CHAPTER 3

Study Guide

Key Concepts

3.1 Measurements and Their Uncertainty

- Measurements are fundamental to the experimental sciences.
- To evaluate accuracy, the measured value must be compared to the correct value. To evaluate precision, you must compare the values of repeated measurements.
- Calculated answers often depend on the number of significant figures in the values used in the calculation.
- In general, a calculated answer cannot be more precise than the least precise measurement from which it was calculated.

3.2 The International System of Units

- Five commonly used SI base units are the meter, kilogram, kelvin, second, and mole.
- Common metric units of length: cm, m, km. Common metric units of volume: μL, mL, L, cm^3. Common metric units of mass: mg, g, kg. Common units of temperature: °C and K. Common units of energy: J and cal.

3.3 Conversion Problems

- Multiplying by a conversion factor does not change the actual size of a measurement.
- Dimensional analysis provides an alternative approach to problem solving.
- Conversion problems are easily solved using dimensional analysis.

3.4 Density

- Density is an intensive property that depends only on the composition of a substance.
- The density of a substance generally decreases as its temperature increases.

Vocabulary

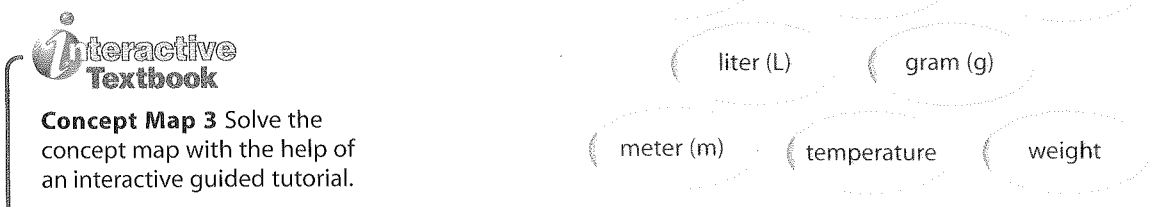
- absolute zero (p. 77)
- accepted value (p. 65)
- accuracy (p. 64)
- calorie (cal) (p. 79)
- Celsius scale (p. 77)
- conversion factor (p. 80)
- density (p. 90)
- dimensional analysis (p. 81)
- energy (p. 79)
- error (p. 65)
- experimental value (p. 65)
- gram (g) (p. 76)
- International System of Units (SI) (p. 73)
- joule (J) (p. 79)
- Kelvin scale (p. 77)
- kilogram (kg) (p. 76)
- liter (L) (p. 75)
- measurement (p. 63)
- meter (m) (p. 74)
- percent error (p. 65)
- precision (p. 64)
- scientific notation (p. 63)
- significant figures (p. 66)
- temperature (p. 77)
- weight (p. 76)

Key Equations

- Error = experimental value − accepted value
- Percent error = $\dfrac{|\text{error}|}{\text{accepted value}} \times 100\%$
- K = °C + 273 and °C = K − 273
- 1 J = 0.2390 cal and 1 cal = 4.184 J
- Density = $\dfrac{\text{mass}}{\text{volume}}$

Organizing Information

Use these terms to construct a concept map that organizes the major ideas of this chapter.



Interactive Textbook

Concept Map 3 Solve the concept map with the help of an interactive guided tutorial.

with ChemASAP

CHAPTER 3

Assessment

Reviewing Content

3.1 Measurements and Their Uncertainty

57. Three students made multiple weighings of a copper cylinder, each using a different balance. Describe the accuracy and precision of each student's measurements if the correct mass of the cylinder is 47.32 g.

