Measurement and Uncertainty*

Prelab Assignment

Read the entire experiment. Submit your completed prelab questions on Labflow before you begin the lab, according to the deadline set in the syllabus.

Experimental Overview

During this experiment you will measure volumes and masses of common labware. Record the correct uncertainty of each measurement.

Introduction

From the type of glass used to make it to the accuracy of the measurements, there are many differences in lab glassware. Most glassware is made of borosilicate glass, which is durable, easy to work with and abundant. Soda lime and quartz glasses are also commonly used for scientific glassware, but differ in cost and coefficient of expansion.[1,2] When glassware has to be repaired, the cleanliness and type of glass is important to the glassblower, so they can safely heat the glass to the correct temperature and not have unintended expansion.[3] Some glassware is made to hold reactions and make them easy to view, such as test tubes, but are not marked to measure volumes. Glassware meant to measure is made specifically *to deliver* or *to contain* the volume indicated. Beakers are made *to contain*, which means they can be trusted to measure the indicated volume when it is in the beaker. Beakers and other glassware made *to contain* commonly retain a small portion of the liquid they measured after it is poured out.

When measuring liquid volumes, there is always some uncertainty in the measured value. This uncertainty is not the same as error or mistakes.[4] The uncertainty is inherent and is not just due to differences between people. The placement of the lines, temperature of the liquid and cleanliness of the glassware can all lead to imprecise measurements.[5] When measuring with graduated glassware that does not have the uncertainty marked, it is commonly held that the uncertainty is one decimal place passed the last value that is certain. Many beakers however have the uncertainty marked as a percentage. This is a percentage of the total volume the beaker can hold. In other words, you will have the same amount of uncertainty if you are attempting to measure 50 mL or 150 mL in a 400 mL beaker.

When reporting the uncertainty from a digital measurement, such as the balances in lab, look for the manufacturer's label. If the label does not report the uncertainty, assume ±1 in the last decimal place.

NOTE Though error and uncertainty are not the same thing, many places refer to error bars as a generic term. You will see the use of "error bars" throughout your careers. Many times they are relating the uncertainty of a measurement, but not always. In our grading rubric, "error bars" refers to the uncertainty of a measurement. During general chemistry we only report uncertainty on measured values.

References

1. Choosing the Right Material. Rayotek Scientific Inc. (accessed August 14, 2017) https://rayotek.com/tech-specs/material-comparisons.htm

2. Glass Blowing Info. Dreams of Glass.com. (accessed August 14, 2017) http://www.dreamsofglass.com/glass-blowing-info.html

3. Glass Explosion In Slo-Mo. iHeart Radio. (accessed August 14, 2017) https://rock101fm.iheart.com/featured/t-bone/content/2017-07-20-glass-explosion-in-slo-mo/

4. Beginner's Guide to Measurement in Mechanical Engineering. National Physical Laboratory. 2013. http://www.npl.co.uk/upload/pdf/beg-guide-measurement-mech-eng.pdf

5. The Origin of Measurement Uncertainty. University of Tartu. (accessed August 14, 2017) https://sisu.ut.ee/measurement/origin-measurement-uncertainty

Procedure:

Part I – Glassware volume

1. In each of the following pieces of equipment, estimate 40 mL of distilled water. Then, pour the amount measured into your 50 mL graduated cylinder. Record the amount (as measured by the graduated cylinder) next to the name of each container.

Test tubes:

Small ________

Large ________

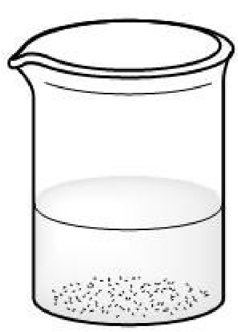
Beakers

50 mL ______

100 mL _____

250 mL _____

400 mL _____



Erlenmeyer Flask

125 mL ______

250 mL ______

Wash Bottle

______

Graduated Cylinders

10 mL _______

50 mL _______

Part II – Glassware Comparison

For each of the containers listed below, determine the amount of uncertainty that is associated with a measurement of 40 mL. Propose the best use of each piece of glassware. (Consider the size, shape and any labels on the container.) State both the use and your reasoning.

	Uncertainty	Best Use	Justification
Test tube			
100 mL Beaker			
125 mL Erlenmeyer flask			
50 mL Graduated cylinder			
Wash bottle			

Part III – Masses

Make your own table to report the mass and uncertainty of 10 items in your drawer. It is acceptable to choose multiple items that appear identical.

Data Analysis:

1. Compare the volumes measured in Part I. Which estimated volume was most reproducible when the water was transferred to the graduated cylinder? What aided your estimation?

2. Compare the objects and masses from Part III. Which measurement included the highest percent of uncertainty? Explain why this measurement had more uncertainty than the others.

Discussion Question:

1. Draw a picture of what you think your glassware looks like on the molecular level. This is a starting point for your semester. You may look at images in your text or other published works to get ideas.

2. Draw another picture that shows a liquid in your glassware.

3. Explain whether a graduated cylinder is made *to contain* or *to deliver*.

4. In 2-3 paragraphs, **summarize** your findings. Support your statements with references that verify the uncertainty inherent in measurements.

Submit your **Observations, Data Analysis** and **Discussion questions** via Labflow. Submit your pictures as scanned images, inserted pictures of your drawing or generate the picture using software. All images must be included.