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.

Graphical Analysis of Data

Graphical analysis is a powerful method for presenting and interpreting scientific data. There are several methods for representing data but one of the most common is an x-y plot of the data.

1. A two-page spreadsheet is available on the website (Lab_1_Density_Plots.xlsx). Download the sheet and enter the appropriate data into the cells.

2. If you have entered the data properly, a graph representing mass (y-axis) and volume (x-axis) will appear beneath each data table. The relationship for density is linear, so the graph should be a straight line with all the data points being very close to the line. If this is not the case, either the data are bad, or the values weren’t entered properly.

3. A linear regression (the red dotted line) is automatically generated by the spreadsheet. The equation of the regression line for each graph is displayed on the graph. There is also an R^2 value showing how close your data correlate to a straight line. A value for R^2 should be very close to 1.0 or something is wrong.

4. The graph provides all the data necessary to determine the densities of isopropanol and salt water. Keep in mind that Excel does not keep track of significant figures. That is your responsibility.

Procedures

Note: Record all laboratory data in non-erasable ink on the sheets provided.

1. Determining the conversion factor between centimeters and inches.

   1.1 Using two rulers, determine and record the number of centimeters that correspond to line segments of ¼, ½, 1, 5½, and 11 inches. 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.
1.2 Place one ruler on the desk showing the English system measurements (inches), and measure each of the lengths in metric units (centimeters). 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. Remember that the entire group will be penalized for recording too many or too few significant figures. Be sure to get agreement on the value you record. If you cannot agree, ask me for help.

2. Determining the volume of a balloon.

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.

General: You will use an Eppendorf tube (see Part 4) for these measurements. Since isopropanol is a volatile liquid (readily evaporates to become a gas) you should keep the top of the tube closed after each transfer to avoid loss of the isopropanol. You will perform the transfers with an Eppendorf automatic transfer pipette (also called a volumetric pipette – see Part 4). I will explain how to use this piece of equipment but these are relatively expensive pipets so please be careful and be sure to use a disposable tip (see part 4) on the end of the pipet.

3. Determining the densities of liquids (isopropanol and salt water solution)

3.1 Determine and record the mass of an empty Eppendorf tube on an analytical balance (see Part 4) that can read to 0.1 mg (0.0001 g) precision. There are four analytical balances near the front of the lab. These four balances are the only balances that may be used for these measurements. Be sure to record ALL the digits, including the zeroes.

3.2 Transfer approximately 1 mL of isopropanol (as measured by the markings on the tube) into a second Eppendorf tube (not the one used in the previous step). This tube is used as a transfer container only. Transferring a liquid from its storage container is a sloppy lab practice and nearly always causes contamination.

3.3 Instructions for transferring a liquid using an Eppendorf (volumetric) pipette:

3.3.1 Be sure that the window at the top of the pipette reads 100.0 and that a plastic pipette tip is firmly attached to the bottom of the pipette. If the pipette does not read 100.0 (for 100.0 microliters), please contact the instructor.

3.3.2 Depress the plunger of the pipette until you reach a ‘resistance point’ (not all the way down) and then place the tip into the solution in the transfer tube.

3.3.3 Release the plunger of the pipette to the fully released position (liquid should be drawn into the plastic tip) which transfers 100.0 μL of isopropanol into the tip.

3.3.4 Place the tip of the pipette over the Eppendorf tube that you placed on the balance and depress the plunger of the pipette all the way down to transfer the entire 100.0 μL. Now cap the tube. This should transfer the desired volume of isopropanol into the Eppendorf tube.

3.4 Record the mass of the Eppendorf tube containing the isopropanol to a precision of 0.0001 grams (0.1 mg) using the same analytical balance that you used to determine the mass of the empty tube – the tare value.

3.5 Without removing the isopropanol from the Eppendorf tube, transfer an additional 100.0 μL of isopropanol to the Eppendorf tube. Again seal the tube and record the mass of the Eppendorf tube containing both transferred volumes of isopropanol.
3.6 Repeat 3.5 once to transfer a third 100.0 µL sample of isopropanol and again record the mass after the transfer. You should have three masses of the Eppendorf tube containing 100.0, 200.0 and 300.0 µL of isopropanol.

3.7 Once you have completed all the transfers for a given solution push the lever on the top of the pipette to discard the tip, and then dispose of the tip in the trash.

3.8 Repeat this procedure (3.1 – 3.7) using salt water solution in place of the isopropanol. As above your should have a tare mass (mass of the empty tube, as well as three masses of the tube containing 100.0, 200.0 and 300.0 µL of salt water solution.

3.9 There should be a graduated cylinder at the instructor’s desk which contains the salt water solution and a hydrometer (a weighted and sealed glass tube with a calibration scale in the narrow upright tube which rests above the liquid level). Record the specific gravity for this salt water solution by observing where the scale intersects with the level of the solution. This should provide a reading with at least 4 places to the right of the decimal point.

3.10 Determine the density of each liquid measured above by graphing the mass of the liquid transferred on the y-axis (Net weight = Gross weight - Tare weight) by the volume transferred on the x-axis. Enter the data for each of the liquids you measured, isopropanol and salt water, into the tables in the spreadsheet, Lab_1_Density_Plot.xlsx. A graph will be generated from your data showing the equation of the line representing the relationship between mass and volume. The slope of that line is the density determined by your measurements. Yes. It’s that simple.

3.11 The specific gravity as measured by the hydrometer is a density relative to water. Since the density of water at room temperature is 0.998 g/mL we can assume that the specific gravity and density can be compared directly. Calculate the percent difference between the value you obtained using the hydrometer and the value you obtained for the slope of the graph for salt water solution. The percent difference can be calculated by dividing the difference between the values by the average of the values and multiplying by 100%. Do not be concerned if this is a negative value.

4 Laboratory Equipment

An important part of your laboratory experience is learning the proper and appropriate uses of laboratory equipment. You will use the following lab equipment during this lab. While doing so, keep in mind that you will be required to demonstrate your knowledge of these and many other instruments on a laboratory practical exam at the end of the semester. If you aren’t familiar with their proper use, be sure to ask for help.

![Micropipette](image1.png)
![Micropipette tips](image2.png)
![Eppendorf Tube](image3.png)
![Analytical Balance](image4.png)

*Micropipette*  *Micropipette tips*  *Eppendorf Tube*  *Analytical Balance*