SUMMARY

LO1 The **scientific method** starts with observations of natural phenomena and/or the results of laboratory experiments; next, a tentative explanation, or **hypothesis**, is developed that explains the observations and results; then the hypothesis is tested through further experimentation before a **scientific theory** is formulated that explains all the results and observations available. A **scientific law** is a comprehensive, succinct description of a phenomenon or process. Dalton's atomic theory explains Proust's **law of definite proportions** and Dalton's **law of multiple proportions**. (Section 1.1 (Chapter01-01.xhtml))

LO2 The COAST framework used in this book to solve problems has four components: **C**ollect and **O**rganize information and ideas, **A**nalyze the information to determine how it can be used to obtain the answer, **S**olve the problem (often the math-intensive step), and **T**hink about the answer. (Section 1.2 (Chapter01-02.xhtml))

LO3 The principal classes of matter are **mixtures** and **pure substances**. Pure substances may be either **elements** or **compounds** (elements chemically combined together). A **chemical formula** indicates the proportion of elements in a substance. The properties of a substance are either **intensive properties**, which are independent of quantity, or **extensive properties**, which are related to the quantity of the substance. The **physical properties** of a substance can be observed without changing the substance into another one, whereas the **chemical properties** of a substance (such as flammability) can be observed only through chemical reactions involving the substance. The **density (*d*)** of an object or substance is the ratio of its mass to its volume. Mixtures may be **homogeneous** (such mixtures are also called **solutions**) or **heterogeneous**, and they can be separated by **physical processes** such as **distillation**, **filtration**, and **chromatography**. Distillation separates substances of differing **volatility**. (Section 1.3 (Chapter01-03.xhtml))

LO4 The states (or phases) of matter include **solid**, in which the particles have an ordered structure; **liquid**, in which the particles are free to move past each other; and **gas** (or *vapor*), in which the particles have the most freedom and completely fill their container. Familiar phase changes

include melting, freezing, vaporization, and condensation. The transformation of a solid directly into a gas is **sublimation**; the reverse process is **deposition**. (Section 1.4 (Chapter01-04.xhtml))

LO5 **Energy** can be defined as the ability to do **work**. **Heat** is the flow of energy due to a difference in temperature. **Potential energy (PE)** is the energy in an object due to its position or composition. **Kinetic energy (KE)** is the energy of motion. According to the **law of conservation of energy**, energy cannot be created or destroyed. (Section 1.5 (Chapter01-05.xhtml))

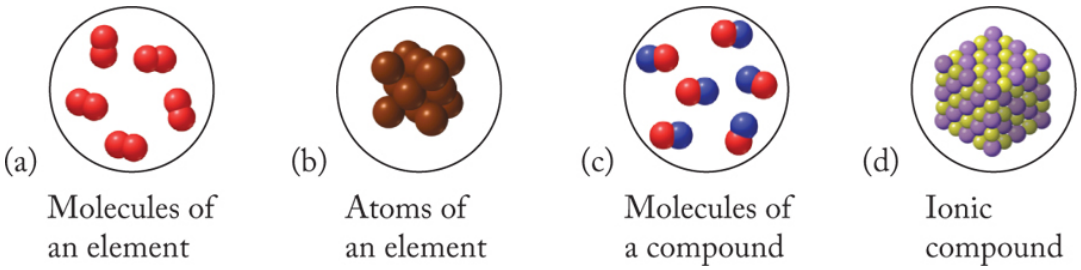
LO6 The composition of molecular compounds is described by their molecular formulas. The three-dimensional arrangements of their atoms may be represented by structural formulas, ball-and-stick models, and space-filling models. (Section 1.6 (Chapter01-06.xhtml))

LO7 Measured quantities and values derived from them are inherently uncertain. Exact values include those derived from counting objects or those that are defined, such as 60 seconds in a minute. The appropriate number of **significant figures** is used to express the certainty in the result of a measurement or calculation. The **precision** of any set of measurements indicates how repeatable the measurement is, whereas the **accuracy** of a measurement indicates how close to the true value the measured value is. (Section 1.7 (Chapter01-07.xhtml))

LO8 The International System of Units (SI), in which the **meter (m)** is the standard unit of length, evolved from the metric system and is widely used in science to express the results of measurements. Prefixes naming powers of 10 are used with SI base units to express quantities much larger or much smaller than the base units. Dimensional analysis uses **conversion factors** (fractions in which the numerators and denominators have different units but represent the same quantity) to convert a value from one unit into another unit. (Section 1.8 (Chapter01-08.xhtml))

LO9 The average value and variability in repeated measurements or analyses are determined by calculating the **arithmetic mean** ($\bar{x}$), **standard deviation** (s), and **confidence interval**. An **outlier** in a data set may be identified based on the results of Grubbs' test. (Section 1.9 (Chapter01-09.xhtml))

