CHAPTER 1 KEYS TO THE STUDY OF CHEMISTRY

FOLLOW–UP PROBLEMS

1.1A Plan: The real question is "Does the substance change composition or just change form?" A change in composition is a chemical change while a change in form is a physical change.
Solution:
The figure on the left shows red atoms and molecules composed of one red atom and one blue atom. The figure on the right shows a change to blue atoms and molecules containing two red atoms. The change is **chemical** since the substances themselves have changed in composition.

1.1B Plan: The real question is "Does the substance change composition or just change form?" A change in composition is a chemical change while a change in form is a physical change.
Solution:
The figure on the left shows red atoms that are close together, in the solid state. The figure on the right shows red atoms that are far apart from each other, in the gaseous state. The change is **physical** since the substances themselves have not changed in composition.

1.2A Plan: The real question is "Does the substance change composition or just change form?" A change in composition is a chemical change while a change in form is a physical change.
Solution:
a) Both the solid and the vapor are iodine, so this must be a **physical** change.
b) The burning of the gasoline fumes produces energy and products that are different gases. This is a **chemical** change.
c) The scab forms due to a **chemical** change.

1.2B Plan: The real question is "Does the substance change composition or just change form?" A change in composition is a chemical change while a change in form is a physical change.
Solution:
a) Clouds form when gaseous water (water vapor) changes to droplets of liquid water. This is a **physical** change.
b) When old milk sours, the compounds in milk undergo a reaction to become different compounds (as indicated by a change in the smell, the taste, the texture, and the consistency of the milk). This is a **chemical** change.
c) Both the solid and the liquid are butter, so this must be a **physical** change.

1.3A Plan: We need to find the amount of time it takes for the professor to walk 10,500 m. We know how many miles she can walk in 15 min (her speed), so we can convert the distance the professor walks to miles and use her speed to calculate the amount of time it will take to walk 10,500 m.
Solution:

$$\text{Time (min)} = 10{,}500\ \text{m}\left(\frac{1\ \text{km}}{1000\ \text{m}}\right)\left(\frac{1\ \text{mi}}{1.609\ \text{km}}\right)\left(\frac{15\ \text{min}}{1\ \text{mi}}\right) = 97.8869 = \mathbf{98\ min}$$

Road map:

Distance (m)

↓ 1000 m = 1 km

Distance (km)

↓ 1.609 km = 1 mi

Distance (mi)

↓ 1 mi = 15 min

Time (min)

1.3B Plan: We need to find the number of virus particles that can line up side by side in a 1 inch distance. We know the diameter of a virus in nm units. If we convert the 1 inch distance to nm, we can use the diameter of the virus to calculate the number of virus particles we can line up over a 1 inch distance.

Solution:

No. of virus particles = $1.0\text{ in}\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)\left(\frac{1\times10^{7}\text{ nm}}{1\text{ cm}}\right)\left(\frac{1\text{ virus particle}}{30\text{ nm}}\right) = 8.4667\times10^{5}$ = **8.5×10^{5} virus particles**

Road map:

Length (in)

↓ 1 in = 2.54 cm

Length (cm)

↓ 1 cm = 1×10^{7} nm

Length (nm)

↓ 30 nm = 1 particle

No. of particles

1.4A Plan: The diameter in nm is used to obtain the radius in nm, which is converted to the radius in dm. The volume of the ribosome in dm^3 is then determined using the equation for the volume of a sphere given in the problem. This volume may then be converted to volume in μL.

Solution:

Radius (dm) = $\frac{\text{diameter}}{2} = \left(\frac{21.4\text{ nm}}{2}\right)\left(\frac{1\text{ m}}{1\times10^{9}\text{ nm}}\right)\left(\frac{1\text{ dm}}{0.1\text{ m}}\right) = 1.07\times10^{-7}$ dm

Volume (dm^3) = $\frac{4}{3}\pi r^3 = \frac{4}{3}(3.14159)(1.07\times10^{-7}\text{ dm})^3 = 5.13145\times10^{-21}$ = **$5.13\times10^{-21}\text{ dm}^3$**

Volume (μL) = $(5.13145\times10^{-21}\text{ dm}^3)\left(\frac{1\text{ L}}{(1\text{ dm})^3}\right)\left(\frac{1\ \mu\text{L}}{10^{-6}\text{ L}}\right) = 5.13145\times10^{-15}$ = **$5.13\times10^{-15}\ \mu\text{L}$**

Road map:

Diameter (dm)

↓ diameter = 2*r*

Radius (dm)

↓ $V = 4/3\pi r^3$

Volume (dm^3)

↓ $1\ dm^3 = 1\ L$; $1\ L = 10^6\ \mu L$

Volume (µL)

1.4B Plan: We need to convert gallon units to liter units. If we first convert gallons to dm^3, we can then convert to L.

Solution:

$$\text{Volume (L)} = 8400\ \text{gal}\left(\frac{3.785\ \text{dm}^3}{1\ \text{gal}}\right)\left(\frac{1\ \text{L}}{1\ \text{dm}^3}\right) = 31{,}794 = \mathbf{32{,}000\ L}$$

Road map:

Volume (gal)

↓ $1\ gal = 3.785\ dm^3$

Volume (dm^3)

↓ $1\ dm^3 = 1\ L$

Volume (L)

1.5A Plan: The time is given in hours and the rate of delivery is in drops per second. Conversions relating hours to seconds are needed. This will give the total number of drops, which may be combined with their mass to get the total mass. The mg of drops will then be changed to kilograms.

Solution:

$$\text{Mass (kg)} = 8.0\ \text{h}\left(\frac{60\ \text{min}}{1\ \text{h}}\right)\left(\frac{60\ \text{s}}{1\ \text{min}}\right)\left(\frac{1.5\ \text{drops}}{1\ \text{s}}\right)\left(\frac{65\ \text{mg}}{1\ \text{drop}}\right)\left(\frac{10^{-3}\ \text{g}}{1\ \text{mg}}\right)\left(\frac{1\ \text{kg}}{10^3\ \text{g}}\right) = 2.808 = \mathbf{2.8\ kg}$$

Road map:

Time (hr)

↓ 1 hr = 60 min

Time (min)

↓ 1 min = 60 s

Time (s)

↓ 1 s = 1.5 drops

No. of drops

↓ 1 drop = 65 mg

Mass (mg) of solution

↓ 1 mg = 10^3 g

Mass (g) of solution

↓ 10^3 g = 1 kg

Mass (kg) of solution

1.5B Plan: We have the mass of apples in kg and need to find the mass of potassium in those apples in g. The number of apples per pound and the mass of potassium per apple are given. Convert the mass of apples in kg to pounds. Then use the number of apples per pound to calculate the number of apples. Use the mass of potassium in one apple to calculate the mass (mg) of potassium in the group of apples. Finally, convert the mass in mg to g.

Solution:

$$\text{Mass (g)} = 3.25\ \text{kg}\left(\frac{1\ \text{lb}}{0.4536\ \text{kg}}\right)\left(\frac{3\ \text{apples}}{1\ \text{lb}}\right)\left(\frac{159\ \text{mg potassium}}{1\ \text{apple}}\right)\left(\frac{1\ \text{g}}{10^3\ \text{mg}}\right) = 3.4177 = \mathbf{3.42\ g}$$

Road map:

Mass (kg) of apples

↓ 0.4536 kg = 1 lb

Mass (lb) of apples

↓ 1 lb = 3 apples

No. of apples

↓ 1 apple = 159 mg potassium

Mass (mg) potassium

↓ 10^3 mg = 1 g

Mass (g) potassium

1.6A Plan: We know the area of a field in m^2. We need to know how many bottles of herbicide will be needed to treat that field. The volume of each bottle (in fl oz) and the volume of herbicide needed to treat 300 ft^2 of field are given. Convert the area of the field from m^2 to ft^2 (don't forget to square the conversion factor when converting from squared units to squared units!). Then use the given conversion factors to calculate the number of bottles of herbicide needed. Convert first from ft^2 of field to fl oz of herbicide (because this conversion is from a squared unit to a non-squared unit, we do not need to square the conversion factor). Then use the number of fl oz per bottle to calculate the number of bottles needed.

Solution:

$$\text{No. of bottles} = 2050\ \text{m}^2 \left(\frac{1\ \text{ft}^2}{(0.3048)^2\ \text{m}^2}\right)\left(\frac{1.5\ \text{fl oz}}{300\ \text{ft}^2}\right)\left(\frac{1\ \text{bottle}}{16\ \text{fl oz}}\right) = 6.8956 = \mathbf{7\ bottles}$$

Road map:

Area (m^2)

↓ $(0.3048)^2\ m^2 = 1\ ft^2$

Area (ft^2)

↓ $300\ ft^2 = 1.5$ fl oz

Volume (fl oz)

↓ 16 oz = 1 bottle

No. of bottles

1.6B Plan: Calculate the mass of mercury in g. Convert the surface area of the lake from mi^2 to ft^2. Find the volume of the lake in ft^3 by multiplying the surface area (in ft^2) by the depth (in ft). Then convert the volume of the lake to mL by converting first from ft^3 to m^3, then from m^3 to cm^3, and from cm^3 to mL. Finally, divide the mass in g by the volume in mL to find the mass of mercury in each mL of the lake.

