CHAPTER 2

Measurements and Calculations

1. measurement

2. "Scientific notation" means we have to put the decimal point after the first significant figure, and then express the order of magnitude of the number as a power of ten. So we want to put the decimal point after the first 2:

   $2{,}421 \rightarrow 2.421 \times 10^{\text{to some power}}$

   To be able to move the decimal point three places to the left in going from 2,421 to 2.421, means I will need a power of 10^3 after the number, where the exponent 3 shows that I moved the decimal point 3 places to the left.

   $2{,}421 \rightarrow 2.421 \times 10^{\text{to some power}} = 2.421 \times 10^3$

3. a. 9.651
   b. 3.521
   c. 9.3241
   d. 1.002

4. a. 10^6
   b. 10^{-2}
   c. 10^{-4}
   d. 10^9

5. a. positive
   b. positive
   c. negative
   d. negative

6. a. negative
   b. zero
   c. negative
   d. positive

7. a. The decimal point must be moved one space to the right, so the exponent is negative; $0.5012 = 5.012 \times 10^{-1}$.
   b. The decimal point must be moved six spaces to the left, so the exponent is positive; $5{,}012{,}000 = 5.012 \times 10^6$.

c. The decimal point must be moved six spaces to the right, so the exponent is negative; $0.000005012 = 5.012 \times 10^{-6}$.

d. The decimal point does not have to be moved, so the exponent is zero; $5.012 = 5.012 \times 10^{0}$.

e. The decimal point must be moved three spaces to the left, so the exponent is positive; $5012 = 5.012 \times 10^{3}$.

f. The decimal point must be moved three spaces to the right, so the exponent is negative; $0.005012 = 5.012 \times 10^{-3}$.

8. a. The decimal point must be moved three spaces to the right: 2,789

   b. The decimal point must be moved three spaces to the left: 0.002789

   c. The decimal point must be moved seven spaces to the right: 93,000,000

   d. The decimal point must be moved one space to the right: 42.89

   e. The decimal point must be moved 4 spaces to the right: 99,990

   f. The decimal point must be moved 5 spaces to the left: 0.00009999

9. a. six spaces to the right

   b. five spaces to the left

   c. one space to the right

   d. The decimal point does not have to be moved.

   e. 18 spaces to the right

   f. 16 spaces to the left

10. a. three spaces to the left

    b. one space to the left

    c. five spaces to the right

    d. one space to the left

    e. two spaces to the right

    f. two spaces to the left

11. To say that scientific notation is in *standard* form means that you have a number between 1 and 10, followed by an exponential term.

    a. The decimal point must be moved 4 spaces to the left, so the exponent will be 4: 9.782×10^{4}

    b. 42.14 must first be converted to 4.214×10^{1} and then the exponents combined: 4.214×10^{4}

    c. 0.08214 must first be converted to 8.214×10^{-2} and then the exponents combined: 8.214×10^{-5}

    d. The decimal point must be moved four spaces to the right, so the exponent will be –4: 3.914×10^{-4}

e. The decimal point must be moved two spaces to the left, so the exponent will be 2: 9.271×10^{2}

f. The exponents must be combined: 4.781×10^{-1}

12. a. The decimal point must be moved 3 places to the right: 6,244

b. The decimal point must be moved 2 spaces to the left: 0.09117

c. The decimal point must be moved 1 space to the right: 82.99

d. The decimal point must be moved 4 spaces to the left: 0.0001771

e. The decimal point must be moved 2 spaces to the right: 545.1

f. The decimal point must be moved 5 spaces to the left: 0.00002934

13. a. $1/1033 = 9.681 \times 10^{-4}$

b. $1/10^{5} = 1 \times 10^{-5}$

c. $1/10^{-7} = 1 \times 10^{7}$

d. $1/0.0002 = 5 \times 10^{3}$

e. $1/3{,}093{,}000 = 3.233 \times 10^{-7}$

f. $1/10^{-4} = 1 \times 10^{4}$

g. $1/10^{9} = 1 \times 10^{-9}$

h. $1/0.000015 = 6.7 \times 10^{4}$

14. a. $1/0.00032 = 3.1 \times 10^{3}$

b. $10^{3}/10^{-3} = 1 \times 10^{6}$

c. $10^{3}/10^{3} = 1\ (1 \times 10^{0})$; 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. $43.2/(4.32 \times 10^{-5}) = \dfrac{4.32 \times 10^{1}}{4.32 \times 10^{-5}} = 1.00 \times 10^{6}$

g. $(4.32 \times 10^{-5})/432 = \dfrac{4.32 \times 10^{-5}}{4.32 \times 10^{2}} = 1.00 \times 10^{-7}$

h. $1/(10^{5})(10^{-6}) = 1/(10^{-1}) = 1 \times 10^{1}$

15. mass, kilogram; length, meter; temperature, kelvin

16. a. kilo

b. milli

c. nano

d. mega

e. deci

f. micro

17. Since a meter is longer than a yard, the floor will require somewhat more than 25 square yards of linoleum. $25\ m^2 = 5\ m \times 5\ m = 5.47\ yd \times 5.47\ yd = 30\ yd^2$

18. Since a pound is 453.6 grams, the 125-g can will be slightly more than ¼ pound.

19. Since a liter is slightly more than a quart, and since 4 quarts make 1 gallon, 48 liters will be approximately 12 gallons.

20. Since 1 inch = 2.54 cm, the nail is approximately an inch long.

21. $100\ \text{km} \times \dfrac{1\ \text{mi}}{1.6093\ \text{km}} = 62\ \text{km}$

22. $100.\ \text{mi}$ ´ $\dfrac{1.6093\ \text{km}}{1\ \text{mi}} = 161\ \text{km}$

23. $2\ \text{m} \times \dfrac{100\ \text{cm}}{1\ \text{m}} = 200\ \text{cm};\ 2\ \text{m} \times \dfrac{100\ \text{cm}}{1\ \text{m}} \times \dfrac{1\ \text{in}}{2.54\ \text{cm}} = 79\ \text{in}$ (80 in to one significant figure)

24. 1.62 m is approximately 5 ft, 4 in. The woman is slightly taller.

