Your Name Chemistry
Date Teacher, Section #

Density, An Intensive Property

Introduction This lab will investigate the intensive property, density.

Purpose To utilize an intensive property (density) in order to identify various materials and to investigate the difference between physical and chemical changes.

Background Information

Physical properties of substances are characteristics that can be observed or measured without changing the composition of the substances in the material. Some physical properties only deal with amounts. These are called extensive properties because they measure quantities like volume, mass, and weight. Other physical properties are useful in identifying a substance. These are called intensive properties (e.g. melting point, boiling point, solubility and density) and to distinguish different elements or compounds.

Density is the ratio of the mass of a substance to its volume and can be expressed mathematically as: $d = m/v$, where "d" is density, "m" is mass, and "v" is volume.

Density can be used to test the purity of a substance as well as distinguish one material or substance from another. In other words, density is an important intensive property used to identify materials or substances. Water has a density of 1.0 g/ml while vegetable oil has a density of 0.9 g/ml. This means one will float on the other due to a difference in their densities.

In order to determine density, volume must be measured. Therefore, density is found in three ways: 1) regularly shaped solids (L x W x H) in cubic units, 2) direct volume measurement in a graduated cylinder, and 3) water displacement for irregularly shaped solids. In this lab, we used direct volume and water displacement.

This lab includes determination of the density of 4 substances and predict the order these substances will take on if mixed together.

Hypothesis

If the mass and volume of four substances (water, oil, wood, and copper) are obtained, then the density of each can be determined.

If water, vegetable oil, and copper coins are mixed together, then they will separate out according to their densities as shown was confirmed. Copper coins have the greatest density and would be at the bottom. Vegetable oil has the lowest densities and would float on the top.

Vegetable oil
Water
Copper coins

If a diet pop can and a regular pop can are submersed in water, then the diet pop can will float and the regular pop can will sink due to density. The diet pop is less dense.

Materials			
	Metric ruler	100 ml Graduated Cylinder	Mass Balance
	Water	Vegetable Oil (yellow)	10 pennies / copper coins
	Small wood block	12 oz. Diet Pop	12 oz. Regular Pop

Procedures

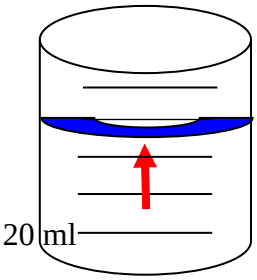
A. Finding Volumes

Use THREE (3) different techniques to determine volume.

1. **<u>Direct Measurement</u>** of a **<u>liquid</u>** using the 100 ml graduated cylinder (ml).

Read the volume **measurement** shown on the graduated cylinder (*see sketch to the right*) by looking at the **meniscus** (*bottom of the "bubble"*).

The reading to the right is ~22.5 ml. The last number (".5") is an estimate and may vary within reason.



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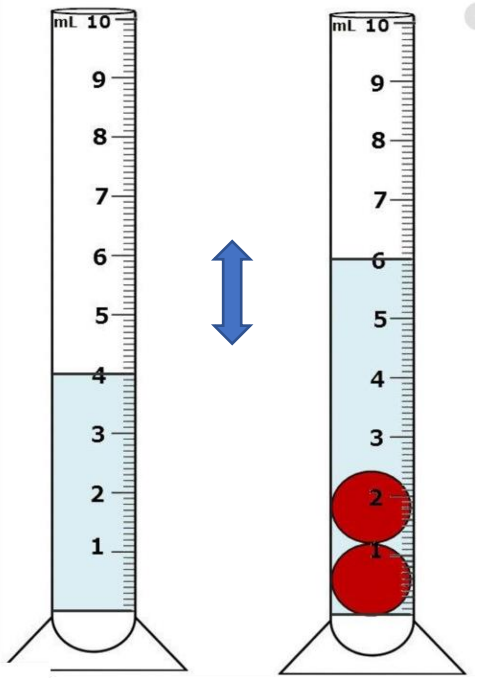
2. **<u>Regularly Shaped</u> <u>Solids</u>**: Measure the Length (longest side) and the width (opposite length) and the height of a regularly shaped solid like the small block of wood. Then, multiply length (L) times width (W) times height (H) to get the cubic volume (cm^3). cm^3 = ml.

