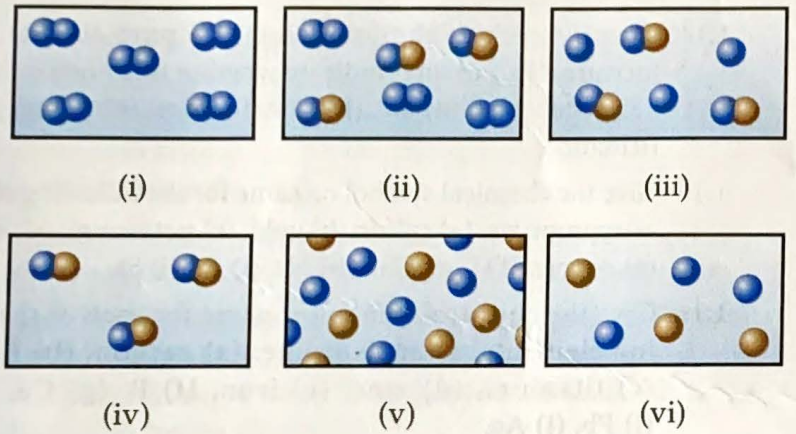
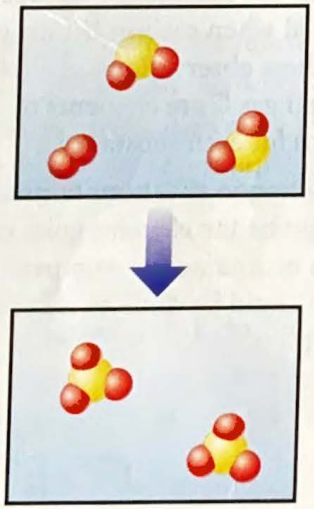
Exercises

Visualizing Concepts

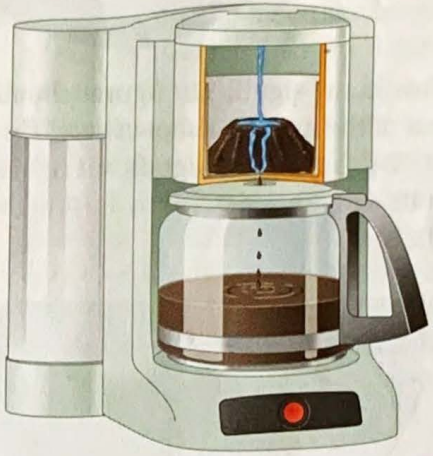
1.1 Which of the following figures represents **(a)** a pure element, **(b)** a mixture of two elements, **(c)** a pure compound, **(d)** a mixture of an element and a compound? (More than one picture might fit each description.) [Section 1.2]



1.2 Does the following diagram represent a chemical or physical change? How do you know? [Section 1.3]



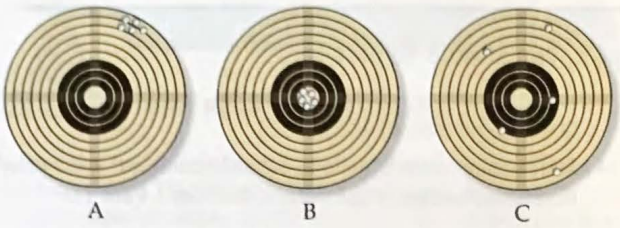
1.3 Describe the separation method(s) involved in brewing a cup of coffee. [Section 1.3]



1.4 Identify each of the following as measurements of length, area, volume, mass, density, time, or temperature: **(a)** 25 ps, **(b)** 374.2 mg, **(c)** 77 K, **(d)** 100,000 km^2, **(e)** 1.06 μm, **(f)** 16 nm^2, **(g)** −78 °C, **(h)** 2.56 g/cm^3, **(i)** 28 cm^3. [Section 1.4]