25. a. kilometers
 b. meters
 c. centimeters
 d. micrometers

26. a. inch
 b. yard
 c. mile

27. a. about 4 liters
 b. about half a liter (500 mL)
 c. about 1/4 of a liter (250 mL)

28. b (the other units would give very small numbers for the length)

29. We estimate measurements between the smallest divisions on the scale; since this is our best estimate, the last significant digit recorded is uncertain.

30. When we use a measuring device with an analog scale, we estimate the reading to 0.1 of the smallest scale divisions on the measuring scale. Since this last reading is decided by the user, not by the divisions on the measuring scale, the final digit of the measurement is uncertain no matter how careful we may be in making the determination.

31. 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 *half way* between the smallest marked scale divisions.

32. 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).

33.
a. three
b. two
c. two
d. four

34.
a. probably only two
b. infinite (definition)
c. infinite (definition)
d. probably one
e. three (the race is defined to be 500. miles)

35. increase the preceding digit by 1

36. It is better to round off only the final answer, and to carry through extra digits in intermediate calculations. If there are enough steps to the calculation, rounding off in each step may lead to a cumulative error in the final answer.

37.
a. 2.55×10^5
b. 2.56×10^{-4}
c. 4.79×10^4
d. 8.21×10^3

38.
a. 1.57×10^6
b. 2.77×10^{-3}
c. 7.76×10^{-2}
d. 1.17×10^{-3}

39.
a. 4.34×10^5
b. 9.34×10^4
c. 9.916×10^1
d. 9.327×10^0

40.
a. 3.42×10^{-4}
b. 1.034×10^4

c. 1.7992×10^1

d. 3.37×10^5

41. Since the only operations in the calculation are multiplication and division, the number of significant figures is limited by the factor of 0.15 that has only two significant figures.

42. 170. mL;

$$\begin{aligned} & 18 \text{ mL} \\ + \; & 128.7 \text{ mL} \\ + \; & 23.45 \text{ mL} \\ = \; & 170.15 \text{ mL} \end{aligned}$$

18 mL limits the precision to the ones place, thus the answer is rounded to 170. mL

43. three (based on 2.31 having 3 significant figures)

44. three; (b), (c), and (d); (a) contains two significant figures

45. two decimal places (based on 2.11 being known only to the second decimal place)

46. none (10,434 is only known to the nearest whole number)

47. a. 52.36 (the answer can only be given to the second decimal place because 0.81 is only known to the second decimal place)

b. 10.90 (the answer can only be given to the second decimal place because 2.21 is only known to the second decimal place)

c. 5.25 (the answer can only be given to the second decimal place because 4.14 is only known to the second decimal place)

d. 6.5 (the answer can only be given to two significant figures because 3.1 is only known to two significant figures.

48. a. 2.3 (the answer can only be given to two significant figures because 3.1 is only known to two significant figures)

b. 9.1×10^2: (the answer can only be given to the first decimal place because 4.1 is only given to the first decimal place; both numbers have the same power of ten)

c. 1.323×10^3: (the numbers must be first expressed as the same power of ten; $1.091 \times 10^3 + 0.221 \times 10^3 + 0.0114 \times 10^3 = 1.323 \times 10^3$)

d. 6.63×10^{-13} (the answer can only be given to three significant figures because 4.22×10^6 is only given to three significant figures)

49. a. two (based on 1.1 having only two significant figures)

b. two (based on 0.22 having only 2 significant figures)

c. two (based on 0.00033 having only two significant figures)

d. three (assuming sum in numerator is considered to second decimal place)

50. a. one (the factor of 2 has only one significant figure)

    b. four (the sum within the parentheses will contain four significant figures)

    c. two (based on the factor 4.7×10^{-6} only having two significant figures)

    d. three (based on the factor 63.9 having only three significant figures)

51. a. two (the factor of 2.1 has only two significant figures)

    b. two (the factor of 0.98 has only two significant figures)

    c. four (the factor of 3.014 has only four significant figures)

    d. three (the factor of 1.86×10^{-3} has only three significant figures)

52. a. $(2.0944 + 0.0003233 + 12.22)/7.001 = (14.31)/7.001 = 2.045$

    b. $(1.42 \times 10^2 + 1.021 \times 10^3)/(3.1 \times 10^{-1}) =$

    $(142 + 1021)/(3.1 \times 10^{-1}) = (1163)/(3.1 \times 10^{-1}) = 3752 = 3.8 \times 10^3$

    c. $(9.762 \times 10^{-3})/(1.43 \times 10^2 + 4.51 \times 10^1) =$

    $(9.762 \times 10^{-3})/(143 + 45.1) = (9.762 \times 10^{-3})/(188.1) = 5.19 \times 10^{-5}$

    d. $(6.1982 \times 10^{-4})^2 = (6.1982 \times 10^{-4})(6.1982 \times 10^{-4}) = 3.8418 \times 10^{-7}$

53. conversion factor

54. an infinite number (a definition)

55. $\frac{1 \text{ mi}}{1760 \text{ yd}}$ and $\frac{1760 \text{ yd}}{1 \text{ mi}}$

56. $\frac{5280 \text{ ft}}{1 \text{ mi}}$; $15.6\ \cancel{\text{mi}}$ ´ $\frac{5280 \text{ ft}}{1\ \cancel{\text{mi}}}$

    $\frac{1 \text{ mi}}{5280 \text{ ft}}$; $86.19\ \cancel{\text{ft}}$ ´ $\frac{1 \text{ mi}}{5280\ \cancel{\text{ft}}}$

57. $\frac{\$1.75}{\text{lb}}$; $5.3\ \cancel{\text{lb}}$ ´ $\frac{\$1.75}{\cancel{\text{lb}}}$

