Chapter 1  Chemistry: An Introduction

1. Obviously, the answer to this question depends on your own experience. You might consider such things as how oven and drain cleaners work, why antifreeze keeps your car’s radiator from freezing, why cuts and scrapes are often cleaned with hydrogen peroxide, how a "permanent wave" curls hair, etc.

2. Examples: physician (understanding cellular processes, understanding how drugs and blood tests work); lawyer (understanding scientific/forensic laboratory tests for use in court); pharmacist (understanding how drugs work, and interactions between drugs); artist (understanding the various media used in art work); photographer (understanding how the film exposure and developing chemical processes occur and how they can be controlled and modified); farmer (understanding which pesticide or fertilizer is needed and how these chemicals work); nurse (understanding how various tests and drugs may affect the patient’s wellbeing).

3. There are obviously many such examples. Many new drugs and treatments have recently become available thanks to research in biochemistry and cell biology. New long-wearing, more comfortable contact lenses have been produced by research in polymer and plastics chemistry. Special plastics and metals were prepared for the production of compact discs to replace vinyl phonograph records.

4. There are, unfortunately, many examples. Chemical and biological weapons are still being produced in some countries. Although the development of new plastics has been a boon in many endeavors, this also increases our depletion of fossil fuels and our solid waste problems. Although many exciting new drugs and treatments have become available, the same biotechnology may lead to testing procedures for determining whether a person has a genetic likelihood of developing a particular disease, which may make it impossible or difficult for that person to obtain health or life insurance.

5. This answer depends on your own experience.

6. This answer depends on your own experience, but consider the following examples: oven cleaner (the label says it contains sodium hydroxide; it converts the burned on grease in the oven to a soapy material that washes away); drain cleaner (the label says it contains sodium hydroxide; it dissolves the clog of hair in the drain); stomach antacid (the label says it contains calcium carbonate; it makes me belch and makes my stomach feel better); hydrogen peroxide (the label says it is a 3% solution of hydrogen peroxide; when applied to a wound, it bubbles); depilatory cream (the label says it contains sodium hydroxide; it removes unwanted hair from skin).

7. David and Susan first recognized the problem (unexplained medical problems). A possible explanation was then proposed (the glaze on their china might be causing lead poisoning). The explanation was tested by experiment (it was determined that the china did contain lead). A full discussion of this scenario is given in the text.

8. Answer will depend on student experience.
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9. The steps are: (1) recognizing the problem and stating it clearly; (2) proposing possible solutions to or explanations of the problem; and (3) performing experiments to test the solutions or explanations.

10. a. quantitative - a number (measurement) is indicated explicitly
b. qualitative - only a qualitative description is given
c. quantitative - a numerical measurement is indicated
d. qualitative - only a qualitative description is given
e. quantitative - a number (measurement) is implied
f. qualitative - a qualitative judgment is given
g. quantitative - a numerical quantity is indicated

11. A hypothesis is a possible explanation of a single observed phenomenon. A theory or model consists of a set of tested hypotheses which give an overall explanation of some part of nature.

12. A natural law is a summary of observed, measurable behavior that occurs repeatedly and consistently. A theory is our attempt to explain such behavior. The conservation of mass observed during chemical reactions is an example of a natural law. The idea that the universe began with a "big bang" is an example of a theory.

13. Scientists are human, too. When a scientist formulates a hypothesis, he or she wants it to be proven correct. In academic research, for example, scientists want to be able to publish papers on their work to gain renown and acceptance from their colleagues. In industrial situations, the financial success of the individual and of the company as a whole may be at stake. Politically, scientists may be under pressure from the government to "beat the other guy."

14. Most applications of chemistry are oriented toward the interpretation of observations and the solving of problems. Although memorization of some facts may aid in these endeavors, it is the ability to combine, relate, and synthesize information that is most important in the study of chemistry.

15. Chemistry is not merely a list of observations, definitions, and properties. Chemistry is the study of very real interactions among different samples of matter, whether within a living cell, or in a chemical factory. When we study chemistry, at least in the beginning, we try to be as general and as nonspecific as possible, so that the basic principles learned can be applied to many situations. In a beginning chemistry course, we learn to interpret and solve a basic set of very simple problems, in the hopes that the method of solving these simple problems can be extended to more complex real life situations later on. The actual solution to a problem, at this point, is not as important as learning how to recognize and interpret the problem, and how to propose reasonable, experimentally testable hypotheses.

