KEY REACTIONS AND EQUATIONS

1. Density of a substance (Section 2.9)

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

2. Conversion of temperature readings from one scale to another (Section 2.10)

$$K = °C + 273 \qquad °C = K - 273$$

$$°F = \frac{9}{5}(°C) + 32 \qquad °C = \frac{9}{5}(°F - 32)$$

3. Relationship between a calorie and a joule (Section 2.11)

$$1 \text{ calorie} = 4.184 \text{ joules}$$

4. Heat energy absorbed by a substance (Section 2.11)

$$\text{Heat energy absorbed} = \text{specific heat} \times \text{mass} \times \text{temperature change}$$

EXERCISES *and* PROBLEMS

The members of each pair of problems in this section test similar material.

Measurement Systems (Section 2.1)

2.1 What is the main reason scientists prefer to use the metric system of measurement rather than the English system of measurement?

2.2 List the more common types of measurements made in chemical laboratories.

Metric System Units (Section 2.2)

2.3 Write the name of the metric system prefix associated with each of the following mathematical meanings.
a. 10^3 b. 10^{-3} c. 10^{-6} d. 1/10

2.4 Write the name of the metric system prefix associated with each of the following mathematical meanings.
a. 10^{-2} b. 10^{-9} c. 10^{6} d. 1/1000

2.5 Write out the names of the metric system units that have the following abbreviations.
a. cm b. kL c. μL d. ng

2.6 Write out the names of the metric system units that have the following abbreviations.
a. mg b. pg c. Mm d. dL

2.7 Arrange each of the following from smallest to largest.
a. Milligram, centigram, nanogram
b. Gigameter, megameter, kilometer
c. Microliter, deciliter, picoliter
d. Milligram, kilogram, microgram

2.8 Arrange each of the following from smallest to largest.
a. Milliliter, gigaliter, microliter
b. Centigram, megagram, decigram
c. Micrometer, picometer, kilometer
d. Nanoliter, milliliter, centiliter

Exact and Inexact Numbers (Section 2.3)

2.9 A person is told that there are 60 minutes in an hour and also that a section of fence is 60 feet long. What is the difference relative to uncertainty between the value of 60 in these two pieces of information?

2.10 A person is told that there are 27 people in attendance at a meeting and also that the speed of a bicyclist is 27 miles per hour. What is the difference relative to uncertainty between the value of 27 in these two pieces of information?

2.11 Indicate whether the number in each of the following statements is an *exact* or an *inexact* number.
a. A classroom contains 32 chairs.
b. There are 60 seconds in a minute.
c. A bowl of cherries weighs 3.2 pounds.
d. A newspaper article contains 323 words.

2.12 Indicate whether the number in each of the following statements is an *exact* or an *inexact* number.
a. A classroom contains 63 students.
b. The car is traveling at a speed of 56 miles per hour.
c. The temperature on the back porch is −3°F.
d. There are 3 feet in a yard.

2.13 Indicate whether each of the following quantities would involve an *exact* number or an *inexact* number.
a. The length of a swimming pool
b. The number of gummi bears in a bag
c. The number of quarts in a gallon
d. The surface area of a living room rug

2.14 Indicate whether each of the following quantities would involve an *exact* number or an *inexact* number.
a. The number of pages in a chemistry textbook
b. The number of teeth in a bear's mouth
c. The distance from Earth to the sun
d. The temperature of a heated oven

Uncertainty in Measurement (Section 2.4)

2.15 What is the magnitude of the uncertainty associated with each of the following measured numbers?
a. 2.730 b. 2345 c. 0.2222 d. 280

2.16 What is the magnitude of the uncertainty associated with each of the following measured numbers?
a. 24.35 b. 0.4006 c. 330 d. 3756.3