58. $\frac{\text{lb}}{\$1.75}$; $\$10.00$ ´ $\frac{\text{lb}}{\$1.75}$

59. a. $12.5 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 31.8 \text{ cm}$

    b. $12.5 \text{ cm} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 4.92 \text{ in}$

    c. $2513 \text{ ft} \times \frac{1 \text{ mi}}{5280 \text{ ft}} = 0.4759 \text{ mi}$

d. $4.53 \text{ ft} \times \frac{1 \text{ yd}}{3 \text{ ft}} \times \frac{1 \text{ m}}{1.0936 \text{ yd}} = 1.38 \text{ m}$

e. $6.52 \text{ min} \times \frac{60 \text{ sec}}{1 \text{ min}} = 391 \text{ sec}$

f. $52.3 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} = 0.523 \text{ m}$

g. $4.21 \text{ m} \times \frac{1.0936 \text{ yd}}{1 \text{ m}} = 4.60 \text{ yd}$

h. $8.02 \text{ oz} \times \frac{1 \text{ lb}}{16 \text{ oz}} = 0.501 \text{ lb}$

60. a. $2.23 \text{ m} \times \frac{1.0936 \text{ yd}}{1 \text{ m}} = 2.44 \text{ yd}$

b. $46.2 \text{ yd} \times \frac{1 \text{ m}}{1.0936 \text{ yd}} = 42.2 \text{ m}$

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

61. a. $1.75 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} = 2.82 \text{ km}$

b. $2.63 \text{ gal} \times \frac{4 \text{ qt}}{1 \text{ gal}} = 10.5 \text{ qt}$

c. $4.675 \text{ cal} \times \frac{4.184 \text{ J}}{1 \text{ cal}} = 19.56 \text{ J}$

d. $756.2 \text{ mm Hg} \times \frac{1 \text{ atm}}{760 \text{ mm Hg}} = 0.9950 \text{ atm}$

e. $36.3 \text{ amu} \times \dfrac{1.66056 \times 10^{-27} \text{ kg}}{1 \text{ amu}} = 6.03 \times 10^{-26} \text{ kg}$

f. $46.2 \text{ in} \times \dfrac{2.54 \text{ cm}}{1 \text{ in}} = 117 \text{ cm}$

g. $2.75 \text{ qt} \times \dfrac{32 \text{ fl oz}}{1 \text{ qt}} = 88.0 \text{ fl oz}$

h. $3.51 \text{ yd} \times \dfrac{1 \text{ m}}{1.0936 \text{ yd}} = 3.21 \text{ m}$

62. a. $254.3 \text{ g} \times \dfrac{1 \text{ kg}}{1000 \text{ g}} = 0.2543 \text{ kg}$

b. $2.75 \text{ kg} \times \dfrac{1000 \text{ g}}{1 \text{ kg}} = 2750 \text{ g}$

c. $2.75 \text{ kg} \times \dfrac{2.2046 \text{ lb}}{1 \text{ kg}} = 6.06 \text{ lb}$

d. $2.75 \text{ kg} \times \dfrac{1000 \text{ g}}{1 \text{ kg}} \times \dfrac{16 \text{ oz}}{453.59 \text{ g}} = 97.0 \text{ oz}$

e. $534.1 \text{ g} \times \dfrac{1 \text{ kg}}{1000 \text{ g}} \times \dfrac{2.2046 \text{ lb}}{1 \text{ kg}} = 1.177 \text{ lb}$

f. $1.75 \text{ lb} \times \dfrac{1 \text{ kg}}{2.2046 \text{ lb}} \times \dfrac{1000 \text{ g}}{1 \text{ kg}} = 794 \text{ g}$

g. $8.7 \text{ oz} \times \dfrac{453.59 \text{ g}}{16 \text{ oz}} = 250 \text{ g}$

h. $45.9 \text{ g} \times \dfrac{16 \text{ oz}}{453.59 \text{ g}} = 1.62 \text{ oz}$

63. $1.89 \times 10^{25} \text{ C atoms} \times \dfrac{12.01 \text{ g}}{6.02 \times 10^{23} \text{ C atoms}} = 377 \text{ g}$

64. $2558 \text{ mi} \times \dfrac{1.6093 \text{ km}}{1 \text{ mi}} = 4117 \text{ km}$

65. 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.

66. $1 \times 10^{-10}\text{ m} \times \frac{100\text{ cm}}{1\text{ m}} = 1 \times 10^{-8}\text{ cm}$

$1 \times 10^{-8}\text{ cm} \times \frac{1\text{ in}}{2.54\text{ cm}} = 4 \times 10^{-9}\text{ in.}$

$1 \times 10^{-8}\text{ cm} \times \frac{1\text{ m}}{100\text{ cm}} \times \frac{10^{9}\text{ nm}}{1\text{ m}} = 0.1\text{ nm}$

67. Celsius

68. freezing

69. 212ºF; 100ºC

70. 373

71. 100

72. Fahrenheit (F)

73. $T_K = T_C + 273$ $T_C = T_K - 273$

a. 44.2°C + 273 = 317.2 K (317 K)

b. 891 K – 273 = 618ºC

c. –20°C + 273 = 253 K

d. 273.1 K – 273 = 0.1ºC (0°C)

74. $T_C = (T_F - 32)/1.80$ $T_K = T_C + 273$ $T_C = T_K - 273$

a. $T_c = (T_f - 32)/1.80 = (-201^\circ\text{F} - 32)/1.80 = (-233)/1.80 = -129.4^\circ\text{C}$

$-129.4^\circ\text{C} + 273 = 144\text{ K}$

b. $-201^\circ\text{C} + 273 = 72\text{ K}$

c. $T_F = 1.80(T_c) + 32 = 1.80(351^\circ\text{C}) + 32 = 664^\circ\text{F}$

d. $T_c = (T_f - 32)/1.80 = (-150^\circ\text{F} - 32)/1.80 = -101^\circ\text{C}$

75. $T_C = (T_F - 32)/1.80$

a. (45 – 32)/1.80 = 13/1.80 = 7.2ºC

b. (115 – 32)/1.80 = 83/1.80 = 46ºC

c. (–10 – 32)/1.80 = –42/1.80 = –23ºC

d. Assuming 10,000ºF to be known to two significant figures: (10,000 – 32)/1.80 = 5500ºC

76. $T_F = 1.80(T_C) + 32$

a. $1.80(78.1) + 32 = 173°F$

b. $1.80(40.) + 32 = 104°F$

c. $1.80(–273) + 32 = –459°F$

d. $1.80(32) + 32 = 90.°F$

77. a. Gallium is in the liquid state over the temperature range of this thermometer.

b. $T_F = 1.80(T_C) + 32$

$T_F = 1.80(50°C) + 32 = 122°F$

$T_F = 1.80(500°C) + 32 = 932°F$

78. $T_F = 1.80(T_C) + 32$ $\qquad$ $T_C = (T_F - 32)/1.80$ $\qquad$ $T_K = T_C + 273$

a. $275 – 273 = 2°C$

b. $(82 – 32)/1.80 = 28°C$

c. $1.80(–21) + 32 = –5.8°F$ ($–6°F$)

d. $(–40 – 32)/1.80 = –40$ °C (Celsius and Fahrenheit temperatures are the same at –40).

