

# 3.1

## MEASUREMENTS AND THEIR UNCERTAINTY

### Section Review

#### Objectives

- Convert measurements to scientific notation
- Distinguish among the accuracy, precision, and error of a measurement
- Identify the number of significant figures in a measurement and in the result of a calculation

#### Vocabulary

- measurement
- scientific notation
- accuracy
- precision
- accepted value
- experimental value
- error
- percent error
- significant figures

#### Key Equations

- Error = experimental value - accepted value
- Percent error =  $\frac{|\text{error}|}{\text{accepted value}} \times 100\%$

#### Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

The 1 of a measurement describes how close the measurement comes to the true value. The 2 of a measurement depends on its reproducibility. An 3 is a value measured in the lab. 4 is calculated by subtracting the 5 from an experimental value. Percent error is calculated by dividing the 6 of the error by the accepted value and then multiplying by 7.

Large and small numbers are more easily handled when expressed in 8. Significant figures in a measurement include all of the digits that are 9 plus a last digit that is 10.

1. Accuracy
2. precision
3. experimental
4. error
5. accepted
6. error
7. 100
8. scientific notation
9. certain
10. uncertain

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### Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

- ST \_\_\_\_\_ 11. Scientific notation is used to express large numbers in convenient form.
- AT \_\_\_\_\_ 12. Significant figures include all the digits that can be known accurately plus a last digit that must be estimated.
- NT \_\_\_\_\_ 13. An answer to calculations done with scientific measurements cannot be more precise than the least precise measurement.

### Part C Matching

accurate

Match each description in Column B to the correct term in Column A.

- | Column A                         | Column B   |
|----------------------------------|--|
| <u>B</u> 14. accuracy            | a. measure of how close a series of measurements are to one another                |
| <u>E</u> 15. measurement         | b. measure of how close a measurement comes to the actual value                    |
| <u>A</u> 16. precision           | c. digits in a measurement that are known plus one that is estimated               |
| <u>F</u> 17. scientific notation | d. a value determined in the laboratory  |
| <u>d</u> 18. experimental value  | e. a quantity that has both a number and a unit                                    |
| <u>C</u> 19. significant figures | f. a method of expressing numbers as a product of a coefficient and a power of 10. |

### Part D Questions and Problems

Answer the following questions or solve the following problems in the space provided. Show your work.

20. Give the number of significant figures in the following measurements.

- |                             |             |
|-----------------------------|-------------|
| a. $3.85 \times 10^{-3}$ dm | a. <u>3</u> |
| b. 17.30 cm <sup>3</sup>    | b. <u>4</u> |
| c. 0.0037 mm                | c. <u>2</u> |

21. Perform the following operations and give the answers in standard exponential form with the correct number of significant figures.

- a.  $37.2 \text{ mL} + 18.0 \text{ mL} + 380 \text{ mL} = 435.2 \text{ mL} = 435 \text{ mL}$
- b.  $0.57 \text{ cm} \times 0.86 \text{ cm} \times 17.1 \text{ cm} = 8.382 \text{ cm}^3 = 8.4 \text{ cm}^3$
- c.  $(8.13 \times 10^4) + (3.8 \times 10^2) = 2.139 \times 10^2 = 2.1 \times 10^2$

## Significant Figures Worksheet

1. Indicate how many significant figures there are in each of the following measured values.

- |            |       |            |       |            |       |
|------------|-------|------------|-------|------------|-------|
| a. 246.32  | _____ | e. 1.008   | _____ | i. 700000  | _____ |
| b. 107.854 | _____ | f. 0.00340 | _____ | j. 350.670 | _____ |
| c. 100.3   | _____ | g. 14.600  | _____ | k. 1.0000  | _____ |
| d. 0.678   | _____ | h. 0.0001  | _____ | l. 320001  | _____ |

2. Calculate the answers to the appropriate number of significant figures.

a.

$$\begin{array}{r} 32.567 \\ 135.0 \\ + 1.4567 \\ \hline \end{array}$$

b.

$$\begin{array}{r} 246.24 \\ 238.278 \\ + 98.3 \\ \hline \end{array}$$

c.

$$\begin{array}{r} 658.0 \\ 23.5478 \\ + 1345.29 \\ \hline \end{array}$$

3. Calculate the answers to the appropriate number of significant figures.

- |                         |   |       |                         |   |       |
|-------------------------|---|-------|-------------------------|---|-------|
| a) $23.7 \times 3.8$    | = | _____ | e) $43.678 \times 64.1$ | = | _____ |
| b) $45.76 \times 0.25$  | = | _____ | f) $1.678 / 0.42$       | = | _____ |
| c) $81.04 \times 0.010$ | = | _____ | g) $28.367 / 3.74$      | = | _____ |
| d) $6.47 \times 64.5$   | = | _____ | h) $4278 / 1.006$       | = | _____ |



# KEY

## Significant Figures Worksheet

1. Indicate how many significant figures there are in each of the following measured values.

a.	246.32	<u>5</u>	e.	1.008	<u>4</u>	i.	700000	<u>?</u>
b.	107.854	<u>6</u>	f.	0.00340	<u>3</u>	j.	350.670	<u>6</u>
c.	100.3	<u>4</u>	g.	14.600	<u>5</u>	k.	1.0000	<u>5</u>
d.	0.678	<u>3</u>	h.	0.0001	<u>1</u>	l.	320001	<u>6</u>

2. Calculate the answers to the appropriate number of significant figures.

a.	$\begin{array}{r} 32.567 \\ 135.0 \\ + 1.4567 \\ \hline 169.0237 \\ 169.0 \end{array}$	b.	$\begin{array}{r} 246.24 \\ 238.278 \\ + 98.3 \\ \hline 582.818 \\ 582.8 \end{array}$	c.	$\begin{array}{r} 658.0 \\ 23.5478 \\ + 1345.29 \\ \hline 2026.8378 \\ 2026.8 \end{array}$
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3. Calculate the answers to the appropriate number of significant figures.

a)	$23.7 \times 3.8 = \frac{90.06}{90.}$	e)	$43.678 \times 64.1 = \frac{2799.759}{2.80 \times 10^3}$
b)	$45.76 \times 0.25 = \frac{11.44}{11}$	f)	$1.678 / 0.42 = \frac{3.995}{4.0}$
c)	$81.04 \times 0.010 = \frac{0.8104}{0.81}$	g)	$28.367 / 3.74 = \frac{7.5847}{7.58}$
d)	$6.47 \times 64.5 = \frac{417.315}{417}$	h)	$4278 / 1.006 = \frac{4252.48}{4252}$





