

Name
Instructor
AP Chemistry, Period
Date

Determination of the Density of a Wood Sample Lab Report

I. Introduction/Purpose:

To determine the density of a wooden sample using a restricted number of materials to the best accuracy possible. The density of an object is $\rho = \text{mass}/\text{volume}$. The concept of Archimedes Principle was used to determine the mass and volume. When an object is freely floating, the mass of the displaced liquid is equal to the mass of the object. By re-arranging density = mass/volume, it can be shown that mass = density x volume. Since the density of water is equal to 1.0 g/ml, then the volume of the displaced water is equal to the mass of the object. When an object is fully submerged, the volume of the water displaced is equal to the volume of the object.

II. Materials:

Wood sample (Popsicle stick), Large test tube, water, dropper (pipette), pen, felt marker, a 10 ml graduated cylinder, a 100 ml graduated cylinder, and an electronic balance.

III. Procedures and Data Collection:

III. A. Calibration of the Pipette

Four volumes, 0.5, 1.0, 2.0, and 3.0 ml, were chosen to calibrate the pipette with. Draw water into the pipette and count each drop as it fills the graduated cylinder. Once it has reached the desired volume, record the number of drops. For each volume, the experiment was performed in triplicate. The results are shown in Table 1. The calibration curve of average volume vs. drops is obtained by linear regression using Microsoft Excel.

Table 1: Number of drops of water from the pipette vs. volume (ml).

Experiment #	Drops of water from pipette	Volume (ml)
1	33	0.50
1	33	0.47
1	33	0.45
2	65	1.00
2	65	1.04
2	65	1.10
3	130	2.00
3	130	2.12
3	130	2.02
4	195	3.00
4	195	3.11
4	195	2.97

III. B. Determination of the Mass of the Wood Sample by the Dropper Method

Once the pipette has been calibrated, fill the large test tube with water and mark the water level with the felt marker on the test tube. Next, gently place the floating Popsicle stick inside the test tube, which causes the water to rise, and mark the new water level. Carefully pipette the water displaced between the two marks into an empty test tube. The volume of the displaced water is measured by counting the drops of water from the pipette into the other test tube. Each experiment is performed in triplicate. The volume of the drops of water is determined from the calibration curve. The mass was calculated by multiplying the volume with the density of water (1.0 g/ml)

Table 2: Number of drops of the volume of water displaced by the floating Popsicle stick.

Experiment #	Drops of water displaced by the floating popsicle stick (Mass Determination)
1	95
2	98
3	110

III. C. Determination of the Volume of the Wood Sample by the Dropper Method

Fill the large test tube again and mark its water level. Completely submerge the Popsicle stick by pushing it down gently with a pen and mark the new water level. Carefully pipette the water displaced between the two marks into an empty test tube. The volume of the displaced water is measured by counting the drops of water from the pipette into the other test tube. Each experiment was performed in triplicate. The volume of the drops of water is determined from the calibration curve.

Table 3: Number of drops of the volume of water displaced by the fully submerged Popsicle stick.

Experiment #	Drops of water displaced by the submerged popsicle stick (Volume Determination)
1	140
2	137
3	148

III D. Determination of the Density of the Wood Sample using an Electronic Scale and a Graduated Cylinder

First, place the Popsicle stick on the electronic scale and record the measured value. Then, fill a larger 100 ml graduated cylinder with water and mark its level. Completely submerge the Popsicle stick by pushing it down gently with a pen and mark its new level. The difference in the water level is the volume of the Popsicle stick. Repeat the experiment in triplicate to obtain the mass and volume needed to determine the density.

Table 4: Volume, mass, and density of the Popsicle stick using more precise instruments.

Experiment #	Volume by Grad. Cylinder (ml)	Mass by Scale (g)	Density (g/ml)
1	2.5	1.574	0.63
2	2.5	1.574	0.63
3	2.5	1.574	0.63
Average Density			0.63

IV. Results and Discussions

The result of the average volume corresponding to its respective number of drops is shown in Table 5. The calibration curve of the average volume vs. number of drops obtained by linear regression is shown in Figure 1. The equation of average volume vs. number of drops is $y = 0.0153x$. Where y represents volume in ml and x represents the number of drops.

Table 5: Average volume corresponding to its respective number of drops. SD represents the standard deviation.

