Experiment 2: The Density of Liquids and Solids

Lab report structure:

Part A: The Density of Water

Part B: The Density of Aluminum and the Thickness of Foil

Part C: Graphical Analysis of Mass and Volume Data of an Unknown Solid

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1 Introduction

1.1 Experiment A

Density is a way that describes how much mass is inside a volume. It is a property of matter that can be measured in wany ways. In this experiment in part A, the density of water will be calculated by measuring the volume of a certain amount of liquid and measuring the weight of the same liquid. Getting the mass of the liquid will involve measuring it with an electronic scale, and the volume of liquid will be measured with a cylinder. With the mass and volume of the liquid water measured, the density can be measured using this equation. $Density(\frac{g}{mL}) = \frac{Mass(g)}{Volume(mL)}$. The g unit represents the mass in grams while the mL unit represents the volume in milliliters or centimeters cubed. With these mass and volume measured the density of the liquid can be found.

1.2 Experiment B

In part B of the experiment instead of the density water that needs to be found, the density of an aluminum piece and the thickness of an aluminum foil will be calculated instead. Again, the mass and volume of the object needs to be measured to calculate the density of that object. The mass itself can be found in the same way in experiment A by measuring the object using an electric scale. However, measuring the volume of a piece of aluminum is trickier. As the piece of aluminum is not a liquid it cannot be measured by only using a graduated cylinder. Instead, the aluminum piece will be measured using Archimedes' principle where it says that an object that is immersed in a fluid displaces the same amount of the volume it took up. Using this principle to measure the piece, first the volume of a liquid would be measured without the object inside and with the object placed inside and the difference of the two would be the volume of the piece. With the mass and the volume of the piece measured the density can be calculated. To calculate the thickness of the aluminum foil, the area and mass of the aluminum foil needs to be measured. Using the mass, area of the foil and the density of aluminum, using this equation $Volume = area * thickness$. The volume is equal to the mass times the 1/the density (mL/g) which will cancel out the mass and leave out the volume. After finding out the volume the only variable would be thickness, which could be solved for.

1.3 Experiment C

In experiment C of the lab an unknown solid's density will be measured and by comparing that density to known density of objects the unknown solid's identity will be found. The density of this object will be calculated in a different way than part A and B. First off, the object will be in four different sizes of a cylinder and each of the masses will be measured using an electronic scale. Instead of using a graduated cylinder to measure the volume the length and diameter of the cylinder will be measured. To calculate the volume, the equation for the volume of a cylinder will be used, $Volume = \pi(\frac{d}{2})^2 * h$. Where the d represents the diameter, and the h represents the height. To get the density of this object the mass and the volume will be graphed, and the slope of the graph will represent the density of the object. To get the slope the equation is used, $m = \frac{y2-y1}{x2-x1}$. Using this formula the density of the object can be calculated.

2 Experimental

2.1 Materials

The materials needed in this experiment are a 250-mL breaker, 100-mL graduated cylinder, a metric ruler, an aluminum metal-piece, plastic weigh boat, aluminum foil, a thermometer, electronic balance, water, 4 unknown solid cylinders, and an electronic cylinder.

2.2 Safety

For safety when adding the aluminum cylinders to the graduated cylinder, don't drop it in as it could break the cylinder due to its weight but tilt the graduated cylinder to allow the aluminum cylinder to slowly slide down. Also, when dumping the water out of the graduated cylinder make sure to catch the aluminum so it doesn't hit the ground. There are no chemicals used in the entire experiment.

2.3 Methods (Exp A)

First using the 250 mL breaker fill it with water and record its temperature using a thermometer. Next measure the 100-mL graduated cylinder mass in grams using an electronic scale in three decimal places. Next add twenty to twenty-five mL of water to the 100-mL graduated cylinder from the 250 mL beaker. Measure the mass of the 100-mL beaker with the water using the electronic scale and measure the volume in mL by one decimal place. Do this process two more times but do not empty the 100-mL cylinder. The first take should be 20-25 mL, the second 40-50 mL and lastly 60-75 mL. Now for the calculations, to get the mass of the only water the mass of the empty cylinder and the mass of the cylinder plus water must be subtracted. Now using the mass and the volume of the water the density of water can be calculated using the density formula. Once the density of water is calculated for each trial the average of the three should be calculated. Using this value find the accepted value for the density of water using the same temperature recorded and get the percent error to determine how off the accepted value is from the experimental value.

