Purpose

Students will use techniques and methods learned in previous labs and apply them to determining the density of an unknown object. Students will learn several different methods to determine the density of a variety of objects.

Discussion

The density of an object is the ratio of the mass to volume, and is unique for any given compound or element. By measuring the density of an object, it is often possible to determine the nature of an unknown compound. A discussion of density can be found in Hein Ch. 2.9 (p. 37), Chang Ch. 1.7 (p. 18), or McMurry 1.10 (p. 16).

The mass of an object is relatively easy to measure using a balance. Volume is more difficult and is generally measured in two ways. Regular objects (such as cubes, rectangles, and spheres) can be measured with a ruler and the volume calculated mathematically ($V_{\text{cube}} = (\text{side length})^3$, $V_{\text{rect}} = \text{length} \times \text{height} \times \text{width}$, $V_{\text{sphere}} = \frac{4}{3}\pi r^3$). The volume of irregular objects is generally measured by submerging the object in water and measuring the change in volume of the water. In this lab either a sealed buret or an open ended buret will be filled half full with water, and the object will be added and the change in volume measured.

Because most substances change in volume when heated or cooled due to expansion or contraction, the density of an object is also temperature-dependent. Usually the variance is quite small for instance, the density of water at 3.98 °C is 1.0000 g/mL which decreases to 0.99987 g/mL at 0 °C. We will generally assume the density of water is 1.00 g/mL at room temperatures.

Procedure

A. Density of a regular object

1. Obtain a regular shaped object from your laboratory instructor. Record its identity.
2. Weigh the object, record your result.
3. Measure the objects length, width, and height.
4. Calculate the volume of the object. Be sure to show your calculation.
5. Calculate the density of the object. Be sure to show your calculation.

B. Density of an irregular object

1. Obtain an irregular shaped object from your laboratory instructor. Record its identity.
2. Weigh the object and record your result.
3. Fill a buret half full of water. Record the volume.
4. Carefully (slide it down the side of the tube, do not drop it in) place your irregular object in the buret and record the volume.
5. Calculate the volume of the item.
6. Calculate the density of the item using the appropriate formula.
7. Compare the density of the item with the value given by your instructor, if your measurement is within 0.2 g/mL of the correct value move onto the next section, if not, redo this section.

C. Density of an unknown object

1. Obtain an unknown object from your instructor. Record its identity.
2. Determine the density of the object using the methods described above.
3. Do 3 trials and average your result.
4. Compare your experimental density with the density of the known elements provided in the discussion section.
5. Write down the identity of the known element which most closely matches your measured density.
Results

A. Density of a regular object

1. Identity of regular object: ____________________________

2. Mass of regular object: ____________________________

3. Length of regular object: __________________________

4. Height of regular object: __________________________

5. Width of regular object: __________________________

6. Calculate the volume of the regular object, show the formula used and the calculation:

7. Calculate the density of the regular object: (Show formula and work)

8. Correct value for density of regular object (ask instructor)

9. Your answer should be within 0.05 g/mL of the correct answer. If your answer is not, redo steps 1-8.

10. Calculate the Percent Error in your measurement using the following formula:

    \[
    \text{Percent Error} = \left( \frac{\text{Actual Density} - \text{Measured Density}}{\text{Actual Density}} \right) \times 100 \%
    \]

B. Density of an irregular object

1. Identity of irregular object: ____________________________

2. Mass of irregular object: ____________________________

3. Initial volume of water in the buret: __________________

4. Final volume of water in the buret after adding irregular object: __________________

5. Calculate the volume of the irregular object. (Show work):

6. Calculate the density of the irregular object (Show work):

7. Correct value for density (obtained from instructor):

8. Calculate the Percent Error in your measurement:
C. Density of an unknown object (3 Trials)

1. Identity of unknown object:

2. Mass of unknown object:

3. Initial volume of water in the buret:

4. Final volume of water in the buret after adding unknown object:

5. Volume of unknown object (show work):

6. Measured density of unknown object (show work):

7. Average density of unknown object:

8. Using Table 1, what metal is the unknown object?

9. What is the percent error in your measurement?

<table>
<thead>
<tr>
<th>Object</th>
<th>Density (g/ml)</th>
<th>Object</th>
<th>Density (g/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (4 °C)</td>
<td>1.000</td>
<td>Aluminum</td>
<td>2.70</td>
</tr>
<tr>
<td>Copper</td>
<td>8.96</td>
<td>Lead</td>
<td>11.34</td>
</tr>
<tr>
<td>Mercury</td>
<td>13.55</td>
<td>Gold</td>
<td>19.3</td>
</tr>
<tr>
<td>Brass</td>
<td>8.5</td>
<td>Iron</td>
<td>7.86</td>
</tr>
<tr>
<td>Nickel</td>
<td>8.90</td>
<td>Steel</td>
<td>7.8</td>
</tr>
<tr>
<td>Tin</td>
<td>7.28</td>
<td>Manganese</td>
<td>7.20</td>
</tr>
<tr>
<td>Zinc</td>
<td>7.10</td>
<td>Woods Alloy</td>
<td>9.63</td>
</tr>
</tbody>
</table>

Table 1: Density of Common Metals
Laboratory 1E: Density Measurements

Name: ___________________________  Class: ___________________________  Date: ___________________________

Questions

1. The density of a lead block is 11.34 g/mL. What is the volume of a lead block weighing 120.5 grams?
   1. __________

2. A lead fishing weight displaces 12.0 mL of water. What is the mass (in milligrams) of the lead weight?
   2. __________

3. An empty graduated cylinder weighs 82.450 g. When filled to 50.0 mL with an unknown liquid it weighs 110.810 g. What is the density of the unknown liquid?
   3. __________