# **E6-ANALYSIS OF AN ALUMINUM-ZINC ALLOY**

Active metals react in acid solution to liberate hydrogen gas. This property can be used to determine the quantity of a metal present in a sample by determining the moles of H2 gas formed and calculating the quantity of metal that will yield that amount of gas.

Zinc and aluminum are two metals that each react with hydrochloric acid as follows:

Zn(s) + 2HCl(aq) 🡪 ZnCl2(aq) + H2(g)

2 Al(s) + 6 HCl(aq) 🡪 2 AlCl3(aq) + 3 H2(g)

If a sample of either of these metals is treated with HCl(aq), the moles of H2 produced can be used to calculate the grams of metal in the sample.

An **alloy** of aluminum and zinc will also react with HCl(aq) and liberate H2(g). In this case, however, the moles of gas produced will depend on the mass of **each** metal (Al or Zn) in the sample as they react independently. The alloy’s composition may be expressed as the decimal fraction (or percent) of each metal in the alloy. If the composition of the alloy is known, then the moles of H2 product can be calculated from the corresponding number of moles of each metal (n = moles):



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Conversely, the composition of the alloy may be determined from the moles of hydrogen liberated by a given mass of the alloy using this same stoichiometric relationship.

In this experiment, an alloy of Al and Zn will be treated with HCl(aq). The product H2(g) is collected, and its volume is measured. Using the ideal gas law, n(H2) can be calculated from

**PV = nRT** where P = P(H2), n = n(H2), and V and T are the volume and temperature of the gas.

Since the H2 is collected over water, the gas is actually a **mixture** of H2 and water vapor. The total internal pressure equals the barometric pressure (Pbar), so the partial pressure of H2 is Pbar minus Pvap, the vapor pressure of water at the temperature during the experiment, according to Dalton’s Law:

P(H2) = Pbar – Pvap

The moles of H2 gas collected from a sample of alloy will be used to determine the percent Al in the sample. This will be done using the graph and equation prepared in the Pre-Lab exercise.

## **PROCEDURE**

Before beginning the experiment, prepare your laboratory notebook, including a data table for recording all data that you will collect during the experiment (unknown code, mass of gelatin capsule, mass of alloy, volume of water, etc.). **NOTE: there is no prepared report sheet for this experiment. You will prepare your own for your notebook entries and your submission to your instructor!**

Wear **safety glasses** while doing this experiment.

Obtain the apparatus from the stockroom; assemble it as shown in the diagram (Figure 1), using a large test tube (200 x 29 mm), a 500 mL Florence flask and a 400 mL beaker. Note that the tubing which extends to the bottom of the flask is the tubing that leads to the beaker.

Experiment assemble diagram.

*Figure 1: Al/Zn Alloy Analysis Apparatus*

Obtain an alloy sample and two gelatin capsules. Weigh a gelatin capsule on the analytical balance. Add approximately 0.1 to 0.2 g of alloy to the capsule and reweigh. Do not touch the capsule with your fingers since it will absorb moisture.

Fill the 500 mL flask and the 400 mL beaker two-thirds full with water. Remove the test tube, open the pinch clamp, and with a pipet bulb, apply suction to the tube leading to the test tube. Pull water into the flask up to the bottom of the neck. Close the pinch clamp and make sure that the tubing from the beaker to the flask is filled with water, with no air bubbles.

Empty the beaker of any water that may be present. Weigh the empty 400 mL beaker on the centigram balance in the laboratory (not the high precision analytical balance; the mass of the beaker is too great). Place the tube back into the beaker. Measure approximately 15 mL of 6 M hydrochloric acid in a graduated cylinder and pour it into the test tube. Drop the gelatin capsule into the HCl solution, insert the stopper firmly into the test tube and open the pinch clamp. If a little water enters the beaker at this point, pour the water out, and place the tubing into the beaker again.

In several minutes, the acid will dissolve the gelatin capsule and the alloy will begin to react. The hydrogen gas formed will enter the Florence flask and displace an equal volume of water which will run into the beaker. As the reaction proceeds, a dark foam may form which contains particles of the alloy. Gently shake the test tube so that all particles of the alloy react with the acid. Once the solution in the test tube is relatively clear, at room temperature and with no more gas being evolved, close the pinch clamp then remove the tubing from the beaker.

Measure the temperature of the water. Weigh the beaker and water on the laboratory balance. Record the barometric pressure. Clean and reassemble the apparatus and repeat the experiment.

Prepare a data table to turn in with the experiment.

Carry out the following analysis of your data:

1. Use your calculated n(H2) and the graph to determine the percent Al in your unknown sample.

b) Use the equation from problem 3 of the Pre-lab to calculate the percent Al.

Explain possible causes of any discrepancies between the two answers. The report that you turn in will consist of your data sheet, calculations, results, and the answers to the questions.

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DATE\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**REPORT SHEET**

Unknown #\_\_\_\_\_\_\_\_\_\_\_\_ % Zn\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ % Al\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1) Upload your excel file separately in canvas and insert it here as well.

2) Insert into this report sheet, your prepared data table with all collected data; make sure to include the following:

a) Use your calculated n(H2) and the graph to determine the percent Al in the sample.

b) Use the equation from problem 3 of the Pre-lab to calculate the percent Al.

3) Show a sample calculation for one trial:

4) Explain possible causes of any discrepancies between the two answers.

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**Post-Lab Questions**

1. What volume (mL) of hydrogen gas, saturated with water vapor, will be obtained from a 0.1138 g sample of alloy which is 73.2% Al? (Pbar=754.3 torr, T=21.2**°**C)

2. What volume (in mL) will the dry hydrogen gas from problem 1 occupy at STP?

3. Which of the following alloys can be analyzed by the method of this experiment? Show the balanced chemical equations for the alloys that can be analyzed. Give the reasons why some alloys cannot be analyzed by this method.

Fe/Ni Cu/Sn Cu/Ag

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Date\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Pre-Laboratory Assignment**

1. Calculate n(H2) obtained from 1.000 gram of Al. Also, calculate n(H2) obtained from 1.000 gram of Zn.

2. Prepare a graph in Excel for a 1.000 gram sample of alloy with n(H2) on the vertical axis and percent Al on the horizontal axis. The graph will be linear. Plot four points, one where the percent Al is 100 (i.e., 1.000 gram of Al) and another point where the percent Al is zero (1.000 gram of zinc). Choose any two other percentages for a **1.000 gram sample**, calculate the moles of hydrogen that will be obtained, and plot the points. **Submit the Excel graph to your instructor before beginning the experiment. Retain a copy of this graph for use in data analysis from your experiment.**

3. Why did we designate that the %Al should be placed on the x-axis? Determine the slope and y-intercept of the line obtained in problem 2 and write the equation of the line, including units.

4. Define alloy.