2.4 Methods (Exp B)

For part B of this experiment, measure the mass of the empty plastic boat and the mass of the plastic boat with the aluminum piece. The difference of these two values would get the mass of the aluminum piece. Next using the water from the 100 mL graduated cylinder first measure the volume without the aluminum piece and with the aluminum piece. The difference between the two would be the volume of the aluminum. Next using the mass and volume of the aluminum find the density. From the experimental density compare it the true value of density and got the percentage error. Next to calculate the thickness of the aluminum foil first measure the length and the width of it using a metric ruler. Next measure the mass of it. Using the area, mass of the foil and the density of aluminum, the thickness of the foil can be calculated.

2.5 Methods (Exp C)

For part C of the experiment, first measure the mass of each of the four unknown cylinders. Next measure the diameter and the length of each cylinder and get the calculated volume using the formula for the volume of a cylinder. Next plot the mass verses the volume on a scatterplot and the slope of the graph would be the density of the unknown cylinder. Using this density, match the density from known values of solids and figure out what the name of the unknown solid is.

3 Results

3.1 Part A:

The mass of the water was found by subtracting the mass of the empty cylinder by the mass of the empty cylinder with water. Next the Density of water was found by dividing the mass of the water by the volume of water.

Part A	1st Water Addition	2nd Water Addition	3rd Water Addition
Mass of Empty Cylinder (g)	13.269	13.269	13.269
Mass of Empty Cylinder + water(g)	37.015	61.525	88.05
Mass of Water (g)	23.746	48.256	74.781
Volume of Water (mL)	24	48.5	75.5
Density of Water (g/mL)	0.989	0.995	0.990
Average Density of Water (g/mL)	0.992		
True Density of Water at 21.7c (g/mL)	0.998		
Percent Error	0.639%		

3.2 Part B:

The mass of the Al piece was calculated by subtracting the mass of the empty weigh boat by the mass of weigh boat and AL piece. The volume of the Al piece was found by subtracting the initial and final volume of water. Lastly the density of Aluminum was found by the mass of the AL piece divided by the volume of the AL piece.

Part B Table 1	Values
Mass of Empty Weigh boat (g)	2.735
Mass of Weigh boat and AL piece (g)	32.201
Mass of Al piece (g)	29.466
Initial volume of water (mL)	30.5
Final Volume of Water (with AL piece) (mL)	41.5
Volume of AL piece (mL)	11
Density of Aluminum (g/mL)	2.679
True Density of Aluminum (g/mL)	2.702
Percent Error	0.861%

For table 2, the thickness of the foil was calculated by finding the volume of the foil by multiplying the mass of the foil by the inverse of the true density aluminum. Now with the volume of the foil the thickness could be found by using the equation for the volume of the cube. Which is V = length * width * thickness. Since we have only one variable thickness. The value of thickness can be solved.

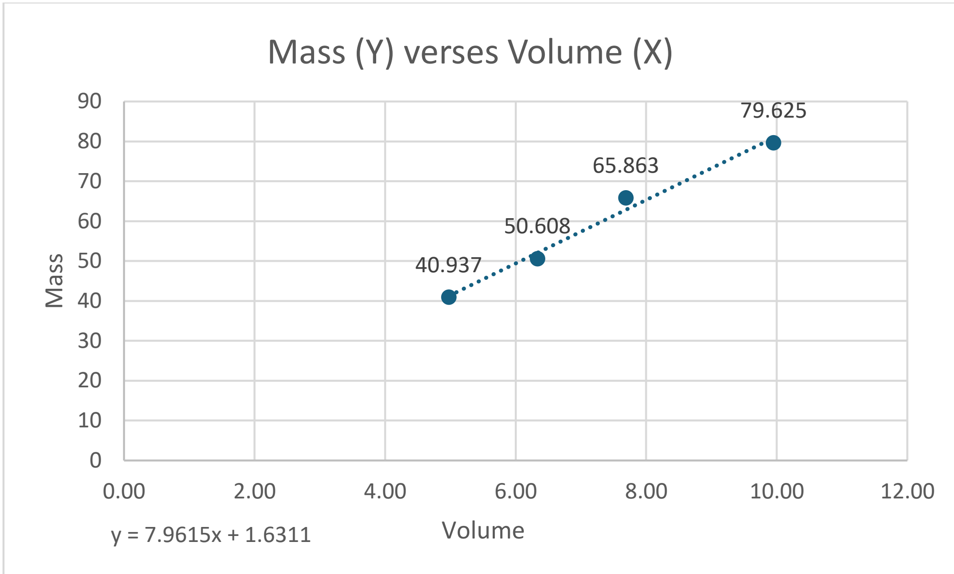
Part B Table 2	Values
Mass of Al Foil (g)	0.253
Length of Al Foil (cm)	5.35
Width of Al Foil (cm)	7.75
True Density of Aluminum	2.702
Thickness (cm)	0.00226

3.3 Part C:

For part C to get the volume of each cylinder, the volume of a cylinder equation must be used, $Volume = \pi(\frac{d}{2})^2 h$. Where d is the diameter and h are the height.

