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Preface

This guide contains complete solutions for the end-of-chapter problems in the ninth editions of *Introductory Chemistry*, *Introductory Chemistry: A Foundation*, and *Basic Chemistry* by Steven S. Zumdahl and Donald J. DeCoste. New problems and questions have been prepared for the new editions of the text, which we hope will be of even greater help to your students in gaining an understanding of the fundamental principles of chemistry.

We have tried to give the most detailed solutions possible to all the problems, even though some problems give repeat drill practice on the same subject. Our chief attempt at brevity is to give molar masses for compounds without showing the calculation (after the subject of molar mass itself has been discussed). We have also made a conscious effort in this guide to solve each problem in the manner discussed in the textbook. The instructor, of course, may wish to discuss alternative methods of solution with his or her students.

One topic that causes many students concern is the matter of significant figures, and the determination of the number of digits to which a solution to a problem should be reported. To avoid truncation errors in the solutions contained in this guide, the solutions typically report intermediate answers to one more digit than appropriate for the final answer. The final answer to each problem is then given to the correct number of significant figures based on the data provided in the problem.

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CHAPTER 1

Chemistry: An Introduction

1. The specific answer will depend on student experiences. In general, students are intimidated by chemistry because they perceive it to be highly mathematical, requiring a great deal of memorization, and having a difficult technical vocabulary. Many students taking chemistry as a foundation science cannot see its relevance to their major.
2. The answer will depend on student examples.
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. As for the “dark side,” chemistry contributes increased global pollution if not conducted carefully.
4. Answer depends on student responses/examples.
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. The scientist must recognize the problem and state it clearly, propose possible solutions or explanations, and then decide through experimentation which solution or explanation is best.
9. A law tells what happens; a theory is our attempt to explain why it happens. Examples of laws include the law of conservation of mass and the ideal gas law (for gases). A theory includes Einstein’s theory of general relativity.
10. Answer depends on student response. A quantitative observation must include a number. For example “There are two windows in this room” represents a quantitative observation, but “The walls of this room are yellow” is a qualitative observation.

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11. Flow charts will vary. Figure 1.1 in the textbook shows a nice example with various parts of the scientific method. The first step in the scientific method is to state the problem and collect data (make observations). Observations may be qualitative or quantitative. The next step is to formulate hypotheses. A hypothesis is a possible explanation for the observation. The final step is to perform experiments. An experiment is something we do to test the hypothesis. We gather new information that allows us to decide whether the hypothesis is supported by the new information we have learned from the experiment. Experiments always produce new observations, and this brings us back to the beginning of the process again. To explain the behavior of a given part of nature, we repeat these steps many times. Laws and theories come out of applying the scientific method.
12. False. Theories can be refined and changed because they are interpretations. They represent possible explanations of why nature behaves in a particular way. Theories are refined by performing experiments and making new observations, not by proving the existing observations as false (which is something that can be witnessed and recorded).
13. Answer depends on student responses/examples.
14. 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."
15. Chemistry is not just a set of facts that have to be memorized. To be successful in chemistry, you have to be able to apply what you have learned to new situations, new phenomena, and new experiments. Rather than just learning a list of facts or studying someone else's solution to a problem, your instructor hopes you will learn *how* to solve problems *yourself*, so that you will be able to apply what you have learned in future circumstances.
16. 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 hope 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.
17. 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.
18. A good student will: learn the background and fundamentals of the subject from their classes and textbook; will develop the ability to recognize and solve problems and to extend what was learned in the classroom to "real" situations; will learn to make careful observations; and will be able to communicate effectively. While some academic subjects may emphasize use of one or more of these skills, Chemistry makes extensive use of all of them.

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. 10^7
 - b. 10^{-1}
 - c. 10^{-5}
 - d. 10^{12}
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; $5,012,000 = 5.012 \times 10^6$.

