# Introductory Chemistry Lab: Density

**Outcomes**

As a result of today's laboratory, you will have:

Measured the mass and volume of a liquid sample.
Graphed mass and volume data to observe a direct proportion relationship.
Determined the slope of the direct proportion between mass and volume of a sample.
Measured the dimensions of a regular solid sample and its corresponding mass.
Determined the density of a a regular solid.
Determined the density of an irregular solid.
Used density to identify an unknown sample.

**Prelab**

Prepare a Title (can use the lab handout for this), Purpose (a concise statement) and a Procedure (short "to do" list … see "Writing a Procedure" in the lab handouts folder), and Data Tables.

**Purpose**

To determine the density of two liquids (water or isopropyl alcohol), a regular shaped solid, an irregular shaped solid and to use the density property to identify an unknown rock.

**Background Information**

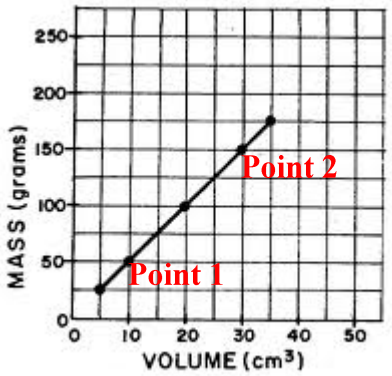
Density is a physical property of a substance that indicates how much mass is found in a given unit volume. Density is defined as Mass/Volume and typically has units of g/mL or $g/cm^3$ for liquids and solids.

$$\text{Density} = \text{Mass} / \text{Volume}$$

Your everyday experiences have probably given you a sense that different materials have different densities. For instance, imagine holding a small cube of lead in one hand and a same-sized cube of wood in the other hand. The lead cube is heavier. The "heaviness" of lead results from the fact that the density of lead is 11.4 $g/cm^3$ while the density of pine wood is only 0.5 $g/cm^3$. Lead has much more mass packed into a given volume than wood.

The density of a substance depends on the mass of the atoms present and how those atoms are arranged in three dimensions. Every substance has a characteristic density that can be calculated by dividing the measured mass of a sample by its measured volume. The density of an unknown substance can be determined and used to help identify the substance. For example, suppose you were panning for gold and found a golden nugget. Measuring the density of the nugget would clarify the identity of the rock. (Gold is 19.3 $g/cm^3$ and fool's gold, iron pyrite, is only 5.00 $g/cm^3$).

Graphing (plotting observed properties on an x-y axis) can be a useful tool. Below is an example of the relationship between mass in grams and volume in cubic centimeters for an unknown substance.




Slope: $(y_2 - y_1) / (x_2 - x_1)$

Slope = $\dfrac{(150 - 50)\ g}{(30 - 10)\ cm^3}$

Slope = 100 g / 20 $cm^3$ or 5.0 g / $cm^3$

The shape of the above graph is a straight line. **When data points plot a straight line, the measured variables are said to be directly proportional.** When mass is plotted on the y axis and volume is plotted on the x axis, the slope of the line turns out to be the density of the measured sample.

So, for any two points on the "best line" (not actual data points), the slope of the line [(rise) / (run)] or $(y_2–y_1) / (x_2-x_1)$ can be used to determine the density.

**Procedure Work In Pairs**

***Part I. Determine the Density of a Liquid*** ***Each pair has a different liquid***

1. Get a 10-mL graduated cylinder and a wash bottle containing one of two liquids (water or the alcohol). Record which liquid you have in Table 1. (One pair has water, the other pair has alcohol)

2. Set the empty graduated cylinder on the balance and **tare the balance**. Leave the graduated cylinder on the balance. Do not touch the Tare button again until you finish step 3.

3. Transfer ~ 1 mL of your liquid from a wash bottle to the graduated cylinder. Measure and record the mass (all digits) and the volume (2 digits to the right of the decimal point) of the liquid in Table 1. Repeat this process seven more times, adding about 1 mL each time. (final volume: 7-8 mL)

4. Exchange data with the other pair in your group.

***Part II. Determine the Density of a Regular Shaped Solid (marble)***

The volume of regularly shaped objects can be calculated using geometry.

