Experiment 2 – Calibration of a Pipette and a Graduated Cylinder

Prior to starting this experiment, please review the video at:
https://www.youtube.com/watch?v=yH4JpWB99sI

Materials Needed to Complete This Experiment

- 3 mL plastic pipette
- 100 mL beaker
- 500 mL beaker (waste material)
- 50 mL graduated cylinder
- Distilled or deionized water
- Scale that holds up to 200.0 g with 0.01 g accuracy
- Temperature probe

Note to student: Please read through the introduction. Once you have read through the introduction and answered the pre-lab questions you are ready to begin the lab.

Common Lab Procedures/Skills in This Lab

(new skills in bold, * denotes these previous skills have videos associated with them)

- **The Calibration of a Piece of Labware** (Title of Lab) (https://www.youtube.com/watch?v=-ncG3rx1Wws)
- Equilibrate to Room Temperature*
- Record the Mass*
- Record the Temperature*
- Condition the Pipette with Distilled Water*
- Deliver 2.0 milliliters Using the Pipette*
- Repeat the Measurement Multiple Times to Allow Us to Determine Precision
- Calculate the Average Density and the Standard Deviation*
- **Calculate the Error**
- Calculate the Percent Error
- **Adapting a Procedure to a New Situation**

Introduction

Reliable and accurate handling of liquids is crucial for many experiments. Inaccurate measurements could have adverse effects on experimental data. Most scientific labware requires periodic calibration or needs confirmation of its previous calibration. It is common to calibrated glassware using a liquid with a known density and a balance. Density is affected by temperature, so it is important to measure the liquid temperature and look up appropriate density values.

In this experiment, you will be calibrating the volume delivered by a plastic pipette at a range of volumes so that you can then use this pipette in future labs. There are at least two aspects of this calibration. First, how accurate are the markings on the pipette? This question involves "instrumental" error, error that is inherent in the piece of labware or equipment. A pipette is a simple, mechanical (non-electronic) instrument; however, it is a tool that we use in the lab to complete a task, so it is an instrument in the broadest sense. One potential source of instrumental error is the location of the markings on the pipette. *Are they placed correctly? Are some of them placed correctly while others are not placed correctly? How much error can I expect if I pipette 2 mL later in the semester for a titration? Can I account for this error?* These are the questions you will answer in this lab.

To account for instrument error, you will calculate the volume difference between the volume you expect to pipette using the markings and the volume you actually get based on the mass of solution.

Second, how accurately and precisely can you use the pipette? This question involves "human" error, error that is associated with how an instrument is used. If the lab asks you to deliver 2.0 mL and you miss the 2.0 mL mark by a tiny bit, then that is human error.

To account for human error, you will measure the standard deviation of your attempts to use the pipette.

In preliminary experiments, results indicate that the plastic pipette can be significantly more accurate and precise than having its last significant figure be in the tenths place. This is one of the questions to think about while performing this experiment.

Once you have calibrated your plastic pipette in part A, you will use what you have learned to calibrate a graduated cylinder. Pipets and burets are usually calibrated *to deliver* specific volumes, the graduated cylinder will be calibrated “to contain” a volume of liquid. This is due to drops that are not accounted for remaining in the cylinder after the liquid has been transferred to another container.

Procedure – You will work on this lab independently (no lab partners).

A. Calibrating a Plastic Pipette to Deliver a Certain Volume

1. **Equilibrate** 400 mL of distilled water **to room temperature** as shown in the video.

2. Mark ✎ one of your 3.0 mL plastic pipettes with your initials using a permanent marker or a piece of tape. This is the pipette that you will be calibrating. It is important to be able to locate this one for future labs during the semester.

3. Take a picture 📷 of you with your marked pipette like the picture to the right.

4. **Condition the Pipette with Distilled Water** as shown in the video.

5. **Record ✎ the temperature** of the distilled water in your notebook formatted like *Table 1* in this document.

6. **Record ✎ the Mass** of a 100 mL beaker in your notebook formatted like *Table 1* in this document.

7. **Deliver 2.0 mL Using your Pipette** into your 100 mL beaker. Be careful to deliver exactly 2.0 mL ensuring

   - the water level is as close as possible to the 2.0 mL mark
   - there are no air bubbles especially at the tip of the pipette
   - remember that your pipet is calibrated “to deliver”

8. **Record ✎ the Mass** of your 100 mL beaker and the water in your notebook formatted like *Table 1* in this document.

REPEAT THE MEASUREMENT NINE MORE TIMES TO DETERMINE THE PRECISION

9. Repeat steps 7 & 8 above for a total of 10 measurements ✎ in your notebook formatted like *Table 1* in this document.

10. Empty the beaker of about 20mL of water that you collected. Please note that the beaker need not be completely dry. Your re-massing of the beaker will take any residual water into account.

11. Repeat steps 5, 6, 7 8, 9 & 10 and this time change from using 2.0mL to **1.0mL**. Your notebook should have the next column completed.