16. In real life situations, the problems and applications likely to be encountered are not simple textbook examples. One must be able to observe an event, hypothesize a cause, and then test this hypothesis. One must be able to carry what has been learned in class forward to new, different situations.
Chapter 2  Measurements and Calculations

1.  4

2.  $10^4$

3.  4,512

4.  Because 0.0021 is less than one, the exponent will be negative. Because 4540 is greater than one, the exponent will be positive.

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

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

7.  a.  The decimal point must be moved four places to the left, so the exponent is positive 4; $12,500 = 1.25 \times 10^4$
    b.  The decimal point must be moved seven places to the left, so the exponent is positive 7; $37,400,000 = 3.74 \times 10^7$
    c.  The decimal point must be moved 23 places to the left, so the exponent is positive 23; $602,300,000,000,000,000,000,000 = 6.023 \times 10^{23}$
    d.  The decimal point must be moved two places to the left, so the exponent is positive 2; $375 = 3.75 \times 10^2$
    e.  The decimal point must be moved two places to the right, so the exponent is negative 2; $0.0202 = 2.02 \times 10^{-2}$
    f.  The decimal point must be moved one place to the right, so the exponent is negative 1; $0.1550 = 1.550 \times 10^{-1}$
    g.  The decimal point must be moved five places to the right, so the exponent is negative 5; $0.00000104 = 1.04 \times 10^{-5}$
    h.  The decimal point must be moved nineteen places to the right, so the exponent is -19; $0.000000000000000000129 = 1.29 \times 10^{-19}$
8. a. The decimal point must be moved six places to the left, so the exponent is positive 6; $9,367,421 = 9.367421 \times 10^6$

b. The decimal point must be moved three places to the left, so the exponent is positive 3; $7241 = 7.241 \times 10^3$

c. The decimal point must be moved four places to the right, so the exponent is negative 4; $0.0005519 = 5.519 \times 10^{-4}$

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 1; $0.721 = 7.21 \times 10^{-1}$

9. a. The decimal point must be moved three places to the right; $6.441 \times 10^3 = 6,442$

b. The decimal point must be moved five places to the left; $5.991 \times 10^{-4} = 0.00005991$

c. The decimal point must be moved four places to the right; $2.001 \times 10^4 = 20,010$

d. The decimal point must be moved three places to the left; $1.997 \times 10^{-3} = 0.001997$

e. The decimal point must be moved one place to the left; $7.871 \times 10^{-1} = 0.7871$

f. The decimal point must be moved one place to the right; $1.001 \times 10^1 = 10.01$

g. The decimal point must be moved four places to the left; $9.721 \times 10^{-4} = 0.0009721$

h. The decimal point must be moved six places to the right; $2.015 \times 10^6 = 2,015,000$

i. The decimal point must be moved two places to the left; $5.583 \times 10^{-2} = 0.05583$

j. The decimal point must be moved six places to the left; $4.227 \times 10^{-6} = 0.000004227$
k. The decimal point must be moved three places to the right;
   \[ 9.734 \times 10^3 = 9,734 \]

l. The decimal point must be moved one places to the right;
   \[ 1.000 \times 10^1 = 10.00 \]

10. 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;
      \[ 9.999 \times 10^3 = 9,999 \]

   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;
      \[ 9.71 \times 10^{-4} = 0.000971 \]

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. The numbers
    given in this problem are not between 1 and 10 as written.

    a. \[ 4381 \times 10^{-4} = (4.381 \times 10^3) \times 10^{-4} = 4.381 \times 10^{-1} \]

    b. \[ 98,784 \times 10^4 = (9.8784 \times 10^6) \times 10^4 = 9.8784 \times 10^8 \]

    c. \[ 78.21 \times 10^2 = (7.821 \times 10^3) \times 10^2 = 7.821 \times 10^5 \]

    d. \[ 9.871 \times 10^{-4} \text{ is already written in standard scientific notation.} \]
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e.  $0.009871 \times 10^7 = (9.871 \times 10^{-3}) \times 10^7 = 9.871 \times 10^4$

f.  $42,221 \times 10^6 = (4.2221 \times 10^4) \times 10^4 = 4.2221 \times 10^8$

g.  $0.00008951 \times 10^6 = (8.951 \times 10^{-5}) \times 10^6 = 8.951 \times 10^1$

h.  $0.00008951 \times 10^{-6} = (8.951 \times 10^{-5}) \times 10^{-6} = 8.951 \times 10^{-11}$

