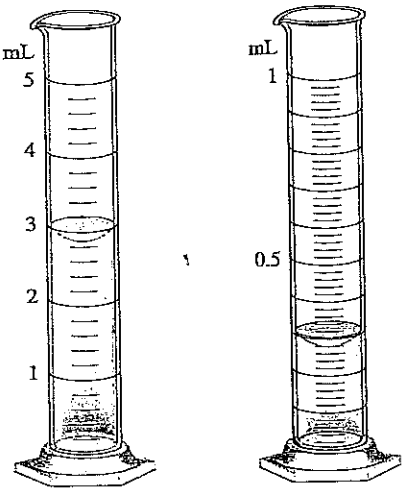
 -Chapter 1 Review Questions

6. If you place a glass rod over a burning candle, the glass appears to turn black. What is happening to each of the following (physical change, chemical change, both, or neither) as the candle burns? Explain each answer.
   a. the wax
   b. the wick
   c. the glass rod
7. Which characteristics of a solid, a liquid, and a gas are exhibited by each of the following substances? How would you classify each substance?
   a. a bowl of pudding
   b. a bucketful of sand
8. You have water in each graduated cylinder shown:

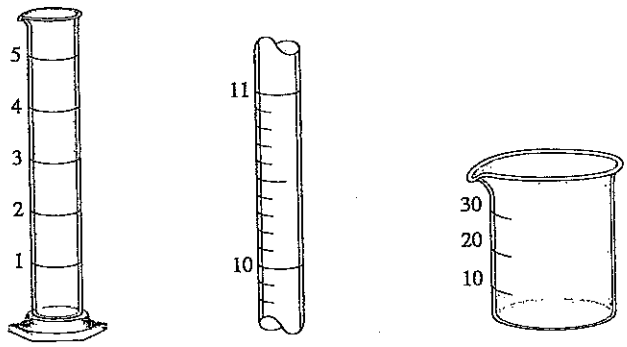


   You then add both samples to a beaker. How would you write the number describing the total volume? What limits the precision of this number?
9. Paracelsus, a sixteenth-century alchemist and healer, adopted as his slogan: "The patients are your textbook, the sickbed is your study." Is this view consistent with using the scientific method?
10. What is wrong with the following statement?
    "The results of the experiment do not agree with the theory. Something must be wrong with the experiment."
11. Why is it incorrect to say that the results of a measurement were accurate but not precise?
12. What data would you need to estimate the money you would spend on gasoline to drive your car from New York to Chicago? Provide estimates of values and a sample calculation.
13. Sketch two pieces of glassware: one that can measure volume to the thousandths place and one that can measure volume only to the ones place.
14. You have a 1.0-cm^3 sample of lead and a 1.0-cm^3 sample of glass. You drop each in separate beakers of water. How do the volumes of water displaced by each sample compare? Explain.
15. Sketch a magnified view (showing atoms/molecules) of each of the following and explain:
    a. a heterogeneous mixture of two different compounds
    b. a homogeneous mixture of an element and a compound

A blue question or exercise number indicates that the answer to that question or exercise appears at the back of this book and a solution appears in the *Solutions Guide*.

Questions

16. Define and explain the differences between the following terms.
    a. law and theory
    b. theory and experiment
    c. qualitative and quantitative
    d. hypothesis and theory
17. Is the scientific method suitable for solving problems only in the sciences? Explain.
18. Which of the following statements (hypotheses) could be tested by quantitative measurement?
    a. Ty Cobb was a better hitter than Pete Rose.
    b. Ivory soap is $99\frac{44}{100}\%$ pure.
    c. Rolaids consumes 47 times its weight in excess stomach acid.
19. For each of the following pieces of glassware, provide a sample measurement and discuss the number of significant figures and uncertainty.



a. b. c.

20. A student performed an analysis of a sample for its calcium content and got the following results:

    14.92% 14.91% 14.88% 14.91%

    The actual amount of calcium in the sample is 15.70%. What conclusion can you draw about the accuracy and precision of these results?
21. Distinguish between physical changes and chemical changes.
22. Why is the separation of mixtures into pure or relatively pure substances so important when performing a chemical analysis?

