**Penny Density**

**Background Information:**

**Density** is defined as the ratio of mass to volume, and its formula is density = mass÷ volume. The units for mass are **grams** **(g)**. The units for volume are either **cubic centimeters (cm3) milliliters** **(mL)**, so the units for **density** can either be **g/cm3** or **g/mL**.

Density is a physical property that can be used to identify an unknown substance. It is also considered an **intensive property**; that is, the density of an object does not depend on how much of the substance is present. For example the density of water is 1.00 g/ml. Whether you have a drop, a glass, or a bucket of water, its density is always 1.00 g/ml.

Over 2000 years ago King Hieron of Syracuse suspected that the jeweler who made his gold crown had mixed the gold with another cheaper metal. Although the king could measure the mass of the crown, its intricate design prevented measurement of its volume.

King Hieron hired Archimedes, a Greek mathematician, physicist, and engineer to solve his dilemma. Archimedes knew that in order to solve the problem, he had to calculate the density of the crown and match it to the density of pure gold.

While taking a bath, Archimedes noticed the water level rise as he lowered himself into the tub and knew he had the solution. He could find the volume of the crown by measuring how much water it moved, or displaced. (This method is now known as **water displacement**). He was so excited about his great discovery that he ran through the streets of Syracuse naked shouting "Eureka!" which is Greek for "I have found it."

Using the mass and volume of the crown, he calculated the density of the crown. The crown was indeed a fake. Archimedes was a hero!

In this lab, you will measure the mass and volume of two sets of pennies: pre-1982 pennies and 1982 and later pennies. You will then graph the data, calculate the slope of the lines, and determine the density of the pennies.

**Materials**:

electronic balance

25 pre-1982 pennies

25 1982 and older pennies

50 mL plastic graduated cylinder

tap water

**Procedure:**

1) Mass 25 post-1982 pennies. Mass this 5 times for accuracy.

2) Determine the volume of the 25 pennies by water displacement.

*things to keep in mind when measuring the volume of the pennies:*

-read the graduated cylinder to the tenths place

-read the graduated cylinder at eye-level

-slide the pennies into the graduated cylinder gently; avoid splashing any water onto the

sides of the graduated cylinder

-tap the graduated cylinder on the lab table to eliminate any air bubbles have formed

between pennies

-keep the pennies in the graduated cylinder until you finish collecting data for all 25

pennies

3) Mass 5, 10, 15, 20 and 25 pre-1982 pennies and get their volume. Calculate the density of each.

4) Repeat steps 1 – 3 for pre-1982 pennies.

**For Pre-1982 Pennies:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Trial for 25 Pennies** | **Mass (g)** | **Initial Volume (mL)** | **Final Volume**  **(mL)** | **Volume of Pennies (mL)** | **Penny Density**  **(g/mL)** |
| **1** |  |  |  |  |  |
| **2** |  |  |  |  |  |
| **3** |  |  |  |  |  |
| **4** |  |  |  |  |  |
| **5** |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Number of Pennies** | **Mass (g)** | **Initial Volume (mL)** | **Final Volume**  **(mL)** | **Volume of Pennies (mL)** | **Penny Density**  **(g/mL)** |
| **5** |  |  |  |  |  |
| **10** |  |  |  |  |  |
| **15** |  |  |  |  |  |
| **20** |  |  |  |  |  |
| **25** |  |  |  |  |  |

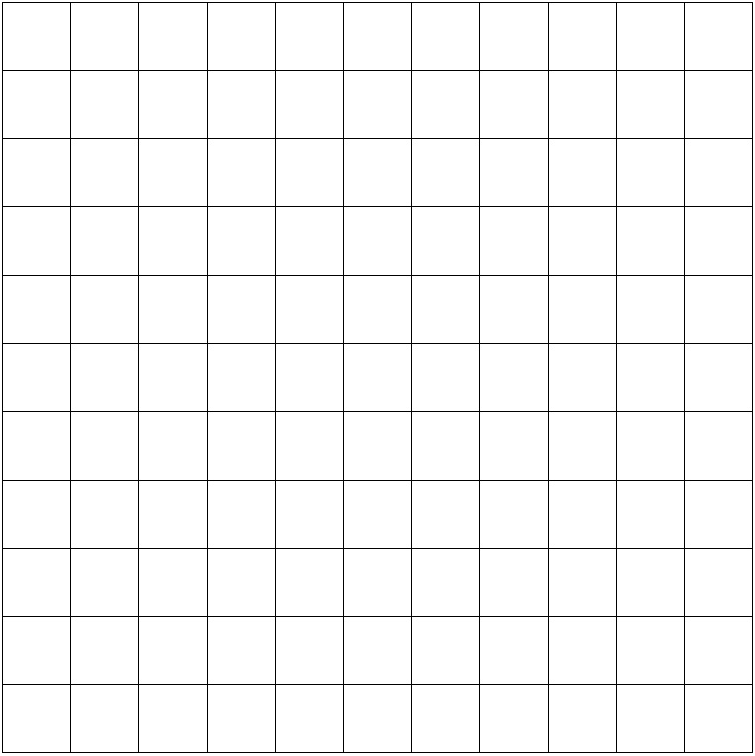
**For Post-1982 Pennies:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Trial for 25 Pennies** | **Mass (g)** | **Initial Volume (mL)** | **Final Volume**  **(mL)** | **Volume of Pennies (mL)** | **Penny Density**  **(g/mL)** |
| **1** |  |  |  |  |  |
| **2** |  |  |  |  |  |
| **3** |  |  |  |  |  |
| **4** |  |  |  |  |  |
| **5** |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Number of Pennies** | **Mass (g)** | **Initial Volume (mL)** | **Final Volume**  **(mL)** | **Volume of Pennies (mL)** | **Penny Density**  **(g/mL)** |
| **5** |  |  |  |  |  |
| **10** |  |  |  |  |  |
| **15** |  |  |  |  |  |
| **20** |  |  |  |  |  |
| **25** |  |  |  |  |  |

**Analysis**

1. Graph the results you got for both pre-1982 and post-1982 pennies in terms of mass below:



**Volume of Pennies**

**Mass of Pennies**

2. Determine the identity of the metal for pre-1982 penny and the post-1982 penny using the chart below. Include an explanation of your logic. (Note: you may want to average the densities for the pre and post pennies to strengthen your case)

|  |  |
| --- | --- |
| **Metal** | **Density (g/mL)** |
| Copper | 8.96 |
| Gold | 19.32 |
| Iron | 7.86 |
| Mercury | 13.55 |
| Nickel | 8.9 |
| Platinum | 21.45 |
| Silver | 10.5 |
| Tin | 7.3 |
| Titanium | 4.5 |
| Zinc | 7.13 |

3. According to the US Mint (www.usmint.gov), pennies minted before 1982 are made of copper (density = 8.96 g/ml). Compare your experimental density value with the accepted value by calculating your percent error for the density of a pre-1982 penny:

**Percent Error = (Experimental Value – Accepted Value) X 100%**

**Accepted Value**

4. Provide a few reasons for why your experimental value differs from the accepted value.

**Questions:**

1. How does this lab show that density is an **intrinsic** property? Use the background information section to read up on what an **intrinsic** property is and use data from your table and graph to provide evidence.

2. Use your density value to calculate the volume of a 1986 penny that has a mass of 5.0 g. Show your

math.

3. Based on your previous experiences, list the substances below in order from the lowest density to the highest. Explain your reasoning.

lead pipe, water, pine 2” X 4” board, styrofoam peanuts.