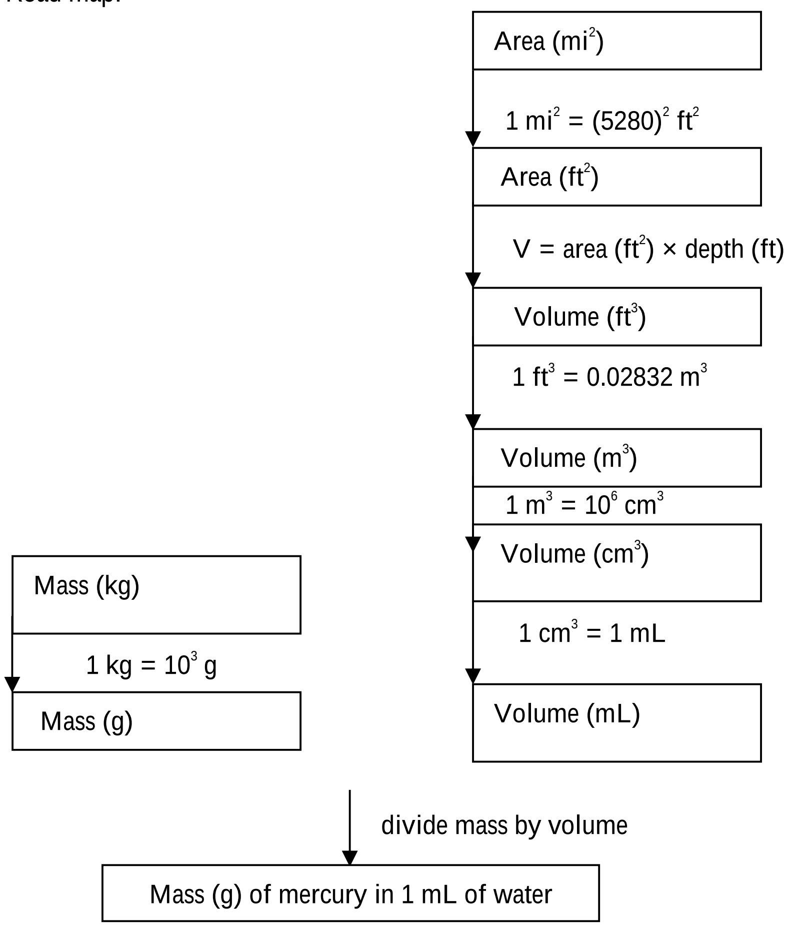
Solution:

$$\text{Mass (g)} = 75{,}000\ \text{kg}\left(\frac{1000\ \text{g}}{1\ \text{kg}}\right) = 7.5 \times 10^7\ \text{g}$$

$$\text{Volume (mL)} = 4.5\ \text{mi}^2\left(\frac{(5280)^2\ \text{ft}^2}{1\ \text{mi}^2}\right)(35\ \text{ft})\left(\frac{0.02832\ \text{m}^3}{1\ \text{ft}^3}\right)\left(\frac{1\times10^6\ \text{cm}^3}{1\ \text{m}^3}\right)\left(\frac{1\ \text{mL}}{1\ \text{cm}^3}\right) = 1.24349 \times 10^{14}\ \text{mL}$$

$$\text{Mass (g) of mercury per mL} = \frac{7.5\times10^7\ \text{g}}{1.24349\times10^{14}\ \text{mL}} = 6.0314 \times 10^{-7} = \mathbf{6.0 \times 10^{-7}\ g/mL}$$

Road map:



1.7A <u>Plan:</u> Find the mass of Venus in g. Calculate the radius of Venus by dividing its diameter by 2. Convert the radius from km to cm. Use the radius to calculate the volume of Venus. Finally, find the density of Venus by dividing the mass of Venus (in g) by the volume of Venus (in cm^3).

<u>Solution:</u>

$$\text{Mass (g)} = 4.9 \times 10^{24}\ \text{kg}\left(\frac{10^3\ \text{g}}{1\ \text{kg}}\right) = 4.9 \times 10^{27}\ \text{g}$$

$$\text{Radius (cm)} = \left(\frac{12{,}100\ \text{km}}{2}\right)\left(\frac{10^3\ \text{m}}{1\ \text{km}}\right)\left(\frac{10^2\ \text{cm}}{1\ \text{m}}\right) = 6.05\ 10^8\ \text{cm}$$

$$\text{Volume (cm}^3) = \frac{4}{3}\pi r^3 = \frac{4}{3}(3.14159)(6.05\times10^8\ \text{cm})^3 = 9.27587 \times 10^{26}\ \text{cm}^3$$

$$\text{Density (g/cm}^3) = \frac{4.9\times10^{27}\text{g}}{9.27587\times10^{26}\text{cm}^3} = 5.28252 = \mathbf{5.3\ g/cm^3}$$

Road map:

Diameter (km)

↓ d = 2r

Radius (km)

↓ 1 km = 10^3 m

Radius (m)

↓ 1 m = 10^2 cm

Radius (cm)

↓ V = $\frac{4}{3}\pi r^3$

Volume (cm^3)

Mass (kg)

↓ 1 kg = 10^3 g

Mass (g)

↓ divide mass by volume

Density (g/cm^3)

1.7B Plan: The mass (pounds) of aluminum must be converted to grams, then dividing by the density of aluminum will give the volume of aluminum available to make cans. Finally, dividing by the volume per can will give the number of cans possible.

Solution:

$$\text{Number of cans} = (16.2\ \text{lb})\left(\frac{453.6\ \text{g}}{1\ \text{lb}}\right)\left(\frac{1\ \text{cm}^3}{2.70\ \text{g}}\right)\left(\frac{1\ \text{can}}{5.1\ \text{cm}^3}\right) = \mathbf{533\ cans}$$

Road map:

Mass (lb)

↓ 1 lb = 453.6 g

Mass (g)

↓ 2.70 g = 1 cm^3

Volume (cm^3)

↓ 5.1 cm^3 = 1 can

Number of cans

1.8A Plan: Using the relationship between the Kelvin and Celsius scales, change the Kelvin temperature to the Celsius temperature. Then convert the Celsius temperature to the Fahrenheit value using the relationship between these two scales.

Solution:

T (in °C) = T (in K) – 273.15 = 234 K – 273.15 = –39.15 = **–39°C**

$$T \text{ (in °F)} = \frac{9}{5} T \text{ (in °C)} + 32 = \frac{9}{5} (-39.15\text{°C}) + 32 = -38.47 = \mathbf{-38°F}$$

Check: Since the Kelvin temperature is below 273, the Celsius temperature must be negative. The low Celsius value gives a negative Fahrenheit value.

1.8B Plan: Convert the Fahrenheit temperature to the Celsius value using the relationship between these two scales. Then use the relationship between the Kelvin and Celsius scales to change the Celsius temperature to the Kelvin temperature.

Solution:

$$T \text{ (in °C)} = \frac{5}{9}(T \text{ (in °F)} - 32) = \frac{5}{9}(2325 \text{ °F} - 32) = 1273.8889 = 1274 \text{ °C}$$

T (in K) = T (in **°C**) + 273.15 = 1274 **°C** + 273.15 = 1547.15 = 1547 K

Check: Since the Fahrenheit temperature is large and positive, both the Celsius and Kelvin temperatures should also be positive. Because the Celsius temperature is greater than 273, the Kelvin temperature should be greater than 273, which it is.

1.9A Plan: Determine the significant figures by counting the digits present and accounting for the zeros. Zeros between non-zero digits are significant, as are trailing zeros to the right of a decimal point. Trailing zeros to the left of a decimal point are only significant if the decimal point is present.

Solution:

a) 31.<u>0</u>7<u>0</u> mg; **five** significant figures

b) 0.06<u>0</u>6<u>0</u> g; **four** significant figures

c) 85<u>0</u>.°C; **three** significant figures — note the decimal point that makes the zero significant.

Check: All significant zeros must come after a significant digit.

1.9B Plan: Determine the significant figures by counting the digits present and accounting for the zeros. Zeros between non-zero digits are significant, as are trailing zeros to the right of a decimal point. Trailing zeros to the left of a decimal point are only significant if the decimal point is present.

Solution:

a) 2.<u>000</u> × 10^2 mL; **four** significant figures

b) 3.90 × 10^{-6} m; **three** significant figures

c) 4.<u>0</u>1 × 10^{-4} L; **three** significant figures

Check: All significant zeros must come after a significant digit.

1.10A Plan: Use the rules presented in the text. Add the two values in the numerator before dividing. The time conversion is an exact conversion and, therefore, does not affect the significant figures in the answer.

Solution:

The addition of 25.65 mL and 37.4 mL gives an answer where the last significant figure is the one after the decimal point (giving three significant figures total):

25.65 mL + 37.4 mL = 63.05 (would round to 63.0 if not an intermediate step)

When a four significant figure number divides a three significant figure number, the answer must round to three significant figures. An exact number (1 min / 60 s) will have no bearing on the number of significant figures.

$$\frac{63.05 \text{ mL}}{73.55 \text{ s}\left(\frac{1 \text{ min}}{60 \text{ s}}\right)} = 51.4344 = \mathbf{51.4 \text{ mL/min}}$$

1.10B Plan: Use the rules presented in the text. Subtract the two values in the numerator and multiply the numbers in the denominator before dividing.

Solution:

The subtraction of 35.26 from 154.64 gives an answer in which the last significant figure is two places after the decimal point (giving five significant figures total):

$$154.64 \text{ g} - 35.26 \text{ g} = 119.38 \text{ g}$$

The multiplication of 4.20 cm (three significant figures) by 5.12 cm (three significant figures) by 6.752 cm (four significant figures) gives a number with three significant figures.

$$4.20 \text{ cm} \times 5.12 \text{ cm} \times 6.752 \text{ cm} = 145.1950 \text{ (would round to 145 cm}^3 \text{ if not an intermediate step)}$$

When a three significant figure number divides a five significant figure number, the answer must round to three significant figures.

$$\frac{119.38 \text{ g}}{145.1950 \text{ cm}^3} = 0.82220 = \mathbf{0.822\ g/cm^3}$$

END–OF–CHAPTER PROBLEMS

1.1 Plan: If only the form of the particles has changed and not the composition of the particles, a physical change has taken place; if particles of a different composition result, a chemical change has taken place.

Solution:

a) The result in C represents a **chemical change** as the substances in A (red spheres) and B (blue spheres) have reacted to become a different substance (particles consisting of one red and one blue sphere) represented in C. There are molecules in C composed of the atoms from A and B.

b) The result in D represents a **chemical change** as again the atoms in A and B have reacted to form molecules of a new substance.

c) The change from C to D is a **physical change**. The substance is the same in both C and D (molecules consisting of one red sphere and one blue sphere) but is in the gas phase in C and in the liquid phase in D.

d) The sample has the **same chemical properties** in both C and D since it is the same substance but has **different physical properties**.

1.2 Plan: Apply the definitions of the states of matter to a container. Next, apply these definitions to the examples. Gas molecules fill the entire container; the volume of a gas is the volume of the container. Solids and liquids have a definite volume. The volume of the container does not affect the volume of a solid or liquid.

Solution:

a) The helium fills the volume of the entire balloon. The addition or removal of helium will change the volume of a balloon. Helium is a **gas**.

b) At room temperature, the mercury does not completely fill the thermometer. The surface of the **liquid** mercury indicates the temperature.

c) The soup completely fills the bottom of the bowl, and it has a definite surface. The soup is a **liquid**, though it is possible that solid particles of food will be present.

1.3 Plan: Apply the definitions of the states of matter to a container. Next, apply these definitions to the examples. Gas molecules fill the entire container; the volume of a gas is the volume of the container. Solids and liquids have a definite volume. The volume of the container does not affect the volume of a solid or liquid.

Solution:

a) The air fills the volume of the room. Air is a **gas**.

b) The vitamin tablets do not necessarily fill the entire bottle. The volume of the tablets is determined by the number of tablets in the bottle, not by the volume of the bottle. The tablets are **solid**.

c) The sugar has a definite volume determined by the amount of sugar, not by the volume of the container. The sugar is a **solid**.

1.4 Plan: Define the terms and apply these definitions to the examples.

Solution:

Physical property – A characteristic shown by a substance itself, without interacting with or changing into other substances.