PARTICULATE **PREVIEW WRAP-UP**



PROBLEM-SOLVING SUMMARY

Type of Problem	Concepts and Equations	Sample Exercises
Calculating density	$d = \frac{m}{V}$	**1.1 (Chapter01-03.xhtml#ATOMS1-1)**
Distinguishing exact from uncertain values	Quantities that can be counted are exact. Measured quantities or conversion factors that are not exact values are inherently uncertain.	**1.5 (Chapter01-07.xhtml#ATOMS1-5)**
Using significant figures in calculations	Apply the weak-link rule: the number of significant figures in a calculated quantity involving multiplication or division can be no greater than the number of significant figures in the least certain value used to calculate it. When adding or subtracting values, the number of digits after the decimal point in the sum or difference can be no greater than in the value that has the fewest digits after its decimal point.	**1.6 (Chapter01-07.xhtml#ATOMS1-6)**

Converting between temperature scales	$T(\text{K}) = T(°\text{C}) + 273.15$ $T(°\text{C}) = (5/9)[T(°\text{F}) - 32]$	**1.7 (Chapter01-08.xhtml#ATOMS1-7)**
Calculating kinetic energy	$\text{KE} = \frac{1}{2}mu^2$	**1.8 (Chapter01-08.xhtml#ATOMS1-8)**
Converting units using dimensional analysis	Converting values from one set of units to another involves multiplication by one or more conversion factors, which are set up so that the original units cancel out.	**1.9 (Chapter01-08.xhtml#ATOMS1-9)–1.10 (Chapter01-08.xhtml#ATOMS1-10)**
Calculating the mean ($\bar{x}$), standard deviation (s), and confidence interval of a set of data	$\bar{x} = \frac{\sum_i (x_i)}{n}$ $s = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{n-1}}$ $\mu = \bar{x} \pm \frac{ts}{\sqrt{n}}$	**1.11 (Chapter01-09.xhtml#ATOMS1-11)**
Testing whether a suspect data point (x_i) is an outlier	Use Grubbs' test: calculate the value of Z using Equation 1.8: $Z = \frac{\lvert x_i - \bar{x} \rvert}{s}$ and compare it to the appropriate reference value in Table 1.7. If the calculated Z is greater, the suspect data point is an outlier.	**1.12 (Chapter01-09.xhtml#ATOMS1-12)**

VISUAL PROBLEMS

(Answers to boldface end-of-chapter questions and problems are in the back of the book.)

1.1. For each image in Figure P1.1, identify what class of pure substance is depicted (an element or compound) and identify the physical state(s).

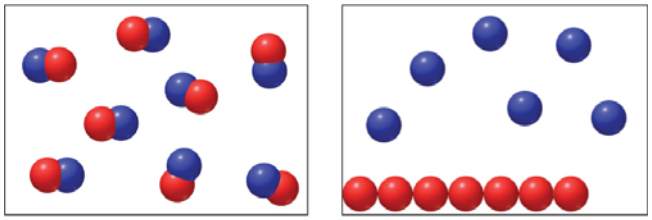


FIGURE P1.1

1.2. For each image in Figure P1.2, identify what class of matter is depicted (an element, a compound, a mixture of elements, or a mixture of compounds) and identify the physical state.

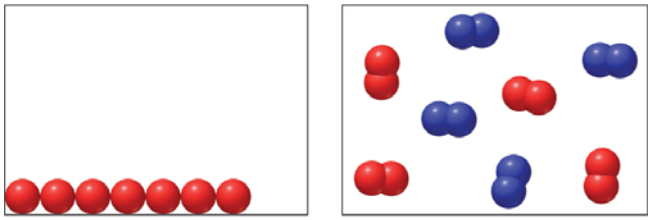


FIGURE P1.2

1.3. Which of the following statements best describes the change depicted in Figure P1.3?

a. A mixture of two gaseous elements undergoes a chemical reaction, forming a gaseous compound.

b. A mixture of two gaseous elements undergoes a chemical reaction, forming a solid compound.

c. A mixture of two gaseous elements undergoes deposition.

d. A mixture of two gaseous elements condenses.

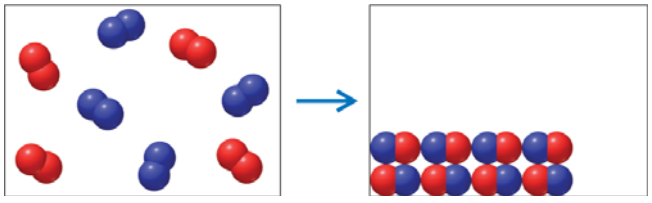


FIGURE P1.3

1.4. Which of the following statements best describes the change depicted in Figure P1.4?

a. A mixture of two gaseous elements is cooled to a temperature at which one of them condenses.

b. A mixture of two gaseous compounds is heated to a temperature at which one of them decomposes.

c. A mixture of two gaseous elements undergoes deposition.

d. A mixture of two gaseous elements reacts to form two compounds, one of which is a liquid.