L (cm) **x** **W** (cm) **x** **H** (cm) = ____ cm^3



3. **<u>Water Displacement</u> for NON-regularly shaped <u>solids</u>.**

a. Add a known amount of water to the graduated cylinder.

b. Read the volume to the nearest 0.1 ml (e.g. 4.0 ml to the left).

c. Gently add the copper coins to the graduated cylinder (to avoid water splashing out).

d. Read the meniscus of the water in the graduated cylinder (e.g. 6.0 ml).

e. Subtract the original volume of water in the cylinder to determine the volume of the substance.

(6.0 ml – 4.0 ml = **2.0 ml**)

B. Finding Mass

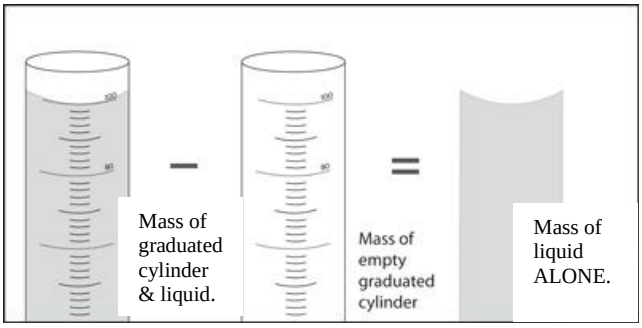
The following are TWO (2) different techniques to determine the mass of a substance.

1. **Direct Measurement** of a **solid** using the mass balance (grams).

   a. Protect the mass balance, add a filter paper or something to keep the surface clean. Then, "zero" the balance so as NOT to include the mass of the paper with the mass of the substance.

   b. Read the mass of the **solid** shown on the balance to the nearest TENTH of a gram (e.g. 16.4 g).

2. **NON-Direct Measurement** of a **liquid** using the 100 ml graduated cylinder and the mass balance (grams).



   a. Find the mass of the graduated cylinder ALONE.

   b. Find the mass of the graduated cylinder AND the liquid (water or vegetable oil) combined.

   c. Subtract the mass of the EMPTY graduated cylinder FROM the mass of the graduated cylinder AND liquid (water or vegetable oil) combined.

   d. Express the mass of the liquid ALONE to the nearest TENTH of a milliliter.

C. Procedures for the Density Lab

1. Determine the mass of the DRY, EMPTY Graduated Cylinder before doing any other measurements. Record this mass in the Calculations and Data section above the data table.
2. Find the mass of the 10 **copper coins** using the mass balance. Record this mass in the Calculations and Data section in the data table.
3. Find the mass of the **wood block** using the mass balance. Record this mass in the Calculations and Data section in the data table.
4. Measure the length (longest side), the width (opposite longest side), and the height of the **wood block**. Record these measurements in the Calculations and Data section below the data table.

5. Add a specific amount of **water** to the graduated cylinder that is an exact multiple of 10 ml (e.g. 20.0 ml, 30.0 ml, 40.0 ml).
   a. Read and record this volume in the Calculations and Data section in the data table.
   b. Place the graduated cylinder with the water on the mass balance. Record this mass in the Calculations and Data section in the data table.
6. Carefully/Slowly add the 10 **copper coins** (*to avoid water splashing out of the graduated cylinder*) and read the NEW volume to the nearest 0.1 ml. Record this volume in the Calculations and Data section in the data table.

7. Dry out the graduated cylinder as best as possible.
8. Add an amount of **vegetable oil** to the graduated cylinder between 10.0 and 20.0 ml. Read and record this volume in the Calculations and Data section in the data table.
9. Place the graduated cylinder with the vegetable oil on the mass balance. Record this mass in the Calculations and Data section in the data table.

