

LEARNING GUIDE 04: MEASUREMENTS

STATE CONTENT STANDARDS

- Investigation and Experimentation 1b: Identify and communicate sources of unavoidable experimental error.

MAJOR CONCEPTS

- Scientific notation
- Accuracy and precision
- Significant figures

VOCABULARY

Using the textbook and other sources, define each vocabulary word in your own words. Provide a sketch or drawing of the idea.

Word	Definition	Sketch or Drawing
Accuracy		
Precision		
Significant figures		

Name: _____ Period: _____ Date: _____ Score: _____

Word	Definition	Sketch or Drawing
Captive zeros		
Rules of significant figures		
Trailing zeros		
Exact zeros		
uncertainty		

Name: _____ Period: _____ Date: _____ Score: _____

READING

Chapter 5.1, 5.4, 5.5

Write a few sentences about the things you thought were important

Section 5.1

Section 5.4

Section 5.5

READING GUIDE

1. What are the two types of observations?
2. What is the other name for a quantitative observation?
3. Of what two things must a measurement consist to be meaningful?

5.1 Title: _____

4. How is a number expressed in scientific notation?
5. In scientific notation, does a negative exponent mean a negative number? _____. What does a negative exponent mean?
6. The number of places the decimal point is moved determines the _____ of _____.
7. Represent the following numbers in scientific notation
 - a. 238,000
 - b. 0.00043
 - c. 357
 - d. 0.0055

Name: _____ Period: _____ Date: _____ Score: _____

8. Complete shelf-check exercise 5.1 (p. 116).

5.4 Title: _____

9. Why is it important to round answers to significant digits?

10. How is the number of significant figures for a given measurements determined?

5.5 Title: _____

11. What are the 3 rules for counting significant figures?

12. Calculate $6.08 \times .0354$, give the answer to the correct number of significant figures.

13. Calculate $(2.68 \times 10^{-2}) \times (7.125) \div 5.25$, give the answer to the correct number of significant figures.

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LECTURE NOTES

5.1 Scientific Notation

A. Scientific Notation

1. A method of representing very large or very small numbers
2. An expression as the product between 1 and 10 and a power of 10

a. $M \times 10^n$

(1) M is a number between 1 and 10

(2) n is an integer

(3) all digits in M are significant

Ex. $1700 = 1.7 \times 10^3$

Note: the number of places the decimal pt. is moved determines the power of 10. The direction of the movement determines pos. or neg.

B. Reducing to Scientific Notation

1. Move decimal so that M is between 1 and 10
2. Determine n by counting the number of places the decimal point was moved
 - a. Moved to the left, n is positive
 - b. Moved to the right, n is negative

Or it is easier to remember

- a. Very small numbers, n is negative
- b. Very large numbers, n is positive

C. Mathematical Operations Using Scientific Notation

1. Addition and subtraction

a. Operations can only be performed if the exponent on each number is the same

2. Multiplication

a. M factors are multiplied

b. Exponents are added

3. Division

a. M factors are divided

b. Exponents are subtracted (numerator - denominator)

Example 5.1 power of 10 (positive)

Example 5.2 power of 10 (negative)

5.4 Uncertainty in measurement

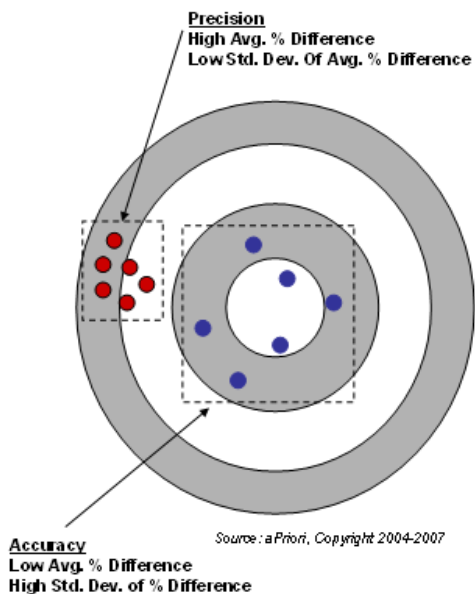
Accuracy, Precision, and Error

A. Accuracy

1. The nearness of a measurement to its accepted value; how close?

B. Precision

1. The agreement between numerical values of two or more measurements that have been made in the same way
 - a. You can be precise without being accurate
 - b. Systematic errors can cause results to be precise but not accurate



Accuracy and Precision

C. Calculating Percent Error (Relative Error)

1. Formula

The formula is always calculated in percent.

$$\text{Percent error} = \frac{\text{Value}_{\text{accepted}} - \text{Value}_{\text{experimental}}}{\text{Value}_{\text{accepted}}} \times 100$$