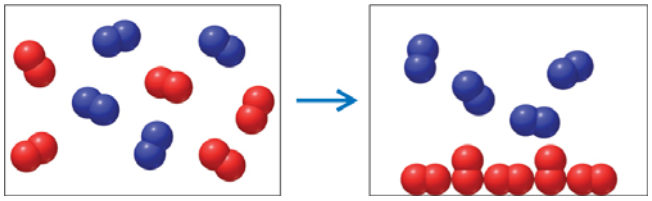


FIGURE P1.4

1.5. A space-filling model of formic acid is shown in Figure P1.5. What is the molecular formula of formic acid?

FIGURE P1.5

1.6. Use representations [A] through [I] in Figure P1.6 to answer questions a–f.

a. Which molecule contains the most atoms?

b. Which compound contains the most elements?

c. Which representation depicts a solid solution?

d. Which representation depicts a homogeneous mixture?

e. Which pure substances are compounds?

f. Which pure substances are elements?

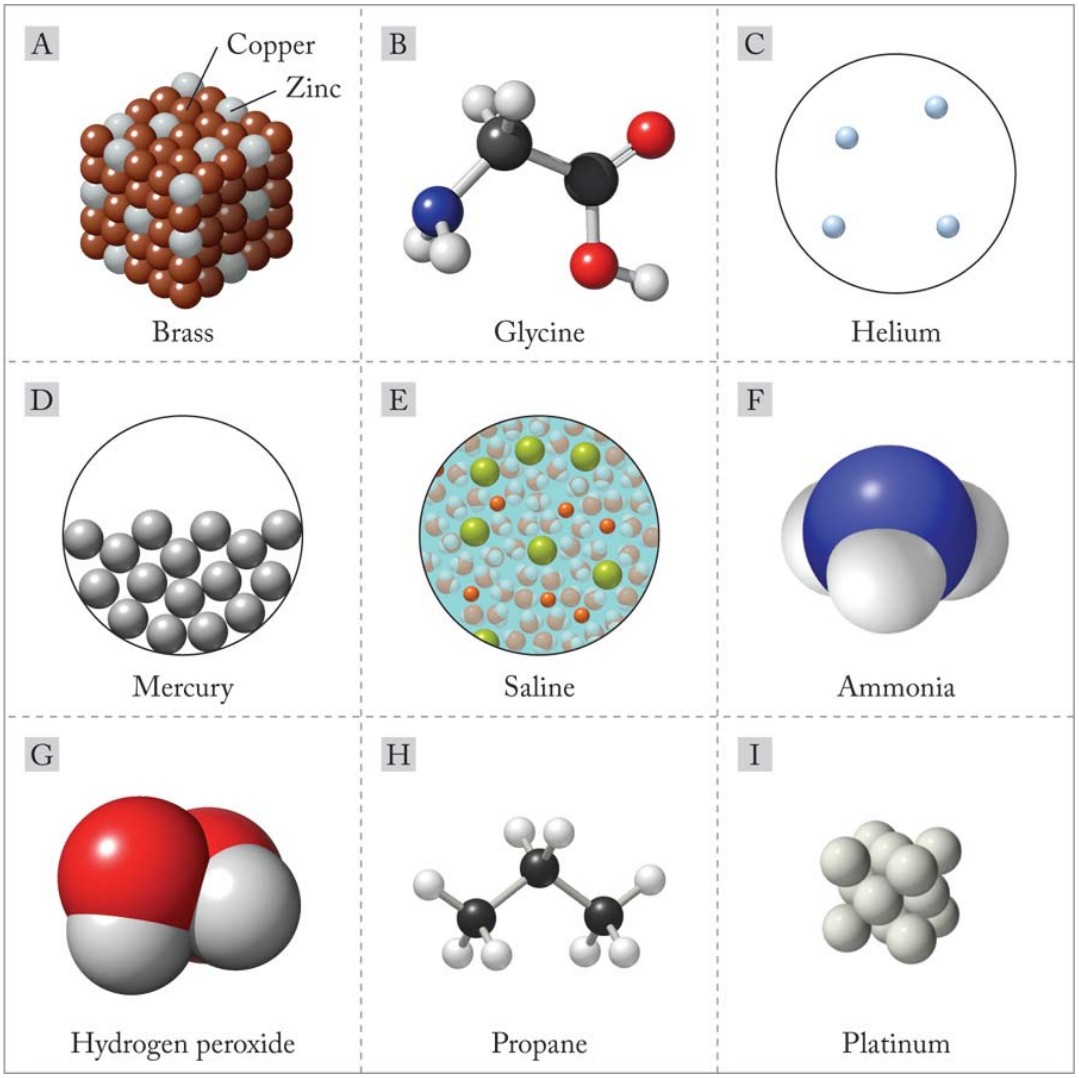


FIGURE P1.6

QUESTIONS AND PROBLEMS

Atomic Theory: The Scientific Method in Action

Concept Review

1.7. How does a hypothesis differ from a scientific theory?

1.8. How does a hypothesis become a theory?

1.9. Describe how Dalton's atomic theory supported his law of multiple proportions.

1.10. Why was the belief that matter consists of atoms a philosophy in ancient Greece but was considered a theory in the early 1800s?

