LAD D2 (pg 1 of 4) Experimentally Measuring Molar Volume

Name____________________Per___

Introduction

The purpose of this lab is to run a gas producing reaction, collect the gas at room conditions, and then calculate the *molar volume* of a gas at standard temperature and pressure. Magnesium will be reacted with hydrochloric acid. Hydrogen gas will be one of the products of the reaction, which will be contained and collected in a *eudiometer* in order to measure the volume at room conditions, which will be "corrected" to STP conditions.. Then knowing the moles of the limiting reactant, we can predict the moles of the gas collected and make a vol/moles ratio which is of course, Molar Volume.

PreLAD – *show any calculations necessary.*

1. Make a data/results table in your Google Spreadsheet. All measurements and subsequent calculations (processing the data) must be included. Include a sample data column. This should be set up with formulas BEFORE the lab.
2. Write the balanced overall equation *and* the net ionic equation that represents the reaction between magnesium and hydrochloric acid.

3. You would like to produce enough gas to fill approximately 80% of your 100 ml eudiometer (gas collecting tube). Calculate the mass of magnesium required to do that at room conditions (1 atm, 22ºC).

4. The magnesium that you will use has very uniform thickness and width. Thus it has a particular mass per length ratio. Consider that ratio to be 1.393 grams/meter. From the mass that you calculated in the previous question, calculate the approximate length of the magnesium that you will need to cut off the roll of magnesium.

5. Because the acid will become diluted during the procedure of this lab, you will need to use approximately 10× the amount actually required. The molarity of the acid you will be using is 3.0 M. Knowing the mass of magnesium that you would like to use as calculated in question 3, determine the volume of acid that you should use in this lab.

Materials – for each lab group

- ~6 cm strip of Mg
- eudiometers
- ring stand with buret clamp
- rubber stoppers, 1-hole
- very thin copper wire
- stoppered flask with HCl (with red food coloring)
- 600 ml beaker
- tap water squirt bottle
- ring stand with buret clamps
- thermometer
- large 1000 ml graduated cylinder
- scissors and ruler

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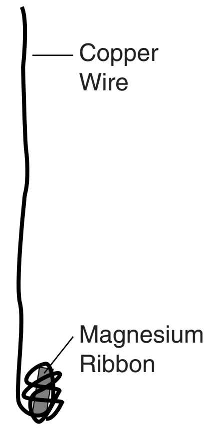
Procedure



A. Cut a piece of magnesium to an approximate length appropriate to generate gas to fill ~80% of *your* eudiometer (be sure and check the size of your eudiometer) and measure an *appropriate* mass of magnesium. Trim the Mg, if the mass is too large and would overfill your eudiometer.

B. Set up a large beaker three-quarters filled with room temperature water from the faucet.

C. Roll up the magnesium and then wrap it loosely in the copper wire, making a little cage to hold the magnesium.

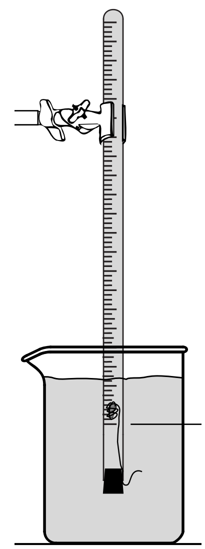
D. Pour the appropriate amount of acid required (as calculated in the preLAD) into the eudiometer. Fill the remaining space in the eudiometer with water using the tap-water squirt bottle - be sure and make a bulge of water at the top of the tube to help avoid catching any air bubble when the stopper is inserted.

E. Using the tail of the copper wire hang the magnesium over the edge of the eudiometer and secure with the holed stopper, as demonstrated by the sample set-up on the center lab bench. Check to see that there are no air bubbles. If so, remove them. With finger over the hole in the stopper, invert the tube in the large beaker of water, remove finger, clamp the tube in place, and allow the reaction to occur.

Make the following observations and answer these questions on the bottom of your data table.

(i) After tipping the eudiometer upside down, observe what happens to the the HCl.