Exercises

In this section similar exercises are paired.

Significant Figures and Unit Conversions

23. Which of the following are exact numbers?
    a. The elevation of Breckenridge, Colorado, is *9600* ft.
    b. There are *12* eggs in a dozen.
    c. One yard is equal to *0.9144* m.
    d. The announced attendance at a football game was *52,806*.
    e. In 1983, *1759* Ph.D.s in chemistry were awarded in the United States.
    f. The budget deficit of the U.S. government in fiscal year 1990 was *$269 billion*.

24. Which of the following are exact numbers?
    a. There are *100* cm in 1 m.
    b. One meter equals *1.094* yard.
    c. We can use the equation

$$°F = \tfrac{9}{5}°C + 32$$

    to convert from Celsius to Fahrenheit temperature. Are the numbers $\frac{9}{5}$ and *32* exact or inexact?
    d. $\pi = 3.1415927$.

25. How many significant figures are in each of the following?
    a. 12
    b. 1098
    c. 2001
    d. 2.001×10^3
    e. 0.0000101
    f. 1.01×10^{-5}
    g. 1000.
    h. 22.04030

26. How many significant figures are in each of the following?
    a. 100
    b. 1.0×10^2
    c. 1.00×10^3
    d. 100.
    e. 0.0048
    f. 0.00480
    g. 4.80×10^{-3}
    h. 4.800×10^{-3}

27. Round off each of the following numbers to three significant figures, and write the answer in standard exponential notation.
    a. 312.54
    b. 0.00031254
    c. 31,254,000
    d. 0.31254
    e. 31.254×10^{-3}

28. Use exponential notation to express the number 480 to
    a. one significant figure
    b. two significant figures
    c. three significant figures
    d. four significant figures

29. Perform the following mathematical operations, and express each result to the correct number of significant figures.
    a. $97.381 + 4.2502 + 0.99195$
    b. $171.5 + 72.915 - 8.23$
    c. $1.00914 + 0.87104 + 1.2012$
    d. $21.901 - 13.21 - 4.0215$

30. Perform the following mathematical operations, and express each result to the correct number of significant figures.
    a. $\dfrac{0.102 \times 0.0821 \times 273}{1.01}$
    b. $0.14 \times 6.022 \times 10^{23}$
    c. $4.0 \times 10^4 \times 5.021 \times 10^{-3} \times 7.34993 \times 10^2$
    d. $\dfrac{2.00 \times 10^6}{3.00 \times 10^{-7}}$

31. Perform the following mathematical operations, and express each result to the correct number of significant figures.
    a. $4.184 \times 100.62 \times (25.27 - 24.16)$
    b. $\dfrac{8.925 - 8.904}{8.925} \times 100$
    (This type of calculation is done many times in calculating a percentage error. Assume that this example is such a calculation; thus 100 can be considered to be an exact number.)
    c. $(9.04 - 8.23 + 21.954 + 81.0) \div 3.1416$
    d. $\dfrac{9.2 \times 100.65}{8.321 + 4.026}$
    e. $0.1654 + 2.07 - 2.114$
    f. $8.27(4.987 - 4.962)$
    g. $\dfrac{9.5 + 4.1 + 2.8 + 3.175}{4}$
    (Assume that this operation is taking the average of four numbers. Thus 4 in the denominator is exact.)
    h. $\dfrac{9.025 - 9.024}{9.025} \times 100$ (100 is exact)

