# Using Densities of Pennies to Determine Chemical Composition

## Introduction:

The chemical composition of pennies has changed a number of times in the United States. For a long time, pennies were made of a copper alloy. But after 1982, pennies were made with a thin outer coating of copper and an inner core of a different metal. These differences in composition between older and more recently minted pennies have also resulted in property differences. One of these differences is in density, which is the mass per unit volume (usually in g/mL or g/cm$^3$). We are going to use density to help us identify the metal inside pennies minted since 1982.

## Objective:

**Determine the density of pennies and use your data to identify the metals they are made of.**

## Materials:

- (50) pre -1982 pennies
- (50) post -1983 pennies
- (1) balance
- (1) 50 mL graduated cylinder
- paper towels

## Pre-lab Questions:

1. Define density.
2. Write the formula for density, including units.
3. What are you measuring today in order to determine density? These are the two variables you will be graphing.
4. What is an alloy?

## Procedure:

1. Before you begin your investigation, read through the procedure and answer the pre-lab questions listed.
2. Work with one set of pennies at a time. You may start with either the pre-1982 pennies or the post-1983 pennies. Find the mass of five dry pennies from one set. Record the mass in the data table of your lab notebook.
3. Add five more pennies to the first group and record the mass.
4. Repeat step 3, each time adding five more pennies to those already on the balance, until all 50 pennies have been used. Be sure to record all mass data.
5. Fill the graduated cylinder with exactly 20.0 mL of water. Use a pipette to add water drop by drop if needed. Make sure to read the water level with the bottom of the meniscus at eye level.
6. Still working with the same set of 50 pennies, hold the graduated cylinder at an angle to avoid splashing, and gently drop five of the pennies, one at a time, into the graduated cylinder. Record the new water level to the nearest tenth of a mL in the first column of your table. Find the actual volume of the five pennies by subtracting the initial volume of 20.0 mL from the total volume.
7. Add five more pennies to the graduated cylinder, making a total of ten pennies. Record the new level. Find the net volume of the ten pennies by subtracting 20.0 mL.
8. Repeat step 7 for totals of 15, 20, 25, 30, 35, 40, 45, and 50 pennies. Record the water level each time and subtract 20.0 mL to determine the net volume.
9. Discard the water. Thoroughly dry the pennies with a paper towel.
10. Repeat steps 1-9, using 50 pennies from the other set of coins. Record your data in the correct data table. Make sure the pennies are dry when you measure their mass.

## DATA TABLE: Measuring Densities of Pennies

### Pre-1982 Pennies (older)

| Number of Pennies | Mass (grams) | Total Volume in Cylinder | Net Volume of Pennies (mL) (subtract starting volume of 20 mL) |
|---|---|---|---|
| 5 | | | |
| 10 | | | |
| 15 | | | |
| 20 | | | |
| 25 | | | |
| 30 | | | |
| 35 | | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |

# DATA TABLE: Measuring Densities of Pennies

## Post-1983 Pennies (newer)

| Number of Pennies | Mass (grams) | Total Volume in Cylinder | Net Volume of Pennies (mL) (subtract starting volume of 20 mL) |
|---|---|---|---|
| 5 | | | |
| 10 | | | |
| 15 | | | |
| 20 | | | |
| 25 | | | |
| 30 | | | |
| 35 | | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |

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## Analysis:

1. Construct a graph of your results for both the pre-1982 pennies and post-1983 pennies. Each student must create a graph. Let the y-axis reflect the mass of the pennies in grams, and let the x-axis reflect the volume of the pennies in $cm^3$ (remember $mL = cm^3$). Make sure to label your axes with "mass/g" and "volume/$cm^3$."

2. Place a dot on the graph for every measurement you made in the lab. The dot should correspond to both the mass (g) and the net volume (mL) for each group of pennies.

3. Draw a straight line (also called a "line of best fit") through the data points for the pre-1982 pennies, and another straight line through the data points for the post-1983 pennies.

4. Determine the slope of both lines and write them on your graph. Use the equation below:

$$\text{slope} = \frac{\textit{change in y}}{\textit{change in x}}$$

The slopes will equal the densities of your pre-1982 and post-1983 pennies.

## Post-lab Questions:

1. What physical property of these pennies does the slope of each line represent?

2. The density of pure copper is 8.92 $g/cm^3$. Is the density you found for the pre-1982 pennies similar to the density of copper? Explain why there might be differences.

3. What is the value you determined for the density of the post-1983 pennies?

4. Below, you will find a list of densities for several elements. Compare the density data for your post-1983 pennies with density data for different elements. What metal has a density most similar to the density of the post-1983 pennies?

| | | | |
|---|---|---|---|
| Magnesium: 1.738 | Beryllium: 1.848 | Carbon: 2.266 | Boron: 2.46 |
| Aluminum: 2.699 | Zinc: 7.14 | Iron: 7.874 | Silver: 10.49 |
| Lead: 11.34 | Mercury: 13.534 | Tungsten: 19.3 | Gold: 19.32 |
| Platinum: 21.41 | | | |

5. **Archimedes, a Greek mathematician and inventor from the second century BC, was commissioned by the King of Syracuse to find out whether his crown was fashioned from pure gold or from a mixture of gold and silver, a less expensive metal. Archimedes could not use chemical tests because they would damage the crown, yet he was able to find the answer to the question. How did he carry out the king's request?**