12. Repeat steps 5, 6, 7 8, 9 & 10 and this time change from using 2.0mL to **0.5mL**. Your notebook should have the next column completed.

13. Repeat steps 5, 6, 7 8, 9 & 10 and this time change from using 2.0mL to **one drop**. Your notebook should have the next column completed.

    - Be careful to position the pipette in the same angle / position each time. Changing your angle will cause differences in the drop formed.
    - Be sure to not touch the tip of the pipette to the beaker.
    - Remember this position as you will be using this position and calibration in future labs.
    - Take a picture of your pipette position as you make a drop (it should not be one of your experimental drops). like the picture to the right.

B. **Adapting a Procedure to a New Situation:** Calibrating a 50.0 mL Graduated Cylinder to Hold a Certain Volume

Based upon what you have learned about calibrating a plastic pipette and based upon how you filled a graduated cylinder in Experiment #1 (measuring the mass with the water in the graduated cylinder), apply this information *to calibrating a 50.0 mL graduated cylinder* to hold 50.0 mL. Detail your procedure, your calculations, and the average volume with standard deviation. Make a table to record all of your data in an organized way. You will still need ten trials for this calibration. Remember to always remove the graduated cylinder from the scale before filling it with water to prevent water from spilling on your scale. If you have any questions about how to do this, please ask your instructor.

Calculations

A. Calculations for Pipette

Note: Please see Experiment 1 or ask your instructor any questions you have about significant figures. Starting with this lab, details about how to keep track of sig figs will (generally) not be included in this section. *But you will be graded on your significant digits.*

1. Calculate the mass of water for the measurement you recorded in Table 1 in your notebook. Your new Table should be similar to *Table 2* in this document.

2. **Calculate the Average Density and the Standard Deviations** for the measurements you recorded in Table 1 in your notebook. Your Table should be similar to *Table 2* in this document.

3. Record the density of water at the temperature you measured by using *Table 3* in this document in your notebook. Your Table should be similar to *Table 2* in this document.

4. Calculate the average mL of water from the average grams of water and the density of water.

$$\text{average mL of water} = \frac{\text{average grams of water}}{\text{density of water at T } (\mathit{from\ Table\ }3)}$$

5. Repeat the above calculation ✎ using the *Std Dev for the Average Mass of Water (g)* and the *Density of Water from Table 3 (g/mL)* to get the standard deviation of the volume of water.

6. **Calculate the Error** ✎ The error is the difference between the experimental and the accepted value. (It is also the numerator of the percent error calculation.)

   Error = Experimental Value – Accepted Value

   Hint: In this calculation, the accepted value of 2.0mL is an exact number with infinite significant figures because you expected a perfect 2.000000… mL. This is subtraction, so your sig figs are limited by the number of decimal places in your average mL of water.

   Error = Average mL of water – 2.000000… mL

7. **Calculate the Percent Error** ✎ The percent error is the difference between the experimental value and the theoretical value divided by the theoretical value.

$$\%\,Error = \frac{Experimental\ Value - Theoretical\ Value}{Theroetical\ Value} * 100\%$$

   Hint: In this calculation, the theoretical value of 2.0mL is an exact number with infinite significant figures because you expected a perfect 2.000000… mL. This is subtraction, so your sig figs are limited by the number of decimal places in your average mL of water.

$$\%\,Error = \frac{Experimental\ Value - 2.000000\ldots mL}{2.000000\ldots mL} * 100\%$$

8. Ensure that you have completed ✎ all of your Table 2 in your notebook. (1.0 mL, 0.5 mL and 1 drop calculations.)

B. Calculations for Graduated Cylinder / Adapting a Procedure to a New Situation

1. Ensure that all of the recordings ✎ and calculations ✎ you performed for the pipette is also performed for the graduated cylinder.

Questions

1. When you use this plastic pipette from now on and it says "deliver 2.0 mL," you will put down that you delivered this amount instead of 2.0 mL. For the schematic of the plastic pipette on the next page, draw its markings for:
   a. *2.0 mL with the average and standard deviation of the mL of water you obtained.*
   b. *1.0 mL with the average and standard deviation of the mL of water you obtained.*
   c. *0.5 mL with the average and standard deviation of the mL of water you obtained.*
   d. *drop with the average and standard deviation of the mL of water you obtained.*
2. How accurate and precise is the 2.0 mL mark on your plastic pipette? How many decimal places should you use when using the pipette to deliver 2.0 mL of water: 2 ml, 2.0 mL, 2.00 mL, 2.000 mL, or 2.0000 mL. Answering this question is the whole point of this lab.
   a. *Accuracy percent error*
   b. *Precision mL*
   c. *2.X? +/- X.X? ml*

