APPENDIX D

Problem Bank

Conversions: Chap. 2, Sec. 2

CONVERTING SIMPLE SI UNITS

1. State the following measured quantities in the units indicated.
   a. 5.2 cm of magnesium ribbon in millimeters
   b. 0.049 kg of sulfur in grams
   c. 1.60 mL of ethanol in microliters
   d. 0.0025 g of vitamin A in micrograms
   e. 0.020 kg of tin in milligrams
   f. 3 kL of saline solution in liters
2. State the following measured quantities in the units indicated.
   a. 150 mg of aspirin in grams
   b. 2500 mL of hydrochloric acid in liters
   c. 0.5 g of sodium in kilograms
   d. 55 L of carbon dioxide gas in kiloliters
   e. 35 mm in centimeters
   f. 8740 m in kilometers
   g. 209 nm in millimeters
   h. 500 000 μg in kilograms
3. The greatest distance between Earth and the sun during Earth's revolution is 152 million kilometers. What is this distance in megameters?
4. How many milliliters of water will it take to fill a 2.00 L bottle that already contains 1.87 L of water?
5. A piece of copper wire is 150 cm long. How long is the wire in millimeters? How many 50 mm segments of wire can be cut from the length?
6. The ladle at an iron foundry can hold 8500 kg of molten iron; 646 metric tons of iron are needed to make rails. How many ladles full of iron will it take to make 646 metric tons of iron? (1 metric ton = 1000 kg)

CONVERTING DERIVED SI UNITS

7. State the following measured quantities in the units indicated.
   a. 310 000 cm^3 of concrete in cubic meters
   b. 6.5 m^2 of steel sheet in square centimeters
   c. 0.035 m^3 of chlorine gas in cubic centimeters
   d. 0.49 cm^2 of copper in square millimeters
   e. 1200 dm^3 of acetic-acid solution in cubic meters
   f. 87.5 mm^3 of actinium in cubic centimeters
   g. 250 000 cm^2 of polyethylene sheet in square meters
8. How many palisade cells from plant leaves would fit in a volume of 1.0 cm^3 of cells if the average volume of a palisade cell is 0.0147 mm^3?

MIXED REVIEW

9. Convert each of the following quantities to the required unit.
   a. 12.75 Mm to kilometers
   b. 277 cm to meters
   c. 30 560 m^2 to hectares (1 ha=10 000 m^2)
   d. 81.9 cm^2 to square meters
   e. 300 000 km to megameters
10. Convert each of the following quantities to the required unit.
    a. 0.62 km to meters
    b. 3857 g to milligrams
    c. 0.0036 mL to microliters
    d. 0.342 metric tons to kg (1 metric ton=1000 kg)
    e. 68.71 kL to liters
11. Convert each of the following quantities to the required unit.
    a. 856 mg to kilograms
    b. 1 210 000 μg to kilograms
    c. 6598 μL to cubic centimeters (1 mL= 1 cm^3)
    d. 80 600 nm to millimeters
    e. 10.74 cm^3 to liters
12. Convert each of the following quantities to the required unit.
    a. 7.93 L to cubic centimeters
    b. 0.0059 km to centimeters
    c. 4.19 L to cubic decimeters
    d. 7.48 m^2 to square centimeters
    e. 0.197 m^3 to liters
13. An automobile uses 0.05 mL of oil for each kilometer it is driven. How much oil in liters is consumed if the automobile is driven 20 000 km?
14. How many microliters are there in a volume of 370 mm^3 of cobra venom?
15. A baker uses 1.5 tsp of vanilla extract in each cake. How much vanilla extract in liters should the baker order to make 800 cakes? (1 tsp = 5 mL)
16. A person drinks eight glasses of water each day, and each glass contains 300 mL. How many liters of water will that person consume in a year? What is the mass of this volume of water in kilograms? (Assume one year has 365 days and the density of water is 1.00 kg/L.)
17. At the equator, Earth rotates with a velocity of about 465 m/s.
    a. What is this velocity in kilometers per hour?
    b. What is this velocity in kilometers per day?
18. A chemistry teacher needs to determine what quantity of sodium hydroxide to order. If each student will use 130 g and there are 60 students, how many kilograms of sodium hydroxide should the teacher order?

19. The teacher in item 18 also needs to order plastic tubing. If each of the 60 students needs 750 mm of tubing, what length of tubing in meters should the teacher order?

20. Convert the following to the required units.
- **a.** 550 μL/h to milliliters per day
- **b.** 9.00 metric tons/h to kilograms per minute
- **c.** 3.72 L/h to cubic centimeters per minute
- **d.** 6.12 km/h to meters per second

21. Express the following in the units indicated.
- **a.** 2.97 kg/L as grams per cubic centimeter
- **b.** 4128 g/dm^2 as kilograms per square centimeter
- **c.** 5.27 g/cm^3 as kilograms per cubic decimeter
- **d.** 6.91 kg/m^3 as milligrams per cubic millimeter

22. A gas has a density of 5.56 g/L.
- **a.** What volume in milliliters would 4.17 g of this gas occupy?
- **b.** What would be the mass in kilograms of 1 m^3 of this gas?

23. The average density of living matter on Earth's land areas is 0.10 g/cm^2. What mass of living matter in kilograms would occupy an area of 0.125 ha?

24. A textbook measures 250 mm long, 224 mm wide, and 50.0 mm thick. It has a mass of 2.94 kg.
- **a.** What is the volume of the book in cubic meters?
- **b.** What is the density of the book in grams per cubic centimeter?
- **c.** What is the area of one cover in square meters?

25. A glass dropper delivers liquid so that 25 drops equal 1.00 mL.
- **a.** What is the volume of one drop in milliliters?
- **b.** How many milliliters are in 37 drops?
- **c.** How many drops would be required to get 0.68 L?

26. Express each of the following in kilograms and grams.
- **a.** 504 700 mg
- **b.** 9 200 000 μg
- **c.** 122 mg
- **d.** 7195 cg

27. Express each of the following in liters and milliliters.
- **a.** 582 cm^3
- **b.** 0.0025 m^3
- **c.** 1.18 dm^3
- **d.** 32 900 μL

28. Express each of the following in grams per liter and kilograms per cubic meter.
- **a.** 1.37 g/cm^3
- **b.** 0.692 kg/dm^3
- **c.** 5.2 kg/L
- **d.** 38 000 g/m^3
- **e.** 5.79 mg/mm^3
- **f.** 1.1 μg/mL

29. An industrial chemical reaction is run for 30.0 h and produces 648.0 kg of product. What is the average rate of product production in the stated units?
- **a.** grams per minute
- **b.** kilograms per day
- **c.** milligrams per millisecond

30. What is the speed of a car in meters per second when it is moving at 100 km/h?

31. A heater gives off energy as heat at a rate of 330 kJ/min. What is the rate of energy output in kilocalories per hour? (1 cal=4.184 J)

32. The instructions on a package of fertilizer tell you to apply it at the rate of 62 g/m^2. How much fertilizer in kilograms would you need to apply to 1.0 ha? (1 ha=10 000 m^2)

33. A water tank leaks water at the rate of 3.9 mL/h. If the tank is not repaired, what volume of water in liters will it leak in a year? Show your setup for solving this. Hint: Use one conversion factor to convert hours to days and another to convert days to years, and assume that one year has 365 days.

