Galvanized Metal Lab

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Abstract: This laboratory uses a piece of galvanized metal to quantify the loss of atoms during a chemical reaction. The area and mass of a small piece of galvanized metal is placed in Muriatic Acid for 15 seconds. Afterwards, the mass is re-determined and the difference attributed to be due to the loss of zinc atoms from the surface. Knowing the density of zinc, as well as the atomic radius of the zinc atom, the reduction in thickness of the zinc is calculated along with the number of zinc atoms lost.

Module objective: This simple lab visually shows the effects of removing zinc from a galvanized piece of sheet metal and provides students an opportunity to mathematically calculate the reduction in thickness of the zinc and number of atoms lost, based on the change in mass. This provides students with an understanding of the numbers of atoms in a thickness of metal.

Student Learning Objectives: Students will be able to

- observe the relative difference in reactivities of iron and zinc to muriatic acid
- take measurements using a micrometer and a beam balance
- safely handle strong acids using appropriate safety precautions
- use Algebra to rearrange an equation to solve for an unknown

MatEd Core Competencies covered:

0.B Prepare tests and analyze data
1.A Carry out measurements of dimensions and physical phenomena
5.A Apply safe and environmentally appropriate methods to chemical handling
5.B Demonstrate knowledge of chemistry fundamentals
7.A Identify the general nature of metals
9.E Identify uses for zinc and its alloys

Key words: corrosion, galvanized metal**,** density, crystal structure

Type of module/mode of presentation: Laboratory

Time required: 30 minutes

Pre-requisite knowledge: none

Target grade levels: 9-12

Table of Contents

Equipment and supplies needed:

Galvanized Metal, about 2"x2"	1 small beaker (150 ml)
micrometer	6 M HCl solution
Beam Balance	(muriatic acid may be substituted)
tongs	Safety glasses
apron	Rubber gloves

Curriculum overview and instructor notes

Hazards: Concentrated solutions of HCl will burn skin and damage clothing. Fumes from acid can be caustic and or irritating; do this experiment in a well ventilated area. (hood, if available). Goggles must be worn.

Instructor notes:

Galvanized steel has a coating of zinc on the surface. This is used because zinc has a much higher corrosion potential than iron or steel, and thus corrodes sacrificially to protect the steel from corrosion. Galvanizing is used in may applications, from street light poles to garbage cans. In this lab we use the principle that (1) the acid attacks the zinc more readily than steel and (2) the larger area of the zinc on the surface means that zinc will be the material most exposed to the acid, this being the atom removed from the sample.

Muriatic acid is commonly sold in hardware stores as a cleaning agent for concrete. To emphasize the strength of this acid, a small amount may be poured

on concrete outside (be sure to flush with water afterwards!). This seems to leave a lasting impression on students.

The chemical reaction the students observe is:

$2\ HCl_{(aq)} + Zn_{(s)} \text{----} > H_{2\ (g)} + Zn^{2+}_{(aq)} + 2\ Cl^{-}_{(aq)}$

Module procedure:

1. Obtain a sample of galvanized metal, and measure the length and the width using a micrometer. Calculate the area. Because the metal is galvanized on both sides, multiply the area x2 for the total surface area that is galvanized.
2. Determine the mass of the metal using a beam balance, to the nearest .005 gram.
3. Taking appropriate safety precautions (gloves and safety goggles), use the tongs to immerse the metal into the 150 ml beaker containing the HCL solution for about 15 seconds. Do this in a well ventilated area!
4. After about 15 seconds, the rate at which H_2 is produced will drop off noticeably. Remove the metal using the tongs and swish it around in a bucket of water to get a thorough rinse. You may now handle the sample without gloves.
5. Rinse and dry the sample, and then determine the mass again to the nearest .005 gram.
6. Subtract the post mass from the pre-acid mass. The difference is due to the zinc that was removed.
7. Calculate the thickness of zinc using the equation:

$$t = \Delta M_{zn} / (\text{Density} \times \text{Area})$$

8. Calculate the number of zinc atoms removed by taking the thickness and dividing by 5.32×10^{-8}, the diameter of a zinc atom.
9. To see the effect that galvanization has, use clear tape and tape your sample to this lab sheet, taping all four edges to the paper. Leave the center of the metal exposed. For additional amusement, carefully leave a fingerprint in the center of the metal.

DATA TABLE

Length of Sample, cm	
Width of Sample, cm	
Initial Mass of Sample, .005 grams	
Final Mass of Sample, .005 grams	

CALCULATIONS

Area of metal = 2 x Length x Width (cm^2)

Mass of Zinc = Initial Mass – Final Mass, (grams, .005)

Thickness of Zinc $t=\Delta M_{zn}$ /(Density x Area) (Density of zinc is 7.140 grams / cm^3)

$$t = \frac{\Delta M_{zn}}{(\text{Density} \times \text{Area})}$$

Zinc has a hexagonal close packed crystal structure, so to find the true number of zinc atoms in the thickness of the zinc, the following calculation should be used, where 4.17×10^{-10} cm is the distance between vertical spacing of two zinc atoms that are in alignment vertically, with another row sandwiched between them. The "2" accounts for the "offset" row of atoms.

$$\text{Number of zinc atoms} = \frac{(2)\ t}{4.17 \times 10^{-10}\ \text{cm}}$$

References:

For more information on Zinc and its crystal structure, see:
http://www.webelements.com/zinc/crystal_structure.html

Toon and Ellis, *Laboratory Experiments for Foundations of Chemistry* ; Holt / Rinehart & Winston, 1973

Evaluation packet:

Student evaluation questions (discussion or quiz):

1. What does "galvanized" mean?

2. Why do we assume that all of the atoms lost come from the zinc coating and not from the steel underneath?
3. Why did the rate of outgassing (fizzing) change when the metal was placed in the acid?
4. Why was there a difference between your answer and that of other students?
5. How could the accuracy of this lab been improved?

Instructor evaluation questions:

1. At what grade level was this module used?
2. If used, did the lab add to student learning? Please note any problems or suggestions.
3. Was the background material sufficient for your background? Sufficient for your discussion with the students?
4. Did the lab generate interest among the students?
5. Please provide other comments or suggestions concerning the approach, focus and effectiveness of this activity in your context.

Course evaluation questions (for the students)

1. Was the module clear and understandable?
2. Was the instructor's explanation comprehensive and thorough?
3. Was the instructor interested in your questions?
4. Was the instructor able to answer your questions?
5. Was the importance of materials testing made clear?
6. What was the most interesting thing that you learned?