79. Density represents the mass per unit volume of a substance.

80. g/cm^3 (g/mL)

81. lead

82. 100 in.^{3}

83. smaller; gases are mostly empty space, so there is less mass in a given volume than for solids and liquids.

84. Density is a *characteristic* property, which is always the same for a pure substance.

85. Gold is the most dense; hydrogen is the least dense; 1 g of hydrogen would occupy the larger volume.

86. Silver is the most dense (10.5 g/cm^3).

87. $\text{density} = \dfrac{\text{mass}}{\text{volume}}$

a. $d = \dfrac{452.1\text{ g}}{292\text{ cm}^3} = 1.55\text{ g/cm}^3$

b. $m = 0.14\text{ lb} = 63.5\text{ g}$ $\qquad$ $v = 125\text{ mL} = 125\text{ cm}^3$

$d = \dfrac{63.5\text{ g}}{125\text{ cm}^3} = 0.51\text{ g/cm}^3$

c. $m = 1.01\text{ kg} = 1010\text{ g}$

$$d = \frac{1010\text{ g}}{1000\text{ cm}^3} = 1.01\text{ g/cm}^3$$

d. m = 225 mg = 0.225 g v = 2.51 mL = 2.51 cm^3

$$d = \frac{0.225\text{ g}}{2.51\text{ cm}^3} = 0.0896\text{ g/cm}^3$$

88. $\text{density} = \frac{\text{mass}}{\text{volume}}$

a. $m = 4.53\text{ kg} \times \frac{1000\text{ g}}{1\text{ kg}} = 4530\text{ g}$

$$d = \frac{4530\text{ g}}{225\text{ cm}^3} = 20.1\text{ g/cm}^3$$

b. $v = 25.0\text{ mL} \times \frac{1\text{ cm}^3}{1\text{ mL}} = 25.0\text{ cm}^3$

$$d = \frac{26.3\text{ g}}{25.0\text{ cm}^3} = 1.05\text{ g/cm}^3$$

c. $m = 1.00\text{ lb} \times \frac{1\text{ kg}}{2.2046\text{ lb}} \times \frac{1000\text{ g}}{1\text{ kg}} = 454\text{ g}$

$$d = \frac{454\text{ g}}{500.\text{ cm}^3} = 0.907\text{ g/cm}^3$$

d. $m = 352\text{ mg} \times \frac{1\text{ g}}{1000\text{ mg}} = 0.352\text{ g}$

$$d = \frac{0.352\text{ g}}{0.271\text{ cm}^3} = 1.30\text{ g/cm}^3$$

89. $125\text{ mL} \times \frac{3.12\text{ g}}{1\text{ mL}} = 390.\text{ g}$

$$85.0\text{ g} \times \frac{1\text{ mL}}{3.12\text{ g}} = 27.2\text{ mL}$$

90. $4.50\text{ L} \times \frac{1000\text{ mL}}{1\text{ L}} \times \frac{0.920\text{ g}}{\text{mL}} = 4140\text{ g}$

$$375\text{ g} \times \frac{\text{mL}}{0.920\text{ g}} \times \frac{1\text{ L}}{1000\text{ L}} = 0.408\text{ L}$$

91. $d = \frac{929\text{ g}}{1000\text{ mL}} = 0.929\text{ g/mL}$ assuming 1000 mL is exact.

92. $m = 3.5 \text{ lb} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 1.59 \times 10^3 \text{ g}$

$v = 1.2 \times 10^4 \text{ in.}^3 \times \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 = 1.97 \times 10^5 \text{ cm}^3$

$d = \frac{1.59 \times 10^3 \text{ g}}{1.97 \times 10^5 \text{ cm}^3} = 8.1 \times 10^{-3} \text{ g/cm}^3$

The material will float.

93. The volume of the iron can be calculated from its mass and density:

$v = 52.4 \text{ g} \times \frac{1 \text{ cm}^3}{7.87\ g} = 6.66 \text{ cm}^3 = 6.66 \text{ mL}.$

The liquid level in the graduated cylinder will rise by 6.66 mL when the piece of iron is added, giving a final volume of (75.0 + 6.66) = 81.7 mL

94. $25.75 \text{ g} \times \frac{\text{cm}^3}{19.32 \text{ g}} = 1.333 \text{ cm}^3 = 1.333 \text{ mL}$

13.3 mL + 1.333 mL = 14.6 mL

95. a. $50.0 \text{ g} \times \frac{1 \text{ cm}^3}{2.16\ g} = 23.1 \text{ cm}^3$

b. $50.0 \text{ g} \times \frac{1 \text{ cm}^3}{13.6\ g} = 3.68 \text{ cm}^3$

c. $50.0 \text{ g} \times \frac{1 \text{ cm}^3}{0.880\ g} = 56.8 \text{ cm}^3$

d. $50.0 \text{ g} \times \frac{1 \text{ cm}^3}{10.5\ g} = 4.76 \text{ cm}^3$

96. 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. $50.0 \text{ cm}^3 \times \frac{2.70 \text{ g}}{1 \text{ cm}^3} = 135 \text{ g}$

