Chem 131A: Precision Adjustable-volume Pipettor Use

The purpose of this exercise is to familiarize the student with the use of precision adjustable-volume pipettors and to investigate what is meant by the terms "accuracy and precision" when applied to scientific measurements. Further, the student will learn one technique that can be used to calibrate pipettors. Proper use of the pipettors is paramount to obtaining good data for future experiments (and hence your grade on the lab exercises) and to insure that these expensive instruments are not damaged.

Introduction:

Any experimental measurement has an associated precision and accuracy. The precision of a measurement refers to the reproducibility of a measurement whereas the accuracy refers to how close a measured value is to the actual value. Precision is dependent on the limits intrinsic to the instrument used to make the measurement and on the skill of the operator. The accuracy of a measurement depends on how well the instrument is calibrated to a known standard, provided the operator does not make a mistake. Both the precision and accuracy associated with the use of an instrument change with time. Hence, it is important to check both of these periodically for all instruments and compare them with manufacturers specifications.

The precision pipettors that you will use in this class may be adjusted to deliver a continuous range of volumes within a specified range. This feature makes them more convenient to use than fixed volume pipettors, as a greater variety of volumes can be delivered. This feature can also save time and reduce waste. However, the precision and accuracy of adjustable pipettors is generally lower than that for fixed-volume pipettors and standard volumetric glassware. In addition, the precision and accuracy of adjustable pipettors change as they are repeatedly used; this is due to mechanical wear. You do not have such problems with standard glass volumetric ware. The benefits of variable volume pipettors outweigh the disadvantages in most, but not all situations, provided that they are regularly checked for precision and accuracy and are not abused.

In this exercise you will examine a method commonly used to check the precision and accuracy of pipettors. You will examine the mid-range volumes delivered by a 2-20 μL, 20-200 μL and a 200-1000 μL variable-volume pipettor. The pipettors are very expensive and can be easily broken. You must handle them with the appropriate care. A few cautions are given below:

1. Make sure that you are familiar with the use of the pipettor before using it. Different brands of pipettors operate somewhat differently.
2. Never adjust the volume to a value outside the range specific for that pipettor (below or above). Doing this can, and usually does, break the pipettor.
3. Always keep the pipettor in the vertical position when pipetting solutions. Turning it sideways can allow solution to enter the pipettor and can result in severe damage to the pipettor.
4. Never place the pipettor on the lab bench with solution in the tip.
5. Always operate the plunger slowly. Never allow it to snap back into position.
6. Notify the instructor immediately if you suspect or know that the solution has been drawn into the pipettor.
7. Always make sure that the pipettor tip is seated properly before pipetting.

EXPERIMENTAL

Measure and record the temperature of the room in which the weight of the samples is measured.

Part A: Precision of L-20 Pipettors

1. Acquire an L-20 type pipettor with the correct tip.
1. Set the pipettor to 10 μL.
1. Place a 0.5 mL tube on the balance and tare the weight to zero.
1. Draw up the 10 μL of millipore water and dispense it onto the tube. Record the weight of the water. Repeat the procedure three more times.

Part B: Precision of L-200

1. Acquire an L-200 type pipettor with the correct tip.
1. Set the pipettor to 100 μL.
1. Place a 0.5 mL tube on the balance and tare the weight to zero.
1. Draw up the 100 μL of millipore water and dispense it onto the tube. Record the weight of the water. Repeat the procedure three more times.

Part C: Precision of L-1000

1. Acquire an L-1000 type pipettor with the correct tip.
2. Set the pipettor to 500 μL.
3. Place a 1.5 mL tube on the balance and tare the weight to zero.
4. Draw up the 500 μL of millipore water and dispense it onto the tube. Record the weight of the water. Repeat the procedure three more times

Calculations: You will work in pairs for this experiment. Both team members should use the same pipettor for each quadruplicate set of measurements. This means that a total of eight measurements of the same quantity will be made by each partnership-four by each member of the team. The data gathered by a pair will be shared among the members.

1. Average (i.e. calculate the mean of) the eight trials for each weight. The mean ($\overline{m}$) is the best estimate of the value of a set of measurements of the same mass:

$$\overline{m} = 1/\mathrm{N} \sum_{i}^{N} m_i$$

2. Calculate the % error between the average of the eight trials and the "set" value (this corresponds to the mass obtained by multiplying the nominal volume by the density of water at the experimental temperature):

$$\%Error = \left|\overline{m} - m_{set}\right| / m_{set}$$

Calculate the mean deviation for the eight trials:

$$\text{Mean deviation} = 1/N \sum_{i}^{N} \left|m_i - \overline{m}\right|$$

Note that the mean deviation is not as good an estimator of the uncertainty of a set of measurements of the same quantity as the sample standard deviation (σ_m). The sample standard deviation differs from the population standard deviation (σ) in that the denominator of the latter is N, not (N-1):

$$\sigma_m = \left(1/(N-1) \sum_{i}^{N} (m_i - \overline{m})^2\right)^{1/2} \qquad \sigma = \left(1/\mathrm{N} \sum_{\mathrm{i}}^{\mathrm{N}} (\mathrm{m_i} - \overline{\mathrm{m}})^2\right)^{1/2}$$

The population standard deviation refers to a very large (essentially infinite) set of measurements.

3. Use all of the data gathered by both partners to calculate the sample standard deviation for each set of measurements.

The optimum way to report the BEST ESTIMATE of the result of a set of mass measurements is $\overline{m} \pm \sigma_{\overline{m}}$, where $\sigma_{\overline{m}}$ (the standard deviation of the mean) is calculated as $\sigma_{\overline{m}} = \sigma_m / \sqrt{N}$. This is how the measured mean of the set of measurements would vary if repeated N times (i.e. if one made N sets of N measurements and calculated the mean of each set, the uncertainty of the means would vary according to the above relationship).

4. Find the standard deviation of the mean for each set of measurements and report your results accordingly.