Molar Volume of a Gas AP Chemistry

Introduction: In this experiment you will measure the volume of hydrogen gas generated by the reaction of a known amount of magnesium metal with hydrochloric acid. The hydrogen gas will be collected over water and resultantly; it will be saturated with water vapor. Using the partial pressure of the hydrogen gas, the volume of gas collected, and the temperature, you can determine the number of moles of hydrogen in the gas sample. Finally you will be able to calculate the molar volume of a gas at standard temperature and pressure.

Safety: Hydrochloric Acid is corrosive and can damage skin or clothing. Use caution when working with this substance. Hydrogen gas is flammable and can be dangerous. Do not perform this experiment around an open flame.

Equipment:

Beaker (250 or 400 mL)
1 or 2 hole rubber stopper
thermometer
thread
dilute hydrochloric acid
Eudiometer tube (graduated gas measuring tube)
clamp
metric ruler
magnesium metal

Procedure:

1. Obtain a strip of magnesium metal about 4-5 cm long. Record its mass to the nearest 0.001 g.

2. Take a length of thread and tie the string around the folded Mg ribbon. Do not fold the Mg too tightly, as maximum surface area of the Mg exposed to the HCl is desired.

3. Prepare a ring stand with utility clamp to support the eudiometer.

4. Slowly pour about 15 mL of 6M HCl into the eudiometer. Tilt the tube slightly so that the air may escape. Fill the beaker with distilled water that has been allowed to reach room temperature. Pour the water, SLOWLY, down the side of the eudiometer tube so the water and the acid mix as little as possible. Refill the beaker until it is $\frac{3}{4}$ full of water.

5. Slide the Mg ribbon on its string into the eudiometer tube. With the thread held against the side of the tube, insert a 1- or 2-hole stopper. The stopper should force water and all air bubbles out of the tube and should hold the thread or wire suspending the magnesium in place.

6. With your finger over the hole in the stopper, quickly invert the tube and immerse the end of the tube in the beaker of water. Clamp the tube in place so that the bottom of the stopper is slightly above the bottom of the beaker. The reaction will start as soon as the HCl has mixed with the water and is able to come into contact with the magnesium metal. The reaction is indicated by the production of H_2 gas bubbles. It is possible during the course of the reaction that the magnesium may become dislodged from the thread and float to the top. As long as the metal is floating on the surface and does not become attached to the side of the eudiometer tube above the surface of the liquid, no harm is done.

Gently agitate the eudiometer to keep the concentration of HCl high near the magnesium metal.

7. When the magnesium has reacted completely and the evolution of gas has stopped, tap the tube gently with your finger to dislodge any bubbles you see attached to the side of the tube.

8. Record the barometric pressure for this moment. You instructor should write it on the board for you. Also, measure and record the temperature in the room for this moment.

9. The gas produced in the reaction is not at barometric pressure since the level of the liquid in the eudiometer and that in the beaker are not equal. The levels need to be equalized. You can do this by transferring the eudiometer to one of the tall water-filled cylinders in the laboratory. Make sure you place you finger over the end of the eudiometer before transferring it (there is a hole in the stopper, right?). Lower the tube into one of the cylinders (stopper below the water level). Remove your finger from the stopper and raise or lower the eudiometer until the level of water inside is equal to the level of water outside the tube. Read the volume from the scale on the tube as accurately as possible, to the nearest 0.1 mL. Record the volume of the gas in the eudiometer in your data table. (Did you estimate a digit?)

Data and Calculations:

Data:

Mass of Mg ribbon.
Volume of H_2 gas collected.
Temperature of gas collected.
Atmospheric pressure.
Vapor pressure of H_2O at the above temp (Appen. D, CRC Manual, reputable source) .
Balanced equation for the above reaction.

Calculations:

1. Calculate the pressure of the *dry* H_2 gas. $P_{total} = P_{H2(g)} + P_{H2O(g)}$
2. Calculate the volume of hydrogen gas corrected to STP.
3. From your balanced equation and mass measurement, calculate the moles (n) of H_2 gas produced.
4. From your calculations, a fractional part of a mole of Mg gave an experimentally determined volume of hydrogen gas as STP. Calculate the ratio of your volume of H_2 gas at STP (in liters) to the moles of Mg used.
5. What is the volume occupied by one mole of any gas at STP?
6. Calculate your experimentally determined molar volume of gas at STP.
7. Calculate the % error of your experiment. Discuss the sources of error in your error analysis. The accepted value is 22.41 L of H_2 gas/mole (@ STP).