12. 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.  $6.272 \times 10^{-5}$ 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.  $97,522 \times 10^{-3} = (9.7522 \times 10^4) \times 10^{-3} = 9.7522 \times 10^1$

g.  $0.0000097752 \times 10^6 = (9.7752 \times 10^{-6}) \times 10^6 = 9.7752 \times 10^0$ (9.7752)

h.  $44,252 \times 10^4 = (4.4252 \times 10^4) \times 10^4 = 4.4252 \times 10^8$

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

15.  International System (SI)

16.  grams

17.  
    a.  \( 10^3 \)
    b.  \( 10^{-2} \)
    c.  \( 10^{-3} \)
    d.  \( 10^{-1} \)
    e.  \( 10^{-9} \)
    f.  \( 10^{-6} \)

18.  
    a.  mega-
    b.  milli-
    c.  nano-
    d.  mega-
    e.  centi-
    f.  micro-

19.  meter

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

21.  centimeter

22.  quart

23.  100 km (approximately 62 mi)

24.  kilogram

25.  5.22 cm

26.  1.62 m is approximately 5 ft, 4". The woman is slightly taller.

27.  c

28.  d

29.  c
30. d (the other units would give very large numbers for the distance)

31. Table 2.6 indicates that a dime is 1 mm thick.
   \[
   \frac{10 \text{ cm}}{1 \text{ cm}} \times \frac{10 \text{ mm}}{1 \text{ mm}} \times \frac{1 \text{ dime}}{10 \text{ dimes}} = 10 \text{ dollars}
   \]

32. Table 2.6 indicates that the diameter of a quarter is 2.5 cm.
   \[
   \frac{100 \text{ cm}}{1 \text{ m}} \times \frac{1 \text{ quarter}}{2.5 \text{ cm}} = 40 \text{ quarters}
   \]

33. 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.

34. uncertainty

35. 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.

36. 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).

37. 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

38. a. probably only two
   b. infinite (a definition)
   c. infinite (a definition)
   d. probably only 1
   e. three (the race is defined to be exactly 500 miles)

39. remain unchanged

40. final
41. 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. \(0.0776\)

42. a. \(4.23 \times 10^{-1}\)  
b. \(7.12 \times 10^6\)  
c. \(4.45 \times 10^{-4}\)  
d. \(2.30 \times 10^{-4}\)  
e. \(9.72 \times 10^5\)

43. a. \(102.40\) (or \(1.0240 \times 10^2\))  
b. \(16.0\)  
c. \(1.639\)  
d. \(7.36\)

44. a. \(3.42 \times 10^{-4}\)  
b. \(1.034 \times 10^4\)  
c. \(1.7992 \times 10^1\)  
d. \(3.37 \times 10^5\)

45. smallest

46. decimal

47. two significant figures (based on \(0.0043\) having two significant figures)

48. three

49. only one (based on \(121.2\) being known only to the first decimal place)

50. none

51. a. \(102.623\) (the answer can only be given to the third decimal place since \(97.381\) is only known to the third decimal place)  
b. \(236.2\) (the answer can only be given to the first decimal place since \(171.5\) is only known to the first decimal place)  
c. \(3.0814\) (the answer can only be given to the fourth decimal place since \(1.2012\) is only known to the fourth decimal place)
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d. 4.67 (the answer can only be given to the second decimal place since 13.21 is only known to the second decimal place)

52. 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.

\[ 2.01 \times 10^2 + 3.014 \times 10^3 = 2.01 \times 10^2 + 30.14 \times 10^2 = 32.15 \times 10^2 \]

This answer should then be converted to standard scientific notation, \[ 32.15 \times 10^2 = 3.215 \times 10^3 \approx 3,215 \].

53. a. 2.26 (the answer can only be given to three significant figures because each number in the problem is known only to three significant figures)

b. \[ 8.4 \times 10^{-22} \] (the answer can only be given to two significant figures because 0.14 is only given to two significant figures)

c. \[ 1.5 \times 10^5 \] (the answer can only be given to two significant figures because 4.0 \times 10^4 is only given to two significant figures)

d. \[ 6.67 \times 10^{12} \] (the answer can only be given to three significant figures because each of the numbers in the problem is only given to three significant figures)

54. 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 two significant figures because 0.15 is only given to two significant figures)

55. a. \[ [2.3232 + 0.2034 - 0.16] \times (4.0 \times 10^3) = \\
[2.3666] \times (4.0 \times 10^3) = 9.4664 \times 10^3 = 9.5 \times 10^3 \]

b. \[ [1.34 \times 10^2 + 3.2 \times 10^1] / (3.32 \times 10^{-6}) = \\
[13.4 \times 10^1 + 3.2 \times 10^1] / (3.32 \times 10^{-6}) = \\
[16.6 \times 10^1] / (3.32 \times 10^{-6}) = 5.00 \times 10^7 \]
c. \[ \frac{(4.3 \times 10^6) - (4.334 + 44.0002 - 0.9820)}{47.3522} = 9.1 \times 10^4 \]

d. \[ (2.043 \times 10^{-2})^3 = 8.527 \times 10^{-6} \]

