Measurement and Physical Properties (Density)

Density, like color, odor, melting point, and boiling point, is a physical property of matter. Therefore, density may be used in identifying matter. Density is defined as mass per unit volume and is expressed mathematically as d = m/V (d is density, m is mass, and V is volume).

The system of measurement used universally by scientists is the metric system. In the metric system, the unit of mass is the gram (g), the unit of volume for a liquid is milliliters (mL), and the unit of volume for a solid is a cubic centimeter (cm^3). Therefore, the density of a liquid is usually expressed as grams per milliliter (g/mL), and the density of a solid is expressed as grams per cubic centimeter (g/cm^3).
[Note: 1 mL = 1 cm^3]

Gold (density =19.7 g/cm^3) is denser than aluminum (2.70 g/cm^3). This means that a gold cube has a larger mass than an aluminum cube of the same size. A block of gold that is 1 cm^3 would have a mass of 19.7 grams while the same size block of aluminum would have a mass of only 2.70 grams.

Determination of density of certain physiological liquids is often an important screening tool in medical diagnosis. For example, if the density of urine differs from normal values, this may indicate a problem with the kidneys secreting substances that should not be lost from the body. The determination of density is almost always performed as part of an urinalysis. Another example utilizing density is the determination of total body fat. Muscle is more dense than fat; therefore, by determining total body mass and volume, the muscle-to-fat ratio can be calculated.

For liquids, a rapid and fairly reliable way to measure density is to determine the specific gravity. Specific gravity is the comparison of the density of a liquid to that of water. It is usually measured with a hydrometer, a calibrated glass float as it is floating in the liquid.

In this lab you will be graded on your lab technique (your ability to determine the density of an unknown solid and liquid within reasonable error) as well as your understanding of significant figures. Remember to record measurements with their units to the proper number of significant digits, according to the precision of the instrument being used. Significant figures are the number of units known with certainty plus one estimated value. Do not forget to follow significant digit computation rules!

PROCEDURE:

Part A: Determination of Density of an Aluminum Rod

1. Obtain a piece of aluminum rod. Measure the diameter and length using a vernier caliper. Your instructor will demonstrate how to read the scale on this device. **Record** measurements in cm.
2. **Record** the mass of the rod to the nearest 0.001 g. (Note: If your scale only reads to 0.01 gram or is not in grams (g), please see your instructor or use a different scale!)
3. Calculate the volume and density of the aluminum rod. $\boldsymbol{Volume = \pi r^2 L}$
4. Calculate the percent error for your density determination.
   The literature value for the density of aluminum is **2.70 g/cm^3**.

$$\textbf{\% error} = \frac{\left|\textbf{literature value - experimental value}\right|}{\textbf{literature value}} \times 100$$

Part B: Determination of Density of a Solid

1. Add water to a 50.0 mL graduated cylinder to the 25 mL mark. **Record** the volume to the proper number of significant digits. If you are unsure of sig figs, ask your instructor!
2. **Record** the mass of the graduated cylinder with the water to 0.001g. (Note: If your scale only reads to 0.01 gram or is not in grams (g), please see your instructor or use a different scale!)
3. Do NOT discard water until step 11!
4. Obtain a sample of an unknown metal and record its ID #. (You will be using most of the sample so it is okay to take one container of your unknown to your lab bench). Dry the metal pieces if they seem wet.
5. Add enough of your dried metal sample to the graduated cylinder to displace 10 mL of water. **Record** the new volume of the water plus the metal.
6. **Record** the mass of the cylinder, water, and metal pieces. (Do NOT discard the water & metal)
7. Add more of the metal pieces to the same cylinder containing the metal so that about 5 mL of water is displaced (i.e., the water level should increase by an additional 5 mL, or 15 mL total).
8. **Record** the new volume of water. **Record** new mass of the cylinder, water, and metal.
9. Add more of the metal pieces to the same cylinder containing the metal so that about 5 mL of water is displaced (i.e., the water level should increase by an additional 5 mL, or 20 mL total)
10. **Record** the new volume of water. **Record** the new mass of the cylinder, water, and metal.
11. Now you can discard the water. Carefully pour off water. Do not dump the metal in sink! Dry the metal pieces and return them to their original containers.
12. Determine the density for each sample and determine the average density for the metal.

Part C: Determination of Density of a Liquid

1. Record the mass of a clean and dry 10.00 mL graduated cylinder to 0.001g. (Note: If your scale only reads to 0.01 gram or is not in grams (g), please see your instructor or use a different scale!)
2. Choose an unknown liquid from the cart and record the unknown number. Fill the 10 mL graduated cylinder approximately halfway with your unknown liquid. Record the mass of your graduated cylinder and liquid.
3. Calculate the mass of the liquid. Remember to show math setups on the data sheet.
4. Read the volume of unknown liquid using the bottom of the meniscus as demonstrated by your instructor. Record your volume to the hundredth decimal place value (i.e. 4.23 mL).
5. Calculate the density of the liquid.
6. Dispose of the liquid in the sink.

Part D: Determination of Specific Gravity of a Liquid

Add enough of the same unknown liquid used in part C to a clean, dry cylinder so the hydrometer floats freely. It should not touch the bottom or the sides of the cylinder and should be free of clinging air bubbles. Record the specific gravity of the unknown liquid. Dispose of the liquid in the sink.

Measurement & Physical Properties (Density) Name_____
Lab Partner:

Part A: **Density of Aluminum**

Diameter of slug _____

Radius of slug, r _____ (recorded to the nearest 0.001 cm)

Length of slug, L _____

Mass of slug, g _____

*Volume of slug, V _____
(show calculation)

*Density of slug _____
(show calculation)

*Percent error _____
(show calculation)

Part B: **Density of Unknown Solid**

Unknown Letter _____	Sample 1	Sample 1 & 2	Sample 1&2&3	*Calculation Set Up for sample 1(*steps)*
Mass of cylinder + water (the same for all 3 samples)	_____	_____	_____	
Mass of cylinder, water + metal	_____	_____	_____	
*Mass of metal *(calc)*	_____	_____	_____	
Initial volume of water (the same for all 3 samples)	_____	_____	_____	
Volume of water with sample	_____	_____	_____	
*Volume of sample *(calc)*	_____	_____	_____	
*Density of the metal *(calc)*	_____	_____	_____	
Average density		_____		

Part C: **Density of a liquid**

Unknown # _____

Mass of graduated cylinder _____

Mass of cylinder + liquid _____

Mass of liquid *(show calc)* _____

Volume of liquid _____

Density of liquid *(show calc)* _____

Part D: Hydrometer Unknown #_____ Specific Gravity _____

POST LAB QUESTIONS:

1. Compare your density of a liquid in part C and your specific gravity of the same liquid in part D. What is similar? What is different?

2. What do you think is an easier method to find the density of a liquid, part C or part D? Why?

3. What procedural part of the lab could you use to find the volume of an irregularly shaped unknown solid that is less dense than water? What modifications to the procedure would you need to make.

4a. Calculate the volume, in cubic centimeters, of 86 mass ounces of copper (density = 8.96 g/mL)

4b. Calculate the weight (in ounces) of an equal volume of aluminum (density in part A).