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- 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. $43.2/(4.32 \times 10^{-5}) = \frac{4.32 \times 10^1}{4.32 \times 10^{-5}} = 1.00 \times 10^6$
 g. $(4.32 \times 10^{-5})/432 = \frac{4.32 \times 10^{-5}}{4.32 \times 10^2} = 1.00 \times 10^{-7}$
 h. $1/(10^5)(10^{-6}) = 1/(10^{-1}) = 1 \times 10^1$
15. mass, kilogram; length, meter; temperature, kelvin
16. a. kilo
 b. milli
 c. nano
 d. mega

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- 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. $25 \text{ m}^2 = 5 \text{ m} \times 5 \text{ m} = 5.47 \text{ yd} \times 5.47 \text{ yd} = 30 \text{ yd}^2$
18. Since a pound is 453.6 grams, the 125-g can will be slightly more than $\frac{1}{4}$ 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. $100 \text{ km} \times \frac{1 \text{ mi}}{1.6093 \text{ km}} = 62 \text{ km}$
22. $100. \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} = 161 \text{ km}$
23. $2 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} = 200 \text{ cm}$; $2 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 79 \text{ in}$ (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. d. 158.5 – 158.7 mL. A measurement always has some degree of uncertainty. Because the last number (the 6 in 158.6 mL) is based on a visual estimate, it may be different when another person makes the same measurement. The first three digits in the measurement (158) are certain numbers of the measurement. However the fourth digit (6) is estimated and can vary; it is called an

uncertain number. When one is making a measurement, the custom is to record all of the certain numbers plus the first uncertain number.

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. three
b. unlimited number (definition)
c. five
d. two
e. two
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. 1.6×10^6
b. 2.8×10^{-3}
c. 7.8×10^{-2}
d. 1.2×10^{-3}
39. a. 4.34×10^5
b. 9.34×10^4
c. 9.916×10^1
d. 9.327×10^0

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40. a. 3.4×10^{-4}
b. 1.0335×10^4
c. 2×10^1
d. 3.365×10^5
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;

18 mL
+ 128.7 mL
+ 23.45 mL
= 170.15 mL

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. Perimeter = $2 \times \text{length} + 2 \times \text{width} = 2 \times 34.29 \text{ cm} + 2 \times 26.72 \text{ cm} = 68.58 \text{ cm} + 53.44 \text{ cm} = 122.02 \text{ cm}$;
For addition, the limiting term is the one with the smallest number of decimal places. In this case, the smallest number of decimal places is to the hundredths place, thus the final answer is reported as 122.02 cm, which contains five 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. $\frac{2.54 \text{ cm}}{1 \text{ in.}}$; $3.25 \cancel{\text{ in.}} \times \frac{2.54 \text{ cm}}{1 \cancel{\text{ in.}}}$
 $\frac{1 \text{ in.}}{2.54 \text{ cm}}$; $46.12 \cancel{\text{ cm}} \times \frac{1 \text{ in.}}{2.54 \cancel{\text{ cm}}}$
57. $\frac{\$1.75}{\text{lb}}$; $5.3 \cancel{\text{ lb}} \times \frac{\$1.75}{\cancel{\text{ lb}}}$
58. $\frac{\text{lb}}{\$1.75}$; $\$25.00 \times \frac{\text{lb}}{\$1.75}$

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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. $36.3 \text{ amu} \times \frac{1.66056 \times 10^{-27} \text{ kg}}{1 \text{ amu}} = 6.03 \times 10^{-26} \text{ kg}$
- f. $46.2 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 117 \text{ cm}$
- g. $2.75 \text{ qt} \times \frac{32 \text{ fl oz}}{1 \text{ qt}} = 88.0 \text{ fl oz}$
- h. $3.51 \text{ yd} \times \frac{1 \text{ m}}{1.0936 \text{ yd}} = 3.21 \text{ m}$
62. a. $254.3 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 0.2543 \text{ kg}$
- b. $2.75 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 2750 \text{ g}$
- c. $2.75 \text{ kg} \times \frac{2.2046 \text{ lb}}{1 \text{ kg}} = 6.06 \text{ lb}$
- d. $2.75 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{16 \text{ oz}}{453.59 \text{ g}} = 97.0 \text{ oz}$
- e. $534.1 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \frac{2.2046 \text{ lb}}{1 \text{ kg}} = 1.177 \text{ lb}$
- f. $1.75 \text{ lb} \times \frac{1 \text{ kg}}{2.2046 \text{ lb}} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 794 \text{ g}$
- g. $8.7 \text{ oz} \times \frac{453.59 \text{ g}}{16 \text{ oz}} = 250 \text{ g}$
- h. $45.9 \text{ g} \times \frac{16 \text{ oz}}{453.59 \text{ g}} = 1.62 \text{ oz}$
63. $1.89 \times 10^{25} \text{ C atoms} \times \frac{12.01 \text{ g}}{6.02 \times 10^{23} \text{ C atoms}} = 377 \text{ g}$
64. $2558 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} = 4117 \text{ km}$