	Mass of Cylinder (g)		
	Lissa	Lamont	Leigh Anne
Weighing 1	47.13	47.45	47.95
Weighing 2	47.94	47.39	47.91
Weighing 3	46.83	47.42	47.89
Weighing 4	47.47	47.41	47.93

58. How many significant figures are in each underlined measurement?

a. 60 s = 1 min **b.** 47.70 g of copper

c. 1 km = 1000 m **d.** 25 computers

59. Round off each of these measurements to three significant figures.

a. 98.473 L **b.** 0.000 763 21 cg

c. 57.048 m **d.** 12.17°C

60. Round off each of the answers correctly.

a. 8.7 g + 15.43 g + 19 g = 43.13 g

b. 853.2 L − 627.443 L = 225.757 L

c. 38.742 kg ÷ 0.421 = 92.023 75 kg

d. 5.40 m × 3.21 m × 1.871 m = 32.431 914 m^3

61. Express each of the rounded-off answers in Questions 59 and 60 in scientific notation.

62. How are the *error* and the *percent error* of a measurement calculated?

3.2 The International System of Units

63. List the SI base unit of measurement for each of these quantities.

a. time **b.** length

c. temperature **d.** mass

64. Order these units from smallest to largest: cm, μm, km, mm, m, nm, dm, pm. Then give each measurement in terms of meters.

65. Measure each of the following dimensions using a unit with the appropriate prefix.

a. the height of this letter I

b. the width of Table 3.3

c. the height of this page

66. The melting point of silver is 962°C. Express this temperature in kelvins.

3.3 Conversion Problems

67. What is the name given to a ratio of two equivalent measurements?

68. What must be true for a ratio of two measurements to be a conversion factor?

69. How do you know which unit of a conversion factor must be in the denominator?

70. Make the following conversions.

a. 157 cs to seconds

b. 42.7 L to milliliters

c. 261 nm to millimeters

d. 0.065 km to decimeters

e. 642 cg to kilograms

f. 8.25×10^2 cg to nanograms

71. Make the following conversions.

a. 0.44 mL/min to microliters per second

b. 7.86 g/cm^2 to milligrams per square millimeter

c. 1.54 kg/L to grams per cubic centimeter

72. How many milliliters are contained in 1 m^3?

73. Complete this table so that all the measurements in each row have the same value.

mg	g	cg	kg
(a)	(b)	28.3	(c)
6.6×10^3	(d)	(e)	(f)
(g)	2.8×10^{-4}	(h)	(i)

3.4 Density

74. What equation is used to determine the density of an object?

75. Would the density of a person be the same on the surface of Earth and on the surface of the moon? Explain.

76. A shiny, gold-colored bar of metal weighing 57.3 g has a volume of 4.7 cm^3. Is the bar of metal pure gold?

77. Three balloons filled with neon, carbon dioxide, and hydrogen are released into the atmosphere. Using the data in Table 3.6 on page 90, describe the movement of each balloon.

Understanding Concepts

78. List two possible reasons for reporting precise, but inaccurate, measurements.

79. Rank these numbers from smallest to largest.

a. 5.3×10^4 **b.** 57×10^3
c. 4.9×10^{-2} **d.** 0.0057
e. 5.1×10^{-3} **f.** 0.0072×10^2

80. Comment on the accuracy and precision of these basketball free-throw shooters.

a. 99 of 100 shots are made.
b. 99 of 100 shots hit the front of the rim and bounce off.
c. 33 of 100 shots are made; the rest miss.

81. Fahrenheit is a third temperature scale. Plot the data in the table and use the graph to derive an equation for the relationship between the Fahrenheit and Celsius temperature scales.

Example	°C	°F
Melting point of selenium	221	430
Boiling point of water	100	212
Normal body temperature	37	98.6
Freezing point of water	0	32
Boiling point of chlorine	−34.6	−30.2

82. Which would melt first, germanium with a melting point of 1210 K or gold with a melting point of 1064°C?

83. Write six conversion factors involving these units of measure: 1 g = 10^2 cg = 10^3 mg.

84. A 2.00-kg sample of bituminous coal is composed of 1.30 kg of carbon, 0.20 kg of ash, 0.15 kg of water, and 0.35 kg of volatile (gas-forming) material. Using this information, determine how many kilograms of carbon are in 125 kg of this coal.

