Name_____

Team Name _____

CHM101 Lab – Density and Specific Gravity – 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 and Specific Gravity

Goals

1. To measure and calculate the density and specific gravity 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.

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

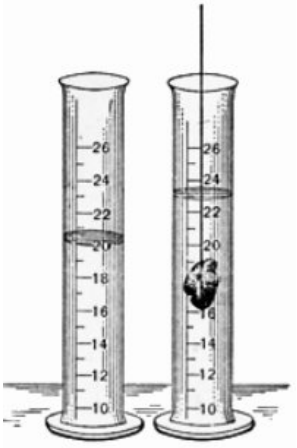
Below are densities for some common substances. Since two substances rarely have the same density, density can be used to identify materials.

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
Steel	7.48	Urine	1.003-1.030	Carbon dioxide	1.96
Brass	8.74	Blood	1.03	Sulfur hexafluoride	6.17
Copper	8.96	Mercury	13.6		
Lead	11.4				
Gold	19.3				

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.

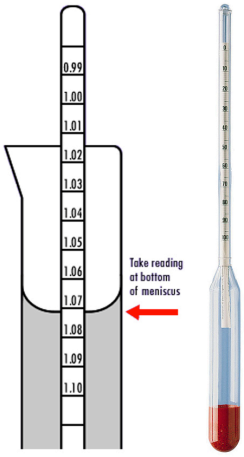


Specific Gravity

Specific gravity is a ratio of the density of a substance to the density of water. Because specific gravity is unitless, it will be the same no matter which system of measurement is used.

$$\text{Specific Gravity} = \frac{\text{density of substance}}{\text{density of water}}$$

For mercury, the specific gravity is equal to 13.6 g/mL divided by 1.00 g/mL = 13.6. When using the metric system, the specific gravity is essentially the density written without a unit. Note if using imperial units, the specific gravity of mercury would be 113 lb/gal divided by 8.3 lb/gal for water which still equals 13.6.



Specific gravity is measured using a hydrometer. To use this instrument, float it in the liquid to be measured and read where the liquid surface hits the scale. The lower the hydrometer floats, the less dense the liquid. Hydrometers can be used to determine the amount of solids in a urine sample – a higher specific gravity indicates less water present and possibly dehydration. Hydrometers are also used to determine alcohol content in beer. Brewers take a specific gravity reading before and after fermentation. As sugars convert to alcohol, the specific gravity decreases. The percent alcohol can be determined by comparing the initial and final specific gravity.

Laboratory Activity

Materials:				
	metal cylinder	Graduated cylinders	aluminum foil	hydrometers
	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 and Specific Gravity of Liquids.

1. Record the mass of a dry 100 mL graduated cylinder to the correct number of significant figures.

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!*

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 dry graduated cylinder for isopropyl alcohol.

5. Two large graduated cylinders in the front of the room will contain water and isopropyl alcochol. Gently place the hydrometer in each liquid and record the specific gravity. Remove and dry the hydrometer for use by the next group.

Waste Disposal

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

Density and Specific Gravity: 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:

C. Density and Specific Gravity of Liquids

	Water	Isopropanol
Mass of empty cylinder		
Mass of cylinder with liquid		
Mass of liquid		
Volume of liquid (use correct sig figs!)		
Density of liquid (calculate)		
Specific Gravity (measure with hydrometer)		

How does you calculated density and measured specific gravity compare for the water?

How do they compare for the isopropanol?

Density and Specific Gravity: Post Lab Questions **Name _____**

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 liters of 25.6 kg of oil. The oil has a density of 0.880 g/mL.