Name ______________________ Date __________ Class __________

3 SCIENTIFIC MEASUREMENT

Conceptual Curriculum	Standard Curriculum	Honors Curriculum
● Concrete concepts	■ Core content	◆ Core honors content
○ More abstract concepts or math/problem-solving	□ Extension topics	◇ Options to accelerate

SECTION 3.1 THE IMPORTANCE OF MEASUREMENT (pages 51–53) ○■◆

This section explains the difference between qualitative and quantitative measurements, and how scientific notation can help express very large or very small numbers.

▶ Qualitative and Quantitative Measurements (page 51)

1. The system of units used for measurements in chemistry is called the International System of Measurements (SI).

2. Is the following statement true or false? A qualitative measurement gives a precise, numerical result. false

3. Is the following statement true or false? A quantitative measurement gives a result in a definite form, usually as a number and a unit. true

Five types of measurements you might make are described below. Label each sentence that describes a qualitative measurement as QUAL. Label each sentence that describes a quantitative measurement as QUAN.

QUAL **4.** You touch another person's forehead and say, "You feel feverish."

QUAN **5.** You need cut to wood to make a shelf for a bookcase. You use a tape measure to mark off a 50-centimeter length of wood.

QUAN **6.** With a thermometer, you find that you have a temperature of 39.0 °C.

QUAL **7.** After visually observing a car speed down a street, you exclaim to a friend that the car was traveling "way too fast."

QUAL **8.** You hold two rocks, one in each hand, and say, "The rock in my right hand is heavier."

9. State one reason quantitative measurements can be more useful than qualitative measurements.

Possible answer: Quantitative measurements give definite, numerical results that eliminate personal biases; quantitative results can be more easily compared with other measurements over time.

CHAPTER 3, Scientific Measurement *(continued)*

Scientific Notation (pages 52–53)

10. Look at Figure 3.3 on page 52. Why are numbers used in chemistry usually expressed in scientific notation?

Atoms are an essential part of chemistry. The numbers used to describe atoms are very small. Writing out all of the place-holding zeros for such small numbers would be very cumbersome. Scientific notation makes it easier to work with these numbers.

11. Circle the letter of each sentence that is true about numbers expressed in scientific notation.

(a.) A number expressed in scientific notation is written as the product of a coefficient and a power of 10.

(b.) The power of 10 is called the exponent.

(c.) The coefficient is always a number greater than or equal to one and less than ten.

d. For numbers less than one, the exponent is positive.

12. Circle the letter of the answer in which 503 000 000 is written correctly in scientific notation.

a. 5.03×10^{-7}

b. 503×10^{6}

(c.) 5.03×10^{7}

d. 503 million

13. Draw an arrow beneath 0.000 76 in the equation below to show the place to which the decimal point moves. Then answer the questions.

$$0.00076 = 7.6 \times 10^{\boxed{?}}$$

a. How many places did the decimal point move? in which direction?

4; right

b. To make the equation true, does 7.6 need to be multiplied by a number greater than one or less than one? less than one

c. Is the exponent for 10 positive or negative? negative

d. What exponent makes the equation true? -4

Name ______________________ Date ___________ Class ___________

14. Draw an arrow beneath 76 000 000 in the equation below to show the place to which the decimal point moves. Then answer the questions.

$$76\ 000\ 000 = 7.6 \times 10^{\boxed{?}}$$

a. What direction did the decimal point move? left

b. To make a true equation, does 7.6 need to be multiplied by a number greater than one or less than one? greater than one

c. Is the exponent for 10 positive or negative? positive

d. What exponent makes the equation true? 7

SECTION 3.2 UNCERTAINTY IN MEASUREMENTS (pages 54–62)

This section describes the concepts of accuracy, precision, and error in measurements. It also explains the proper use of significant figures in measurements and calculations.

▶ Accuracy, Precision, and Error (pages 54–55)

1. Is the following sentence true or false? To decide whether a measurement has good precision or poor precision, the measurement must be made more than once. true

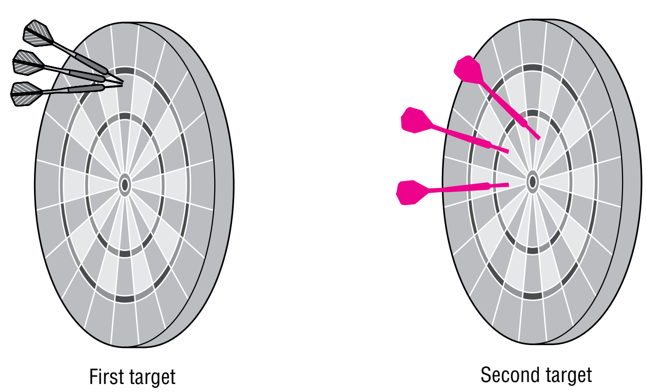
Label each of the three following sentences that describes accuracy with an *A*. Label each sentence that describes precision with a *P*.

