cancel{\text{g}}}{1\ \cancel{\text{kg alcohol}}} \times \dfrac{1\ \cancel{\text{mL}}}{0.785\ \cancel{\text{g}}} \times \dfrac{1\text{ L}}{1000\ \cancel{\text{mL}}} = 1.91\text{ L}$

**b.** $6.5\ \cancel{\text{mL}} \times \dfrac{13.6\text{ g}}{1\ \cancel{\text{mL}}} = 88\text{ g}$

**c.** $225\ \cancel{\text{mL}} \times \dfrac{7.8\ \cancel{\text{g}}}{1\ \cancel{\text{mL}}} \times \dfrac{1\ \cancel{\text{lb}}}{453.6\ \cancel{\text{g}}} \times \dfrac{16\text{ oz}}{1\ \cancel{\text{lb}}} = 62\text{ oz}$

**d.** $74.1\ \cancel{\text{cm}^3} \times \dfrac{1\ \cancel{\text{mL}}}{1\ \cancel{\text{cm}^3}} \times \dfrac{8.92\text{ g}}{1\ \cancel{\text{mL}}} = 661\text{ g}$

**e.** $12.0\ \cancel{\text{gal}} \times \dfrac{4\ \cancel{\text{qt}}}{1\ \cancel{\text{gal}}} \times \dfrac{1000\ \cancel{\text{mL}}}{1.057\ \cancel{\text{qt}}} \times \dfrac{0.66\ \cancel{\text{g}}}{1\ \cancel{\text{mL}}} \times \dfrac{1\text{ kg}}{1000\ \cancel{\text{g}}} = 30.\text{ kg}$

**2.74** **a.** $35.6\ \cancel{\text{g}} \times \dfrac{1\text{ mL}}{10.5\ \cancel{\text{g}}} = 3.39\text{ mL silver metal}$

18.0 mL water + 3.39 mL silver = 21.4 mL total volume

**b.** $8.3\ \cancel{\text{g}} \times \dfrac{1\text{ mL}}{13.6\ \cancel{\text{g}}} = 0.61\text{ mL mercury metal}$

**c.** $35\ \cancel{\text{gal}} \times \dfrac{4\ \cancel{\text{qt}}}{1\ \cancel{\text{gal}}} \times \dfrac{1\ \cancel{\text{L}}}{1.057\ \cancel{\text{qt}}} \times \dfrac{1000\ \cancel{\text{mL}}}{1\ \cancel{\text{L}}} \times \dfrac{1.0\ \cancel{\text{g}}}{1\ \cancel{\text{mL}}} \times \dfrac{1\text{ lb}}{453.6\ \cancel{\text{g}}} = 290\text{ lb}$

**d.** 82.1 mL
**e.** 0.904 kg

**2.75** **a.** The number of legs is a counted number; it is exact.
**b.** The height is measured with a ruler or tape measure; it is a measured number.
**c.** The number of chairs is a counted number; it is exact.
**d.** The area is measured with a ruler or tape measure; it is a measured number.

**2.76** **a.** 61.5°C **b.** 53.80°C **c.** 4.9°C

**2.77** **a.** length = 6.96 cm; width = 4.75 cm
**b.** length = 69.6 mm; width = 47.5 mm
**c.** There are three significant figures in the length measurement.

**d.** There are three significant figures in the width measurement.
**e.** 33.3 $cm^2$
**f.** Since there are three significant figures in the width and length measurements, there are three significant figures in the area.

**2.78** **a.** Length is 3.7 cm; the 7 is the estimated digit.
**b.** Length is 2.50 cm; the 0 is the estimated digit.
**c.** Length is 4.10 cm; the 0 is the estimated digit.

**2.79** The volume of the object is: 23.1 mL − 18.5 mL = 4.6 mL.
The mass is 8.24 g and the density is: $\dfrac{8.24\text{ g}}{4.6\text{ mL}} = 1.8\text{ g/mL}$.

**2.80** **a.** This is cube 3, since it has sunk to the bottom.
**b.** This is cube 4, since it is floating about one-third out of the water.
**c.** This is cube 1, since it is floating about one-half out of the water.
**d.** This is cube 2, since it is floating just at the surface of the water.

