Lab: Comparing Density of Liquids & Irregular Solids

FOR THE TEACHER

Summary
In this lab, students will measure mass and volume, calculate density, and compare the density of given liquids and solids, inferring what causes objects to sink or float in a given liquid.

Grade Level
Elementary and Middle School

Objectives
By the end of this lab, students should be able to
- Measure mass and volume of liquids and irregular solids.
- Calculate density.
- Compare density of liquids and irregular solids.
- Understand how substances in a solution can affect density and if objects will sink/float.

Chemistry Topics
- Density
- Mass
- Volume of liquids and irregular solids
- Measurement

Time
Teacher Preparation: 15 minutes
Lesson: 50 minutes

Materials: Each group will need:
- 2- 250ml beakers
- 1- 100ml graduated cylinder
- ~300 ml tap water
- 1/4 cup salt (approx. 76 g of table salt)
- Medium sized rock (must be able to fit in the graduated cylinder)
- Plastic beads
- Penny
- Eraser
- Digital gram scale
- Paper towels for clean up

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- Be careful with glass materials. Report any broken glass immediately to the teacher.
Teacher Notes

- **Background:**
  - Mass is the amount of matter in an object. It is measured in grams (g).
  - Volume is the amount of space an object takes up.
    - The volume of a liquid can be found using a beaker or graduated cylinder. It is measured in milliliters (ml).
    - The volume of an irregular solid can be found using the water displacement method in a graduated cylinder. It is also measured in ml.
    - To use the water displacement method, add water into a graduated cylinder and note the original volume of the water. Then add the irregular solid. Note the new measurement. The new volume minus the original volume of water equals the volume of the irregular solid.
  - Density is the amount of mass in a given volume of a substance.
    - \( \text{Density} = \frac{\text{mass}}{\text{volume}} \)
    - Density is a physical property of an object and be used to identify some substances.
    - Objects with greater density than water will sink in water; objects with lesser density than water will float in water.
    - Saltwater solutions have a greater density than water because there is more mass in the same amount of volume of substance.

- **Helpful tips:**
  - Have materials set up at lab tables when students arrive, including paper towels in case of spills.
  - Groups of 4 can designate a member for each irregular object to determine its mass, volume, density, and if it sinks or floats in water and/or salt water.
  - Elementary teachers may decide to have the mass of the beakers already labeled on the beakers and the water already poured into the beaker. To do this, place the beaker on the scale while it is empty. Write the mass measurement of the beaker on a label on the beaker. Pour 100mL of water into each beaker and into the graduated cylinder.
  - Mark a line with a dry erase marker on each beaker and graduated cylinder pointing to 100 mL mark so that students can easily identify how much water is in each.
  - Students can sometimes forget that subtractions need to be made for volume of irregular solids and mass of liquids inside the beaker. This can be remedied by setting up the subtraction problem for them on their lab report format or having a reminder taped next to the scale and graduated cylinder.
  - Pre-portion \( \frac{1}{4} \) cup of salt (76g) for each group in a small plastic cup or a separate beaker or graduated cylinder to save time having to do this additional measurement.

- **Differentiation:**
  - Lower level students can have a lab report worksheet, which includes the measurements noted above and subtraction problem set up.
  - Higher level students can make the additional measurements.
  - Technology option: have students set up a lab report in PowerPoint with one step of the scientific method on each slide (Slide 1 = Purpose, Slide 2 = Research, Slide 3 = Hypothesis...)
  - Early finishers can examine a liquid density column model with a list of substances in the column and their density (out of order). These students can identify which substance is which by putting the density in order from least to greatest, then labeling the substance with the least density at the top and the substance with the greatest density at the bottom.
  - You can find a useful video animation on comparing Density on the AACT website:
FOR THE STUDENT

Comparing Density of Liquids and Irregular Solids

Background
Some physical properties of matter include mass, volume, and density. Mass is the amount of matter in an object, which is measured in grams using a triple beam balance or electronic scale. Volume is the amount of space an object takes up. It is measured in milliliters (mL) using a beaker or graduated cylinder. Once you have identified mass and volume, you can divide in order to find the density of a substance. Density equals mass divided by volume (D=m/v). Water has a density of 1 g/mL. If a substance has a greater density than water, it will sink in water. If a substance has a lesser density than water, it will float.

Prelab Questions
1. Do you think that saltwater will have a greater density or lesser density than tap water? Explain your thinking.
2. Which of the irregular solids on the materials list do you think will sink in tap water?
3. Which of the irregular solids on the materials list do you think will sink in salt water?
4. Why is it important to record the mass of the empty beaker first before pouring water into it?