97. a. three

b. three

c. three

98. a. $3.011 \times 10^{23} = 301,100,000,000,000,000,000,000$

b. $5.091 \times 10^{9} = 5,091,000,000$

c. $7.2 \times 10^{2} = 720$

d. $1.234 \times 10^{5} = 123,400$

e. $4.32002 \times 10^{-4} = 0.000432002$

f. $3.001 \times 10^{-2} = 0.03001$

g. $2.9901 \times 10^{-7} = 0.00000029901$

h. $4.2 \times 10^{-1} = 0.42$

99. a. 4.25×10^{2}

b. 7.81×10^{-4}

c. 2.68×10^{4}

d. 6.54×10^{-4}

e. 7.26×10^{1}

100. (e)

101. a. $1.25 \text{ in.} \times \frac{1 \text{ ft}}{12 \text{ in}} = 0.104 \text{ ft}$

$1.25 \text{ in.} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 3.18 \text{ cm}$

b. $2.12 \text{ qt} \times \frac{1 \text{ gal}}{4 \text{ qt}} = 0.530 \text{ gal}$

$2.12 \text{ qt} \times \frac{1 \text{ L}}{1.0567 \text{ qt}} = 2.01 \text{ L}$

c. $2640 \text{ ft} \times \frac{1 \text{ mi}}{5280 \text{ ft}} = 0.500 \text{ mi}$

$2640 \text{ ft} \times \frac{1.6093 \text{ km}}{5280. \text{ ft}} = 0.805 \text{ km}$

d. $1.254 \text{ kg} \times \frac{10^3 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ cm}^3}{11.34 \text{ g}} = 110.6 \text{ cm}^3$

e. $250. \text{ mL} \times 0.785 \text{ g/mL} = 196 \text{ g}$

f. $3.5 \text{ in.}^3 \times \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 = 57 \text{ cm}^3 = 57 \text{ mL}$

$57 \text{ cm}^3 \times 13.6 \text{ g/cm}^3 = 7.8 \times 10^2 \text{ g} = 0.78 \text{ kg}$

102. a. $36.2 \text{ blim} \times \frac{1400 \text{ kryll}}{1 \text{ blim}} = 5.07 \times 10^4 \text{ kryll}$

b. $170 \text{ kryll} \times \frac{1 \text{ blim}}{1400 \text{ kryll}} = 0.12 \text{ blim}$

c. $72.5 \text{ kryll}^2 \times \left(\frac{1 \text{ blim}}{1400 \text{ kryll}}\right)^2 = 3.70 \times 10^{-5} \text{ blim}^2$

103. $110 \text{ km} \times \frac{1 \text{ hr}}{100 \text{ km}} = 1.1 \text{ hr}$

104. $\frac{45 \text{ mi}}{\text{hr}} \times \frac{1.61 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ hr}}{3600 \text{ s}} = 20. \text{ m/s}$

105. $45 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} = 72.4 \text{ km}$

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

1 gal = 3.7854 L

highway: 72.4 km/3.7854 L = 19 km/L

city: 61.2 km/3.7854 L = 16 km/L

106. $1 \text{ lb} \times \frac{1 \text{ kg}}{2.205 \text{ lb}} \times \frac{2.76 \text{ euros}}{1 \text{ kg}} \times \frac{\$1.00}{1.44 \text{ euros}} = \$0.87$

107. $15.6 \text{ g} \times \frac{1 \text{ capsule}}{0.65 \text{ g}} = 24 \text{ capsules}$

108. °X = 1.26°C + 14

109. $v = \frac{4}{3}\left(\pi r^3\right) = \frac{4}{3}(3.1416)(0.5 \text{ cm})^3 = 0.52 \text{ cm}^3$

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

110. $d = \frac{36.8 \text{ g}}{10.5 \text{ L}} = 3.50 \text{ g/L}$ $(3.50 \times 10^{-3} \text{ g/cm}^3)$

111. a. $25.0 \text{ g} \times \frac{1 \text{ cm}^3}{0.000084\ g} = 2.98 \times 10^5 \text{ cm}^3$

b. $25.0 \text{ g} \times \frac{1 \text{ cm}^3}{13.6 \text{ g}} = 1.84 \text{ cm}^3$

c. $25.0\ \text{g} \times \dfrac{1\ \text{cm}^3}{11.34\ \text{g}} = 2.20\ \text{cm}^3$

d. $25.0\ \text{g} \times \dfrac{1\ \text{cm}^3}{1.00\ g} = 25.0\ \text{cm}^3$

112. For ethanol, $100.\ \text{mL} \times \dfrac{0.785\ \text{g}}{1\ \text{mL}} = 78.5\ \text{g}$

For benzene, $1000\ \text{mL} \times \dfrac{0.880\ \text{g}}{1\ \text{mL}} = 880.\ \text{g}$

total mass, 78.5 + 880. = 959 g

113. three

114.
- a. negative
- b. negative
- c. positive
- d. zero
- e. negative

115.
- a. positive
- b. negative
- c. negative
- d. zero

116.
- a. 2; positive
- b. 11; negative
- c. 3; positive
- d. 5; negative
- e. 5; positive
- f. 0; zero
- g. 1; negative
- h. 7; negative

117.
- a. 4; positive
- b. 6; negative
- c. 0; zero
- d. 5; positive
- e. 2; negative

118. a. 1; positive

b. 3; negative

c. 0; zero

d. 3; positive

e. 9; negative

119. a. The decimal point must be moved two places to the left, so the exponent is positive 2; $529 = 5.29 \times 10^{2}$.

b. The decimal point must be moved eight places to the left, so the exponent is positive 8; $240{,}000{,}000 = 2.4 \times 10^{8}$.

c. The decimal point must be moved 17 places to the left, so the exponent is positive 17; $301{,}000{,}000{,}000{,}000{,}000 = 3.01 \times 10^{17}$.

d. The decimal point must be moved four places to the left, so the exponent is positive 4; $78{,}444 = 7.8444 \times 10^{4}$.

e. The decimal point must be moved four places to the right, so the exponent is negative 4; $0.0003442 = 3.442 \times 10^{-4}$.

f. The decimal point must be moved 10 places to the right, so the exponent is negative 10; $0.000000000902 = 9.02 \times 10^{-10}$.

g. The decimal point must be moved two places to the right, so the exponent is negative 2; $0.043 = 4.3 \times 10^{-2}$.

h. The decimal point must be moved two places to the right, so the exponent is negative 2; $0.0821 = 8.21 \times 10^{-2}$.

