Quantitative Analysis of Zinc Layers on Galvanized Steel

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September 10, 2024

Introduction

Galvanized steel is a widely used material due to its resistance to corrosion, which is due to the presence of a layer of zinc metal on the surface. The goal of this experiment was to experimentally determine the number of zinc atoms on a sample of galvanized steel and then calculate how many layers of zinc atoms are present.

Claim

The sample of galvanized steel was found to contain 1.21×10^{20} zinc atoms and 25,000 layers.

Evidence

Quantity	**Measured Value**
Initial Mass of Steel Sample	0.1432 g
Final Mass of Steel Sample	0.1301 g
Mass of Zinc on Sample	0.0131 g
Length of Steel Sample	2.0 cm
Width of Steel Sample	1.7 cm
Area of Steel Sample	3.4 cm^2

Reasoning

The zinc layer can be selectively removed by reaction with hydrochloric acid as shown in *Equation 1*. Conservation of mass then allows us to relate the change in mass of the sample to the amount of zinc on the steel.

$$\mathrm{Zn\,(s) + HCl\,(aq) \rightarrow ZnCl_2\,(aq) + H_2\,(g)} \tag{1}$$

The mass of zinc can then be converted to atoms of zinc using dimensional analysis as illustrated in *Equation 2*

$$0.0131\,g\,Zn \times \frac{1\,mol\,Zn}{65.409\,g\,Zn} \times \frac{N_A}{1\,mol\,Zn} = 1.21 \times 10^{20}\,zinc\,atoms \tag{2}$$

To determine the number of layers we will assume that the zinc atoms have a radius of 135 pm and thus a diameter of 270 pm.

With a measured length of 2.0 cm (2.0×10^{10} pm), 7.407×10^7 zinc atoms will fit side by side along this length:

$$\frac{2.0 \times 10^{10}\,pm}{270\,pm} = 7.4 \times 10^7\,zinc\,atoms \tag{3}$$

The width will hold 6.3×10^7 zinc atoms. This implies that a single layer will hold approximately 4.7×10^{15} zinc atoms and approximately 25,000 layers of zinc atoms.

Discussion

This experiment serves to illustrate a number of key scientific principles key to the study of chemistry: Dalton's atomic theory and the conservation of mass.

John Dalton was the first to suggest that all compounds are composed of indivisible particles called atoms that combine with each other in whole number ratios. The calculation of the number of zinc atoms in a layer placed on the sample of stainless steel is only valid if we can assume that the zinc atoms are the same.

Furthermore, the mass of the sample before and after the reaction with hydrochloric acid is used to determine the mass of zinc present. This calculation would have no meaning if mass was not conserved and particles could disappear or pop into existence on a whim.