32. Perform the following mathematical operations, and express the result to the correct number of significant figures.
    a. $6.022 \times 10^{23} \times 1.05 \times 10^2$
    b. $\dfrac{6.6262 \times 10^{-34} \times 2.998 \times 10^8}{2.54 \times 10^{-9}}$
    c. $1.285 \times 10^{-2} + 1.24 \times 10^{-3} + 1.879 \times 10^{-1}$
    d. $1.285 \times 10^{-2} - 1.24 \times 10^{-3}$
    e. $\dfrac{(1.00866 - 1.00728)}{6.02205 \times 10^{23}}$
    f. $\dfrac{9.875 \times 10^2 - 9.795 \times 10^2}{9.875 \times 10^2} \times 100$ (100 is exact)
    g. $\dfrac{9.42 \times 10^2 + 8.234 \times 10^2 + 1.625 \times 10^3}{3}$ (3 is exact)

33. Perform each of the following conversions.
    a. 8.43 cm to millimeters
    b. 2.41×10^2 cm to meters
    c. 294.5 nm to centimeters
    d. 1.445×10^4 m to kilometers
    e. 235.3 m to millimeters
    f. 903.3 nm to micrometers

34. a. How many kilograms are in one teragram?
    b. How many nanometers are in 6.50×10^2 terameters?
    c. How many kilograms are in 25 femtograms?

d. How many liters are in 8.0 cubic decimeters?
e. How many microliters are in one milliliter?
f. How many picograms are in one microgram?

35. Perform the following unit conversions.
a. Congratulations! You and your spouse are the proud parents of a new baby, born while you are studying in a country that uses the metric system. The nurse has informed you that the baby weighs 3.91 kg and measures 51.4 cm. Convert your baby's weight to pounds and ounces and her length to inches (rounded to the nearest quarter inch).
b. The circumference of the earth is 25,000 mi at the equator. What is the circumference in kilometers? in meters?
c. A rectangular solid measures 1.0 m by 5.6 cm by 2.1 dm. Express its volume in cubic meters, liters, cubic inches, and cubic feet.

36. Perform the following unit conversions.
a. 908 oz to kilograms
b. 12.8 L to gallons
c. 125 mL to quarts
d. 2.89 gal to milliliters
e. 4.48 lb to grams
f. 550 mL to quarts

37. Use the following exact conversion factors to perform the stated calculations:

$$5\tfrac{1}{2} \text{ yards} = 1 \text{ rod}$$
$$40 \text{ rods} = 1 \text{ furlong}$$
$$8 \text{ furlongs} = 1 \text{ mile}$$

a. The Kentucky Derby race is 1.25 miles. How long is the race in rods, furlongs, meters, and kilometers?
b. A marathon race is 26 miles, 385 yards. What is this distance in rods, furlongs, meters, and kilometers?

38. Although the preferred SI unit of area is the square meter, land is often measured in the metric system in hectares (ha). One hectare is equal to 10,000 m^2. In the English system, land is often measured in acres (1 acre = 160 rod^2). Use the exact conversions and those given in Exercise 37 to calculate the following.
a. 1 ha = _____ km^2.
b. The area of a 5.5-acre plot of land in hectares, square meters, and square kilometers.
c. A lot with dimensions 120 ft by 75 ft is to be sold for $6500. What is the price per acre? What is the price per hectare?

39. Precious metals and gems are measured in troy weights in the English system:

$$24 \text{ grains} = 1 \text{ pennyweight (exact)}$$
$$20 \text{ pennyweight} = 1 \text{ troy ounce (exact)}$$
$$12 \text{ troy ounces} = 1 \text{ troy pound (exact)}$$
$$1 \text{ grain} = 0.0648 \text{ gram}$$
$$1 \text{ carat} = 0.200 \text{ gram}$$

a. The most common English unit of mass is the pound avoirdupois. What is one troy pound in kilograms and in pounds?
b. What is the mass of a troy ounce of gold in grams and in carats?
c. The density of gold is 19.3 g/cm^3. What is the volume of a troy pound of gold?

40. Apothecaries (druggists) use the following set of measures in the English system:

$$20 \text{ grains ap} = 1 \text{ scruple (exact)}$$
$$3 \text{ scruples} = 1 \text{ dram ap (exact)}$$
$$8 \text{ dram ap} = 1 \text{ oz ap (exact)}$$
$$1 \text{ dram ap} = 3.888 \text{ g}$$

a. Is an apothecary grain the same as a troy grain? (See Exercise 39.)
b. 1 oz ap = _____ oz troy.
c. An aspirin tablet contains 5.00×10^2 mg of active ingredient. How many grains ap of active ingredient does it contain? How many scruples?
d. What is the mass of 1 scruple in grams?