Chapter 2: Measurements and Calculations

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. 212°F; 100°C

70. 273

71. 100

72. Fahrenheit (F)

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

a. $44.2^\circ\text{C} + 273 = 317.2 \text{ K} (317 \text{ K})$

b. $891 \text{ K} - 273 = 618^\circ\text{C}$

c. $-20^\circ\text{C} + 273 = 253 \text{ K}$

d. $273.1 \text{ K} - 273 = 0.1^\circ\text{C} (0^\circ\text{C})$

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

a. $T_C = (T_F - 32)/1.80 = (-153^\circ\text{F} - 32)/1.80 = (-185)/1.80 = -103^\circ\text{C}$

$$T_K = -103^\circ\text{C} + 273 = 170. \text{ K}$$

b. $T_K = -153^\circ\text{C} + 273 = 120. \text{ K}$

c. $T_F = 1.80(T_C) + 32 = 1.80(555^\circ\text{C}) + 32 = 1031^\circ\text{F}$

d. $T_C = (T_F - 32)/1.80 = (-24^\circ\text{F} - 32)/1.80 = -31^\circ\text{C}$

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

- 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 $10,000^{\circ}\text{F}$ to be known to two significant figures: $(10,000 - 32)/1.80 = 5500^{\circ}\text{C}$
76. $T_{\text{F}} = 1.80(T_{\text{C}}) + 32$
- a. $1.80(78.1) + 32 = 173^{\circ}\text{F}$
- b. $1.80(40.) + 32 = 104^{\circ}\text{F}$
- c. $1.80(-273) + 32 = -459^{\circ}\text{F}$
- d. $1.80(32) + 32 = 90.^{\circ}\text{F}$
77. a. Gallium is in the liquid state over the temperature range of this thermometer.
- b. $T_{\text{F}} = 1.80(T_{\text{C}}) + 32$
 $T_{\text{F}} = 1.80(50^{\circ}\text{C}) + 32 = 122^{\circ}\text{F}$
 $T_{\text{F}} = 1.80(500^{\circ}\text{C}) + 32 = 932^{\circ}\text{F}$
78. $T_{\text{F}} = 1.80(T_{\text{C}}) + 32$ $T_{\text{C}} = (T_{\text{F}} - 32)/1.80$ $T_{\text{K}} = T_{\text{C}} + 273$
- a. $275 - 273 = 2^{\circ}\text{C}$
- b. $(82 - 32)/1.80 = 28^{\circ}\text{C}$
- c. $1.80(-21) + 32 = -5.8^{\circ}\text{F}$ (-6°F)
- d. $(-40 - 32)/1.80 = -40^{\circ}\text{C}$ (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. Ethanol is the least dense ($0.785 \text{ g}/\text{cm}^3$).
87. $\text{density} = \frac{\text{mass}}{\text{volume}}$

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

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

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

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. $m = 225 \text{ mg} = 0.225 \text{ g}$ $v = 2.51 \text{ mL} = 2.51 \text{ cm}^3$

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

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

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

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

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

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

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

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

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

The material will float.

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

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

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

94. e. 38 cm; The density of the box must be less than water's density of 1.0 g/cm^3 in order to keep it afloat.

$$2.0 \text{ lbs} \times \frac{453.59 \text{ g}}{1 \text{ lb}} = 907.18 \text{ g (mass of box in grams)}$$

$$\frac{1.0 \text{ g}}{\text{cm}^3} = \frac{907.18 \text{ g}}{x \text{ cm}^3}$$

$$x = 907.18 \text{ cm}^3 \text{ to exactly match the density of water}$$

Thus, the volume of the box must be greater than 907.18 cm^3 to make the density less than 1.0 g/cm^3 . Let's say:

$$\text{Volume} = \text{length} \times \text{width} \times \text{height}$$

$$908 \text{ cm}^3 = \text{length} \times \text{width} \times \text{height}$$

$$908 \text{ cm}^3 = l \times 5.0 \text{ cm} \times 5.0 \text{ cm}$$

$$h = 36.32 \text{ cm or greater}$$

The minimum length is thus 38 cm (closest to 36.32 cm). To test:

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$$908 \text{ cm}^3 = l \times w \times h$$

$$38 \text{ cm} \times 5.0 \text{ cm} \times 5.0 \text{ cm} = 950 \text{ cm}^3$$

$$\text{Density} = \frac{907.18 \text{ g}}{950 \text{ cm}^3} = 0.95 \text{ g/cm}^3$$

95. 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. $50.0 \text{ g} \times \frac{1 \text{ cm}^3}{10.5 \text{ g}} = 4.76 \text{ cm}^3$

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

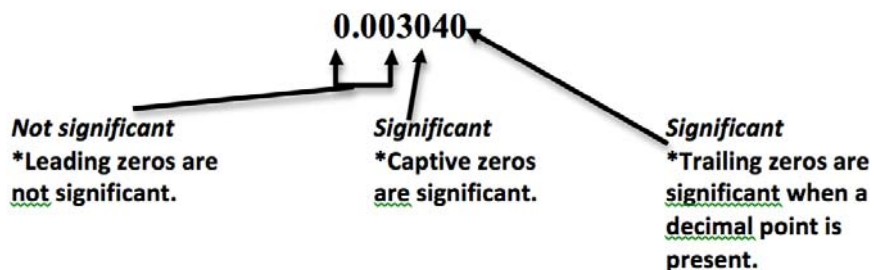
h. $4.2 \times 10^{-1} = 0.42$

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.



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

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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. Statements *a*, *c*, and *d* are true.

Statement *a* is true: $1.00 \text{ L} \times \frac{1.0567 \text{ qt}}{1 \text{ L}} = 1.06 \text{ qt}$

1.00 L is equivalent to 1.06 qt.

Statement *b* is false:
 $5 \text{ ft} \times \frac{12 \text{ in.}}{1 \text{ ft}} = 60. \text{ in.} + 3 \text{ in.} = 63 \text{ in.}$
 $63 \text{ in.} \times \frac{2.54 \text{ cm}}{1 \text{ in.}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 1.6 \text{ m}$

1.6 m is taller than 1.52 m.

Statement *c* is true: $335 \text{ g} \times \frac{1 \text{ lb}}{453.59 \text{ g}} = 0.739 \text{ lb}$

0.739 lb is heavier than $\frac{1}{2}$ lb.

Statement *d* is true: $\frac{45 \text{ mi}}{\text{hr}} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} = 72 \text{ km/hr}$

72 km/hr is faster than 65 km/hr.

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

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

$$1 \text{ gal} = 3.7854 \text{ L}$$

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

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

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

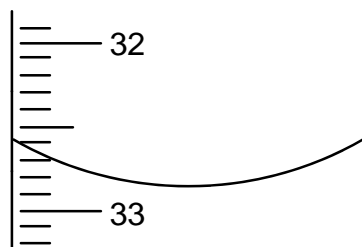
108. $^{\circ}\text{X} = 1.26^{\circ}\text{C} + 14$
109. $v = \frac{4}{3}(\pi r^3) = \frac{4}{3}(3.1416)(0.5 \text{ cm})^3 = 0.52 \text{ cm}^3$
 $d = \frac{2.0 \text{ g}}{0.52 \text{ cm}^3} = 3.8 \text{ g/cm}^3$ (the ball will sink)
110. $d = \frac{36.8 \text{ g}}{10.5 \text{ L}} = 3.50 \text{ g/L}$ ($3.50 \times 10^{-3} \text{ g/cm}^3$)
111. a. $25.0 \text{ g} \times \frac{1 \text{ cm}^3}{0.000084 \text{ g}} = 2.98 \times 10^5 \text{ cm}^3$
 b. $25.0 \text{ g} \times \frac{1 \text{ cm}^3}{13.6 \text{ g}} = 1.84 \text{ cm}^3$
 c. $25.0 \text{ g} \times \frac{1 \text{ cm}^3}{11.34 \text{ g}} = 2.20 \text{ cm}^3$
 d. $25.0 \text{ g} \times \frac{1 \text{ cm}^3}{1.00 \text{ g}} = 25.0 \text{ cm}^3$
112. 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, $78.5 + 880. = 959 \text{ g}$
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

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- 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; $301,000,000,000,000 = 3.01 \times 10^{17}$.
 - 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. $55/10^3 = \frac{5.5 \times 10^1}{1 \times 10^3} = 5.5 \times 10^{-2}$
- 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. $(10^6)(10^4)/(10^2) = \frac{(1 \times 10^6)(1 \times 10^4)}{(1 \times 10^2)} = 1 \times 10^8$
- g. $1/0.0034 = \frac{1}{3.4 \times 10^{-3}} = 2.9 \times 10^2$
- h. $3.453/10^{-4} = \frac{3.453}{1 \times 10^{-4}} = 3.453 \times 10^4$
123. meter

124.



