Chapter 5  Measurements and Calculations

1.  4

2.  4512

3.  
   a.  0.06235  
   b.  7229  
   c.  0.000005001  
   d.  86,210

4.  
   a.  \(-5; 6.7 \times 10^{-5}\)  
   b.  \(6; 9.331442 \times 10^6\)  
   c.  \(-4; 1 \times 10^{-4}\)  
   d.  \(4; 1.631 \times 10^4\)

5.  
   a.  The decimal point must be moved six places to the left, so the exponent is positive six.  \(9,367,421 = 9.367421 \times 10^6\)  
   
   b.  The decimal point must be moved three places to the left, so the exponent is positive three.  \(7241 = 7.241 \times 10^3\)  
   
   c.  The decimal point must be moved four places to the right, so the exponent is negative four.  \(0.0005519 = 5.519 \times 10^{-4}\)  
   
   d.  The decimal point does not have to be moved, so the exponent is zero.  \(5.408 = 5.408 \times 10^0\)  
   
   e.  \(6.24 \times 10^2\) is already written in standard scientific notation.  
   
   f.  The decimal point must be moved three places to the left, and the resulting exponent of positive three must be combined with the exponent of negative two in the multiplier.  \(6.319 \times 10^2 = 6.319 \times 10^1\)  
   
   g.  The decimal point must be moved nine places to the right, so the exponent is negative nine.  \(0.00000007215 = 7.215 \times 10^{-9}\)  
   
   h.  The decimal point must be moved one place to the right, so the exponent is negative one.  \(0.721 = 7.21 \times 10^{-1}\)

6.  
   a.  The decimal point must be moved two places to the right.  \(4.83 \times 10^2 = 483\)  
   
   b.  The decimal point must be moved four places to the left.  \(7.221 \times 10^{-4} = 0.0007221\)  
   
   c.  The decimal point does not have to be moved.  \(6.1 \times 10^0 = 6.1\)
d. The decimal point must be moved eight places to the left.
\[ 9.11 \times 10^{-8} = 0.0000000911 \]

e. The decimal point must be moved six places to the right.
\[ 4.221 \times 10^{6} = 4,221,000 \]

f. The decimal point must be moved three places to the left.
\[ 1.22 \times 10^{-3} = 0.00122 \]

g. The decimal point must be moved three places to the right.
\[ 9.999 \times 10^{3} = 9999 \]

h. The decimal point must be moved five places to the left.
\[ 1.016 \times 10^{-5} = 0.00001016 \]

i. The decimal point must be moved five places to the right.
\[ 1.016 \times 10^{5} = 101,600 \]

j. The decimal point must be moved one place to the left.
\[ 4.11 \times 10^{-1} = 0.411 \]

k. The decimal point must be moved four places to the right.
\[ 9.71 \times 10^{4} = 97,100 \]

l. The decimal point must be moved four places to the left.
\[ 9.71 \times 10^{-4} = 0.000971 \]

7. To say that scientific notation is in **standard form** means that you have a number between 1 and 10, followed by an exponential term. The numbers given in this problem are **not** between 1 and 10 as written.

a. \[ 142.3 \times 10^{3} = (1.423 \times 10^{2}) \times 10^{3} = 1.423 \times 10^{5} \]

b. \[ 0.0007741 \times 10^{-9} = (7.741 \times 10^{-4}) \times 10^{-9} = 7.741 \times 10^{-13} \]

c. \[ 22.7 \times 10^{3} = (2.27 \times 10^{1}) \times 10^{3} = 2.27 \times 10^{4} \]

d. \[ 6.272 \times 10^{-5} \text{ is already written in standard scientific notation.} \]

e. \[ 0.0251 \times 10^{4} = (2.51 \times 10^{-2}) \times 10^{4} = 2.51 \times 10^{2} \]

f. \[ 97.522 \times 10^{-3} = (9.7522 \times 10^{1}) \times 10^{-3} = 9.7522 \times 10^{1} \]

g. \[ 0.000097752 \times 10^{6} = (9.7752 \times 10^{-4}) \times 10^{6} = 9.7752 \times 10^{9} (9.97752) \]

h. \[ 44.252 \times 10^{4} = (4.4252 \times 10^{4}) \times 10^{4} = 4.4252 \times 10^{8} \]

