**Answer Key Further Experimentation: Density of Pennies**

**Problem:**

In this experiment, you will determine if two different sets of pennies- pre-1982 pennies and post-1983 pennies, are made up of the same substance. Since density is a physical property of matter that is specific for that substance, it can be used to identify if the pennies are actually made up of the same material. Density is a ratio of mass over volume. You will measure the mass of the penny and then the volume by using the water displacement method. Afterwards, you can then use this information to help you determine if the silver, and gold pennies you made are actually made up of these elements.

**Prelab Questions**

1. Define density
   
   Density is a physical property of matter. It is the ratio of mass to volume. Many considers it as the “heaviness” of the substance.

2. How is mass determined?
   
   Mass can be measured using a balance. (an electronic one will be easier and faster)

3. How is volume determined?
   
   Using water displacement method would be the easiest, measure the volume of water in a graduated cylinder, then measure the volume of water after pennies have been added. (Students may have used this method is previous science classes).
   
   Another method is to measure the radius, and thickness of penny and calculate the volume of each penny.

4. How would you determine the density of the penny?
   
   Students can use the math equation and then take average value. An alternative, is to graph the data (as described on the handout in the Analysis section.)

**Materials**

- 25- pre-82 pennies
- 25 post-82 pennies
- 0.01 g balance
- 50.0 mL graduated cylinder
- water

**Safety**

- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.

**Procedure**

1. Work with one set of pennies at a time, either pre-1982 or post-1983 pennies.
2. Find the mass of 5 pennies from one set. Record the mass in the appropriate data table.
3. Add 5 more pennies to the first group and obtain the mass of these pennies. Record the mass.
4. Repeat step 2, each time adding 5 more pennies to those already on the balance, until you have used all 25 pennies.
5. Fill a 50 mL graduated cylinder to about the 20 mL mark with water. Be sure to use the bottom of the meniscus and record the exact volume.
6. Still working with the same set of 25 pennies, gently drop 5 pennies into the graduated cylinder. Be careful not to splash the water. Record the new water level in the data table.
7. Add 5 more pennies to the graduated cylinder, making a total of 10 pennies. Record the water level on the table.
8. Repeat step 7 until all 25 pennies have been added. Record the volume of water after each addition.
9. Discard the water and recover the pennies from the graduated cylinder. Dry the pennies with a paper towel.
10. Repeat steps 1-9 using the 25 pennies in the other set of coins. Record your data on the other table.
11. Complete your data tables. Find the net volume of each group of pennies by subtracting the original volume (~20 mL) from the total volume recorded for each group. Enter the net volume for each group on the data table.

### Data

<table>
<thead>
<tr>
<th>Number of Pennies</th>
<th>Mass (g)</th>
<th>Total Volume in Cylinder (mL)</th>
<th>Net Volume of Pennies (mL)</th>
<th>Mass to net volume Ratio (Density) (g/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>13.53</td>
<td>21.5</td>
<td>1.5</td>
<td>9.02</td>
</tr>
<tr>
<td>10</td>
<td>31.54</td>
<td>23.5</td>
<td>3.5</td>
<td>9.01</td>
</tr>
<tr>
<td>15</td>
<td>40.56</td>
<td>24.5</td>
<td>4.5</td>
<td>9.01</td>
</tr>
<tr>
<td>20</td>
<td>54.18</td>
<td>26.0</td>
<td>6.0</td>
<td>9.03</td>
</tr>
<tr>
<td>25</td>
<td>68.54</td>
<td>27.5</td>
<td>7.5</td>
<td>9.14</td>
</tr>
</tbody>
</table>

### Post-1983 Pennies

<table>
<thead>
<tr>
<th>Number of Pennies</th>
<th>Mass (g)</th>
<th>Total Volume in Cylinder (mL)</th>
<th>Net Volume of Pennies (mL)</th>
<th>Mass to net volume Ratio (Density) (g/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>12.66</td>
<td>21.5</td>
<td>1.5</td>
<td>8.44</td>
</tr>
<tr>
<td>10</td>
<td>25.49</td>
<td>23.5</td>
<td>3.5</td>
<td>7.28</td>
</tr>
<tr>
<td>15</td>
<td>37.20</td>
<td>25.0</td>
<td>5.0</td>
<td>7.44</td>
</tr>
<tr>
<td>20</td>
<td>50.03</td>
<td>26.5</td>
<td>6.5</td>
<td>7.69</td>
</tr>
<tr>
<td>25</td>
<td>63.56</td>
<td>28.0</td>
<td>8.0</td>
<td>7.94</td>
</tr>
</tbody>
</table>
Analysis

1. Mathematical analysis:
   a. Calculate the ratio of mass to net volume for each measurement for the two sets of pennies. Record the ratio on the table.
      See table
   b. Calculate the average value for each set of pennies.
      Avg: Pre-82 pennies: 9.04 g/mL; Post-83 pennies: 7.76 gm/mL. Results will vary depending on the student's technique.
   c. Compare the ratio of the pre-1982 to the post-1983 pennies.
      In general, the pre-82 pennies will have a higher density than the post-83 pennies.
   d. Are they made of the same material?
      Students should arrive at the conclusion that these pennies are made up of different elements.

2. Graphical analysis:
   This would be a good place to introduce graphical analysis. Can skip this if students are not ready for it.
   a. Construct a graph of your results. Use one color for the old pennies and one for the new pennies. Place the mass on the "y" axis and the volume on the "x" axis.
   b. Determine the slope of each line. Clearly show your calculations.
      May need to show students how to draw a best-fit line and how to determine the slope of the line.
   c. The slope is describing how mass changes with volume. What physical property is this?
      Density
   d. Compare the slope of the pre-1982 pennies to the post-1983 pennies.
      Should be pretty different. Not important what the values actually are. But the pre-1982 slope will be steeper than the post-83 slope.
   e. Are they made of the same material?
      Responses will vary depending on how good the students results are. This would be a good place to discuss laboratory errors as well.

3. Compare your results from question 1 to question 2. Is there a difference?
   Can omit, if students are not able to graph. If so, this would be a good place for students to see how results may differ and to discuss which would be the better method for analysis.
Conclusion

1. What element do you think the pre-1982 and post-1983 pennies are made up of? Why.
   
   Can give the students the density of various metals or have them look up the density of different elements and see what they come up with in terms of the composition of these pennies.

2. Looking at the silver and gold pennies from the golden penny experiment, would you expect the density of the silver and gold penny to be the same or different. Explain.
   
   Students should expect the density of the silver and gold penny be different since they are different elements.

3. How you could determine the density of the treated pennies from the golden penny lab?
   
   Students can repeat this lab but using the silver and gold pennies produced from the golden penny lab. Gather all the made pennies so groups can use multiple coins to help obtain a supply of silver and gold pennies. Can also accept other reasonable ideas.