Determination of the Thickness of Aluminum Foil Name

 Chemistry, Period x

 Date Exp performed

 Report date

Introduction

Aluminum foil is a common household material that is so thin it is impossible to measure directly using a ruler. It is however possible to determine the thickness of aluminum foil through the use of the density of aluminum. Density is mass divided by volume and the density of pure aluminum is well known to be 2.70 g/cm3. If the mass of a sample of aluminum foil is known, then it is possible to calculate the volume of the foil. In general volume is the product of length times width times height of an object. If we know the length and width of a piece of foil, we can then determine its height, or thickness.

Aluminum foil is pure elemental aluminum and consists of nothing but aluminum atoms lined up in a three dimensional grid work. For this lab, we will assume the aluminum atoms are stacked side by side and direction on top of each other. Using this assumption, we can determine the number of Aluminum atoms thick the foil is, as well as the number of aluminum atoms preset in a given piece of foil.

Because aluminum foil is so thin and atoms are so small, many of the quantities used in this experiment will be very small and best expressed using scientific notation. Scientific notation expresses all of the significant digits for a quantity as a number between 1 and 9.999… followed by a multiple of 10 to express the order of magnitude of the number. Positive exponents of 10 indicate very large numbers while negative exponents of 10 indicate very small numbers.

Purpose

* To determine the thickness of a piece of aluminum foil in centimeters.
* To determine the number of atoms thick the foil is.
* To determine the total number of aluminum atoms present in a piece of aluminum foil.

Hypothesis

The thickness of foil will probably be about a micrometer thick so for centimeters that means a thickness of 1 x 10-4  cm. Given that the size of an atom is about 10-10  m, the number of atoms in a 1 x 10-4 cm will be 1 x 104. For a 100 cm2 piece of foil (10 cm by 10 cm), the number of aluminum atoms will be about 1 x 1022.

Procedure

The only equipment used for this lab were a small sample of aluminum foil , approximately 10 x 10 cm2, an electronic balance, and a standard 12” ruler.

I placed the aluminum foil on the balance and recorded its mass. I used the ruler to measure the length and width of the foil. No other measurements were made.

Data

Qualitative: The foil sample was not exactly a rectangle and had sloped edges. There were also several wrinkles across its face, so it did not have uniform thickness. One corner was slightly torn.

Quantitative:

Mass of Aluminum foil sample: 0.407 g

Length of foil sample: 10.44 cm

Width of foil sample: 6.16 cm

Data Analysis

To determine the thickness, first the volume of the foil sample was found using the known density and the measured mass.

$$d=\frac{m}{V}$$

$$2.70\frac{g}{cm^{3}}= \frac{0.407 g}{V}$$

$$V=\frac{0.407 g}{2.70 g/cm^{3}}$$

$$V=0,1507 cm^{3}$$

Using the formula for volume, the height or thickness of the aluminum foil was determined.

$$V=L×W×H$$

$$0.1507 cm^{3}=10.44 cm×6.16 cm×H$$

$$H=0.0023439 cm=2.34 ×10^{-3}cm$$

The radius of an aluminum atom is 1.43 x 10-8 cm, so the size of an aluminum atom is represented by its diameter. Diameter is two time the radius so the size of an aluminum atom is 2.86 x 10-8 cm.

To determine the number of atoms thick the foil was, dimensional analysis was used to convert the centimeter thickness to number of atoms.

$$2.34 ×10^{-3} cm∙\frac{1 Al atom}{2.86 ×10^{-8}}=81956 Al atoms=8.20 ×10^{4}Al atoms$$

To determine the number of atoms in the whole piece of foil, the volume of the foil was converted to atoms using dimensional analysis.

$$0,1507 cm^{3}∙\left(\frac{1 Al atom}{2.86 ×10^{-8}}\right)^{3}=6.44×10^{21}Al atoms$$

1. An entire roll of aluminum foil is 37.5 ft2. Again, dimensional analysis was used to determine the number of Al atoms in the entire roll.

$$37.5 ft^{2}∙\left(\frac{12 in}{1 ft}\right)^{2}∙\left(\frac{2.54 cm}{1 in}\right)^{2}=34838.64 cm^{2}$$

$$V= 34838.64 cm^{2}×2.34 ×10^{-3}cm=81.66 cm^{3}$$

$$81.66 cm^{3}∙\left(\frac{1 Al atom}{2.86 ×10^{-8}}\right)^{3}=3.49 ×10^{24}Al atoms$$

1. Finding the cost of an individual Al atom for a roll costing $3.00 again is solved using dimensional analysis.

$$1 Al atom∙\frac{\$3.00}{3.49 ×10^{24}Al atoms}=\$8.59×10^{-25}=8.59×10^{-23}cents$$

1. For the number of atoms per penny, one only needs to invert the number of cents per atom.

$$1 penny∙\frac{1 Al at}{8.59×10^{-23}cents}=1.16 ×10^{22 }Al atoms$$

Discussion

For this experiment there was no known value, so I cannot determine a percent error for any of my results. However, there is always error present in every experiment. Some random error is always present from the use of laboratory to measure items. Using the ruler, even using it properly, contains some error. The same applies to the use of the balance which may be influenced by breezes or wind caused by motion nearby. There was more random error due to the way the length and width were measured. Only one measurement was made for each even though the foil was not rectangular. A better procedure would be to take multiple measurements of each dimension and find the average length and average width. Systematic error is present because I assumed the foil was exactly flat, which cannot be true because there were wrinkles. This would increase the mass and make the calculated thickness bigger than it really is.

Conclusion

The foil was found to be 2.34 x 10-3  cm and 8.20 x 104 atoms thick. The entire sample was found to contain 6.44 x 1021 atoms. These quantities fulfilled the three stated purposes of the lab. My hypothesized values of 1 x 10-4  cm, 1 x 104 and 1 x 1022 were close to the experimental results. The first and third values differed by only one order of magnitude, the second was of the same order.