LAB 2: DENSITY OF LIQUIDS AND SOLIDS

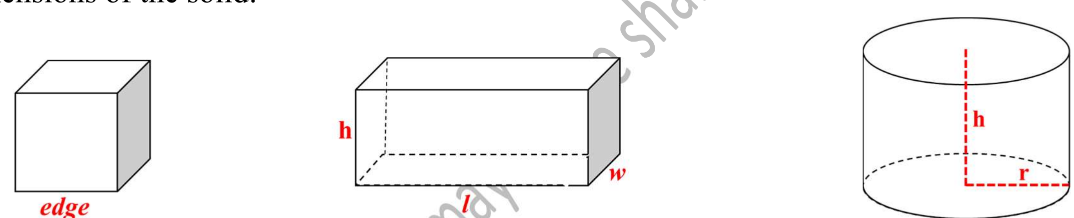
Density is defined as mass/volume: $\text{Density} = \frac{\text{mass}}{\text{volume}}$

Density is typically expressed as ***grams/cm³*** or ***grams/mL*** (derived units). It is an intensive physical property (that is, a property that is independent of the amount of substance measured). The physical properties of mass and volume that determine a substance's density are extensive physical properties of matter (properties are dependent on amount). Densities of liquids and gases are affected by temperature. To determine the densities of a solid and liquid sample, we must determine both the mass and volume of the sample.

Determination of Mass. For a solid sample, this can be directly determined using a balance. The mass of a liquid can be obtained indirectly, using a method called ***weighing by difference***; this method requires one to first weigh an empty container ($m_{container}$), then weigh the container with the liquid sample being studied ($m_{container + liquid}$).The difference between the two masses is the mass of the liquid sample being investigated ($m_{liquid} = m_{container + liquid} - m_{container}$).

Determination of Volume. The volume of a liquid can be measured directly using calibrated labware (*e.g.*, graduated cylinders, burets, pipets).

The volume of solids with regular shapes (rectangular, cubic, cylindrical, etc.) can be calculated using the dimensions of the solid:



$V_{cube} = (edge)^3$ $V_{rectangular\ prism} = lwh$ $V_{cylinder} = \pi r^2 h$

The volume of solids with irregular shapes can be obtained indirectly, using a method called *volume by displacement*. In this method, the irregular solid is submerged in a graduated cylinder containing a liquid (typically water). The water volume displaced by the solid is equal to solid's own volume. The difference between the final and initial volume measurements is the volume of the solid object.

In this week's lab you will investigate different experimental techniques for determining the densities of various liquids and solids, including deionized water; a solution of an unknown alcohol; a rubber stopper; an unknown metal; and a sample of aluminum. You will also determine the thickness of aluminum foil using the known density of aluminum.

Based in part on *Chemistry 1792 Lab Manual: General Chemistry I*. Central New Mexico Community College © 2015

Experimental Procedures

<u>How to Use a Top-loading Electronic Balance</u> (the balance should be on; if it is off, please inform your TA).

- Tare the balance (press the tare button to zero the balance). The reading may fluctuate around 0.000 g since the balance is very sensitive and may be disturbed by the air flow around it.
- Once the balance reads 0.000 g, carefully place the object you are weighing onto the balance pan. Wait a few seconds for the mass reading to stop fluctuating, then record the mass (with all the digits seen on the balance; you should never round the mass displayed by electronic balances)
- Note: To minimize errors, ***use the same balance throughout your experiment.***

<u>How to Correctly Read the Volume of a Liquid Sample Using a Graduated Cylinder</u>

- Make sure your eyes are at the same level with the liquid and look straight at the meniscus.
- Read the liquid level at the bottom of the meniscus and record it with the correct number of significant figure (according to the markings on the cylinder).

Experiment 1. Determining the Density of Deionized (DI) Water

1. Using a top-loading balance, weigh a clean, **dry** 10 mL graduated cylinder (±0.001 g), and record the mass on your Report Sheet.

2. Pour ~7–8 mL of DI water into your graduated cylinder. Record the volume (±0.01 mL) under Sample #1 on your Report Sheet.

3. Weigh the 10 mL graduated cylinder containing the water sample (±0.001 g), and record the mass for Sample #1 on your Report Sheet.

4. Discard the DI water (into the sink). Note: only DI water should be discarded down the drain. Chemicals (or any contaminated water) should be disposed of in waste containers, according to your TA's instructions.

5. Repeat steps 2, 3, and 4 with a second sample of DI water (Sample #2). Record the information in your Report Sheet.

Experiment 2. Determining the Density of a Sample of an Unknown Alcohol

1. In your Report Sheet, record the mass (to ±0.001 g) for your empty10 mL graduated cylinder (obtained for Experiment 1).

2. Select a sample of an unknown alcohol and record the identification number of your unknown alcohol.

3. Pump 2 mL of the selected alcohol (from the bottle-top dispenser) into the graduated cylinder and use it to rinse out the cylinder. Discard the alcohol into a waste container (as indicated by your TA) and repeat the rinsing process. This rinsing will remove any water present in your cylinder and coat the inside with the alcohol.

