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| **chem** | **LAB: DENSITY OF A PENNY** |

**Purpose:**

Determine the densities of “new” pennies which date from 1983 and later and of “old” pennies from 1981 and earlier.

**Materials List:**

Graduated Cylinder Water

Balance (Triple beam) Pennies

**Background:**

Density is mass per unit volume (D = M / V). The density of an object can be determined from the mass and volume of that object. Mass can be easily measured using a balance. The volume of a regular object could be determined from its dimensions. For example the volume of a cube can be determined from its length times width times height. But the volume of irregularly shaped objects can be best determined by water displacement.

Archimedes was a scientist in ancient Greece. King Hieron, the King of Syracuse, ordered a new crown to be fashioned for him. Upon completion of the crown, Hieron became suspicious that the crown was not made of the solid gold that Hieron had supplied to the jewelers. He summoned Archimedes to determine (without damaging the crown) whether the crown was made of solid gold. Archimedes was perplexed until one day when he was stepping into his bath; he noticed that the level of water rose. Archimedes took the crown and submerged it in a tub of water, then took and equal mass of gold and submerged it to determine the volumes by displacement. When Archimedes did this, the volumes were not the same…much to the dismay of the deceitful goldsmith. A small amount of the less dense silver had been alloyed with the gold. We will use the same principle of displacement for volume for the determination of the density of the pennies.

We will use a graphical method to determine density by graphing mass (y) versus volume (x). The measured density is the slope of this graph. This process minimizes errors and gives the best possible measurement.

We will determine the density twice; once for pennies from 1982 or later and once for pennies from prior to 1982. In 1982 the composition of pennies was changed because they contained more than 1 cent’s worth of copper. Pennies were being melted down for the value of their metal.

**Procedure:**

1. Place approximately 15-20 mL of water into a graduated cylinder. Record this volume to one decimal place. Recall: always read the level at the bottom of the meniscus (the bottom of the curve of the water).
2. Place the graduated cylinder on the balance and record its mass. (record to two places if using an electronic scale, three if using a triple-beam balance.)
3. Using pennies from 1982 or later, add one penny and record the new mass and volume.
4. Add another penny and record the new mass and volume.
5. Repeat step 4 until 7 pennies from 1983 or later have been added.
6. Repeat steps 1 – 5 for pennies from 1981 or before

**Data Analysis: (round all answers to the proper number of sigfigs)**

1. Calculate the mass of the pennies (equals the mass of pennies and water and cylinder less the mass of the water and cylinder) Show one sample calculation in your report.

2. Calculate the volume of the pennies (by water displacement). Show one sample calculation in your report.

3. Plot both sets of penny mass (y-axis) and penny volume (x-axis) data on the same graph (attach). Draw a “best fit” straight line through each set of data. (Not a “connect the dots” line.) From the graph, determine the densities for the pre- and post-1982 pennies. Show all calculations for slope in your report and attach your graph.

Date performed: Name:

Lab Partner:

**Penny Density Lab**

**“New” Post-1982 Pennies**

Graduated cylinder & water mass m0 =

Initial water volume: v0 =

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Data** | |  | **Calculations** | |
| # of  new pennies | Mass of Pennies, water & cylinder (g)  mn | Measured Volume on Cylinder (mL)  vn |  | Mass of n Pennies (g)  mn – m0  Y | Volume of Pennies (mL)  vn – v0  X |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |

**“Old” Pre-1982 Pennies**

Graduated cylinder & water mass m0 =

Initial water volume: v0 =

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Data** | |  | **Calculations** | |
| # of  old pennies | Mass of Pennies, water & cylinder (g)  mn | Measured Volume on Cylinder (mL)  vn |  | Mass of n Pennies (g)  mn – m0  Y | Volume of Pennies (mL)  vn – v0  X |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |

**Prelab Questions:**

1. What is the relationship between mass, density and volume?
2. Determine the density of a liquid if a 35.2 mL sample has a mass of 28.548 g.
3. A graduated cylinder of water reads 8.3 mL. A pebble is dropped into the water and the cylinder now reads 9.7 mL. What is the volume of the pebble?
4. Sketch what your graph should look like for this lab. Include axis labels for your graph.

**Discussion questions**

* 1. Pre-1982 pennies were 95% copper. Do your results for the pre-1982 pennies agree with the data for copper in the table below? What is your percent error?
  2. Post-1982 pennies are only 2.4% copper and 97.6% some other element. Based on your findings, which of the elements below is probably used in the post-1982 pennies?

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Atomic Symbol | Density (g/mL) | Melting Point |
| Aluminum | Al | 2.70 | 660ºC |
| Copper | Cu | 8.96 | 1083ºC |
| Iron | Fe | 7.86 | 1535ºC |
| Nickel | Ni | 8.90 | 1453ºC |
| Titanium | Ti | 4.50 | 3260ºC |
| Zinc | Zn | 7.14 | 420ºC |
| Zirconium | Zr | 6.49 | 1852ºC |

1. Identify two sources of experimental error for this lab. (not mistakes or part of the calculations.)
2. (Bonus possible 3pt extra credit) Propose an alternate procedure that could have been used for this experiment. Write the steps for your procedure and explain what calculations you would need to do to generate the X-Y data for your density graph.