Chemical property – A characteristic of a substance that appears as it interacts with, or transforms into, other substances.

a) The change in color (yellow–green and silvery to white), and the change in physical state (gas and metal to crystals) are examples of **physical properties**. The change in the physical properties indicates that a chemical change occurred. Thus, the interaction between chlorine gas and sodium metal producing sodium chloride is an example of a **chemical property**.

b) The sand and the iron are still present. Neither sand nor iron became something else. Colors along with magnetism are **physical properties**. No chemical changes took place, so there are no chemical properties to observe.

1.5 Plan: Define the terms and apply these definitions to the examples.

Solution:

Physical change – A change in which the physical form (or state) of a substance, but not its composition, is altered.

Chemical change – A change in which a substance is converted into a different substance with different composition and properties.

a) The changes in the physical form are **physical changes**. The physical changes indicate that there is also a **chemical change**. Magnesium chloride has been converted to magnesium and chlorine.

b) The changes in color and form are **physical changes**. The physical changes indicate that there is also a **chemical change**. Iron has been converted to a different substance, rust.

1.6 Plan: Apply the definitions of chemical and physical changes to the examples.

Solution:

a) Not a chemical change, but a **physical change** — simply cooling returns the soup to its original form.

b) There is a **chemical change** — cooling the toast will not "un–toast" the bread.

c) Even though the wood is now in smaller pieces, it is still wood. There has been no change in composition, thus this is a **physical change**, and not a chemical change.

d) This is a **chemical change** converting the wood (and air) into different substances with different compositions. The wood cannot be "unburned."

1.7 Plan: If there is a physical change, in which the composition of the substance has not been altered, the process can be reversed by a change in temperature. If there is a chemical change, in which the composition of the substance has been altered, the process cannot be reversed by changing the temperature.

Solution:

a) and c) **can be reversed** with temperature; the dew can evaporate and the ice cream can be refrozen.

b) and d) involve chemical changes and **cannot be reversed** by changing the temperature since a chemical change has taken place.

1.8 Plan: A system has a higher potential energy before the energy is released (used).

Solution:

a) The exhaust is lower in energy than the fuel by an amount of energy equal to that released as the fuel burns. The **fuel** has a higher potential energy.

b) **Wood**, like the fuel, is higher in energy by the amount released as the wood burns.

1.9 Plan: Kinetic energy is energy due to the motion of an object.

Solution:

a) **The sled sliding down the hill** has higher kinetic energy than the unmoving sled.

b) **The water falling over the dam** (moving) has more kinetic energy than the water held by the dam.

1.10 **Observations** are the first step in the scientific approach. The first observation is that the toast has not popped out of the toaster. The next step is a **hypothesis** (tentative explanation) to explain the observation. The hypothesis is that the spring mechanism is stuck. Next, there will be a **test** of the hypothesis. In this case, the test is an additional observation — the bread is unchanged. This observation leads to a new hypothesis — the toaster is unplugged. This hypothesis leads to additional tests — seeing if the toaster is plugged in, and if it works when plugged into a different outlet. The final test on the toaster leads to a new hypothesis — there is a problem with the power in the kitchen. This hypothesis leads to the final test concerning the light in the kitchen.

1.11 A quantitative observation is easier to characterize and reproduce. A qualitative observation may be subjective and open to interpretation.
a) This is **qualitative**. When has the sun completely risen?
b) The astronaut's mass may be measured; thus, this is **quantitative**.
c) This is **qualitative**. Measuring the fraction of the ice above or below the surface would make this a quantitative measurement.
d) The depth is known (measured) so this is **quantitative**.

1.12 A well-designed experiment must have the following essential features:
1) There must be two variables that are expected to be related.
2) There must be a way to control all the variables, so that only one at a time may be changed.
3) The results must be reproducible.

1.13 A model begins as a simplified version of the observed phenomena, designed to account for the observed effects, explain how they take place, and to make predictions of experiments yet to be done. The model is improved by further experiments. It should be flexible enough to allow for modifications as additional experimental results are gathered.

1.14 Plan: Review the definitions of mass and weight.
Solution:
Mass is the quantity of material present, while **weight** is the interaction of gravity on mass. An object has a definite mass regardless of its location; its weight will vary with location. The lower gravitational attraction on the Moon will make an object appear to have approximately one-sixth its Earth weight. The object has the same mass on the Moon and on Earth.

1.15 The unit you begin with (feet) must be in the denominator to cancel. The unit desired (inches) must be in the numerator. The feet will cancel leaving inches. If the conversion is inverted the answer would be in units of feet squared per inch.

1.16 Plan: $\text{Density} = \frac{\text{mass}}{\text{volume}}$. An increase in mass or a decrease in volume will increase the density. A decrease in density will result if the mass is decreased or the volume increased.

Solution:
a) Density **increases**. The mass of the chlorine gas is not changed, but its volume is smaller.
b) Density **remains the same**. Neither the mass nor the volume of the solid has changed.
c) Density **decreases**. Water is one of the few substances that expands on freezing. The mass is constant, but the volume increases.
d) Density **increases**. Iron, like most materials, contracts on cooling; thus the volume decreases while the mass does not change.
e) Density **remains the same**. The water does not alter either the mass or the volume of the diamond.

1.17 Plan: Review the definitions of heat and temperature. The two temperature values must be compared using one temperature scale, either Celsius or Fahrenheit.

Solution:

Heat is the energy that flows between objects at different temperatures while temperature is the measure of how hot or cold a substance is relative to another substance. Heat is an **extensive property** while temperature is an **intensive property**. It takes more heat to boil a gallon of water than to boil a teaspoon of water. However, both water samples boil at the same temperature.

Convert 65°C to °F: $T\text{ (in °F)} = \frac{9}{5}T\text{ (in °C)} + 32 = \frac{9}{5}(65°\text{C}) + 32 = 149°\text{F}$

A temperature of 65°C is 149°F. Heat will flow from the hot water (65°C or 149°F) to the cooler water (65°F). The 65°C water contains more heat than the cooler water.

1.18 There are two differences in the Celsius and Fahrenheit scales (size of a degree and the zero point), so a simple one-step conversion will not work. The size of a degree is the same for the Celsius and Kelvin scales; only the zero point is different so a one-step conversion is sufficient.

1.19 Plan: Review the definitions of extensive and intensive properties.

Solution:

An extensive property depends on the amount of material present. An intensive property is the same regardless of how much material is present.

a) Mass is an **extensive property**. Changing the amount of material will change the mass.

b) Density is an **intensive property**. Changing the amount of material changes both the mass and the volume, but the ratio (density) remains fixed.

c) Volume is an **extensive property**. Changing the amount of material will change the size (volume).

d) The melting point is an **intensive property**. The melting point depends on the substance, not on the amount of substance.

1.20 Plan: Review the table of conversions in the chapter or inside the back cover of the book. Write the conversion factor so that the unit initially given will cancel, leaving the desired unit.

Solution:

a) To convert from in^2 to cm^2, use $\frac{\mathbf{(2.54\ cm)^2}}{\mathbf{(1\ in)^2}}$; to convert from cm^2 to m^2, use $\frac{\mathbf{(1\ m)^2}}{\mathbf{(100\ cm)^2}}$

b) To convert from km^2 to m^2, use $\frac{\mathbf{(1000\ m)^2}}{\mathbf{(1\ km)^2}}$; to convert from m^2 to cm^2, use $\frac{\mathbf{(100\ cm)^2}}{\mathbf{(1\ m)^2}}$

c) This problem requires two conversion factors: one for distance and one for time. It does not matter which conversion is done first. Alternate methods may be used.

To convert distance, mi to m, use:

$$\left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right)\left(\frac{1000\ \text{m}}{1\ \text{km}}\right) = \mathbf{1.609 \times 10^3\ m/mi}$$

To convert time, h to s, use:

$$\left(\frac{1\ \text{h}}{60\ \text{min}}\right)\left(\frac{1\ \text{min}}{60\ \text{s}}\right) = \mathbf{1\ h/3600\ s}$$

Therefore, the complete conversion factor is $\left(\frac{1.609\times10^3\ \text{m}}{1\ \text{mi}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = \frac{\mathbf{0.4469\ m \cdot h}}{\mathbf{mi \cdot s}}$.

Do the units cancel when you start with a measurement of mi/h?

d) To convert from pounds (lb) to grams (g), use $\frac{\mathbf{1000\ g}}{\mathbf{2.205\ lb}}$.

To convert volume from ft^3 to cm^3 use, $\left(\frac{(1\ ft)^3}{(12\ in)^3}\right)\left(\frac{(1\ in)^3}{(2.54\ cm)^3}\right)$ = $\mathbf{3.531 \times 10^{-5}\ ft^3/cm^3}$.

1.21 Plan: Review the table of conversions in the chapter or inside the back cover of the book. Write the conversion factor so that the unit initially given will cancel, leaving the desired unit.
Solution:
a) This problem requires two conversion factors: one for distance and one for time. It does not matter which conversion is done first. Alternate methods may be used.

To convert distance, cm to in, use: $\left(\frac{\mathbf{1\ in}}{\mathbf{2.54\ cm}}\right)$

To convert time, min to s, use: $\left(\frac{\mathbf{1\ min}}{\mathbf{60\ s}}\right)$

b) To convert from m^3 to cm^3, use $\frac{(\mathbf{100\ cm})^3}{(\mathbf{1\ m})^3}$; to convert from cm^3 to in^3, use $\frac{(\mathbf{1\ in})^3}{(\mathbf{2.54\ cm})^3}$

c) This problem requires two conversion factors: one for distance and one for time. It does not matter which conversion is done first. Alternate methods may be used.

To convert distance, m to km, use: $\left(\frac{\mathbf{1\ km}}{\mathbf{1000\ m}}\right)$

To convert time, s^2 to h^2, use:

$$\left(\frac{(60\ s)^2}{(1\ min)^2}\right)\left(\frac{(60\ min)^2}{(1\ h)^2}\right) = \frac{\mathbf{3600\ s^2}}{\mathbf{h^2}}$$

d) This problem requires two conversion factors: one for volume and one for time. It does not matter which conversion is done first. Alternate methods may be used.