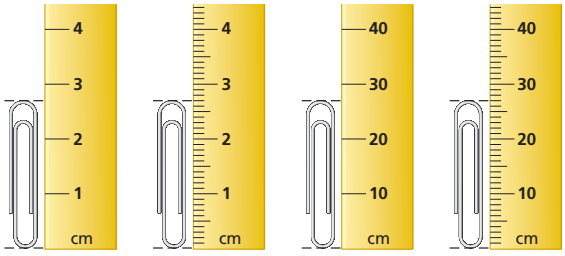
2.17 Indicate to what decimal position readings should be recorded (nearest 0.1, 0.01, etc.) for measurements made with the following devices.
a. A thermometer with a smallest scale marking of 1°C
b. A graduated cylinder with a smallest scale marking of 0.1 mL
c. A volumetric device with a smallest scale marking of 10 mL
d. A ruler with a smallest scale marking of 1 mm

2.18 Indicate to what decimal position readings should be recorded (nearest 0.1, 0.01, etc.) for measurements made with the following devices.
a. A ruler with a smallest scale marking of 1 cm
b. A device for measuring angles with a smallest scale marking of 1°
c. A thermometer with a smallest scale marking of 0.1°F
d. A graduated cylinder with a smallest scale marking of 10 mL

2.19 The number of people present at a college football game was estimated by police to be 50,000. How many people were present at the football game if you assume that this estimate has each of the following uncertainties?
a. 10,000 b. 1000 c. 100 d. 10

2.20 The number of people present at an outdoor rock concert was estimated by police to be 38,000. How many people were present at the concert if you assume that this estimate has each of the following uncertainties?
a. 10,000 b. 1000 c. 100 d. 10

2.21 Consider the following rulers as instruments for the measurement of length.



1 2 3 4

What would the uncertainty be in measurements made using the following?
a. Ruler 1 b. Ruler 4

2.22 Using the rulers given in Problem 2.21, what would the uncertainty be in measurements made using the following?
a. Ruler 2 b. Ruler 3

2.23 Using the rulers given in Problem 2.21, what is the length of the paper clip shown by the side of the following?
a. Ruler 2 b. Ruler 3

2.24 Using the rulers given in Problem 2.21, what is the length of the paper clip shown by the side of the following?
a. Ruler 1 b. Ruler 4

2.25 With which of the rulers in Problem 2.21 was each of the following measurements made, assuming that you cannot use a ruler multiple times in making the measurement? (It is possible that there may be more than one correct answer.)
a. 20.4 cm b. 2.3 cm c. 3.74 cm d. 32 cm

2.26 With which of the rulers in Problem 2.21 was each of the following measurements made, assuming that you cannot use a ruler multiple time in making the measurement? (It is possible that there may be more than one correct answer.)
a. 3.2 cm b. 3.22 cm c. 22 cm d. 3 cm

Significant Figures and Measurement (Section 2.4)

2.27 Determine the number of significant figures in each of the following measured values.
a. 6.000 b. 0.0032 c. 0.01001
d. 65,400 e. 76.010 f. 0.03050

2.28 Determine the number of significant figures in each of the following measured values.
a. 23,009 b. 0.00231 c. 0.3330
d. 73,000 e. 73.000 f. 0.40040

2.29 In which of the following pairs of numbers do both members of the pair contain the same number of significant figures?
a. 11.01 and 11.00 b. 2002 and 2020
c. 0.000066 and 660,000 d. 0.05700 and 0.05070

2.30 In which of the following pairs of numbers do both members of the pair contain the same number of significant figures?
a. 345,000 and 340,500 b. 2302 and 2320
c. 0.6600 and 0.66 d. 936 and 936,000

2.31 Identify the *estimated digit* in each of the measured values in Problem 2.27.

2.32 Identify the *estimated digit* in each of the measured values in Problem 2.28.

2.33 What is the magnitude of the uncertainty (±10, ±0.1, etc.) associated with each of the measured values in Problem 2.27?

2.34 What is the magnitude of the uncertainty (±10, ±0.1, etc.) associated with each of the measured values in Problem 2.28?

