Chem 1 Lab: Measurement and Density

Introduction

This is a small scale lab which will introduce you to lab and measurement techniques. You will get experience using the metric system, doing some calculations (watching units and significant figures!!) of densities, and carrying out scientific problem solving. The density of a material, which is an intensive property, is the ratio of the amount of matter in a sample, its mass, to its volume:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Its units are typically g/mL or g/cm^3, which are equivalent since 1 mL = 1 cm^3. In practical terms, higher density indicates more mass in less volume. Since density is an intensive property, it can be used to identify a substance by comparing it to the known densities of materials. In addition, the relative densities of two materials can be determined because materials with lower densities will float in materials with higher densities, a characteristic known as "buoyancy."

Prelab Questions. Answer on a separate sheet of paper. Show all calculations. All numbers must have units and the answer must have the correct significant figures. [5 points]

1. A block of aluminum occupies a volume of 15.0 cm^3 and has a mass of 40.5 g. What is its density?
2. Mercury metal (a liquid) is poured into a graduated cylinder to a volume of 22.5 mL. The mercury used to fill the cylinder has a mass of 306.0 g. From this information, calculate the density of mercury.
3. A rectangular block of copper metal has a mass of 1896 g. The volume of the block is 212.52 cm^3. From this data, determine the density of copper.
4. 28.5 g of iron shot is added to a graduated cylinder containing 45.50 mL of water. The water level rises to the 49.10 mL mark. From this information, calculate the density of iron.
5. Calculate the volume of a substance that has a mass of 54.5 g and a density of 2.5 g/mL.

Procedure

Carry out experiments that accomplish the tasks below. Careful measurement of masses and volumes will be required. Be sure to record all information in the data tables provided. You **MUST** read all measurements to the **correct precision**, write **units** for *every* number written and keep the appropriate amount of **significant figures ("sig figs")** throughout your calculations. You may do the tasks in any order you wish.

Task 1: Determine which of two methods for determining the volume of a sample produces a more accurate determination of the density.

1) Choose a cylindrical metal slug. You may select any metal you wish. Record the identity of your metal on your data sheet.
2) Mass your metal cylinder on a balance. Record the mass to two decimal places (0.01 g) in the data table.
3) Find the *smallest* graduated cylinder that the slug fits in.
4) Fill the graduated cylinder about ½ full of water and measure the volume to one decimal place, 0.1 mL (bottom of the meniscus!). Record volume of water in data table.
5) Gently place the metal sample into the graduated cylinder (don't splash any water out or break the graduated cylinder) and measure the volume of the water + slug. Record volume of water + slug in data table.

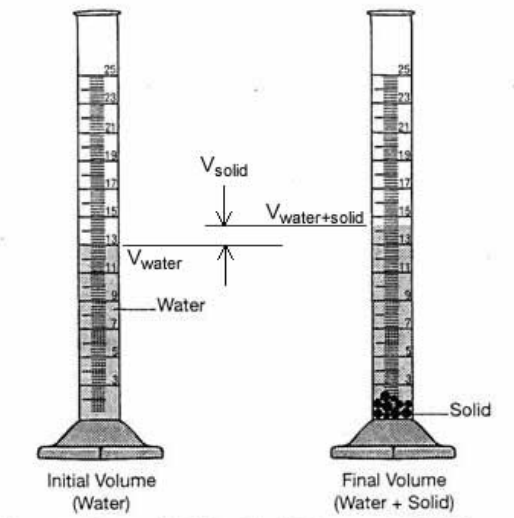

Figure 1. Volume of Solid = Final Volume − Initial Volume

6) Dry the metal cylinder, then use a ruler to measure the height (h) and diameter (d) of the metal cylinder, in cm, to *two decimal places* (0.01 cm). Record in data table.

Task 2: Determine the identities of three unknown liquids by determination of their densities using class data.

1) You will be assigned an unknown liquid—X, Y, or Z—record its letter in the data table.
2) Mass a **clean and dry** 25-mL graduated cylinder to two decimal places & record in data table.
3) Measure out between 10 and 15 mL of your liquid into the graduated cylinder. Record precise volume, in mL, to one decimal point.
4) Obtain the mass of the liquid and graduated cylinder combined and record in data table.
5) Clean out the graduated cylinder thoroughly.

Task 3: Determine the identity of two unknown metals by graphically determining the density of the metal using class data.

1) You will be assigned one metal. Obtain a numbered metal slug of your assigned unknown (A or B) and record unknown letter and slug # in data table. Do not return metal slug until everyone has completed Task 4.
2) Record mass of slug
3) Use a graduated cylinder as in Steps 3 – 5 of Task 1 to determine the volume of H_2O without the slug and the volume of H_2O and the slug together, to one decimal place. Record both measurements in data table.

Task 4: Explain basic operation of a **Cartesian diver**.

1) Obtain a plastic bulb with nut (this is the Cartesian Diver), fill it about half-full with some water and place into a large (at least 400 mL) beaker of water. Adjust the amount of water in the bulb until you get the bulb to just BARELY float at the surface of the water.
2) Now take the bulb and put it inside a plastic bottle filled to the top with water. Put on the cap tightly. Squeeze the bottle and see your diver MOVE!!!!
3) Ask me to come over and check off that you made your own Cartesian diver._____
4) Clean up: pour the water out of the bottle (catch the diver & empty it). Return the bottle and diver.