41. Science fiction often uses nautical analogies to describe space travel. If the starship *U.S.S. Enterprise* is traveling at warp factor 1.71, what is its speed in knots? (Warp 1.71 = 5.00 times the speed of light; speed of light = 3.00×10^8 m/s; 1 knot = 2000 yd/h, exactly.)

42. The world record for the hundred meter dash is 9.79 s. What is the corresponding average speed in units of m/s, km/h, ft/s, and mi/h? At this speed, how long would it take to run 1.00×10^2 yards?

43. You're planning to buy a new car. One model that you're considering gets 32 miles to a gallon of gasoline in highway travel. The one that your spouse likes gets 14 kilometers to the liter. Which car has the better gas mileage?

44. You pass a road sign saying "New York 112 km." If you drive at a constant speed of 65 mi/h, how long should it take you to reach New York? If your car gets 28 miles to the gallon, how many liters of gasoline are necessary to travel 112 km?

45. You are in Paris and want to buy some peaches for lunch. The sign in the fruit stand indicates that peaches are 4.00 euros per kilogram. Assuming that there are 1.14 euros to the dollar, calculate what a pound of peaches will cost in dollars.

46. A children's pain relief elixir contains 80. mg acetaminophen per 0.50 teaspoon. The dosage recommended for a child who weighs between 24 and 35 lb is 1.5 teaspoons. What is the range of acetaminophen dosages, expressed in mg acetaminophen/kg body weight, for children who weigh between 24 and 35 lb?

Temperature

47. A person has a temperature of 102.5°F. What is this temperature on the Celsius scale? on the Kelvin scale?

48. If the temperature in a room is 74°F, what is this temperature on the Celsius scale? on the Kelvin scale?

49. Convert the following Celsius temperatures to Kelvin and to Fahrenheit degrees.
   a. the boiling point temperature of ethyl alcohol, 78.1°C
   b. a cold wintery day, −25°C
   c. the lowest possible temperature, −273°C
   d. the melting-point temperature of sodium chloride, 801°C

50. Convert the following Kelvin temperatures to Celsius and Fahrenheit degrees.
   a. the temperature that registers the same value on both the Fahrenheit and Celsius scales, 233 K
   b. the boiling point of helium, 4 K
   c. the temperature at which many chemical quantities are determined, 298 K
   d. the melting point of tungsten, 3680 K

51. A thermometer gives a reading of 20.6°C ± 0.1°C. What is the temperature in °F? What is the uncertainty?

52. A thermometer gives a reading of 96.1°F ± 0.2°F. What is the temperature in °C? What is the uncertainty?

Density

53. The density of aluminum is 2.70 g/cm^3. Express this value in units of kilograms per cubic meter and pounds per cubic foot.

54. A material will float on the surface of a liquid if the material has a density less than that of the liquid. Given that the density of water is approximately 1.0 g/mL, will a block of material having a volume of 1.2×10^4 in^3 and weighing 350 lb float or sink when placed in a reservoir of water?

55. A star is estimated to have a mass of 2×10^{36} kg. Assuming it to be a sphere of average radius 7.0×10^5 km, calculate the average density of the star in units of grams per cubic centimeter.

56. A rectangular block has dimensions 2.9 cm × 3.5 cm × 10.0 cm. The mass of the block is 615.0 g. What are the volume and density of the block?

57. Diamonds are measured in carats, and 1 carat = 0.200 g. The density of diamond is 3.51 g/cm^3. What is the volume of a 5.0-carat diamond?

58. The volume of a diamond is found to be 2.8 mL. What is the mass of the diamond in carats? (See Exercise 57.)

59. A sample containing 33.42 g of metal pellets is poured into a graduated cylinder initially containing 12.7 mL of water, causing the water level in the cylinder to rise to 21.6 mL. Calculate the density of the metal.