1.11. Why was Proust's law of definite proportions opposed by many scientists of his time?

*1.12. Describe a chemical reaction that produces two compounds whose compositions illustrate Dalton's law of multiple proportions.

1.13. Describe how a scientific theory differs from the meaning of *theory* as it is used in normal conversation.

1.14. Can a theory be proven?

Classes of Matter

Concept Review

1.15. Which of the following foods is a heterogeneous mixture? (a) bottled water; (b) a Snickers bar; (c) grape juice; (d) an uncooked hamburger

1.16. Which of the following foods is a homogeneous mixture? (a) freshly brewed coffee; (b) vinegar; (c) a slice of white bread; (d) a slice of ham

1.17. Which of the following foods is a heterogeneous mixture? (a) apple juice; (b) cooking oil; (c) solid butter; (d) orange juice; (e) tomato juice

1.18. Which of the following is a homogeneous mixture? (a) a bronze sword from ancient Greece; (b) sweat; (c) Nile River water; (d) gasoline; (e) compressed air in a scuba tank

***1.19.** Filters can be used to remove suspended particles of soil from drinking water. Would distillation also remove these particles? If so, suggest a reason why it is not widely used.

1.20. Which of the colored compounds in the photograph in Figure 1.9(b) interact more strongly with the stationary phase of the separation: those at the very top or those below them? Assume the liquid phase migrates upward.

Properties of Matter

Concept Review

1.21. List one chemical and four physical properties of gold.

1.22. Describe three physical properties that gold and silver have in common and three physical properties that distinguish them.

1.23. Give three properties that enable a person to distinguish between table sugar, water, and oxygen.

1.24. Give three properties that enable a person to distinguish between table salt, sand, and copper.

1.25. Indicate whether each of the following properties is a physical or chemical property of sodium (Na):

a. Its density is greater than that of kerosene and less than that of water.

b. It has a lower melting point than most other metals.

c. It is an excellent conductor of heat and electricity.

d. It is soft and can be easily cut with a knife.

e. Freshly cut sodium is shiny, but it rapidly tarnishes when it comes in contact with air.

f. It reacts very vigorously with water, releasing hydrogen gas (H_2).

1.26. Indicate whether each of the following is a physical or chemical property of hydrogen gas (H_2):

a. At room temperature, its density is less than that of any other gas.

b. It reacts vigorously with oxygen (O_2) to form water.

c. Liquefied H_2 boils at −253°C.

d. H_2 gas does not conduct electricity.

1.27. Can an extensive property be used to identify a substance? Explain why or why not.

1.28. Which of the following are intensive properties of a sample of a substance? (a) freezing point; (b) heat content; (c) temperature

***1.29.** Is the capacity of carbon dioxide to extinguish fires linked to its chemical properties, its physical properties, or both? Explain your answer.

1.30. The stainless steel used to make kitchen knives and many other tools gets its name from its capacity to resist corrosion and, therefore, *stain less*. Is this a chemical or physical property of stainless steel?

States of Matter

Concept Review

1.31. In what ways are the arrangements of water molecules in ice and liquid water similar and in what ways are they different?

1.32. What occupies the space between the particles that make up a gas?

1.33. Substances have characteristic *triple points*, unique combinations of temperature and pressure at which substances can simultaneously exist as solids, liquids, and gases. In which of these three states do the particles of a substance at its triple point have the greatest motion and in which state do they have the least motion?

1.34. A pot of water on a stove is heated to a rapid boil. Identify the gas inside the bubbles that forms in the boiling water.

1.35. A brief winter storm leaves a dusting of snow on the ground. During the sunny but very cold day after the storm, the snow disappears even though the air temperature never gets above freezing. If the snow didn't melt, where did it go?

1.36. Equal masses of water undergo condensation, deposition, evaporation, and sublimation.

a. Which of the processes is accompanied by the *release* of the greatest amount of energy?

b. In which of the processes is the greatest amount of energy *absorbed*?

Forms of Energy

Concept Review

1.37. How are energy and work related?

1.38. Explain the difference between potential energy and kinetic energy.

1.39. Which of the following statements about heat are true?

a. Heat is the transfer of energy from a warmer place to a cooler one.

b. Heat flows faster from a full container of hot coffee than a half-full container of coffee at the same temperature.

c. A cup of hot coffee loses heat faster than the same cup full of warm coffee.