Trials id T1	Diameter(cm)	Length (cm)	Volume (mL)	Mass (g)
1	2.4	1.1	4.98	40.937
2	2.4	1.4	6.33	50.608
3	2.4	1.7	7.69	65.863
4	2.4	2.2	9.95	79.625

The mass vs volume is plotted to get the density of the unknown cylinder which is the slope. To get the slope, the slope formula was used $m = \frac{y2-y1}{x2-x1}$. The density of the unknown metal is 7.96 g/Ml. Which is very comparable to steel where the true density of steel was at 7.85 g/Ml.



4 Discussion / Analysis

4.1 Part A:

In part A of the experiment the true density of water was made by measuring the mass and volume of water in a graduated cylinder. The values of density that were got is 0.989 g/mL, 0.995 g/mL, and 0.990 g/mL, with an average density of 0.992 g/mL. The accepted density of water at 21.7°C is 0.998 g/mL, leading to a percent error of 0.639%. The results are very accurate when compared to the accepted values, however some factors that might have made the small error are the variation in the instruments like the electronic balance and the thermometer. Secondly, human errors such as measuring the temperature of the water only once for the three trials as the temperature could have changed through the trials and error in measuring the volume in the graduated cylinder.

4.2 Part B:

In part B of the experiment the density of the aluminum block was calculated by measuring mass of an aluminum piece and its volume using the water displacement method. The experimental density of aluminum was found to be 2.679 g/mL, compared to the true density of aluminum (2.702 g/mL), giving an error rate of 0.861%. Some reasons why there might be a disparity between the experimental and the accepted values are again the electronic balance and the human error in measuring the graduated cylinder. However, the biggest error would be not measuring the temperature of the Aluminum as the temperature would affect its density. If the density of the aluminum was measured it would have to be after it was dunked in water as that might change the temperature of the Aluminum.

For the thickness calculation of aluminum foil, using the equation for volume ($V = L \times W \times T$) and rearranging to solve for thickness, the value was determined to be 0.00226 cm. There is not an accepted value to compare the experimental value to. However, despite this this value should be very accurate as the above experimental values were very close to the actual value. Some ways the calculation could be off would the human error in measuring it's length and width and machine error in measuring it's weight.

4.3 Part C:

In Part C, we calculated the density of an unknown metal by measuring the mass and volume of cylindrical samples and plotting a graph of mass versus volume. The slope of the line, which is the experimental density of the unknown metal, is 7.96 g/mL which is very close to steel 7.85 g/mL. Since steel is an alloy, it contains different metal elements in it. Because of this steel, there are different types of steel with different elements and thus different densities. Despite this steel was the closest comparison of the unknown metal as it has a .16 g/mL difference. Some ways the experiment could have the wrong result are the temperature as the metal was measured of its temperature. Human errors such as measuring the length and diameter of the cylinders and machine error in the electric balance. In addition of the plotted graph equation, $y = 7.9615x +$

1.6311, ideally the constant of 1.63 should not exist, the existence of this constant in the equation implies that there is some error in the experiment. When the mass is zero the equation should not be 1.63 volume.

5 Conclusions

To conclude, density of water, aluminum, and an unknown metal was found using various methods. In Part A, the experimental density of water (0.992 g/mL) was found to be very close to the true density, with a percent error of 0.639%. In Part B, the density of aluminum was calculated as 2.679 g/mL, with a percent error of 0.861%, while the thickness of aluminum foil was accurately measured using its dimensions and mass. Lastly, in Part C, the density of an unknown metal was determined to be 7.96 g/mL, closely matching the accepted density of steel (7.85 g/mL). Overall, the experiment demonstrated the accuracy and effectiveness of the methods used, with low percent errors in all parts, confirming the reliability of the results.

6 Acknowledgements

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7 References

8 (1) Brown, T. L., LeMay, H. E., Bursten, B. E., Murphy, C. J., Woodward, P. M., Stoltzfus, M., and Lufaso, M. W. (2018) Chemistry: The central science. Pearson, London.