Significant Figures and Mathematical Operations (Section 2.5)

2.35 Round off each of the following numbers to the number of significant figures indicated in parentheses.
a. 0.350763 (three) b. 653,899 (four)
c. 22.55555 (five) d. 0.277654 (four)

2.36 Round off each of the following numbers to the number of significant figures indicated in parentheses.
a. 3883 (two) b. 0.0003011 (two)
c. 4.4050 (three) d. 2.1000 (three)

2.37 Without actually solving, indicate the number of significant figures that should be present in the answers to the following multiplication and division problems.
a. $10.300 \times 0.30 \times 0.300$ b. $3300 \times 3330 \times 333.0$
c. $\dfrac{6.0}{33.0}$ d. $\dfrac{6.000}{33}$

2.38 Without actually solving, indicate the number of significant figures that should be present in the answers to the following multiplication and division problems.
a. $3.00 \times 0.0003 \times 30.00$ b. $0.3 \times 0.30 \times 3.0$
c. $\dfrac{6.00}{33{,}000}$ d. $\dfrac{6.00000}{3}$

2.39 Carry out the following multiplications and divisions, expressing your answer to the correct number of significant figures. Assume that all numbers are measured numbers.
a. $2.0000 \times 2.00 \times 0.0020$ b. 4.1567×0.00345
c. $0.0037 \times 3700 \times 1.001$ d. $\dfrac{6.00}{33.0}$
e. $\dfrac{530{,}000}{465.300}$ f. $\dfrac{4670 \times 3.00}{2.450}$

2.40 Carry out the following multiplications and divisions, expressing your answer to the correct number of significant figures. Assume that all numbers are measured numbers.
a. $2.000 \times 0.200 \times 0.20$ b. 3.6750×0.04503
c. $0.0030 \times 0.400 \times 4.00$ d. $\dfrac{6.0000}{33.00}$
e. $\dfrac{45{,}000}{1.2345}$ f. $\dfrac{3.00 \times 6.53}{13.567}$

2.41 Carry out the following additions and subtractions, expressing your answer to the correct number of significant figures. Assume that all numbers are measured numbers.
a. 12 + 23 + 127 b. 3.111 + 3.11 + 3.1
c. 1237.6 + 23 + 0.12 d. 43.65 − 23.7

2.42 Carry out the following additions and subtractions, expressing your answer to the correct number of significant figures. Assume that all numbers are measured numbers.
a. 237 + 37.0 + 7.0 b. 4.000 + 4.002 + 4.20
c. 235.45 + 37 + 36.4 d. 3.111 − 2.07

Scientific Notation (Section 2.6)

2.43 Express the following numbers in scientific notation.
a. 120.7 b. 0.0034 c. 231.00
d. 23,000 e. 0.200 f. 0.1011

2.44 Express the following numbers in scientific notation.
a. 37.06 b. 0.00571 c. 437.0
d. 4370 e. 0.20340 f. 230,000

2.45 Which number in each pair of numbers is the larger of the two numbers?
a. 1.0×10^{-3} or 1.0×10^{-6}
b. 1.0×10^{3} or 1.0×10^{-2}
c. 6.3×10^{4} or 2.3×10^{4}
d. 6.3×10^{-4} or 1.2×10^{-4}

2.46 Which number in each pair of numbers is the larger of the two numbers?
a. 2.0×10^{2} or 2.0×10^{-2} b. 1.0×10^{6} or 3.0×10^{6}
c. 4.4×10^{-4} or 4.4×10^{-5} d. 9.7×10^{3} or 8.3×10^{2}

2.47 How many significant figures are present in each of the following measured numbers?
a. 1.0×10^{2} b. 5.34×10^{6}
c. 5.34×10^{-4} d. 6.000×10^{3}

2.48 How many significant figures are present in each of the following measured numbers?
a. 1.01×10^{2} b. 1.00×10^{2}
c. 6.6700×10^{8} d. 6.050×10^{-3}