8. a. \[ \frac{1}{0.00032} = 3.1 \times 10^{3} \]

b. \[ 10^{3}/10^{3} = 1 \times 10^{0} \]

c. \[ 10^{4}/10^{3} = 1 (1 \times 10^{0}) \text{; any number divided by itself is unity.} \]

d. \[ 1/55,000 = 1.8 \times 10^{-5} \]

e. \[ (10^{5})(10^{4})(10^{-4})/10^{-2} = 1 \times 10^{7} \]

f. \[ 43.2/(4.32 \times 10^{-5}) = \frac{4.32 \times 10^{1}}{4.32 \times 10^{-5}} = 1.00 \times 10^{6} \]
g. \( \frac{4.32 \times 10^{-5}}{432} = \frac{4.32 \times 10^{-5}}{4.32 \times 10^2} = 1.00 \times 10^{-7} \)

h. \( \frac{1}{10^5} \cdot \frac{1}{10^{-6}} = \frac{1}{10^1} = 1 \times 10^1 \)

9. a. \( 10^3 \)
b. \( 10^{-2} \)
c. \( 10^{-3} \)
d. \( 10^{-1} \)
e. \( 10^{-9} \)
f. \( 10^{-6} \)

10. a. mega-
b. milli-
c. nano-
d. mega-
e. centi-
f. micro-

11. A mile represents, by definition, a greater distance than a kilometer. Therefore, 100 mi represents a greater distance than 100 km.

12. quart

13. 5.22 cm

14. 1.62 m is approximately 5 ft 4 in. The woman is slightly taller.

15. c

16. d

17. c

18. d (the other units would give very large numbers for the distance)

19. Table 5.6 indicates that a dime is 1 mm thick.

\[
10 \text{ cm} \times \frac{10 \text{ mm}}{1 \text{ cm}} \times \frac{1 \text{ dime}}{1 \text{ mm}} \times \frac{\$1}{10 \text{ dimes}} = \$10
\]

20. Table 5.6 indicates that the diameter of a quarter is 2.5 cm.

\[
1 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} \times \frac{1 \text{ quarter}}{2.5 \text{ cm}} = 40 \text{ quarters}
\]
21. When we use a measuring scale to the limit of precision, we estimate between the smallest divisions on the scale: since this is our best estimate, the last significant digit recorded is uncertain.

22. The third figure in the length of the pin is uncertain because the measuring scale of the ruler has tenths as the smallest marked scale division. The length of the pin is given as 2.85 cm (rather than any other number) to indicate that the point of the pin appears to the observer to be halfway between the smallest marked scale divisions.

23. The scale of the ruler shown is only marked to the nearest tenth of a centimeter; writing 2.850 would imply that the scale was marked to the nearest hundredth of a centimeter (and that the zero in the thousandths place had been estimated).

24. 
   a. four
   b. five
   c. four
   d. one
   e. three (the decimal point makes the zeroes significant)
   f. three (because the number is written in scientific notation)
   g. six
   h. five

25. 
   a. probably only two
   b. infinite (a definition)
   c. infinite (a definition)
   d. probably only one
   e. three (the race is defined to be exactly 500. miles)

26. 
   a. 1,570,000 (or better, $1.57 \times 10^6$)
   b. $2.77 \times 10^{-3}$
   c. 84,600 (or better, $8.46 \times 10^4$)
   d. 0.00117
   e. 0.0776

27. 
   a. $3.42 \times 10^{-4}$
   b. $1.034 \times 10^4$
   c. $1.7992 \times 10^1$
   d. $3.37 \times 10^5$

28. two significant figures (based on 0.0043 having two significant figures)

29. three
30. only one (based on 121.2 being known only to the first decimal place)

31. none

32. a. 641.0 (the answer can only be given to one decimal place, since 212.7 and 26.7 are only given to one decimal place)
   b. 1.327 (the answer can only be given to three decimal places, since 0.221 is only given to three decimal places)
   c. 77.34 (the answer can only be given to two decimal places, since 26.01 is only given to two decimal places)
   d. Before performing the calculation, the numbers have to be converted so that they contain the same power of ten.
      \[2.01 \times 10^2 + 3.014 \times 10^2 = 2.01 \times 10^2 + 30.14 \times 10^2 = 32.15 \times 10^2\]
      This answer should then be converted to standard scientific notation.
      \[32.15 \times 10^2 = 3.215 \times 10^3 = 3215.\]