**2.81** A is vegetable oil, B is water, and C is mercury.

**2.82** **A.** would be gold; it has the highest density and the smallest volume.
**B.** would be silver; its density is intermediate and the volume is intermediate.
**C.** would be aluminum; it has the lowest density and the largest volume.

**2.83** **a.** Drop 8 and increase retained digits by 1 to give 0.000 0126 L ($1.26 \times 10^{-5}$ L).
**b.** Drop 8 and increase retained digits by 1 to give $3.53 \times 10^2$ kg.
**c.** Drop 111, keep retained digits, and add three zeros as placeholders to give 125 000 $m^3$, or $1.25 \times 10^5\ m^3$.
**d.** Drop 03 and keep retained digits to give 58.7 m.
**e.** Add 2 significant zeros to give $3.00 \times 10^{-3}$ s.
**f.** Drop 26 and keep retained digits, 0.0108 g.

**2.84** 265 g

**2.85** Plan: ft ⟶ in. ⟶ cm ⟶ m ⟶ min

$$7500\ \cancel{\text{ft}} \times \frac{12\ \cancel{\text{in.}}}{1\ \cancel{\text{ft}}} \times \frac{2.54\ \cancel{\text{cm}}}{1\ \cancel{\text{in.}}} \times \frac{1\ \cancel{\text{m}}}{100\ \cancel{\text{cm}}} \times \frac{1\text{ min}}{55.0\ \cancel{\text{m}}} = 42\text{ min}$$

**2.86** **a.** 22 kg salmon + 5.5 kg crab + 3.48 kg oysters = 31 kg seafood
**b.** $31\ \cancel{\text{kg}}\text{ seafood (total)} \times \dfrac{2.205\text{ lb}}{1\ \cancel{\text{kg}}} = 68\text{ lb}$

**2.87** Plan: lb ⟶ g ⟶ onions

$$4.0\ \cancel{\text{lb onions}} \times \frac{453.6\ \cancel{\text{g onions}}}{1\ \cancel{\text{lb onions}}} \times \frac{1\text{ onion}}{115\ \cancel{\text{g onions}}} = 16\text{ onions}$$

Because the number of onions is a counting number, the value for onions, 15.8, is rounded to a whole number, 16.

**2.88** $\cancel{\$}1420 \times \dfrac{1\ \cancel{\text{lb}}}{\cancel{\$}1.75} \times \dfrac{1\text{ kg}}{2.205\ \cancel{\text{lb}}} = 4 \times 10^2\text{ kg}$

**2.89** **a.** Plan: oz ⟶ crackers

$$8.0\ \cancel{\text{oz}} \times \frac{6\text{ crackers}}{0.50\ \cancel{\text{oz}}} = 96\text{ crackers}$$

**b.** Plan: crackers ⟶ servings ⟶ g ⟶ lb ⟶ oz

$$10\ \cancel{\text{crackers}} \times \frac{1\ \cancel{\text{serving}}}{6\ \cancel{\text{crackers}}} \times \frac{4\ \cancel{\text{g}}\text{ fat}}{1\ \cancel{\text{serving}}} \times \frac{1\ \cancel{\text{lb}}}{453.6\ \cancel{\text{g}}} \times \frac{16\text{ oz}}{1\ \cancel{\text{lb}}} = 0.2\text{ oz fat}$$

**c.** Plan: boxes → oz → servings → mg → g

$$50\ \cancel{\text{boxes}} \times \frac{8.0\ \cancel{\text{oz}}}{1\ \cancel{\text{box}}} \times \frac{1\ \cancel{\text{serving}}}{0.50\ \cancel{\text{oz}}} \times \frac{140\ \cancel{\text{mg}}\ \text{sodium}}{1\ \cancel{\text{serving}}} \times \frac{1\ \text{g}}{1000\ \cancel{\text{mg}}} = 110\ \text{g sodium}$$

**2.90** $$75\,000\ \cancel{\text{mL}} \times \frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}} \times \frac{1.057\ \cancel{\text{qt}}}{1\ \cancel{\text{L}}} \times \frac{1\ \text{gal}}{4\ \cancel{\text{qt}}} = 20.\ \text{gal}$$

