Molar Volume of a Gas:

Background: When magnesium metal reacts with hydrochloric acid, hydrogen gas is produced. The volume of this gas can be measure by using an eudiometer. By determining the number of moles of magnesium used and the volume of hydrogen produced, the volume of hydrogen per mole of magnesium can e calculated. The balanced equation for the reaction allows you to predict the theoretical number of moles of hydrogen per mole of magnesium. From these two calculations the volume of one mole of hydrogen can be calculated.

Objective: To determine the volume of one mole of hydrogen gas at STP and to be able to identify several sources of error in the experiment.

**Pre-Lab Assignment: YOU MUST COMPLETE THIS BEFORE DOING THE LAB!!!**

1. Write the balanced equation for the reaction between magnesium and hydrochloric acid.
2. Calculate the mass of magnesium needed to produce 90 ml of hydrogen gas @ STP conditions.
3. Copy down the table of aqueous vapor pressures.

Materials:

- large plastic pitcher, battery jar, or large beaker

- one small piece of magnesium (about 3-5 cm) - rolled into a loose ball

- 1 thermometer

- piece of copper wire (serves as hook to hold ball of magnesium)

- barometer (mounted on the cabinet by the East door in the room)

Safety: Wear safety goggles and aprons. Avoid contact with the hydrochloric acid. If any of the concentrated acid is spilled, neutralize it with sodium bicarbonate. Handle the reagent bottles using proper lab safety techniques. (Change the water in your container after each experiment!!!!)

Procedures:

1. Fill a battery jar, pitcher or large container with water. (2000 ml beaker or pitcher)
2. Determine to the nearest 0.01 cm the length of the ribbon and record in the data table.
3. Record in your data table the mass per meter of the magnesium ribbon as supplied by your instructor.
4. Create a coil or ball of magnesium ribbon 3 to 5 cm long.

6. Pour 20 ml of 3.0 M hydrochloric acid into the eudiometer.

# CAUTION: Hydrochloric acid is caustic and corrosive. Avoid contact with eyes and skin. Avoid breathing the vapors. Make certain that you are wearing goggles and an apron. If any acid should splash on you, immediately flush the area with water and report the incident to your teacher. If you spill any on the counter neutralize with baking soda before cleaning up.

# 7. Fill the eudiometer completely to the top with DI water.

# 8. Anchor the coil of magnesium ribbon in the end of the eudiometer loosely on the bottom of your container using the copper hook.

# 9. Cover the end of the eudiometer with your thumb and invert the tube into the battery jar of water, being careful to not allow any air into the tube, resting the eudiometer loosely on the bottom of your container.

# 10. Observe the hydrochloric acid in the tube and the ensuing reaction. Describe in your observations.

11. When the reaction has finished, allow the system to stabilize for about 5 min.

12. Adjust the level of the liquid in the eudiometer to the level of the water in the battery jar. Add more water to the jar if necessary. If the levels cannot be equalized in the battery jar you are using, move to a larger jar by putting your finger over the mouth of the eudiometer moving it from one jar to the other. This makes the pressure in the tube the same as the atmospheric pressure.

13. Determine the barometric pressure of the water using the table of aqueous vapor pressure of water for your water temperature.

**Incomplete Sample Data And Calculations Tables :**

DATA

Length of magnesium used --------------------------cm

Volume of hydrogen at lab conditions --------------------------ml

Temperature of the hydrogen --------------------------C Degrees

CALCULATIONS

Moles of Mg consumed moles

Volume of H2 per mole of Mg ml/mol

Balanced Equations

Volume of 1.00 mole H2 at STP ml/mol

Error

\*\*Record the results of all calculations IN your calculations table –make it big enough; all the actual calculations should be beneath this table, properly labeled

CALCULATIONS:

1. Calculate the mass of the magnesium ribbon you used.
2. Calculate the number of moles of magnesium you used.
3. Since the hydrogen is collected over water two gasses are actually present: hydrogen and water vapor.

Calculate the partial pressure of the dry hydrogen subtract water vapor pressure from atmospheric pressure

4. Calculate the volume the dry hydrogen would have at STP by using the combined gas law. The combined gas law will adjust your experimental volume to the volume it would be at STP (Experimental volume at STP)

5. Calculate the volume of hydrogen at STP per mole of magnesium used (Theoretical volume at STP)

6. Write the balanced equation for the reaction.

7. Using info from 4 and 5, what is your experimental error adjusted to STP?

8. Using the ideal gas law calculate the theoretical volume at lab conditions

## My Notes

Each time the lab is done, the “g/cm” of magnesium needs to be calculated; the magnesium ribbon varies in thickness so that the amount needed each year needs to be checked.

**Calculations**

1. Mass of Mg 🡪 (your length here) ~~cm~~ x 0.0134g = gMg

1 1 ~~cm~~

2. Moles of Mg 🡪 (your) g x 1 mol Mg = moles Mg

1 g Mg

(Hint: Look at Periodic table)

3. Atm pressure = PH2 + PH2O , Atm Pressure – PH2O = PH2

(PH2O dependent upon temperature)

4. Combined Gas Law See Sect. 11-7 pg 301-303

p1 x v1 = p2 x v2 v2 is what you are solving for

t1 t2 p2 and t2 are at STP

p2 = 760 mm Hg ; t2 = 273 K

use your experimental values

p1 = what was determined in #3

v1 = the volume of gas observed (remember gases fill their container)

t1 = the temperature of the water

This adjusts your experimental volume to a volume at STP 🡪 Experimental Volume

5. (answer from #2) moles of Mg x 1 mol H2 x 22.4L H2 = Theoretical Volume

1 1 mol Mg 1 mol H2

6. Chemical equation: Mg + 2HCl 🡪 MgCl2 + H2

7. Error (see pg. 52-53)

(Theoretical volume - Experimental volume) x 100 = % Error

Theoretical volume

8. Ideal Gas Law 🡪 pv = nRt

p, n and t are experimental values; in other words, what was observed in the lab

\*R = 62.4 (mmHg)(L)/(mol)(K)

\*This is used in place of (8.31 kpa L/mol K); this way mmHg does not have to be converted to kpa