INTRODUCTION TO THE LABORATORY

OBJECTIVES: The goals of this session include (1) an introduction to the general chemistry laboratory and course policies and procedures, (2) safety instruction, (3) checking into lab lockers, (4) learning how to use electronic balances, (5) learning how to measure volume accurately, and (6) determining the density of a solution.

SKILLS: Using a balance; making volume measurements; writing significant figures and units; determining density.

EQUIPMENT: Top loading balances, beakers, pipets.

SAFETY AND DISPOSAL: Aqueous samples and glassware used in this lab present no special hazards.

INTRODUCTION: Starting a chemistry lab course involves becoming familiar with the lab setting, equipment and instruments, potential hazards and safety procedures, and the use, cleanup, and disposal of chemicals. It also involves making and recording measurements and observations and reporting experimental results. In this week’s exercises, lab policies and safety equipment will be introduced, and the lab drawer check-in procedure will be discussed. During each experiment, students will record information into their lab notebooks and submit a report of their results. Instructions for recording and reporting experimental observations are given below.

Weighing with an electronic balance is a specific skill that will be used throughout the course. It is, therefore, important to learn to use such balances correctly. The ability to properly report the results is also critical to good laboratory technique. Reporting the results with the correct number of significant figures will show how good the measurement is. The balances available in the laboratory are all milligram balances. A milligram balance does not yield the mass of an object in mg, but rather shows the mass in grams and allows it to be determined to the nearest milligram (±0.001 g). Two other common balances that you may encounter are centigram balances and analytical balances, which measure to one less and one more significant figure, respectively. Finally, results can be reported in a variety of different units, including kilograms, grams, centigrams, milligrams, pounds, and ounces. Using correct units is essential. Measurements should never be reported without the inclusion of the appropriate units or with a number of significant figures that does not reflect the precision of the measurement.

The type of glassware used to measure the volume of a liquid also has an impact on the quality of the measurement. Beakers are very inaccurate for measuring volumes and should only be used if the precise volume is not important. Graduated cylinders are more precise and are commonly used to measure volumes, but it can be difficult to transfer all of the measured solution. For higher quality measurements, volumetric glassware that has been carefully calibrated should be used. There are several different types of volumetric glassware, including burets, pipets and volumetric
flasks. Today’s lab will use only pipets; burets and volumetric flasks will be used in other labs this semester. Unlike graduated cylinders, pipets are designed to fully deliver the volume measured.

Density (D), the mass (m) of a sample divided by its volume (V), provides a straightforward way to get comfortable using both the electronic balances and pipets and is thus the focus of today’s experiment.

Density is dependent on temperature and solution concentration but is independent of sample size: a large sample has the same density as a small sample. Determining the density for liquids or regularly shaped solids is straightforward, simply measure the mass of the sample and calculate its volume. Not all objects have volumes that are easily measured and determining the density cannot be measured directly. In this experiment, the density of an irregularly shaped object will be determined indirectly by measuring the density of a solution in which it just floats. Students will enter their own data into the laboratory computer so that it can be included in the analysis of class data as part of Experiment 2.

A HISTORICAL QUESTION*: It used to be common for soap to be made at home. Store bought soap was a luxury and few people, especially in rural or agricultural areas, would have wanted to spend precious cash on an item easily made in from a range of readily available resources. Most recipes called for animal fat such as from cattle (tallow) to be cooking a lye solution. Lye is mostly sodium hydroxide and can be easily purchased as a solution today. Home soap makers would have made their own lye solutions from ashes and water. The ashes were treated with hot water and filtered to give a clear solution. Before the lye could be used for soap making, the concentration of the solution needed to be checked.

On way to check the concentration of the solution was to determine the density of the solution. The density of the solution will be greater at higher concentrations of sodium hydroxide. One simple test was to try to just float a raw egg in the solution. If the egg sank, the density of the lye solution was too low. If the egg floated high in the solution, the density was too great and water would have been added before adding the fat. At that point, the density of the lye, and thus its concentration, was correct.

Left: The egg is more dense than the solution, sinking to the bottom
Center: The egg is less dense than the solution, breaking the surface
Right: The egg and the solution have the same density
In this lab, this same strategy will be used essentially in reverse. Measuring the density of a liquid solution is readily done in the lab. The density of an egg is more difficult to determine directly. We will use a solution that just floats an egg to determine the density of the egg indirectly.

*The Historical Question was adapted from materials developed by Dr. Susan Hershberger at Miami University Middleton.

LABORATORY NOTEBOOKS AND REPORTS: Scientists and working professionals need to keep clear records of what they do and need to transmit the results of their work to others. The daily records are contained in a laboratory notebook; the results are given in a laboratory report.

The Laboratory Notebook: A laboratory notebook serves several purposes. The first is for your own reference. To avoid forgetting any important information, the details of each experiment should be recorded in the notebook when they are performed during the lab. The second purpose is so that someone else can review your work and repeat it exactly. This is necessary in research and industry, where legal and financial consequences often hinge on what is in a laboratory notebook. It is also necessary in a student laboratory. If a particular experiment does not work well for you, the instructor would want to know why. Your detailed written procedure and observations can give clues to what happened if an experiment fails. The laboratory notebook is also analogous to keeping records on patient care, where accurate and legible notes are critical.

