Investigating Density

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Purpose of the Experiment

- Learn the correct use of common lab equipment (top loading balances, graduated cylinders)
- To practice making measurements and reporting them correctly.
- To master the concept of density as an intensive property

Background Required:

Complete prelab assignments for Lab 1 and your Lab Procedure Outline as your instructor assigned.

Background Information:

We all know that same-size blocks of wood, concrete, and Styrofoam will have different masses. We expect that the wood and Styrofoam blocks will float in water and the concrete block will sink. This knowledge that there can be differences in mass for same-sized objects and the expectation that a substance will float or sink in water means we already have an intuitive understanding of the physical property called density. The concrete sinks because its density is greater than that of water, the wood and Styrofoam float because their density is less than water. Density tells us how much a substance weighs for its size or, more specifically, its volume. Mathematically, density (D) is defined as the mass (m) of a substance or object divided by its volume (V) or $\mathbf{D = m/V}$. We usually report density using units of g/mL (liquids) or g/cm^3 (solids). Since density is a physical property, we can measure it without changing the composition of a substance. Density is also an **intensive property**. This means **the density of a homogeneous substance is the same no matter what quantity of the substance we measure**.

To determine the density of a substance, we must be able to measure its mass and volume. We can determine the mass of solid objects directly by placing them on a balance. We can also determine the mass of either liquids or solid substances by **difference;** that is by weighing a container, adding the substance and weighing the container with the substance. The mass of the substance is the difference between the mass of the container and the mass of the container with the substance.

The method we use for determining the volume of a substance depends on the state and shape of the substance. For liquids, we can measure the volume directly in a graduated cylinder. For regular solids such as blocks or spheres, we can measure their dimensions and calculate the volume. For small irregularly shaped objects that are not soluble in water, we can measure their volume by *displacement.* We add water to a graduated cylinder, record the volume, then add the object and record the new volume. The object *displaces* the water in the cylinder, and the volume level of the water increases. **The change in the measured volume of water is the volume of the object**. We calculate it by subtracting the volume of water alone from the volume of the water with the object.

In this lab, we will use common lab equipment to measure mass and volume of a liquid (isopropyl alcohol), an irregularly shaped solid (sulfur chunks) and a regular solid (wood blocks) and calculate their densities. By the end of this lab, you should be able to: make measurements with the correct number of digits, calculate density from measurements of mass and volume, and calculate percent error with correct significant figures.

Equipment:

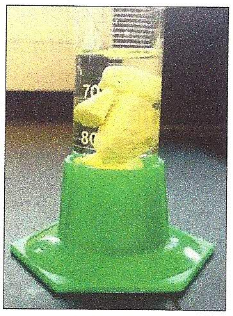
10 mL, 100 mL graduated cylinders	Isopropyl alcohol	Small (50 mL) beaker
Wood blocks of different densities	Ruler (markings to 0.1 cm)	Small plastic transfer pipets
Sulfur chunks	Top loading balance	Weighing paper

Safety: Always wear your safety goggles while in the lab room. Avoid inhaling the isopropyl alcohol fumes. Note: We do not normally pour anything back into a reagent bottle, however, you will in this lab so the alcohol can be reused. Wash your hands well before leaving the laboratory.

Procedure: Work with a partner, but each partner must make and record their own measurements.

Part A: Density of isopropyl alcohol

1. Measure the mass of your 10 mL graduated cylinder by following the instructions below for the top loading balance:
   a. Place your clean dry cylinder on the balance and wait for the digital readout to stabilize
   b. Record the mass of the cylinder (write all digits in the display) in the data section
   c. Remove the cylinder from the pan
2. Add between 7-10 mL of isopropyl alcohol to the cylinder using a transfer pipet and record the volume. Measure from the base of the meniscus, read to 0.1mL and estimate the second decimal place. Remember, an estimated value of zero is a valid significant figure.
3. Measure the mass of the cylinder with alcohol on the same balance you used before and record all balance digits.
4. Pour the isopropyl alcohol back into the reagent bottle.



Part B: Density of sulfur

1. Bring 4-5 sulfur chunks to a balance using a small beaker.
2. Measure the mass of the sulfur chunks as follows:
   a. Place a piece of weighing paper on the balance pan
   b. Press zero/tare and wait for the balance to read 0.00 g
   c. Place the sulfur chunks on the paper and let the readout stabilize.
   d. Record the mass of the sulfur chunks (all balance digits)
   e. Place the sulfur chunks back into your beaker.
3. Add 30-40 mL of water to your 100 mL graduated cylinder and record the volume. Read from the base of the meniscus and reading to 1 mL (the smallest marks) and estimating between the marks to 0.1 mL. **Remember, an estimated value of zero is a valid significant figure.**
4. Tilt the cylinder slightly and slide the sulfur chunks into the water. Be careful not to let the water splash out of the cylinder. If water splashes out, you must repeat Part B.
5. Read the volume of water and sulfur and record this value (estimate 1 decimal place).
6. Pour the water into the drain, and catch the sulfur chunks with a paper towel. Place the wet sulfur chunks into the container labeled "Wet Sulfur".