34. A nurse plans to give flu injections of 50μL each from a bottle containing 2.0 mL of vaccine. How many doses are in the bottle?

Significant Figures: Chap. 2, Sec. 2

35. Determine the number of significant figures in the following measurements.
- **a.** 640 cm^3
- **b.** 200.0 mL
- **c.** 0.5200 g
- **d.** 1.005 kg
- **e.** 10 000 L
- **f.** 20.900 cm
- **g.** 0.000 000 56 g/L
- **h.** 0.040 02 kg/m^3
- **i.** 790 001 cm^2
- **j.** 665.000 kg•m/s^2

36. Perform the following calculations, and express the results in the correct units and number of significant figures.
- **a.** 47.0 m÷2.2 s
- **b.** 140 cm×35 cm
- **c.** 5.88 kg÷200 m^3
- **d.** 0.00 50 m^2×0.042 m
- **e.** 300.3 L÷180 s
- **f.** 33.00 cm^2×2.70 cm
- **g.** 35 000 kJ÷0.250 min

37. Perform the following calculations, and express the results in the correct units and number of significant figures.
- **a.** 22.0 m+5.28 m+15.5 m
- **b.** 0.042 kg+1.229 kg+0.502 kg
- **c.** 170 cm^2+3.5 cm^2−28 cm^2
- **d.** 0.003 L+0.0048 L+0.100 L
- **e.** 24.50 dL+4.30 dL+10.2 dL
- **f.** 3200 mg+325 mg−688 mg
- **g.** 14 000 kg+8000 kg+590 kg

MIXED REVIEW

38. Determine the number of significant figures in the following measurements.
- **a.** 0.0120 m
- **b.** 100.5 mL
- **c.** 101 g
- **d.** 350 cm^2
- **e.** 0.97 km
- **f.** 1000 kg
- **g.** 180. mm
- **h.** 0.4936 L
- **i.** 0.020 700 s

39. Round the following quantities to the specified number of significant figures.
- **a.** 5 487 129 m to three significant figures
- **b.** 0.013 479 265 mL to six significant figures
- **c.** 31 947.972 cm^2 to four significant figures
- **d.** 192.6739 m^2 to five significant figures
- **e.** 786.9164 cm to two significant figures
- **f.** 389 277 600 J to six significant figures
- **g.** 225 834.762 cm^3 to seven significant figures

40. Perform the following calculations, and express the answers in the correct units and number of significant figures.
- **a.** 651 cm × 75 cm
- **b.** 7.835 kg ÷ 2.5 L
- **c.** 14.75 L ÷ 1.20 s
- **d.** 360 cm × 51 cm × 9.07 cm
- **e.** 5.18 m × 0.77 m × 10.22 m
- **f.** 34.95 g ÷ 11.169 cm^3

41. Perform the following calculations, and express the answers in the correct units and number of significant figures.
- **a.** 7.945 J + 82.3 J − 0.02 J
- **b.** 0.0012 m − 0.000 45 m − 0.000 11 m
- **c.** 500 g + 432 g + 2 g
- **d.** 31.2 kPa + 0.0035 kPa − 0.147 kPa
- **e.** 312 dL − 31.2 dL − 3.12 dL
- **f.** 1701 kg + 50 kg + 43 kg

42. A rectangle measures 87.59 cm by 35.1 mm. Express its area with the proper number of significant figures in the specified unit.
- **a.** in cm^2
- **b.** in mm^2
- **c.** in m^2

43. A box measures 900 mm by 31.5 mm by 6.3 cm. State its volume with the proper number of significant figures in the specified unit.
- **a.** in cm^3
- **b.** in m^2
- **c.** in mm^3

44. A 125 mL sample of liquid has a mass of 0.16 kg. What is the density of the liquid in the following measurements?
- **a.** kg/m^3
- **b.** g/mL
- **c.** kg/dm^3

45. Perform the following calculations, and express the results in the correct units and with the proper number of significant figures.
- **a.** 13.75 mm × 10.1 mm × 0.91 mm
- **b.** 89.4 cm^2 × 4.8 cm
- **c.** 14.9 m^3 ÷ 3.0 m^2
- **d.** 6.975 m × 30 m × 21.5 m

46. What is the volume of a region of space that measures 752 m × 319 m × 110 m? Give your answer in the correct unit and with the proper number of significant figures.

47. Perform the following calculations, and express the results in the correct units and with the proper number of significant figures.
- **a.** 7.382 g + 1.21 g + 4.7923 g
- **b.** 51.3 mg + 83 mg − 34.2 mg
- **c.** 0.007 L − 0.0037 L + 0.012 L
- **d.** 253.05 cm^2 + 33.9 cm^2 + 28 cm^2
- **e.** 14.77 kg + 0.086 kg − 0.391 kg
- **f.** 319 mL + 13.75 mL + 20. mL

48. A container measures 30.5 mm × 202 mm × 153 mm. When it is full of a liquid, it has a mass of 1.33 kg. When it is empty, it has a mass of 0.30 kg. What is the density of the liquid in kilograms per liter?

49. If 7.76 km of wire has a mass of 3.3 kg, what is the mass of the wire in g/m? What length in meters would have a mass of 1.0 g?

50. A container of plant food recommends an application rate of 52 kg/ha. If the container holds 10 kg of plant food, how many square meters will it cover? (1 ha = 10 000 m^2)

51. A chemical process produces 974 550 kJ of energy as heat in 37.0 min. What is the rate in kilojoules per minute? What is the rate in kilojoules per second?

52. A water pipe fills a container that measures 189 cm × 307 cm × 272 cm in 97 s.
- **a.** What is the volume of the container in cubic meters?
- **b.** What is the rate of flow in the pipe in liters per minute?
- **c.** What is the rate of flow in cubic meters per hour?