56. a. \[ \frac{(2.0944 + 0.0003233 + 12.22)}{7.001} = 14.3147233 \div 7.001 = 2.045 \]

b. \[ \frac{(1.42 \times 10^2 + 1.021 \times 10^3)}{(3.1 \times 10^{-1})} = \frac{142 + 1021}{3.1 \times 10^{-1}} = \frac{1163}{3.1 \times 10^{-1}} = 3751 = 3.8 \times 10^3 \]

c. \[ \frac{(9.762 \times 10^{-3})(1.43 \times 10^2 + 4.51 \times 10^4)}{(9.762 \times 10^{-3})(143 + 45.1)} = \frac{9.762 \times 10^{-3}}{143 + 45.1} = 5.19 \times 10^{-8} \]

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

57. conversion factor

58. an infinite number (a definition)

59. \[ \frac{1 \text{ mi}}{1760 \text{ yd}} = \frac{1760 \text{ yd}}{1 \text{ mi}} \]

60. \[ \frac{1000 \text{ mL}}{1 \text{ L}} = \frac{1 \text{ L}}{1000 \text{ mL}} \]

61. \[ \frac{0.79}{1 \text{ lb}} = \frac{1 \text{ lb}}{0.79} \]

62. \[ \frac{1 \text{ lb}}{0.79} \]

63. a. \[ 36 \text{ ft} \times \frac{12 \text{ in.}}{1 \text{ ft}} = 432 \text{ in.} = 4.3 \times 10^2 \text{ in} \] (2 significant figures)

b. \[ 36 \text{ in.} \times \frac{1 \text{ ft}}{12 \text{ in.}} = 3.0 \text{ ft} \]

c. \[ 6.25 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} = 10.1 \text{ km} \]

d. \[ 6.25 \text{ km} \times \frac{1 \text{ mi}}{1.6093 \text{ km}} = 3.88 \text{ mi} \]

e. \[ 552 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 552,000 \text{ g} = 5.52 \times 10^5 \text{ g} \]

f. \[ 552 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 0.552 \text{ kg} \]
g. \[
552 \text{ lb} \times \frac{1 \text{ kg}}{2.2046 \text{ lb}} = 250. \text{ kg}
\]

h. \[
55 \text{ min} \times \frac{1 \text{ hr}}{60 \text{ min}} = 0.92 \text{ hr}
\]

64. 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. \[
0.501 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 5.01 \times 10^4 \text{ cm}
\]

65. a. \[
62.5 \text{ cm} \times \frac{1 \text{ in.}}{2.54 \text{ cm}} = 24.6 \text{ in.}
\]

b. \[
2.68 \text{ in.} \times \frac{2.54 \text{ cm}}{1 \text{ in.}} = 6.81 \text{ cm}
\]

c. \[
3.25 \text{ yd} \times \frac{1 \text{ m}}{1.0936 \text{ yd}} = 2.97 \text{ m}
\]

d. \[
4.95 \text{ m} \times \frac{1.0936 \text{ yd}}{1 \text{ m}} = 5.41 \text{ yd}
\]

e. \[
62.5 \text{ cm} \times \frac{1 \text{ in.}}{2.54 \text{ cm}} \times \frac{1 \text{ yd}}{36 \text{ in.}} = 0.684 \text{ yd}
\]

f. \[
2.45 \text{ mi} \times \frac{1 \text{ km}}{0.62137 \text{ mi}} = 3.94 \text{ km}
\]

g. \[
4.42 \text{ m} \times \frac{1.0936 \text{ yd}}{1 \text{ m}} \times \frac{36 \text{ in.}}{1 \text{ yd}} = 174 \text{ in}
\]

h. \[
5.01 \text{ kg} \times \frac{1 \text{ lb}}{0.45359 \text{ kg}} \times \frac{16 \text{ oz}}{1 \text{ lb}} = 177 \text{ oz}
\]
66. a. \[\frac{254.3 \text{ g}}{1000 \text{ g}} \times \frac{1 \text{ kg}}{1 \text{ kg}} = 0.2543 \text{ kg}\]

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

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

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

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

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

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

h. \[\frac{45.9 \text{ g}}{453.59 \text{ g}} \times \frac{1 \text{ lb}}{1 \text{ lb}} \times \frac{16 \text{ oz}}{1 \text{ lb}} = 1.62 \text{ oz}\]

67. \[\frac{\text{DM} 1.74}{\text{DM} 1.74} \times \frac{\text{DM} 34.80}{\text{DM} 1.74} = \text{DM} 20.00 \text{ (assuming the exchange rate is exact)}\]

\[\frac{\text{DM} 100.0}{\text{DM} 1.74} \times \frac{\text{DM} 57.47}{\text{DM} 1.74} = \text{DM} 20.00 \text{ (assuming the exchange rate is exact)}\]

68. \[190 \text{ mi} = 1.9 \times 10^2 \text{ mi} \text{ to two significant figures}\]

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

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

\[1.9 \times 10^2 \text{ mi} \times \frac{5,280 \text{ ft}}{1 \text{ mi}} = 1.0 \times 10^6 \text{ ft}\]

69. 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.

