Experiment 2
How Do You Measure Up?

OUTCOMES

After completing this lab activity, the student should be able to:

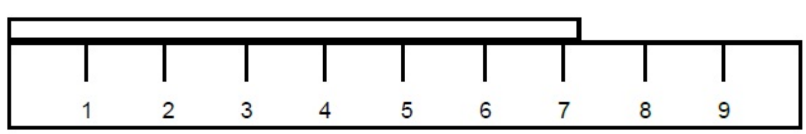
- perform basic laboratory measurements of length, mass, and volume.
- express measurements and calculated results with the proper number of significant figures.
- find the density of liquids and solids, regardless of shape or size.

DISCUSSION

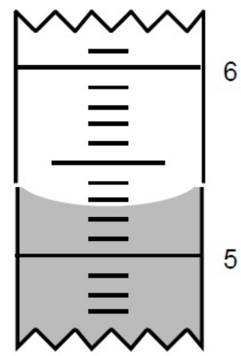
Measurements play an important role in everyday life for most people and much could certainly be discussed about their importance to the sciences. Most introductory chemistry texts do a good job of that. However, how are measurements properly made in the laboratory? How much uncertainty is in a measurement? This experiment should lend some insight to these questions.

Measurements made in this experiment should be reported with the proper number of significant figures. Significant figures are all of the digits which are certain in a measurement, plus one digit which is uncertain. On a digital display, such as one found on an electronic balance, the last digit is the uncertain digit. You may notice that when an object is placed on the balance that there is some fluctuation in the last digit. Simply report the reading most frequently displayed, including any zero digits displayed to the right of the decimal. We can then assume that the uncertainty of this measurement is plus or minus 1 in the place of the uncertain digit. So, if a balance reads 3.68 g, its uncertainty would be ± 0.01 g.

Some measurements may include an estimate of the last digit. For example, if a ruler has marks every 1 centimeter and you were measuring the length of the metal rod below, the length should be reported as 7.2 cm, or possibly 7.3 cm. The last digit is estimated and is the only uncertain digit. The uncertainty for the measurement would therefore be ± 0.1 cm. It would be inappropriate to report the length as 7.25 cm, since the last two digits are estimated and, therefore, uncertain. Measurements may have no more than one uncertain digit.



When water and other liquids are placed in a graduated cylinder or pipet (pipe-ETT), they form a curved surface, called a meniscus. Laboratory glassware is calibrated such that the liquid level is always read at the *bottom* of the meniscus. The liquid level to the right may be read as 5.25 mL, assuming we are capable of estimating to the nearest 0.05 mL. Note that, once again, there is only one uncertain digit. As you perform calculations in this experiment, observe all rules for determining significant figures.



In this experiment, you will be calculating densities from measured masses and volumes. If you have not yet covered density in your lecture, carefully read the section on density in your textbook before coming to lab.

PROCEDURE

⚠ ***Wear safety glasses or goggles at all times for this experiment*** *because you will be working with chemical unknowns. It is a chemistry department rule that whenever anybody in the room is working with chemicals, everyone must wear eye protection.*

Length

1. Measure the distance from the top to the bottom of this page in inches. Then measure it in centimeters. How much uncertainty is in each measurement? Is it possible to measure to the nearest 0.1 cm? 0.01 cm? 0.01 in? Use *your* measurements to calculate the number of centimeters per inch and the number of inches per centimeter. Report your measurements and calculated results with the proper number of significant figures. Show all calculations.

2. Stand against the wall and measure your height in inches and again in centimeters. Use *your* measurements to calculate the number of centimeters per inch and the number of inches per centimeter. How do your results compare to the accepted conversion factors?

Mass

⚠ ***Handle glassware carefully.*** *It breaks easily.*

1. Place a coin on the balance and measure its mass. Then place a 400 mL beaker on the balance and measure its mass. Place the coin in the beaker and measure their combined mass. Subtract the mass of the empty beaker from the combined mass. What answer should be obtained by subtracting? Did your answer vary from what you expected? Explain any variation.

2. Use the following conversion factors to express the mass of the coin in ounces and in pounds: 28.35 g = 1 oz, 16 oz = 1 lb. Show your work.

Volume

1. Fill a small test tube to the brim with water. Pour the water into a 10 mL graduated cylinder. Measure and report the volume with the correct number of digits (being sure to include one uncertain digit). Fill the test tube again and pour the contents into a 100 mL graduated cylinder. Measure and report this volume with the correct number of digits (being sure to include one uncertain digit). How much uncertainty is in each measurement? Are the measured volumes the same? Explain.