53. Perform the following calculations, and express the results in the correct units and with the proper number of significant figures. Note that in problems with multiple steps, it is better to perform the entire calculation and then round to significant figures.
- **a.** (0.054 kg + 1.33 kg) × 5.4 m^2
- **b.** 67.35 cm^2 ÷ (1.401 cm − 0.399 cm)
- **c.** 4.198 kg × (1019 m^2 − 40 m^2) ÷ (54.2 s × 31.3 s)
- **d.** 3.14159 m × (4.17 m + 2.150 m)
- **e.** 690 000 m ÷ (5.022 h − 4.31 h)
- **f.** (6.23 cm + 3.111 cm − 0.05 cm) × 14.99 cm

Scientific Notation: Chap. 2, Sec. 3

CONVERTING QUANTITIES TO SCIENTIFIC NOTATION

54. Express the following quantities in scientific notation.
- **a.** 8 800 000 000 m
- **b.** 0.0015 kg
- **c.** 0.000 000 000 06 kg/m^3
- **d.** 8 002 000 Hz
- **e.** 0.009 003 A
- **f.** 70 000 000 000 000 000 km
- **g.** 6028 L
- **h.** 0.2105 g
- **i.** 600 005 000 kJ/h
- **j.** 33.8 m^2

CALCULATING WITH QUANTITIES IN SCIENTIFIC NOTATION

55. Carry out the following calculations. Express the results in scientific notation and with the correct number of significant figures.

a. $4.74 \times 10^4\,\text{km} + 7.71 \times 10^3\,\text{km} + 1.05 \times 10^3\,\text{km}$
b. $2.75 \times 10^{-4}\,\text{m} + 8.03 \times 10^{-5}\,\text{m} + 2.122 \times 10^{-3}\,\text{m}$
c. $4.0 \times 10^{-5}\,\text{m}^3 + 6.85 \times 10^{-6}\,\text{m}^3 - 1.05 \times 10^{-5}\,\text{m}^3$
d. $3.15 \times 10^2\,\text{mg} + 3.15 \times 10^3\,\text{mg} + 3.15 \times 10^4\,\text{mg}$
e. 3.01×10^{22} atoms $+ 1.19 \times 10^{23}$ atoms $+ 9.80 \times 10^{21}$ atoms
f. $6.85 \times 10^7\,\text{nm} + 4.0229 \times 10^8\,\text{nm} - 8.38 \times 10^6\,\text{nm}$

56. Carry out the following computations, and express the results in scientific notation.

a. $7.20 \times 10^3\,\text{cm} \times 8.08 \times 10^3\,\text{cm}$
b. $3.7 \times 10^4\,\text{mm} \times 6.6 \times 10^4\,\text{mm} \times 9.89 \times 10^3\,\text{mm}$
c. $8.27 \times 10^2\,\text{m} \times 2.5 \times 10^{-3}\,\text{m} \times 3.00 \times 10^{-4}\,\text{m}$
d. $4.44 \times 10^{-35}\,\text{m} \times 5.55 \times 10^{19}\,\text{m} \times 7.69 \times 10^{-12}\,\text{kg}$
e. $6.55 \times 10^4\,\text{dm} \times 7.89 \times 10^9\,\text{dm} \times 4.01893 \times 10^5\,\text{dm}$

57. Carry out the following computations, and express the results in scientific notation.

a. $2.290 \times 10^7\,\text{cm} \div 4.33 \times 10^3\,\text{s}$
b. $1.788 \times 10^{-5}\,\text{L} \div 7.111 \times 10^{-3}\,\text{m}^2$
c. $5.515 \times 10^4\,\text{L} \div 6.04 \times 10^3\,\text{km}$
d. $3.29 \times 10^{-4}\,\text{km} \div 1.48 \times 10^{-2}\,\text{min}$
e. $4.73 \times 10^{-4}\,\text{g} \div (2.08 \times 10^{-3}\,\text{km} \times 5.60 \times 10^{-4}\,\text{km})$

MIXED REVIEW

58. Express the following quantities in scientific notation.

a. 158 000 km
b. 0.000 009 782 L
c. 837 100 000 cm^3
d. 6 500 000 000 mm^2
e. 0.005 93 g
f. 0.000 000 006 13 m
g. 12 552 000 J
h. 0.000 008 004 g/L
i. 0.010 995 kg
j. 1 050 000 000 Hz

59. Perform the following calculations, and express the results in scientific notation with the correct number of significant figures.

a. $2.48 \times 10^2\,\text{kg} + 9.17 \times 10^3\,\text{kg} + 7.2 \times 10^1\,\text{kg}$
b. $4.07 \times 10^{-5}\,\text{mg} + 3.966 \times 10^{-4}\,\text{mg} + 7.1 \times 10^{-2}\,\text{mg}$
c. $1.39 \times 10^4\,\text{m}^3 + 6.52 \times 10^2\,\text{m}^3 - 4.8 \times 103\,\text{m}^3$
d. $7.70 \times 10^{-9}\,\text{m} - 3.95 \times 10^{-8}\,\text{m} + 1.88 \times 10^{-7}\,\text{m}$
e. $1.111 \times 10^5\,\text{J} + 5.82 \times 10^4\,\text{J} + 3.01 \times 10^6\,\text{J}$
f. 9.81×10^{27} molecules $+ 3.18 \times 10^{25}$ molecules $- 2.09 \times 10^{26}$ molecules
g. $1.36 \times 10^7\,\text{cm} + 3.456 \times 10^6\,\text{cm} - 1.01 \times 10^7\,\text{cm} + 5.122 \times 10^5\,\text{cm}$

60. Perform the following computations, and express the results in scientific notation with the correct number of significant figures.

a. $1.54 \times 10^{-1}\,\text{L} \div 2.36 \times 10^{-4}\,\text{s}$
b. $3.890 \times 10^4\,\text{mm} \times 4.71 \times 10^2\,\text{mm}^2$
c. $9.571 \times 10^3\,\text{kg} \div 3.82 \times 10^{-1}\,\text{m}^2$
d. $8.33 \times 10^3\,\text{km} \div 1.97 \times 10^2\,\text{s}$
e. $9.36 \times 10^2\,\text{m} \times 3.82 \times 10^3\,\text{m} \times 9.01 \times 10^{-1}\,\text{m}$
f. $6.377 \times 10^4\,\text{J} \div 7.35 \times 10^{-3}\,\text{s}$

61. Your electric company charges you for the electric energy you use, measured in kilowatt-hours (kWh). One kWh is equivalent to 3 600 000 J. Express this quantity in scientific notation.

62. The pressure in the deepest part of the ocean is 11 200 000 Pa. Express this pressure in scientific notation.

63. Convert 1.5 km to millimeters, and express the result in scientific notation.

64. Light travels at a speed of about 300 000 km/s.
a. Express this value in scientific notation.
b. Convert this value to meters per hour.
c. What distance in centimeters does light travel in 1 μs?

65. There are 7.11×10^{24} molecules in 100.0 cm^3 of a certain substance.
a. What is the number of molecules in 1.09 cm^3 of the substance?
b. What would be the number of molecules in $2.24 \times 10^4\text{cm}^3$ of the substance?
c. What number of molecules are in 9.01×10^{-6} cm^3 of the substance?

