

CHM-201 – General Chemistry and Laboratory I
Laboratory 1 (Remotely Performed)
Introduction to Experimental Measurement
Spring 2021

Purpose

This laboratory introduces you to basic laboratory measurement techniques with a focus on the proper use of significant figures. You will become familiar with measuring mass, volume and length. You will employ the proper method of recording of scientific raw data using non-erasable on the data sheets provided. You will become familiar with the laboratory equipment used in this lab, and you will perform calculations that require a working knowledge of significant figures.

Introduction

It is important when performing laboratory work to measure quantities properly. The accuracy (closeness of a measurement to its true value) and precision (variability of identical measurements) of a measurement are determined by the instrument(s) used to make the measurements and the skill and training of the operator – *you*. All instruments have an inherent limit to the accuracy and precision of a measurement. Put another way, an instrument will normally provide data with a set number of significant figures. When recording data in the laboratory, you should ask yourself “*How many of the numbers I am recording are meaningful?*” Sometimes you don’t know the answer to this question until you perform the same measurement more than once (called replication) and look at the variability of the data. In certain cases, the instrument will have a limit to the number of significant figures it will display. In general, if an instrument displays a value with several digits, we assume that all are reliable, but the last digit is uncertain (but still significant). If we are unable to reproduce results to the same level of accuracy and precision, we may reassess the accuracy of the instrument. In all cases replication of the measurement is the only true way to assess the precision of the measurement. This is why laboratory measurements are usually taken more than once. When evaluating significant figures, the first digit that has some uncertainty is reported and all further digits are discarded.

Procedures and Exercises

1. Determining the conversion factor between centimeters and inches.

While this may appear to be a trivial exercise, after more careful consideration you should see that there is more to it than immediately meets the eye. Pay close attention

- 1.1** Using two rulers, determine and record the number of centimeters that correspond to line segments of $\frac{1}{4}$, $\frac{1}{2}$, 1, $5\frac{1}{2}$, and 11 inches. If you do not have access to a second ruler, you may draw line segments of each specified length on a piece of paper (*demonstrated in the video*). Measure the value for each of these lengths in centimeters. For this exercise, we will assume that the fractional and whole number values for inches are not subject to the limitations of the instrument. We will, however, limit our reporting of the measurements in centimeters to the correct number of significant figures for the instrument you are using (in cm to two decimal places).
- 1.2** Place one ruler on the desk showing the English system measurements (inches), and measure each of the lengths in metric units (centimeters). As mentioned in 1.1, you may draw a line segment for each length if you have only one ruler. Be sure to estimate one more digit than the finest marks on the metric scale on the ruler. Record these measurements in pen on the data sheet provided.

2. Determining the volume of a balloon. (*Exercise performed in the video.*)
 - 2.1 Blow up a balloon. Make sure you haven't inflated it to a size that is too large to measure easily. The circumference should not be so large as to require any addition of measurements to determine the value.
 - 2.2 Measure and record its circumference in metric units (centimeters). Repeat the measurement two more times. The same person should not perform more than one measurement, if possible. Use only one balloon. Do not inflate a different balloon for each trial.
 - 2.3 Provide a brief statement to indicate how close the balloon shape is to a perfect sphere. How, if at all, does this effect your calculated volume?

General: You will determine the mass from a top-loading or balance for a three of liquids (labeled A, B and C). The volumes will be determined by measuring the volume in a several types of laboratory glassware. In all cases be aware of how fine the markings are for the volume of the glassware and how that will affect the correct number of significant figures that should be used to report the volume. In all cases you will divide the mass by the volume to determine the density of the liquid that should also be reported to the correct number of significant figures. In addition you will measure the density obtained directly using a hydrometer that provides values of specific gravity that are identical to values of density in grams per mL or grams per cubic centimeter.

3. Determining the densities of liquids (*see the video*)
 - 3.1 From the video recording record a value for the density of liquid A, liquid B and liquid C from the use of a hydrometer when suspended in a graduated cylinder. Record the value in the data sheet for part three.
 - 3.2 From the data provided determine the net mass to the correct number of significant figures in grams (from the top-loading balance – data provided).
 - 3.3 From the video provide your best value being aware of significant figures for the volumes in the 50 mL beaker, the 10 mL graduated cylinder and the 25 mL graduated cylinder. Note the markings on the beaker are 10 mL increments; 0.1 mL increments in the 10 mL graduate; and 1 mL increments on the 25 mL graduated cylinder. Record the volumes observed from the video on the data sheet provided using significant figures to the best of your ability.
 - 3.4 Determine the density of each of the liquids by dividing the net mass by the observed volume using significant figures appropriately, and record your results below.
 - 3.5 Determine the percent error between the hydrometer reading and the calculated density. Record this in the data sheet provided. The percent error is calculated from:

$$\text{percent error} = \frac{|\text{hydrometer reading} - \text{calculated density}|}{\text{hydrometer reading}} \times 100\%$$

Questions

1. In exercise #1, what conclusions can you come to regarding the accuracy in determining the conversion factor? Include a statement about the significant figures in this exercise.

2. Convert the volume of the balloon calculated in part #2 into cubic meters (m^3).

3. Suggest a method to correct for the non-spherical nature of the balloon.

4. Do you think that the number of significant figures that you report for your volume is appropriate? Explain your answer.

3. In your graphical analysis which variable (mass or volume) is the dependent variable? Why do you think this is the case when you examine the experiment performed? Can you describe a different experiment which would make the other quantity the dependent variable? If so describe what you would measure in this experiment and what you would then graph.

4. If your laboratory partner were to leave the cap off the microcentrifuge tube during the isopropanol density determination then what error would you predict for your density value? Would you expect a density determined from the slope of the graphical data to be larger or smaller than the actual density? Explain your reasoning.