The correct notebook for the laboratory is a bound book containing lined pages. These are available at bookstores and stationary supply stores. A loose-leaf or spiral notebook is not satisfactory because the pages are easily lost. If the pages in the notebook are not numbered, number them before using the book. Write your name and laboratory section number on the cover of your notebook. Enter experiments consecutively in ink; use permanent blue or black ink (ball point pen) because your book will become splashed and stained with use. Other colors of ink are more difficult on the eyes and should not be used. The use of pencils is also inappropriate as pencil marks can easily be erased and the data altered. Alteration of data is fraud in both laboratory and clinical settings and for this reason pencils are prohibited; records in pencil are too easily changed without leaving evidence of their alteration.

Your notebook can become cluttered and illegible if an organized format is not observed. For this reason, certain conventions have been developed. At the top of the page, write the date on which the experiment was performed and the title of the experiment. As you go along, leave plenty of space for notes that you might want to insert later. Write clearly so that your instructor will be able to read and grade your notebook. If you make errors, do not rip out the
page, use whiteout or completely cover the error in ink. Instead, line out errors (or draw an "X" over the entire page) and go on.

**Notebook Format for Experiments**

1. **Introduction.** Give a brief introduction to the experiment in which you clearly state the purpose(s) of the procedure. If there is background information that will be particularly helpful in data analysis, such as chemical formulae or reactions, this should also be included in the lab notebook.

2. **Experimental Plan.** Enter a one- or two-line statement for each part of an experiment. Do not copy the experimental procedure from the book but provide a summary of it. This section should be completed before coming to the laboratory. It is particularly useful to include an outline of what should be done. Preparing this outline is very good way to prepare for the laboratory experiment.

3. **Experiments and Results.** In this section, write down what you actually do and observe during the experiment. You should write this section while you are in the laboratory. Every measurement that you make should be written here with the appropriate units when you make it, and observations should be entered as they happen. For some experiments, it will be helpful to have a table prepared to enter measured values. Templates of these tables will be provided in some of the instructions. The post-laboratory report forms are another source for table layouts.

4. **Conclusions.** Record the conclusions that can be reached based on the results you have obtained in the experiment. It is appropriate to include calculations that are made during the lab in this section.

**EXPERIMENTAL PROCEDURE**

Your instructor will demonstrate how to use a balance, a graduated cylinder, and a pipet. Your goal should be to learn how to use this equipment correctly and efficiently.

I. **Safety:** As part of the safety introduction, be sure to know where the exits, eye washes, and showers are. If you have a medical condition or take medication that could affect your performance, please inform your lab instructor. This information will be kept confidential and be used only to maintain a safe working environment.

II. **Lab Drawer Check-In:** Check into the lab drawer, making sure that all the listed equipment is there. Each individual is responsible for the contents of his/her drawer and will need to bring the key to lab each week. Approved goggles can be purchased from the campus bookstore and stored in the lab drawer during the week.
III. Preparation of the Solution

You will be assigned to a group for the first portion of this experiment.

Sodium hydroxide is caustic and corrosive. Since we are not making soap, sodium chloride will used in its place. As a group, develop a procedure and prepare a solution that will just float an egg. Available materials include sodium chloride, standard glassware, balances, and deionized water. Other materials may be available on request. Each group should use a single egg, recording whether the egg is fresh or older.

Once your group has made a solution that will just float your egg, use that solution to compare the density of your egg quickly and qualitatively to other eggs available by carefully placing several other eggs into your solution and recording how they float in the solution compared to your egg. Including the results for your egg, you should have observational data on two fresh eggs and two older eggs. Record which groups the other eggs came from.

IV. Density

Each member of the group must work individually on this portion of the laboratory.

Determine the density of the solution made in part III. Each student must independently determine the density of the solution made by the group. Record the mass of an empty 50 mL beaker. Carefully pipet 5.00 mL of the salt solution made in part III into the beaker using a 5-mL volumetric pipet. Record the mass of the beaker and solution. Add a second 5.00 mL aliquot (portion) to the beaker and again record the mass (The beaker now contains 10.00 mL of solution). Continue this until you have added a total of 25.00 mL of the salt solution to the beaker. Clean your pipet and beaker.

Repeat the procedure used a graduated pipet. If you undershoot or overshoot the 5.00 mL mark, read and record the actual volume you deliver.

ANALYSIS OF THE EXPERIMENTAL DATA

Enter your mass and volume data for both pipets into the lab computer for use in class data analysis as part of Experiment 2. Find the density of each trial by determining the mass of each 5.00 mL portion added, and then dividing the mass by the 5.00 mL volume. The average density of each solution will be included in the lab report.

Using graph paper, plot the Total Volume on the X axis and the experimental Mass of Beaker + Solution using volumetric pipet on the Y axis. With a straight edge, draw the best straight line through these points. The line fits the form for a linear equation \( Y = mX + b \). Find the slope and the intercept of the line.
Add points for Mass of Beaker + Solution using graduated pipet to the graph of the data above. Data for both pipets should be plotted on a single graph. Draw the best straight line through these points and then find the slope and intercept of the line. This graph and the values of the slope and intercept should be included in the lab report.