66. The number of transistors on a particular integrated circuit is 3 578 000, and the integrated circuit measures 9.5 mm × 8.2 mm.
a. What is the area occupied by each transistor?
b. Using your answer from (a), how many transistors could be formed on a silicon sheet that measures 353 mm × 265 mm?

67. A solution has 0.0501 g of a substance in 1.00 L. Express this concentration in grams per microliter.

68. Cesium atoms are the largest of the naturally occurring elements. They have a diameter of 5.30×10^{-10}m. Calculate the number of cesium atoms that would have to be lined up to give a row of cesium atoms 2.54 cm (1 in.) long.

69. The neutron has a volume of approximately $1.4 \times 10^{-44}\text{m}^3$ and a mass of 1.675×10^{-24}g. Calculate the density of the neutron in g/m^3. What is the mass of 1.0 cm^3 of neutrons in kilograms?

70. The pits in a compact disc are some of the smallest things ever mass-produced mechanically by humans. These pits represent the 1s and 0s of digital information on a compact disc. These pits are only 1.6×10^{-8}m deep (1/4 the wavelength of red laser light). How many of these pits would have to be stacked on top of each other to make a hole 0.305 m deep?

71. 22 400 mL of oxygen gas contains 6.022×10^{23} oxygen molecules at 0° C and standard atmospheric pressure.
a. How many oxygen molecules are in 0.100 mL of gas?
b. How many oxygen molecules are in 1.00 L of gas?
c. What is the average space in milliliters occupied by one oxygen molecule?

72. The mass of the atmosphere is calculated to be 5.136×10^{18} kg, and there are 6 500 000 000 people living on Earth. Calculate the following values.
- **a.** The mass of atmosphere in kilograms per person.
- **b.** The mass of atmosphere in metric tons per person.
- **c.** If the number of people increases to 9 500 000 000, what is the mass in kilograms per person?

73. The mass of the sun is 1.989×10^{30} kg, and the mass of Earth is 5.974×10^{24} kilograms. How many Earths would be needed to equal the mass of the sun?

74. A new landfill has dimensions of 2.3 km × 1.4 km × 0.15 km.
- **a.** What is the volume in cubic kilometers?
- **b.** What is the volume in cubic meters?
- **c.** If 250 000 000 objects averaging 0.060 m^3 each are placed into the landfill each year, how many years will it take to fill the landfill?

75. A dietary calorie (C) is exactly equal to 1000 cal. If your daily intake of food gives you 2400 C, what is your intake in joules per day? (1 cal = 4.184 J)

Four Steps for Solving Quantitative Problems: Chap. 2, Sec. 3

76. Gasoline has a density of 0.73 g/cm^3. How many liters of gasoline would be required to increase the mass of an automobile from 1271 kg to 1305 kg?

77. A swimming pool measures 9.0 m long by 3.5 m wide by 1.75 m deep. What mass of water in metric tons (1 metric ton = 1000 kg) does the pool contain when filled? The density of the water in the pool is 0.997 g/cm^3.

78. A tightly packed box of crackers contains 250 g of crackers and measures 7.0 cm × 17.0 cm × 19.0 cm. What is the average density in kilograms per liter of the crackers in the package? Assume that the unused volume is negligible.

MIXED REVIEW

Solve these problems by using the Four Steps for Solving Quantitative Problems.

79. The aluminum foil on a certain roll has a total area of 18.5 m^2 and a mass of 1275 g. Using a density of 2.7 g per cubic centimeter for aluminum, determine the thickness in millimeters of the aluminum foil.

80. If a liquid has a density of 1.17 g/cm^3, how many liters of the liquid have a mass of 3.75 kg?

81. A stack of 500 sheets of paper measuring 28 cm× 21 cm is 44.5 mm high and has a mass of 2090 g. What is the density of the paper in grams per cubic centimeter?

82. A triangular-shaped piece of a metal has a mass of 6.58 g. The triangle is 0.560 mm thick and measures 36.4 mm on the base and 30.1 mm in height. What is the density of the metal in grams per cubic centimeter?

83. A packing crate measures 0.40 m × 3 0.40 m × 3 0.25 m. You must fill the crate with boxes of cookies that each measure 22.0 cm × 12.0 cm × 5.0 cm. How many boxes of cookies can fit into the crate?

84. Calculate the unknown quantities in the following table. Use the following relationships for volumes of the various shapes.

Volume of a cube = $l \times l \times l$
Volume of a rectangle = $l \times w \times h$
Volume of a sphere = $4/3\ \pi r^3$
Volume of a cylinder = $\pi\ r^2 \times h$

	D	*m*	*V*	Shape	Dimensions
a.	2.27 g/cm^3	3.93 kg	? L	cube	? m × ? m × ? m
b.	1.85 g/cm^3	? g	? cm^3	rectangle	33 mm × 21 mm × 7.2 mm
c.	3.21 g/L	? kg	? dm^3	sphere	3.30 m diameter
d.	? g/cm^3	497 g	? m^3	cylinder	7.5 cm diameter × 12 cm
e.	0.92 g/cm^3	? kg	? cm^3	rectangle	3.5 m × 1.2 m × 6.5 m

85. When a sample of a metal alloy that has a mass of 9.65 g is placed into a graduated cylinder containing water, the volume reading in the cylinder increases from 16.0 mL to 19.5 mL. What is the density of the alloy sample in grams per cubic centimeter?

86. Pure gold can be made into extremely thin sheets called gold leaf. Suppose that 50. kg of gold is made into gold leaf having an area of 3620 m^2. The density of gold is 19.3 g/cm^3.
- **a.** How thick in micrometers is the gold leaf?
- **b.** A gold atom has a radius of 1.44×10^{-10} m. How many atoms thick is the gold leaf?

87. A chemical plant process requires that a cylindrical reaction tank be filled with a certain liquid in 238 s. The tank is 1.2 m in diameter and 4.6 m high. What flow rate in liters per minute is required to fill the reaction tank in the specified time?

88. The radioactive decay of 2.8 g of plutonium-238 generates 1.0 joule of energy as heat every second. Plutonium has a density of 19.86 g/cm^3. How many calories (1 cal = 4.184 J) of energy as heat will a rectangular piece of plutonium that is 4.5 cm × 3.05 cm × 15 cm generate per hour?

89. The mass of Earth is 5.974×10^{24} kg. Assume that Earth is a sphere of diameter 1.28×10^4 km, and calculate the average density of Earth in g/cm^3.

90. What volume of magnesium in cubic centimeters would have the same mass as 1.82 dm^3 of platinum? The density of magnesium is 1.74 g/cm^3, and the density of platinum is 21.45 g/cm^3.

91. A roll of transparent tape has 66 m of tape on it. If an average of 5.0 cm of tape is needed each time the tape is used, how many uses can you get from a case of tape containing 24 rolls?