60. The density of pure silver is 10.5 g/cm^3 at 20°C. If 5.25 g of pure silver pellets is added to a graduated cylinder containing 11.2 mL of water, to what volume level will the water in the cylinder rise?

61. In each of the following pairs, which has the greater mass? (See Table 1.5.)
   a. 1.0 kg of feathers or 1.0 kg of lead
   b. 1.0 mL of mercury or 1.0 mL of water
   c. 19.3 mL of water or 1.00 mL of gold
   d. 75 mL of copper or 1.0 L of benzene

62. In each of the following pairs, which has the greater volume?
   a. 1.0 kg of feathers or 1.0 kg of lead
   b. 100 g of gold or 100 g of water
   c. 1.0 L of copper or 1.0 L of mercury

63. The density of osmium (the densest metal) is 22.57 g/cm^3. If a 1.00-kg rectangular block of osmium has two dimensions of 4.00 cm × 4.00 cm, calculate the third dimension of the block.

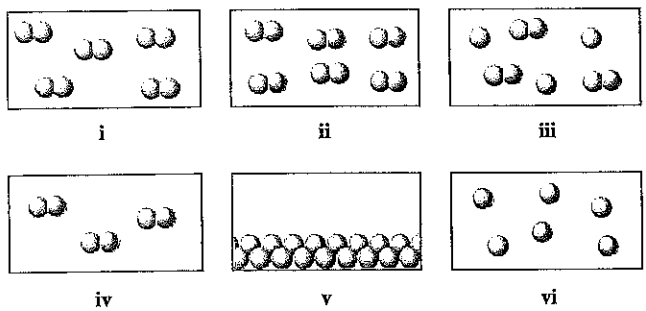
64. A copper wire (density = 8.96 g/cm^3) has a diameter of 0.25 mm. If a sample of this copper wire has a mass of 22 g, how long is the wire?

Classification and Separation of Matter

65. What are some of the differences between a solid, a liquid, and a gas?

66. What is the difference between homogeneous and heterogeneous matter? Classify each of the following as homogeneous or heterogeneous.
   a. soil
   b. the atmosphere
   c. a carbonated soft drink
   d. gasoline
   e. gold
   f. a solution of ethanol and water

67. Match each description below with the following microscopic pictures. More than one picture may fit each description. A picture may be used more than once or not used at all.



   a. a gaseous compound
   b. a mixture of two gaseous elements
   c. a solid element
   d. a mixture of a gaseous element and a gaseous compound

68. Classify each of the following as a mixture or a pure substance.

a. water	f. uranium
b. blood	g. wine
c. the oceans	h. leather
d. iron	i. table salt (NaCl)
e. brass	

Of the pure substances, which are elements and which are compounds?

69. Classify the following as physical or chemical changes.
   a. Moth balls gradually vaporize in a closet.
   b. Hydrofluoric acid attacks glass, and is used to etch calibration marks on glass laboratory utensils.
   c. A French chef making a sauce with brandy is able to burn off the alcohol from the brandy, leaving just the brandy flavoring.
   d. Chemistry majors sometimes get holes in the cotton jeans they wear to lab because of acid spills.

70. The properties of a mixture are typically averages of the properties of its components. The properties of a compound may differ dramatically from the properties of the elements that combine to produce the compound. For each process described below, state whether the material being discussed is most likely a mixture or a compound, and state whether the process is a chemical change or a physical change.
   a. An orange liquid is distilled, resulting in the collection of a yellow liquid and a red solid.
   b. A colorless, crystalline solid is decomposed, yielding a pale yellow-green gas and a soft, shiny metal.
   c. A cup of tea becomes sweeter as sugar is added to it.

Additional Exercises

71. A mole of helium gas contains 6.02×10^{23} helium atoms. How many helium atoms are there in a micromole of helium? How many moles of helium does 1.25×10^{20} atoms of helium represent?

