DETERMINING THE DENSITY OF LIQUIDS & SOLIDS

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 the **milliliter** (**mL**), and the unit of volume for a **solid** is a **cubic centimeter** (**cm^3**). Therefore, the density of a liquid is usually expressed in 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]

When we say that gold (density =19.7 g/cm^3) is more dense than aluminum (2.70 g/cm^3), we mean that a gold cube is heavier (has a larger mass) than an aluminum cube of the same size. For example, 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.

Determining the 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 a 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.

In this experiment you will determine densities of an unknown liquid and solid by measuring their mass with a balance and their volume. First, you will determine the exact volume of a flask using water. You will determine the density of a solid by displacement of a known quantity of water.

PROCEDURE: Part A: Density of a Liquid

1. Clean a 10 mL volumetric flask with soap and water. Dry with a small amount of acetone in the hood and by gently blowing compressed air into it. Determine and record the mass (to the nearest mg) of the *clean* and *dry* 10 mL volumetric flask with a stopper in it.

2. Fill this 10 mL volumetric flask with distilled water. Insert stopper so no air remains in flask. Dry the outside of the volumetric flask. Record the mass to the nearest 0.001 grams.

3. Calculate the mass of the water in the flask. Remember to show all calculation steps in your lab report.

4. Determine the temperature of the water to the tenths place. Use the *Handbook of Chemistry and Physics* to find the density of water at this temperature.

5. Calculate the volume of this volumetric flask. Remember significant digits!

6. Dry the volumetric flask. Obtain an unknown liquid and record the identification number. Fill the volumetric flask with the unknown liquid, stopper and record the mass.

7. Calculate the mass of the unknown liquid added.

8. Calculate the density of the unknown liquid to the correct number of significant digits.

Part B: Density of a solid

1. Select an unknown metal and record its number. Clean and dry a 25 mL Erlenmeyer flask that will fit your metal sample. Record the mass of the dry flask and stopper. Fill the flask with water. Record the mass.

2. Determine the volume of the Erlenmeyer flask as in part A.

3. Dry the flask thoroughly. Add small chunks of a dry metal sample to the flask until the flask is at least half full. Weigh the flask, with its stopper and the metal, to the nearest milligram. You should have about 50 g of metal in the flask.

4. Determine the mass of metal added.

5. Leaving the metal in the flask, fill the flask with water and replace the stopper. Roll the metal around in the flask to make sure that no air is trapped between the metal pieces. Refill the flask if necessary, and then weigh the stoppered flask full of water plus the metal sample.

6. Calculate the mass of water added.

7. Calculate the volume of water added based on its density and mass.

8. Calculate the volume of metal added. Use this value to calculate the density of the metal.

9. Pour the water from the flask. Dry the metal before returning to its container.

POSTLAB QUESTIONS

1. To what decimal place value can a 10 mL graduated cylinder be read? 50 mL?

2. In the original Indiana Jones movie, our hero is attempting to claim a precious ancient gold relic from a poor third world country. He estimates the size of his prize and carefully adjusts the *volume* of sand in his bag to equal that of the gold relic. With the dexterity that only Indiana Jones possesses, he swiftly but delicately swaps the sand for the gold. After a moment of delight, our hero realizes he has misjudged and the ancient tomb is not fooled. What went wrong?

3. How can the volume of an irregularly shaped object that is less dense than water be found?

4. Dennis obtained a clean, dry stoppered flask. He determined the mass of the flask and stopper to be 32.634 g. He then filled the flask with water and determined the mass of the full stoppered flask to be 59.479 g. Based on the temperature of the water, Dennis found the density of water in the *Handbook of Chemistry and Physics* to be 0.998730 g/cm^3. Calculate the volume of the flask.

5. Dennis emptied the flask from question #4, dried it and filled it with an unknown liquid. The mass of the stoppered flask when completely filled with liquid was 50.376 g. Calculate the density of the unknown liquid.

6. Dennis emptied the flask from question #4 and #5 and dried it again. He added an unknown metal to the flask. He determined the mass of the stoppered flask and metal to be 152.047 g. He then filled the flask with water, stoppered it and obtained a total mass of 165.541 g. Calculate the volume of metal added and the density of the unknown metal.