Experiment 3 Chemistry 110 Lab

DENSITY

PURPOSE: The purpose of this laboratory exercise it to measrue the mass and volume of several objects and calculate their density. Students will also determine the percent error.

I. INTRODUCTION

Density is the ratio of the mass of a substance to the volume occupied by the object:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

The units of density varies, depending upon the substance measured. Density is grams per cubic centimeter (g/cm^3) for solids, grams per milliliter (g/mL) for liquids, and grams per liter (g/L) for gases. The density of aluminum is given as 2.7 g/cm^3 $\left(\frac{2.7\text{ g Al}}{1.0\text{ cm}^3\text{ Al}}\right)$. This means that a 1 cm x 1 cm x 1 cm cube of aluminum would weigh 2.7 g.

The number of **Significant Figures** in measured numbers shows the uncertainty of the measuring device. Significant figures are the digits in any measurement that are known with certainty plus one more digit which is estimated.

A. Determining the Number of Significant Figures in a **Measured** value

1. All non-zero digits are significant.
   For example: 1283 has 4 significant figures

2. Zeros between non-zero digits are significant.
   For example: 1200056 has 7 significant figures

3. Zeros on the left side of a non-zero digit are not significant.
   For example: 0.000000000034 has 2 significant figures

4. Zeros on the right side of non-zero digits.....
   a. If the number has a decimal point, the zeros are significant.
      130.00 has 5 significant figures.

   b. If the number does not have a decimal point, the zeros may/may not be significant--it is ambiguous!!! Always write these type of numbers in scientific notation!
      For example:
      "two hundred" should be written as 2.00×10^2 to indicate 3 significant figures present
      "four hundred thousand" should be written as 4.0×10^5 to indicate 2 significant figures present.

B. Significant Figures in Calculations

1. Addition and Subtraction

The answer may not have any more **decimal places** than the least accurate number

For example: 91. *This is the least accurate number (least number of decimal places)*

+ 4.00

95. *The answer has 2 significant figures*

2. Multiplication and division

The answer contains the same number of sig. fig. as the measurement with the **least number** of sig. fig.

For example: 23 x 2.00 = 46 *The answer has 2 sig figs.*

Accuracy (how close you are to the correct value) may be improved by carrying out several determinations and then computing an average value. The significance of the error in any given measurement depends on the magnitude of the error compared to that of the measurement. An error of one foot in measuring the height of a person is a relatively large error, whereas an error of one foot in determining the distance to Mars is a relatively small error. This relative error is usually expressed as a percentage of the measurement and is called percent error.

$$\% \text{ Error} = \frac{|\text{measured value - accurate (theoretical) value}|}{\text{accurate (theoretical) value}} \times 100$$

Chemistry is an experimental science, observations and making accurate measurements are very important. In this experiment you will measure mass, volume, length and temperature. From these measurements you will perform calculations to obtain other values.

II. PROCEDURE

A Density of water.

1. Obtain a dry 10 ml graduated cylinder (from the side bench).

2. Weigh the 10 ml graduated cylinder to ± 0.01 g and record.

3. Pour approximately 9 ml (somewhere between 8-10 ml) of water into the cylinder. Record the exact volume (measured to the nearest 0.01 ml).

4. Reweigh the cylinder with the water and record. Keep the graduated cylinder for part C.

5. Calculate the density of water.

DATA:

Mass of 10 ml graduated cylinder	
Mass of cylinder and water	
Volume of water	

Did you record the correct units and number of sig figs in your measurements?

CALCULATIONS:

	Set-up	Answer
Mass of water		
Density of water		

Do you have the correct number of sig figs in your answers?

Instructor's Initials_____

B. Density of an irregular shaped object.

1. Obtain two size # 2 rubber stoppers and a 100 ml graduated cylinder from the side bench.

2. Weigh the rubber stoppers together and record to $\pm$ 0.01 g.

3. Pour approximately 40 ml (somewhere between 35-50 ml) of water into the cylinder. Record the exact volume (measured to the nearest 0.1 ml).

4. Tilt (slightly) the graduated cylinder and carefully slide in the two rubber stoppers (Don't splash!) Record the new volume.

DATA:

Mass of rubber stoppers	
Volume of water	
Volume of water plus rubber stoppers	

Did you record the correct units and number of sig figs in your measurements?

CALCULATIONS:

1. Calculate the volume of the stoppers. The volume of the water displaced is equal to the volume of the stoppers.

NOTE: 1ml = 1 cm^3 = 1 c

2. Calculate the density of the rubber stoppers:

	Set-up	Answer
Volume of Rubber Stoppers		
Density of rubber stoppers		

Do you have the correct units and number of sig figs in your answers?

C Density of an unknown liquid

1. Obtain a 50 ml beaker from the side bench. Clean and dry it.

2. Take the beaker and report sheet to your instructor, who will pour an unknown into the beaker. Write down your unknown number.