10. Add a drop of food coloring to a small glass of water (at least 20 ml). SLOWLY / CAREFULLY pour the colored water into the graduated cylinder that contains the vegetable oil.
    a. The amount of water added does not have to be exact or recorded, but should occupy at least 20 ml in the graduated cylinder.
    b. SLOWLY add ONE of the copper coins to the graduated cylinder.
    c. Record observations in the Calculation and Data section.
11. Take a picture or draw a sketch of what is in the graduated cylinder. Especially note the layers of the substances.

D. Real Life Application: Observing the effect of the density difference between Diet Versus Regular Pop.1. Obtain a 12 ounce (355 ml) can of Pepsi or Coke, and a 12 ounce can of Diet Pepsi or Diet Coke (any diet brand should work).
   2. Determine the mass of the soda pop cans and record on the data table in the calculations and data section.
   3. Calculate the density of diet and regular pop.
   4. Obtain a large pitcher or container that can completely submerse the cans. Fill the large container with water, leaving about 2 inches from the top. The water should be deep enough to easily tell which cans are floating and sinking.
   5. Slowly place each can into the water one at a time. Record observations.
   6. Take a picture of the results and include it in the Calculations and Data section.

Refer to the "Density Lab: An Intensive Property" worksheet from Study Place, week 5-6.

Calculations and Data

Mass of the EMPTY Graduated Cylinder: **120.2 g**

Density Data Table

	Mass of grad cyl	Mass of cyl + substance	Mass of substance	Volume (grad cyl)	Volume (L x W x H)	Density	Identity of Substance
1	120.2 g	129.3 g	9.1 g	10.0 ml		0.9 g/ml	Vegetable Oil
2			146.5 g		244.2 cm^3	0.6 g/cm^3	Wood Block
3	120.2 g	151.6 g	31.4 g	31.1 g		1.0 g/ml	Tap Water
4			28.8 g		4.1 ml	7.0 g/ml	10 copper coins

1. For the wood block #2 … show work for calculating the volume

length x width x height = ____ cm^3

2. For 10 copper coins … show work for calculating the volume

(Volume of grad cyl, water, coins) - (Volume of grad cyl with water) = ____ ml

3. Show Work for Calculating the Density of each substance (to the nearest tenth):

   a. Vegetable Oil #1

   9.1 g / 10.0 ml = 0.9 g/ml

   b. Wood Block #2

   146.5 g / 244.2 cm^3 = 0.6 g/ cm^3

   c. Water #3

   31.4 g / 31.1 ml = 1.0 g/ml

   d. Copper Coins #4

   28.8 g / 4.1 ml = 7.0 g/ml

   e. Diet Pop

   355 g / 355 ml = 1.0 g/ml

   f. Regular Pop

   394 g / 355 ml = 1.1 g/ml

The following image shows the measurement of the 10 copper coins on a mass balance.

The 10 copper coins had a mass of 25.0 g, as part of determining the density of the coins.

The following image shows the layering of water, vegetable oil, and a copper coin based on density:

The copper coin was most dense and therefore, sank to the bottom. Vegetable oil is less dense than water so it floats on top of the water.

D. Real Life Application: Observing the effect of the density difference between Diet Versus Regular Pop.

Data Type	Measurement of Data
Mass of Regular Pop (g)	394 g
Volume of Regular Pop (mL)	355 mL
Density of Regular Pop (g/mL)	1.1 g/mL
Mass of Diet Pop (g)	355 g
Volume of Diet Pop (mL)	355 mL
Density of Diet Pop (g/mL)	1.0 g/mL

Container showing Diet pop floating and Regular pop sinking due to density differences:

d = m/V

Regular Coke
d = 394 g / 355 ml = 1.1 g/ml

Diet Coke
d = 355 g / 355 ml = 1.0 g/ml

The following Density Table gives densities as guidance for the substances used.