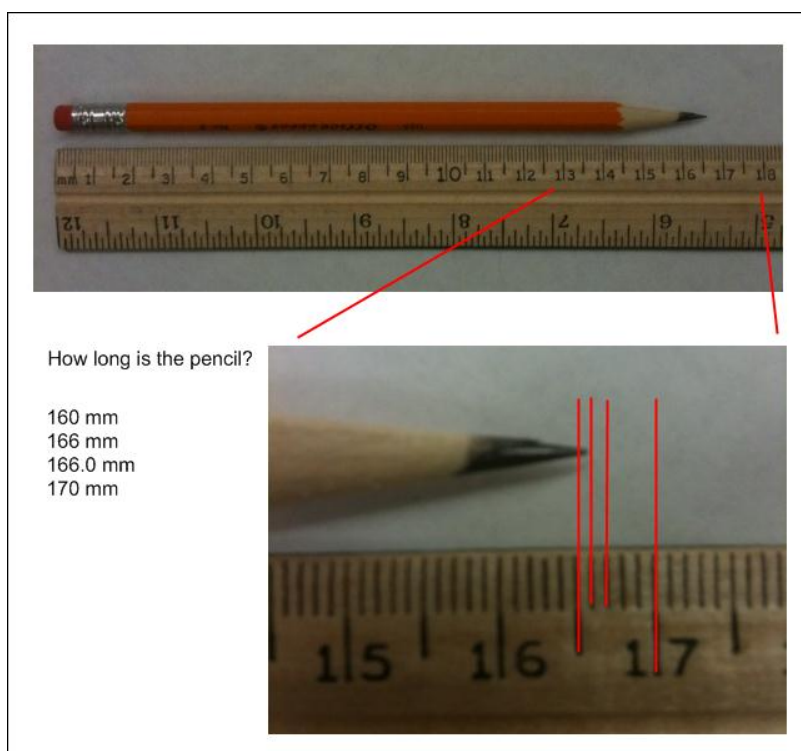
Accepted value = found in chemistry resources

Experimental value = student determines during the experiment

2. Percent error can have a negative or positive value

D. Error in Measurement (p.122)

1. Some error or uncertainty exists in all measurement because all measurements require an estimate
 - a. no measurement is known to an infinite number of decimal places
 - b. for example ruler fig.5.5
2. All measurements should include every digit known with certainty plus the first digit that is uncertain - these are the significant figures



5.5 Significant Figures**A. Determining the Number of Significant Figures (Counting)**

1. All nonzero digits are significant
2. Rules for zeros

Significant Figures Rules for Zeros	
Zeros appearing between nonzero digits are significant	a) 40.7 L has three sig figs b) 87 009 km has five sig figs
Zeros appearing in front of nonzero digits are not significant	a) 0.095 987 m has five sig figs b) 0.0009 kg has one sig fig
Zeros at the end of a number and to the right of a decimal are significant	a) 85.00 g has four sig figs b) 9.000 000 000 m has 10 sig figs
Zeros at the end of a number but to the left of a decimal may or may not be significant. <ul style="list-style-type: none"> • If such a zero has been measured, or is the first estimated digit, it is significant. • On the other hand, if the zero has not been measured or estimated but is just a placeholder, it is not significant. 	a) 2000 m may contain from one to four sig figs, depending on how many zeros are placeholders. For measurements given in this text, assume that 2000 has one sig fig.
A decimal placed after the zeros indicates that the zeros are significant.	b) 2000. m contains four sig figs, indicated by the presence of the decimal point

See Example 5.3 (p. 125) Counting Significant Figures

B. Addition and Subtraction with Significant Figures

1. The answer must have the same number of digits to the right of the decimal as there are in the measurement having the fewest digits to the right of the decimal point

C. Multiplication and Division with Significant Figures

1. The answer can have no more sig figs than are in the measurement with the fewest total sig figs

D. Conversion Factors and Sig Figs

1. Conversion factors that are known EXACTLY have no uncertainty factor and do not contribute to limitations in calculations
 - a. 12 inches per foot
 - b. 1000 grams per kilogram

E. Rounding Off

1. The removed digit < 5 , preceding number stays the same
2. The removed digit > 5 , preceding number increased by one
3. In a series of calculations, carry the extra digits through to the figure result

Example 5.5

QUESTIONS AND PROBLEMS

- When you are writing numbers using scientific notation, very large numbers have _____ exponents and very small numbers have _____ exponents.
- Change the following to scientific notation
 - 8, 475, 000
 - 0.0000754
 - 1000
 - 0.35724
- Why are all measurements uncertain to some extent?
- Mark the zeros with a bar over the significant figures in the following numbers.
 - 0.003042
 - 1.4030
 - 1000
 - 0.060
 - 50.0
 - 10.47020
 - 250
- Why must a unit be included with a measurement?
- How many significant figures are in each number in question 4?
- Without doing the calculation, how many significant figures should be in each of the following results?
 - $3.2 \div 4.17 + 1.243$
 - $1.3478 - 0.02$
 - 4.6×3.435
 - $(4.2 \times 10^{-5}) \times 3.74 \div 6.783$
 - $50 - 0.00473$
- Evaluate each of the following mathematical expressions, express the answer to the correct number of significant figures
 - $[(7.815 + 2.01)(4.5)]/(1.90001)$
 - $(1.67 \times 10^{-9})(1.1 \times 10^{-4})$
 - $(4.02 \times 10^{-4})(2.91 \times 10^3) / (9.102 \times 10^{-1})$
 - $(1.04 \times 10^2 + 2.1 \times 10^1)/(4.51 \times 10^3)$
- Why is reporting the correct number of significant figures so important to science?

Name: _____ Period: _____ Date: _____ Score: _____

JOURNAL

What points in the material strike you as important?

Have you learned anything new? If so, what did you learn?

Do you have any questions about what you learned?

EXAM PREPARATION

Review this document several times. Know the definitions, types of chemistry, key chemists. Skim the reading again. Do NOT wait until the night before to study for the exam.

Write the dates and times you studied this learning guide:

_____	_____
_____	_____
_____	_____
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Initial here that you have studied and completed this learning guide _____