120. a. The decimal point must be moved five places to the left; $2.98 \times 10^{-5} = 0.0000298$.

b. The decimal point must be moved nine places to the right; $4.358 \times 10^{9} = 4{,}358{,}000{,}000$.

c. The decimal point must be moved six places to the left; $1.9928 \times 10^{-6} = 0.0000019928$.

d. The decimal point must be moved 23 places to the right; $6.02 \times 10^{23} = 602{,}000{,}000{,}000{,}000{,}000{,}000{,}000$.

e. The decimal point must be moved one place to the left; $1.01 \times 10^{-1} = 0.101$.

f. The decimal point must be moved three places to the left; $7.87 \times 10^{-3} = 0.00787$.

g. The decimal point must be moved seven places to the right; $9.87 \times 10^{7} = 98{,}700{,}000$.

h. The decimal point must be moved two places to the right; $3.7899 \times 10^{2} = 378.99$.

i. The decimal point must be moved one place to the left; $1.093 \times 10^{-1} = 0.1093$.

j. The decimal point must be moved zero places; $2.9004 \times 10^{0} = 2.9004$.

k. The decimal point must be moved four places to the left; $3.9 \times 10^{-4} = 0.00039$.

l. The decimal point must be moved eight places to the left; $1.904 \times 10^{-8} = 0.00000001904$.

121. 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. $102.3 \times 10^{-5} = (1.023 \times 10^{2}) \times 10^{-5} = 1.023 \times 10^{-3}$

b. $32.03 \times 10^{-3} = (3.203 \times 10^{1}) \times 10^{-3} = 3.203 \times 10^{-2}$

c. $59933 \times 10^{2} = (5.9933 \times 10^{4}) \times 10^{2} = 5.9933 \times 10^{6}$

d. $599.33 \times 10^{4} = (5.9933 \times 10^{2}) \times 10^{4} = 5.9933 \times 10^{6}$

e. $5993.3 \times 10^{3} = (5.9933 \times 10^{3}) \times 10^{3} = 5.9933 \times 10^{6}$

f. $2054 \times 10^{-1} = (2.054 \times 10^{3}) \times 10^{-1} = 2.054 \times 10^{2}$

g. $32{,}000{,}000 \times 10^{-6} = (3.2 \times 10^{7}) \times 10^{-6} = 3.2 \times 10^{1}$

h. $59.933 \times 10^{5} = (5.9933 \times 10^{1}) \times 10^{5} = 5.9933 \times 10^{6}$

122. a. $1/10^{2} = 1 \times 10^{-2}$

b. $1/10^{-2} = 1 \times 10^{2}$

c. $55/10^{3} = \dfrac{5.5 \times 10^{1}}{1 \times 10^{3}} = 5.5 \times 10^{-2}$

d. $(3.1 \times 10^{6})/10^{-3} = \dfrac{3.1 \times 10^{6}}{1 \times 10^{-3}} = 3.1 \times 10^{9}$

e. $(10^{6})^{1/2} = 1 \times 10^{3}$

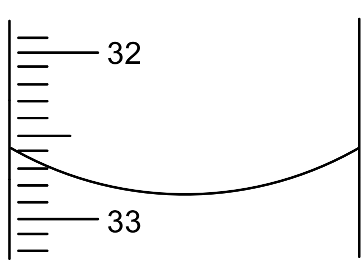
f. $(10^{6})(10^{4})/(10^{2}) = \dfrac{(1 \times 10^{6})(1 \times 10^{4})}{(1 \times 10^{2})} = 1 \times 10^{8}$

g. $1/0.0034 = \dfrac{1}{3.4 \times 10^{-3}} = 2.9 \times 10^{2}$

h. $3.453/10^{-4} = \dfrac{3.453}{1 \times 10^{-4}} = 3.453 \times 10^{4}$

123. meter

124.



125. 100 km (See inside cover of textbook.)

126. 1 L = 1 dm^3 = 1000 cm^3 = 1000 mL

127. 250. mL

128. 0.105 m

129. 100 km/hr = 62.1 mi/hr; you would not violate the speed limit.

130. They weigh the same.

$$1 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 0.001 \text{ g}$$

131. 4.25 g (425 mg = 0.425 g)

132. 5×10^{11} nm

$$500 \text{ m} \times \frac{10^9 \text{ nm}}{1 \text{ m}} = 5 \times 10^{11} \text{ nm}$$

133. volume

134. $v = l \times h \times w$

$0.310 \text{ m}^3 = (0.7120 \text{ m})(0.52458 \text{ m}) \times w$

w = 0.830 m (The answer is to three significant figures because the final volume of the box is reported to three significant figures. The other two measurements contain more significant figures and do not limit the precision of the volume.)

135.
- a. one
- b. one
- c. four
- d. two
- e. infinite (definition)
- f. one

136.
- a. 0.000426
- b. 4.02×10^{-5}
- c. 5.99×10^{6}
- d. 400.
- e. 0.00600

137.
- a. 0.7556
- b. 293

c. 17.01

d. 432.97

138. a. 2149.6 (the answer can only be given to the first decimal place, because 149.2 is only known to the first decimal place)

b. 5.37×10^3 (the answer can only be given to two decimal places because 4.34 is only known to two decimal places; moreover, since the power of ten is the same for each number, the calculation can be performed directly)

c. Before performing the calculation, the numbers have to be converted so that they contain the same power of ten.

$4.03 \times 10^{-2} - 2.044 \times 10^{-3} = 4.03 \times 10^{-2} - 0.2044 \times 10^{-2} = 3.83 \times 10^{-2}$ (the answer can only be given the second decimal place because 4.03×10^{-2} is only known to the second decimal place)

d. Before performing the calculation, the numbers have to be converted so that they contain the same power of ten.