To convert volume, gal to qt, use: $\left(\frac{\mathbf{4\ qt}}{\mathbf{1\ gal}}\right)$; to convert qt to L, use: $\left(\frac{\mathbf{1\ L}}{\mathbf{1.057\ qt}}\right)$

To convert time, h to min, use: $\left(\frac{\mathbf{1\ h}}{\mathbf{60\ min}}\right)$

1.22 Plan: Use conversion factors from the inside back cover: 1 pm = 10^{-12} m; 10^{-9} m = 1 nm.
Solution:

Radius (nm) = $(1430\ pm)\left(\frac{10^{-12}\ m}{1\ pm}\right)\left(\frac{1\ nm}{10^{-9}\ m}\right)$ = **1.43 nm**

1.23 Plan: Use conversion factors from the inside back cover: 10^{-12} m = 1 pm; 1 pm = 0.01 Å.
Solution:

Radius (Å) = $(2.22\times10^{-10}\ m)\left(\frac{1\ pm}{10^{-12}\ m}\right)\left(\frac{0.01\ \text{Å}}{1\ pm}\right)$ = **2.22 Å**

1.24 Plan: Use conversion factors: 0.01 m = 1 cm; 2.54 cm = 1 in.
Solution:

Length (in) = $(100.\ m)\left(\frac{1\ cm}{0.01\ m}\right)\left(\frac{1\ in}{2.54\ cm}\right)$ = 3.9370×10^3 = $\mathbf{3.94 \times 10^3\ in}$

1.25 Plan: Use the conversion factor 12 in = 1 ft to convert 6 ft 10 in to height in inches. Then use the conversion factors 1 in = 2.54 cm; 1 cm = 10 mm.

Solution:

$$\text{Height (in)} = (6\text{ ft})\left(\frac{12\text{ in}}{1\text{ ft}}\right) + 10\text{ in} = 82\text{ in}$$

$$\text{Height (mm)} = (82\text{ in})\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)\left(\frac{10\text{ mm}}{1\text{ cm}}\right) = 2.0828 \times 10^3 = \mathbf{2.1 \times 10^3\ mm}$$

1.26 Plan: Use conversion factors $(1\text{ cm})^2 = (0.01\text{ m})^2$; $(1000\text{ m})^2 = (1\text{ km})^2$ to express the area in km^2. To calculate the cost of the patch, use the conversion factor: $(2.54\text{ cm})^2 = (1\text{ in})^2$.

Solution:

$$\text{a) Area (km}^2) = (20.7\text{ cm}^2)\left(\frac{(0.01\text{ m})^2}{(1\text{ cm})^2}\right)\left(\frac{(1\text{ km})^2}{(1000\text{ m})^2}\right) = \mathbf{2.07 \times 10^{-9}\ km^2}$$

$$\text{b) Cost} = (20.7\text{ cm}^2)\left(\frac{(1\text{ in})^2}{(2.54\text{ cm})^2}\right)\left(\frac{\$3.25}{1\text{ in}^2}\right) = 10.4276 = \mathbf{\$10.43}$$

1.27 Plan: Use conversion factors $(1\text{ mm})^2 = (10^{-3}\text{ m})^2$; $(0.01\text{ m})^2 = (1\text{ cm})^2$; $(2.54\text{ cm})^2 = (1\text{ in})^2$; $(12\text{ in})^2 = (1\text{ ft})^2$ to express the area in ft^2.

Solution:

$$\text{a) Area (ft}^2) = (7903\text{ mm}^2)\left(\frac{(10^{-3}\text{ m})^2}{(1\text{ mm})^2}\right)\left(\frac{(1\text{ cm})^2}{(0.01\text{ m})^2}\right)\left(\frac{(1\text{ in})^2}{(2.54\text{ cm})^2}\right)\left(\frac{(1\text{ ft})^2}{(12\text{ in})^2}\right)$$

$$= 8.5067 \times 10^{-2} = \mathbf{8.507 \times 10^{-2}\ ft^2}$$

$$\text{b) Time (s)} = (7903\text{ mm}^2)\left(\frac{45\text{ s}}{135\text{ mm}^2}\right) = 2.634333 \times 10^3 = \mathbf{2.6 \times 10^3\ s}$$

1.28 Plan: Use conversion factors 1 lb = 16 oz, 0.4536 kg = 1 lb, and 1000 g = 1 kg.

Solution:

$$\text{Mass (g)} = (6.14\text{ oz})\left(\frac{1\text{ lb}}{16\text{ oz}}\right)\left(\frac{0.4536\text{ kg}}{1\text{ lb}}\right)\left(\frac{1000\text{ g}}{1\text{ kg}}\right) = \mathbf{174\ kg}$$

1.29 Plan: Use conversion factor 1 short ton = 2000 lb; 2.205 lb = 1 kg; 1000 kg = 1 metric ton.

Solution:

$$\text{Mass (T)} = (2.60 \times 10^{15}\text{ ton})\left(\frac{2000\text{ lb}}{1\text{ ton}}\right)\left(\frac{1\text{ kg}}{2.205\text{ lb}}\right)\left(\frac{1\text{ T}}{10^3\text{ kg}}\right) = 2.35828 \times 10^{15} = \mathbf{2.36 \times 10^{15}\ T}$$

1.30 Plan: Mass in g is converted to kg in part (a) with the conversion factor 1000 g = 1 kg; mass in g is converted to lb in part (b) with the conversion factors 1000 g = 1 kg; 1 kg = 2.205 lb. Volume in cm^3 is converted to m^3 with the conversion factor $(1\text{ cm})^3 = (0.01\text{ m})^3$ and to ft^3 with the conversion factors $(2.54\text{ cm})^3 = (1\text{ in})^3$; $(12\text{ in})^3 = (1\text{ ft})^3$. The conversions may be performed in any order.

Solution:

$$\text{a) Density (kg/m}^3) = \left(\frac{5.52\text{ g}}{\text{cm}^3}\right)\left(\frac{(1\text{ cm})^3}{(0.01\text{ m})^3}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right) = \mathbf{5.52 \times 10^3\ kg/m^3}$$

b) Density (lb/ft^3) = $\left(\frac{5.52\text{ g}}{\text{cm}^3}\right)\left(\frac{(2.54\text{ cm})^3}{(1\text{ in})^3}\right)\left(\frac{(12\text{ in})^3}{(1\text{ ft})^3}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right)\left(\frac{2.205\text{ lb}}{1\text{ kg}}\right)$ = 344.661 = **345 lb/ft^3**

1.31 Plan: Length in m is converted to km in part (a) with the conversion factor 1000 m = 1 km; length in m is converted to mi in part (b) with the conversion factors 1000 m = 1 km; 1 km = 0.62 mi. Time is converted using the conversion factors 60 s = 1 min; 60 min = 1 h. The conversions may be performed in any order.

Solution:

a) Velocity (km/h) = $\left(\frac{2.998\times10^8\text{ m}}{1\text{ s}}\right)\left(\frac{60\text{ s}}{1\text{ min}}\right)\left(\frac{60\text{ min}}{1\text{ h}}\right)\left(\frac{1\text{ km}}{10^3\text{ m}}\right)$ = 1.07928 × 10^9 = **1.079 × 10^9 km/h**

b) Velocity (mi/min) = $\left(\frac{2.998\times10^8\text{ m}}{1\text{ s}}\right)\left(\frac{60\text{ s}}{1\text{ min}}\right)\left(\frac{1\text{ km}}{10^3\text{ m}}\right)\left(\frac{0.62\text{ mi}}{1\text{ km}}\right)$ = 1.11526 × 10^7 = **1.1 × 10^7 mi/min**

1.32 Plan: Use the conversion factors $(1\ \mu\text{m})^3 = (1\times10^{-6}\text{ m})^3$; $(1\times10^{-3}\text{ m})^3 = (1\text{ mm})^3$ to convert to mm^3. To convert to L, use the conversion factors $(1\ \mu\text{m})^3 = (1\times10^{-6}\text{ m})^3$; $(1\times10^{-2}\text{ m})^3 = (1\text{ cm})^3$; 1 cm^3 = 1 mL; 1 mL = 1 × 10^{-3} L.

Solution:

a) Volume (mm^3) = $\left(\frac{2.56\ \mu\text{m}^3}{\text{cell}}\right)\left(\frac{(1\times10^{-6}\text{ m})^3}{(1\ \mu\text{m})^3}\right)\left(\frac{(1\text{ mm})^3}{(1\times10^{-3}\text{ m})^3}\right)$ = **2.56 × 10^{-9} mm^3/cell**

b) Volume (L) = $(10^5\text{ cells})\left(\frac{2.56\ \mu\text{m}^3}{\text{cell}}\right)\left(\frac{(1\times10^{-6}\text{ m})^3}{(1\ \mu\text{m})^3}\right)\left(\frac{(1\text{ cm})^3}{(1\times10^{-2}\text{ m})^3}\right)\left(\frac{1\text{ mL}}{1\text{ cm}^3}\right)\left(\frac{1\times10^{-3}\text{ L}}{1\text{ mL}}\right)$

= 2.56 × 10^{-10} = **10^{-10} L**

1.33 Plan: For part (a), convert from qt to mL (1 qt = 946.4 mL) to L (1 mL = 1 × 10^{-3} L) to m^3 (1 L = 10^{-3} m^3). For part (b), convert from gal to qt (1 gal = 4 qt) to mL (1 qt = 946.4 mL) to L (1 mL = 10^{-3} L).

Solution:

a) Volume (m^3) = $(1\text{ qt})\left(\frac{946.4\text{ mL}}{1\text{ qt}}\right)\left(\frac{10^{-3}\text{ L}}{1\text{ mL}}\right)\left(\frac{10^{-3}\text{ m}^3}{1\text{ L}}\right)$ = **9.464 × 10^{-4} m^3**

b) Volume (L) = $(835\text{ gal})\left(\frac{4\text{ qt}}{1\text{ gal}}\right)\left(\frac{946.4\text{ mL}}{1\text{ qt}}\right)\left(\frac{10^{-3}\text{ L}}{1\text{ mL}}\right)$ = 3.160976 × 10^3 = **3.16 × 10^3 L**

1.34 Plan: The mass of the mercury in the vial is the mass of the vial filled with mercury minus the mass of the empty vial. Use the density of mercury and the mass of the mercury in the vial to find the volume of mercury and thus the volume of the vial. Once the volume of the vial is known, that volume is used in part (b). The density of water is used to find the mass of the given volume of water. Add the mass of water to the mass of the empty vial.

Solution:

a) Mass (g) of mercury = mass of vial and mercury – mass of vial = 185.56 g – 55.32 g = 130.24 g

Volume (cm^3) of mercury = volume of vial = $(130.24\text{ g})\left(\frac{1\text{ cm}^3}{13.53\text{ g}}\right)$ = 9.626016 = **9.626 cm^3**

b) Volume (cm^3) of water = volume of vial = 9.626016 cm^3

Mass (g) of water = $(9.626016\text{ cm}^3)\left(\frac{0.997\text{ g}}{1\text{ cm}^3}\right)$ = 9.59714 g water

Mass (g) of vial filled with water = mass of vial + mass of water = 55.32 g + 9.59714 g = 64.91714 = **64.92 g**

1.35 Plan: The mass of the water in the flask is the mass of the flask and water minus the mass of the empty flask. Use the density of water and the mass of the water in the flask to find the volume of water and thus the volume of the flask. Once the volume of the flask is known, that volume is used in part (b). The density of chloroform is used to find the mass of the given volume of chloroform. Add the mass of the chloroform to the mass of the empty flask.