1.40. Describe three examples of energy transfer that happen when you speak on a cell phone to a friend.

Problems

1.41. A subcompact car with a mass of 1400 kg and a loaded dump truck with a mass of 18,000 kg are traveling at the same speed. How many times more kinetic energy does the dump truck have than the car?

1.42. **Speed of Baseball Pitches** Major League Baseball pitchers throw a pitch called a *changeup*, which looks like a fastball leaving the pitcher's hand but has less speed than a typical fastball. How much more kinetic energy does a 92 mph fastball have than a 78 mph changeup? Express your answer as a percentage of the kinetic energy of the changeup.

Making Measurements and Expressing the Results; Unit Conversions and Dimensional Analysis

Concept Review

1.43. Describe in general terms how the SI and U.S. customary systems of units differ.

1.44. Suggest two reasons why SI units are not more widely used in the United States.

1.45. Both the Fahrenheit and Celsius scales are based on reference temperatures that are 100 degrees apart. Suggest a reason why the Celsius scale is preferred by scientists.

1.46. In what way are the Celsius and Kelvin scales similar and in what way are they different?

1.47. What is meant by an *absolute* temperature scale?

1.48. Can a temperature in °C ever have the same value in °F?

Problems

Note: Some physical properties of the elements are listed in Appendix 3.

1.49. **Olympic Mile** An Olympic "mile" is actually 1500 m. What percentage is an Olympic mile of a U.S. mile (5280 ft)?

1.50. A sport-utility vehicle has an average mileage rating of 18 miles per gallon. How many gallons of gasoline are needed for a 389-mile trip?

1.51. A single strand of natural silk may be as long as 4.0×10^3 m. What is this length in miles?

1.52. The speed of light in a vacuum is 2.998×10^8 m/s. What is the speed of light in km/h?

1.53. If a wheelchair-marathon racer moving at 13.1 miles per hour expends energy at a rate of 665 Calories per hour, how much energy in Calories would be required to complete a marathon race (26.2 miles) at that pace?

1.54. **Boston Marathon** To qualify to run in the 2016 Boston Marathon, a distance of 26.2 miles, an 18-year-old woman had to have completed another marathon in 3 hours and 35 minutes or less. Translate this qualifying time and distance into average speeds expressed in (a) miles per hour and (b) meters per second.

1.55. **Nearest Star** At a distance of 4.3 light-years, Proxima Centauri is the nearest star to our solar system. What is the distance to Proxima Centauri in kilometers? (The speed of light in space is 2.998×10^8 m/s.)

1.56. **Sports Car** The Porsche Boxster Spyder (on the left in Figure P1.56) is powered by a 320-horsepower gasoline engine. The electric motor in the Tesla Roadster (on the right in Figure P1.56) is rated at 215 kilowatts. Which is the more powerful sports car? (1 horsepower = 745.7 watts.)

FIGURE P1.56

***1.57.** The level of water in an Olympic-size swimming pool (50.0 m long, 25.0 m wide, and about 2 m deep) needs to be lowered 3.0 cm. If water is pumped out at a rate of 5.2 L per second, how long will it take to lower the water level 3.0 cm?

*1.58. The price of a popular soft drink is $1.00 for 24 fluid ounces (fl oz) or $0.75 for 0.50 L. Which is a better buy? (1 qt = 32 fl oz.)

1.59. Suppose a runner completes a 10K (10.0 km) road race in 41 minutes and 23 seconds. What is the runner's average speed in meters per second?

1.60. **Kentucky Derby Record** In 1973 a horse named Secretariat ran the fastest Kentucky Derby in history, taking 1 minute and 59.4 seconds to run 1.25 miles. What was Secretariat's average speed in (a) miles per hour and (b) meters per second?

1.61. What is the mass of a magnesium block that measures 2.5 cm × 3.5 cm × 1.5 cm?

1.62. What is the mass of an osmium block that measures 6.5 cm × 9.0 cm × 3.25 cm? Do you think you could lift it with one hand?

1.63. A chemist needs 35.0 g of concentrated sulfuric acid for an experiment. The density of concentrated sulfuric acid at room temperature is 1.84 g/mL. What volume of the acid is required?

1.64. What is the mass of 65.0 mL of ethanol? (Its density at room temperature is 0.789 g/mL.)

1.65. A brand new silver U.S. dollar weighs 0.934 oz. Express this mass in grams and kilograms. (1 oz = 28.35 g.)

1.66. A U.S. dime weighs 2.5 g. What is the U.S. dollar value of exactly 1 kg of dimes?

1.67. What volume of gold would be equal in mass to a piece of copper with a volume of 125 cm^3?

*1.68. A small hot-air balloon is filled with 1.00×10^6 L of air at a temperature at which the density of air is 1.18 g/L. As the air in the balloon is heated further, it expands and 9×10^4 L escapes out the open bottom of the balloon. What is the density of the heated air remaining inside the balloon?

