Measurement in the Laboratory

(This lab was adapted from chem.libretexts.org)

Introduction

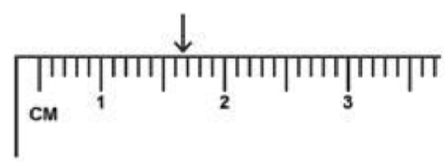
Chemistry is the study of matter. Our understanding of chemical processes thus depends on our ability to acquire accurate information about matter. Often, this information is quantitative in the form of *measurements*. In this lab, you will be introduced to some common measuring devices and learn how to use them to obtain correct measurements, each with correct precision. A metric ruler will be used to measure length in centimeters (cm).

All measuring devices are subject to error, making it impossible to obtain exact measurements. Students will record all the digits of the measurement using the markings that we know exactly and one further digit that we estimate and call uncertain. The *uncertain digit* is our best estimate using the smallest unit of measurement given and estimating between two of these values. These digits are collectively referred to as significant figures. Note that the electronic balance is designed to register these values, and the student should only record the value displayed.

It is important to be as accurate and precise as possible when making measurements. Accuracy is a measure of how close an experimental measurement is to the true, accepted value. Precision refers to how close repeated measurements (using the same device) are to each other.

Example 1.1: Measuring length

Here the "ruler" markings are every 0.1-centimeter. The correct reading is 1.67 cm. The first 2 digits **1.6**7 are known exactly. The last digit 1.6**7** is uncertain. You may have instead estimated it as 1.68 cm.



The measuring devices used in this lab may have different scale graduations than the ones shown Precision is basically how many significant figures you have in your measurement. To find the precision, you basically take the smallest unit on your measuring device and add a decimal place (the uncertain digit).

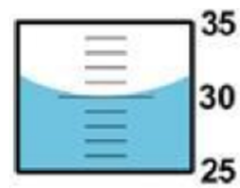
In general, the more decimal places provided by a device, the more precise the measurement will be.

Measurements obtained in lab will often be used in subsequent calculations to obtain other values of interest. Thus, it is important to consider the number of significant figures that should be recorded for such calculated values. If multiplying or dividing measured values, the result should be reported with the lowest number of *significant figures* used in the calculation. If adding or subtracting measured values, the result should be reported with the lowest number of *decimal places* used in the calculation.

In this lab, students will also determine the density of water as well as aluminum. Volume is the amount of space occupied by matter. An extensive property is one that is dependent on the amount of matter present. Volume is an extensive property.

Example 1.2: Measuring the Volume of a liquid

The *volume* of a liquid can be directly measured with specialized glassware, typically in units of milliliters (mL) or liters (L). In this lab, a beaker, two graduated cylinders and a burette will be used to measure liquid volumes, and their precision will be compared. Note that when measuring liquid volumes, it is important to read the graduated scale from the lowest point of the curved surface of the liquid, known as the liquid *meniscus*.



Here, the graduated cylinder markings are every 1-milliliter. When read from the lowest point of the meniscus, the correct volume reading is 30.0 mL. The first 2 digits **30**.0 are known exactly. The last digit 30.**0** is uncertain. Even though it is a zero, it is significant and must be recorded.

The volume of a solid must be measured indirectly based on its shape. For regularly shaped solids, such as a cube, sphere, cylinder, or cone, the volume can be calculated using an appropriate equation from its measured dimensions (length, width, height, diameter).

For irregularly shaped solids, the volume can be indirectly determined via the volume of water (or any other liquid) that the solid displaces when it is immersed in the water (*Archimedes Principle*). The units for solid volumes are typically cubic centimeters (cm^3) or cubic meters (m^3). Note that 1 mL = 1 cm^3.

Procedure

Part A: Measuring the Dimensions of Regular Geometric Shapes

1. Borrow a ruler and "shape sheet" from the front bench. Record the ID code on your report form. Measure the dimensions of the two geometric shapes: the length and width of the rectangle and the diameter of the circle. Record these values on your lab report.
2. When finished, return the ruler and sheet to the front bench.
3. Use your measurements to calculate the area of each shape:

- Area of a rectangle: $A=l\times w$
- Area of a circle: $A=\pi r^2$ (r = radius = 1⁄2 the diameter)

Part B: Measuring the Mass of Solids

Comparing the Precision of two types of Balances

1. Obtain a 250-mL Erlenmeyer flask from your locker. Use the triple-beam balance to determine the mass of this flask.
2. Use the electronic balance to determine the mass of the same Erlenmeyer flask. Be sure to record your measured masses on your lab report.

Weighing by Difference

1. Obtain a 100-mL beaker from your locker. Use the electronic balance to determine the mass of this beaker.
2. Add two spoonfuls of sugar to this beaker using your scoopula. **Do not do this over the balance!** Determine the new combined mass of both the beaker and the sugar. Be sure to use the same electronic balance as before. When finished, dispose of the used sugar in the sink.
3. Use your two measurements to calculate the mass of sugar (only) by difference.

Part C: Measuring Volumes of Liquids

1. At the front bench, you will find a burette, 10-mL graduated cylinder, 100-mL graduated cylinder, and 100-mL beaker, each filled with a certain quantity of water. Measure the volume of water in each. Remember to read the volume **at the bottom of the meniscus.** It is useful to hold a piece of white paper behind the burette/cylinder/beaker to make it clearer.

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Lab 2: Measurement in the Laboratory

Name: ____________________ Date: _____________ Teammate: _____________________

Data Sheet:

Part A: Measuring the Dimensions of Regular Geometric Shapes

Experimental Data

Shape Sheet ID Code:

Shape	Dimensions	Precision	Measurement	# Significant Figures
Rectangle	Length			
	Width			
Circle	Diameter			

Part B: Measuring the Mass of Solids

Experimental Data

Table 1: Mass of an Erlenmeyer Flask

Measuring Device	Mass Measurement	# Significant Figures
Triple-Beam Balance		
Electronic Balance		

Table 2: Weighing by Difference

	Mass Measurement	# Significant Figures
Mass of Empty Beaker		
Mass of Beaker + Sugar		
Mass of Sugar		

Part C: The Volumes of Liquids and Solids

Table 1: The Volume of Liquid Water

Measuring Device	Precision	Volume Measurement	# Significant Figures
Burette			
Beaker			
100-mL Graduated Cylinder			
10-mL Graduated Cylinder			

Name: ____________________ Date: _____________ Teammate: _____________________

Questions:

1.

a) Please summarize today's experiment in a few sentences. Describe the purpose, techniques used, and main results of the experiment

b) How can you apply this knowledge in your daily life?

2. Calculate the areas of your rectangle and circle in cm^2. Show your work, and report your answers to the correct number of significant figures.

a) Area of rectangle

b) Area of circle

3. Compare the mass values obtained for the Erlenmeyer flask (Part B Table 1). Which balance, triple-beam or electronic, provides the more precise measurement? Explain.

4. Compare the volume values obtained for the water (Part C Table 1). Which glassware, Burette, Beaker, 100-mL graduated cylinder, or 10-mL graduated cylinder provides the more precise measurement? Explain.