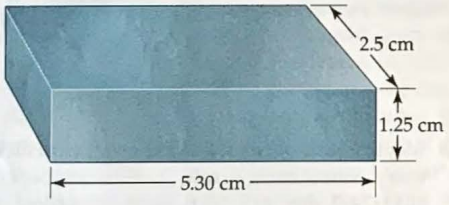
1.5 **(a)** Three spheres of equal size are composed of aluminum (density = 2.70 g/cm^3), silver (density = 10.49 g/cm^3), and nickel (density = 8.90 g/cm^3). List the spheres from lightest to heaviest. **(b)** Three cubes of equal mass are composed of gold (density = 19.32 g/cm^3), platinum (density = 21.45 g/cm^3), and lead (density = 11.35 g/cm^3). List the cubes from smallest to largest. [Section 1.4]

1.6 The three targets from a rifle range shown on the next page were produced by: **(A)** the instructor firing a newly acquired target rifle; **(B)** the instructor firing his personal target rifle; and **(C)** a student who has fired his target rifle only a few times. **(a)** Comment on the accuracy and precision for each of these three sets of results. **(b)** For the A and C results in the future to look like those in B, what needs to happen? [Section 1.5]



1.7 **(a)** What is the length of the pencil in the following figure if the ruler reads in centimeters? How many significant figures are there in this measurement? **(b)** An automobile speedometer with circular scales reading both miles per hour and kilometers per hour is shown. What speed is indicated, in both units? How many significant figures are in the measurements? [Section 1.5]

1.8 **(a)** How many significant figures should be reported for the volume of the metal bar shown here? **(b)** If the mass of the bar is 104.72 g, how many significant figures should be reported when its density is determined using the calculated volume? [Section 1.5]



1.9 When you convert units, how do you decide which part of the conversion factor is in the numerator and which is in the denominator? [Section 1.6]

1.10 Show the steps to convert the speed of sound, 344 meters per second, into miles per hour. [Section 1.6]

1.11 Consider the jar of jelly beans in the photo. To get an estimate of the number of beans in the jar you weigh six beans and obtain masses of 3.15, 3.12, 2.98, 3.14, 3.02, and 3.09 g. Then you weigh the jar with all the beans in it, and obtain a mass of 2082 g. The empty jar has a mass of 653 g. Based on these data estimate the number of beans in the jar. Justify the number of significant figures you use in your estimate. [Section 1.5]

1.12 The photo below shows a picture of an agate stone. Jack, who picked up the stone on the Lake Superior shoreline and polished it, insists that agate is a chemical compound. Ellen argues that it cannot be a compound. Discuss the relative merits of their positions. [Section 1.2]

Classification and Properties of Matter (Sections 1.2 and 1.3)

1.13 Classify each of the following as a pure substance or a mixture. If a mixture, indicate whether it is homogeneous or heterogeneous: **(a)** rice pudding, **(b)** seawater, **(c)** magnesium, **(d)** crushed ice.

1.14 Classify each of the following as a pure substance or a mixture. If a mixture, indicate whether it is homogeneous or heterogeneous: **(a)** air, **(b)** tomato juice, **(c)** iodine crystals, **(d)** sand.

1.15 Give the chemical symbol or name for the following elements, as appropriate: **(a)** sulfur, **(b)** gold, **(c)** potassium, **(d)** chlorine, **(e)** copper, **(f)** U, **(g)** Ni, **(h)** Na, **(i)** Al, **(j)** Si.

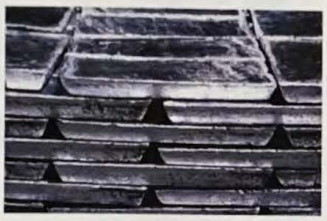
1.16 Give the chemical symbol or name for each of the following elements, as appropriate: **(a)** carbon, **(b)** nitrogen, **(c)** titanium, **(d)** zinc, **(e)** iron, **(f)** P, **(g)** Ca, **(h)** He, **(i)** Pb, **(j)** Ag.