1.69. What is the volume of 1.00 kg of mercury?

1.70. A student wonders whether a piece of jewelry is made of pure silver. She determines that its mass is 3.17 g. Then she drops it into a 10-mL graduated cylinder partially filled with water and determines that its volume is 0.3 mL. Could the jewelry be made of pure silver?

***1.71.** The average density of Earth is 5.5 g/cm^3. The mass of Venus is 81.5% of Earth's mass, and the volume of Venus is 88% of Earth's volume. What is the density of Venus?

1.72. Earth has a mass of 6.0×10^{27} g and an average density of 5.5 g/cm^3.

a. What is the volume of Earth in cubic kilometers?

*b. Geologists sometimes express the "natural" density of Earth after doing a calculation that corrects for gravitational squeezing (compression of the core because of high pressure). Should the natural density be more or less than 5.5 g/cm^3?

***1.73.** **Utility Boats for the Navy** A plastic material called high-density polyethylene (HDPE) was once evaluated for use in impact-resistant hulls of small utility boats for the U.S. Navy. A cube of this material measures 1.20×10^{-2} m on a side and has a mass of 1.70×10^{-3} kg. Seawater at the surface of the ocean has a density of 1.03 g/cm^3. Will this cube float on water?

1.74. **Dimensions of the Sun** The sun is a sphere with an estimated mass of 2×10^{30} kg. If the radius of the sun is 7.0×10^5 km, what is the average density of the sun in units of grams per cubic centimeter? The volume of a sphere is $\frac{4}{3}\pi r^3$.

1.75. The Golden Jubilee diamond (Figure P1.75) has a mass of 545.67 carats (1 carat = 0.200 g). What is the mass of the diamond in (a) grams and (b) ounces? (1 pound = 16 ounces.)

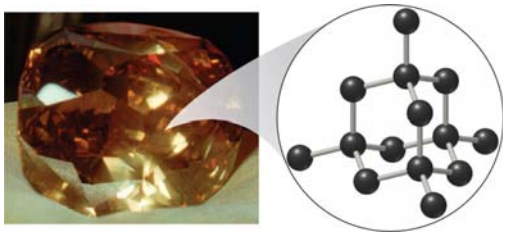


FIGURE P1.75

1.76. The density of diamond is 3.51 g/cm^3. What is the volume of the Golden Jubilee diamond in Figure P1.75?

1.77. Which of the following numbers have just three significant figures? (a) 7.02; (b) 6.452; (c) 302; (d) 6.02×10^{23}; (e) 12.77; (f) 3.43

1.78. Which of the following numbers have four significant figures? (a) 0.0592; (b) 0.08206; (c) 8.314; (d) 273.15; (e) 5.091×10^3; (f) 9.490

1.79. Perform each of the following calculations and express the answer with the correct number of significant figures:

a. $3.15 \times 2255 / 7.7 =$

b. $(6.7399 \times 10^{-18}) \times (1.0135 \times 10^{3}) / (52.67 + 0.144) =$

c. $(4.7 + 58.69)/(6.022 \times 10^{23} \times 6.864) =$

d. $(76.2 - 60.0)/[43.53 \times (9.988 \times 10^{4})] =$

1.80. Perform each of the following calculations, and express the answer with the correct number of significant figures:

a. $[(12 \times 60.0) + 55.3]/(5.000 \times 10^{3}) =$

b. $3.1416 \times (2.031)^{2} \times 3.75 \times 8.00 =$

c. The number of cubic centimeters in 389 cubic inches

d. The average (mean) of 8.7, 8.5, 8.5, 8.9, and 8.8

1.81. Liquid helium boils at 4.2 K. What is the boiling point of helium in degrees Celsius?

1.82. Liquid hydrogen boils at −253°C. What is the boiling point of H_2 on the Kelvin scale?

1.83. **Topical Anesthetic** Ethyl chloride acts as a mild topical anesthetic because it chills the skin when sprayed on it. It dulls the pain of injury and is sometimes used to make removing splinters easier. The boiling point of ethyl chloride is 12.3°C. What is its boiling point on the Fahrenheit and Kelvin scales?

1.84. **Dry Ice** The temperature of the dry ice (solid carbon dioxide) in ice cream vending carts is −78°C. What is this temperature on the Fahrenheit and Kelvin scales?

1.85. **Record Low** The lowest temperature measured on Earth is −128.6°F, recorded at Vostok, Antarctica, in July 1983. What is this temperature on the Celsius and Kelvin scales?

1.86. **Record High** The highest temperature ever recorded in the United States is 134°F at Greenland Ranch, Death Valley, California, on July 13, 1913. What is this temperature on the Celsius and Kelvin scales?