92. An automobile can travel 38 km on 4.0 L of gasoline. If the automobile is driven 75% of the days in a year and the average distance traveled each day is 86 km, how many liters of gasoline will be consumed in one year (assume the year has 365 days)?

93. A hose delivers water to a swimming pool that measures 9.0 m long by 3.5 m wide by 1.75 m deep. It requires 97 h to fill the pool. At what rate in liters per minute will the hose fill the pool?

94. Automobile batteries are filled with a solution of sulfuric acid, which has a density of 1.285 g/cm^3. The solution used to fill the battery is 38% (by mass) sulfuric acid. How many grams of sulfuric acid are present in 500 mL of battery acid?

Mole Concept: Chap. 3, Sec. 3; Chap. 7, Sec. 3

PROBLEMS INVOLVING ATOMS AND ELEMENTS

95. Calculate the number of moles in each of the following masses.
- **a.** 64.1 g of aluminum
- **b.** 28.1 g of silicon
- **c.** 0.255 g of sulfur
- **d.** 850.5 g of zinc

96. Calculate the mass of each of the following amounts.
- **a.** 1.22 mol sodium
- **b.** 14.5 mol copper
- **c.** 0.275 mol mercury
- **d.** 9.37×10^{-3} mol magnesium

97. Calculate the amount in moles in each of the following quantities.
- **a.** 3.01×10^{23} atoms of rubidium
- **b.** 8.08×10^{22} atoms of krypton
- **c.** 5 700 000 000 atoms of lead
- **d.** 2.997×10^{25} atoms of vanadium

98. Calculate the number of atoms in each of the following amounts.
- **a.** 1.004 mol bismuth
- **b.** 2.5 mol manganese
- **c.** 0.000 0002 mol helium
- **d.** 32.6 mol strontium

99. Calculate the number of atoms in each of the following masses.
- **a.** 54.0 g of aluminum
- **b.** 69.45 g of lanthanum
- **c.** 0.697 g of gallium
- **d.** 0.000 000 020 g beryllium

100. Calculate the mass of the following numbers of atoms.
- **a.** 6.022×10^{24} atoms of tantalum
- **b.** 3.01×10^{21} atoms of cobalt
- **c.** 1.506×10^{24} atoms of argon
- **d.** 1.20×10^{25} atoms of helium

PROBLEMS INVOLVING MOLECULES, FORMULA UNITS, AND IONS

101. Calculate the number of moles in each of the following masses.
- **a.** 3.00 g of boron tribromide, BBr_3
- **b.** 0.472 g of sodium fluoride, NaF
- **c.** 7.50×10^2 g of methanol, CH_3OH
- **d.** 50.0 g of calcium chlorate, $Ca(ClO_3)_2$

102. Determine the mass of each of the following amounts.
- **a.** 1.366 mol of NH_3
- **b.** 0.120 mol of glucose, $C_6H_{12}O_6$
- **c.** 6.94 mol barium chloride, $BaCl_2$
- **d.** 0.005 mol of propane, C_3H_8

103. Calculate the number of molecules in each of the following amounts.
- **a.** 4.99 mol of methane, CH_4
- **b.** 0.005 20 mol of nitrogen gas, N_2
- **c.** 1.05 mol of phosphorus trichloride, PCl_3
- **d.** 3.5×10^{-5} mol of vitamin C, ascorbic acid, $C_6H_8O_6$

104. Calculate the number of formula units in the following amounts.
- **a.** 1.25 mol of potassium bromide, KBr
- **b.** 5.00 mol of magnesium chloride, $MgCl_2$
- **c.** 0.025 mol of sodium carbonate, Na_2CO_3
- **d.** 6.82×10^{-6} mol of lead(II) nitrate, $Pb(NO_3)_2$

105. Calculate the amount in moles of the following numbers of molecules or formula units.
- **a.** 3.34×10^{34} formula units of $Cu(OH)_2$
- **b.** 1.17×10^{16} molecules of H_2S
- **c.** 5.47×10^{21} formula units of nickel(II) sulfate, $NiSO_4$
- **d.** 7.66×10^{19} molecules of hydrogen peroxide, H_2O_2

106. Calculate the mass of each of the following quantities.
- **a.** 2.41×10^{24} molecules of hydrogen, H_2
- **b.** 5.00×10^{21} formula units of aluminum hydroxide, $Al(OH)_3$
- **c.** 8.25×10^{22} molecules of bromine pentafluoride, BrF_5
- **d.** 1.20×10^{23} formula units of sodium oxalate, $Na_2C_2O_4$

107. Calculate the number of molecules or formula units in each of the following masses.
- **a.** 22.9 g of sodium sulfide, Na_2S
- **b.** 0.272 g of nickel(II) nitrate, $Ni(NO_3)_2$
- **c.** 260 mg of acrylonitrile, CH_2CHCN

MIXED REVIEW

108. Calculate the number of moles in each of the following masses.
- **a.** 0.039 g of palladium
- **b.** 8200 g of iron
- **c.** 0.0073 kg of tantalum
- **d.** 0.006 55 g of antimony
- **e.** 5.64 kg of barium

109. Calculate the mass in grams of each of the following amounts.
- **a.** 1.002 mol of chromium
- **b.** 550 mol of aluminum
- **c.** 4.08×10^{-8} mol of neon
- **d.** 7 mol of titanium
- **e.** 0.0086 mol of xenon
- **f.** 3.29×10^{4} mol of lithium

110. Calculate the number of atoms in each of the following amounts.
- **a.** 17.0 mol of germanium
- **b.** 0.6144 mol of copper
- **c.** 3.02 mol of tin
- **d.** 2.0×10^{6} mol of carbon
- **e.** 0.0019 mol of zirconium
- **f.** 3.227×10^{-10} mol of potassium

111. Calculate the number of moles in each of the following quantities.
- **a.** 6.022×10^{24} atoms of cobalt
- **b.** 1.06×10^{23} atoms of tungsten
- **c.** 3.008×10^{19} atoms of silver
- **d.** 950 000 000 atoms of plutonium
- **e.** 4.61×10^{17} atoms of radon
- **f.** 8 trillion atoms of cerium

112. Calculate the number of atoms in each of the following masses.
- **a.** 0.0082 g of gold
- **b.** 812 g of molybdenum
- **c.** 2.00×10^{2} mg of americium
- **d.** 10.09 kg of neon
- **e.** 0.705 mg of bismuth
- **f.** 37 μ g of uranium

113. Calculate the mass of each of the following.
- **a.** 8.22×10^{23} atoms of rubidium
- **b.** 4.05 Avogadro's constants of manganese atoms
- **c.** 9.96×10^{26} atoms of tellurium
- **d.** 0.000 025 Avogadro's constants of rhodium atoms
- **e.** 88 300 000 000 000 atoms of radium
- **f.** 2.94×10^{17} atoms of hafnium