$2.094 \times 10^5 - 1.073 \times 10^6 = 2.094 \times 10^5 - 10.73 \times 10^5 = -8.64 \times 10^5$

139. a. 5.57×10^7 (the answer can only be given to three significant figures because 0.0432 and 4.43×10^8 are only known to three significant figures)

b. 2.38×10^{-1} (the answer can only be given to three significant figures because 0.00932 and 4.03×10^2 are only known to three significant figures)

c. 4.72 (the answer can only be given to three significant figures because 2.94 is only known to three significant figures)

d. 8.08×10^8 (the answer can only be given to three significant figures because 0.000934 is only known to three significant figures)

140. a. $(2.9932 \times 10^4)(2.4443 \times 10^2 + 1.0032 \times 10^1) =$

$(2.9932 \times 10^4)(24.443 \times 10^1 + 1.0032 \times 10^1) =$

$(2.9932 \times 10^4)(25.446 \times 10^1) = 7.6166 \times 10^6$

b. $(2.34 \times 10^2 + 2.443 \times 10^{-1})/(0.0323) =$

$(2.34 \times 10^2 + 0.002443 \times 10^2)/(0.0323) =$

$(2.34 \times 10^2)/(0.0323) = 7.24 \times 10^3$

c. $(4.38 \times 10^{-3})^2 = 1.92 \times 10^{-5}$

d. $(5.9938 \times 10^{-6})^{1/2} = 2.4482 \times 10^{-3}$

141. $\dfrac{1\text{ L}}{1000\text{ cm}^3}$; $\dfrac{1000\text{ cm}^3}{1\text{ L}}$

142. $\dfrac{1\text{ year}}{12\text{ months}}$; $\dfrac{12\text{ months}}{1\text{ year}}$

143. a. $8.43\text{ cm} \times \frac{10\text{ mm}}{1\text{ cm}} = 84.3\text{ mm}$

b. $2.41 \times 10^2\text{ cm} \times \frac{1\text{ m}}{100\text{ cm}} = 2.41\text{ m}$

c. $294.5\text{ nm} \times \frac{1\text{ m}}{10^9\text{ nm}} \times \frac{100\text{ cm}}{1\text{ m}} = 2.945 \times 10^{-5}\text{ cm}$

d. $404.5\text{ m} \times \frac{1\text{ km}}{1000\text{ m}} = 0.4045\text{ km}$

e. $1.445 \times 10^4\text{ m} \times \frac{1\text{ km}}{1000\text{ m}} = 14.45\text{ km}$

f. $42.2\text{ mm} \times \frac{1\text{ cm}}{10\text{ mm}} = 4.22\text{ cm}$

g. $235.3\text{ m} \times \frac{1000\text{ mm}}{1\text{ m}} = 2.353 \times 10^5\text{ mm}$

h. $903.3\text{ nm} \times \frac{1\text{ m}}{10^9\text{ nm}} \times \frac{10^6\ \mu\text{m}}{1\text{m}} = 0.9033\ \mu\text{m}$

144. a. $908\text{ oz} \times \frac{1\text{ lb}}{16\text{ oz}} \times \frac{1\text{ kg}}{2.2046\text{ lb}} = 25.7\text{ kg}$

b. $12.8\text{ L} \times \frac{1\text{ qt}}{0.94633\text{ L}} \times \frac{1\text{ gal}}{4\text{ qt}} = 3.38\text{ gal}$

c. $125\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} \times \frac{1\text{ qt}}{0.94633\text{ L}} = 0.132\text{ qt}$

d. $2.89\text{ gal} \times \frac{4\text{ qt}}{1\text{ gal}} \times \frac{1\text{ L}}{1.0567\text{ qt}} \times \frac{1000\text{ mL}}{1\text{ L}} = 1.09 \times 10^4\text{ mL}$

e. $4.48\text{ lb} \times \frac{453.59\text{ g}}{1\text{ lb}} = 2.03 \times 10^3\text{ g}$

f. $550\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} \times \frac{1.0567\text{ qt}}{1\text{ L}} = 0.58\text{ qt}$

145. $9.3 \times 10^7\text{ mi} \times \frac{1\text{ km}}{0.62137\text{ mi}} = 1.5 \times 10^8\text{ km}$

$1.5 \times 10^8\text{ km} \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{100\text{ cm}}{1\text{ m}} = 1.5 \times 10^{13}\text{ cm}$

146. $5.3 ´\ 10^3\text{ lbs}\ ´\ \frac{1\text{ kg}}{2.2046\text{ lbs}}\ ´\ \frac{1\text{ metric ton}}{1000\text{ kg}} = 2.4\text{ metric tons}$

147. $T_K = T_C + 273$

a. 0 + 273 = 273 K

b. 25 + 273 = 298 K

c. 37 + 273 = 310. K

d. 100 + 273 = 373 K

e. –175 + 273 = 98 K

f. 212 + 273 = 485 K

148. a. Celsius temperature = (175 – 32)/1.80 = 79.4°C

Kelvin temperature = 79.4 + 273 = 352 K

b. 255 – 273 = –18 °C

c. (–45 – 32)/1.80 = –43°C

d. 1.80(125) + 32 = 257°F

149. density = $\dfrac{\text{mass}}{\text{volume}}$

a. $d = \dfrac{234\text{ g}}{2.2\text{ cm}^3} = 110\text{ g/cm}^3$

b. $m = 2.34\text{ kg} \times \dfrac{1000\text{ g}}{1\text{ kg}} = 2340\text{ g}$

$v = 2.2\text{ m}^3 \times \left(\dfrac{100\text{ cm}}{1\text{ m}}\right)^3 = 2.2 \times 10^6\text{ cm}^3$

$d = \dfrac{2340\text{ g}}{2.2 \times 10^6\text{ cm}^3} = 1.1 \times 10^{-3}\text{ g/cm}^3$

c. $m = 1.2\text{ lb} \times \dfrac{453.59\text{ g}}{1\text{ lb}} = 544\text{ g}$

$v = 2.1\text{ ft}^3 \times \left(\dfrac{12\text{ in}}{1\text{ ft}}\right)^3 \times \left(\dfrac{2.54\text{ cm}}{1\text{ in}}\right)^3 = 5.95 \times 10^4\text{ cm}^3$