72. In Shakespeare's *Richard III,* the First Murderer says:

"Take that, and that! [*Stabs Clarence*]
If that is not enough, I'll drown you in a malmsey butt within!"

Given that 1 butt = 126 gal, in how many liters of malmsey (a foul brew similar to mead) was the unfortunate Clarence about to be drowned?

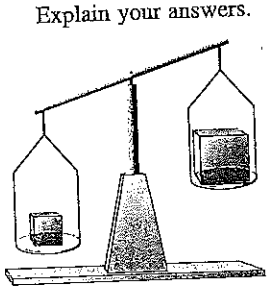
73. The contents of one 40. lb bag of topsoil will cover 10. square feet of ground to a depth of 1.0 inch. How many bags are needed to cover a plot which measures 200. by 300. m to a depth of 4.0 cm?

74. In the opening scenes of the movie *Raiders of the Lost Ark,* Indiana Jones tries to remove a gold idol from a booby-trapped pedestal. He replaces the idol with a bag of sand of approximately equal volume. (Density of gold = 19.32 g/cm^3; density of sand $\approx$ 2 g/cm^3.)
   a. Did he have a reasonable chance of not activating the mass-sensitive booby trap?
   b. In a later scene he and an unscrupulous guide play catch with the idol. Assume that the volume of the idol is about 1.0 L. If it were solid gold, what mass would the idol have? Is playing catch with it plausible?

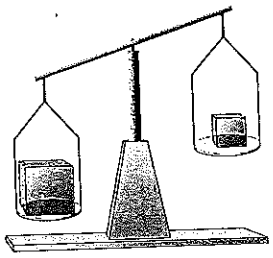
75. Mercury poisoning is a debilitating disease that is often fatal. In the human body, mercury reacts with essential enzymes leading to irreversible inactivity of these enzymes. If the amount of mercury in a polluted lake is 0.4 μg Hg/mL, what is the total mass in kilograms of mercury in the lake? (The lake has a surface area of 100 mi^2 and an average depth of 20 ft.)

76. A 25.00 g-sample of a solid is placed in a graduated cylinder and then the cylinder is filled to the 50.0 mL mark with benzene. The mass of benzene and solid together is 58.80 g. Assuming that the solid is insoluble in benzene and that the density of benzene is 0.880 g/cm^3, calculate the density of the solid.

77. For each of the following, decide which block is more dense: the orange block, the blue block, or it cannot be determined. Explain your answers.



a.



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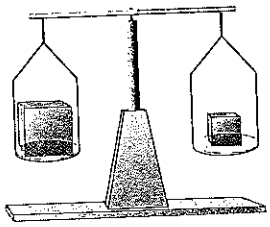

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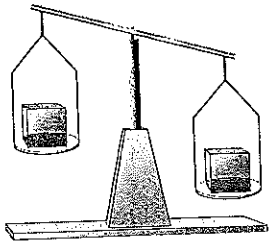


d.

78. According to the *Official Rules of Baseball,* a baseball must have a circumference not more than 9.25 in or less than 9.00 in and a mass not more than 5.25 oz or less than 5.00 oz. What range of densities can a baseball be expected to have? Express this range as a single number with an accompanying uncertainty limit.

79. The density of an irregularly shaped object was determined as follows. The mass of the object was found to be 28.90 g $\pm$ 0.03 g. A graduated cylinder was partially filled with water. The reading of the level of the water was 6.4 cm^3 $\pm$ 0.1 cm^3. The object was dropped in the cylinder, and the level of the water rose to 9.8 cm^3 $\pm$ 0.1 cm^3. What is the density of the object with appropriate error limits? (See Appendix 1.5.)

Challenge Problems

80. Many times errors are expressed in terms of percentage. The percent error is the absolute value of the difference of the true value and the experimental value, divided by the true value, and multiplied by 100.

$$\text{Percent error} = \frac{|\text{true value} - \text{experimental value}|}{\text{true value}} \times 100$$

Calculate the percent error for the following measurements.

a. The density of an aluminum block determined in an experiment was 2.64 g/cm^3. (True value 2.70 g/cm^3.)

b. The experimental determination of iron in iron ore was 16.48%. (True value 16.12%.)

c. A balance measured the mass of a 1.000-g standard as 0.9981 g.