2.49 Carry out the following multiplications and divisions, expressing your answer in scientific notation to the correct number of significant figures.
a. $(3.20 \times 10^{7}) \times (1.720 \times 10^{5})$
b. $(3.71 \times 10^{-4}) \times (1.117 \times 10^{2})$
c. $(1.00 \times 10^{3}) \times (5.00 \times 10^{3}) \times (3.0 \times 10^{-3})$
d. $\dfrac{3.0 \times 10^{-5}}{1.5 \times 10^{2}}$ e. $\dfrac{4.56 \times 10^{7}}{3.0 \times 10^{-4}}$
f. $\dfrac{(2.2 \times 10^{6}) \times (2.3 \times 10^{-6})}{(1.2 \times 10^{-3}) \times (3.5 \times 10^{-3})}$

2.50 Carry out the following multiplications and divisions, expressing your answer in scientific notation to the correct number of significant figures.
a. $(4.0 \times 10^{4}) \times (1.32 \times 10^{8})$
b. $(2.23 \times 10^{-6}) \times (1.230 \times 10^{-2})$
c. $(3.200 \times 10^{7}) \times (1.10 \times 10^{-2}) \times (2.3 \times 10^{-7})$
d. $\dfrac{6.0 \times 10^{-5}}{3.0 \times 10^{3}}$ e. $\dfrac{5.132 \times 10^{7}}{1.12 \times 10^{3}}$
f. $\dfrac{(3.2 \times 10^{2}) \times (3.31 \times 10^{6})}{(4.00 \times 10^{-3}) \times (2.0 \times 10^{6})}$

2.51 What is the uncertainty, in terms of a power of ten, associated with each of the following measured values?
a. 3.60×10^{4} b. 3.60×10^{6}
c. 3.6×10^{5} d. 3.6×10^{-3}

2.52 What is the uncertainty, in terms of a power of ten, associated with each of the following measured values?
a. 4.30×10^{-2} b. 4.300×10^{-1}
c. 4.3×10^{3} d. 4.300×10^{5}

Conversion Factors (Section 2.7)

2.53 Give the two forms of the conversion factor that relate each of the following pairs of units.
a. Days and hours b. Decades and centuries
c. Feet and yards d. Quarts and gallons

2.54 Give the two forms of the conversion factor that relate each of the following pairs of units.
a. Days and weeks b. Years and centuries
c. Inches and feet d. Pints and quarts

2.55 Give the two forms of the conversion factor that relate each of the following pairs of units.
a. kL and L b. mg and g
c. m and cm d. μsec and sec

2.56 Give the two forms of the conversion factor that relate each of the following pairs of units.
a. ng and g b. dL and L
c. m and Mm d. psec and sec

2.57 Indicate whether each of the following equations relating units would generate an *exact* set of conversion factors or an *inexact* set of conversion factors relative to significant figures.
a. 1 dozen = 12 objects
b. 1 kilogram = 2.20 pounds
c. 1 minute = 60 seconds
d. 1 millimeter = 10^{-3} meter

2.58 Indicate whether each of the following equations relating units would generate an *exact* set of conversion factors or an *inexact* set of conversion factors relative to significant figures.
a. 1 gallon = 16 cups b. 1 week = 7 days
c. 1 pint = 0.4732 liter d. 1 mile = 5280 feet

Dimensional Analysis (Section 2.8)

2.59 Using dimensional analysis, convert each of the following measurements to meters.
a. 1.6×10^{3} dm b. 24 nm
c. 0.003 km d. 3.0×10^{8} mm

2.60 Using dimensional analysis, convert each of the following measurements to meters.
a. 2.7×10^{3} mm b. 24 μm
c. 0.003 pm d. 4.0×10^{5} cm

2.61 The human stomach produces approximately 2500 mL of gastric juice per day. What is the volume, in liters, of gastric juice produced?

2.62 A typical loss of water through sweating per day for a human is 450 mL. What is the volume, in liters, of sweat produced per day?

2.63 The mass of premature babies is customarily determined in grams. If a premature baby weighs 1550 g, what is its mass in pounds?

2.64 The smallest bone in the human body, which is in the ear, has a mass of 0.0030 g. What is the mass of this bone in pounds?