Density

1. *Trial 1.* Measure the mass of a stoppered 125 mL flask. Obtain a liquid unknown from your instructor. Record the unknown number or letter. Your instructor will demonstrate the proper use of a pipet. Pipet 10.00 mL of the unknown into the flask, stopper, and measure the combined mass. What is the mass of the liquid? Calculate the density of the liquid, using the proper units and significant figures.

2. *Trial 2.* Pipet an additional 5.00 mL of the unknown into the flask (it is not necessary to empty the flask — why?), stopper, and find the combined mass. Calculate only the mass of the liquid that was ***added in this trial only***. Use this mass and the volume of unknown liquid added in this trial to calculate the density. How does this density compare to that found in trial 1? Explain any difference.

3. Place about 60 mL of tap water into a 100 mL graduated cylinder. Estimate the volume to the nearest ±0.1 mL. Obtain 3 cylinders of the same metal, record the identity of the metal used, and measure the combined mass of the cylinders. Carefully slide the pieces down the side of the graduated cylinder. All of the pieces of metal should be fully submerged. Record the new volume. Use your data to calculate the density of the solid. Show your calculations.

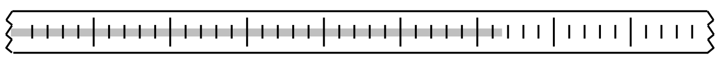
⚠ ***Dispose of any chemical waste in the proper waste container.***

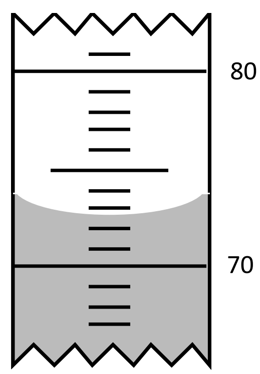
Name____ Lab Section_______________

PRELAB QUESTIONS

1. The mass of a large diamond was measured on an analytical balance, as shown on the display below. Circle the uncertain digit. What is the uncertainty of this measurement? How should the mass of the diamond be reported?

2. What is the temperature shown in the thermometer, read to the nearest ±0.01°C? What is the volume shown in the graduated cylinder, read to the nearest ±0.1 mL?





Temperature = ____________________________

Volume = ____________________________

3. An automobile tank is filled to capacity with 12.5 gal of gasoline. What is the volume of the tank in liters? Show your work, using the provided conversions.
(29.6 mL = 1 fl oz, 128 fl oz = 1 gal, 1000 mL = 1 L)

(*more on back*)

4. What is the equation used for calculating density? How does the density of one gallon of water compare to two gallons of water? Explain.

5. A block of wood measures 15.64 cm × 9.21 cm × 4.60 cm and has a mass of 371.06 g. What is the volume of the wood block? What is the density of the wood block?

6. As precision increases, does uncertainty increase or decrease? Why?

7. Which safety precautions, if any, must be observed during this experiment?

Name____ Lab Section______________

Partner's Name___________________________

DATA AND QUESTIONS

Length

Make sure each of your measurements and calculations show the correct number of significant figures. Include the uncertainties for the four measurements below.

	Page Height	Your Height
inches	±	±
centimeters	±	±
cm/in		
in/cm		

How do your calculated cm/in values above compare to the actual conversion factor (2.54 cm/in)? Explain any variations.

Mass

(1) Mass of coin	
(2) Combined mass	
(3) Mass of beaker	
(4) = (2) – (3)	

DATA AND QUESTIONS (cont'd)

What answer should be obtained by subtracting? Did your answer vary from what you expected? Explain any variation.

Express the mass of the coin in ounces and in pounds. Show your work.

Volume

Volume with 10 mL graduated cylinder	±	Volume with 100 mL graduated cylinder	±

Are the measured volumes the same? Explain.

Which graduated cylinder is more precise?

DATA AND QUESTIONS (cont'd)

Density of a Liquid

Unknown ___________	Trial 1	Trial 2
Mass of stoppered flask after addition of liquid		
Mass of stoppered flask before addition of liquid		
Mass of liquid added		
Volume of liquid added		
Density of liquid		

How do the densities compare between the two trials? What did you expect to find? Explain any difference.

Density of a Solid

Identity of Assigned Solid	
Mass of the Solid	
Volume Reading AFTER Adding Solid	
Volume of Water BEFORE Adding Solid	
Volume of the Solid	
Density of the Solid	