Experiment 1
Calibration of Volumetric Glassware

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CONTENTS

I. INTRODUCTION

This experiment evaluates the accuracy of three important tools used in chemistry: volumetric flasks, pipettes, and measuring cylinders. These instruments are required to achieve precise volume measurements for gravimetric and titrimetric analyses. Any inaccuracies introduced through improper calibration can lead to systematic errors that degrade the quality of the entire analysis. Therefore, careful calibration is important to minimize errors and guarantee reliable results.

The experiment involves calibrating each instrument with the help of water. We measure the mass of water each instrument contains or delivers by subtracting the empty weight from the filled weight and then converting it to volume using the known density of water at the calibration temperature. Finally, we compare the measured volume to the designed volume of each instrument to analyze their accuracy. This process allows us to identify discrepancies and implement corrections for future use.

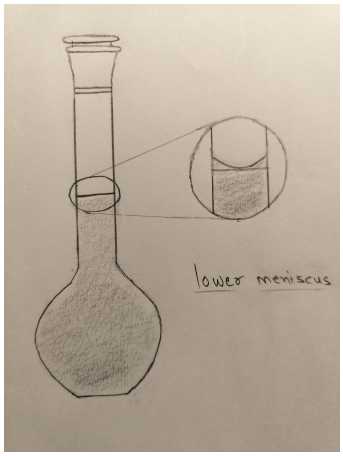

Fig. 1: Reading lower meniscus

II. EXPERIMENT DETAILS

A. Apparatus

1) Standard Pipette (10 mL)
2) Graduated Pipette (10 mL)
3) Volumetric Flask (100 mL)
4) Measuring Cylinder (10 mL)
5) Beaker (50 mL)
6) Test Tube
7) Wash Bottle
8) Weight Balance

B. Materials

1) Distilled water

C. Procedure

1) For graduated and standard pipettes and unknown volume of test tube

i Measure the empty beaker using the weight balance accurately.
ii Now, fill the glassware with water up to the mark.
iii Then, empty the glassware into the empty beaker and measure its new weight.
iv Repeat the same process twice and use tissue in between to ensure that the glassware and beaker are completely dry. And record all the measurements.
v Now, repeat the same process for the remaining glassware.

2) For volumetric flask and measuring cylinder:

i First, weigh the empty volumetric flask, measure the cylinder separately using the weighing machine, and note the readings.

ii Now, fill them to the respective marking with distilled water and measure their weight on the weighing machine.

iii Empty both the apparatus and completely dry them out using tissue paper. Make sure that no water droplet is left behind.

iv Now, fill them again, repeat the process two more times, and record all the measurements.

D. Volume calculation

To calculate the volume, we first need to subtract the empty apparatus's weight from the apparatus's total weight with water. This will give us the weight of the total water inside the apparatus. By using the formula of density,

$$\rho = \frac{m}{V} \tag{1}$$

Where m is mass in g, and V is the volume in mL.

III. Results

A. Readings

TABLE I: Table of Readings

Glassware	Empty Weight (g)	Filled Weight (g)	Difference (g)
Volumetric Flask	68.1657	167.6004	99.4347
		167.5783	99.4126
		167.5760	99.4103
Pipette	27.5615	37.5367	9.9752
		37.5440	9.9825
		37.5151	9.9536
Graduated Pipette	27.5615	37.5423	9.9808
		37.5521	9.9906
		37.5308	9.9693
Measuring Cylinder	38.6085	48.4851	9.8766
		48.4812	9.8727
		48.4768	9.8683
Test Tube	27.5615	38.7847	11.2232
		38.7969	11.2354
		38.7991	11.2376

The density of distilled water at room temperature was given to be $0.997 g/mL$.

B. Calculations

Using the formula for volume,

$$V = \frac{m}{\rho} \tag{2}$$

For the unknown volume test tube,
Standard deviation is given by,

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(V_{mean} - V_i)^2}{n}} \tag{3}$$

Mean:

$$V_{mean} = \frac{11.223 + 11.235 + 11.238}{3} \tag{4}$$

TABLE II: Error Calculation

Glassware	Volume (mL)	Average volume (mL)	Absolute Error (mL)	Error Percentage (%)
Volumetric Flask (100 mL)	99.734	99.718	0.282	0.282
	99.712			
	99.709			
Pipette (10 mL)	10.005	10.004	0.004	0.04
	10.012			
	9.994			
Graduated Pipette (10 mL)	10.011	10.007	0.007	0.07
	10.021			
	9.999			
Measuring Cylinder (10 mL)	9.906	9.902	0.098	0.98
	9.902			
	9.898			

$$V_{mean} = 11.232\ mL \tag{5}$$

Variance:

$$\begin{aligned}\sigma^2 = \frac{1}{3} \times [&(11.223 - 11.232)^2 \\ &+ (11.235 - 11.232)^2 \\ &+ (11.238 - 11.232)^2]\end{aligned}$$

$$\sigma^2 = 0.000126\ mL^2 \tag{6}$$

Standard deviation:

$$\sigma = 0.011\ mL \tag{7}$$

IV. Conclusion

In this experiment, we calibrated the tools for measuring volume, such as a pipette, volumetric flask, test tube, etc. To check the volume, we measured the weight difference between filled and empty glassware three times, got their average, and calculated the error percentage with the known volume. The error percentage for the volumetric flask was 0.282 %, for the pipette was 0.04 %, for the graduated pipette was 0.07 %, and for the measuring cylinder was 0.98 %. We also found out the volume of an unknown test tube, which came out to be 11.232 mL with a standard deviation of 0.011 mL.

V. Reading Image

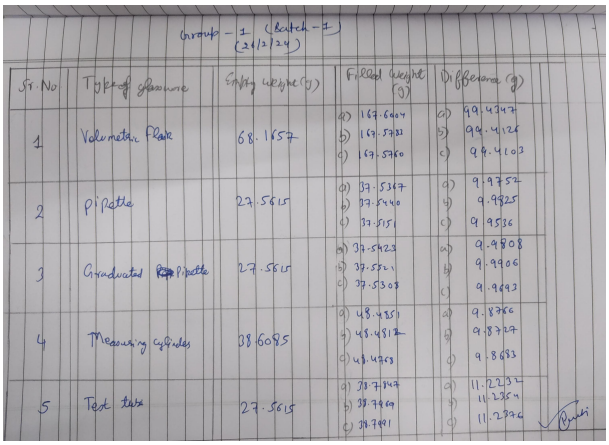

Fig. 2: Reading Image

VI. Author Contribution

Name	Contribution	Signature
Jaskirat Singh Maskeen (23110146)	Document structure, Results, Calculations and Conclusion, Handling pipette (and its readings)	
Nishchay Bhutoria (23110222)	Introduction, Handling volumetric flask (and its readings)	
Aayush Bundel (23110005)	Experimental details, Handling measuring cylinder	
Kavya Lavti (23110164)	Experimental details, Handling graduated pipette	
Kanhiyalal (23110155)	Diagram, Handling unknown test tube	