P 2. Four of five repetitions of a measurement were numerically identical, and the fifth varied from the others in value by less than 1%.

P 3. Eight measurements were spread over a wide range.

A 4. A single measurement is within 1% of the correct value.

5. On a dartboard, darts that are closest to the bull's-eye have been thrown with the greatest accuracy. On the second target, draw three darts to represent three tosses of lower precision, but higher accuracy than the darts on the first target.



CHAPTER 3, Scientific Measurement *(continued)*

6. What is the meaning of "accepted value" with respect to an experimental measurement?

The accepted value is the correct value based on reliable references.

7. Complete the following sentence. For an experimental measurement, the accepted value minus the experimental value is called the ___error___ .

8. Is the following sentence true or false? The value of an error must be positive. ___false___

9. Relative error is also called ___percent error___ .

10. The accepted value of a length measurement is 200 cm, and the experimental value is 198 cm. Circle the letter of the value that shows the percent error of this measurement.

a. 2%

b. −2%

(c.) 1%

d. −1%

▶ Significant Figures in Measurements (pages 56–58)

11. If a thermometer is calibrated to the nearest degree, to what part of a degree can you estimate the temperature it measures? ___one tenth of a degree___

12. Circle the letter of the correct digit. In the measurement 43.52 cm, which digit is the most uncertain?

a. 4 **c.** 5

b. 3 **(d.)** 2

13. Circle the letter of the correct number of significant figures in the measurement 6.80 m.

a. 2 **c.** 4

(b.) 3 **d.** 5

14. List two situations in which measurements have an unlimited number of significant figures.

a. When the measurement involves counting.

b. When the measurement involves exactly defined quantities.

15. Circle the letter of each sentence that is true about significant figures.

(a.) Every nonzero digit in a reported measurement is assumed to be significant.

b. Zeros appearing between nonzero digits are never significant.

(c.) Leftmost zeros acting as placeholders in front of nonzero digits in numbers less than one are not significant.

(d.) All rightmost zeros to the right of the decimal point are always significant.

(e.) Zeros to the left of the decimal point that act as placeholders for the first nonzero digit to the left of the decimal point are not significant.

▶ Significant Figures in Calculations (pages 58–61)

16. Is the following sentence true or false? An answer is as precise as the most precise measurement from which it was calculated. ____false____

Round the following measurements as indicated.

17. Round 65.145 meters to 4 significant figures. ____65.15 meters____

18. Round 100.1 °C to 1 significant figure. ____100 °C____

19. Round 155 cm to two significant figures. ____160 cm____

20. Round 0.000 718 kilograms to two significant figures. ____0.000 72 kilograms____

21. Round 65.145 meters to three significant figures. ____65.1 meters____

SECTION 3.3 INTERNATIONAL SYSTEM OF UNITS (pages 63–67) ●■◇

This section defines units of measurement for length, volume, and mass in the International System of Units (SI).

▶ Units of Length (pages 63–64)

1. Complete the table showing selected SI base units of measurement.

Units of Measurement		
Quantity	SI base unit	Symbol
Length	meter	m
Mass	kilogram	kg
Temperature	kelvin	K
Time	second	s

CHAPTER 3, Scientific Measurement *(continued)*

2. All metric units of length are based on multiples of ___10___ .

3. The International System of Units (SI) is a revised version of the ___metric system___ .

4. Explain what is meant by a "derived unit."

Derived units are combinations of base units. All SI units are base units, or are derived from base units.

5. Give at least one example of a derived unit.

Students' responses will vary. Possible responses are volume, density, and pressure.

6. Complete the following table showing some metric units of length. Remember that the meter is the SI base unit for length.

Metric Units of Length		
Unit	**Symbol**	**Factor Multiplying Base Unit**
Meter	m	1
Kilometer	km	1000
Centimeter	cm	1/100
Millimeter	mm	1/1000
Nanometer	nm	1/1 000 000 000

Match each metric unit with the best estimate of its length or distance.

___b___ **7.** Height of a stove top above the floor — **a.** 1 km

___d___ **8.** Thickness of about 10 sheets of paper — **b.** 1 m

___a___ **9.** Distance along a road spanning about 10 telephone poles — **c.** 1 cm

___c___ **10.** Width of a key on a computer keyboard — **d.** 1 mm

Name ______________________ Date __________ Class ______________

▶ Units of Volume (pages 65–66)

11. The space occupied by any sample of matter is called its volume.

12. Circle the letter of each sentence that is true about units of volume.

(**a.**) The SI unit for volume is derived from the meter, the SI unit for length.

(**b.**) The liter (L) is a unit of volume.

c. The liter is an SI unit.

(**d.**) There are 1000 cm^3 in 1 L, and there are also 1000 mL in 1 L, so 1 cm^3 is equal to 1 mL.

