Name: Date Completed:
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Lab # 2: Significant Figures in Data

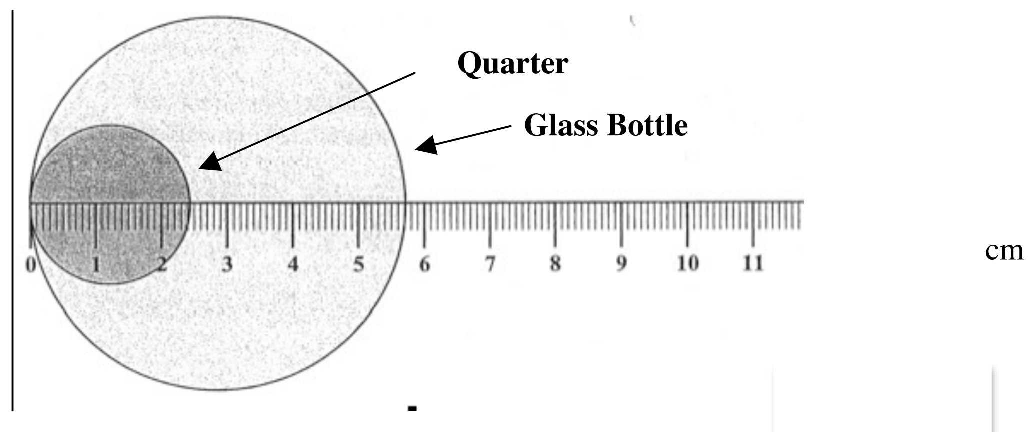
Why?

The number of digits, i.e. significant figures, reported for a numerical quantity conveys to the reader the precision of the instrument used to make the measurement. In this course when recording data in the laboratory you will have to record your measurements in a way that conveys the measuring instrument's precision.

Learning Objectives

- Understand the relationship between precision of a measuring instrument and the number of significant figures in a measurement.
- To manipulate measurements in calculations to convey the proper precision of the data.

Model 1: Outlines of a quarter and a glass bottle on top of a centimeter ruler



Key Questions:

1. Use the centimeter ruler shown to determine the diameter of the quarter (the smaller circle) in Model 1. **Express your answer as a decimal number with 2 digits following the decimal point.**

2. Explain how you determined the value of the **final decimal place** in the measurement in question 1.

3. Use the centimeter ruler shown to determine the diameter of the glass bottle (the larger circle) in Model 1. **Express your answer as a decimal number with 2 digits following the decimal point.**

4. Explain how you determined the value of the **final decimal place** in the measurement in question 3.

5. The definition of a significant figure is "all of the certain numbers plus one uncertain number in a measurement." Reference the measurement of the glass bottle in question 3; explain which numbers in the measurement are "certain," **and explain why they are certain**. Explain which number is uncertain **and explain why it is uncertain**.

Determining which figures in reported numbers are significant without the measuring instrument

Table 1: Rules for significant figures in measurements

Rule	Examples (sig. figs. are underlined)
1. All non-zeros are significant	2.25
2. Leading zeros are **not** significant	0.0054
3. Trapped zeros **are** significant	203, 0.0203
4. Trailing zeros are significant only if a decimal point is present – numbers expressed in scientific notation only show the significant digits	700, 700., 7.00×10^2
5. Numbers that are exact by definition i.e. conversion factors have an infinite number of sig. figs. (1 in = 2.54 cm)	$189\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}} = 1.89\ \text{m}$ (exact)

Exercises:

1. Specify the number of significant figures in each of the following.

(a) 101.1

(b) 0.0125

(c) 1.00×10^2

(e) 100

(d) 100. (Note: including the decimal point is a convention)

(f) 0.005700

2. Express the number 500 clearly in two significant figures.

3. Write each of the following measurements in scientific notation without changing the number of significant digits. Remember there is no math pornography allowed in this class – include units.

a. 100 m __________ b. 0.00095 g _________ c. 3600.0 s ___________

4. Round each of these to three significant digits

a. 0.00320700 L ________ b. 3.265×10^{-4} m __________ c. 129762 s ___________

Model 2. Significant Digits in Calculations

Key Questions:

1. Observe the 1000 mL graduated cylinder. Record the volume of the water in the cylinder to the correct number of sig figs. ______________________

2. Observe the 10 mL graduated cylinder. Record the volume of water in the cylinder to the correct number of sig figs. ______________________

3. Add the water in the 10 mL graduated cylinder to the water in the 1000 mL graduated cylinder.

4. Record the volume of water in the 1000 mL graduated cylinder, to the correct number of sig figs. ______________________

5. How many sig figs did you record for the resulting volume of water after the addition of the 10 mL graduated cylinder's volume?

6. Does the resulting measurement more closely relate to that from the original volume of water in the 1000 mL graduated cylinder or that from the 10 mL graduated cylinder? Why?

Significant Digits in Calculations

Table 2 lists "rules of thumb" for determining the precision to report in the result of a calculation including two measurements made with instruments with different levels of precision. **The result of the calculation cannot indicate a higher level of precision than the least precise measuring instrument.**

Since most calculations in chemistry involve multiplication or division, we often use the following rule of thumb: Keep only as many significant digits in your answer as in the measurement with the fewest number of significant digits. Also, to avoid compounding errors, one should never round off intermediate results, but wait to round until you have the final answer. The exception to this is if you are switching between multiplication/division and subtraction/addition.

Table 2: Rules for calculations with significant digits and rounding

Operation	Rule	Example (sig. digits underlined)
Multiplication/Division	Keep the smallest number of input **significant digits**	250/7.134 = 35.043 rounds to **35**
Addition/Subtraction	Keep the smallest number of significant input **place holder values** (decimal places)	73.147 + 52.1 + 0.05411 = 125.30111 rounds to **125.3** 32.100 + 250 + 1.337 = 283.437 rounds to **280**
Exact Numbers!!	**Numbers obtained by counting (such as 3 eggs)** have no uncertainty unless the number is very large. Numbers obtained **by definition** have no uncertainty **(1" = 2.54 cm)** Do not consider these when determining the number of sig figs in the result of a calculation.	**10.** mi (1609m/1mi) = **1.6** $x10^4$ m Both have 2 sig figs. The definition 1 mi = 1609 m is not considered.

7. Perform the following calculations, reporting your answer with the correct number of significant digits and units.

   a. 26.234 g – 5.6 g = _______________

   b. 67.6 oz. (1 cup / 8oz.) = ______________________

   c. 189 cm + 6.0 in x (2.54 cm/1 in) = ____________________

8. Calculate the circumference of the glass bottle from **Model 1** in centimeters. Report your answer with the correct number of significant digits and units.

Critical Thinking

9. Considering the picture of the partially filled buret at the right. Circle the reading below that shows the correct level of precision. Explain your answer.

a. 40.01 mL b. 40 mL c. 40.0 mL

d. 40.010 mL

10. An overseas flight leaves New York in the late afternoon and arrives in London 8.50 hours later. The airline distance from New York to London is about $5.6x10^3$ km, depending to some extent on the flight path followed. What is the average speed of the plane, in kilometers per hour **to the correct number of significant digits**?

11. A wicker basket has a mass of $2.30x10^2$ g. Ten apples with a collective mass of $4.31x10^3$ g are added to the basket. What is the resulting mass of the basket, **reported to the correct number of significant figures?**

12. The mass of a gold coin was measured three times and each measurement was made to five digits. The mass values were 23.319 g, 23.341 g, and 23.296 g. The average mass was reported as 23.319 g.

Why is the average mass of the gold coin reported to five significant figures, even though you had to divide by “3” to obtain the average?