70. \[1 \times 10^{-10} \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} = 1 \times 10^{-8} \text{ cm}\]
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\[ 1 \times 10^{-8} \text{ cm} \times \frac{1 \text{ in.}}{2.54 \text{ cm}} = 4 \times 10^{-9} \text{ in.} \]

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

71. Fahrenheit

72. Celsius

73. 212°F; 100°C

74. 273

75. 100

76. Fahrenheit (F)

77. \( t_K = t_C + 273 \)

   a. \(-155 + 273 = 118 \text{ K}\)
   
   b. \(200 + 273 = 473 \text{ K}\)
   
   c. \(-52 + 273 = 221 \text{ K}\)
   
   d. \(101 \ ^\circ\text{F} = 38.3 \ ^\circ\text{C}; 38.3 + 273 = 311 \text{ K}\)
   
   e. \(-52 \ ^\circ\text{F} = -46.6 \ ^\circ\text{C}; -46.6 + 273 = 226 \text{ K}\)
   
   f. \(-196 + 273 = 77 \text{ K}\)

78. \( t_C = t_K - 273 \)

   a. \(275 - 273 = 2^\circ\text{C}\)
   
   b. \(445 - 273 = 172^\circ\text{C}\)
   
   c. \(0 - 273 = -273^\circ\text{C}\)
   
   d. \(77 - 273 = -196^\circ\text{C}\)
   
   e. \(10,000. - 273 = 9727^\circ\text{C}\)
   
   f. \(2 - 273 = -271^\circ\text{C}\)

79. \( t_C = (t_F - 32)/1.80 \)

   a. \((45 - 32)/1.80 = 13/1.80 = 7.2 \ ^\circ\text{C}\)
   
   b. \((115 - 32)/1.80 = 83/1.80 = 46 \ ^\circ\text{C}\)
   
   c. \((-10 - 32)/1.80 = -42/1.80 = -23 \ ^\circ\text{C}\)
d. Assuming 10,000°F to be known to two significant figures:
   \[(10,000 - 32)/1.80 = 5500 °C\]

80. \[t_p = 1.80(t_c) + 32\]
   a. \[1.80(78.1) + 32 = 173 °F\]
   b. \[1.80(40.) + 32 = 104 °F\]
   c. \[1.80(-273) + 32 = -459 °F\]
   d. \[1.80(32) + 32 = 90 °F\]

81. a. \[1.80(-40) + 32 = -40°F\]
   b. \[(-40 -32)/180 = -40 °C\]
   c. \[232 - 273 = -41 °C\]
   d. \[232 K = -41 °C; 1.80(-41) + 32 = -42 °F\]

82. a. \[t_c = (t_p - 32)/1.80 = (-201 °F -32)/1.80 = (-233)/1.80 = -129.4 °C\]
   \[-129.4 °C + 273 = 143.6 = 144 K\]
   b. \[-201 °C + 273 = 72 K\]
   c. \[t_p = 1.80(t_c) + 32 = 1.80(351 °C) + 32 = 664 °F\]
   d. \[t_c = (t_p - 32)/1.80 = (-150 °F - 32)/1.80 = -101 °C\]

83. volume

84. g/cm³ (g/mL)

85. lead

86. 100 in³

87. low

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

89. aluminum (2.70 g/cm³)

90. copper

91. density = \frac{mass}{volume}
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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. \[ m = 352 \text{ mg} = 0.352 \text{ g} \]
\[
d = \frac{0.352 \text{ g}}{0.271 \text{ cm}^3} = 1.30 \text{ g/cm}^3
\]