1. Get a small glass marble and a 10 mL beaker (to hold the marble while weighing). Use a caliper to measure the diameter of the spherical marble and record the diameter in Table 2.

2. Record the mass of the marble in Table 2.

***Part III. Determine the Density of an Irregular Shaped Solid Unknown (rock)***

The volume of irregularly shaped objects cannot be calculated using geometry. Instead, the volume of objects more dense than water can be determined by water displacement.

1. Record the mass and identity of a dry rock in Table 3.

2. Record an initial volume (1 digit to the right of the decimal) of water that is approximately ½ of the volume of a graduated cylinder.

3. Carefully immerse the rock in the water.

4. Carefully tap the graduated cylinder carefully on the lab bench to remove any air bubbles.

5. Record the final volume (1 digit to the right of the decimal) of water in the graduated cylinder in Table 3.

**Data**

**Table 1: Volume and Mass of Liquid Samples**

| | **Water** | | **Isopropyl Alcohol** | |
|---|---|---|---|---|
| | Volume (mL) | Mass (g) | Volume (mL) | Mass (g) |
| #1 | | | | |
| #2 | | | | |
| #3 | | | | |
| #4 | | | | |
| #5 | | | | |
| #6 | | | | |
| #7 | | | | |
| #8 | | | | |

**Table 2: Density of the Marble**

| | |
|---|---|
| Mass (g) | |
| Diameter (cm) | |

**Table 3: Density of the Rock**

| | |
|---|---|
| Rock (sample letter) | |
| Mass (g) | |
| Initial volume (mL) | |
| Final volume (mL) | |

## Calculations

Using "Best-Fit Line" (not data points), determine the slope of your Volume vs Mass data plot

Determine the Density of a Regular Solid (Marble)

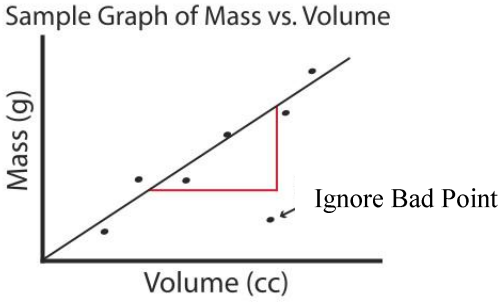
Determine the Density of an Irregular Solid Unknown (Rock)

Identify the rock based on the densities of the possible unknowns.
Magnetite: 5.00g/ $cm^3$,
Basalt: 3.00 g/ $cm^3$,
Granite: 2.70 g/ $cm^3$.

## Results

### Plot Your Mass vs. Volume Data (From Table 1)

Graphing tips:
- Use an entire page for your graph (Download the graph paper from the lab handout folder)
- Use convenient and uniform divisions on the axes.
- Label the axes, including proper units
- Title your graph.
- Plot each of your data points (mass and corresponding volume)
- Draw the "Best-Fit Line" for each set of data points
- There will be 2 lines (water and isopropyl alcohol) on the graph




**Slope = $(y_2 - y_1) / (x_2 - x_1)$**
**The slope is equal to the density of the liquid.**

Summarize your observations and calculations:

**Table 4: Density Values**

| Sample | Density |
|---|---|
| Water | |
| Isopropyl Alcohol | |
| Marble | |
| Rock | |
| Rock Identity | |

**Conclusion**
Your conclusion should respond to the purpose which was to determine various densities. (Basically you are to summarize your results in sentence form.) In addition, state which of the two liquids studied is denser.

**Questions**

1. How confident are you that the density of the regular solid is accurate? What could you have done to make you more confident of your results?

2. How would the density of your irregular solid be changed if some water splashed out of the graduated cylinder when you added the object? Would your calculated density be too high, too low or unaffected?

3. Use your graph to predict the volume of 6.400 grams of the alcohol. Show on the graph how you make this prediction. Indicate the volume as the answer to this question.

4. Use the density of your regular solid (marble) as a conversion factor to calculate the volume of a sample of this solid that has a mass of 375 grams. Show all of your work!