1.17 A solid white substance A is heated strongly in the absence of air. It decomposes to form a new white substance B and a gas C. The gas has exactly the same properties as the product obtained when carbon is burned in an excess of oxygen. Based on these observations, can we determine whether solids A and B and gas C are elements or compounds? Explain your conclusions for each substance.

1.18 You are hiking in the mountains and find a shiny gold nugget. It might be the element gold, or it might be "fool's gold," which is a nickname for iron pyrite, FeS_2. What kinds of experiments could be done to determine if the shiny nugget is really gold?

1.19 In the process of attempting to characterize a substance, a chemist makes the following observations: The substance is a silvery white, lustrous metal. It melts at 649 °C and boils at 1105 °C. Its density at 20 °C is 1.738 g/cm^3. The substance burns in air, producing an intense white light. It reacts with chlorine to give a brittle white solid. The substance can be pounded into thin sheets or drawn into wires. It is a good conductor of electricity. Which of these characteristics are physical properties, and which are chemical properties?

1.20 (a) Read the following description of the element zinc and indicate which are physical properties and which are chemical properties.



Zinc melts at 420 °C. When zinc granules are added to dilute sulfuric acid, hydrogen is given off and the metal dissolves. Zinc has a hardness on the Mohs scale of 2.5 and a density of 7.13g/cm^3 at 25 °C. It reacts slowly with oxygen gas at elevated temperatures to form zinc oxide, ZnO.

(b) Which properties of zinc can you describe from the photo? Are these physical or chemical properties?

1.21 Label each of the following as either a physical process or a chemical process: (a) rusting of a metal can, (b) boiling a cup of water, (c) pulverizing an aspirin, (d) digesting a candy bar, (e) exploding of nitroglyerin.

1.22 A match is lit and held under a cold piece of metal. The following observations are made: (a) The match burns. (b) The metal gets warmer. (c) Water condenses on the metal. (d) Soot (carbon) is deposited on the metal. Which of these occurrences are due to physical changes, and which are due to chemical changes?

1.23 Suggest a method of separating each of the following mixtures into two components: (a) sugar and sand, (b) oil and vinegar.

1.24 Three beakers contain clear, colorless liquids. One beaker contains pure water, another contains salt water, and another contains sugar water. How can you tell which beaker is which? (No tasting allowed!)

Units and Measurement (Section 1.4)

1.25 What exponential notation do the following abbreviations represent? (a) d, (b) c, (c) f, (d) μ, (e) M, (f) k, (g) n, (h) m, (i) p.

1.26 Use appropriate metric prefixes to write the following measurements without use of exponents: (a) 2.3×10^{-10} L, (b) 4.7×10^{-6} g, (c) 1.85×10^{-12} m, (d) 16.7×10^{6} s, (e) 15.7×10^{3} g, (f) 1.34×10^{-3} m, (g) 1.84×10^{2} cm.

1.27 Make the following conversions: (a) 72 °F to °C, (b) 216.7 °C to °F, (c) 233 °C to K, (d) 315 K to °F, (e) 2500 °F to K, (f) 0 K to °F.

1.28 (a) The temperature on a warm summer day is 87 °F. What is the temperature in °C? (b) Many scientific data are reported at 25 °C. What is this temperature in kelvins and in degrees Fahrenheit? (c) Suppose that a recipe calls for an oven temperature of 400 °F. Convert this temperature to degrees Celsius and to kelvins. (d) Liquid nitrogen boils at 77 K. Convert this temperature to degrees Fahrenheit and to degrees Celsius.

1.29 (a) A sample of tetrachloroethylene, a liquid used in dry cleaning that is being phased out because of its potential to cause cancer, has a mass of 40.55 g and a volume of 25.0 mL at 25 °C. What is its density at this temperature? Will tetrachloroethylene float on water? (Materials that are less dense than water will float.) (b) Carbon dioxide (CO_2) is a gas at room temperature and pressure. However, carbon dioxide can be put under pressure to become a "supercritical fluid" that is a much safer dry-cleaning agent than tetrachloroethylene. At a certain pressure, the density of supercritical CO_2 is 0.469 g/cm^3. What is the mass of a 25.0-mL sample of supercritical CO_2 at this pressure?