114. Calculate the number of moles in each of the following masses.
- **a.** 45.0 g of acetic acid, CH_3COOH
- **b.** 7.04 g of lead(II) nitrate, $Pb(NO_3)_2$
- **c.** 5000 kg of iron(III) oxide, Fe_2O_3
- **d.** 12.0 mg of ethylamine, $C_2H_5NH_2$
- **e.** 0.003 22 g of stearic acid, $C_{17}H_{35}COOH$
- **f.** 50.0 kg of ammonium sulfate, $(NH_4)_2SO_4$

115. Calculate the mass of each of the following amounts.
- **a.** 3.00 mol of selenium oxybromide, $SeOBr_2$
- **b.** 488 mol of calcium carbonate, $CaCO_3$
- **c.** 0.0091 mol of retinoic acid, $C_{20}H_{28}O_2$
- **d.** 6.00×10^{-8} mol of nicotine, $C_{10}H_{14}N_2$
- **e.** 2.50 mol of strontium nitrate, $Sr(NO_3)_2$
- **f.** 3.50×10^{-6} mol of uranium hexafluoride, UF_6

116. Calculate the number of molecules or formula units in each of the following amounts.
- **a.** 4.27 mol of tungsten(VI) oxide, WO_3
- **b.** 0.003 00 mol of strontium nitrate, $Sr(NO_3)_2$
- **c.** 72.5 mol of toluene, $C_6H_5CH_3$
- **d.** 5.11×10^{-7} mol of α-tocopherol (vitamin E), $C_{29}H_{50}O_2$
- **e.** 1500 mol of hydrazine, N_2H_4
- f. 0.989 mol of nitrobenzene $C_6H_5NO_2$

117. Calculate the number of molecules or formula units in each of the following masses.
- **a.** 285 g of iron(III) phosphate, $FePO_4$
- **b.** 0.0084 g of C_5H_5N
- **c.** 85 mg of 2-methyl-1-propanol, $(CH_3)_2CHCH_2OH$
- **d.** 4.6×10^{-4} g of mercury(II) acetate, $Hg(C_2H_3O_2)_2$
- **e.** 0.0067 g of lithium carbonate, Li_2CO_3

118. Calculate the mass of each of the following quantities.
- **a.** 8.39×10^{23} molecules of fluorine, F_2
- **b.** 6.82×10^{24} formula units of beryllium sulfate, $BeSO_4$
- **c.** 7.004×10^{26} molecules of chloroform, $CHCl_3$
- **d.** 31 billion formula units of chromium(III) formate, $Cr(CHO_2)_3$
- **e.** 6.3×10^{18} molecules of nitric acid, HNO_3
- **f.** 8.37×10^{25} molecules of Freon 114, $C_2Cl_2F_4$

119. Precious metals are commonly measured in troy ounces. A troy ounce is equivalent to 31.1 g. How many moles are in a troy ounce of gold? How many moles are in a troy ounce of platinum? of silver?

120. A chemist needs 22.0 g of phenol, C_6H_5OH, for an experiment. How many moles of phenol is this?

121. A student needs 0.015 mol of iodine crystals, I_2, for an experiment. What mass of iodine crystals should the student obtain?

122. The weight of a diamond is given in carats. One carat is equivalent to 200. mg. A pure diamond is made up entirely of carbon atoms. How many carbon atoms make up a 1.00 carat diamond?

123. 8.00 g of calcium chloride, $CaCl_2$, is dissolved in 1.000 kg of water.
- **a.** How many moles of $CaCl_2$ are in solution? How many moles of water are present?
- **b.** Assume that the ionic compound, $CaCl_2$, separates completely into Ca^{2+} and Cl^- ions when it dissolves in water. How many moles of each ion are present in the solution?

124. How many moles are in each of the following masses?
- **a.** 453.6 g (1.000 pound) of sucrose (table sugar), $C_{12}H_{22}O_{11}$
- **b.** 1.000 pound of table salt, NaCl

125. When the ionic compound NH_4Cl dissolves in water, it breaks into one ammonium ion, NH_4^+, and one chloride ion, Cl^-. If you dissolved 10.7 g of NH_4Cl in water, how many moles of ions would be in solution?

126. What is the total amount in moles of atoms in a jar that contains 2.41×10^{24} atoms of chromium, 1.51×10^{23} atoms of nickel, and 3.01×10^{23} atoms of copper?

127. The density of liquid water is 0.997 g/mL at 25°C.
- **a.** Calculate the mass of 250.0 mL (about a cupful) of water.
- **b.** How many moles of water are in 250.0 mL of water? Hint: Use the result of (a).
- **c.** Calculate the volume that would be occupied by 2.000 mol of water at 25°C.
- **d.** What mass of water is 2.000 mol of water?

128. An Avogadro's constant (1 mol) of sugar molecules has a mass of 342 g, but an Avogadro's constant (1 mol) of water molecules has a mass of only 18 g. Explain why there is such a difference between the mass of 1 mol of sugar and the mass of 1 mol of water.

129. Calculate the mass of aluminum that would have the same number of atoms as 6.35 g of cadmium.

130. A chemist weighs a steel cylinder of compressed oxygen, O_2, and finds that it has a mass of 1027.8 g. After some of the oxygen is used in an experiment, the cylinder has a mass of 1023.2 g. How many moles of oxygen gas are used in the experiment?

131. Suppose that you could decompose 0.250 mol of Ag_2S into its elements.
- **a.** How many moles of silver would you have? How many moles of sulfur would you have?
- **b.** How many moles of Ag_2S are there in 38.8 g of Ag_2S? How many moles of silver and sulfur would be produced from this amount of Ag_2S?
- **c.** Calculate the masses of silver and sulfur produced in (b).

Percentage Composition: Chap. 7, Sec. 3

132. Determine the percentage composition of each of the following compounds.
- **a.** sodium oxalate, $Na_2C_2O_4$
- **b.** ethanol, C_2H_5OH
- **c.** aluminum oxide, Al_2O_3
- **d.** potassium sulfate, K_2SO_4

133. Suppose that a laboratory analysis of white powd showed 42.59% Na, 12.02% C, and 44.99% O. Would you report that the compound is sodium oxalate or sodium carbonate? (Use 43.38% Na, 11.33% C, and 45.29% O for sodium carbonate, and 34.31% Na, 17.93% C, and 47.76% O for sodium oxalate.)

