Prelab: Using the equation for air buoyancy derived in class, write an Excel program to calculate the true mass of an object (weighed in a vacuum) from the mass of the object weighed in the air. Inputs for your program should include the mass of the object determined using a balance, density of the object, density of the balance weights, room temperature, barometric pressure, and vapor pressure of water in the air. Program outputs should include the density of air and the mass of the object weighed in vacuum. Save a copy of your program into your folder on the Chemistry Server and bring to lab a hard copy of the spreadsheet. Please label and document your program.

Objective: The objective of this lab is to evaluate the analytical abilities of a wide range of measurement systems. We will look at both the precision and accuracy of transfer and blowout pipets, computer controlled pumps, top loading balances, and analytical balances. By the end of the lab you should be proficient using the range of measurement devices and also have an idea of the performance characteristics of each device.

Procedure: Table 1 is a list of the analytical devices that you will evaluate. Double check each device to make sure it is clean. A clean buret or pipet will not have any water drops clinging to the inside of the glass.

Table 1. Analytical devices to be evaluated

<table>
<thead>
<tr>
<th>Pipets (transfer, TD)</th>
<th>Digital Pipets (TC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 ml</td>
<td>25-100 µl</td>
</tr>
<tr>
<td>25 ml</td>
<td>100-1000 µl</td>
</tr>
</tbody>
</table>

FMI Pip Pump (computer controlled)

Volumetric Flasks

50 ml

Top loading balances

Analytical Balances

Each student will be assigned a top-loading and an analytical balance which you will use for the entire semester. I will begin the lab by showing you how each balance works. You are responsible for keeping the balances clean. You will begin the lab by calibrating both of your balances. I will have several sets of calibration weights available in the lab. Measure the mass of two different sets of calibration weights. Make replicate (five or more) measurements of the two different weights. Investigate the effect of sample positioning on balance pan on the observed mass. These tests will give you an idea on the reproducibility of the balance. Finally,
select some object in the lab and investigate the effect of sample handling on mass measurements. Try handling the object with tongs, Kimwipes, your hands, etc. Record all of your results in your lab book.

Now that you are a master masser, you will use the balances to calibrate assorted volumetric devices. Starting with your 25 ml pipet, pipet distilled water into the pre-weighed weighing vial. Calculate the volume of water delivered from the weight and density of the water. Make sure to record the temperature of the water. Use Harris table 2-6 for the density of water. Repeat the process until successive volume determinations agree within 0.3%. Repeat the above procedure for your 10 ml pipet. Use the same procedure for calibrating the digital pipets. Make at least three measurements on each pipet so that you can calculate the deviation of the device. For one of the adjustable pipets investigate the effect of changing the dispensing volume on the accuracy of the device. Finally, calibrate a volumetric flask. Make sure you dry the inside of the flask completely before the calibration.

The last exercise of the lab is to compare the accuracy and precision of a FMI Pip pump versus a buret. Use the data available in Chapter 2 of your text to predict the precision and accuracy of a 50 ml buret. I will show you how to use the computer controlled pump. Each pulse delivers about 20 µL. Deliver three volumes of water (=500 µl) into a small beaker and use this data to evaluate the accuracy and precision of the pump. Repeat the pump calibration at three additional volumes over the range from 1-5 ml. Plot the relative error of the pump vs. volume of solution delivered. Explain your results. How do the pump and buret compare?

**Report:** Based on your calibration data, generate a table in your lab book which lists the measurement device, operating mass/volume range, accuracy, and precision. Comment briefly on the ease of use of each device. In much of our future work, we will have the option of preparing solutions on the molar (M) or molal (m) scale (see chapter 1 in Harris for definitions). Considering the measurement devices available to you describe how you would prepare a 1 M and 1 m NaCl solution. In which solution would you know the concentration most accurately. Write and attach a short Excel program which will allow you to conveniently convert between the two concentration scales.