85. A piece of wood sinks in ethanol but floats in gasoline. Give a range of possible densities for the wood.

86. The density of dry air measured at 25°C is 1.19×10^{-3} g/cm^3. What is the volume of 50.0 g of air?

87. A flask that can hold 158 g of water at 4°C can hold only 127 g of ethanol at the same temperature. What is the density of ethanol?

88. A watch loses 0.15 s every minute. How many minutes will the watch lose in 1 day?

89. A tank measuring 28.6 cm by 73.0 mm by 0.72 m is filled with olive oil. The oil in the tank has a mass of 1.38×10^4 g. What is the density of olive oil in kilograms per liter?

90. Alkanes are a class of molecules that have the general formula C_nH_{2n+2}, where n is an integer (whole number). The table below gives the boiling points for the first five alkanes with an odd number of carbon atoms. Using the table, construct a graph with number of carbon atoms on the x-axis.

Boiling point (°C)	Number of carbon atoms
−162.0	1
−42.0	3
36.0	5
98.0	7
151.0	9

a. What are the approximate boiling points for the C_2, C_4, C_6, and C_8 alkanes?
b. Which of these nine alkanes are gases at room temperature (20°C)?
c. How many of these nine alkanes are liquids at 350 K?
d. What is the approximate increase in boiling point per additional carbon atom in these alkanes?

91. Earth is approximately 1.5×10^8 km from the sun. How many minutes does it take light to travel from the sun to Earth? The speed of light is 3.0×10^8 m/s.

92. What is the mass of a cube of aluminum that is 3.0 cm on each edge? The density of aluminum is 2.7 g/cm^3.

93. The average density of Earth is 5.52 g/cm^3. Express this density in units of kg/dm^3.

94. How many kilograms of water (at 4°C) are needed to fill an aquarium that measures 40.0 cm by 20.0 cm by 30.0 cm?

Critical Thinking

95. Is it possible for an object to lose weight but at the same time not lose mass? Explain.

96. One of the first mixtures of metals, called amalgams, used by dentists for tooth fillings consisted of 26.0 g of silver, 10.8 g of tin, 2.4 g of copper, and 0.8 g of zinc. How much silver is in a 25.0 g sample of this amalgam?

97. A cheetah can run 112 km/h over a 100-m distance. What is this speed in meters per second?

98. You are hired to count the number of ducks on three northern lakes during the summer. In the first lake, you estimate 500,000 ducks, in the second 250,000 ducks, and in the third 100,000 ducks. You write down that you have counted 850,000 ducks. As you drive away, you see 15 ducks fly in from the south and land on the third lake. Do you change the number of ducks that you report? Justify your answer.

99. What if ice were more dense than water? It would certainly be easier to pour water from a pitcher of ice cubes and water. Can you imagine situations of more consequence?

100. Why is there a range of values given for the density of gasoline on Table 3.6 on page 90?

101. Plot these data that show how the mass of sulfur increases with an increase in volume. Determine the density of sulfur from the slope of the line.

Volume of sulfur (cm^3)	Mass of sulfur (g)
11.4	23.5
29.2	60.8
55.5	115
81.1	168

102. At 20°C, the density of air is 1.20 g/L. Nitrogen's density is 1.17 g/L. Oxygen's density is 1.33 g/L.

a. Will balloons filled with oxygen and balloons filled with nitrogen rise or sink in air?

b. Air is mainly a mixture of nitrogen and oxygen. Which gas is the main component? Explain.

Concept Challenge

103. The mass of a cube of iron is 355 g. Iron has a density of 7.87 g/cm^3. What is the mass of a cube of lead that has the same dimensions?

104. Sea water contains 8.0×10^{-1} cg of the element strontium per kilogram of sea water. Assuming that all the strontium could be recovered, how many grams of strontium could be obtained from one cubic meter of sea water? Assume the density of sea water is 1.0 g/mL.

105. The density of dry air at 20°C is 1.20 g/L. What is the mass of air, in kilograms, of a room that measures 25.0 m by 15.0 m by 4.0 m?