**2.91** Plan: lb → kg → pesos → dollar → cents

$$0.45\ \cancel{\text{lb}} \times \frac{1\ \cancel{\text{kg}}}{2.205\ \cancel{\text{lb}}} \times \frac{48\ \cancel{\text{pesos}}}{1\ \cancel{\text{kg}}} \times \frac{1\ \cancel{\text{dollar}}}{10.8\ \cancel{\text{pesos}}} \times \frac{100\ \text{cents}}{1\ \cancel{\text{dollar}}} = 91\ \text{cents}$$

Because the calculation is for a counted number of cents, the value 90.7 is rounded to 91.

**2.92** $$8.0\ \cancel{\text{oz burger}} \times \frac{15.0\ \cancel{\text{oz protein}}}{100.0\ \cancel{\text{oz burger}}} \times \frac{1\ \cancel{\text{lb}}}{16\ \cancel{\text{oz}}} \times \frac{453.6\ \text{g}}{1\ \cancel{\text{lb}}} = 34\ \text{g protein}$$

Yes, the hamburger contains 34 g of protein, which is 10 grams more than she is allowed. To stay within her diet, Celeste could have only a 5.6-oz burger, as shown by the following calculation:

$$24\ \cancel{\text{g protein}} \times \frac{1\ \cancel{\text{lb}}}{453.6\ \cancel{\text{g}}} \times \frac{16\ \cancel{\text{oz}}}{1\ \cancel{\text{lb}}} \times \frac{100.0\text{-oz burger}}{15.0\ \cancel{\text{oz protein}}} = 5.6\text{-oz burger}$$

This one burger would use her entire day's allowance of protein!

**2.93** Plan: tubes → oz → lb → g → kg sunscreen → kg benzyl salicylate

$$325\ \cancel{\text{tubes}} \times \frac{4.0\ \cancel{\text{oz}}}{1\ \cancel{\text{tube}}} \times \frac{1\ \cancel{\text{lb}}}{16\ \cancel{\text{oz}}} \times \frac{453.6\ \cancel{\text{g}}}{1\ \cancel{\text{lb}}} \times \frac{1\ \cancel{\text{kg}}}{1000\ \cancel{\text{g}}} \times \frac{2.50\ \text{kg}}{100\ \cancel{\text{kg}}\ \text{sunscreen}} = 0.92\ \text{kg}$$

**2.94** 442.5 mL total − 325.2 mL water = 117.3 mL object

$$\frac{3.15\ \cancel{\text{oz}}\ \text{object}}{117.3\ \text{mL object}} \times \frac{1\ \cancel{\text{lb}}}{16\ \cancel{\text{oz}}} \times \frac{453.6\ \text{g}}{1\ \cancel{\text{lb}}} = 0.761\ \text{g/mL}$$

**2.95** This problem has two units. Convert g to mg, and convert L in the denominator to dL.

$$\frac{1.85\ \cancel{\text{g}}}{1\ \cancel{\text{L}}} \times \frac{1000\ \text{mg}}{1\ \cancel{\text{g}}} \times \frac{1\ \cancel{\text{L}}}{10\ \text{dL}} = 185\ \text{mg/dL}$$

**2.96** 9.60 L

**2.97** The difference between the initial volume of the water and its volume with the lead object will give us the volume of the object. 285 mL total − 215 mL water = 70 mL lead

Using the density of lead, we can convert mL to the mass in grams of the lead object.

$$70.\ \cancel{\text{mL lead}} \times \frac{11.3\ \text{g lead}}{1\ \cancel{\text{mL lead}}} = 790\ \text{g lead}$$

**2.98** $$15.0\ \cancel{\text{g iron}} \times \frac{1\ \cancel{\text{cm}^3}\ \text{iron}}{7.86\ \cancel{\text{g iron}}} \times \frac{1\ \text{mL}}{1\ \cancel{\text{cm}^3}} = 1.91\ \text{mL iron}$$

$$20.0\ \cancel{\text{g lead}} \times \frac{1\ \cancel{\text{cm}^3}\ \text{lead}}{11.3\ \cancel{\text{g lead}}} \times \frac{1\ \text{mL}}{1\ \cancel{\text{cm}^3}} = 1.77\ \text{mL lead}$$