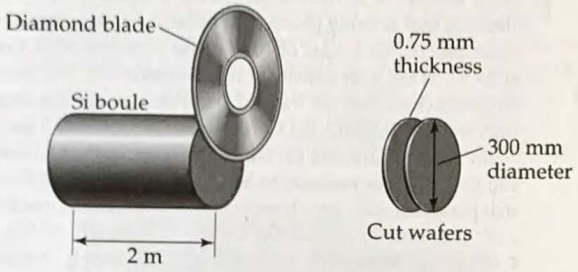
1.30 (a) A cube of osmium metal 1.500 cm on a side has a mass of 76.31 g at 25 °C. What is its density in g/cm^3 at this temperature? (b) The density of titanium metal is 4.51g/cm^3 at 25 °C. What mass of titanium displaces 125.0 mL of water at 25 °C? (c) The density of benzene at 15 °C is 0.8787g/mL. Calculate the mass of 0.1500 L of benzene at this temperature.

1.31 (a) To identify a liquid substance, a student determined its density. Using a graduated cylinder, she measured out a 45-mL sample of the substance. She then measured the mass of the sample, finding that it weighed 38.5 g. She knew that the substance had to be either isopropyl alcohol (density 0.785 g/mL) or toluene (density 0.866/mL). What are the calculated density and the probable identity of the substance? (b) An experiment requires 45.0 g of ethylene glycol, a liquid whose density is 1.114 g/mL. Rather than weigh the sample on a balance, a chemist chooses to dispense the liquid using a graduated cylinder. What volume of the liquid should he use? (c) Is a graduated cylinder such as that shown in Figure 1.19 likely to afford the accuracy of measurement needed? (d) A cubic piece of metal measures 5.00 cm on each edge. If the metal is nickel, whose density is 8.90 g/cm^3, what is the mass of the cube?

1.32 (a) After the label fell off a bottle containing a clear liquid believed to be benzene, a chemist measured the density of the liquid to verify its identity. A 25.0-mL portion of the liquid had a mass of 21.95 g. A chemistry handbook lists the density of benzene at 15 °C as 0.8787 g/mL. Is the calculated density in agreement with the tabulated value? (b) An experiment requires 15.0 g of cyclohexane, whose density at 25 °C is 0.7781 g/mL. What volume of cyclohexane should be used? (c) A spherical ball of lead has a diameter of 5.0 cm. What is the mass of the sphere if lead has a density of 11.34 g/cm^3? (The volume of a sphere is $(4/3)\pi r^3$, where r is the radius.)

1.33 In the year 2011, an estimated amount of 35 billion tons of carbon dioxide (CO_2) was emitted worldwide due to fossil fuel combustion and cement production. Express this mass of CO_2 in grams without exponential notation, using an appropriate metric prefix.

1.34 Silicon for computer chips is grown in large cylinders called "boules" that are 300 mm in diameter and 2 m in length, as shown. The density of silicon is 2.33 g/cm^3. Silicon wafers for making integrated circuits are sliced from a 2.0 m boule and are typically 0.75 mm thick and 300 mm in diameter. **(a)** How many wafers can be cut from a single boule? **(b)** What is the mass of a silicon wafer? (The volume of a cylinder is given by $\pi r^2 h$, where r is the radius and h is its height.)



Uncertainty in Measurement (Section 1.5)

1.35 Indicate which of the following are exact numbers: **(a)** the mass of a 3 by 5–inch index card, **(b)** the number of ounces in a pound, **(c)** the volume of a cup of Seattle's Best coffee, **(d)** the number of inches in a mile, **(e)** the number of microseconds in a week, **(f)** the number of pages in this book.