Solution:

a) Mass (g) of water = mass of flask and water – mass of flask = 489.1 g – 241.3 g = 247.8 g

Volume (cm^3) of water = volume of flask = $(247.8\ g)\left(\frac{1\ cm^3}{1.00\ g}\right)$ = 247.8 = **248 cm³**

b) Volume (cm^3) of chloroform = volume of flask = 247.8 cm^3

Mass (g) of chloroform = $(247.8\ cm^3)\left(\frac{1.48\ g}{cm^3}\right)$ = 366.744 g chloroform

Mass (g) of flask and chloroform = mass of flask + mass of chloroform = 241.3 g + 366.744 g

= 608.044 g = **608 g**

1.36 Plan: Calculate the volume of the cube using the relationship Volume = (length of side)^3. The length of side in mm must be converted to cm so that volume will have units of cm^3. Divide the mass of the cube by the volume to find density.

Solution:

Side length (cm) = $(15.6\ mm)\left(\frac{10^{-3}\ m}{1\ mm}\right)\left(\frac{1\ cm}{10^{-2}\ m}\right)$ = 1.56 cm (convert to cm to match density unit)

Al cube volume (cm^3) = (length of side)^3 = (1.56 cm)^3 = 3.7964 cm^3

Density (g/cm^3) $= \frac{mass}{volume} = \frac{10.25\ g}{3.7964\ cm^3}$ = 2.69993 = **2.70 g/cm³**

1.37 Plan: Use the relationship $c = 2\pi r$ to find the radius of the sphere and the relationship $V = 4/3\pi r^3$ to find the volume of the sphere. The volume in mm^3 must be converted to cm^3. Divide the mass of the sphere by the volume to find density.

Solution:

$c = 2\pi r$

Radius (mm) = $\frac{c}{2\pi} = \frac{32.5\ mm}{2\pi}$ = 5.17254 mm

Volume (mm^3) = $\frac{4}{3}\pi r^3 = \left(\frac{4}{3}\right)\pi(5.17254\ mm)^3$ = 579.6958 mm^3

Volume (cm^3) = $(579.6958\ mm^3)\left(\frac{10^{-3}\ m}{1\ mm}\right)^3\left(\frac{1\ cm}{10^{-2}\ m}\right)^3$ = 0.5796958 cm^3

Density (g/cm^3) $= \frac{mass}{volume} = \frac{4.20\ g}{0.5796958\ cm^3}$ = 7.24518 = **7.25 g/cm³**

1.38 Plan: Use the equations given in the text for converting between the three temperature scales.

Solution:

a) T (in °C) = [T (in °F) – 32] $\frac{5}{9}$ = [68°F – 32] $\frac{5}{9}$ = **20.°C**

T (in K) = T (in °C) + 273.15 = 20.°C + 273.15 = 293.15 = **293 K**

b) T (in K) = T (in °C) + 273.15 = –164°C + 273.15 = 109.15 = **109 K**

$T \text{ (in °F)} = \frac{9}{5} T \text{ (in °C)} + 32 = \frac{9}{5}(-164°C) + 32 = -263.2 = \mathbf{-263°F}$

c) T (in °C) = T (in K) – 273.15 = 0 K – 273.15 = –273.15 = **–273°C**

$T \text{ (in °F)} = \frac{9}{5} T \text{ (in °C)} + 32 = \frac{9}{5}(-273.15°C) + 32 = -459.67 = \mathbf{-460.°F}$

1.39 Plan: Use the equations given in the text for converting between the three temperature scales.

Solution:

a) $T \text{ (in °C)} = [T \text{ (in °F)} - 32]\frac{5}{9} = [106°F - 32]\frac{5}{9} = 41.111 = \mathbf{41°C}$

(106 – 32) = 74 This limits the significant figures.

T (in K) = T (in °C) + 273.15 = 41.111°C + 273.15 = 314.261 = **314 K**

b) $T \text{ (in °F)} = \frac{9}{5} T \text{ (in °C)} + 32 = \frac{9}{5}(3410°C) + 32 = \mathbf{6170°F}$

T (in K) = T (in °C) + 273.15 = 3410°C + 273 = **3683 K**

c) T (in °C) = T (in K) –273.15 = 6.1×10^3 K – 273 = 5.827×10^3 = $\mathbf{5.8 \times 10^3 °C}$

$T \text{ (in °F)} = \frac{9}{5} T \text{ (in °C)} + 32 = \frac{9}{5}(5827°C) + 32 = 1.0521 \times 10^4 = \mathbf{1.1 \times 10^4 °F}$

1.40 Plan: Find the volume occupied by each metal by taking the difference between the volume of water and metal and the initial volume of the water (25.0 mL). Divide the mass of the metal by the volume of the metal to calculate density. Use the density value of each metal to identify the metal.

Solution:

Cylinder A: volume of metal = [volume of water + metal] – [volume of water]

volume of metal = 28.2 mL – 25.0 mL = 3.2 mL

$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{25.0 \text{ g}}{3.2 \text{ mL}} = 7.81254 = \mathbf{7.8\ g/mL}$

Cylinder A contains **iron**.

Cylinder B: volume of metal = [volume of water + metal] – [volume of water]

volume of metal = 27.8 mL – 25.0 mL = 2.8 mL

$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{25.0 \text{ g}}{2.8 \text{ mL}} = 8.92857 = \mathbf{8.9\ g/mL}$

Cylinder B contains **nickel**.

Cylinder C: volume of metal = [volume of water + metal] – [volume of water]

volume of metal = 28.5 mL – 25.0 mL = 3.5 mL

$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{25.0 \text{ g}}{3.5 \text{ mL}} = 7.14286 = \mathbf{7.1\ g/mL}$

Cylinder C contains **zinc**.

1.41 Plan: Use 1 nm = 10^{-9} m to convert wavelength in nm to m. To convert wavelength in pm to Å, use 1 pm = 0.01 Å.

Solution:

a) $\text{Wavelength (m)} = (247 \text{ nm})\left(\frac{10^{-9} \text{ m}}{1 \text{ nm}}\right) = \mathbf{2.47 \times 10^{-7}\ m}$

b) $\text{Wavelength (Å)} = (6760 \text{ pm})\left(\frac{0.01 \text{ Å}}{1 \text{ pm}}\right) = \mathbf{67.6\ Å}$

1.42 Plan: The liquid with the larger density will occupy the bottom of the beaker, while the liquid with the smaller density volume will be on top of the more dense liquid.
Solution:
a) Liquid A is more dense than water; liquids B and C are less dense than water.
b) Density of liquid B could be **0.94 g/mL**. Liquid B is more dense than C so its density must be greater than 0.88 g/mL. Liquid B is less dense than water so its density must be less than 1.0 g/mL.

1.43 Plan: Calculate the volume of the cylinder in cm^3 by using the equation for the volume of a cylinder. The diameter of the cylinder must be halved to find the radius. Convert the volume in cm^3 to dm^3 by using the conversion factors $(1\ cm)^3 = (10^{-2}\ m)^3$ and $(10^{-1}\ m)^3 = (1\ dm)^3$.
Solution:
Radius = diameter/2 = 0.85 cm/2 = 0.425 cm
Volume (cm^3) = $\pi r^2 h = \pi(0.425\ cm)^2(9.5\ cm) = 5.3907766\ cm^3$

$$\text{Volume (dm}^3\text{)} = \left(5.3907766\ cm^3\right)\left(\frac{10^{-2}\ m}{1\ cm}\right)^3\left(\frac{1\ dm}{10^{-1}\ m}\right)^3 = 5.39078 \times 10^{-3} = \mathbf{5.4 \times 10^{-3}\ dm^3}$$

1.44 Plan: Use the percent of copper in the ore to find the mass of copper in 5.01 lb of ore. Convert the mass in lb to mass in g. The density of copper is used to find the volume of that mass of copper. Use the volume equation for a cylinder to calculate the height of the cylinder (the length of wire); the diameter of the wire is used to find the radius which must be expressed in units of cm. Length of wire in cm must be converted to m.
Solution:

$$\text{Mass (lb) of copper} = \left(5.01\ lb\ \text{Covellite}\right)\left(\frac{66\%}{100\%}\right) = 3.3066\ lb\ \text{copper}$$

$$\text{Mass (g) of copper} = \left(3.3066\ lb\right)\left(\frac{1\ kg}{2.205\ lb}\right)\left(\frac{1000\ g}{1\ kg}\right) = 1.49959 \times 10^3\ g$$

$$\text{Volume (cm}^3\text{) of copper} = \left(1.49959\times10^3\ g\ Cu\right)\left(\frac{cm^3\ Cu}{8.95\ g\ Cu}\right) = 167.552\ cm^3\ Cu$$

$V = \pi r^2 h$

$$\text{Radius (cm)} = \left(\frac{6.304\times10^{-3}\ in}{2}\right)\left(\frac{2.54\ cm}{1\ in}\right) = 8.00608 \times 10^{-3}\ cm$$

$$\text{Height (length) in cm} = \frac{V}{\pi r^2} = \frac{167.552\ cm^3}{(\pi)\left(8.00608\times10^{-3}\ cm\right)^2} = 8.3207 \times 10^{-5}\ cm$$

$$\text{Length (m)} = \left(8.3207\times10^5\ cm\right)\left(\frac{10^{-2}\ m}{1\ cm}\right) = 8.3207 \times 10^3 = \mathbf{8.32 \times 10^3\ m}$$

1.45 An exact number is defined to have a certain value (exactly). There is no uncertainty in an exact number. An exact number is considered to have an infinite number of significant figures and, therefore, does not limit the digits in the calculation.

1.46 Random error of a measurement is decreased by **(1)** taking the average of more measurements. More measurements allow a more precise estimate of the true value of the measurement. Calibrating the instrument will allow greater accuracy but not necessarily greater precision.

1.47 a) If the number is an exact count then there are an infinite number of significant figures. If it is not an exact count, there are only 5 significant figures.
b) Other things, such as number of tickets sold, could have been counted instead.
c) A value of 15,000 to two significant figures is 1.5×10^4.
Values would range from 14,501 to 15,499. Both of these values round to 1.5×10^4.