Results

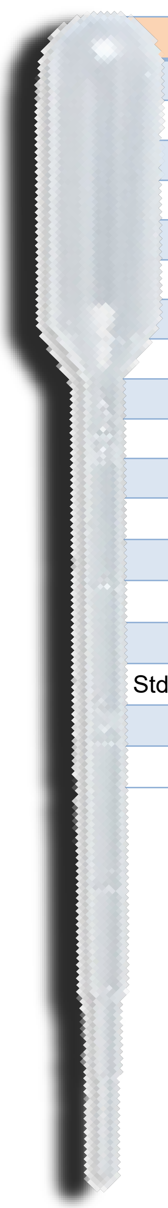
Pictures of Parts of the Experiment

1. You with your marked pipette
2. Pipette position as you make a drop

Table 1: Part A – Calibrating a Plastic Pipette Raw Data

Data:	2.0 mL	1.0 mL	0.5 mL	1 drop
Temperature (°C)				
Mass of Empty Beaker at Start (g)				
Mass of Beaker + Water: Trial 1 (g)				
Mass of Beaker + Water: Trial 2 (g)				
Mass of Beaker + Water: Trial 3 (g)				
Mass of Beaker + Water: Trial 4 (g)				
Mass of Beaker + Water: Trial 5 (g)				
Mass of Beaker + Water: Trial 6 (g)				
Mass of Beaker + Water: Trial 7 (g)				
Mass of Beaker + Water: Trial 8 (g)				
Mass of Beaker + Water: Trial 9 (g)				
Mass of Beaker + Water: Trial 10 (g)				

Table 2: Part A – Calibrating a Plastic Pipette Calculations



Data:	2.0 mL	1.0 mL	0.5 mL	1 drop
Temperature (°C)				
Mass of Water: Trial 1 (g)				
Mass of Water: Trial 2 (g)				
Mass of Water: Trial 3 (g)				
Mass of Water: Trial 4 (g)				
Mass of Water: Trial 5 (g)				
Mass of Water: Trial 6 (g)				
Mass of Water: Trial 7 (g)				
Mass of Water: Trial 8 (g)				
Mass of Water: Trial 9 (g)				
Mass of Water: Trial 10 (g)				
Average Mass of Water (g)				
Std Dev for the Average Mass of Water (g)				
Density of Water from Table 3 (g/mL)				
Average Volume of Water (mL)				
Std Dev for the Average Volume of Water (mL)				
Error (mL)				
Percent Error (%)				

Table 3 - Calculations: Density of Water (g/mL) vs. Temperature (°C) (from Handbook of Chemistry and Physics, 53rd Edition, p. F4)

Whole degrees are listed down the left-hand side of the table, while ***tenths of a degree*** are listed across the top.

	0.0	***0.1***	***0.2***	***0.3***	***0.4***	***0.5***	***0.6***	***0.7***	***0.8***	***0.9***
15	0.999099	0.999084	0.999069	0.999054	0.999038	0.999023	0.999007	0.998991	0.998975	0.998959
16	0.998943	0.998926	0.998910	0.998893	0.998877	0.998860	0.998843	0.998826	0.998809	0.998792
17	0.998774	0.998757	0.998739	0.998722	0.998704	0.998686	0.998668	0.998650	0.998632	0.998613
18	0.998595	0.998576	0.998558	0.998539	0.998520	0.998501	0.998482	0.998463	0.998444	0.998424
19	0.998405	0.998385	0.998365	0.998345	0.998325	0.998305	0.998285	0.998265	0.998244	0.998224
20	0.998203	0.998183	0.998162	0.998141	0.998120	0.998099	0.998078	0.998056	0.998035	0.998013
21	0.997992	0.997970	0.997948	0.997926	0.997904	0.997882	0.997860	0.997837	0.997815	0.997792
22	0.997770	0.997747	0.997724	0.997701	0.997678	0.997655	0.997632	0.997608	0.997585	0.997561
23	0.997538	0.997514	0.997490	0.997466	0.997442	0.997418	0.997394	0.997369	0.997345	0.997320
24	0.997296	0.997271	0.997246	0.997221	0.997196	0.997171	0.997146	0.997120	0.997095	0.997069
25	0.997044	0.997018	0.996992	0.996967	0.996941	0.996914	0.996888	0.996862	0.996836	0.996809
26	0.996783	0.996756	0.996729	0.996703	0.996676	0.996649	0.996621	0.996594	0.996567	0.996540
27	0.996512	0.996485	0.996457	0.996429	0.996401	0.996373	0.996345	0.996317	0.996289	0.996261
28	0.996232	0.996204	0.996175	0.996147	0.996118	0.996089	0.996060	0.996031	0.996002	0.995973
29	0.995944	0.995914	0.995885	0.995855	0.995826	0.995796	0.995766	0.995736	0.995706	0.995676
30	0.995646	0.995616	0.995586	0.995555	0.995525	0.995494	0.995464	0.995433	0.995402	0.995371

Example: to find the density of water at 16.1 °C, you would first find the whole degree by searching down the left-hand column until you reach '16'. Then you would slide across that row until you reach the column labeled '0.1'. The density of water at 16.1°C is 0.998926 g/mL