Experiment 13: Calculation of the Molar Volume of a Gas at STP and the Ideal Gas Constant, R

Format & Clarity of the Report: See lab report checklist. You are graded on how you format the lab and record your data, not just data collection.

Before class starts: Read the lab for the week carefully before you start writing your pre-lab. The purpose, introduction, and procedure should be neatly written in your lab book before class starts.

Spacing: You will probably use 2 pages for your purpose and procedure, 1 page for the data table, 1-2 pages for calculations, 1 page (or less for results table), 1-2 pages for the analysis statement, . If you allot an appropriate amount of space, you will not have to mix labs together if you have to do more than one in a week. You will lose points for poorly formated labs

Purpose: The title indicates the purpose of the lab.

Introduction: No introduction please, instead list the equations and constants to be used in the experiment.

Pre-lab questions:

1. Write the balanced equation for the reaction of magnesium metal and hydrochloric acid
2. What kind of reaction is the magnesium and the hydrochloric acid undergoing?
3. Why doesn't the copper wire, which we use to form a cage to hold the magnesium in place, react with the acid.
4. What two gases will be collected in the gas collection tube?
5. In a certain experiment, 0.0400 grams of Mg reacted with excess HCl. The temperature recorded for the experiment was 22.5°C[1], the total volume of the gases was 38.0 mL, the height of the column was 17.87 cm, the barometric pressure was 763.2 mmHg,
    a. Calculate the moles of hydrogen evolved. [0.001646 mole]
    b. Calculate the temperature of the experiment in kelvin [295.7K]
    c. Calculate the pressure due to the column of water. [13.8 mmHg]
    d. Calculate the pressure of the hydrogen gas using Dalton's Law of Partial Pressures [728.9 mmHg]
    e. Calculate the volume of the hydrogen gas at STP using the Combined Gas Law [0.0337L].
    a. Calculate the molar volume of hydrogen gas at STP.[20.5L/mole]

Procedure: **YOU HAVE TIME TO DO THIS EXPERIMENT THREE TIMES (although more is always better), YOU WILL BE GRADED ON THE PRECISION AND ACCURACY OF YOUR WORK. Do as many trials as you can.**

1. Since you are repeating the experiment several times, use a longer piece. Weigh a sample of the Mg ribbon and measure the length needed to provide 0.04 g of Mg. Multiply this length by 4 (three trials, + some extra). Divide this into the approximate size needed for the 0.04 g

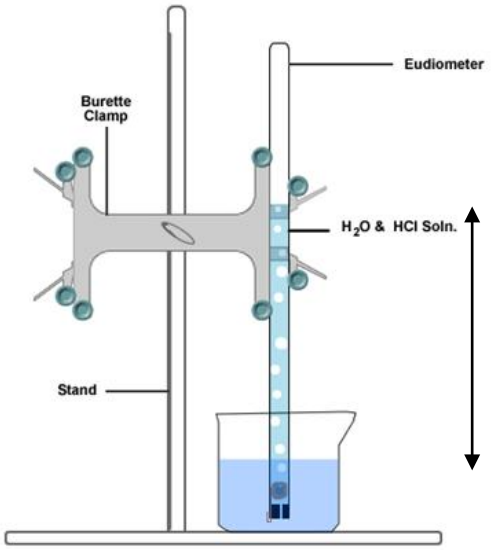
[1] Vapor pressure calculator. Vapor pressures are given in tables, here is a nifty link that calculates the vapor pressure of water at a given temperature: http://www.endmemo.com/chem/vaporpressurewater.php

samples for the experiment. It is much easier to clean a long piece of ribbon then several small pieces of ribbon.

2. Wet the cage and Mg sample before adding it to the eudiometer
3. In Step 6, feed the tail of the copper cage through the hole of the stopper.
4. In step 7, use an eyedropper to fill the hole with water. You don't want any air in the eudiometer.
5. YOU WILL RE-USE THE COPPER WIRE.
6. Be very careful when pouring the concentrated acid into the eudiometer. (This is also stated in step 8).
7. Be careful when using the ruler for measuring the height of the column. THIS IS A SOURCE OF ERROR.
8. Almost every step in this lab has a source of error.
9. USE THE ANALYTICAL BALANCE, not the centigram balances.

Qualitative Observations/ Data Collection: You should pay appropriate attention to details in this lab. The observations will help you identify sources of error. Data collection need to be done with care, Use this section to look beyond the obvious observations: **You should describe:** What does the magnesium metal looks like before reacting? What happens to the copper metal? What happens to the liquid in the eudiometer? What happens when the acid hits the Mg ribbon? Did you observe the mixing of water and acid? What did it look like? What other things did you observe? Include a drawing of the set up in your observation section. (see below)

For this experiment, you should collect your data with the correct significant figures and units in the observation section with the correct precision and units.: mass of Mg to the nearest 0.0001 g; the volume of the gas in the eudiometer (±0.01mL); the height of the column above the level of water (±0.1cm); the barometric pressure (look at board); the temperature of the gas (±0.1°C); the vapor pressure of water at your temperature (chart given)



Measure the volume of the gas

Measure the height of the column of solution in the eudiometer to the top of the water in the beaker

Take the temperature of the water in the beaker

Record the pressure of the atmosphere

Data Tables: For this experiment, you should transfer your data with the correct significant figures and units from the observation section into a data table that is easy to understand: mass of Mg to the nearest 0.0001 g; the volume of the gas in the eudiometer; the height of the column above the level of water; the

barometric pressure (look at board); the temperature of the gas; the vapor pressure of water at your temperature (chart is on line on my website)

Calculations: For this experiment, you should calculate: the moles of Mg used; the mole of Hydrogen gas produced; the pressure due to the column of water; the pressure due to hydrogen gas in mmHg; the adjusted vapor pressure of water, the temperature of the gas in K; an experiment value of V_{exp}, the V_{molar} for each trial, the average value of V_{molar}. the percent difference of your V_{molar}, the % error of V_{molar}, the R value for each trial (you can use 62.363 $L \bullet torr \bullet K^{-1} \bullet mol^{-1}$, but on a test I give you 0.08206 $L \bullet atm \bullet K^{-1} \bullet mol^{-1}$) the average R, the % difference for R, and the % error for R.