$d = \dfrac{544\text{ g}}{5.95 \times 10^4\text{ cm}^3} = 9.1 \times 10^{-3}\text{ g/cm}^3$

d. $m = 4.3 \text{ ton} \times \dfrac{2000 \text{ lb}}{1 \text{ ton}} \times \dfrac{453.59 \text{ g}}{1 \text{ lb}} = 3.90 \times 10^6 \text{ g}$

$v = 54.2 \text{ yd}^3 \times \left(\dfrac{1 \text{ m}}{1.0936 \text{ yd}}\right)^3 \times \left(\dfrac{100 \text{ cm}}{1 \text{ m}}\right)^3 = 4.14 \times 10^7 \text{ cm}^3$

$d = \dfrac{3.90 \times 10^6 \text{ g}}{4.14 \times 10^7 \text{ cm}^3} = 9.4 \times 10^{-2} \text{ g/cm}^3$

150. $85.5 \text{ mL} \times \dfrac{0.915 \text{ g}}{1 \text{ mL}} = 78.2 \text{ g}$

151. $50.0 \text{ g} \times \dfrac{1 \text{ mL}}{1.31 \text{ g}} = 38.2 \text{ g}$

152. $m = 155 \text{ lb} \times \dfrac{453.59 \text{ g}}{1 \text{ lb}} = 7.031 \times 10^4 \text{ g}$

$v = 4.2 \text{ ft}^3 \times \left(\dfrac{12 \text{ in}}{1 \text{ ft}}\right)^3 \times \left(\dfrac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 = 1.189 \times 10^5 \text{ cm}^3$

$d = \dfrac{7.031 \times 10^4 \text{ g}}{1.189 \times 10^5 \text{ cm}^3} = 0.59 \text{ g/cm}^3$

153. Volume = 21.6 mL – 12.7 mL = 8.9 mL

$d = \dfrac{33.42 \text{ g}}{8.9 \text{ mL}} = 3.8 \text{ g/mL}$

154. $T_F = 1.80(T_C) + 32$

a. 23 °F

b. 32 °F

c. –321 °F

d. –459 °F

e. 187 °F

f. –459 °F

155. a. 10^3

b. 10^9

c. 10^{-2}

d. 10^{-3}

156. a. The Mars Climate Orbiter dipped 100 km lower in the Mars atmosphere than was planned. Using the conversion factor between miles and kilometers found inside the cover of this text

$$100 \text{ km} \times \frac{1 \text{ mi}}{1.6093 \text{ km}} = 62 \text{ mi}$$

b. The aircraft required 22,300 kg of fuel, but only 22,300 lb of fuel was loaded. Using the conversion factor between pounds and kilograms found inside the cover of this text, the amount of fuel required in pounds was

$$22{,}300 \text{ kg} \times \frac{2.2046 \text{ lb}}{1 \text{ kg}} = 49{,}163 \text{ lb}$$

Therefore, (49,163 – 22,300) = 26,863 = 2.69×10^4 lb additional fuel was needed.

157. a. The text mentions oxygen sensors in automobile exhaust systems; detection of nitrogen-containing compounds in airline baggage; use of sensory hair from crabs to detect low levels of hormones; use of pineapple extracts to detect hydrogen peroxide

b. We can now detect the presence of impurities or contaminants to much lower levels than was possible in the past. Although that may seem helpful, we now have to determine whether these contaminants were always present and are not harmful or if they are something new that we should be concerned about.

158. $$\frac{10^{-8} \text{ g}}{\text{L}} \times \frac{1 \text{ lb}}{453.59 \text{ g}} \times \frac{1 \text{ L}}{1.0567 \text{ qt}} \times \frac{4 \text{ qt}}{1 \text{ gal}} = 8 \times 10^{-11} \text{ lb/gal}$$

159.

Scientific Notation	*Number of Significant Figures*
9.000×10^2	4
3.007×10^3	4
2.345×10^4	4
2.700×10^2	4
4.37×10^5	3

160.

Number of Significant Figures	*Result*
2	0.51
3	29.1
3	8.61
3	1.89
4	134.6
3	14.4

161. $$4145 \text{ mi} \times \frac{5280 \text{ ft}}{1 \text{ mi}} \times \frac{1 \text{ fathom}}{6 \text{ ft}} \times \frac{1 \text{ cable length}}{100 \text{ fathoms}} = 3.648 \times 10^4 \text{ cable lengths}$$

$$4145 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} = 6.671 \times 10^6 \text{ m}$$

$$3.648 \times 10^4 \text{ cable lengths} \times \frac{1 \text{ nautical mile}}{10 \text{ cable lengths}} = 3648 \text{ nautical miles}$$

162. $$1.25 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} = 2011.625 \text{ m}$$

60 sec + 59.2 sec = 119.2 sec

$$\frac{2011.625 \text{ m}}{119.2 \text{ s}} = 16.9 \text{ m/s}$$

163. $T_C = (T_F - 32)/1.80$

$T_C = (69.1 – 32)/1.80 = 20.6$ºC

164. $T_C = (T_F - 32)/1.80$

$T_C = (134 – 32)/1.80 = 56.7$ºC

Since the temperature is higher than the melting point (44ºC), phosphorus would be a liquid.

165. $1.84 \text{ cm} \times 3.61 \text{ cm} \times 2.10 \text{ cm} = 13.9 \text{ cm}^3$

$$13.9 \text{ cm}^3 \times \frac{22.57 \text{ g}}{\text{cm}^3} = 315 \text{ g}$$

166. $$69 \text{ pm} \times \frac{1 \text{ m}}{10^{12} \text{ pm}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 6.9 \times 10^{-9} \text{ cm}$$

$$V = \tfrac{4}{3}\rho(6.9 \times 10^{-9} \text{ cm})^3 = 1.4 \times 10^{-24} \text{ cm}^3$$

$$d = \frac{mass}{volume} = \frac{3.35 \times 10^{-23} \text{ g}}{1.4 \times 10^{-24} \text{ cm}^3} = 24 \text{ g/cm}^3$$