2.65 What volume of water, in gallons, would be required to fill a 25-mL container?

2.66 What volume of gasoline, in milliliters, would be required to fill a 17.0-gal gasoline tank?

2.67 An individual weighs 83.2 kg and is 1.92 m tall. What are the person's equivalent measurements in pounds and feet?

2.68 An individual weighs 135 lb and is 5 ft 4 in. tall. What are the person's equivalent measurements in kilograms and meters?

Density (Section 2.9)

2.69 A sample of mercury is found to have a mass of 524.5 g and to have a volume of 38.72 cm^3. What is its density in grams per cubic centimeter?

2.70 A sample of sand is found to have a mass of 12.0 g and to have a volume of 2.69 cm^3. What is its density in grams per cubic centimeter?

2.71 Acetone, the solvent in nail polish remover, has a density of 0.791 g/mL. What is the volume, in milliliters, of 20.0 g of acetone?

2.72 Silver metal has a density of 10.40 g/cm^3. What is the volume, in cubic centimeters, of a 100.0-g bar of silver metal?

2.73 The density of homogenized milk is 1.03 g/mL. How much does 1 cup (236 mL) of homogenized milk weigh in grams?

2.74 Nickel metal has a density of 8.90 g/cm^3. How much does 15 cm^3 of nickel metal weigh in grams?

2.75 Water has a density of 1.0 g/cm^3 at room temperature. State whether each of the following will sink or float when placed in water.
a. Paraffin wax (density = 0.90 g/cm^3)
b. Limestone (density = 2.8 g/cm^3)

2.76 Air has a density of 1.29 g/L at room temperature. State whether each of the following will rise or sink in air.
a. Helium gas (density = 0.18 g/L)
b. Argon gas (density = 1.78 g/L)

Temperature Scales (Section 2.10)

2.77 An oven for baking pizza operates at approximately 525°F. What is this temperature in degrees Celsius?

2.78 A comfortable temperature for bathtub water is 95°F. What temperature is this in degrees Celsius?

2.79 Mercury freezes at −38.9°C. What is the coldest temperature, in degrees Fahrenheit, that can be measured using a mercury thermometer?

2.80 The body temperature for a hypothermia victim is found to have dropped to 29.1°C. What is this temperature in degrees Fahrenheit?

2.81 Which is the higher temperature, −10°C or 10°F?

2.82 Which is the higher temperature, −15°C or 4°F?

Heat Energy and Specific Heat (Section 2.11)

2.83 A substance has a specific heat of 0.63 cal/g · °C. What is its specific heat in J/g · °C?

2.84 A substance has a specific heat of 0.24 cal/g · °C. What is its specific heat in J/g · °C?

2.85 If it takes 18.6 cal of heat to raise the temperature of 12.0 g of a substance by 10.0°C, what is the specific heat of the substance?

2.86 If it takes 35.0 cal of heat to raise the temperature of 25.0 g of a substance by 12.0°C, what is the specific heat of the substance?

2.87 How many calories of heat energy are required to raise the temperature of 42.0 g of each of the following substances from 20.0°C to 40.0°C?
a. Silver b. Liquid water c. Aluminum

2.88 How many calories of heat energy are necessary to raise the temperature of 20.0 g of each of the following substances from 25°C to 55°C?
a. Gold b. Ethyl alcohol c. Olive oil

ADDITIONAL PROBLEMS

2.89 A person is told that there are 12 inches in a foot and also that a piece of rope is 12 inches long. What is the fundamental difference between the value of 12 in these two pieces of information?