134. Calculate the mass of the given element in each of the following compounds.
- **a.** bromine in 50.0 g potassium bromide, KBr
- **b.** chromium in 1.00 kg sodium dichromate, $Na_2Cr_2O_7$
- **c.** nitrogen i 85.0 mg of the amino acid lysine, $C_6H_{14}N_2O_2$
- **d.** cobalt in 2.84 g cobalt(II) acetate, $Co(C_2H_3O_2)_2$

HYDRATES

135. Calculate the percentage of water in each of the following hydrates.
- **a.** sodium carbonate decahydrate, $Na_2CO_3 \bullet 10H_2O$
- **b.** nickel(II) iodide hexahydrate, $NiI_2 \bullet 6H_2O$
- **c.** ammonium hexacyanoferrate(III) trihydrate (commonly called ammonium ferricyanide), $(NH_4)_2Fe(CN)_6 \bullet 3H_2O$
- **d.** aluminum bromide hexahydrate, $AlBr_3 \bullet 6H_2O$

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136. Write formulas for the following compounds, and determine the percentage composition of each.
- **a.** nitric acid
- **b.** ammonia
- **c.** mercury(II) sulfate
- **d.** antimony(V) fluoride

137. Calculate the percentage composition of the following compounds.
- **a.** lithium bromide, LiBr
- **b.** anthracene, $C_{14}H_{10}$
- **c.** ammonium nitrate, NH_4NO_3
- **d.** nitrous acid, HNO_2
- **e.** silver sulfide, Ag_2S
- **f.** iron(II) thiocyanate, $Fe(SCN)_2$
- **g.** lithium acetate
- **h.** nickel(II) formate

138. Calculate the percentage of the given element in each of the following compounds.
- **a.** nitrogen in urea, NH_2CONH_2
- **b.** sulfur in sulfuryl chloride, SO_2Cl_2
- **c.** thallium in thallium(III) oxide, Tl_2O_3
- **d.** oxygen in potassium chlorate, $KClO_3$
- **e.** bromine in calcium bromide, $CaBr_2$
- **f.** tin in tin(IV) oxide, SnO_2

139. Calculate the mass of the given element in each of the following quantities.
- **a.** oxygen in 4.00 g of manganese dioxide, MnO_2
- **b.** aluminum in 50.0 metric tons of aluminum oxide, Al_2O_3
- **c.** silver in 325 g silver cyanide, AgCN
- **d.** gold in 0.780 g of gold(III) selenide, Au_2Se_3
- **e.** selenium in 683 g sodium selenite, Na_2SeO_3
- **f.** chlorine in 5.0×10^4 g of 1,1-dichloropropane, $CHCl_2CH_2CH_3$

140. Calculate the percentage of water in each of the following hydrates.
- **a.** strontium chloride hexahydrate, $SrCl_2 \bullet 6H_2O$
- **b.** zinc sulfate heptahydrate, $ZnSO_4 \bullet 7H_2O$
- **c.** calcium fluorophosphate dihydrate, $CaFPO_3 \bullet 2H_2O$
- **d.** beryllium nitrate trihydrate, $Be(NO_3)_2 \bullet 3H_2O$

141. Calculate the percentage of the given element in each of the following hydrates. You must first determine the formulas of the hydrates.
- **a.** nickel in nickel(II) acetate tetrahydrate
- **b.** chromium in sodium chromate tetrahydrate
- **c.** cerium in cerium(IV) sulfate tetrahydrate

142. Cinnabar is a mineral that is mined in order to produce mercury. Cinnabar is mercury(II) sulfide, HgS. What mass of mercury can be obtained from 50.0 kg of cinnabar?

143. The minerals malachite, $Cu_2(OH)_2CO_3$, and chalcopyrite, $CuFeS_2$, can be mined to obtain copper metal. How much copper could be obtained from 1.00×10^3 kg of each? Which of the two has the greater copper content?

144. Calculate the percentage of the given element in each of the following hydrates.
- **a.** vanadium in vanadium oxysulfate dihydrate, $VOSO_4 \cdot 2H_2O$
- **b.** tin in potassium stannate trihydrate, $K_2SnO_3 \cdot 3H_2O$
- **c.** chlorine in calcium chlorate dihydrate, $CaClO_3 \cdot 2H_2O$

145. Heating copper sulfate pentahydrate will evaporate the water from the crystals, leaving anhydrous copper sulfate, a white powder. *Anhydrous* means "without water." What mass of anhydrous $CuSO_4$ would be produced by heating 500.0 g of $CuSO_4 \cdot 5H_2O$?

146. Silver metal may be precipitated from a solution of silver nitrate by placing a copper strip into the solution. What mass of $AgNO_3$ would you dissolve in water in order to get 1.00 g of silver?

147. A sample of Ag_2S has a mass of 62.4 g. What mass of each element could be obtained by decomposing this sample?

148. A quantity of epsom salts, magnesium sulfate heptahydrate, $MgSO_4 \cdot 7H_2O$, is heated until all the water is driven off. The sample loses 11.8 g in the process. What was the mass of the original sample?

149. The process of manufacturing sulfuric acid begins with the burning of sulfur. What mass of sulfur would have to be burned in order to produce 1.00 kg of H_2SO_4? Assume that all of the sulfur ends up in the sulfuric acid.

Empirical Formulas: Chap. 7, Sec. 4

150. Determine the empirical formula for compounds that have the following analyses.
- **a.** 28.4% copper, 71.6% bromine
- **b.** 39.0% potassium, 12.0% carbon, 1.01% hydrogen, and 47.9% oxygen
- **c.** 77.3% silver, 7.4% phosphorus, 15.3% oxygen
- **d.** 0.57% hydrogen, 72.1% iodine, 27.3% oxygen

151. Determine the simplest formula for compounds that have the following analyses. The data may not be exact.
- **a.** 36.2% aluminum and 63.8% sulfur
- **b.** 93.5% niobium and 6.50% oxygen
- **c.** 57.6% strontium, 13.8% phosphorus, and 28.6% oxygen
- **d.** 28.5% iron, 48.6% oxygen, and 22.9% sulfur

152. Determine the molecular formula of each of the following unknown substances.
- **a.** empirical formula CH_2
  experimental molar mass 28 g/mol
- **b.** empirical formula B_2H_5
  experimental molar mass 54 g/mol
- **c.** empirical formula C_2HCl
  experimental molar mass 179 g/mol
- **d.** empirical formula C_6H_8O
  experimental molar mass 290 g/mol
- **e.** empirical formula C_3H_2O
  experimental molar mass 216 g/mol

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153. Determine the empirical formula for compounds that have the following analyses.
- **a.** 66.0% barium and 34.0% chlorine
- **b.** 80.38% bismuth, 18.46% oxygen, and 1.16% hydrogen
- **c.** 12.67% aluminum, 19.73% nitrogen, and 67.60% oxygen
- **d.** 35.64% zinc, 26.18% carbon, 34.88% oxygen, and 3.30% hydrogen
- **e.** 2.8% hydrogen, 9.8% nitrogen, 20.5% nickel, 44.5% oxygen, and 22.4% sulfur
- **f.** 8.09% carbon, 0.34% hydrogen, 10.78% oxygen, and 80.78% bromine