Match each of the three descriptions of a volume to the appropriate metric unit of volume.

	Example	Unit of Volume
b	**13.** Interior of an oven	**a.** 1 L
a	**14.** A box of cookies	**b.** 1 m^3
c	**15.** One-quarter teaspoon	**c.** 1 mL

16. Circle the letter of each type of volumetric glassware that can be used to make accurate measurements of liquid volume.

a. graduated cylinder

(**b.**) pipet

(**c.**) buret

17. The volume of any solid, liquid, or gas will change with temperature.

▶ Units of Mass (pages 66–67)

18. Is the following sentence true or false? The mass of an object changes with location. false

19. When brought to the surface of the moon, will a mass have more or less weight than it did on the surface of Earth, or will it be the same weight? Explain.

Its weight will be less, because weight is a measure of gravitational force, and the force of gravity on the moon is one-sixth what it is on Earth.

20. A kilogram was originally defined as the mass of 1 L of liquid water at 4 °C.

21. Circle the letter of the unit of mass commonly used in chemistry that equals 1/1000 kilogram.

(**a.**) gram **b.** milligram **c.** milliliter

CHAPTER 3, Scientific Measurement *(continued)*

Match each unit of mass with the object whose mass would be closest to that unit.

	Mass	Unit of Mass
c	**22.** A few grains of sand	**a.** 1 kg
a	**23.** A liter bottle of soda	**b.** 1 g
b	**24.** Five aspirin tablets	**c.** 1 mg

25. Look at Figure 3.14 on page 67. Circle the letter of the instrument shown that is used to measure mass.

a. scale

b. balance beam

(c.) platform balance

d. analytical balance

SECTION 3.4 DENSITY (pages 68–72) ●■◆

This section defines density and specific gravity. It explains that density is a characteristic property that depends on the composition of a substance, not on the size of the sample.

▶ Determining Density (page 68–71)

1. Is the mass of one pound of lead greater than, less than, or equal to the mass of one pound of feathers? equal to

2. Which material has a greater density, lead or feathers? lead

3. How is density defined?

Density is the ratio of the mass of an object to its volume.

4. The mass of a sample is measured in grams, and its volume is measured in cubic centimeters. In what units would its density be reported?

grams per cubic centimeter (g/cm^3)

5. Look at Table 3.7 on page 69. Circle the letter of the material that will sink in liquid water at 4 °C.

(a.) aluminum

b. corn oil

c. ice

d. gasoline

6. The density of a substance generally decreases as its temperature increases. Are there any exceptions to this statement? Explain.

Yes. Over a small range of temperatures near the freezing point, the density of water decreases as the temperature *decreases.* As a result, ice floats on liquid water.

▶ Specific Gravity (page 72)

7. What is specific gravity?

Specific gravity is a ratio of the density of a substance to the density of a reference substance.

8. Do all substances have a specific gravity? Explain.

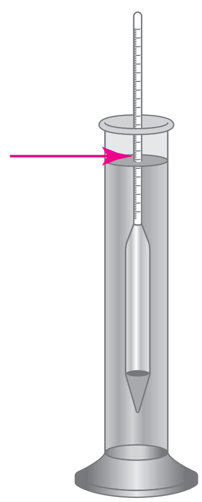
Yes, but generally only liquids are measured.

9. What is the material commonly used as a reference for calculation of specific gravity? water at 4 °C

10. Why does specific gravity have no units?

Because specific gravity is a ratio, the units cancel.

Use the instrument shown below to answer Questions 11 and 12.



11. The instrument is used to measure specific gravity. What is it called? a hydrometer

12. Draw an arrow to show the point at which you read the scale.

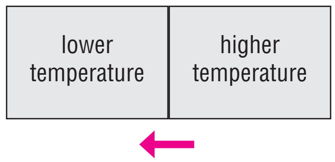
Name ______________________ Date __________ Class ______________

SECTION 3.5 TEMPERATURE (pages 74–75) ●■◆

This section describes the concept of temperature and explains how temperature is measured.

▶ Measuring Temperature (page 74)

1. Draw an arrow below the diagram, showing the direction of heat transfer between two objects.



2. What properties explain the behavior of liquid-filled thermometers?

Almost all liquids expand in volume with an increase in temperature. This expansion forces the liquid higher in the thermometer tube as the temperature rises. As the temperature falls, the liquid contracts and its level in the tube drops.

▶ Temperature Scales (page 74)

3. What are the two reference temperatures on the Celsius scale?

The freezing point of water is 0 °C and the boiling point of water is 100 °C.

4. What is the zero point, 0 K, on the Kelvin scale called?

absolute zero

5. A change of temperature equal to one Kelvin is equal to a change of temperature of how many degrees Celsius? 1 °C

6. Complete the diagram to show the reference temperatures in the Celsius and Kelvin scales.