92. density = \[ \frac{\text{mass}}{\text{volume}} \]

a. \[ d = \frac{122.4 \text{ g}}{5.5 \text{ cm}^3} = 22 \text{ g/cm}^3 \]

b. \[ v = 0.57 \text{ m}^3 \times \left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3 = 5.7 \times 10^5 \text{ cm}^3 \]
\[
d = \frac{1.9302 \times 10^4 \text{ g}}{5.7 \times 10^5 \text{ cm}^3} = 0.034 \text{ g/cm}^3
\]

c. \[ m = 0.0175 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 17.5 \text{ g} \]
\[
d = \frac{17.5 \text{ g}}{18.2 \text{ mL}} = 0.962 \text{ g/mL} = 0.962 \text{ g/cm}^3
\]

d. \[ v = 0.12 \text{ m}^3 \times \left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3 = 1.2 \times 10^5 \text{ cm}^3 \]
\[
d = \frac{2.49 \text{ g}}{1.2 \times 10^5 \text{ cm}^3} = 2.1 \times 10^{-5} \text{ g/cm}^3
\]

93. \[ d = \frac{75.0 \text{ g}}{62.4 \text{ mL}} = 1.20 \text{ g/mL} \]

94. \[ d = \frac{75.2 \text{ g}}{89.2 \text{ mL}} = 0.843 \text{ g/mL} \]

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

96. \[ m = 3.5 \text{ lb} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 1.59 \times 10^3 \text{ g} \]

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

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

The material will float.

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

\[ v = \frac{52.4 \text{ g}}{7.87 \text{ g}} = 6.66 \text{ cm}^3 = 6.66 \text{ mL} \]

The liquid level in the graduated cylinder will rise by 6.66 mL when the cube of metal is added, giving a final volume of \((75.0 + 6.66) = 81.7 \text{ mL}\)

98. \[ 5.25 \text{ g} \times \frac{1 \text{ cm}^3}{10.5 \text{ g}} = 0.500 \text{ cm}^3 = 0.500 \text{ mL} \]

\[ 11.2 \text{ mL} + 0.500 \text{ mL} = 11.7 \text{ mL} \]

99. 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. \[ 50.0 \text{ g} \times \frac{1 \text{ cm}^3}{10.5 \text{ g}} = 4.76 \text{ cm}^3 \]

100. 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. \[ 50.0 \text{ cm}^3 \times \frac{2.70 \text{ g}}{1 \text{ cm}^3} = 135 \text{ g} \]
101. a. three
b. three
c. three

102. 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. $4.2 \times 10^{-1} = 0.42$

103. a. $4.25 \times 10^2$
b. $7.81 \times 10^{-4}$
c. $2.68 \times 10^4$
d. $6.54 \times 10^{-4}$
e. $7.26 \times 10^1$

104. a. centimeters
b. meters
c. kilometers
d. centimeters
e. millimeters

105. 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. $250. \text{ mL} \times 0.785 \text{ g/mL} = 196 \text{ g}$
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f.  $3.5 \text{ in}^3 \times \left(\frac{2.54 \text{ cm}}{1 \text{ in.}}\right)^3 = 57 \text{ cm}^3 = 57 \text{ mL}$

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

106. 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.  $72.5 \text{ kryll}^2 \times \left(\frac{1 \text{ blim}}{1400 \text{ kryll}}\right)^2 = 3.70 \times 10^{-5} \text{ blim}^2$

107.  $110 \text{ km} \times \frac{1 \text{ hr}}{100 \text{ km}} = 1.1 \text{ hr}$

108.  $52 \text{ cm} \times \frac{1 \text{ in.}}{2.54 \text{ cm}} = 20. \text{ in.}$

109.  $45 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} = 72.4 \text{ km}$

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

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

• 110.  $1 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} \times \frac{1 \text{ }$1}{\text{F5}} \times \frac{11.5\text{F}}{1 \text{ kg}} = $1$

111.  $15.6 \text{ g} \times \frac{1 \text{ capsule}}{0.65 \text{ g}} = 24 \text{ capsules}$

112.  $\text{o}X = 1.26 \text{o}C + 14$

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

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

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

115.  a.  $25.0 \text{ g} \times \frac{1 \text{ cm}^3}{0.000084 \text{ g}} = 2.98 \times 10^5 \text{ cm}^3$
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b. \[ 25.0 \text{ g} \times \frac{1 \text{ cm}^3}{13.6 \text{ g}} = 1.84 \text{ cm}^3 \]

c. \[ 25.0 \text{ g} \times \frac{1 \text{ cm}^3}{11.34 \text{ g}} = 2.20 \text{ cm}^3 \]

d. \[ 25.0 \text{ g} \times \frac{1 \text{ cm}^3}{1.00 \text{ g}} = 25.0 \text{ cm}^3 \]

116. 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, \[ 78.5 + 880. = 959 \text{ g} \]