4. From the bottle-top dispenser, pump 2 mL four times for a total of 8 mL of alcohol into your rinsed graduated cylinder. Record the volume (±0.01 mL) for Sample #1 in the Report Sheet.

5. Weigh the 10 mL graduated cylinder with the alcohol, and record the mass (±0.001 g).

6. Discard the alcohol into a waste container.

7. Repeat steps 4, 5, and 6 for a second sample of the same unknown alcohol (Sample #2). Record the information in your Report Sheet.

Experiment 3. Determining the Density of a Rubber Stopper

1. Obtain and weigh a dry rubber stopper (size 1) and record the mass (±0.001 g).

2. Fill a 50 mL graduated cylinder with ~25–30 mL of DI water. Record the initial volume of water (±0.1 mL) in your Report Sheet.

3. With the cylinder tilted, carefully immerse the rubber stopper in the water; avoid splashing the water as this will give you an inaccurate volume for the stopper. If you notice any bubbles attached to the rubber stopper, gently shake the cylinder to remove them. Record the new water volume (water + stopper) in your Report Sheet.

4. Discard the water and dry the stopper. Return the rubber stopper to the proper container.

Experiment 4. Determining the Density of an Unknown Metal

1. Obtain a sample of an unknown metal. Record the Unknown identification number in your Report Sheet.

2. Weigh the metal sample and record the mass (±0.001 g).

3. If your metal sample is small enough, use your 10 mL graduated cylinder; otherwise, use your 50 mL graduated cylinder. Half-fill the cylinder with DI water. Record the initial volume of water (±0.01 mL for the 10 mL graduated cylinder or ±0.1 mL for the 50 mL graduated cylinder).

4. With the cylinder tilted, carefully immerse the metal sample in the water; avoid splashing the water as this will give you an inaccurate volume for your sample. If you notice any bubbles attached to the metal, gently shake the cylinder to remove them. Record the new water volume (water + metal) in your Report Sheet.

5. Discard the water from the graduated cylinder and dry the metal sample. Return it to the proper container.

6. Calculate the density of your unknown metal sample, and compare it to known densities of some metals given in the following table. Select the metal that most closely matches your calculated density and identify it in your Report Sheet.

Metal	Aluminum (Al)	Zinc (Zn)	Copper (Cu)	Molybdenum (Mo)	Lead (Pb)
Density (g/cm^3)	2.70	7.14	8.94	10.22	11.35

Experiment 5. Determining the Density of Aluminum

1. Obtain a small rod (**not foil**) of aluminum. Weigh the aluminum rod, and record the mass in your Report Sheet.

2. Fill a 10 mL graduated cylinder with ~5–6 mL of deionized water. Record the volume of water (±0.01 mL).

3. With the cylinder tilted, carefully immerse the aluminum rod in the water; avoid splashing the water as this will give you an inaccurate volume for your sample. If you notice any bubbles attached to the metal, gently shake the cylinder to remove them. Record the new water volume (water + aluminum rod) in your Report Sheet.

4. Drain the water from the graduated cylinder. Dry the aluminum sample, and return it to the proper container.

5. Calculate the density of the aluminum and compare it with the literature value of 2.70 g/cm^3.

Experiment 6. Determining the Thickness of Aluminum Foil

1. Obtain a pre-cut sample of aluminum foil.

2. Measure the length and width of the foil to ±0.01 cm using the metric ruler. Record these measurements in your Report Sheet.

3. Fold the foil in half so that it is approximately no more 5 cm on either side. This will assure that the foil will fit on the balance pan. Weigh the foil, and record the mass in your Report Sheet.

4. Unfold the foil, and return it to the proper container.

Report Sheet: Raw Data & Data Processing

Your Name:______________________

Section #:_______

1. Density of Water Data	Sample #1	Sample #2
Mass of 10 mL graduated cylinder (g)		
Mass of 10 mL graduated cylinder + water (g)		
Mass of water (g)		

Volume of water (mL)		
Calculate the density (d = $\frac{mass}{volume}$) of water (g/mL)		
Mean density of water (g/mL)		

2. Density of an Unknown Alcohol Data Unknown Identification #:_________	Sample #1	Sample #2
Mass of 10 mL graduated cylinder (g) (from the water table above)		
Mass of 10 mL graduated cylinder + alcohol (g)		
Mass of alcohol (g)		
Volume of alcohol (mL)		
Density of alcohol (g/mL)		
Mean density of alcohol (g/mL)		

3. Density of a Rubber Stopper Data	
Mass of rubber stopper (g)	
Volume of water in cylinder (mL)	
Volume of water + rubber stopper in cylinder (mL)	
Volume of rubber stopper (mL)	
Density of rubber stopper (g/mL)	

4. Density of an Unknown Metal Data	
Unknown Identification #	
Mass of metal sample (g)	
Volume of water in cylinder (mL)	
Volume of water + metal in cylinder (mL)	
Volume of metal (mL)	
Density of metal (g/mL)	
Identity of metal	

5. Thickness of Aluminum Foil Data	
Density of aluminum (literature value) (g/cm^3)	2.70
Length of aluminum foil (cm)	
Width of aluminum foil (cm)	
Mass of aluminum foil (g)	
Volume of aluminum foil (cm^3)	
Thickness of aluminum foil (cm)	