Graph: No graph

Results Tables: The results table should show three (four) experimental values of V_{molar}., the average value of V_{molar}., the three values of R, the average R, the percent difference of your values, and the % error of your average value compared to the theoretical value

Results Statement

YOU WILL WRITE A RESULTS STATEMENT FOR THIS LAB. I have stated what you need above, but here is a checklist. (This should be no more than 1000-1500 words minimum. More is better, but less is not). Think of the 4 W (Why did I do the lab? What did I do in the lab? What did I observe in the lab? Where did the observations lead me?)

In the summary, you should explore the following:

1. What was the purpose of the lab?
2. Briefly describe what you did in lab and summarize your observations. Include the balanced stoichiometric relationships for the processes that occurred during the lab.
3. Do not confuse observations and conclusions.
4. Summarize your final data and include a % error AND a % difference.
5. What was the experimental value for R, the gas constant?
6. From the observations and data, draw conclusions about what you observed. Hint: if you observed bubbles, what was in them? (You cannot directly observe hydrogen gas!)
7. Do your results support your purpose?
8. Do your results make sense?
9. Were the values of the results what you expected? (Here is the challenging part, if your results were what you expected, can you explain why? If the results were not what you expect can you explain why?) Compare the results to literature values, results of other students, and/or the results expected based on an understanding of chemistry.

   For example:

   > 'I looked up the molar volume of hydrogen in my book. The molar volume was 22.42L/mol. My calculated value was 21.6L/mol. The actual value is close to mine, with a 4% error; experimental errors such as the height of the column measurement or reading the burette could contribute to the difference in the value.'

10. Check out chapter 10; you should be able to explain microscopically what is happening and what we observe macroscopically based on gas laws and gas behavior.
11. **NO ERROR ANAYLSIS!!!** In step 9, you are thinking about sources of error, but you are not analyzing how the error might affect your data. The difference:
    a. 'I looked up the molar volume of hydrogen in my book. The molar volume was 22.42L/mol. My calculated value was 20.8/mol. The actual value is close to mine,

with a 7% error. One error that could affect my results is the temperature. Monst thermometers have a 5% error. If my experimental temperature was 22.5°C a 5% error could change my temperature to 23.6°C, this would lower my molar volume to 20.6L/mole because the non STP temperature of the gas is larger than expected so the molar volume would be smaller than expected.'

The result summary is easy to read, had good grammar, and a logical flow of ideas. You should demonstrate, during writing the evaluation, that you have a good grasp of the concepts presented in the lab.

FOR ANY STATEMENT: Submit a typed statement in 12 pt, serf font (i.e. Palatino, Garibaldi, or Times), using good grammar, syntax, and Standard English. Complete sentences are used: short well-worded sentences are better than long, poorly, worded sentences. The spelling has been checked. Questions that are presented throughout the lab can be answered in a coherent set of paragraphs, but the points must be addressed within**.** All of this was done in a manner that was well thought out, logically presented and interesting to read. The evaluation should be neatly trimmed and **GLUED OR TAPED** into your book (two copies, one original, one yellow).). **Use transparent tape please not lab tape.**

(In the end, I should have a good sense of what you were looking for in this experiment, what you did and observed in the experiment, what your results were for the experiment. Think about it this way. "Oh no, I lost my report. That's okay, I can describe what I did, my results in the conclusion.")

Post Lab Questions: The questions in the instructions should be answered clearly and completely in your lab book. You should write thoughtful answers to the questions in the lab manual using complete sentences, good grammar, and in Standard English. You might want to consider typing these answers, to give you more time to think about the quality of your answer. (No credit if you did not show your work or explain your reasoning). The answers should address the main thrust of each question. Answers involving calculations should have the correct significant figures and units.

1. Why don't you need to measure the exact volume of acid used?
2. What made the water in the tube go down?
3. If the water levels inside the eudiometer and the level of the beaker are the same what can we assume about the pressure of the gas in the eudiometer?
4. We made many assumptions in this lab which can lead to error in our calculated value of V compared to the actual or expected value of V (not the theoretical value)
    a. Will the calculated V be larger than the expected value if: The density of the solution in the column is lower than 1.05g/mL, given that the vapor pressure, and the atmospheric pressure do not change.
    b. The temperature of the solution in the column is higher than the measured value, given that the density of the column, the other pressures, and the height of the column do not change
    c. The volume read from the eudiometer was slightly lower than the actual value, given that all other measurements stayed the same, since some of the gas does escape out the hole of the stopper in the setup
    d. The moles of Mg were lower than the actual, because the magnesium metal was not sufficiently cleaned, all other measurements do not change the height of the column was larger than actual, all other measurements do not change

5. In a similar experiment, a piece of aluminum was reacted with HCl, the hydrogen gas produced was collected in a eudiometer in the same way. Using the PV=nRT and the balanced equation, calculate the mass of aluminum needed to produce 39.5 mL of H_2 at 21°C when the atmospheric pressure is 762.8mmHg, and the height of the liquid column in the eudiometer is 11.0 cm.