Data Table

|  |  |
| --- | --- |
| Temperature |  |
| Barometric pressure |  |
| Length of Mg Ribbon |  |
| Mass of 1 meter Mg ribbon | 1.59g |
| Volume of Gas Collected |  |

**Ideal Gas Law: Molar Volume of Hydrogen Gas**

**Lab Question:** How are the variables that describe a gas related?

**Background Information:**

Both solids and gases must often be handled in the same experiment. The amount of solid used or produced can be determined by measuring the mass of the material on a balance. It. Is difficult, however, to find the mass of a gas. For convenience the chemist measures gas volume and used this value to calculate the mass of the gas. Therefore, it is necessary for the chemist to know the quantitative relationship between the molar mass and the molar volume of a gas. **Avogadro’s law** explains the relationship between the molar volume, the molecular mass, and the actual mass of a sample gas. This law states that *equal volumes of gases under the same temperature and pressure contain equal numbers of molecules.* Also, the volume occupied by one mole of any gas at STP equals 22.4 L.

In this experiment you will investigate the chemical significance of Avogadro’s law. You will determine the volume of hydrogen gas evolved in a reaction between magnesium metal and hydrochloric acid, and from your results determine the mass of H2 produced. Your experimental results will then be compared to the results predicted by Avogadro’s law. You will need to convert room temperature and pressure to standard conditions (STP) in order to compare your results.

**Safety:**

* Goggles, gloves and aprons are required.
* Hydrogen is explosive! No open flames.
* Hydrochloric acid is corrosive. Notify your teacher at once of any spills.
* Spilt water on the floor will make it slippery. Notify your teacher at once of any water on the floor.

**Procedure:**

* 1. Fill your pneumatic trough with tap water – leave about 1 inch at the top.
* 2. Record the temperature of the water in the pneumatic trough (in °C).
* 3. Record the barometric pressure of the room (in cm Hg).
* 4. Record the length of your piece of magnesium ribbon (in mm).
* 5. Fold the magnesium so that it will fit into the gas collecting tube. Tie your piece of thread to your magnesium. Set aside for now.
* 6. Clamp your gas collecting tube to a ring stand.
* 7. Slowly pour ~10 mL of HCl into your gas collecting tube.
* 8. Incline (tilt) the tube slightly so that air may escape and S-L-O-W-L-Y fill it with tap water from a beaker. Pour the water slowly down the side of the tube so the water and acid mix as little as possible. Fill the tube completely.
* 9. With the tube completely full of water, insert the magnesium ribbon about 3 or 4 cm into the tube. With the thread against the side of the tube, insert a 1-hole stopper. The stopper should force water and all air bubbles out of the tube and should hold the thread suspending the magnesium in place.
* 10. Remove the tube from the clamp. With your finger over the hole in the stopper (make sure there is no air in the hole of the stopper), invert stoppered end of the tube in the pneumatic trough. Re-clamp the tube in place so that the bottom of the rubber stopper is slightly above the bottom of the rubber stopper is slightly above the bottom of the pneumatic trough. The reaction will not start immediately because it takes time for the acid to diffuse down through the column of water to the metal.
* 11. When the magnesium has reacted completely and evolution of gas has stopped, tap the tube with your finger to dislodge any bubbles you see attached to the side of the tube.
* 12. Place your finger over the hole in the stopper and remove the tube from the pneumatic trough. Lower the tube into a larger container of water (Provided by your teacher) and remove your finger. Raise or lower the tube until the level of the water inside the tube is the same as the level of water outside the tube. This equalizes the pressure. Read the scale on the tube as accurately as possible. This reading will give the volume of the gases (hydrogen and water vapor) in the tube. Record the volume.

**Calculations:**

1. **Temperature (T)**

Convert temperature (in °C) to kelvins.

2. **Barometric Pressure (Patm)**

Convert pressure (in cm Hg) to mm Hg.

3. **Vapor pressure of water (PH2O)**

Look up the vapor pressure of water at this temperature (in mm Hg).

4. **Corrected Pressure of Dry Hydrogen Gas (Phydrogen)**

Since you collected the hydrogen over water, there are two gases in the graduated cylinder: water vapor and hydrogen. Use Dalton’s Law of Partial Pressures to calculate the partial pressure of hydrogen.

**Phydrogen  = Patm  - PH2O**

5. **Volume of Hydrogen Gas (V)**

Convert volume of gas collected (in mL) to L.

6. **Volume of the Hydrogen Gas That Would Be Occupied At STP.**

Use the combined gas law to calculate the volume that would be occupied by the gas at STP (273 K & 1 atm). Use the volume of the hydrogen gas (from your experiment) at the corrected pressure (answer #4) and room temperature.

P1V1 = PSTPVSTP

T1 TSTP

6. **Mass of Magnesium**

Calculate the mass of magnesium by using the known mass per meter of ribbon.

7. **Moles of Magnesium**

Calculate the number of moles of magnesium by using the mass of magnesium and the molar mass of magnesium.

8. **Volume per Mole of Hydrogen: Molar Volume of Hydrogen at STP**

Calculate the molar volume of butane at STP by dividing the volume of the of the hydrogen gas that would be occupied at STP by the number of moles of magnesium.

**Extra Credit:** Percentage Error

Calculate your % error in determining the molar volume of hydrogen gas at STP. Use your experimental value and the standard molar volume of a gas as the accepted value.

% error = accepted value - experimental value x 100

accepted value