1.87. **Critical Temperature** The discovery of "high-temperature" superconducting materials in the mid-1980s spurred a race to prepare the material with the highest superconducting temperature. The critical temperatures (T_c)—the temperatures at which the material becomes superconducting—of $YBa_2Cu_3O_7$, Nb_3Ge, and $HgBa_2CaCu_2O_6$ are 93.0 K, −250.0°C, and −231.1°F, respectively. Convert these temperatures into a single temperature scale, and determine which superconductor has the highest T_c value.

1.88. The boiling point of O_2 is −183°C, whereas the boiling point of N_2 is 77 K. As air is cooled, which gas condenses first?

Assessing and Expressing Precision and Accuracy

Concept Review

1.89. How many suspect data points can be identified in a data set using Grubbs' test?

1.90. Which confidence interval is the largest for a given value of *n*: 50%, 90%, or 95%?

1.91. The concentration of ammonia in an aquarium tank is determined each day for a week. Which of these measures of the variability in the results of these analyses is greater: (a) mean ± standard deviation, or (b) 95% confidence interval? Explain your selection.

1.92. If the results of Grubbs' test indicate that a suspect data point is not an outlier at the 95% confidence level, could it be one at the 99% confidence level?

Problems

***1.93.** The widths of copper lines in printed circuit boards must be close to a design value. Three manufacturers were asked to prepare circuit boards with copper lines that are 0.500 µm (micrometers) wide (1 µm = 1×10^{-6} m). Each manufacturer's quality control department reported the following line widths on five sample circuit boards (given in micrometers):

a. What is the mean and standard deviation of the data provided by each manufacturer?

b. For which of the three sets of data does the 95% confidence interval include 0.500 µm?

c. Which of the data sets fit the description "precise and accurate," and which is "precise but not accurate"?

Manufacturer 1	Manufacturer 2	Manufacturer 3
0.512	0.514	0.500
0.508	0.513	0.501
0.516	0.514	0.502
0.504	0.514	0.502
0.513	0.512	0.501

1.94. **Diabetes Test** Glucose concentrations in the blood above 110 mg/dL can be an early indication of several medical conditions, including diabetes. Suppose analyses of a series of blood samples from a patient at risk of diabetes produce the following results: 106, 99, 109, 108, and 105 mg/dL.

a. What are the mean and the standard deviation of the data?

b. Patients with blood glucose levels above 120 mg/dL are considered diabetic. Is this value within the 95% confidence interval of these data?

1.95. Use Grubbs' test to decide whether the value 3.41 should be considered an outlier in the following data set from the analyses of portions of the same sample conducted by six groups of students: 3.15, 3.03, 3.09, 3.11, 3.12, and 3.41.

1.96. Use Grubbs' test to decide whether any one of the values in the following set of replicate measurements should be considered an outlier: 61, 75, 64, 65, 64, and 66.

Additional Problems

***1.97.** **Agricultural Runoff** A farmer applies 1.50 metric tons of a fertilizer that contains 10% nitrogen to his fields each year (1 metric ton = 1000 kg). Fifteen percent of the fertilizer washes into a stream that runs through the farm. If the stream flows at an average rate of 1.4 cubic meters per minute, what is the additional concentration of nitrogen (expressed in milligrams of nitrogen per liter) in the stream water due to the farmer's yearly application of fertilizer?

1.98. Your laboratory instructor has given you two shiny, light-gray metal cylinders (A and B). Your assignment is to determine which one is made of aluminum (d = 2.699 g/mL) and which one is made of titanium (d = 4.54 g/mL). The mass of each cylinder was determined on a balance to five significant figures. The volume of each was determined by immersing it in a partially filled graduated cylinder as shown in Figure P1.98.

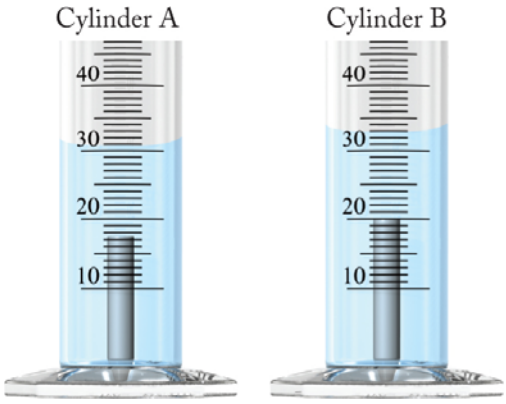


FIGURE P1.98

The initial volume of water was 25.0 mL in each graduated cylinder. The following data were collected:

	Mass (g)	Height (cm)	Diameter (cm)

Cylinder A	15.560	5.1	1.2
Cylinder B	35.536	5.9	1.3

a. Calculate the volume of each cylinder using the dimensions of the cylinder only.

b. Calculate the volume from the water displacement method.

c. Which volume measurement allows for the greater number of significant figures in the calculated densities?

d. Express the density of each cylinder to the appropriate number of significant figures.