33. a. 124 (the answer can only be given to three significant figures because 0.995 is only given to three significant figures)
   b. \(1.995 \times 10^{-23}\) (the answer can only be given to four significant figures because 6.022 \(\times 10^{23}\) is only given to four significant figures)
   c. \(1.14 \times 10^{-2}\) (the answer can only be given to three significant figures because 0.500 is only given to three significant figures)
   d. \(5.3 \times 10^{-4}\) (the answer can only be given to three significant figures because 0.15 is only given to two significant figures)

34. a. \((2.0944 + 0.0003233 + 12.22)/7.001 = (14.3147233)/7.001 = 2.045\)
   b. \((1.42 \times 10^2 + 1.021 \times 10^3)/(3.1 \times 10^{-1}) = (142 + 1021)/(3.1 \times 10^{-1}) = (1163)/(3.1 \times 10^{-1}) = 3751 = 3.8 \times 10^3\)
   c. \((9.762 \times 10^{-3})/(1.43 \times 10^2 + 4.51 \times 10^1) = (9.762 \times 10^{-3})/(143 + 45.1) = (9.762 \times 10^{-3})/(188.1) = 5.19 \times 10^{-5}\)

35. an infinite number (a definition)

36. \(\frac{1 \text{ mi}}{1760 \text{ yd}} ; \frac{1760 \text{ yd}}{1 \text{ mi}}\)

37. \(\frac{\$0.79}{1 \text{ lb}}\)

38. \(\frac{1 \text{ lb}}{\$0.79}\)
39. a. $2.23 \text{ m} \times \frac{1.094 \text{ yd}}{1 \text{ m}} = 2.44 \text{ yd}$

b. $46.2 \text{ yd} \times \frac{1 \text{ m}}{1.094 \text{ yd}} = 42.2 \text{ m}$

c. $292 \text{ cm} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 115 \text{ in}$

d. $881.2 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 2238 \text{ cm}$

e. $1043 \text{ km} \times \frac{1 \text{ mi}}{1.6093 \text{ km}} = 648.1 \text{ mi}$

f. $445.5 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} = 716.9 \text{ km}$

g. $36.2 \text{ m} \times \frac{1 \text{ km}}{1000 \text{ m}} = 0.0362 \text{ km}$

h. $0.501 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 5.01 \times 10^4 \text{ cm}$

40. a. $254.3 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 0.2543 \text{ kg}$

b. $2.75 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 2.75 \times 10^3 \text{ g}$

c. $2.75 \text{ kg} \times \frac{1 \text{ lb}}{0.45359 \text{ kg}} = 6.06 \text{ lb}$

d. $2.75 \text{ kg} \times \frac{1 \text{ lb}}{0.45359 \text{ kg}} \times \frac{16 \text{ oz}}{1 \text{ lb}} = 97.0 \text{ oz}$

e. $534.1 \text{ g} \times \frac{1 \text{ lb}}{453.59 \text{ g}} = 1.177 \text{ lb}$

f. $1.75 \text{ lb} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 794 \text{ g}$

g. $8.7 \text{ oz} \times \frac{1 \text{ lb}}{16 \text{ oz}} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 2.5 \times 10^2 \text{ g}$

h. $45.9 \text{ g} \times \frac{1 \text{ lb}}{453.59 \text{ g}} \times \frac{16 \text{ oz}}{1 \text{ lb}} = 1.62 \text{ oz}$
41. \[\frac{20.00 \times \frac{1.2 \text{ euros}}{1.00}}{100 \text{ euros}} = 24.00 \text{ euros} \text{ (assuming the exchange rate is exact)}\]

\[\frac{1.00}{1.2 \text{ euros}} \times \frac{83.33 \text{ euros}}{100} = 83.33 \text{ euros} \text{ (assuming the exchange rate is exact)}\]

42. \[190 \text{ mi} = 1.9 \times 10^2 \text{ mi} \text{ to two significant figures}\]

\[1.9 \times 10^2 \text{ mi} \times \frac{1 \text{ km}}{0.62137 \text{ mi}} = 3.1 \times 10^2 \text{ km}\]

\[3.1 \times 10^2 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} = 3.1 \times 10^5 \text{ m}\]

\[1.9 \times 10^2 \text{ mi} \times \frac{5.280 \text{ ft}}{1 \text{ mi}} = 1.0 \times 10^6 \text{ ft}\]

43. To decide which train is faster, both speeds must be expressed in the same unit of distance (either miles or kilometers):

\[\frac{225 \text{ km}}{1 \text{ hr}} \times \frac{1 \text{ mi}}{1.6093 \text{ km}} = 140. \text{ mi/hr}\]

So the Boston–New York trains will be faster.