106. Different volumes of the same liquid were added to a flask on a balance. After each addition of liquid, the mass of the flask with the liquid was measured. Graph the data using mass as the dependent variable. Use the graph to answer these questions.

Volume (mL)	Mass (g)
14	103.0
27	120.4
41	139.1
55	157.9
82	194.1

a. What is the mass of the flask?

b. What is the density of the liquid?

107. A 34.5-g gold nugget is dropped into a graduated cylinder containing water. By how many milliliters does the measured volume increase? The density of water is 1.0 g/mL. The density of gold is 19.3 g/cm^3.

108. Equal amounts of mercury, water, and corn oil are added to a beaker.

a. Describe the arrangement of the layers of liquids in the beaker.

b. A small sugar cube is added to the beaker. Describe its location.

c. What change will occur to the sugar cube over time?

Standardized Test Prep

Test-Taking Tip

Interpreting Diagrams Diagrams present information in a visual format. Before you answer questions about a diagram, be sure to study the diagram carefully. Ask yourself some questions: *What is the diagram showing? What does the diagram tell me?*

Select the choice that best answers each question or completes each statement.

1. Which of these series of units is ordered from smallest to largest?
   a. μg, cg, mg, kg
   b. mm, dm, m, km
   c. μs, ns, cs, s
   d. nL, mL, dL, cL

2. Which answer represents the measurement 0.00428 g rounded to two significant figures?
   a. 4.28×10^3 g **b.** 4.3×10^{-3} g
   c. 4.3×10^3 g **d.** 4.0×10^{-3} g

3. An over-the-counter medicine has 325 mg of its active ingredient per tablet. How many grams does this mass represent?
   a. 325,000 g **b.** 32.5 g
   c. 3.25 g **d.** 0.325 g

4. If 10^4 μm = 1 cm, how many $\mu m^3 = 1\ cm^3$?
   a. 10^4 **b.** 10^6
   c. 10^8 **d.** 10^{12}

5. How many meters does a car moving at 95 km/h travel in 1.0 s?
   a. 1.6 m **b.** 340 m
   c. 1600 m **d.** 26 m

6. If a substance contracts when it freezes, its
   a. density will remain the same.
   b. density will increase.
   c. density will decrease.
   d. change in density cannot be predicted.

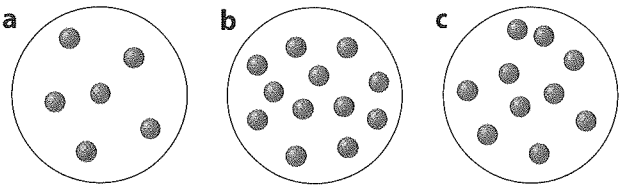
For Questions 7–9, identify the known and the unknown. Include units in your answers.

7. The density of water is 1.0 g/mL. How many deciliters of water will fill a 0.5-L bottle?

8. A clock loses 4 minutes every day. How many seconds does the clock lose in 1 minute?

9. A graduated cylinder contains 44.2 mL of water. A 48.6-g piece of metal is carefully dropped into the cylinder. When the metal is completely covered with water, the water rises to the 51.3-mL mark. What is the density of the metal?

Use the atomic windows below to answer Questions 10 and 11.



The atomic windows represent particles of the same gas occupying the same volume at the same temperature. The systems differ only in the number of gas particles per unit volume.

10. List the windows in order of decreasing density.

11. Compare the density of the gas in window (a) to the density of the gas in window (b).

For each question there are two statements. Decide whether each statement is true or false. Then decide whether Statement II is a correct explanation for Statement I.

	Statement I		Statement II
12.	There are five significant figures in the measurement 0.00450 m.	BECAUSE	All zeros to the right of a decimal point in a measurement are significant.
13.	Precise measurements will always be accurate measurements.	BECAUSE	A value that is measured 10 times in a row must be accurate.
14.	A temperature in kelvins is always numerically larger than the same temperature in degrees Celsius.	BECAUSE	A temperature in kelvins equals a temperature in degrees Celsius plus 273.