DETERMINING THE THICKNESS OF ALUMINUM FOIL

A NOTE TO THE TEACHER

Because the students are expected to work through this problem, the instruction sheets should be handed out one at a time as needed. There is no Teacher's Guide for this activity; all explanations are on the individual student instruction sheets.

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INTRODUCTION

Determining the thickness of a thin sheet of a substance can be difficult. If one has access to a micrometer, and if the material is not too thin, the thickness can be measured directly with this instrument. If a micrometer is not available, thickness must be determined by indirect means. For example, one way of finding the thickness of a sheet of paper is to measure the thickness of a ream (500 sheets) of paper with a ruler and divide that value by 500.

Most indirect methods of measurement involve another measurement of some type. The result is used in one or more mathematical formulas to arrive at the answer to the problem. For example, we can determine the volume of a spherical object such as a marble directly by measuring the water displaced when a marble is dropped into a container of water. But we could determine the volume of the marble indirectly by measuring the diameter of the marble and using the formula for the volume of a sphere, $V = \frac{4}{3}\pi r^3$. Since this formula involves the radius (*r*) of the marble, we use another formula $r = \frac{d}{2}$ (d = diameter) to convert the measured diameter to the unmeasurable radius.

Now compare the ease and convenience of the direct and the indirect methods of determining the volume of the marble. The direct method requires the use of calibrated laboratory glassware and involves the potentially messy job of pouring and measuring the volume of water. The indirect method requires only a ruler and a few calculations.

YOUR ASSIGNMENT

Your group is to develop a detailed plan for determining the thickness of aluminum foil by an indirect means. Members of the group should discuss the problem and work out a plan together. All members of the group must understand the plan in detail. Any member may be asked to explain it.

If, after careful thought, no ideas come to mind, ask the instructor for a “hint” sheet.

HINT SHEET #1

You might start by referring to the information about aluminum in a handbook of chemistry. Listed are such items as formula, molecular weight, crystalline form, color, density, melting point, boiling point, solubility in water, and solubility in other liquids.

If, after thought and discussion, members of your group do not have any good ideas for solving the problem, ask the instructor for Hint Sheet #2.

HINT SHEET #2

Most of the information about aluminum in the handbook has no bearing on our problem but the density information might be useful.

The density of aluminum is 2.702 grams per cubic centimeter. Keep in mind the formula, $\text{density} = \frac{\text{mass}}{\text{volume}}$.

If, after thought and discussion, members of your group still cannot think of how to solve the problem, ask the instructor to supply you with some details.

HOW TO SOLVE THE PROBLEM

We can find the value for the density of aluminum in a handbook. We remember the formula, $\text{density} = \frac{\text{mass}}{\text{volume}}$.

We also remember the formula, volume = length x width x thickness. Since length x width = area, we could rewrite the density formula to read:

$$\text{density of Al} = \frac{\text{mass of Al}}{\text{area of Al x thickness of Al}}$$

The formula can be rearranged in this manner:

$$\text{thickness of Al} = \frac{\text{mass of Al}}{\text{area of Al x density of Al}}$$

All we need to do is cut a piece of the aluminum foil in question, measure its length and height (so we can find its area), crumple the foil into a small ball and weigh it on a milligram balance. We will then have all the data necessary to determine by indirect means the thickness of the aluminum foil.

LABORATORY PROCEDURE

1. Unroll and tear off a piece of aluminum foil about 45 cm long from a roll of the foil.

2. Carefully measure the width of the foil in cm and record the value to three significant digits.

3. Carefully mark a length exactly 40.0 cm long on the 45 cm sheet you have and mark it off with a pencil. Be sure to keep the ends square.

4. Now cut out the segment along your penciled line. You should have a sheet of foil that is 30.4 cm x 40.0 cm. (30.4 cm is the standard width of commercial aluminum foil.)

5. Crush the sheet of foil into a small ball, and weigh it on a milligram balance to the nearest milligram. Record this value.

6. Using the formula below, calculate the thickness of commercial aluminum foil in centimeters. Then convert to thickness in inches.

DATA AND CALCULATIONS

Width of foil _____ cm

Length of foil _____ cm

Area of foil _____ cm^2

Mass of foil _____ g

$$\text{Thickness of Al foil} = \frac{\text{mass of Al foil}}{\text{area of Al foil} \times \text{density of Al}}$$

Thickness of Al foil = _____ cm

Thickness of Al foil = _____ inch