Substance	Vegetable Oil	Wood Block	Water	Penny
Density	0.9 g/ml	0.6 g/ cm^3	1.0 g/ml	7.0 g/ml

Percent Error for ONE of the substances

$$\% \text{ Error} = \frac{\left|(\text{Accepted} - \text{Experimental Results})\right|}{\text{Accepted}} \times 100\% =$$

*Designate which object/substance.

Conclusions

Address Hypothesis

The mass and volume of four substances (water, oil, wood, and copper) were obtained using a mass balance and various volume measurements in order to determine the density of each.

Vegetable oil
Water
Copper coins

The hypothesis that if water, vegetable oil, and copper coins are mixed together, they will separate out according to their densities as shown was confirmed. Copper coins have the greatest density and would be at the bottom. Vegetable oil has the lowest densities and would float on the top.

The hypothesis that if a diet pop can and a regular pop can are submersed in water, then the diet pop can will float and the regular pop can will sink due to density was confirmed. The diet pop had the same density as water and floated while the regular pop had a density of 1.1 g/ml and sank.

Analysis

Density = mass / volume … give an example from the lab

Volume was found using water displacement (irregular solids), L x W x H (regular solids), and by using the graduated cylinder (liquids)

Intensive properties (used to identify substances … density)
Extensive properties (how much … mass, volume)

Density was used to distinguish substances. The diet pop can floated while the regular pop can sank due to density.

Questions

1. Mass, weight, and volume all measure quantities and are extensive physical properties.

2. Density is an intensive physical property which is used to identify substances. Extensive physical properties only give quantities or amounts.

3. Given that the density of glycerol is 1.261 g/mL, 15.00 mL of glycerol has a mass of 18.92 g. Density was determined using the formula, d = m/v. This formula can be rearranged to find the mass: m = dv. Therefore, m = 1.261 g/mL x 15.00 mL = 18.92 g.

4. Percent error is a mathematical way to show accuracy and precision. The percent error in this lab (e.g. 2%) indicated accuracy. The measurements were all taken to the nearest tenth of the unit, showing consistent precision.

5. Density is an intensive property, meaning that we can use density to identify or distinguish substances. Based on real life application, an object like regular soda pop (density 1.11 g/mL) will sink in water (density 1.00 mL) because it is more dense than water. Diet soda pop (density 1.00 g/mL) will float in water because it has the same or slightly less density than water.

Error

There are many possible sources of error in this lab. For the density calculations:
1) inaccurate measurements of volume and mass
2) incorrect calculations of density
3) improper comparison of density values to determine the substance tested

Bibliography

Chemistry, Week 5. *Density Lab Help Video*. Learning CTR Online, n.d. Web. 15 Sept. 2019. <www.learningctronline.com>

Chemistry, Week 5. *Density Lab Worksheet*. Learning CTR Online, n.d. Web. 15 Sept. 2019. <www.learningctronline.com>

Chemistry, Week 5. *Directions for lab*. Learning CTR Online, n.d. Web. 15 Sept. 2019. <www.learningctronline.com>

Chemistry, Week 5. *Videos: Measuring Density (Part 1 & 2)*. Learning CTR Online, n.d. Web. 23 Sept. 2020. <www.learningctronline.com>

Wilbraham, Antony C., et al. Pearson Chemistry. Upper Saddle River: Pearson Education, Inc., 2017. Print.

Grading Comments:
Please review the comments. You will have opportunity to revise your lab report for points.
A Sample Lab Report will be posted in class next week.
Each general comment is a 1 pt deduction unless otherwise indicated.

Improper or No Heading
Improper Title or no Title – (not centered)

INTRODUCTION:
-Did not clearly label/address purpose, backgrd info or hypothesis
-Purpose, backgrd info and hypothesis need to be indented under the introduction (title and content)
-Backgrd info must include extensive properties, intensive properties, density (definition, d=m/v, 3 volumes used), denser objects sink. [5]
- The concepts should be related to each other and this lab experiment.
-Hypothesis must include density of 4 substances [1] and the pop cans [1] ("if-then" format) [1]
-Table not filled out.