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

126. $1 \text{ L} = 1 \text{ dm}^3 = 1000 \text{ cm}^3 = 1000 \text{ mL}$

127. 250. mL

128. 0.105 m

129. $100 \text{ km/hr} = 62.1 \text{ mi/hr}$; 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 ($425 \text{ mg} = 0.425 \text{ g}$)

132. $5 \times 10^{11} \text{ nm}$

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

133.

$$21.57 \text{ Mg} \times \frac{1 \times 10^6 \text{ g}}{1 \text{ Mg}} = 2.157 \times 10^7 \text{ g}$$

$$V = l \times w \times h = (1.40 \text{ m})^3 = 2.74 \text{ m}^3 \times \left(\frac{100 \text{ cm}}{1 \text{ m}} \right)^3 = 2.74 \times 10^6 \text{ cm}^3 \times \frac{1 \text{ mL}}{1 \text{ cm}^3} = 2.74 \times 10^6 \text{ mL}$$

$$D = \frac{m}{V} = \frac{2.157 \times 10^7 \text{ g}}{2.74 \times 10^6 \text{ mL}} = 7.86 \text{ g/mL} = \text{Fe (iron)}$$

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

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

$w = 0.830 \text{ m}$ (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)

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

142.

1 L = 1 dm³ (so convert all sides to dm)

$$1.0 \text{ m} \times \frac{10 \text{ dm}}{1 \text{ m}} = 10. \text{ dm}$$

$$2.4 \text{ mm} \times \frac{1 \text{ dm}}{100 \text{ mm}} = 0.024 \text{ dm}$$

$$V = l \times w \times h = 10. \text{ dm} \times 0.024 \text{ dm} \times 3.9 \text{ dm} = 0.94 \text{ dm}^3 = 0.94 \text{ L}$$

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

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. $5.3 \times 10^3 \text{ lbs} \times \frac{1 \text{ kg}}{2.2046 \text{ lbs}} \times \frac{1 \text{ metric ton}}{1000 \text{ kg}} = 2.4 \text{ metric tons}$
147. $T_K = T_C + 273$
- 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. $212 + 273 = 485 \text{ K}$
148. a. Celsius temperature = $(175 - 32)/1.80 = 79.4^\circ\text{C}$
Kelvin temperature = $79.4 + 273 = 352 \text{ K}$
- b. $255 - 273 = -18^\circ\text{C}$
- c. $(-45 - 32)/1.80 = -43^\circ\text{C}$
- d. $1.80(125) + 32 = 257^\circ\text{F}$
149. density = $\frac{\text{mass}}{\text{volume}}$

Chapter 2: Measurements and Calculations

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

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

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

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

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

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

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

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

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

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

Chapter 2: Measurements and Calculations

- | | | |
|------|--|--------|
| | 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. | $1.25 \text{ mi} \times \frac{1.6093 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} = 2011.625 \text{ m}$ | |
| | $60 \text{ sec} + 59.2 \text{ sec} = 119.2 \text{ sec}$ | |
| | $\frac{2011.625 \text{ m}}{119.2 \text{ s}} = 16.9 \text{ m/s}$ | |
| 163. | $T_C = (T_F - 32)/1.80$ | |
| | $T_C = (69.1 - 32)/1.80 = 20.6^\circ\text{C}$ | |
| 164. | $T_C = (T_F - 32)/1.80$ | |
| | $T_C = (134 - 32)/1.80 = 56.7^\circ\text{C}$ | |
| | <p>Since the temperature is higher than the melting point (44°C), phosphorus would be a liquid.</p> | |
| 165. | $1.84 \text{ cm} \times 3.61 \text{ cm} \times 2.10 \text{ cm} = 13.9 \text{ cm}^3$ | |

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

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

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

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