3. Prerinse the Same 10 ml graduated cylinder, used in part A, with approximately 1-2 ml of your unknown. Empty the prerinse solution into the waste container labelled "Waste Unknown" located in the hood. (Prerinsing will remove any residue water left in the cylinder).

4. Pour approximately 7 ml (between 6-8 ml) of your unknown into the 10 ml graduated cylinder. Record the exact volume to 0.01ml under "Run 1".

5. Weigh the graduated cylinder plus unknown liquid to $\pm$ 0.01. Record the weight under "Run 1".

6. Add more unknown to the graduated cylinder until you have approximately 9 ml (between 9-10 ml) of unknown. Weigh. Record the exact volume and weight under "Run 2".

*** DISPOSAL:** Dispose (after your calculations have been instructor approved on your report sheet) the unknown liquid in the waste container labelled "Waste unknown liquid".

DATA: **Unknown Number**_____

	RUN 1	RUN 2
Volume of unknown		
Mass of graduate cylinder plus unknown		

Did you record the correct units and number of sig figs in your measurements?

CALCULATIONS:

1. Calculate the mass of the unknown for both runs, using the weight of the empty graduated cylinder from part A.

2. Calculate the density for both runs..

3. Calculate an average of the two runs on the next page.

	Run 1 (show work in boxes)	Run 2
Mass of unknown		
Density of unknown		

AVERAGE Density
Set-up:

Average density = _____

4. Write your unknown number and average density on the report sheet. Then, take your report sheet to your instructor and obtain the correct value. Calculate the % error.

$$\% \text{ Error} = \frac{|\text{measured value - accurate (theoretical) value}|}{\text{accurate (theoretical) value}} \times 100$$

PERCENT ERROR
Set-up:

Percent error = _____

Do you have the correct units and number of sig figs in your answers?

Before you leave the lab you must have your lab instructor initial your report sheet.
NO CREDIT will be given for lab reports without the instructor's initials!

Chem. 110 Lab Report

Name _____ Date _____

Lab Section _____ Initials_____

EXPERIMENT 3

DENSITY

A Density of water.

DATA:

Mass of 10 ml graduated cylinder	
Mass of cylinder and water	
Volume of water	

CALCULATIONS:

	Set-up	Answer
Mass of water		
Density of water		

B. Density of an irregular shaped object.

DATA:

Mass of rubber stoppers	
Volume of water	
Volume of water plus rubber stoppers	

CALCULATIONS:

	Set-up	Answer
Volume of Rubber Stoppers		
Density of rubber stoppers		

C Density of an unknown liquid

DATA:

	RUN 1	RUN 2
Volume of unknown		
Mass of graduate cylinder plus unknown		

CALCULATIONS:

Show your work in the boxes below.	Run 1	Run 2
Mass of unknown		
Density of unknown		

RESULTS:

	Run 1 **Show your answers to the above calculations in the boxes below.**	Run 2
Mass of unknown		
Density of unknown		

AVERAGE DENSITY

Unknown number _____

Set-up:

Density = _____

Correct density = _____
(From instructor)

PERCENT ERROR

Set-up:

Percent error = _____

Questions and Problems:

1. 7.72×10^{-2} g of a substance is put into 20.0 ml of water in a graduated cylinder. The new volume reading was 23.9 ml. Find the density of the substance in g/cm^3.
   Set-up:

   Answer_____

2. Lead has a density of 11.34 g/cm^3. what is the volume of 25.1 grams of lead?
   Set-up:

   Answer _____

3. Tell how many significant figures are in the following:

   0.74 _____ sig. fig 720.0 _____sig figs

   0.0409 _____ sig. figs 0.0010700 _____sig.figs

4. Tell **how many sig figs** you should report in each answer.

   a. (0.74) (31.5) (22.4) a. _____ sig figs.

   b. 16.3 + 9.27 + 4.025 b. _____

   c. $\frac{61.5 - 57.3}{57.3}$ (100) = % error c. _____

   d. 25.65 - 18.47 d. _____

   e. 1125 cm x $\frac{1 \text{ inch}}{2.54 \text{ cm}}$ x $\frac{1 \text{ ft}}{12 \text{ in}}$ x $\frac{1 \text{ yd}}{3 \text{ ft}}$ e. _____

5. Consider the density of the unknown liquid in todays experiment. Will the following make the experimental density higher, lower or not change? Circle the correct answer.

   a. Using 15 ml of unknown liquid instead of 7 ml. high low no change

   b. Using the theoretical density of water (1.00 g/mL) instead of the experimentally determined density of 0.8082 g/ml.
   high low no change

   c. Including the mass of the graduated cylinder in the weight of unknown liquid
   . high low no change