EQUIPMENT/MATERIALS:
- LIST items in neat columns, not paragraph form

Why did you change the worksheet format?

PROCEDURES:
-A – D (5 experiments)
-Should be listed as steps (numbered) for each experiment & not in paragraph form
-use third person, not "you" or "I"
-Needed a reference with title for the procedures (Density Lab Worksheet)

CALCULATIONS AND DATA:
-Density Data Table not completed accurately or correctly
-Do not split a table between pages
-Show work for density calculations (-5)
-Did not use the equations provided (so remove them)
-q3b needs density
-give units for all measurements
-Did not calculate densities correctly or they are inaccurate
-Did not use proper precision (as given in the table)
-Did not calculate any densities which was the point of the lab (-20)
-Did not include or explain experiment 5 (pop cans sinking and floating) [5]
-No equation for percent error or Did not find a percent error or did it incorrectly [2]
-Did not specify which object for percent error.

-PICTURES – needed 2 minimum for experiments 1-4
-what were you trying to show? (label and explain relevance to lab)
... give actual values of mass and volume [2]

-No pictures or picture should have shown finished results (-10)
-needed a picture of the food coloring, oil, water, copper coins with relevance [2]
-Needed a picture of Experiment D (pop cans) with relevance [2]

CONCLUSIONS:
-Did not clearly address/distinguish hypothesis or analysis or error in the conclusion section
- Hypothesis not complete (4 substances, layers, pop cans) [2]

Analysis should include:
-Remove directions
-Density is an intensive property that helped identify substances
-Determining volume can be direct (liquids) or by water displacement (metals)
-more dense substances sink in less dense substances

Questions [3 each]
-Did not use complete sentences (statements) conveying a stand-alone thought (-5)
-Left or copied and pasted the questions instead of making concluding statements with evidence.[3]

1. Mass, weight, and volume all measure quantities and are extensive physical properties.
2. Density is an intensive physical property which is used to identify substances. Extensive physical properties only give quantities or amounts.
3. Given that the density of glycerol is 1.261 g/mL, 15.00 mL of glycerol has a mass of 18.92 g.

   Density was determined using the formula, d = m/v. This formula can be rearranged to find the mass: m = dv. Therefore, m = 1.261 g/mL x 15.00 mL = 18.92 g. (4 sig figs)
4. Percent error is a mathematical way to show accuracy and precision. The percent error in this lab (e.g. 2%) indicated accuracy. The measurements were all taken to the nearest tenth of the unit, showing consistent precision.
5. Density is an intensive property, meaning that we can use density to identify or distinguish substances. Based on real life application, an object like regular soda pop (density 1.11 g/mL) will sink in water (density 1.00 mL) because it is more dense than water. Diet soda pop (density 1.00 g/mL) will float in water because it has the same or slightly less density than water.

Errors
There are many possible sources of error in this lab. For the density calculations:
1) inaccurate measurements of volume and mass
2) incorrect calculations of density
3) improper comparison of density values to determine the substance tested
   -did not address error or future considerations

RESOURCES:
-need 3 (-3 for each missing resources)
-do not use the word “citation” for each source
-Needs to be in APA format (-3)
  -alphabetical

-include Study Place (directions, density lab handout, lab help video, tutorial videos) in resources

Study Place, Chemistry, Week 5. *Density Lab Worksheet*. The Potter's School, n.d. Web. 23 Sept. 2020. https://www.pottersschool.org/teacher/

Study Place, Chemistry, Week 5. *Density Lab Help Video*. The Potter's School, n.d. Web. 23 Sept. 2020. <https://www.pottersschool.org/teacher/>

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Study Place, Chemistry, Week 5. *Video: Measuring Density (Part 1 & 2)*. The Potter's School, n.d. Web. 23 Sept. 2020. <https://www.pottersschool.org/teacher/>

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-Watch your spacing of each section and item… label everything clearly