

# 1—Mass, volume, and the uncertainty of physical measurements



Name: \_\_\_\_\_

Date: \_\_\_\_\_

Section: \_\_\_\_\_

## Objectives

- Reinforce concepts of mass, length and volume
- Learn how to use electronic analytical balance
- Learn about the uncertainty of physical measurements
- Learn how to use significant figures in laboratory measurements
- Learn how to calculate the average, deviation, average deviation and relative average deviation
- Learn proper pipetting technique
- Measure the uncertainty of volume contained in a beaker, a graduated cylinder and a volumetric pipet

## Pre-Laboratory Requirements

- Read Chapter 1.2 – 1.5 in Silberberg
- Watch the instructional videos titled “Mass Balance/Analytical Balance” and “Pipetting”
- Pre-Lab Questions (if required by your instructor)
- Laboratory Notebook—prepared before lab (if required by your instructor)

## Safety Notes

- Eye protection must be worn at all times

## Discussion

Measurements provide a way to describe an object or a process, and when expressed as a number, measurements provide a way to quantify observations about the world around us. In CHEM 131L we will do experiments requiring you to measure (1) length, (2) mass, (3) time, (4) temperature, and (5) amount of a substance. The standard international system of units (SI) is used when reporting scientific data. Base units for the SI system are: (1) meter, (2) kilogram, (3) second, (4) kelvin, and (5) mole. You should read and understand the material in chapter 1 in Silberberg before doing this experiment.

You will learn to measure the mass of objects using an electronic balance in this experiment and to measure volume with three devices that have different uncertainties in their calibration. You will use the average volume delivered, the deviation of the volume delivered, and the relative average deviation of the volume delivered to compare three different devices (a beaker, a graduated cylinder and a volumetric pipet). Finally, you will gain valuable practice reporting the correct number of significant figures associated with physical measurements.

Mass and length are considered fundamental units, and are sometimes called base units. Volume, which is the product of the height x width x length of an object, is a derived unit because it is based on a mathematical

operation of the fundamental unit, length. Density is also a derived unit since it is the ratio of the mass of an object divided by its volume.

## Procedure

### Part I: Mass of a 50 mL Beaker

1. Watch the instructional video titled “Mass Balance/Analytical Balance.”
2. Tare the balance so the display reads 0.000 g.
3. Open a side door to the balance and place a clean 50 mL beaker on the balance pan.
4. Close the side door to the balance and record the beaker’s mass to the nearest milligram.
5. Remove the beaker from the balance pan and verify that the display again reads 0.000 g.
6. Repeat this process 2 additional times; recording the beaker’s mass on two other balances.
7. Calculate the average mass of the beaker from the three separate mass determinations.

Mass of 50 mL beaker (g) \_\_\_\_\_

Average mass of 50 mL beaker (g) \_\_\_\_\_

Average deviation of 50 mL beaker (g) \_\_\_\_\_

Relative average deviation 50 mL beaker \_\_\_\_\_

Reported value for 50 mL beaker: \_\_\_\_\_  $\pm$  \_\_\_\_\_ or \_\_\_\_\_  $\pm$  \_\_\_\_\_ %

Calculations:

### Part II: Volume Delivered by Three Different Measuring Devices

The electronic analytical balance is the most precise measurement device we use in CHEM 131L, and part two of today’s experiment takes advantage of the highly precise measurements obtained on the electronic balance to measure actual volumes delivered by different measuring devices. This is possible because we know the density of the water. Simply dividing the mass of water delivered by a measuring device by the density of water gives the volume of water delivered to three places beyond the decimal point.

$$\text{mass of water} \div \text{density of water} = \text{volume of water}$$

$$(\text{g of water}) \div (\text{g of water/mL of water}) = \text{mL of water}$$

You will need to record the temperature of water with the thermometer provided and then checked the Water Density Table provided in the laboratory. It is necessary to consult the table because water density changes with temperature.

The mass of water delivered by each device (50 mL beaker, graduated cylinder, or volume transfer pipet) will be measured three times. You will use the three measurements to calculate an average of the volume delivered by each device, the deviation for the volumes delivered, the average deviation and the relative average deviation, again, for each device. The goal of this part of the experiment is to compare the accuracy of the three measuring devices and to also compare the precision with which they deliver known volumes of water.

Water temperature and density: \_\_\_\_\_ °C \_\_\_\_\_ g/mL

### Part II-A: Volume Delivered by a 50 mL Beaker

1. Record the mass of a 50 mL beaker.
2. Add 25 mL of deionized water from a DI water bottle to the beaker and record the mass.
3. Empty the water in the sink, dry the beaker, and record the mass of the dry beaker.
4. Repeat these steps for a total of three trials.

	Trial 1	Trial 2	Trial 3
Volume of water placed in beaker (mL)	_____	_____	_____
Mass of beaker + water (g)	_____	_____	_____
Mass of empty beaker (g)	_____	_____	_____
Mass of water in grams (g)	_____	_____	_____
Volume of water in mL (mL)	_____	_____	_____
Average volume of water delivered (mL)		_____	
Average deviation of water delivered (mL)		_____	
Relative average deviation of water delivered (mL)		_____	
Reported value for water delivered: _____ ± _____ or _____ ± _____ %			

Calculations:

## Part II-B: Volume Delivered by a 50.0 mL Graduated Cylinder

1. Record the mass of a 50 mL beaker.
2. Add 25 mL of deionized water from a 50.0 mL graduated cylinder to the beaker and record the mass.
3. Empty the water in the sink, dry the beaker, and record the mass of the dry beaker.
4. Repeat these steps for a total of 3 trials.

	Trial 1	Trial 2	Trial 3
Volume of water placed in beaker (mL)	_____	_____	_____
Mass of beaker + water (g)	_____	_____	_____
Mass of empty beaker (g)	_____	_____	_____
Mass of water in grams (g)	_____	_____	_____
Volume of water in mL (mL)	_____	_____	_____
Average volume of water delivered (mL)		_____	
Average deviation of water delivered (mL)		_____	
Relative average deviation of water delivered (mL)		_____	
Reported value for water delivered: _____ $\pm$ _____ or _____ $\pm$ _____ %			

Calculations:

### Part II-C: Volume Delivered by a 25.00 mL Transfer Pipet

1. Your instructor will demonstrate proper technique for using a volumetric transfer pipet.
2. Record the mass of a 50 mL beaker.
3. Add 25 mL of deionized water from a 25.00 mL transfer pipet to the beaker and record the mass.
4. Empty the water in the sink, dry the beaker, and record the mass.
5. Repeat these steps for a total of three trials.

	Trial 1	Trial 2	Trial 3
Volume of water placed in beaker (mL)	_____	_____	_____
Mass of beaker + water (g)	_____	_____	_____
Mass of empty beaker (g)	_____	_____	_____
Mass of water in grams (g)	_____	_____	_____
Volume of water in mL (mL)	_____	_____	_____
Average volume of water delivered (mL)		_____	
Average deviation of water delivered		_____	
Relative average deviation of water delivered		_____	
Reported value for water delivered: _____ $\pm$ _____ or _____ $\pm$ _____ %			

Calculations:

### Final Report

Your final report should compare the accuracy of the three measuring devices used in this experiment. Answer the questions “What was the most accurate measuring device? What was the second most accurate measuring device and what was the least accurate measuring device?” Which measuring device had the largest average deviation? Which measuring device had the smallest average deviation? Be sure to use the proper number of significant figures in your written report, both in the tables and in the text.