Lab-- Honors [20 pts]
Mg + HCl : *PV= nRT*

Name_____
Lab Partner_____
Period_____ ***Date*** _____

Purpose: The purpose of this lab is to experimentally determine the ideal gas law constant, R. This will be accomplished by producing hydrogen gas by reacting magnesium metal with excess hydrochloric acid as shown in this balanced equation: **Mg (s) + 2 HCl (aq) ------> $MgCl_2$ (aq) + H_2 (g)**
The P, V, n, and T values for the hydrogen gas produced will all be experimentally measured. R will be determined using the equation, PV = nRT.

Procedure: **GOGGLES MUST ALWAYS BE WORN IN LAB AREA!!!!**

1) Mass out a strip of magnesium metal using a balance which has 0.001 cm precision. **Record mass.** *(Note: The magnesium strip must not have a mass greater than 0.046 g)*
2) Loosely wrap the magnesium into a ball. Form a copper metal "cage" around the magnesium with a piece of copper wire. Then, bend the copper wire at the other end to form a small hook.
3) Fill a 400 mL beaker with DI water. (Fill water to ~350 mL.)
4) Carefully pour about 15 ml of 3M HCl(aq) into a eudiometer (the long glass tube). Hold it BELOW eye level when pouring.
5) Hold the eudiometer at an angle and slowly pour DI water into the tilted tube (try not to disturb the acid layer more than necessary.) Fill the eudiometer to the brim with water.
6) Place the Mg/Cu cage into the mouth of the eudiometer--hook the copper cage so it is hanging in the inside of the eudiometer.
7) Insert a one-holed stopper. Fill the hole in the stopper with some water. Cover the hole in the stopper with your finger. Then, invert the eudiometer and slip the mouth of the eudiometer below the surface of the water in the beaker. Remove your finger. Secure the eudiometer with the clamps.
8) While you are waiting for this *mesmerizing* reaction to come to completion, use a thermometer to **measure the temperature of the water** and ask your teacher for today's **atmospheric pressure**.
9) When the magnesium has completely reacted, place your finger over the hole in the stopper and transfer the eudiometer into a large (250 mL to 1000 mL) graduated cylinder that has been filled with to the brim water and located in a sink or a basin to catch the overflow. Move the eudiometer down until the water level in the eudiometer is equal to the water level in the graduated cylinder. n the data chart below, **record the volume of the gas in the eudiometer.**
10) Now, see what happens to the volume of gas when you raise and lower the eudiometer.
    a) Raise the eudiometer so that the water level in the eudiometer is above the water level in the cylinder. The volume of gas is now **(greater, less)** than when water levels were equal.
    b) Lower the eudiometer so that the water level in the eudiometer is below the water level in the cylinder. The volume of gas is now **(greater, less)** than when water levels were equal.
11) **Clean up**. Rinse out your eudiometer with a few batches of water. Throw away your copper cage.

Data: *Record all data as precisely as possible*.

Mass of Mg (s) _____g Atmospheric Pressure= _____ mm Hg

Temperature of water (We are assuming this is temp of H_2 gas) = _____ °C = _____ K

Volume of gas = _____ mL = _____ L *(Volume of gas when water levels are equal.)*

Reference Table: ***Vapor pressure of water at various temperatures***

Temperature °C	*Vapor Pressure (mm Hg)*	*Temperature °C*	*Vapor Pressure (mm Hg)*
16	***13.6***	***21***	***18.6***
17	***14.5***	***22***	***19.8***
18	***15.5***	***23***	***21.0***
19	***16.5***	***24***	***22.4***
20	***17.5***	***25***	***23.7***

Calculations: ***Do the rest of the lab on a separate sheet of paper****. You MUST show all calculation steps clearly. All numbers must have units. KEEP three significant figures throughout all your calculations.*

The goal of this lab is to determine the value of the constant R by experimentally determining the values of P, V, moles and T for a sample of H_2 gas. These steps will lead you to this goal.

1) [2 pt] Determine the moles of H_2 gas that theoretically should have been produced. (Magnesium is the limiting reactant, HCl is excess reactant.) *Show a factor label calculation. Label units and substances. Please keep 3 significant figures in your answer even though you should officially only keep 2 sig figs.*

2) [1 pt] What did you do in this experiment to make the pressure of the gas in the eudiometer equal to the atmospheric pressure?

3) [1 pt] Since you collected the hydrogen gas *over water*, there is actually a mix of hydrogen gas and water vapor inside the eudiometer. Use Dalton's law to solve for the pressure of just the H_2 gas in the tube.

4) [3 pts] You can now solve for your experimental value for R because you have experimental values of P, V, n, and T for the sample of H_2 gas. To solve for R, rearrange PV=nRT using variables only and then plug in your numbers and solve. Make sure you are using the correct units in your calculation. Make sure that every number is written with units, including your final R value. (Again—keep 3 sig figs in your answer.)

5) [1 pt] The accepted value of R is $0.0821 \frac{L \cdot atm}{mol \cdot K}$. Compute your **percent error.** (Do not compute % yield!)

6) [1 pt] Was your R value higher or lower than the accepted value?

Post Lab Questions: Answer all questions in complete sentences on a separate sheet of paper.

7) [1 pt] Why was it important for the stopper to have a hole in it?

8) [2 pts] In this lab, it was important to make sure that the eudiometer was completely filled with water before inverting it. If the eudiometer wasn't completely filled with water, how would this have affected the **volume** of gas measured-- too high or too low? Explain reasoning. Would your R value be too high or too low? *(Hint- is there a direct or inverse relationship between V and R?)*

9) [2 pts] Mg can react with oxygen in the air to form a layer of MgO. This MgO does not react with HCl to form hydrogen gas. Thus, before massing out the magnesium metal, it was important to use steel wool to remove any MgO solid that could be on the magnesium metal. If some MgO solid remained, how would this affect the **volume** of gas measured? Explain reasoning. Would your R value be too high or too low?

10) [3 pts] In this lab, it was assumed that the temperature of the water was equivalent to the temperature of the hydrogen gas. However, since the tube is surrounded by air, the temperature of the hydrogen gas might be more similar to the warmer temperature of the air than to the colder temperature of the water. If this were true, the temperature value you used in your calculations would have been too low. Thus, would your calculated R value have been too high or too low? Explain reasoning. *(Be aware, your temp value was used twice in your calculations. The temperature value was used in PV=nRT and it was used when determining the vapor pressure of water. You must explain how a low temperature value effects R for each of these situations.)*

11) [3 pts] In this lab, it was difficult to read the volume of the gas when one made the water levels exactly equal. Thus, suppose one had this difficulty and ended up measuring the volume of gas when the water level in the eudiometer was slightly higher than the water level in the graduated cylinder.
    a) With this error being made, the measured volume of gas would have been slightly higher than it should have been. *(Check to make sure this is what you noticed in procedure step #10b).* Thus, would your R value have been higher or lower than it should have been? *(Hint—direct or inverse relationship?)*
    b) Since the volume of gas would have been higher than it should have been, would the pressure in the eudiometer be higher or lower than it should have been? *(Hint- direct or inverse relationship?)*
    c) Since the pressure in the eudiometer should have been equal to the atmospheric pressure, would the pressure in the eudiometer have been higher or lower than the pressure of the atmosphere? Explain why this is the case by discussing which pressure is "holding up" the column of water in the eudiometer.