Copper Penny Lab

INTRODUCTION

Non-Destructive Testing

Hiero II, king of Syracuse (a region of Greece) during the 3rd century BC, commissioned the production of a gold crown, but then suspected that the goldsmith may have defrauded him by substituting a less precious metal in the interior of the crown. Hiero II then commissioned a man by the name of Archimedes to determine if the crown was made of pure gold but demanded that he not damage or disassemble the crown. In other words, Archimedes had to answer the king's question by developing a non-destructive test for composition.

According to tradition, Archimedes is said to have placed a block of pure gold equal to the mass of the crown in a container and filled it to the brim with water. He then removed the gold and placed the crown in the container and noticed that the water overflowed. He concluded that the goldsmith had cheated the king because the crown had the same mass as the gold object, but it had larger volume and caused the water to overflow. Archimedes showed that the goldsmith had partially substituted a metal other than gold when fashioning the crown because its density (mass/volume ratio) was less than gold!

$$\text{Density } (\rho) = \frac{\text{mass}}{\text{volume}}$$

Copper Pennies

Early on, American pennies were made of 95% copper and 5% zinc. In the late 1970s the price of copper rose so dramatically that Congress feared the copper content in pennies would be more valuable than one cent and that people would hoard pennies, melt them down, and sell the copper. Consequently, a bill was proposed in Congress to reduce the copper content of pennies. In this activity, you will use the same basic principle Archimedes used to determine if Congress passed the bill and changed the copper content of pennies.

In this lab you will:

- Collect 10 pre-1982 pennies and 10 post-1982 pennies.
- Determine the mass of both sets of pennies.
- Determine the volume of each group by the method of water displacement.
- Calculate the density of the pre-1982 and post-1982 pennies and look at *Table A: Densities of Substances* to compare densities and determine if the bill was approved.

Question your lab group is trying to answer: _____

_____

Hypothesis: If the density of the post-1982 pennies is different than the density of the pre-1982 pennies then _____

_____

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Materials

- 50-mL graduated cylinder
- 250 mL beaker filled 3/4 with tap water
- Digital mass scale
- Weighing boat
- 10 pre-1982 pennies
- 10 post-1982 pennies

GOALS FOR THIS LAB:

1. Understanding how to use a digital mass scale and a graduated cylinder
2. Understanding how to read measurements from a digital mass scale and graduated cylinder.
3. Proper use of metric units and significant figures.

Procedure

Calculate ***mass*** of pre-1982 pennies and post-1982 pennies

1. Turn on the digital mass scale. Check out the buttons on the scale. **TARE** (tair) sets the scale to zero when a graduated cylinder, beaker, or weighing boat is placed on the scale and you only want to measure the mass of what is inside the cylinder, beaker, or boat. There is also a button that says **MODE**. You can switch between the mass units. This scale measures in grams, ounces, troy-ounces, and pennyweight. Press the button until the readout has a "g" at the end, to indicate you are measuring grams.
2. If the readout on the scale doesn't say "0.0 g," press the tare again to make it read "0.0 g."
3. Put a weighing boat on the scale and press TARE to zero the scale.
4. Add 10 pre-1982 pennies to the boat. Record the mass in Data Table 1.
5. Determine the mass of one penny by dividing this value by 10. Record in Data Table 1.
6. Repeat steps 2-5 with post-1982 pennies.

Calculate ***volume*** of pre-1982 pennies and post-1982 pennies

1. Fill a graduated cylinder about half-way with water and carefully record the volume to the correct significant figure. When reading volumes, always report the value at the bottom of the meniscus. Record (V_1) in Data Table 2.
2. Place 10 pre-1982 pennies in the cylinder. Record the final volume to the correct significant figure. Record (V_2) in Data Table 2.
3. Calculate the difference between the two volume measurements. This is the volume of 10 pre-1982 pennies. Record ($V_d=V_2-V_1$) in Data Table 2.
4. You can determine the volume of one penny by dividing this value by 10. Record ($V=V_d/n$) in Data Table 2.
5. Repeat steps 1-4 with post-1982 pennies.
6. Using mass and volume, calculate the densities of the pre-1982 penny and the post-1982 penny. Record in Data Table 3.

Table A: Densities of Substances

Substance	Density at 20°C (g/mL)	Substance	Density at 20°C (g/mL)
ice	0.91	zinc	7.14
water	1.00	copper	8.96
aluminum	2.70	silver	10.5
magnesium	1.74	lead	11.35
titanium	4.51	gold	19.32

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Data/Observations

Table 1: Mass of Pennies

Type of Penny	**Mass of Pennies** (M_1)	**Quantity of Pennies** (n)	**Mass of Single Penny** (M_1 / n = M)
Pre-1982			
Post-1982			

Table 2: Volume of Pennies

Type of Penny	**Original Volume** (V_1)	**Final Volume** (V_2)	**Displacement Volume** ($V_2 - V_1 = V_d$)	**Quantity of Objects** (n)	**Volume of Single Object** (V_d / n = V)
Pre-1982					
Post-1982					

Table 3: Density of Pennies

Type of Penny	**Mass**	**Volume**	**Density (M / V = ρ)**
Pre-1982			
Post-1982			

Conclusion

1. CLAIM: _____

   _____

2. EVIDENCE: _____

   _____

   _____

   _____

3. REASONING: _____

   _____

   _____

   _____

4. ERRORS: _____

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