Part C: Density of wooden block

1. Obtain a wooden block and record the identification letter in the data section.
2. Measure the mass of the block following the directions below for the top loading balance:
   a. Press zero/tare and wait for the balance to read 0.00 g
   b. Place the block onto the pan and wait for the digital readout to stabilize
   c. Record the mass of the block in the data section (all digits)
3. Using a ruler marked in centimeters, measure the length, width and height of the block, and record each measurement. Use the correct number of significant figures by reading to the tenth of a centimeter and estimating to one hundredth of a centimeter (0.01 cm).
4. Return the wooden block to the bin.

Data, Calculations and Discussion: Record all data in the indicated spaces in the Data Table. Complete all calculations on the table and answer the discussion questions with your partner before leaving. Follow your instructor's directions for turning in the Data, Calculations and Discussion Questions pages.

① Students do density of alcohol or sulfur in any order they want
② Each partner reads his/her own data with right sig.fig
③ Calculate in right place & underline in correct digit & final answer

Name________________________ Partner____________________________ #_________

Data and Calculations ***(Make sure you are recording the correct digits for all devices!)***

Part A: Density of isopropyl alcohol Example Only

Data EXAMPLE	My value (units)	Partner's value (units)
Mass of empty 10 mL cylinder (g) *(all balance digits)*	8.020 g	
Volume of alcohol (mL) *(2 decimal places)*	7.92 mL	
Mass of cylinder and alcohol (g) *(all balance digits)*	10.4321 g	
Calculations (Show set-up below with numbers and units)		
Mass of alcohol (g) Mass of cylinder and alcohol – Mass of empty 10 mL cylinder 10.4321 − 8.020 = 2.4101 g	2.410 g	
Density of alcohol (g/mL) Mass of alcohol (g)/volume of alcohol (mL) $\frac{2.4101\,g}{7.92\,mL}$ = 0.304305	0.304 g/mL	

Part B: Density of sulfur

Data	My value (units)	Partner's value (units)
Mass of sulfur (g) *(all balance digits)*		
Volume of water (mL) *(1 decimal place)*		
Volume of water and sulfur (mL)		
Calculations (Show set-up below with numbers and units)		
Volume of sulfur (mL) (Volume of water and sulfur - volume of water)		
Experimental density of sulfur (g/mL) (Mass of sulfur (g)/volume of sulfur(mL))	2.085	
Reference value for density of sulfur (g/mL)	**2.07 g/mL**	
Percent error (%) (*Watch SFs, this is a mixed operation)* $\frac{\text{experimental value – reference value}}{\text{reference value}}$ x 100% = $\frac{2.085-2.07}{2.07}\times100 = \frac{0.015}{2.07}\times100$ = 0.724637 %	0.7%	

Part C: Density of wood block: Block ID ______

Data	**My Values (units)**	**Partner's Values (units)**
Mass of wood block (g) *(all balance digits)*		
Length (cm) *(2 decimal places)*		
Width (cm) *(2 decimal places)*		
Height (cm) *(2 decimal places)*		
Calculations (Show set-up below with numbers and units)		
Volume of block (cm^3) L x W x H		
Density of wood block (g/cm^3) Mass (g)/volume (cm^3)		

Discussion Questions:

1. Record the alcohol density determined by another pair of students:
   Other students' names ________________________ Density value(s)________
   a. Are their density values close to yours (within +/- 0.05 g/mL)?

   b. Theoretically, should the densities be approximately the same value? Why or why not?

2. **Do significant figures matter?** Students A and B recorded these measurements at the **same time** for the **same alcohol sample** using the **same equipment** you used. The only differences were how they read and recorded each measurement.

Measurement	**Student A**	**Student B**
Mass of empty 10 mL cylinder	23.303 g	23.3 g
Mass of cylinder and alcohol	30.395 g	30.3 g
Volume of alcohol	8.61mL	9.0 mL
Calculated density		
% error (True value for sample = 0.830 g/mL)		

   Calculate the density and percent error for each set of data and write these values in the table.

   a. Which student's percent error is greater?

   b. What types of errors in reading measurements and recording data were made by the student with the greater percent error?

3. **Error analysis:** While performing Part B, some of the water splashed out when the sulfur chunks were added to the graduated cylinder. Think about each step in Part B and review the calculations, then explain whether this error will make the calculated sulfur density value too high, too low, or have no effect on the calculated value.