Objective
You will investigate how the density of an object affects whether it will sink or float in tap water and in saltwater.

Materials (for each group)
- 2- 250ml beakers
- 1- 100ml graduated cylinder
- ~300 ml tap water
- 1/4 cup salt (approx. 76 g of table salt)
- Medium sized rock
- Plastic beads
- Penny
- Eraser
- Digital gram scale
- Calculator
- Paper towels

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow instructions to clean up materials and dispose of any chemicals.
- Be careful with glass materials. Report any broken glass immediately to your teacher.

Procedure
Mass and Volume of Liquid and Solution:
1. Place beaker 1 on the scale while it is empty. Record the mass of the empty beaker.
2. Repeat step 1 using beaker 2.
3. Pour 100 mL of water into each beaker.
4. Pour ¼ cup (76 grams) of salt into beaker 2 and stir until it seems completely dissolved.
5. Place beaker 1 with tap water on the scale. Record new mass measurement.
6. Subtract to find the mass of the water: new mass measurement minus the measurement of the empty beaker.
7. Repeat steps 5-6 using beaker 2.
8. Record any change in volume of saltwater solution on your data table.

Density of Liquid and Solution:
1. Divide mass of the liquid in beaker 1 by its volume to determine its density value. Record measurements and final answers in the “Calculations” data table.
2. Divide mass of the liquid in beaker 2 by its volume to determine its density value. Record measurements and final answers in the “Calculations” data table.

Mass and Volume of Irregular Solids:
1. Place each object on the scale and record its mass in the data table.
2. Pour ~50 mL of water into the graduated cylinder. Record exact volume for “Volume of Water only” category in data table.
3. Place object 1 into graduated cylinder. Record new volume measurement in “Total Volume” category in data table.
4. Subtract “volume of water only” measurement from the “total volume” measurement to determine the volume of the irregular solid.
5. Remove the object from the graduated cylinder and dry off.
6. Repeat steps 2-5 for each remaining irregular solid.

Density of Irregular Solids:
1. Divide mass by volume for each irregular solid to determine density values for each object. Record measurements and final density values in the “Calculations” data table.

Comparing Density:
1. Based on your density calculations, make predictions for each object about whether it will sink or float in tap water and in saltwater. Record your predictions in the data table below. Remember – objects with GREATER density than the liquid will sink, and objects with LESSER density than the liquid will float.
2. Place each irregular solid in water, one at a time. Record if it sinks or floats.
3. Repeat step 2 with each irregular solid in saltwater.

Data

<table>
<thead>
<tr>
<th>Substance</th>
<th>Total Mass</th>
<th>- Mass of Beaker</th>
<th>= Mass of Substance</th>
<th>Volume of Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saltwater Solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mass and Volume of Irregular Solids

<table>
<thead>
<tr>
<th>Substance</th>
<th>Mass</th>
<th>Total Volume (object &amp; water)</th>
<th>- Volume of water only</th>
<th>= Volume of Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic bead</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eraser</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penny</td>
<td></td>
<td></td>
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</tbody>
</table>

Calculations
Density of Liquids and Irregular Solids

<table>
<thead>
<tr>
<th>Substance</th>
<th>Mass</th>
<th>(divided by) Volume</th>
<th>= Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saltwater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic Bead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eraser</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Penny</td>
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<td></td>
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</tbody>
</table>

Analysis

<table>
<thead>
<tr>
<th>Substance</th>
<th>Tap Water</th>
<th>Saltwater Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prediction</td>
<td>Observation</td>
</tr>
<tr>
<td></td>
<td>Prediction</td>
<td>Observation</td>
</tr>
<tr>
<td>Rock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic Bead</td>
<td></td>
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<tr>
<td>Eraser</td>
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<tr>
<td>Penny</td>
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1. Which object had the greatest density in this lab activity?
2. Which object had the least density?
3. Did any object float in saltwater that did not float in tap water? If so, why do you think this happened?
4. Once you calculated the density of each object, were you able to accurately predict when the objects would sink or float in each liquid or solution? Why or why not?

Conclusion
Refer back to the objective statement. Based on the results of your investigation, what did you learn about density and how it affects when objects sink or float?

Extension:
Think about a helium-filled balloon floating in the air. What can you infer about the density of helium in the balloon compared to the density of the air surrounding the balloon?