NAME: **HONORS CHEMISTRY**

SECTION: Lab: Comparing the Density of Pennies

Occasionally the US Department of Treasury changes the composition of pennies, which changes the overall mass and density of each coin. In this experiment, you will determine the average density of two groups of pennies made at different times. Then you will compare the average densities of the pennies in the two groups. In the process, you will apply your knowledge of scientific measurements and significant figures.

Density is a physical property. It can be used in conjunction with other properties to help identify a substance or check on its purity. Conceptually, it is a measure of how closely the particles in the sample are packed together. Density is calculated by dividing the mass by the volume.

$$D=\frac{mass}{volume}$$

Density values for pure substances are tabulated and can be used for comparison to an unknown sample. Density of many substances changes with temperature since many objects expand as they are heated. The table shown below is for metals at 20oC—roughly room temperature.

|  |  |
| --- | --- |
| **Metal** | **Density (g/ml)** |
| Aluminum | 2.70 |
| Copper | 8.89 |
| Gold | 19.33 |
| Iron | 7.86 |
| Lead | 11.35 |
| Magnesium | 1.74 |
| Mercury | 13.60 |
| Nickel | 8.85 |
| Potassium | 0.87 |
| Silver | 10.60 |
| Zinc | 7.19 |

**Problem**

How did changing the composition of pennies in 1982 change the density of pennies?

## Objectives

1. Determine the average densities of pennies by using mass and volume.
2. Compare the average densities of pennies made before and after 1982.
3. Infer the change made in the composition of pennies in 1982.
4. Using lab equipment for precise measurements
5. Applying rules of significant figures in measurements
6. Applying rules of significant figures in calculations

**Materials**

 Pre-1982 and post-1982 pennies

electronic balance

 Plastic cups

 cm ruler

**Roles** Record the names of your group members—make sure this information is included in your lab report.

* Project Manager \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Reads directions; keeps track of time; keeps group on task

* Quality Control Manager \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Approves data table; checks data quality; checks calculations

* Materials Manager \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Gets and returns materials; supervises sharing of materials

# Procedure

1. Sort your pennies into two piles. One pile should contain 20 pennies coined prior to 1982, and one pile should contain 20 pennies coined after 1982. You do not want any pennies coined in 1982.
2. Carefully read through the data tables. Use the materials listed above and write out a step-by-step plan in your lab notebook.
3. Have your instructor approve your plan.
4. Collect your data.
5. Clean up your lab space.

**Data and Calculations**

 Table 1

|  |  |  |
| --- | --- | --- |
| **Volume: Height and Diameter Method** | **Pre-1982 pennies** | **Post-1982 pennies** |
| Height of 5 pennies (cm) |  |  |
| Height of 10 pennies (cm) |  |  |
| Height of 15 pennies (cm) |  |  |
| Height of 20 pennies (cm) |  |  |
| Diameter of 1st penny (cm) |  |  |
| Diameter of 2nd penny (cm)  |  |  |
| Diameter of 3rd penny (cm) |  |  |
| Diameter of 4th penny (cm) |  |  |
| Diameter of 5th penny (cm) |  |  |

 Table 2

|  |  |  |
| --- | --- | --- |
| **Mass Data** | **Pre-1982 pennies** | **Post-1982 pennies** |
| Mass of empty cup (g) |  |  |
| Mass of cup and 5 pennies (g) |  |  |
| Mass of cup and 10 pennies (g) |  |  |
| Mass of cup and 15 pennies (g) |  |  |
| Mass of cup and 20 pennies (g) |  |  |

**Calculations:** (include the formula and show one sample calculation for each type; report answers with the correct number of significant figures and an appropriate unit)

 The average diameter of one penny: pre-1982 and post-1982

The volumes of the 5, 10, 15, and 20 penny stacks for both pre-1982 and post-1982 pennies

The average height of one penny: pre-1982 and post-1982

The average volume of one penny: pre-1982 and post-1982

The masses of the 5, 10, 15, and 20 penny stacks for both pre-1982 and post-1982 pennies

 The average mass of one penny: pre-1982 and post-1982

 The experimental density of pre-1982 pennies and post-1982 pennies

**Analyze and Apply**

Answer these questions in complete sentences!

1. According to your data, which group of pennies has the greater average density, pre-1982 or post-

 1982?

1. You calculated the volume of the pennies assuming that the stack was a cylinder.
	1. List three plausible drawbacks of this method.
	2. Suggest an alternative procedure you could use to determine the volume of a penny.
2. Using the volumes and masses of the stacks of pennies, create a graph of your data. Use volume of the pre-1982 pennies as the independent variable and mass as the dependent variable. On the same graph, but using a different color, plot the data for the post-1982 pennies.

For both plots, draw the line of best fit (a different color for each). Calculate the slope of each best-fit line (remember to show your work) and report it with appropriate units and significant figures. You are encouraged to create your graph electronically (you can install LoggerPro on your Macbooks from Self Service, or you can use Excel). Of course you will remember to include all the required features of graphs, such as axis labels and a title.

1. Compare your slopes from the graphs with the densities you calculated. Which data set do you think is more accurate? Justify your answer based on the quality of your measurements and the meaning of accuracy.
2. Compare your experimental densities for the pre and post 1982 pennies to the actual densities for pennies pre and post 1982. To determine the actual densities of pre and post 1982 pennies, use your density values for copper and zinc and plug them into the formula below where x and y represent the % composition of copper and zinc.

(x)(7.13 g/mL) + (y)(8.96 g/mL) = density (g/ml)

You will find the following website helpful: <http://www.usmint.gov/about_the_mint/fun_facts/index.cfm?action=fun_facts2>

Then, to calculate percent error, use the equation below:

$$\% error=100\*\left|\frac{Accepted value-Experimental value}{Accepted value}\right|$$

1. Why is it important to use the correct number of significant figures when expressing measurements and calculated values based on those measurements?

*Remember to write an appropriate conclusion for this lab!*

Restate your results—be quantitative. *Based on your data, explain how the composition of the penny was changed in 1982.* Discuss experimental or procedural sources of error, and specifically describe how these errors affected your results.

In your introduction:

* Use picture (particle level) models to compare densities of substances (create your own illustrations!)
* Compare precision and accuracy—explain in your own words
* Compare dependent and independent variables
* Compare intensive and extensive properties—use examples from the lab in your explanation
* Describe types of error: random, systematic—explain in your own words and give examples
* State the overall purpose of the lab

Your introduction needs to demonstrate that you understand and can explain the key concepts explored in this lab. You need to go further than simply providing definitions. You will turn in an individual lab report, in hard copy. Use the standard Bromfield heading and accepted conventions of written language. You may hand write in any calculations that are shown, or use the equation editor in MS Word if you want to be fancy!