# of Drops	Average Volume \pm SD
0	0
33	0.47 ± 0.03
65	1.05 ± 0.05
130	2.05 ± 0.06
195	3.03 ± 0.07

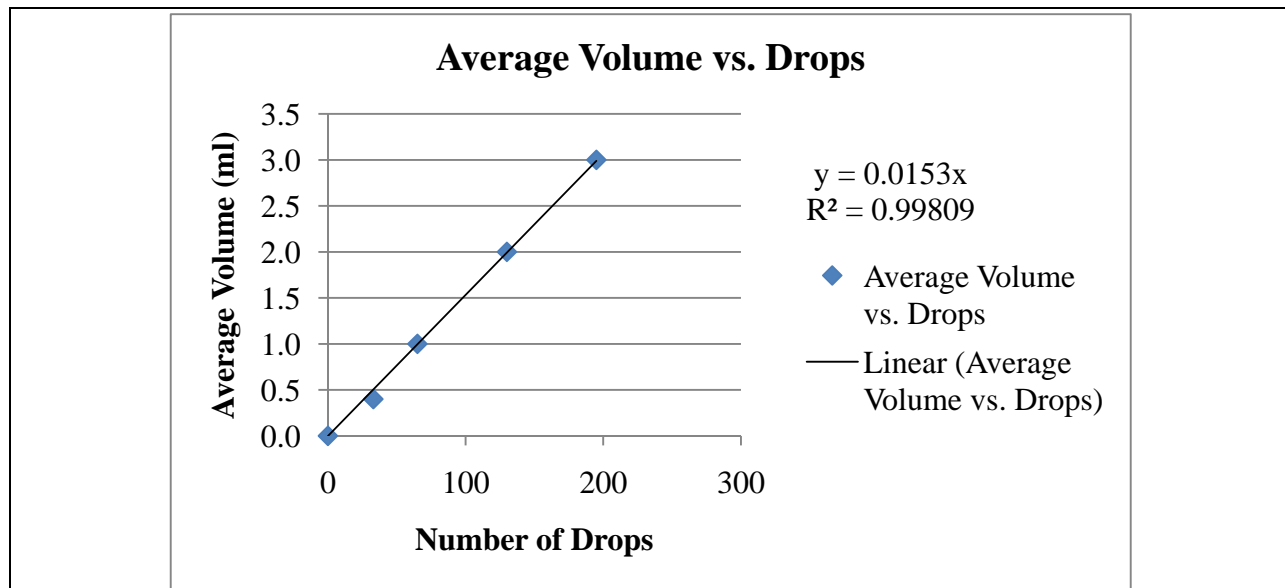


Figure 1: The calibration curve of the average volume vs. number of drops.

It is shown that the volume is proportional to the drops with a good correlation coefficient (R^2) of 0.998. Because of the high R^2 value, it is safe to use the equation $y = 0.0153x$ to convert drops to volume in ml. For example, in the case of experiment 1, when $x = 95$ drops, the volume = $95 \times$

0.0153 = 1.45 ml and its mass = 1.45 x 1 (density of water) = 1.45 g. The corresponding density to experiment 1 is 1.45/2.14 = 0.68 g/ml.

The volume, mass, and density of the Popsicle stick in their respective units are shown below in Table 6.

Table 6: Volume, mass, and density calculated using the equation obtained by linear regression.

Experiment #	Volume (Fully Submerged)		Mass (Freely Floating)		Density (g/ml or calculated mass/ calculated volume)
	Drops	Calculated Volume (ml)	Drops	Calculated Mass (g)	
1	140	2.14	95	1.45	0.68
2	137	2.10	98	1.50	0.71
3	148	2.26	110	1.68	0.74
Average Density					0.71 ± 0.03

Table 7: Calculated density for each of the experiments. (Assuming the accepted value of the density of the Popsicle stick is the density obtained by the scale and graduated cylinder method.)

Experiment #	Density by drops (g/ml)	Density by Scale and Grad. Cylinder (g/ml)	Relative Error
1	0.68	0.63	
2	0.71	0.63	
3	0.74	0.63	
Average Density	0.71 ± 0.03	0.63	12.7%

The relative error is equal to the [(measured – standard) / (standard)] x 100. The measured is equal to the experimentally obtained value and the standard in this case is assumed as the value of the density obtained by scale and graduated cylinder.

Calculation of relative error:

$$[(0.71-0.63)/(0.63)] \times 100 = 12.7\%$$

The precision of the experiment is limited to the precision of the 10 ml graduated cylinder used to calibrate the pipette. The 10 ml graduated cylinder had a precision up to ± 0.01. This explains why the density is only listed up to 2 decimal places. The average density is 0.71 ± 0.03. The experiment by the dropper method measured the value of the density with a good precision as shown by the low standard deviation. However, the dropper method to measure the density was not very accurate with a relative error of 12.7%.

Table 8: Average calculated densities of the other groups' Popsicle sticks.

Group #	Average Densities (g/ml)
1	0.65
2	0.53
3	0.57
4	0.56
5	0.59
6	0.67
7	0.66
8	0.70
9	0.71
10	0.75
11	0.83
12 (This experiment)	0.71 ± 0.03
Overall Average Density	0.66 ± 0.09
Relative Error (Overall to Standard)	4.8%

Comparing the standard deviations of our dropper method experiment to the overall average, ours is more precise because of the lower standard deviation. However, the overall average was more accurate compared to our experiment because of the lower relative error of 4.8% instead of 12.7%.

V. Sources of Error

A main source of error found in calibrating the pipette was that it was immensely difficult to count each drop the pipette squirted out. As the numbers increased, the harder it became to count and make sure each drop was separate from another. Another source of error was the Popsicle stick absorbing water and getting wetter and wetter. This served as two problems. Firstly, the Popsicle stick was getting heavier and heavier and therefore denser. Second, if the Popsicle stick were kept inside the test tube too long, it would absorb water in the test tube and change the water level. One more potential source of error was that in order to calculate the volume of the object, it needed to be fully submerged in the water. However, since the density of the Popsicle stick was less than 1, it didn't automatically submerge itself. Since it needed to be pushed down, there was a small chance of error. The one instrument or method that was prone to the greatest uncertainty was the pipette. Since it was not a direct measurement, there was a lot of room for error. Instead of directly measuring the displacement in water, the pipette needed to be calibrated and drops needed to be counted.

VI. Conclusion

The dropper method experiment used to determine the density yielded a high precision but with a somewhat low accuracy with a relative error of 12.7%, compared to the scale and graduated cylinder method. It is less accurate due to the many errors in the dropper method used. In contrast, the scale and graduated cylinder method has less sources of errors because of less manipulation and more direct measurement. In this case, it would be simpler to use the scale and graduated cylinder method to determine the density instead of using the dropper method.