

Experiment 2 - Density Measurements

Density is a physical property of matter which describes the relative “heaviness” of an object at a given volume. Density is defined as mass per volume. For solids and liquids, the units are usually reported in grams per milliliter.

$$d = \frac{\text{mass}}{\text{volume}} = \frac{g}{mL}$$

In Part I, you will weigh a sample and then determine its volume by three different methods. You will then use the volume obtained to calculate the density of the sample for each method.

Direct Measurement

The volume of an object will be measured using a ruler. If the measurements are made in cm, then the units will be cm^3 which is equal to mL. The volume of the object can then be determined for the following shapes:

Cube: Volume = length x height x width

Cylinder: Volume = length x π x (radius)²

Sphere: Volume = $4/3$ x π x radius³

Volume Displacement

The object is lowered into a graduated cylinder containing water. As the object sinks, water is displaced and the volume of water displaced is equal to the volume of the object placed into the graduated cylinder. The volume can be determined by calculating the difference in the water levels in the cylinder.

$$\text{Volume} = V_{\text{final}} - V_{\text{initial}}$$

Archimede's Principle (Mass Displacement)

An object immersed in a fluid is buoyed up by a force equal to the mass of the fluid displaced. This buoyant force can be determined by weighing the object in air and in water. *Buoyancy* or *buoyant force* is the upward force on an object placed into a liquid. When an object is immersed in water, it will feel lighter. The difference between the two masses is the buoyant force of water.

$$\text{Buoyant Force} = \text{Mass}_{\text{in air}} - \text{Mass}_{\text{in water}}$$

Using the mass of water displaced (the buoyant force) and the density of water, you can calculate the volume of water displaced.

In Part II, you will use the mass displacement technique to find the density of a NaCl solution.

Equipment and Reagents

Metal sample (cube)	String or thread	400 mL beaker
Metric ruler	Scissors	Thermometer
Triple beam balance	Tap water	
Large graduated cylinder	NaCl solution	

Procedure

Part I – Finding the density of an object.

Direct Measurement

1. Obtain a metal sample (cube). Weigh it to the nearest 0.01 grams on a triple beam balance. Record the mass in your notebook.
2. Measure the each dimension (length, height , width) to the nearest 0.01 cm with a metric ruler and record the measurements in your notebook.
3. Calculate the volume in cm^3 (mL) of the cube from the dimension measurements.
4. Calculate the density of the sample.

Volume Displacement

1. Re-enter the mass of the sample from the direct measurement.
2. Obtain a graduated cylinder large enough to contain the metal sample cube. A large plastic cylinder would be ideal because it is less likely to break upon insertion of the metal cube. Fill the cylinder about half full. This should be enough to completely submerge the cube. Record the initial volume before insertion of the cube.
3. Tilt the cylinder at an angle and then carefully insert the cube into the cylinder. Avoid breaking the cylinder or splashing the water. Record the final volume after insertion of the cube.
4. Calculate the volume of the sample.
5. Calculate the density of the sample.

Mass Displacement

1. Re-enter the mass of the sample from the direct measurement.
2. Suspend the sample by a string or thread from the hook at the top of the balance pan hanger.
3. Fill the 400 mL beaker about half full with tap water.
4. Place the beaker of tap water on the platform of the balance and adjust the height of the platform so that the sample is suspended freely but not in contact with the beaker. Record the mass of the sample suspended and submerged in the water.
5. Record the temperature of the tap water in the beaker and look up the density of water at the recorded temperature and record this value in your notebook.
6. Calculate the buoyant force of the water on the metal sample.

- Calculate the volume of water displaced from the buoyant force and the density of water.
- Calculate the density of the sample.

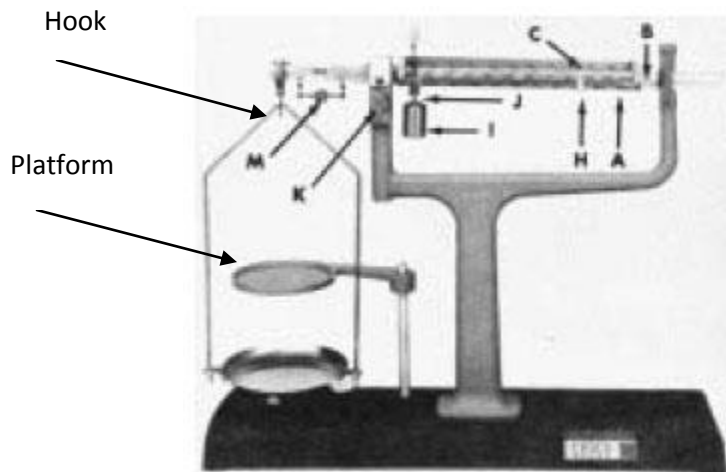


Figure 1: Triple Beam Balance

Part II - Finding the density of a NaCl solution by the mass displacement method.

- Re-enter the mass of the metal sample used in part I.
- Suspend the metal cube from the hanger on the triple beam balance.
- Replace the beaker filled with tap water with a 400 mL beaker filled with a sodium chloride solution of unknown density. Record the ID number of the sample used.
- Record the mass of the sample submerged into the NaCl solution.
- Calculate the buoyant force of the NaCl solution on the metal sample.
- Calculate the density of the NaCl solution. The mass of the solution is the buoyant force and the volume is taken from volume of water displaced in part I of the mass displacement technique.

Report

Results and Discussion

Tabulate the results as follows:

Method	Sample	Mass (g)	Volume (mL)	Density (g/mL)
Direct	Metal Cube			
Vol. Displacement	Metal Cube			
Mass Displacement	Metal Cube			
Mass Displacement	NaCl Solution			

Record the final answer to the correct number of significant figures. Compare the values with each other.