(ii) Watch closely to see if any magnesium gets out of its cage. If Mg gets loose, the generating gas may buoy the Mg up to the top of the liquid in the eudiometer. If this happens during your trial, please alert your classmates so they can observe what happens to the piece of Mg. (If this does not happen, we will discuss in class so you can make observational comments.)



F. After the reaction appears to have finished, take the tube out of the clamp and tap the tube gently against the bottom of the beaker to dislodge any gas bubbles. If the height of the water inside the column is above or below the water, adjust the tube to make the water level inside the eudiometer the same as the water outside the eudiometer, then read the volume of gas produced. (You may need to put your finger over the bottom and transfer your cylinder to the large graduated cylinder to make this level adjustment.)

G. Be sure and measure the water/air temperature and record the air pressure of the room, reported on the white board up front. Look up and record the water vapor pressure appropriate to your recorded temperature. Remember you have a table in your last Lab D.1 (If this lab has been handed in, there will be a table up on the projector.)

Disposal

The empty copper wire cage can go in the trash. The remaining solution can be washed down the sink with plenty of water. Rinse the eudiometer with a with the tap-water squirt bottle and hang it upside down to dry at your lab bench.

Processing the data – *Put these results and embed the formul in your data/results table.*

1. Using the mass of Mg used, calculate the number of moles of magnesium reacted.

2. Using stoichiometry of the balanced equation, convert the moles of magnesium to moles of hydrogen gas formed.

3. Determine the pressure of the gas collected by knowing the pressure in the room, and correcting for the water vapor pressure. Use the Equilibrium Vapor Pressure Table for water that was in the PreLAD of LAD D.1

4. Using the combined gas law $\left(\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}\right)$, convert your *experimental* volume of gas that you collected at room conditions to an *equivalent experimental* volume **at standard temperature and pressure conditions** (STP), i.e. "correct" to STP.

5. Calculate *experimental* molar volume at STP by dividing out the ratio of volume to moles: $\left(\frac{\#4, volume}{\#2, moles}\right)$.

6. Knowing the theoretical molar volume at STP, calculate the percent error.

Post Lab Questions - ***these can be answered directly on this sheet***

1. What gas was formed in the lab? What is a simple lab test and the confirmatory result used to determine this gas' presence in small quantities? Write a balanced equation that represents the reaction that causes the result of this test.

2. In this lab there are actually two gases in the eudiometer? What is the other gas, and how is this problem corrected?

3. Why was it necessary to tap the tube at the end of the experiment? Would the resulting molar volume be larger, smaller, or remain the same if gas bubbles were still clinging to the wire cage?

4. In this lab it is important to get the apparatus upright before any of the gas started forming. Look up the density of magnesium metal. Explain how the cage was *helpful* in the procedure both *before* and *after* tipping the buret and upside down to start the reaction.

5. How did the differences in the density of water and the density of aqueous hydrochloric acid help in the procedure of this lab?

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6. Iron wire is cheaper than copper wire. Why then was copper wire used for the cage instead of iron wire? Would the experimental molar volume be larger, smaller or remain the same, if iron wire had been used instead of copper wire. Justify your answer. *Write a balanced chemical equation to support your answer.*

7. Which reactant is the limiting reactant in this procedure? What chemicals are left in the water after the reaction is complete?

8. Hydrogen chloride is naturally a gas. In this lab HCl was dissolved in water. When a solution of hydrochloric acid evaporates, the HCl molecule evaporates as hydrogen chloride gas along with the water. This would allow you recover the other product to complete the stoichiometric picture. **Calculate the mass of magnesium chloride** that you would expect to recover had you been instructed to evaporate away all of the water and acid solution after the reaction.
(This mass should be very small, and you can see why we did not bother to evaporate all that water and acid to recover this so very tiny mass.)

9. It is possible that the magnesium had a magnesium oxide coating. This would not react with acid the same way that the magnesium reacts with acid. If your magnesium had a significant amount of magnesium oxide coating, would this have caused more or less hydrogen gas to be produced? Write a balanced net ionic equation to represent the reaction of magnesium oxide with hydrochloric acid to justify your answer. (*We will do this net ionic equation together in class.)*

Scoring Rubric

5	**PRE**
35	Questions
35	Data Table
________	*Out of 75*
25	Lab Quiz