1.48 Plan: Review the rules for significant zeros.
Solution:
a) No significant zeros (leading zeros are not significant)
b) No significant zeros (leading zeros are not significant)
c) $0.041\underline{0}$ (terminal zeros to the right of the decimal point are significant)
d) $4.\underline{0}1\underline{00} \times 10^4$ (zeros between nonzero digits and terminal zeros to the right of the decimal point are significant)

1.49 Plan: Review the rules for significant zeros.
Solution:
a) $5.\underline{0}8$ (zeros between nonzero digits are significant)
b) $5\underline{0}8$ (zeros between nonzero digits are significant)
c) $5.\underline{0}8\underline{0} \times 10^3$ (zeros between nonzero digits are significant; terminal zeros to the right of the decimal point are significant)
d) $0.05\underline{0}8\underline{0}$ (leading zeros are not significant; zeros between nonzero digits are significant; terminal zeros to the right of the decimal point are significant)

1.50 Plan: Review the rules for rounding.
Solution: (significant figures are underlined)
a) $0.000\underline{35}54$: the extra digits are 54 at the end of the number. When the digit to be removed is 5 and that 5 is followed by nonzero numbers, the last digit kept is increased by 1: **0.00036**
b) $\underline{35.83}48$: the extra digits are 48. Since the digit to be removed (4) is less than 5, the last digit kept is unchanged: **35.83**
c) $\underline{22.4}555$: the extra digits are 555. When the digit to be removed is 5 and that 5 is followed by nonzero numbers, the last digit kept is increased by 1: **22.5**

1.51 Plan: Review the rules for rounding.
Solution: (significant figures are underlined)
a) $\underline{231.5}54$: the extra digits are 54 at the end of the number. When the digit to be removed is 5 and that 5 is followed by nonzero numbers, the last digit kept is increased by 1: **231.6**
b) $0.00\underline{84}5$: the extra digit is 5 at the end of the number. When the digit to be removed is 5 and that 5 is not followed by nonzero numbers, the last digit kept remains unchanged if it is even and increased by 1 if it is odd: **0.0084**
c) $\underline{14}4{,}000$: the extra digits are 4000 at the end of the number. When the digit to be removed (4) is less than 5, the last digit kept remains unchanged: **140,000** (or 1.4×10^5)

1.52 Plan: Review the rules for rounding.
Solution:
19 rounds to 20: the digit to be removed (9) is greater than 5 so the digit kept is increased by 1.
155 rounds to 160: the digit to be removed is 5 and the digit to be kept is an odd number, so that digit kept is increased by 1.
8.3 rounds to 8: the digit to be removed (3) is less than 5 so the digit kept remains unchanged.
3.2 rounds to 3: the digit to be removed (2) is less than 5 so the digit kept remains unchanged.
2.9 rounds to 3: the digit to be removed (9) is greater than 5 so the digit kept is increased by 1.
4.7 rounds to 5: the digit to be removed (7) is greater than 5 so the digit kept is increased by 1.

$\left(\dfrac{20\times160\times8}{3\times3\times5}\right)$ = 568.89 = **6 × 10^2**

Since there are numbers in the calculation with only one significant figure, the answer can be reported only to one significant figure. (Note that the answer is 560 with the original number of significant digits.)

1.53 Plan: Review the rules for rounding.

Solution:

10.8 rounds to 11: the digit to be removed (8) is greater than 5 so the digit kept is increased by 1.
6.18 rounds to 6.2: the digit to be removed (8) is greater than 5 so the digit kept is increased by 1.
2.381 rounds to 2.38: the digit to be removed (1) is less than 5 so the digit kept remains unchanged.
24.3 rounds to 24: the digit to be removed (3) is less than 5 so the digit kept remains unchanged.
1.8 rounds to 2: the digit to be removed (8) is greater than 5 so the digit kept is increased by 1.
19.5 rounds to 20: the digit to be removed is 5 and the digit to be kept is odd, so that digit kept is increased by 1.

$\left(\dfrac{11\times6.2\times2.38}{24\times2\times20}\right)$ = 0.1691 = **0.2**

Since there is a number in the calculation with only one significant figure, the answer can be reported only to one significant figure. (Note that the answer is 0.19 with original number of significant figures.)

1.54 Plan: Use a calculator to obtain an initial value. Use the rules for significant figures and rounding to get the final answer.

Solution:

a) $\dfrac{(2.795\text{ m})(3.10\text{ m})}{6.48\text{ m}}$ = 1.3371 = **1.34 m** (maximum of 3 significant figures allowed since two of the original numbers in the calculation have only 3 significant figures)

b) V = $\left(\dfrac{4}{3}\right)\pi(17.282\text{ mm})^3$ = 21,620.74 = **21,621 mm^3** (maximum of 5 significant figures allowed)

c) 1.110 cm + 17.3 cm + 108.2 cm + 316 cm = 442.61 = **443 cm** (no digits allowed to the right of the decimal since 316 has no digits to the right of the decimal point)

1.55 Plan: Use a calculator to obtain an initial value. Use the rules for significant figures and rounding to get the final answer.

Solution:

a) $\dfrac{2.420\text{ g}+15.6\text{ g}}{4.8\text{ g}}$ = 3.7542 = **3.8** (maximum of 2 significant figures allowed since one of the original numbers in the calculation has only 2 significant figures)

b) $\dfrac{7.87\text{ mL}}{16.1\text{ mL}-8.44\text{ mL}}$ = 1.0274 = **1.0** (After the subtraction, the denominator has 2 significant figures; only one digit is allowed to the right of the decimal in the value in the denominator since 16.1 has only one digit to the right of the decimal.)

c) V = π(6.23 cm)^2(4.630 cm) = 564.556 = **565 cm^3** (maximum of 3 significant figures allowed since one of the original numbers in the calculation has only 3 significant figures)

1.56 Plan: Review the procedure for changing a number to scientific notation. There can be only 1 nonzero digit to the left of the decimal point in correct scientific notation. Moving the decimal point to the left results in a positive exponent while moving the decimal point to the right results in a negative exponent.

Solution:
a) **1.310000×10^5** (Note that all zeros are significant.)
b) **4.7×10^{-4}** (No zeros are significant.)
c) **2.10006×10^5**
d) **2.1605×10^3**

1.57 Plan: Review the procedure for changing a number to scientific notation. There can be only 1 nonzero digit to the left of the decimal point in correct scientific notation. Moving the decimal point to the left results in a positive exponent while moving the decimal point to the right results in a negative exponent.
Solution:
a) **2.820×10^2** (Note that the zero is significant.)
b) **3.80×10^{-2}** (Note the one significant zero.)
c) **4.2708×10^3**
d) **5.82009×10^4**

1.58 Plan: Review the examples for changing a number from scientific notation to standard notation. If the exponent is positive, move the decimal back to the right; if the exponent is negative, move the decimal point back to the left.
Solution:
a) **5550** (Do not use terminal decimal point since the zero is not significant.)
b) **10070.** (Use terminal decimal point since final zero is significant.)
c) **0.000000885**
d) **0.003004**

1.59 Plan: Review the examples for changing a number from scientific notation to standard notation. If the exponent is positive, move the decimal back to the right; if the exponent is negative, move the decimal point back to the left.
Solution:
a) **6500.** (Use terminal decimal point since the final zero is significant.)
b) **0.0000346**
c) **750** (Do not use terminal decimal point since the zero is not significant.)
d) **188.56**

1.60 Plan: In most cases, this involves a simple addition or subtraction of values from the exponents. There can be only 1 nonzero digit to the left of the decimal point in correct scientific notation.
Solution:
a) **8.025×10^4** (The decimal point must be moved an additional 2 places to the left: $10^2 + 10^2 = 10^4$)
b) **1.0098×10^{-3}** (The decimal point must be moved an additional 3 places to the left: $10^3 + 10^{-6} = 10^{-3}$)
c) **7.7×10^{-11}** (The decimal point must be moved an additional 2 places to the right: $10^{-2} + 10^{-9} = 10^{-11}$)

1.61 Plan: In most cases, this involves a simple addition or subtraction of values from the exponents. There can be only 1 nonzero digit to the left of the decimal point in correct scientific notation.

Solution:
a) **1.43×10^2** (The decimal point must be moved an additional 1 place to the left: $10^1 + 10^1 = 10^2$)
b) **8.51** (The decimal point must be moved an additional 2 places to the left: $10^2 + 10^{-2} = 10^0$)
c) **7.5** (The decimal point must be moved an additional 3 places to the left: $10^3 + 10^{-3} = 10^0$)

1.62 Plan: Calculate a temporary answer by simply entering the numbers into a calculator. Then you will need to round the value to the appropriate number of significant figures. Cancel units as you would cancel numbers, and place the remaining units after your numerical answer.

Solution:

a) $\frac{(6.626\times10^{-34}\text{ J/s})(2.9979\times10^{8}\text{ m/s})}{489\times10^{-9}\text{ m}}$ = 4.062185 × 10^{-19}

= **4.06 × 10^{-19} J** (489 × 10^{-9} m limits the answer to 3 significant figures; units of m and s cancel)

b) $\frac{(6.022\times10^{23}\text{ molecules/mol})(1.23\times10^{2}\text{ g})}{46.07\text{ g/mol}}$ = 1.6078 × 10^{24}

= **1.61 × 10^{24} molecules** (1.23 × 10^{2} g limits answer to 3 significant figures; units of mol and g cancel)

c) $(6.022\times10^{23}\text{ atoms/mol})(2.18\times10^{-18}\text{ J/atom})\left(\frac{1}{2^2}-\frac{1}{3^2}\right)$ = 1.82333 × 10^{5}

= **1.82 × 10^{5} J/mol** (2.18 × 10^{-18} J/atom limits answer to 3 significant figures; unit of atoms cancels)

1.63 Plan: Calculate a temporary answer by simply entering the numbers into a calculator. Then you will need to round the value to the appropriate number of significant figures. Cancel units as you would cancel numbers, and place the remaining units after your numerical answer.

Solution:

a) $\frac{4.32\times10^{7}\text{ g}}{\frac{4}{3}(3.1416)(1.95\times10^{2}\text{ cm})^3}$ = 1.3909 = **1.39 g/cm^3**

(4.32 × 10^{7} g limits the answer to 3 significant figures)

b) $\frac{(1.84\times10^{2}\text{ g})(44.7\text{ m/s})^2}{2}$ = 1.8382 × 10^{5} = **1.84 × 10^{5} g·m^2/s^2**

(1.84 × 10^{2} g limits the answer to 3 significant figures)

c) $\frac{(1.07\times10^{-4}\text{ mol/L})^2(3.8\times10^{-3}\text{ mol/L})}{(8.35\times10^{-5}\text{ mol/L})(1.48\times10^{-2}\text{ mol/L})^3}$ = 0.16072 = **0.16 L/mol**

(3.8 × 10^{-3} mol/L limits the answer to 2 significant figures; mol^3/L^3 in the numerator cancels mol^4/L^4 in the denominator to leave mol/L in the denominator or units of L/mol)

1.64 Plan: Exact numbers are those which have no uncertainty. Unit definitions and number counts of items in a group are examples of exact numbers.

Solution:

a) The height of Angel Falls is a measured quantity. This is **not** an exact number.
b) The number of planets in the solar system is a number count. This **is** an exact number.
c) The number of grams in a pound is not a unit definition. This is **not** an exact number.
d) The number of millimeters in a meter is a definition of the prefix "milli–." This **is** an exact number.

