Experiment #3. Density

Goals

1. To measure and calculate the density of various substances.
2. To use significant figures correctly in calculations.

Background

Density is the mass per unit volume of a substance. If a substance has a lot of mass in small volume we would say it is dense. For instance, fishing weights usually weigh only a few ounces, but they are heavy for their size. Fishing weights are often made out of lead, one of the densest metals. Hay, on the other hand is not dense; its mass per volume is very small. Bales of hay, while not dense, are very heavy due to their size and have been know to kill people they roll on. So having a lot of mass does not make something dense, it must be a lot of mass packed into a small volume.

Density is calculated as mass divided by volume. In chemistry, the most common units of density are g/mL (used for liquids) and g/cm^3 (used for solids). Recall that a milliliter and a cubic centimeter are the same volume.

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

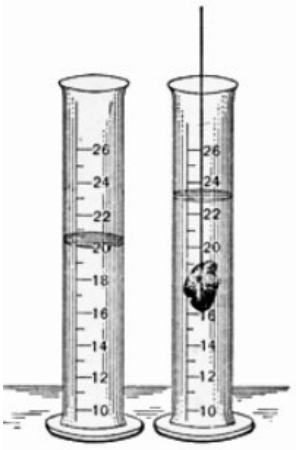
Below are densities for some common substances. Since two substances rarely have the same density, density can be used to identify materials.

Solids (25°C)	Density (g/cm^3)	Liquids (25°C)	Density (g/mL)	Gases (0°C, 1 atm)	Density (g/L)
Hay bale	0.2 - 0.35	Gasoline	0.74	Helium	0.179
Ice (0°C)	0.92	Honey	1.42	Nitrogen	1.25
Aluminum	2.70	Olive oil	0.92	Air	1.29
Zinc	7.14	Water	1.00	Oxygen	1.43
Tin	7.31	Urine	1.003-1.030	Carbon dioxide	1.96
Steel	7.48	Blood	1.03	Sulfur hexafluoride	6.17
Brass	8.74	Mercury	13.6		
Copper	8.96				
Lead	11.4				

Buoyancy stems from differences in density. Helium balloons float in air, because helium is less dense than air. In fact, the earth's atmosphere contains almost no helium because the gravitational pull is not strong enough to prevent its loss to outer space. Or helium supply comes from gases trapped in ores deep in the earth, a resource we are using up at an alarming rate. Other examples of how buoyancy is determined by density include oil floating on water and stones sinking in a river. Water is an unusual substance in that its solid form is less dense than its liquid form. The less dense ice floating in water allows pond life to survive over the winter.

Volume by displacement

If an object does not have a regular, easily measured shape, its volume can be determined by displacement. First, choose a partially filled graduated cylinder large enough to accommodate the object with enough liquid to completely submerge it. Carefully measure the volume in the cylinder. Submerge the object in the cylinder and measure the volume again. The difference between the two volumes is equal to the volume of the object. Once you have determined the volume, divide by the mass to find the density of the irregular object.



Laboratory Activity

Materials:	metal cylinder	Graduated cylinders	aluminum foil
	Ruler	Deionized water	isopropanol

Procedure

A. Density of an Unknown Metal

1. Obtain an unknown metal sample and record the mass measured with a balance.

2. Find the volume of the cylinder by displacement. Fill a 25 mL graduated cylinder about halfway with water. Carefully read and record the volume to the correct number of significant figures. Angle the graduated cylinder and gently slide in the metal. If liquid splashes out, start over. Record the new volume. Subtract the two water volumes to find the volume of the metal.

3. Calculate the density of the metal. Determine the identity by comparing your value to the densities of metals in the table in the background section.

B. Thickness of Aluminum Foil

1. Obtain a piece of aluminum foil and measure its length and width in centimeters with a ruler. Be sure to record the correct number of significant figures.

2. Record the mass of the aluminum foil. Fold the foil if necessary so that it only touches the pan of the balance.

3. Use the density of aluminum given in the table to find volume of the foil sheet. Given that the volume of the foil sheet is length x width x height, find the thickness (height) of the foil.

C. Density of Liquids.

1. Record the mass of a dry 100 mL graduated cylinder to the correct number of significant figures. Write this number in the table on the first line in the column for water.

2. Fill the graduated cylinder roughly 2/3 full with deionized water and record the mass. *The amount of water is not important – do not try to fill exactly to a line!* Record this value in the second line in the column for water.

3. Read the volume of the graduated cylinder to the correct number of significant figures. Use volume and mass to calculate the density of water.

4. Repeat steps 1-3 with a different dry graduated cylinder for isopropyl alcohol. Record the values in the isopropyl column.

Waste Disposal

- deionized water – sink
- Isopropyl alcohol – return to the bottle.

Name_____

Team Name _____

CHM101 Lab – Density – Grading Rubric

To participate in this lab you must have splash-proof goggles, proper shoes and attire.

Criteria	Points possible	Points earned
Lab Performance		
Printed lab handout and rubric was brought to lab	3	
Safety and proper waste disposal procedures observed	2	
Followed procedure correctly without depending too much on instructor or lab partner	3	
Work space and glassware was cleaned up	1	
Lab Report		
Part A (data recorded with correct sig figs and units, calculations shown clearly, all questions answered)	2	
Part B (data recorded with correct sig figs and units, calculations shown clearly, all questions answered)	2	
Part C (data recorded with correct sig figs and units, calculations shown clearly, all questions answered)	2	
Post Lab: Question 1	1	
Post Lab: Question 2 (work shown in detail with units)	2	
Post Lab: Question 3 (work shown in detail with units)	2	
Total	20	

Subject to additional penalties at the discretion of the instructor.

Density: Data Sheet **Name_____**

Include the **proper units** for all measurements and **show all your work** for any calculations.
Report your answers to the correct number of significant digits.

A. Density of an Unknown Metal

Mass of metal	
Volume of water	
Volume of water + metal	
Volume of metal	

Show calculations for the density of the metal. Write out all units and use correct significant figures.

Based on density, what is your unknown metal? Explain your choice.

B. Thickness of Aluminum Foil

Length of foil	
Width of foil	
Mass of foil	

Use the density of aluminum and mass to find the volume of the aluminum foil:

Use volume of the foil, length and width to calculate thickness (height) of the aluminum foil:
($V = l \times w \times h$)

Density: Post Lab Questions **Name _____**

C. Density of Liquids

	Water	Isopropanol
Mass of empty cylinder		
Mass of cylinder with liquid		
Mass of liquid		
Volume of liquid *(read the cylinder!)*		
Density of liquid *(calculate from data above)*		

Q1. Calculate your percent error for the density of water.

$$\text{Percent Error} = \frac{|\text{true value - your value}|}{\text{true value}} \times 100\%$$

Q2. An irregular object with a mass of 92.5 g is placed in a graduated cylinder containing 54.3 mL of water. The new volume is 88.0 mL. What is the density of the object?

Q3. Determine the volume in quarts of 25.6 kg of oil. The oil has a density of 0.880 g/mL.