81. A rule of thumb in designing experiments is to avoid using a result that is the small difference between two large measured quantities. In terms of uncertainties in measurement, why is this good advice?

82. A person weighed 15 pennies on a balance and recorded the following masses:

3.112 g	3.109 g	3.059 g
2.467 g	3.079 g	2.518 g
3.129 g	2.545 g	3.050 g
3.053 g	3.054 g	3.072 g
3.081 g	3.131 g	3.064 g

Curious about the results, he looked at the dates on each penny. Two of the light pennies were minted in 1983 and one in 1982. The dates on the 12 heavier pennies ranged from 1970 to 1982. Two of the 12 heavier pennies were minted in 1982.

a. Do you think the Bureau of the Mint changed the way it made pennies? Explain.

b. The person calculated the average mass of the 12 heavy pennies. He expressed this average as 3.0828 g $\pm$ 0.0482 g. What is wrong with the numbers in this result, and how should the value be expressed?

83. On October 21, 1982, the Bureau of the Mint changed the composition of pennies (see Exercise 82). Instead of an alloy of 95% Cu and 5% Zn by mass, a core of 99.2% Zn and 0.8% Cu with a thin shell of copper was adopted. The overall composition of the new penny was 97.6% Zn and 2.4% Cu by mass. Does this account for the difference in mass among the pennies in Exercise 82? Assume the volume of the individual metals that make up each penny can be added together to give the overall volume of the penny, and assume each penny is the same size. (Density of Cu = 8.96 g/cm^3; density of Zn = 7.14 g/cm^3.)

84. Ethylene glycol is the main component in automobile antifreeze. To monitor the temperature of an auto cooling system, you intend to use a meter that reads from 0 to 100. You devise a new temperature scale based on the approximate melting and boiling points of a typical antifreeze solution (−45°C and 115°C). You wish these points to correspond to 0°A and 100°A, respectively.

a. Derive an expression for converting between °A and °C.

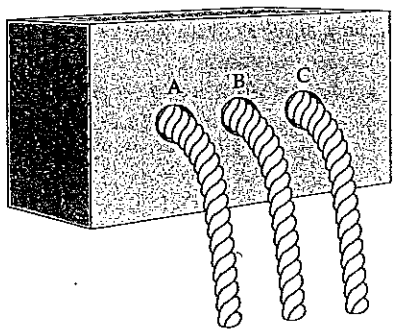
b. Derive an expression for converting between °F and °A.

c. At what temperature would your thermometer and a Celsius thermometer give the same numerical reading?

d. Your thermometer reads 86°A. What is the temperature in °C and in °F?

e. What is a temperature of 45°C in °A?

85. Confronted with the box shown in the diagram, you wish to discover something about its internal workings. You have no tools and cannot open the box. You pull on rope B, and it moves rather freely. When you pull on rope A, rope C appears to be pulled slightly into the box. When you pull on rope C, rope A almost disappears into the box.*



a. Based on these observations, construct a model for the interior mechanism of the box.

b. What further experiments could you do to refine your model?

86. An experiment was performed in which an empty 100-mL graduated cylinder was weighed. It was weighed once again after it had been filled to the 10.0-mL mark with dry sand. A 10-mL pipet was used to transfer 10.00 mL of methanol to the cylinder. The sand–methanol mixture was stirred until bubbles no longer emerged from the mixture and the sand looked uniformly wet. The cylinder was then weighed again. Use the data obtained from this experiment (and displayed at the end of this problem) to find the density of the dry sand, the density of methanol, and the density of sand particles. Does the bubbling that occurs when the methanol is added to the dry sand indicate that the sand and methanol are reacting?

*From Yoder, Suydam, and Snavely, *Chemistry* (New York: Harcourt Brace Jovanovich, 1975), pp. 9–11.