1.65 Plan: Exact numbers are those which have no uncertainty. Unit definitions and number counts of items in a group are examples of exact numbers.

Solution:

a) The speed of light is a measured quantity. It is **not** an exact number.
b) The density of mercury is a measured quantity. It is **not** an exact number.
c) The number of seconds in an hour is based on the definitions of minutes and hours. This **is** an exact number.
d) The number of states is a counted value. This **is** an exact number.

1.66 Plan: Observe the figure, and estimate a reading the best you can.
Solution:
The scale markings are 0.2 cm apart. The end of the metal strip falls between the mark for 7.4 cm and 7.6 cm. If we assume that one can divide the space between markings into fourths, the uncertainty is one-fourth the separation between the marks. Thus, since the end of the metal strip falls between 7.45 and 7.55 we can report its length as **7.50 ± 0.05 cm**. (Note: If the assumption is that one can divide the space between markings into halves only, then the result is 7.5 ± 0.1 cm.)

1.67 Plan: You are given the density values for five solvents. Use the mass and volume given to calculate the density of the solvent in the cleaner and compare that value to the density values given to identify the solvent. Use the uncertainties in the mass and volume to recalculate the density.
Solution:
a) Density (g/mL) $= \frac{\text{mass}}{\text{volume}} = \frac{11.775\ \text{g}}{15.00\ \text{mL}}$ = 0.7850 g/mL. The closest value is **isopropanol**.
b) Ethanol is denser than isopropanol. Recalculating the density using the maximum mass = (11.775 + 0.003) g with the minimum volume = (15.00 – 0.02) mL, gives
Density (g/mL) $= \frac{\text{mass}}{\text{volume}} = \frac{11.778\ \text{g}}{14.98\ \text{mL}}$ = 0.7862 g/mL. This result is still clearly not ethanol.
Yes, the equipment is precise enough.

1.68 Plan: Calculate the average of each data set. Remember that accuracy refers to how close a measurement is to the actual or true value while precision refers to how close multiple measurements are to each other.
Solution:
a) $I_{avg} = \frac{8.72\ \text{g} + 8.74\ \text{g} + 8.70\ \text{g}}{3}$ = 8.7200 = **8.72 g**

$II_{avg} = \frac{8.56\ \text{g} + 8.77\ \text{g} + 8.83\ \text{g}}{3}$ = 8.7200 = **8.72 g**

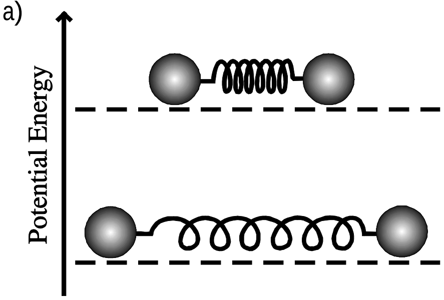
$III_{avg} = \frac{8.50\ \text{g} + 8.48\ \text{g} + 8.51\ \text{g}}{3}$ = 8.4967 = **8.50 g**

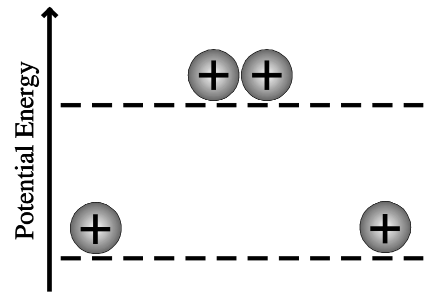
$IV_{avg} = \frac{8.41\ \text{g} + 8.72\ \text{g} + 8.55\ \text{g}}{3}$ = 8.5600 = **8.56 g**

Sets **I** and **II** are most accurate since their average value, 8.72 g, is closest to the true value, 8.72 g.
b) To get an idea of precision, calculate the range of each set of values: largest value – smallest value. A small range is an indication of good precision since the values are close to each other.
I_{range} = 8.74 g – 8.70 g = 0.04 g
II_{range} = 8.83 g – 8.56 g = 0.27 g
III_{range} = 8.51 g – 8.48 g = 0.03 g
IV_{range} = 8.72 g – 8.41 g = 0.31 g
Set III is the most precise (smallest range), but is the least accurate (the average is the farthest from the actual value).
c) **Set I** has the best combination of high accuracy (average value = actual value) and high precision (relatively small range).
d) **Set IV** has both low accuracy (average value differs from actual value) and low precision (has the largest range).

1.69 Plan: Remember that accuracy refers to how close a measurement is to the actual or true value; since the bull's-eye represents the actual value, the darts that are closest to the bull's-eye are the most accurate. Precision refers to how close multiple measurements are to each other; darts that are positioned close to each other on the target have high precision.

Solution:
a) **Experiments II and IV** — the averages appear to be near each other.
b) **Experiments III and IV** — the darts are closely grouped.
c) **Experiment IV and perhaps Experiment II** — the average is in or near the bull's-eye.
d) **Experiment III** — the darts are close together, but not near the bull's-eye.

1.70 Plan: If it is necessary to force something to happen, the potential energy will be higher.
Solution:
a)


b)


a) The balls on the relaxed spring have a lower potential energy and are more stable. The balls on the compressed spring have a higher potential energy, because the balls will move once the spring is released. This configuration is less stable.
b) The two + charges apart from each other have a lower potential energy and are more stable. The two + charges near each other have a higher potential energy, because they repel one another. This arrangement is less stable.

1.71 Plan: A physical change is one in which the physical form (or state) of a substance, but not its composition, is altered. A chemical change is one in which a substance is converted into a different substance with different composition and properties.
Solution:
a) Bonds have been broken in three yellow diatomic molecules. Bonds have been broken in three red diatomic molecules. The six resulting yellow atoms have reacted with three of the red atoms to form three molecules of a new substance. The remaining three red atoms have reacted with three blue atoms to form a new diatomic substance.
b) There has been one physical change as the blue atoms at 273 K in the liquid phase are now in the gas phase at 473 K.

1.72 Plan: Use the concentrations of bromine given.
Solution:

$$\frac{\text{Mass bromine in Dead Sea}}{\text{Mass bromine in seawater}} = \frac{0.50\text{ g/L}}{0.065\text{ g/L}} = \mathbf{7.7/1}$$

1.73 Plan: The swimming pool is a rectangle so the volume of the water can be calculated by multiplying the three dimensions of length, width, and the depth of the water in the pool. The depth in ft must be converted to units of m before calculating the volume. The volume in m^3 is then converted to volume in gal. The density of water is used to find the mass of this volume of water.
Solution:

$$\text{a) Depth of water (m)} = (4.8\text{ ft})\left(\frac{12\text{ in}}{1\text{ ft}}\right)\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)\left(\frac{10^{-2}\text{ m}}{1\text{ cm}}\right) = 1.46304\text{ m}$$

$$\text{Volume (m}^3\text{)} = \text{length} \times \text{width} \times \text{depth} = (50.0\text{ m})(25.0\text{ m})(1.46304\text{ m}) = 1828.8\text{ m}^3$$

$$\text{Volume (gal)} = (1828.8\text{ m}^3)\left(\frac{10^3\text{ L}}{1\text{ m}^3}\right)\left(\frac{1.057\text{ qt}}{1\text{ L}}\right)\left(\frac{1\text{ gal}}{4\text{ qt}}\right) = 4.8326 \times 10^5 = \mathbf{4.8 \times 10^5\text{ gal}}$$

b) Using the density of water = 1.0 g/mL.

$$\text{Mass (kg)} = \left(4.8326\times10^5\ \text{gal}\right)\left(\frac{4\ \text{qt}}{1\ \text{gal}}\right)\left(\frac{1000\ \text{mL}}{1.057\ \text{qt}}\right)\left(\frac{1.0\ \text{g}}{\text{mL}}\right)\left(\frac{1\ \text{kg}}{1000\ \text{g}}\right) = 1.8288 \times 10^6 = \mathbf{1.8 \times 10^6\ kg}$$

1.74 Plan: In each case, calculate the overall density of the ball and contents and compare to the density of air. The volume of the ball in cm^3 is converted to units of L to find the density of the ball itself in g/L. The densities of the ball and the gas in the ball are additive because the volume of the ball and the volume of the gas are the same.

Solution:

a) Density of evacuated ball: the mass is only that of the sphere itself:

$$\text{Volume of ball (L)} = \left(560\ \text{cm}^3\right)\left(\frac{1\ \text{mL}}{1\ \text{cm}^3}\right)\left(\frac{10^{-3}\ \text{L}}{1\ \text{mL}}\right) = 0.560 = 0.56\ \text{L}$$

$$\text{Density of evacuated ball} = \frac{\text{mass}}{\text{volume}} = \frac{0.12\ \text{g}}{0.560} = 0.21\ \text{g/L}$$

The evacuated ball will **float** because its density is less than that of air.

b) Because the density of CO_2 is greater than that of air, a ball filled with CO_2 will **sink**.

c) Density of ball + density of hydrogen = 0.0899 + 0.21 g/L = 0.30 g/L

The ball will **float** because the density of the ball filled with hydrogen is less than the density of air.

d) Because the density of O_2 is greater than that of air, a ball filled with O_2 will **sink**.

e) Density of ball + density of nitrogen = 0.21 g/L + 1.165 g/L = 1.38 g/L

The ball will **sink** because the density of the ball filled with nitrogen is greater than the density of air.

f) To sink, the total mass of the ball and gas must weigh $\left(0.560\ \text{L}\right)\left(\frac{1.189\ \text{g}}{1\ \text{L}}\right) = 0.66584\ \text{g}$

For the evacuated ball:

0.66584 – 0.12 g = 0.54585 = **0.55 g**. More than 0.55 g would have to be added to make the ball sink.

For ball filled with hydrogen:

$$\text{Mass of hydrogen in the ball} = \left(0.56\ \text{L}\right)\left(\frac{0.0899\ \text{g}}{1\ \text{L}}\right) = 0.0503\ \text{g}$$

Mass of hydrogen and ball = 0.0503 g + 0.12 g = 0.17 g

0.66584 – 0.17 g = 0.4958 = **0.50 g**. More than 0.50 g would have to be added to make the ball sink.

1.75 Plan: Convert the cross-sectional area of 1.0 μm^2 to mm^2 and then use the tensile strength of grunerite to find the mass that can be held up by a strand of grunerite with that cross-sectional area. Calculate the area of aluminum and steel that can match that mass.