Discussion & Conclusions

Answer the following questions on a separate sheet of paper. Show any required calculations in full, and answer all questions in full sentences. Remember CER when addressing your conclusions. Hand in the Data and Calculations sheet, the prelab questions, your graph, and the Discussion & Conclusion answers. Do NOT hand in the procedure sheets

Task 1: Density by Two Methods of Determining Volume

1) [2 pts] Determine the percent error (see your yellow packet) for each of your density values. (You need to show both calculations in full.) Refer to Table 1 below. Remember that 1 mL = 1 cm^3, so g/mL is the same as g/cm^3.

Table 1. Accepted density values for several metals

Aluminum = 2.70 g/cm^3	*Copper = 8.92 g/cm^3*	*Brass = 8.25 g/cm^3*
Iron = 7.87 g/cm^3	*Tin = 7.31 g/cm^3*	*Lead = 11.34 g/cm^3*
Nickel = 7.81 g/cm^3		*Zinc = 7.04 g/cm^3*

Task 2: Densities of 3 Unknown Liquids

2) [3 pts] Determine the most likely identity of each liquid from the following accepted density values:

Table 2. Accepted density values for several liquids

Gasoline = 0.66 g/mL	*Turpentine = 0.74 g/mL*	*Glycerin = 1.20 g/mL*
Ethyl alcohol = 0.79 g/mL	*Water =1.00 g/mL*	*Chloroform = 1.49 g/mL*
Vegetable oil = 0.89 g/mL	*Ethylene glycol = 1.11 g/mL*	*Corn Syrup = 1.36 g/mL*

3) [1 pt] Determine the percent error for each liquid based on your identifications.

Task 3: Identification of an Unknown Metal by Graphical Density Determination

4) [5 pts] Construct a plot of the class data for the unknown metal you measured, with mass as the dependent variable and volume as the independent variable.
   a) Hand-draw your graph (do not use Excel or other graphing programs) on printed graph paper. Make your plot occupies as much of the page as possible).
   b) Give the graph a descriptive title and label the axes with correct units.
   c) Draw the *best fit straight lines* through your points. Your lines must go through the origin, (0 cm^3, 0 g) [think about why!].
5) [2 pts] Select two points *on the line* from which to calculate the slope of the line, which is the density of the metal. Label these points clearly and indicate their coordinates. Calculate the density of each metal, with correct units. Use the data in the table to determine the correct number of significant figures.
6) [1 pt] From the slope and the density values in Table 1 above determine the identity of your metal and label the plot with this identity.
7) [1 pt] Calculate the percent error in your graphical density value.

Task 4: Cartesian Diver

8) [2 pts] Use the CER model to explain why the Cartesian diver behaves as it does. What must be happening to the diver as you squeeze the bottle? [Hint: think about why the materials in the density column are where they are.] *WHY* is this happening to the diver—be specific about any changes that you observe and relate these changes to the density of the diver.

Conclusions

1) [1 pt] In **Task 1**, which of your density techniques gave a more accurate value for the density of that metal? Give a reasonable explanation as to why the one value was more accurate than the other.
2) [1 pt] For **Task 2**, you determined the identity of three unknown liquids based on class average densities. Why did we use the averages rather than individual data measurements?
3) [1 pt] In **Task 3**, you determined the densities and identities of two metals from the slope of the mass vs. volume plots. Explain why this method should yield more accurate values than a single mass and volume measurement as in Task 1.
4) [1 pt] Identify one systematic error in tasks 1, 2, or 3 that could have led to inaccurate density calculations. For the error, suggest one change in *procedure* that could minimize or eliminate this error and describe why.

Chem 1 Lab
Measurement and Density
35 Points

Name _____
Lab Partner _____
Date _____ Period _____

Data & Calculations
All measurements MUST have units and be recorded to the correct precision (sig figs—see procedure and/or class notes).

Task 1: Density by Two Methods of Determining Volume [4 pts]

Identity of Metal: _____ Mass of Metal, m_{metal}: _____

Initial volume of H_2O, V_{init}: _____ Height of Metal Cylinder, h: _____

Final volume of H_2O, V_{final}: _____ Diameter of Metal Cylinder, d: _____

Show your calculations below. Label all numbers, and make sure all numbers have units.

a) Volume by water displacement method	b) Volume by formula of a cylinder: $V = \pi\left(\frac{d}{2}\right)^2 h$
a) Density value using water displacement volume	b) Density value using formula of cylinder volume

Task 2: Densities of 3 Unknown Liquids [3 pts]

Assigned liquid: _____	
Mass of Graduated Cylinder, m_{init}: _____	Volume of Unknown Liquid, V_{liquid}: _____
Mass of Liquid + Graduated Cylinder, m_{final}: _____	

Mass of Liquid (show calculation), m_{liquid}:

Density of Liquid (show calculation), D_{liquid}:

Enter your data in the correct column in the Google Sheet, then copy down the class data below and determine the average densities:

Class Data Table (from Google Sheet)

Group	Density, Liquid X, g/mL	Group	Density, Liquid Y,' g/mL	Group	Density, Liquid Z, g/mL
Averages:					

Task 3: Identification of An Unknown Metal by Graphical Density Determination [2 pts]

Slug Letter & Number: _____

Mass of Metal, m_{metal}: _____

Initial volume of H_2O, V_{init}: _____

Final volume of H_2O, V_{final}: _____

Volume of Slug (show calculation), V_{metal}: _____
*Note: do NOT calculate the density of the slug directly from mass & volume!

Enter your slug #, group initials, mass and volume into the proper columns in the Google Sheet then copy the class data below for your metal only (ignore the other metal data):

Class Data Table (from Google Sheet)

Metal _____			
#	**Group**	**Mass (g)**	**Volume (mL)**