Investigating Density

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Purpose of the Experiment

- To learn how to use common lab equipment including top loading balances, rulers, and the small and large graduated cylinders.
- To practice making measurements and reporting them correctly.
- To master the concept of density as an intensive property

Background Required:

Complete the online prelab assignment for "Investigating Density" BEFORE the start of the lab session. You will work in pairs for this experiment.

Background Information:

We all know that the 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 **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; 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 its 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 the density of a liquid (isopropyl alcohol), an irregular shaped solid (sulfur chunks) and a regular solid (wood blocks). By the

end of this lab, you should be able to relate mass, volume and density mathematically, and you should be able to define and calculate percent error.

Equipment:

100 mL graduated cylinder	Isopropyl alcohol
Ruler (markings to 0.1 cm)	Wood blocks
Top loading balance	Sulfur chunks
50 mL beaker	

Safety: Always wear your safety goggles while in the lab room. Do not dispose of anything in the drain unless specifically directed to by your instructor. Note: We do not normally pour anything back into a reagent bottle! However, you will do so in this particular lab so that reagents can be reused.

Procedure:

Part A: Density of isopropyl alcohol

1. Measure the mass of your small graduated cylinder by following the instructions below for the top loading balance:
    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 your cylinder on the paper and wait for the digital readout to stabilize
    d. Record the mass of the cylinder in the data section
    e. Remove the cylinder from the pan and return to your lab bench
2. Add between 5-10 mL of isopropyl alcohol to your small cylinder and record the volume. Measure from the base of the meniscus and estimate to 2 decimal places (0.01 mL).
3. Being careful not to spill any isopropyl alcohol, measure the mass of the cylinder with alcohol on the same balance that you used before. Remember to follow the instructions in Part A1 for weighing the cylinder. Record the mass of cylinder with alcohol.
4. Pour the isopropyl alcohol back into the reagent bottle.

Part B: Density of sulfur

A. Add 3-4 sulfur chunks to your 50 mL beaker.
B. Measure the mass of the sulfur chunks following the instructions below for the top loading balance:
    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 onto the paper and wait for the readout to stabilize.
    d. Record the mass of the sulfur chunks in the data section
    e. Place the sulfur chunks back into your beaker and throw away the weighing paper
C. Add about 25-30 mL of water to your large graduated cylinder and record the volume in the data table. Read from the base of the meniscus and use the correct number of significant figures by reading to the tenth of a milliliter (0.1 mL).
D. Tilt the cylinder and carefully 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.
E. Read the volume of the water plus the sulfur and record this value.
F. Use the CRC Handbook of Chemistry and Physics to find the density of sulfur. Record this theoretical value in the data section.
G. Determine the percent error by using the equation in the calculations section.

H. 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. 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 wood block onto the paper and wait for the digital readout to stabilize
    d. Record the mass of the block in the data section
    e. Remove the block from the balance and return to your lab bench
3. Using your ruler, measure the length, width and height of the wood block in cm, and record each measurement in the data section. Use the correct number of significant figures by reading to the tenth of a millimeter (0.01 cm).
4. Calculate the density of the wood block in the calculations section, and record this in the data section. Your instructor will confirm whether your experimental density is reasonable.
5. 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. Staple and turn in only the Data and Discussion Questions on the due date.

Name_____ **Partner**_____ **Section #**_____

Data and Calculations

Part A: Density of isopropyl alcohol

Data	**Value (units)**
Mass of empty small graduated cylinder (g)	
Volume of alcohol (mL)	
Mass of cylinder with alcohol (g)	
Calculations (Show set-up)	
Mass of alcohol only (g) (mass of cylinder with alcohol – mass of empty cylinder)	
Density of alcohol (g/mL) (Mass of alcohol (g)/volume of alcohol(mL))	

Part B: Density of sulfur

Data	**Value (units)**
Mass of sulfur (g)	
Volume of water (mL)	
Volume of water plus sulfur (mL)	
Calculations (Show set-up)	
Volume of sulfur alone (mL) (Volume of water - volume of water plus sulfur)	
Density of sulfur (g/mL) (Mass of sulfur (g)/volume of sulfur(mL)	
Actual density of sulfur (g/mL) from CRC Handbook	
Percent error in sulfur density determination (%) $\frac{\text{Experimental value – Actual value}}{\text{Actual value}} \times 100\% =$	

Part C: Density of wood block: Letter _____

Data	**Value (units)**
Mass of wood block (g)	
Length (cm)	
Width (cm)	
Height (cm)	
Calculations	
Volume of wood block (cm^3) L x W x H	
Density of wood block (g/cm^3) (Mass of wood block (g)/volume of wood block (cm^3)	

Discussion Questions:

1. Record the alcohol density determined by another pair of students:

   Other students' names _____ Their density _____

   a. Are the densities close to the same value (within +/- 0.05 g/mL)?

   b. Should they be the same? Why or why not?

2. A student carefully rinsed their small graduated cylinder with deionized water before adding the isopropyl alcohol.

   a. How (high, low or no effect) might this affect (high, low or no effect) the student's calculated density for alcohol and why?

   b. What should the student have done to avoid any error?

3. If some of the water splashed out when you added the sulfur chunks to the cylinder, how would this have affected your calculated density? Explain/show your logic.