44. 212°F; 100°C

45. 100

46. Fahrenheit (F)

47. \[t_K = t_C + 273 \quad t_C = (t_F - 32)/1.80\]

a. \[-155 + 273 = 118 \text{ K}\]

b. \[200 + 273 = 473 \text{ K}\]

c. \[-52 + 273 = 221 \text{ K}\]

d. \[101°F = 38.3°C; 38.3 + 273 = 311 \text{ K}\]

e. \[-52°F = -46.6°C; -46.6 + 273 = 226 \text{ K}\]

f. \[-196 + 273 = 77 \text{ K}\]

48. \[t_C = t_K - 273\]

a. \[275 - 273 = 2°C\]

b. \[445 - 273 = 172°C\]

c. \[0 - 273 = -273°C\]
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49. d. \(77 - 273 = -196^\circ C\)
   e. \(10,000 - 273 = 9727^\circ C\)
   f. \(2 - 273 = -271^\circ C\)

50. a. \(1.80(-40) + 32 = -40^\circ F\)
    b. \((-40 - 32)/180 = -40^\circ C\)
    c. \(232 - 273 = -41^\circ C\)
    d. \(232 K = -41^\circ C; 1.80(-41) + 32 = -42^\circ F\)

51. volume

52. lead

53. low

54. Density is a characteristic property of a pure substance; all samples of the same pure substance have the same density.

55. aluminum (2.70 g/cm\(^3\))

56. density = \(\frac{\text{mass}}{\text{volume}}\)
    a. \(m = 4.53 \text{ kg} = 4530 \text{ g}\)
       \(d = \frac{4530 \text{ g}}{225 \text{ cm}^3} = 20.1 \text{ g/cm}^3\)
    b. \(v = 25.0 \text{ mL} = 25.0 \text{ cm}^3\)
       \(d = \frac{26.3 \text{ g}}{25.0 \text{ cm}^3} = 1.05 \text{ g/cm}^3\)
    c. \(m = 1.00 \text{ lb} = 453.59 \text{ g}\)
       \(d = \frac{453.59 \text{ g}}{500. \text{ cm}^3} = 0.907 \text{ g/cm}^3\)
    d. \(m = 352 \text{ mg} = 0.352 \text{ g}\)
       \(d = \frac{0.352 \text{ g}}{0.271 \text{ cm}^3} = 1.30 \text{ g/cm}^3\)
57. \( d = \frac{75.2 \text{ g}}{89.2 \text{ mL}} = 0.843 \text{ g/mL} \)

58. \( m = 1.45 \text{ kg} \times \frac{10^3 \text{ g}}{1 \text{ kg}} = 1.45 \times 10^3 \text{ g} \)
   \[ d = \frac{1.45 \times 10^3 \text{ g}}{542 \text{ mL}} = 2.68 \text{ g/mL} \]

59. \( m = 3.5 \text{ lb} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 1.59 \times 10^3 \text{ g} \)
   \[ v = 1.2 \times 10^4 \text{ in}^3 \times \left( \frac{2.54 \text{ cm}}{1 \text{ in}} \right)^3 = 1.97 \times 10^5 \text{ cm}^3 \]
   \[ d = \frac{1.59 \times 10^3 \text{ g}}{1.97 \times 10^5 \text{ cm}^3} = 8.1 \times 10^{-3} \text{ g/cm}^3 \]

The material will float.

