TESTING A METHOD FOR FINDING DENSITY OF A LIQUID

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Introduction

A physical property of a substance is one that can be determined without causing a substance to undergo a chemical change (Wolfe et al., 1999). Density is a physical characteristic that is considered characteristic to a particular substance; this means that it can be used as an identifying property, since it is unique to each substance (Barker et al., 2010).

Density is defined as the mass of matter that is contained within a given volume. It is typically measured in grams per millilitres (g/mL) and can be calculated using the formula $D = m/V$, where D represents density, m represents mass in grams, and V represents volume in millilitres (Barker et al., 2010). It represents a constant relationship between mass and volume, and does not depend on the total quantity of the sample.

The mass of a sample of liquid should increase as the amount (volume) of that liquid is increased. It has been suggested that graphing mass against volume of a liquid is a valid method of determining its density (Institute of Physics, 2007). The slope of a line is defined as the ratio of rise (y values) to run (x values) ("Slope of a Line", 2009). In the case of the mass vs. volume plot, the rise has a unit of grams, while the run has a unit of millilitres. The slope for each plot, therefore, has a unit of grams per millilitre, the same unit of measure as that of density. The purpose of this lab investigation was to evaluate whether this method is accurate. It is hypothesized that this technique will indeed produce an accurate estimate of density.

Materials

- Tap water

Apparatus

- 10-mL graduated cylinder
- 250-mL beaker
- 250-mL Erlenmeyer flask
- medicine dropper x2
- balance

Procedure

1. The mass of the empty beaker was recorded.
2. 10 mL of water was measured out in the graduated cylinder and transferred to the beaker. The mass of the beaker with water was recorded.
3. Step 2 was repeated four more times, until a total volume of 50 mL had been transferred into the beaker.
4. The beaker was emptied. Steps 2 and 3 were repeated, using vegetable oil instead of water.

Observations

Mass of empty beaker = 107.0 g

Table 1. *The mass of beaker, with several volumes of water.*

Volume of water (mL)	Mass (g)
10	117.1
20	125.7
30	134.4
40	143.4
50	153.3

Analysis

Table 2. *The mass of each volume of water. Masses were calculated by subtracting the mass of the empty beaker from the total mass of the beaker and water.*

Volume of water (mL)	Mass (g)
10	10.1
20	20.0
30	29.9
40	40.2
50	50.4

<u>Sample calculation</u>: *Mass of 10 mL of water*

Mass of water = (Mass of beaker + water) – (Mass of empty beaker)
= 117.1 g – 107.0 g
= 10.1 g

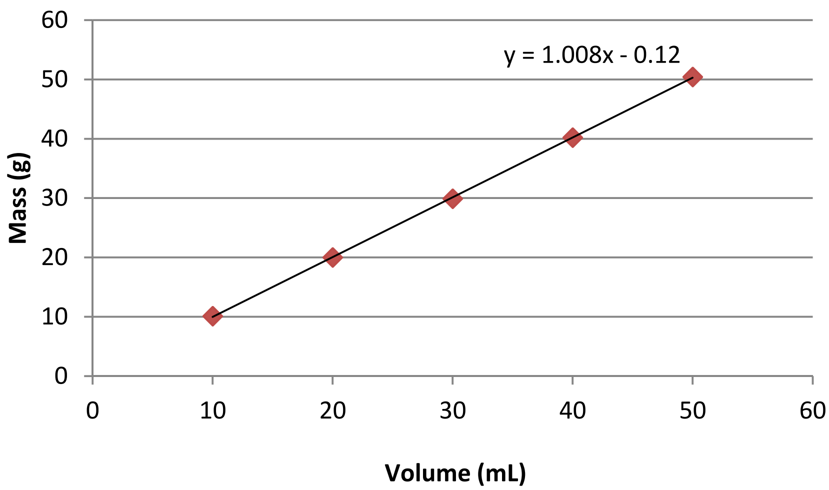

Figure 1. Scatter plot of the masses of five volumes of water, the values of which are provided in Table 2. The line on the plot is the line of best fit; the equation of the line indicates that the slope of the line is 1.008 g/mL.

Discussion

Plotting mass against volume of water produced a linear plot, which showed mass increasing as volume increased. The line of best fit for the data points provided a slope value of 1.008 g/mL.

Comparing the slope values obtained from the data to reference density values supports the hypothesis that graphing is a valid method of finding density. The accepted value for the density of water at 25°C is 0.997 g/mL (Walker, 1998), while the experimentally-obtained value for water was 1.008 g/mL, a difference of 1.1%. Although the percentage error is within the margin of acceptable error, possible sources of the discrepancy may lie in experimental error during the measurement of liquid volume. Additionally, the experiment was performed at a temperature higher than that listed in the literature, which may have had the effect of lowering the water's density. Out of convenience, tap water was used, instead of pure water. Tap water contains solutes such as chlorine and aluminum (City of Toronto, n.d.). It is possible that these impurities in the tap water may have had an effect on the density.

This technique can be applied to any substance, regardless of state of matter. It is useful because it makes use of differing volumes of sample, which demonstrates that density is a property that remains constant, no matter the size of the sample. The line of best fit can also be used to extrapolate or interpolate the masses of volumes that have not actually been measured.

Conclusion

Density is defined as the mass per unit volume of a substance, and can be calculated according to the formula $D = m/V$. In this experiment, determining the slope of a graph of mass against volume yielded a slope of 1.008 g/mL for water. This values is sufficiently close enough to the accepted literature value to support the hypothesis that this method is a valid alternative for finding density.

Works cited

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