117. three

118. a. negative
    b. negative
    c. positive
    d. zero
    e. negative

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

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

121. a. 4; positive
    b. 6; negative
    c. 0; zero
    d. 5; positive
    e. 2; negative
122. a. 1; positive  
b. 3; negative  
c. 0; zero  
d. 3; positive  
e. 9; negative  

123. 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 seventeen 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 ten places to the right, so the exponent is negative 10; \(0.0000000000902 = 9.02 \times 10^{-10}\)  
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; \(0.0821 = 8.21 \times 10^{-2}\)  

124. 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; \(6.02 \times 10^{23} = 602,000,000,000,000,000,000\)  
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; \(7.87 \times 10^{-2} = 0.00787\)
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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;
\[ 1.904 \times 10^{-8} = 0.00000001904 \]

125. 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. \[ 59.933 \times 10^5 = (5.9933 \times 10^1) \times 10^5 = 5.9933 \times 10^6 \]

126. a. \[ 1/10^3 = 1 \times 10^{-2} \]

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

c. \[ 55/10^3 = \frac{5.5 \times 10^1}{1 \times 10^3} = 5.5 \times 10^{-2} \]

d. \[ (3.1 \times 10^6)/10^{-3} = \frac{3.1 \times 10^6}{1 \times 10^{-3}} = 3.1 \times 10^9 \]

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

f. \[ (10^6)(10^4)/(10^2) = \frac{(1 \times 10^6)(1 \times 10^4)}{(1 \times 10^2)} = 1 \times 10^8 \]
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\[ g. \quad 1/0.0034 = \frac{1}{3.4 \times 10^{-3}} = 2.9 \times 10^2 \]

\[ h. \quad 3.453/10^{-4} = \frac{3.453}{1 \times 10^{-4}} = 3.453 \times 10^4 \]

127. meter
128. kelvin, K
129. 100 km (see inside back cover of textbook)
130. centimeter
131. 250. mL
132. 0.105 m
133. 100 km/hr = 62.1 mi/hr; you would not violate the speed limit.
134. 1 kg (100 g = 0.1 kg)
135. 4.25 g (425 mg = 0.425 g)
136. 10 cm (1 cm = 10 mm)
137. significant figures (digits)
138. 2.8 (the hundredths place is estimated)

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

140. a. 0.000426
    b. 4.02 \times 10^{-5}
    c. 5.99 \times 10^6
    d. 400.
    e. 0.00600
141. a. 0.7556

b. 293

c. 17.01

d. 432.97

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

b. $5.37 \times 10^3$ (the answer can only be given to two decimal places since 4.34 is only known to two decimal places; 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 since $4.03 \times 10^{-2}$ 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.

$2.094 \times 10^8 - 1.073 \times 10^6 = 2.094 \times 10^8 - 10.73 \times 10^5 = 8.64 \times 10^6$

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

b. $2.38 \times 10^{-1}$ (the answer can only be given to three significant figures because 0.00932 and $4.03 \times 10^2$ 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. $8.08 \times 10^8$ (the answer can only be given to three significant figures because 0.000934 is only known to three significant figures)

144. a. $(2.9932 \times 10^4)(2.4443 \times 10^2 + 1.0032 \times 10^3) = (2.9932 \times 10^4)(24.443 \times 10^1 + 1.0032 \times 10^1) = (2.9932 \times 10^4)(25.446 \times 10^1) = 7.6166 \times 10^6$
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. \( (5.9938 \times 10^{-6})^{1/2} = 2.4482 \times 10^{-3} \)

145. \[ \frac{1 \text{ L}}{1000 \text{ cm}^3} = \frac{1000 \text{ cm}^3}{1 \text{ L}} \]

146. 1 year/12 months; 12 months/1 year

147. 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. \[ 294.5 \text{ nm} \times \frac{1 \text{ m}}{10^5 \text{ nm}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 2.945 \times 10^{-5} \text{ cm} \]

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

148. 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. \[ 4.48 \text{ lb} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 2.03 \times 10^3 \text{ g} \]
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f. \[ 550 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1.0567 \text{ qt}}{1 \text{ L}} = 0.58 \text{ qt} \]

149. \[ 9.3 \times 10^7 \text{ mi} \times \frac{1 \text{ km}}{0.62137 \text{ mi}} = 1.5 \times 10^8 \text{ km} \]
\[ 1.5 \times 10^8 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 1.5 \times 10^{13} \text{ cm} \]

150. Assuming exactly 6 gross, 864 pencils

151. \( t_k = t_c + 273 \)
   a. \( 0 + 273 = 273 \text{ K} \)
   b. \( 25 + 273 = 298 \text{ K} \)
   c. \( 37 + 273 = 310 \text{ K} \)
   d. \( 100 + 273 = 373 \text{ K} \)
   e. \( -175 + 273 = 98 \text{ K} \)
   f. \( 212 + 273 = 485 \text{ K} \)