60. \( 5.25 \text{ g} \times \frac{1 \text{ cm}^3}{10.5 \text{ g}} = 0.500 \text{ cm}^3 = 0.500 \text{ mL} \)
   \[ 11.2 \text{ mL} + 0.500 \text{ mL} = 11.7 \text{ mL} \]

61. a. \( 50.0 \text{ g} \times \frac{1 \text{ cm}^3}{2.16 \text{ g}} = 23.1 \text{ cm}^3 \)
   b. \( 50.0 \text{ g} \times \frac{1 \text{ cm}^3}{13.6 \text{ g}} = 3.68 \text{ cm}^3 \)
   c. \( 50.0 \text{ g} \times \frac{1 \text{ cm}^3}{0.880 \text{ g}} = 56.8 \text{ cm}^3 \)
   d. \( 50.0 \text{ g} \times \frac{1 \text{ cm}^3}{10.5 \text{ g}} = 4.76 \text{ cm}^3 \)

62. a. \( 50.0 \text{ cm}^3 \times \frac{19.32 \text{ g}}{1 \text{ cm}^3} = 966 \text{ g} \)
   b. \( 50.0 \text{ cm}^3 \times \frac{7.87 \text{ g}}{1 \text{ cm}^3} = 394 \text{ g} \)
c. \[ 50.0 \text{ cm}^3 \times \frac{11.34 \text{ g}}{1 \text{ cm}^3} = 567 \text{ g} \]

d. \[ 50.0 \text{ cm}^3 \times \frac{2.70 \text{ g}}{1 \text{ cm}^3} = 135 \text{ g} \]

63.

a. centimeters

b. meters

c. kilometers

d. centimeters

e. millimeters

64. \[ 45 \text{ mi} \times \frac{1.6093}{1 \text{ mi}} = 72.4 \text{ km} \]

\[ 38 \text{ mi} \times \frac{1.6093}{1 \text{ mi}} = 61.2 \text{ km} \]

1 gal = 3.7854 L

highway: \[ 72.4 \text{ km/3.7854 L} = 19 \text{ km/L} \]

city: \[ 61.2 \text{ km/3.7854 L} = 16 \text{ km/L} \]

65. \[ 1 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} \times \frac{2.76 \text{ euros}}{1 \text{ kg}} \times \frac{1 \text{.00}}{1.12 \text{ euros}} = \$1.12 \]

66. \[ 15.6 \text{ g} \times \frac{1 \text{ capsule}}{0.65 \text{ g}} = 24 \text{ capsules} \]

67. \[ v = \frac{4}{3} \pi r^3 = \frac{4}{3} (3.1416)(0.5 \text{ cm})^3 = 0.52 \text{ cm}^3 \]

\[ d = \frac{2.0 \text{ g}}{0.52 \text{ cm}^3} = 3.8 \text{ g/cm}^3 \text{ (the ball will sink)} \]

68. for ethanol, \[ 100. \text{ mL} \times \frac{0.785 \text{ g}}{1 \text{ mL}} = 78.5 \text{ g} \]

for benzene, \[ 1000 \text{ mL} \times \frac{0.880 \text{ g}}{1 \text{ mL}} = 880. \text{ g} \]

total mass, \[ 78.5 \text{ g} + 880. \text{ g} = 959 \text{ g} \]
69. a. 4; positive  
b. 6; negative  
c. 0; zero  
d. 5; positive  
e. 2; negative

70. 4.25 g (425 mg = 0.425 g)

71. a. one  
b. one  
c. four  
d. two  
e. infinite (definition)  
f. one

72. \[50.0 \text{ g} \times \frac{1 \text{ mL}}{1.31 \text{ g}} = 38.2 \text{ mL}\]

73. Volume = 21.6 mL – 12.7 mL = 8.9 mL  
\[d = \frac{33.42 \text{ g}}{8.9 \text{ mL}} = 3.8 \text{ g/mL}\]

74. Density = mass/volume  
Mass = 15.0 g  
Volume = 11.91 mL – 10.00 mL = 1.91 mL  
Density = 15.0 g/1.91 mL = 7.853 g/mL = 7.85 g/mL (with proper significant figures)

75. \[
1 \text{ second} \times \frac{1 \text{ minute}}{60 \text{ seconds}} \times \frac{1 \text{ hour}}{60 \text{ minutes}} \times \frac{55 \text{ miles}}{1 \text{ hour}} \times \frac{5280 \text{ feet}}{1 \text{ mile}} = 81 \text{ feet}\]