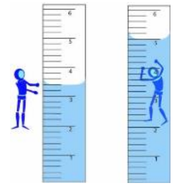
Lab 02.2a
Determining Density

BACKGROUND

Density is an intensive property of matter that basically describes how tightly particles are packed together in a sample of matter. It is expressed as the ratio of mass to volume for the sample. Credit for the concept is typically given to the Greek natural philosopher Archimedes.



While the mass of a sample is easy to measure using a balance, the volume can be a challenging measurement depending on its shape. If the object has a regular geometric shape, its volume can usually be calculated using its dimensions. If the object has an irregular shape, however, the its volume can be determined through displacement. In displacement, a volume of liquid is placed in a graduated cylinder and noted. The object is then completely submerged in the graduated cylinder and the final volume is noted. The displacement (i.e., volume) of the object is the difference of these noted volumes.

Calculating density (represented by the Greek letter "ρ") requires dividing the mass(m) of the object by its volume(V).

$$\rho = \frac{m}{V}$$

While the SI unit of density is technically kilogram per cubic meter (kg/m^3), in chemistry it will be typically expressed as grams per milliliter (g/mL). It should be noted that milliliters and cubic centimeters are equivalent volumes 1 mL = 1 cm^3.

Density has many uses. It can help in the identification of an unknown substance, allows for predictions regarding how materials will interact, and can provide ways to measure substances that would otherwise be difficult. Noting a change in density of a material may help note that a chemical change has taken place.

Density can be used to solve for mass and volume if the other quantity is known.

$$V\rho = m \qquad or \qquad V = \frac{m}{\rho}$$

Density is a key concept in analyzing how materials interact in fluid mechanics, weather, geology, material sciences, engineering, and other fields of physics.

Safety

- Standard Bunsen burner precautions should be taken (hair tied back, loose clothing secured or removed, etc.)
- Handle the crucible and its lid only with tongs. The crucible remains hot for a long period and represents a significant burn hazard.
- Wear appropriate personal safety equipment (goggles, aprons, gloves, etc.)
- Wash hands with soap and water before leaving the laboratory.

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Chemistry I/H

I. PURPOSE
To explore the concept of density and learn methods for measuring substances and calculating densities.

II. MATERIALS
1. Balance
2. Caliper or Ruler
3. Graduated cylinders
4. 3 Geometrically Regular Objects
5. 3 Irregularly Shaped Objects
6. 2 Unknown Liquids

III. PROCEDURES
Part A - Geometrically Regular Objects
1. Measure & record the mass of each geometrically regular object in Data Table A.
2. Measure & record the dimensions of each geometrically regular object in centimeters.

Part B – Irregularly Shaped Objects
1. Measure & record the mass of each irregularly shaped object.
2. Fill the smallest graduated cylinder that will hold the object being tested approximately ½ full. Record the initial volume of the water in Data Table B.
3. Holding the graduated cylinder at an angle, slide the object into the graduated cylinder. Record the final volume of the graduated cylinder.
4. Repeat steps 2&3 for each of the irregularly shaped objects.

Part C - Liquids
1. Measure & record the mass of a clean, dry 10 mL graduated cylinder.
2. Add between 9. & 10. mL of distilled water to the graduated cylinder and record the exact volume in Data Table C. Weigh and record the cylinder and water. Dispose of the water, then clean and dry the graduated cylinder.
3. Repeat the above procedure for unknown liquids A & B.
4. Return the unknown liquids A & B to the proper containers. DO NOT THROW THEM AWAY!

IV. PRE-LAB QUESTIONS
1. What is the formula for determining the volume of a cylinder?
2. What procedure can be used for determining the volume of an irregularly-shaped object?
3. Why must the graduated cylinder in Part C be dried before each trial?
4. How many decimal places should be recorded when using the ruler in Part A?
5. How many decimal places should be recorded when using the graduated cylinders in Parts B & C?

V. DATA & CALCULATIONS
A. DATA

Data Table A - Geometrically Regular Objects

Object Description	Mass (g)	Length (cm)	Width (cm)	Depth (cm)	Diameter (cm)
Block					/
Cylinder 1			/	/	
Cylinder 2			/	/	

Data Table B - Geometrically Irregular Objects

Object Description	Mass (g)	Initial Volume (mL)	Final Volume (mL)	Displacement (mL)

Data Table C - Liquids

Item Description	Mass w/Cylinder (g)	Sample Mass (g)	Volume (mL)
Empty Grad Cylinder		/	/
Water			
Unknown Solution A			
Unknown Solution B			

B. CALCULATIONS
1. Complete the data tables showing all necessary work below.
2. Calculate the volume of the objects in Part A using geometric formulas. Show all work.
3. Calculate the density of each of the nine samples in Parts A – C using the relationship:

$$\text{density} = \text{mass (g)} / \text{volume (cm}^3\text{)}.$$

4. The density of water in Part C should have been 1.0 g/ml. Calculate the percent error for the density of water.

VI. POST-LAB QUESTIONS

1. Explain in detail why the rods in part A have similar volumes, but different densities.
2. How would the densities of the liquids in Part C have been different if the graduated cylinder was not properly dried before each trial?
3. How would the densities of the objects in Parts B have been different if they had been wet before weighing?
4. Suggest a method of determining the density of a gas.
5. Why is it necessary to indicate temperature when giving density values for fluids?

VII. CONCLUSION