1.36 Indicate which of the following are exact numbers: **(a)** the mass of a 32-oz can of coffee, **(b)** the number of students in your chemistry class, **(c)** the temperature of the surface of the Sun, **(d)** the mass of a postage stamp, **(e)** the number of milliliters in a cubic meter of water, **(f)** the average height of NBA basketball players.

1.37 What is the number of significant figures in each of the following measured quantities? **(a)** 601 kg, **(b)** 0.054 s, **(c)** 6.3050 cm, **(d)** 0.0105 L, **(e)** 7.0500×10^{-3} m^3, **(f)** 400 g.

1.38 Indicate the number of significant figures in each of the following measured quantities: **(a)** 3.774 km, **(b)** 205 m^2, **(c)** 1.700 cm, **(d)** 350.00 K, **(e)** 307.080 g, **(f)** 1.3×10^3 m/s.

1.39 Round each of the following numbers to four significant figures and express the result in standard exponential notation: **(a)** 102.53070, **(b)** 656.980, **(c)** 0.008543210, **(d)** 0.000257870, **(e)** −0.0357202.

1.40 **(a)** The diameter of Earth at the equator is 7926.381 mi. Round this number to three significant figures and express it in standard exponential notation. **(b)** The circumference of Earth through the poles is 40,008 km. Round this number to four significant figures and express it in standard exponential notation.

1.41 Carry out the following operations and express the answers with the appropriate number of significant figures.

(a) $14.3505 + 2.65$

(b) $952.7 - 140.7389$

(c) $(3.29 \times 10^4)(0.2501)$

(d) $0.0588/0.677$

1.42 Carry out the following operations and express the answer with the appropriate number of significant figures.

(a) $320.5 - (6104.5/2.3)$

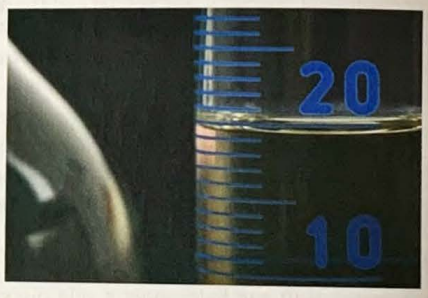
(b) $[(285.3 \times 10^5) - (1.200 \times 10^3)] \times 2.8954$

(c) $(0.0045 \times 20{,}000.0) + (2813 \times 12)$

(d) $863 \times [1255 - (3.45 \times 108)]$

1.43 You weigh an object on a balance and read the mass in grams according to the picture. How many significant figures are in this measurement?

1.44 You have a graduated cylinder that contains a liquid (see photograph). Write the volume of the liquid, in milliliters, using the proper number of significant figures.



Dimensional Analysis (Section 1.6)

1.45 Using your knowledge of metric units, English units, and the information on the back inside cover, write down the conversion factors needed to convert **(a)** mm to nm, **(b)** mg to kg, **(c)** km to ft, **(d)** in.^{3} to cm^3.

1.46 Using your knowledge of metric units, English units, and the information on the back inside cover, write down the conversion factors needed to convert **(a)** μm to mm, **(b)** ms to ns, **(c)** mi to km, **(d)** ft^3 to L.

1.47 **(a)** A bumblebee flies with a ground speed of 15.2 m/s. Calculate its speed in km/hr. **(b)** The lung capacity of the blue whale is 5.0×10^3 L. Convert this volume into gallons. **(c)** The Statue of Liberty is 151 ft tall. Calculate its height in meters. **(d)** Bamboo can grow up to 60.0 cm/day. Convert this growth rate into inches per hour.

1.48 **(a)** The speed of light in a vacuum is 2.998×10^8 m/s. Calculate its speed in miles per hour. **(b)** The Sears Tower in Chicago is 1454 ft tall. Calculate its height in meters. **(c)** The Vehicle Assembly Building at the Kennedy Space Center in Florida has a volume of 3,666,500 m^3. Convert this volume to liters and express the result in standard exponential notation. **(d)** An individual suffering from a high cholesterol level in her