2.90 Round off the number 4.7205059 to the indicated number of significant figures.
a. Six b. Five c. Four d. Two

2.91 Write each of the following numbers in scientific notation to the number of significant figures indicated in parentheses.
a. 0.00300300 (three) b. 936,000 (two)
c. 23.5003 (three) d. 450,000,001 (six)

2.92 For each of the pairs of units listed, indicate whether the first unit is larger or smaller than the second unit, and then indicate how many times larger or smaller it is.
a. Milliliter, liter b. Kiloliter, microliter
c. Nanoliter, deciliter d. Centiliter, megaliter

2.93 Indicate how each of the following conversion factors should be interpreted in terms of significant figures present.
a. $\frac{2.540\ \text{cm}}{1.000\ \text{in.}}$ b. $\frac{453.6\ \text{g}}{1.000\ \text{lb}}$
c. $\frac{2.113\ \text{pt}}{1.00\ \text{L}}$ d. $\frac{10^{-9}\ \text{m}}{1\ \text{nm}}$

2.94 A one-gram sample of a powdery white solid is found to have a volume of two cubic centimeters. Calculate the solid's density using the following uncertainty specifications, and express your answers in scientific notation.
a. 1.0 g and 2.0 cm^3 b. 1.000 g and 2.00 cm^3
c. 1.0000 g and 2.0000 cm^3 d. 1.000 g and 2.0000 cm^3

2.95 Calculate the volume, in *milliliters,* for each of the following.
a. 75.0 g of gasoline (density = 0.56 g/mL)
b. 75.0 g of sodium metal (density = 0.93 g/cm^3)
c. 75.0 g of ammonia gas (density = 0.759 g/L)
d. 75.0 g of mercury (density = 13.6 g/mL)

2.96 Which quantity of heat energy in each of the following pairs of heat energy values is the larger?
a. 2.0 joules or 2.0 calories
b. 1.0 kilocalorie or 92 calories
c. 100 Calories or 100 calories
d. 2.3 Calories or 1000 kilocalories

2.97 The concentration of salt in a salt solution is found to be 4.5 mg/mL. What is the salt concentration in each of the following units?
a. mg/L b. pg/mL c. g/L d. kg/m^3

Multiple-Choice Practice Test

2.98 In which of the following pairings of metric system prefix and power of ten is the pairing *incorrect*?
a. Kilo- and 10^{-3} b. Micro- and 10^{-6}
c. Deci- and 10^{-1} d. Mega and 10^{6}

2.99 Which of the following statements about the "significance" of zeros in recorded measurements is *incorrect*?
a. Leading zeros are never significant.
b. Confined zeros are always significant.
c. Trailing zeros are never significant.
d. Trailing zeros may or may not be significant.

2.100 The *estimated* digit in the measurement 65,430 seconds is
a. the zero. b. the three. c. the four. d. the five.

2.101 When rounded to three significant figures, the number 43267 becomes
a. 432 b. 433 c. 43200 d. 43300

2.102 The uncertainty associated with the measurement 0.3030 lies in the
a. tenths place (0.1).
b. hundredths place (0.01).
c. thousandths place (0.001).
d. ten-thousandths place (0.0001).

2.103 The number 273.00, when expressed in scientific notation, becomes
a. 2.73×10^{-2} b. 2.7300×10^{-2}
c. 2.73×10^{2} d. 2.7300×10^{2}

2.104 The calculator answer obtained by multiplying the measurements 53.534 and 5.00 is 267.67. This answer
a. is correct as written. b. should be rounded to 267.7.
c. should be rounded to 268. d. should be rounded to 270.

2.105 The calculator answer obtained by adding the measurements 8.1, 2.19, and 3.123 is 13.413. This answer
a. is correct as written.
b. should be rounded to two significant figures.
c. should be rounded to 13.41.
d. should be rounded to 13.4.

2.106 What is the volume, in milliliters, of 50.0 g of a liquid if its density is 1.20 g/mL?
a. 32.1 mL b. 41.7 mL c. 60.0 mL d. 75.0 mL

2.107 Which of the following statements concerning the three major temperature scales is *incorrect*?
a. Kelvin scale temperatures can never have negative values.
b. A Celsius degree and a Kelvin are equal in size.
c. The addition of 273 to a Fahrenheit scale reading will convert it to a Kelvin scale reading.
d. The freezing point of water has a lower numerical value on the Celsius scale than on the Fahrenheit scale.