***1.99.** Table salt contains 1.54 g of chlorine (as chloride ions) for every 1.00 g of sodium ions. Which of the following mixtures would react to produce NaCl with no sodium or chlorine left over?

a. 11.0 g of sodium and 17.0 g of chlorine

b. 6.5 g of sodium and 10.0 g of chlorine

c. 6.5 g of sodium and 12.0 g of chlorine

d. 6.5 g of sodium and 8.0 g of chlorine

*1.100. The wood of the black ironwood tree (*Krugiodendron ferreum*, Figure P1.100), which grows in the West Indies and coastal areas of South Florida, is so dense that it sinks in seawater. Does it sink in fresh water, too? Explain your answer.

FIGURE P1.100

1.101. Manufacturers of trail mix have to control the distribution of ingredients in their products. Deviations of more than 2% from specifications may cause production delays and supply problems. A favorite trail mix is supposed to contain 67% peanuts and 33% raisins. Bags of trail mix were sampled from the production line on different days with the following results:

Day	Number of Peanuts	Number of Raisins
1	50	32
11	56	26
21	48	34
31	52	30

On which day(s) did the product meet the specification of 65% to 69% peanuts?

*1.102. Gasoline and water are immiscible. Regular-grade (87 octane) gasoline has a lower density (0.73 g/mL) than water (1.00 g/mL). A 100-mL graduated cylinder with an inside diameter of 3.2 cm contains 34.0 g of gasoline and 34.0 g of water. What is the combined height of the two liquid layers in the cylinder? The volume of a cylinder is $\pi r^2 h$, where r is the radius and h is the height.

1.103. **Drug Overdose** In 1999 a drug overdose incident occurred when a prescription that called for a patient to receive 0.5 *grain* of the powerful sedative phenobarbital each day was misread, and the patient was given 0.5 *gram* of the drug. Actually, four intravenous injections of 130 mg each were administered each day for 3 days. How many times as much phenobarbital was administered with respect to the prescribed amount? (1 grain = 64.79891 mg.)

*1.104. **Mercury in Dental Fillings** The controversy over human exposure to mercury from dental fillings (Figure P1.104) is linked to concerns that mercury may volatilize from fillings made of a combination of silver and mercury and may then be breathed into the lungs and absorbed into the blood. In 1995 the U.S. Environmental Protection Agency (EPA) set a safe exposure level for mercury vapor in air of 0.3 μg/m^3. Typically, an adult breathes in 0.5 L of air 15 times per minute.

a. What rate of volatilization of mercury (in μg/minute) from dental fillings would create an exposure level of 0.3 μg Hg/m^3 in the air entering the lungs of an adult?

b. The safe exposure level to inhaled mercury vapor adopted by Health Canada is only 0.06 μg/m^3. What rate of volatilization of mercury (in μg/minute) from dental fillings would create this exposure level in air entering the lungs of a child who breathes in 0.35 L of air 18 times per minute?

FIGURE P1.104

***1.105.** The digital thermometers used in a hospital are evaluated by immersing them in an ice-water bath at 0.0°C and then in boiling water at 100.0°C. The following results were obtained for three thermometers (A, B, and C):

	Measured Temperature (°C)	
Thermometer	Ice Water	Boiling Water
A	−0.8	99.4
B	0.2	99.8
C	0.4	101.0

a. Which of the three thermometers, if any, would detect an increase of 0.1°C in the temperature of a patient?

b. Which of the three thermometers, if any, would accurately give a reading of 36.8°C (under-the-tongue temperature) for a patient without a fever?

1.106. **Deepwater Horizon Oil Spill** According to the U.S. government, 4.9 billion barrels of crude oil flowed into the Gulf of Mexico following the explosion that destroyed the Deepwater Horizon drilling rig in April 2010. Express this volume of crude oil in liters and in cubic kilometers. (1 barrel of oil = 42 gallons.)

1.107. **New Horizons** As the *New Horizons* spacecraft approached Pluto (Figure P1.107) in June 2015, it was traveling away from the sun at a speed of 14.51 km/s. What was this velocity in miles per hour?

FIGURE P1.107

1.108. **Sodium in Candy Bars** Three different analytical techniques were used to determine the quantity of sodium in a Mars Milky Way candy bar. Each technique was used to analyze five portions of the same candy bar, with the following results (expressed in milligrams of sodium per candy bar):

mg of Na: Technique 1	mg of Na: Technique 2	mg of Na: Technique 3
109	110	114
111	115	115
110	120	116
109	116	115
110	113	115

The actual quantity of sodium in the candy bar was 115 mg. Which techniques would you describe as precise, which as accurate, and which as both? What is the range of the values (the difference between the highest and lowest measurements) for each technique?

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