155 mL water + 1.91 mL iron + 1.77 mL lead = 159 mL total volume

**2.99** Plan: L gas → mL gas → g gas → g oil → mL oil → $\text{cm}^3$ oil

$$1.00\ \cancel{\text{L gas}} \times \frac{1000\ \cancel{\text{mL gas}}}{1\ \cancel{\text{L gas}}} \times \frac{0.66\ \cancel{\text{g gas}}}{1\ \cancel{\text{mL gas}}} \times \frac{1\ \cancel{\text{g oil}}}{1\ \cancel{\text{g gas}}} \times \frac{1\ \cancel{\text{mL}}\ \text{oil}}{0.92\ \cancel{\text{g oil}}} \times \frac{1\ \text{cm}^3}{1\ \cancel{\text{mL}}} = 720\ \text{cm}^3\ \text{oil}$$

**2.100** Plan: kg → g → mL → L → qt

$$1.50\ \cancel{\text{kg alcohol}} \times \frac{1000\ \cancel{\text{g}}}{1\ \cancel{\text{kg}}} \times \frac{1\ \cancel{\text{mL}}\ \text{alcohol}}{0.785\ \cancel{\text{g alcohol}}} \times \frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}} \times \frac{1.057\ \text{qt}}{1\ \cancel{\text{L}}} = 2.02\ \text{qt alcohol}$$

**2.101** **a.** Plan: kg mass → kg fat → lb (percent equality: 100.0 kg mass = 3.0 kg fat)

$$45\ \cancel{\text{kg body weight}} \times \frac{3.0\ \cancel{\text{kg}}\ \text{fat}}{100.0\ \cancel{\text{kg body mass}}} \times \frac{2.205\ \text{lb}}{1\ \cancel{\text{kg}}} = 3.0\ \text{lb fat}$$

**b.** Plan: L fat → mL → g → lb

$$3.0\ \cancel{\text{L fat}} \times \frac{1000\ \cancel{\text{mL}}}{1\ \cancel{\text{L}}} \times \frac{0.94\ \cancel{\text{g}}\ \text{fat}}{1\ \cancel{\text{mL fat}}} \times \frac{1\ \text{lb}}{453.6\ \cancel{\text{g}}} = 6.2\ \text{lb fat}$$

**2.102** 5.77 kg

**2.103** Plan: $cm^3$ → g → g silver → lb → oz (percent equality: 100 g sterling = 92.5 g silver)

$$27.0\ \cancel{\text{cm}^3} \times \frac{10.3\ \cancel{\text{g}}}{1\ \cancel{\text{cm}^3}} \times \frac{92.5\ \cancel{\text{g}}\ \text{silver}}{100\ \cancel{\text{g}}} \times \frac{1\ \cancel{\text{lb}}}{453.6\ \cancel{\text{g}}} \times \frac{16\ \text{oz}}{1\ \cancel{\text{lb}}} = 9.07\ \text{oz pure silver}$$

**2.104** Plan: kg → lb body mass → lb water

$$65\ \cancel{\text{kg body mass}} \times \frac{2.205\ \cancel{\text{lb}}}{1\ \cancel{\text{kg}}} \times \frac{55\ \text{lb water}}{100.\ \cancel{\text{lb body mass}}} = 79\ \text{lb water}$$

**2.105** Since the balance can measure mass to 0.001 g, the mass should be given to 0.001 g; you should record the mass of the object as 34.075 g.

**2.106** The student who reports 5.8 cm is not reading to the nearest mm. The others are estimating differently.

**2.107** 6.4 gal

**2.108** **a.** 79 cups **b.** 314 cans **c.** 157 tablets

**2.109** $3.8 \times 10^2$ g aluminum

**2.110** **a.** 69 $m^3$ **b.** $6.9 \times 10^4$ kg

**2.111** **a.** 43 g **b.** 3.9 g copper **c.** 2.8 $cm^3$

**2.112** 0.203 mm

**2.113** 75.7 mL + 4.8 mL (silver) + 2.6 mL (gold) = 82.9 mL