Solution:

$$\text{Cross-sectional area (mm}^2\text{)} = \left(1.0\ \mu\text{m}^2\right)\left(\frac{\left(1\times10^{-6}\text{m}\right)^2}{\left(1\ \mu\text{m}\right)^2}\right)\left(\frac{(1\ \text{mm})^2}{\left(1\times10^{-3}\ \text{m}\right)^2}\right) = 1.0 \times 10^{-6}\ \text{mm}^2$$

Calculate the mass that can be held up by grunerite with a cross-sectional area of 1.0 × 10^{-6} mm^2:

$$\left(1\times10^{-6}\text{mm}^2\right)\left(\frac{3.5\times10^2\ \text{kg}}{1\ \text{mm}^2}\right) = 3.5\times10^{-4}\ \text{kg}$$

Calculate the area of aluminum required to match a mass of 3.5 × 10^{-4} kg:

$$\left(3.5\times10^{-4}\ \text{kg}\right)\left(\frac{2.205\ \text{lb}}{1\ \text{kg}}\right)\left(\frac{1\ \text{in}^2}{2.5\times10^4\ \text{lb}}\right)\left(\frac{(2.54\ \text{cm})^2}{(1\ \text{in})^2}\right)\left(\frac{(10\ \text{mm})^2}{(1\ \text{cm})^2}\right) = 1.9916\times10^{-5} = \mathbf{2.0 \times 10^{-5}\ mm^2}$$

Calculate the area of steel required to match a mass of 3.5 × 10^{-4} kg:

$$\left(3.5\times10^{-4}\ \text{kg}\right)\left(\frac{2.205\ \text{lb}}{1\ \text{kg}}\right)\left(\frac{1\ \text{in}^2}{5.0\times10^4\ \text{lb}}\right)\left(\frac{(2.54\ \text{cm})^2}{(1\ \text{in})^2}\right)\left(\frac{(10\ \text{mm})^2}{(1\ \text{cm})^2}\right) = 9.9580\times10^{-6} = \mathbf{1.0 \times 10^{-5}\ mm^2}$$

1.76 Plan: Convert the surface area to m^2 and then use the surface area and the depth to determine the volume of the oceans (area × depth = volume) in m^3. The volume is then converted to liters, and finally to the mass of gold using the density of gold in g/L. Once the mass of the gold is known, its density is used to find the volume of that amount of gold. The mass of gold is converted to troy oz and the price of gold per troy oz gives the total price.

Solution:

a) Area of ocean (m^2) = $\left(3.63\times10^{8}\ \text{km}^2\right)\left(\frac{(1000\ \text{m})^2}{(1\ \text{km})^2}\right)$ = $3.63 \times 10^{14}\ \text{m}^2$

Volume of ocean (m^3) = (area)(depth) = ($3.63 \times 10^{14}\ \text{m}^2$)(3800 m) = $1.3794 \times 10^{18}\ \text{m}^3$

Mass of gold (g) = $\left(1.3794\times10^{18}\ \text{m}^3\right)\left(\frac{1\ \text{L}}{10^{-3}\ \text{m}^3}\right)\left(\frac{5.8\times10^{-9}\ \text{g}}{\text{L}}\right)$ = 8.00052×10^{12} = $\mathbf{8.0 \times 10^{12}\ g}$

b) Use the density of gold to convert mass of gold to volume of gold:

Volume of gold (m^3) = $\left(8.00052\times10^{12}\ \text{g}\right)\left(\frac{1\ \text{cm}^3}{19.3\ \text{g}}\right)\left(\frac{(0.01\ \text{m})^3}{(1\ \text{cm})^3}\right)$ = 4.14535×10^5 = $\mathbf{4.1 \times 10^5\ m^3}$

c) Value of gold = $\left(8.00052\times10^{12}\ \text{g}\right)\left(\frac{1\ \text{tr. oz}}{31.1\ \text{g}}\right)\left(\frac{\$1595}{1\ \text{tr. oz.}}\right) = 4.1032\times10^{14}$ = $\mathbf{\$4.1\times10^{14}}$

1.77 Plan: The mass of zinc in the sample of yellow zinc in part (a) is found from the percent of zinc in the sample. The mass of copper is found by subtracting the mass of zinc from the total mass of yellow zinc. In part (b), subtract the mass percent of zinc from 100 to find the mass percent of copper.

Solution:

a) Mass of zinc in the 34% zinc sample = $(185\ \text{g yellow zinc})\left(\frac{34\%\ \text{zinc}}{100\%\ \text{yellow zinc}}\right)$ = 62.9 g Zn

Mass of zinc in the 37% zinc sample = $(185\ \text{g yellow zinc})\left(\frac{37\%\ \text{zinc}}{100\%\ \text{yellow zinc}}\right)$ = 68.45 g Zn

Mass copper = total mass – mass zinc
Mass copper (34% zinc sample) = 185 g – 62.9 g = 122.1 = 122 g
Mass copper (37% zinc sample) = 185 g – 68.45 g = 116.55 = 117 g
117 to 122 g copper

b) The 34% zinc sample contains 100 – 34 = 66% copper. The 37% zinc sample contains 100 – 37 = 63% copper.

Mass of zinc = $(46.5\ \text{g copper})\left(\frac{34\%\ \text{zinc}}{66\%\ \text{copper}}\right)$ = 23.95 = 24 g

Mass of zinc = $(46.5\ \text{g copper})\left(\frac{37\%\ \text{zinc}}{63\%\ \text{copper}}\right)$ = 27.31 = 27 g

24 to 27 g zinc

1.78 Plan: Use the equations for temperature conversion given in the chapter. The mass of nitrogen is conserved when the gas is liquefied; the mass of the nitrogen gas equals the mass of the liquid nitrogen. Use the density of nitrogen gas to find the mass of the nitrogen; then use the density of liquid nitrogen to find the volume of that mass of liquid nitrogen.

Solution:

a) T (in °C) = T (in K) – 273.15 = 77.36 K – 273.15 = **–195.79°C**

b) T (in °F) = $\frac{9}{5}T(\text{in °C}) + 32 = \frac{9}{5}(-195.79\text{°C}) + 32$ = –320.422 = **–320.42°F**

c) Mass of liquid nitrogen = mass of gaseous nitrogen = $(895.0\text{ L})\left(\frac{4.566\text{ g}}{1\text{ L}}\right)$ = 4086.57 g N_2

Volume of liquid N_2 = $(4086.57\text{ g})\left(\frac{1\text{ L}}{809\text{ g}}\right)$ = 5.0514 = **5.05 L**

1.79 Plan: For part (a), convert mi to m and h to s. For part (b), time is converted from h to min and length from mi to km. For part (c), convert the distance in ft to mi and use the average speed in mi/h to find the time necessary to cover the given distance.

Solution:

a) Speed (m/s) = $\left(\frac{5.9\text{ mi}}{\text{h}}\right)\left(\frac{1000\text{ m}}{0.62\text{ mi}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)$ = 2.643 = **2.6 m/s**

b) Distance (km) = $(98\text{ min})\left(\frac{1\text{ h}}{60\text{ min}}\right)\left(\frac{5.9\text{ mi}}{\text{h}}\right)\left(\frac{1\text{ km}}{0.62\text{ mi}}\right)$ = 15.543 = **16 km**

c) Time (h) = $(4.75\times10^4\text{ ft})\left(\frac{1\text{ mi}}{5280\text{ ft}}\right)\left(\frac{1\text{ h}}{5.9\text{ mi}}\right)$ = 1.5248 = 1.5 h

If she starts running at 11:15 am, 1.5 hours later the time is **12:45 pm**.

1.80 Plan: A physical change is one in which the physical form (or state) of a substance, but not its composition, is altered. A chemical change is one in which a substance is converted into a different substance with different composition and properties. A physical property is a characteristic shown by a substance itself, without interacting with or changing into other substances. A chemical property is a characteristic of a substance that appears as it interacts with, or transforms into, other substances.

Solution:

a) **Scene A** shows a physical change. The substance changes from a solid to a gas but a new substance is not formed.

b) **Scene B** shows a chemical change. Two diatomic elements form from a diatomic compound.

c) Both **Scenes A and B** result in different physical properties. Physical and chemical changes result in different physical properties.

d) **Scene B** is a chemical change; therefore, it results in different chemical properties.

e) **Scene A** results in a change in state. The substance changes from a solid to a gas.

1.81 Plan: In visualizing the problem, the two scales can be set next to each other.

Solution:

There are 50 divisions between the freezing point and boiling point of benzene on the °X scale and 74.6 divisions (80.1°C – 5.5°C) on the °C scale. So °X = $\left(\frac{50°\text{X}}{74.6°\text{C}}\right)$°C

This does not account for the offset of 5.5 divisions in the °C scale from the zero point on the °X scale.

So °X = $\left(\frac{50°\text{X}}{74.6°\text{C}}\right)$(°C – 5.5°C)

Check: Plug in 80.1°C and see if result agrees with expected value of 50°X.

So °X = $\left(\frac{50°\text{X}}{74.6°\text{C}}\right)$(80.1°C – 5.5°C) = 50°X

Use this formula to find the freezing and boiling points of water on the °X scale.

fp_{water} °X = $\left(\frac{50°\text{X}}{74.6°\text{C}}\right)$(0.00°C – 5.5°C) = 3.68°X = **–3.7°X**

$$\text{bp}_{\text{water}}\ °X = \left(\frac{50°X}{74.6°C}\right)(100.0°C - 5.5°C) = \mathbf{63.3°X}$$

1.82 Plan: Determine the total mass of Earth's crust in metric tons (t) by finding the volume of crust (surface area × depth) in km^3 and then in cm^3 and then using the density to find the mass of this volume, using conversions from the inside back cover. The mass of each individual element comes from the concentration of that element multiplied by the mass of the crust.

Solution:

Volume of crust (km^3) = area × depth = $(35\ km)(5.10 \times 10^8\ km^2)$ = $1.785 \times 10^{10}\ km^3$

Volume of crust (cm^3) = $\left(1.785 \times 10^{10}\ km^3\right)\left(\frac{(1000\ m)^3}{(1\ km)^3}\right)\left(\frac{(1\ cm)^3}{(0.01\ m)^3}\right)$ = $1.785 \times 10^{25}\ cm^3$

Mass of crust (t) = $\left(1.785 \times 10^{25}\ cm^3\right)\left(\frac{2.8\ g}{1\ cm^3}\right)\left(\frac{1\ kg}{1000\ g}\right)\left(\frac{1\ t}{1000\ kg}\right)$ = 4.998×10^{19} t

Mass of oxygen (g) = $\left(4.998 \times 10^{19}\ t\right)\left(\frac{4.55 \times 10^5\ g\ oxygen}{1\ t}\right)$ = 2.2741×10^{25} = **2.3×10^{25} g oxygen**

Mass of silicon (g) = $\left(4.998 \times 10^{19}\ t\right)\left(\frac{2.72 \times 10^5\ g\ silicon}{1\ t}\right)$ = 1.3595×10^{25} = **1.4×10^{25} g silicon**

Mass of ruthenium = mass of rhodium = $\left(4.998 \times 10^{19}\ t\right)\left(\frac{1 \times 10^{-4}\ g\ element}{1\ t}\right)$

= 4.998×10^{15} = **5×10^{15} g each of ruthenium and rhodium**