DENSITY OF LIQUIDS and SOLIDS

Applications of Density

- Determining the density of an unknown liquid and cola.
- Identifying an unknown metal from its specific gravity/density.
- Using density to estimate the mass of an iceberg.
- Determining the alcohol content of beer from density.

Density is defined as mass per unit volume (***D = M/V***). Density of solids and liquids is usually expressed in units of g/mL or g/cm^3. In order to experimentally determine the density of any substance, its mass and volume must be measured. Although mass is conserved and constant, volume depends on temperature. Most materials expand when warm and contract when cold. Their mass does not expand and contract, but the space that they occupy does. Roads and bridges are designed and built to allow for this or they would buckle and crack.

Many, many substances have had their densities experimentally calculated and can be found in reference books.

Water is ubiquitous to life. Your body is 70% water by mass. Fruits and vegetables are up to 95 % water. Eighty percent of the earth's surface is covered by water. It accounts for 5 percent of the earth's mass. Because of water's importance to life as we know it, its physical and chemical properties have been painstakingly researched including its density, which has been calculated at a vast number of different temperatures. Water's volumetric behavior is rather strange. Instead of expanding with temperature increases as most materials, water's volume decreases when its temperature is raised from 0ºC to 4ºC where it reaches a maximum. Since our brains are 92% water, this phenomenon has a potential, powerful impact on improving our ability to learn. If we studied in a freezer with a frozen brain, we conceivably would be less dense!

In ***Part I*** of this experiment, you will first find and use the CRC Handbook value(s) for the density of pure water at a measured temperature in order to calculate the volume of a weighing bottle to a very high degree of accuracy after measuring the mass of the water in the bottle. After calculating the accurate volume of the weighing bottle, the density of an unknown liquid can be determined with approximately the same accuracy. This avoids using a volumetric directly to measure volume, which at best can accurately measure volume to 0.01 mL depending on the volumetric used, vs. 0.0001 mL for this method.

♠ Before beginning, prepare a pre-lab report in your lab notebook for Dr. R.'s signature that includes tables in which to record your data and the results. Be sure to follow the required format. Don't forget to include units and the correct number of decimal places / significant figures. Record the experimental data in your lab notebook, **not in the table examples.** Leave room in your report to show your calculations.

Volume of a Weighing Bottle *(from the mass and density of H_2O)*

Mass, bottle + stopper + water	
Mass, bottle + stopper	
Mass, water	
Temperature of water	
Density of water *[Extrapolated from CRC Handbook]*	
Volume of bottle *[Calculated]*	

Density of a Liquid

Unknown number	
Mass, bottle + stopper + unknown	
Mass, bottle + stopper	
Mass, unknown liquid	
Density, unknown liquid *[Calculated]*	

Procedure

A) Insure that your weighing bottle is clean, wash it with detergent, rinse it with tap water and then again with several portions of deionized water. Rinse one last time with acetone and let it sit for a few minutes at room temperature to air dry. Weigh the bottle and stopper to the nearest 0.0001 g and record the mass. Completely fill the bottle with deionized water until the level is above the very top of the ground glass surface in the neck. Carefully work the stopper into the bottle so as to drive out the excess water and not trap any air. Wipe off any water on the outside of the bottle. The bottle should be completely dry on the outside before you weigh it.

Weigh the water-filled bottle to the nearest 0.0001 g and record the mass. Record the temperature of the water. Find the density of the water from the table in the CRC Handbook. It will very likely be necessary to extrapolate from the values found in the CRC Handbook to determine water's density at the actual temperature measured. From the mass of the water and its density given at that temperature, calculate the volume of your bottle to the correct number of significant figures.

Empty the weighing bottle, dry it, and fill it with your unknown liquid. Stopper and dry the outside of the bottle as you did with the water and weigh the bottle full of unknown liquid. From the mass of the unknown liquid and the volume of the bottle, calculate the density of your unknown liquid. Don't forget to record your unknown number.

B) Select a partner. Your group will determine the respective density of either unknown cola (A) and unknown cola (B). Dr. R. will assign one of them. Use the calculated volume of the weighing bottle as determined above, repeat the procedure that was used for the unknown liquid but now using the unknown cola. Report your data on the Blackboard. Include it plus all of the other class results for both colas in your individual reports. Identify which you think is the diet cola. Offer an explanation in your lab report as to why the densities of diet and non-diet soft drinks differ and why there can be differences in the densities between similar diet products eg. *Coke* and *Pepsi* and similar non-diet products.

(Hint: Consider the ingredients listed on the respective cans of the identifiable soft drinks.)

Refer to: http:/chemconnections.org/general/chem120/density.html

Part II: Using the Web, find a reference that will allow you to identify your unknown metal from Experiment 1 using its density.

Complete ***Parts III, IV and V***.

Name(s)___________________________

POST-Lab Questions: Parts III, IV and V: *Can be done individually or with a partner and turned-in as a single submission with your partner's and your name. Attach to one of the lab reports.* Refer to: http:/chemconnections.org/general/chem120/density.html

III. Answer the Web questions, include calculations where called for.

Table of Physical Data					
Object	Diameter or length	Mass	Object's Volume	Object's Density	% Volume of Object below the surface
Sphere 1	10.0 mm	0.4975 g			
Sphere 2	22.0 mm	4.7655 g			
Sphere 3	37.0 mm	0.9763 g			
Cube	10.0 mm	1.0160 g			

B) Assume the density of this iceberg is 0.890 g/cm^3 and the density of the upper layer of water in the Ross Sea is 0.999 g/cm^3. The shape of the iceberg above water can be approximated as a rectangular block. The surface volume can be calculated from the estimated dimensions :

Length = 500 meters, Height = 90 meters, Width = 150 meters.
1) Calculate the percent volume of the iceberg below the surface.
2) Calculate the total mass of the iceberg. (Show your calculations.)

IV.

1. What is the percent alcohol by mass?

2. What is the percent alcohol by volume?

3. What is the number of calories per pint of a homemade beer which had an original specific gravity of 1.10 and a final specific gravity of 1.05?

Part V: (Show your calculations.)

1. The density of 24 Karat, pure gold is 19.32 g/mL.

   A 10-mL graduated cylinder is filled to 5.00 mL. A ring is placed in the graduated cylinder, and the water level rises to 5.15 mL. The ring is then dried and placed on a balance, and its mass is 2.8315 g. Find the density of the ring. Is it 24 Karat gold?

2. The density of water is 1.00 g/mL. Use this fact and the following conversion factors to determine the number of moles of water in 1.00 cup.

1 gal = 3.785 L	4 qt = 1 gal
1 qt = 32 fl oz	1 cup = 8 fl oz

3. The density of aniline, $C_6H_5NH_2$, is 1.02 g/mL. How many milliliters are needed for a laboratory scale reaction that requires the addition of 250. millimoles of aniline?