154. Sometimes, instead of percentage composition, you will have the composition of a sample by mass. Using the actual mass of the sample, determine the empirical formula for compounds that have the following analyses.
- **a.** a 0.858 g sample of an unknown substance is composed of 0.537 g of copper and 0.321 g of fluorine
- **b.** a 13.07 g sample of an unknown substance is composed of 9.48 g of barium, 1.66 g of carbon, and 1.93 g of nitrogen
- **c.** a 0.025 g sample of an unknown substance is composed of 0.0091 g manganese, 0.0106 g oxygen, and 0.0053 g sulfur

155. Determine the empirical formula for compounds that have the following analyses.
- **a.** a 0.0082 g sample contains 0.0015 g of nickel and 0.0067 g of iodine
- **b.** a 0.470 g sample contains 0.144 g of manganese, 0.074 g of nitrogen, and 0.252 g of oxygen
- **c.** a 3.880 g sample contains 0.691 g of magnesium, 1.824 g of sulfur, and 1.365 g of oxygen
- **d.** a 46.25 g sample contains 14.77 g of potassium, 9.06 g of oxygen, and 22.42 g of tin

156. Determine the empirical formula for compounds that have the following analyses:
- **a.** 60.9% As and 39.1% S
- **b.** 76.89% Re and 23.12% O
- **c.** 5.04% H, 35.00% N, and 59.96% O
- **d.** 24.3% Fe, 33.9% Cr, and 41.8% O
- **e.** 54.03% C, 37.81% N, and 8.16% H
- **f.** 55.81% C, 3.90% H, 29.43% F, and 10.85% N

157. Determine the molecular formulas for compounds having the following empirical formulas and molar masses.
- **a.** C_2H_4S; experimental molar mass 179
- **b.** C_2H_4O; experimental molar mass 176
- **c.** $C_2H_3O_2$; experimental molar mass 119
- **d.** C_2H_2O; experimental molar mass 254

158. Use the experimental molar mass to determine the molecular formula for compounds having the following analyses.
- **a.** 41.39% carbon, 3.47% hydrogen, and 55.14% oxygen; experimental molar mass 116.07
- **b.** 54.53% carbon, 9.15% hydrogen, and 36.32% oxygen; experimental molar mass 88
- **c.** 64.27% carbon, 7.19% hydrogen, and 28.54% oxygen; experimental molar mass 168.19

159. A 0.400 g sample of a white powder contains 0.141 g of potassium, 0.115 g of sulfur, and 0.144 g of oxygen. What is the empirical formula for the compound?

160. A 10.64 g sample of a lead compound is analyzed and found to be made up of 9.65 g of lead and 0.99 g of oxygen. Determine the empirical formula for this compound.

161. A 2.65 g sample of a salmon-colored powder contains 0.70 g of chromium, 0.65 g of sulfur, and 1.30 g of oxygen. The molar mass is 392.2. What is the formula of the compound?

162. Ninhydrin is a compound that reacts with amino acids and proteins to produce a dark-colored complex. It is used by forensic chemists and detectives to see fingerprints that might otherwise be invisible. Ninhydrin's composition is 60.68% carbon, 3.40% hydrogen, and 35.92% oxygen. What is the empirical formula for ninhydrin?

163. Histamine is a substance that is released by cells in response to injury, infection, stings, and materials that cause allergic responses, such as pollen. Histamine causes dilation of blood vessels and swelling due to accumulation of fluid in the tissues. People sometimes take *anti*histamine drugs to counteract the effects of histamine. A sample of histamine having a mass of 385 mg is composed of 208 mg of carbon, 31 mg of hydrogen, and 146 mg of nitrogen. The molar mass of histamine is 111 g/mol. What is the molecular formula for histamine?

164. You analyze two substances in the laboratory and discover that each has the empirical formula CH_2O. You can easily see that they are different substances because one is a liquid with a sharp, biting odor and the other is an odorless, crystalline solid. How can you account for the fact that both have the same empirical formula?

Stoichiometry: Chap. 9, Sec. 1–2

165. How many moles of sodium will react with water to produce 4.0 mol of hydrogen in the following reaction?

$$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$$

166. How many moles of lithium chloride will be formed by the reaction of chlorine with 0.046 mol of lithium bromide in the following reaction?

$$2LiBr(aq) + Cl_2(g) \longrightarrow 2LiCl(aq) + Br_2(l)$$

167. Aluminum will react with sulfuric acid in the following reaction.

$$2Al(s) + 3H_2SO_4(l) \longrightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

- **a.** How many moles of H_2SO_4 will react with 18 mol Al?
- **b.** How many moles of each product will be produced?

168. Propane burns in excess oxygen according to the following reaction.

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

- **a.** How many moles each of $CO_2$and H_2O are formed from 3.85 mol of propane?
- **b.** If 0.647 mol of oxygen is used in the burning of propane, how many moles each of $CO_2$and H_2O are produced? How many moles of C_3H_8 are consumed?

169. Phosphorus burns in air to produce a phosphorus oxide in the following reaction:

$$4P(s) + 5O_2(g) \longrightarrow P_4O_{10}(s)$$

- **a.** What mass of phosphorus will be needed to produce 3.25 mol of P_4O_{10}?
- **b.** If 0.489 mol of phosphorus burns, what mass of oxygen is used? What mass of P_4O_{10} is produced?

170. Hydrogen peroxide breaks down, releasing oxygen, in the following reaction.

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

- **a.** What mass of oxygen is produced when 1.840 mol of H_2O_2 decompose?
- **b.** What mass of water is produced when 5.0 mol O_2 is produced by this reaction?

171. Sodium carbonate reacts with nitric acid according to the following equation:

$$Na_2CO_3(s) + 2HNO_3 \longrightarrow 2NaNO_3 + CO_2 + H_2O$$

- **a.** How many moles of Na_2CO_3 are required to produce 100.0 g of $NaNO_3$?
- **b.** If 7.50 g of Na_2CO_3 reacts, how many moles of CO_2 are produced?

172. Hydrogen is generated by passing hot steam over iron, which oxidizes to form Fe_3O_4, in the following equation:

$$3Fe(s) + 4H_2O(g) \longrightarrow 4H_2(g) + Fe_3O_4(s)$$

- **a.** If 625 g of Fe_3O_4 is produced in the reaction, how many moles of hydrogen are produced at the same time?
- **b.** How many moles of iron would be needed to generate 27 g of hydrogen?

173. Calculate the mass of silver bromide produced from 22.5 g of silver nitrate in the following reaction:

$$2AgNO_3(aq) + MgBr_2(aq) \longrightarrow 2AgBr(s) + Mg(NO_3)_2(aq)$$

174. What mass of acetylene, C_2H_2, will be produced from the reaction of 90. g of calcium carbide, CaC_2, with water in the following reaction?

$$CaC_2(s) + 2H_2O(l) \longrightarrow C_2H_2(g) + Ca(OH)_2(s)$$