152. a. \( \text{Celsius temperature} = (175 - 32)/1.80 = 79.4 \text{ °C} \)
   \( \text{Kelvin temperature} = 79.4 + 273 = 352 \text{ K} \)
   b. \( 255 - 273 = -18 \text{ °C} \)
   c. \( (-45 - 32)/1.80 = -43 \text{ °C} \)
   d. \( 1.80(125) + 32 = 257 \text{ °F} \)

153. \( \text{density} = \frac{\text{mass}}{\text{volume}} \)
   a. \( d = \frac{234 \text{ g}}{2.2 \text{ cm}^3} = 110 \text{ g/cm}^3 \)
   b. \( m = 2.34 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 2340 \text{ g} \)
   \( v = 2.2 \text{ m}^3 \times \left( \frac{100 \text{ cm}}{1 \text{ m}} \right)^3 = 2.2 \times 10^6 \text{ cm}^3 \)
   \( d = \frac{2340 \text{ g}}{2.2 \times 10^6 \text{ cm}^3} = 1.1 \times 10^{-3} \text{ g/cm}^3 \)
   c. \( m = 1.2 \text{ lb} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 544 \text{ g} \)
\[ v = 2.1 \text{ ft}^3 \times \left(\frac{12 \text{ in}}{1 \text{ ft}}\right)^3 \times \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 = 5.95 \times 10^4 \text{ cm}^3 \]

\[ d = \frac{544 \text{ g}}{5.95 \times 10^4 \text{ cm}^3} = 9.1 \times 10^{-3} \text{ g/cm}^3 \]

\[ d. \quad m = 4.3 \text{ ton} \times \frac{2000 \text{ lb}}{1 \text{ ton}} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 3.90 \times 10^6 \text{ g} \]

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

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

154. \[ 85.5 \text{ mL} \times \frac{0.915 \text{ g}}{1 \text{ mL}} = 78.2 \text{ g} \]

155. \[ 50.0 \text{ g} \times \frac{1 \text{ mL}}{1.31 \text{ g}} = 38.2 \text{ g} \]

156. \[ m = 155 \text{ lb} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 7.031 \times 10^4 \text{ g} \]

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

\[ d = \frac{7.031 \times 10^4 \text{ g}}{1.189 \times 10^5 \text{ cm}^3} = 0.59 \text{ g/cm}^3 \]

157. Volume = 21.6 mL - 12.7 mL = 8.9 mL

\[ d = \frac{33.42 \text{ g}}{8.9 \text{ mL}} = 3.8 \text{ g/mL} \]

158. a. 23 \text{ °F} 
   b. 32 \text{ °F} 
   c. -321 \text{ °F} 
   d. -459 \text{ °F} 
   e. 187 \text{ °F} 
   f. -459 \text{ °F}
Chapter 3  Matter and Energy

1. matter

2. solid, liquid, gas (vapor)

3. incompressible: solids, liquids; compressible: gases

4. Liquids

5. fixed in position: solids; move freely: liquids and gases

6. gaseous

7. Liquids and gases both have no rigid shape and take on the shape of their containers (because the molecules in them are free to move relative to each other). Liquids are essentially incompressible, whereas gases are readily compressible.

8. stronger

9. The gaseous 10-g sample of water has a much larger volume than either the solid or liquid samples. While the 10-g sample of water vapor contains the same amount of water as the solid and liquid sample (the same number of water molecules), there is a great deal of empty space in the gaseous sample.

10. Gases are easily compressed into smaller volumes, whereas solids and liquids are not. Since a gaseous sample consists mostly of empty space, it is this empty space which is compressed when pressure is applied to a gas.

11. physical

12. chemical

13. the orange color

14. the substance reacts with iron(II) sulfate

15. An ice cube consists of water in its solid state. This solid state is characterized by a closely packed, regular array of water molecules in a crystal lattice. Because of the close-packing of the molecules, intermolecular forces between water molecules are very strong, and the molecules are more or less fixed in position. As heat is applied to an ice cube, the molecules of water absorb the energy being applied and begin to vibrate and move more and more strongly, until finally the molecules are able to separate physically from one another to form the liquid state. As more heat is applied to the liquid state, the energy being applied is again converted to the energy of motion (kinetic energy) of the molecules. The water molecules move quickly and more violently, and the tendency increases for molecules at the surface of the liquid to be moving in such a direction as to escape from the bulk of liquid. As heat continues to be applied, more and more molecules will have sufficient energy to escape from the surface of the liquid until