Molar Volume of Hydrogen Gas

**Abstract:** Using hydrochloric acid and magnesium the volume of hydrogen was found, calculations were performed and showed that error occurred. The percent error was positive which implies the reaction wasn’t complete when the data was taken. There were many important factors in the experiment that could have impacted the results such as STP, an accurate measurement of a very small piece of magnesium, and air bubbles under the shrink wrap.

**Introduction:** To measure the mass and volume of a gas is difficult because the gas like hydrogen will fill the container it is placed in to the volume will change along with the mass. To measure an accurately the gas has to be a STP (Standard Temperature and Pressure). Thanks to Avogadro’s number of $6.02 \times 10^{23}$ particles in one mole and that there are 22.4 liters in one mole for a gas at STP we are able to determine the volume and other important items.

In this experiment the fact that there is 22.4 liters in one mole was confirmed. And a value for the molar volume of hydrogen was found for this experiment. All of these experiments were done at a temperature near 0°C.

**Purpose:** The purpose of this experiment is to determine the molar volume of hydrogen gas by using hydrochloric acid and magnesium to produce hydrogen.

**Procedure:** First the plastic basin was filled one-third full of ice then 5-10 cm of tap water was added and the temperate using a Celsius thermometer was tested and the atmospheric pressure was measured using a barometer. Next, about 1.0 cm long strip of magnesium was cut and measured to the nearest 0.02 cm and recorded. With a micropipet about 3mL of 3.0 MHCl was placed into a 10 mL graduated cylinder. After the micropipet was rinsed out it was used to fill the rest of the graduated cylinder with tap water dripping down the inside surface. Then the magnesium was placed on the water in the cylinder and the cylinder was quickly covered with plastic wrap and secured with a rubber band. Next a very small hole was put on the plastic over the cylinder using a pin then it was placed upside down in the basin of ice water. After the reaction was complete with the reaction of the magnesium and acid producing hydrogen the gas was chilled by placing it completely under ice water for about one minute. Lastly, the volume of
hydrogen gas was found by lifting the cylinder vertically until the liquid inside the cylinder is equal the water in the basin. Then the volume was recorded

**Results:** The strip of magnesium was thin with a silver color. The hydrochloric acid was clear, but when the reaction was happening the solution turned white and was bubbling.

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
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</thead>
<tbody>
<tr>
<td>length of Mg strip (cm)</td>
<td>1.01 cm</td>
<td>.99 cm</td>
</tr>
<tr>
<td>volume of hydrogen collected (mL)</td>
<td>8.7 mL</td>
<td>7.4 mL</td>
</tr>
<tr>
<td>temperature of water in basin (°C)</td>
<td>0 ºC</td>
<td>0 ºC</td>
</tr>
<tr>
<td>atmospheric pressure (mm Hg)</td>
<td>768.2 mm Hg</td>
<td>768.2 mm Hg</td>
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**Calculations**

**Trial 1**

\[
0.00734 \text{ g/cm Mg} \times 1.01 \text{ cm} = 0.00741 \text{ g Mg}
\]

\[
\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2
\]

\[
0.00741 \text{ g Mg} \times \frac{1 \text{ mol Mg}}{24.31 \text{ g Mg}} = 3.0481 \times 10^{-4} \text{ mol Mg}
\]

\[
= 3.0481 \times 10^{-4} \text{ mol H}_2
\]

\[
8.7 \text{ mL} = 0.0087L \times \frac{768.2 \text{ mm Hg}}{760 \text{ mm Hg}} = 0.0088L \text{ H}_2
\]

\[
\frac{0.0088L \text{ H}_2}{3.0481 \times 10^{-4} \text{ mol H}_2} = 28.9L \text{ H}_2
\]

\[
\frac{28.9 - 22.4}{22.4} \times 100 = 29\% \text{ Percent Error}
\]

**Trial 2**
\[ \frac{.00734 \ g/cm \ Mg \times .99 \ cm}{24.31 \ g \ Mg} = \frac{1 \ mol \ Mg}{24.31 \ g \ Mg} = 2.98 \times 10^{-4} \ mol \ Mg \]

\[ = 2.98 \times 10^{-4} \ mol \ H_2 \]

\[ 7.4 \ mL = .0074L \ \frac{768.2 \ mm \ Hg}{760 \ mm \ Hg} = .0075L \ H_2 \]

\[ \frac{.0075L \ H_2}{2.98 \times 10^{-4} \ mol \ H_2} = 25.17L \ H_2 \]

\[ \frac{25.17 - 22.4}{22.4} \times 100 = 12.36\% \ Percent \ Error \]

Using the atmospheric pressure of 768.2 mm Hg, length of the magnesium strip, and volume of hydrogen collected calculations were performed. With the results obtained the average percent error was 20.68%.

**Conclusion:** The purpose of this experiment was to determine the molar volume of hydrogen gas. The average volume collected was 8.05 mL with 8.7 mL in the first trial and 7.4 mL in the second trial. The purpose was accomplished because the volume of hydrogen was found. The purpose was accomplished to a high degree because the percent error was fairly low. The results were not expected obtain no percent error because of the great chance of error and even the smallest changes would affect the outcome. Therefore, the results were expected to contain an imperfect outcome. The results were neither precise nor accurate due to the 1.3 mL difference of hydrogen collected and the great percent error. Redesigning this experiment to reduce the percent error by being in a controlled environment where STP is constant. A single replacement reaction occurred in this experiment. The graduated cylinder was inserted into the ice water so the magnesium strip would be in contact with the liquid so the reaction could take place and the water in the cylinder could escape to leave only hydrogen.

**Discussion:** Possible error that could have occurred consists of an inaccurate measurement of the magnesium strip because it was so small an inaccurate reading may have taken place. The temperature may have rose and been higher than 0°C and there could have been an air bubble under the shrink wrap. Error that did occur consists of the reaction not being complete when the data was taken. This is the reason for the percent error being positive. This lowers my confidence in my results because the temperature rising and not being at 0°C is not STP and that is
something required for an accurate reading and experiment. The results are invalid because the ideal amount of hydrogen that should have been obtained is 22.4 liters. If the gas temperature was higher than 0°C then that would cause a higher volume of gas to be produced. If evaporations of the water vapor took place and was collected into the hydrogen then the volume would be higher because more hydrogen would be added. Using a longer strip of magnesium would cause more gas to produce which means a longer reaction would occur. The minimum information you need to compare suppliers to propane gas is how much pressure the gas is put under.

With the error that occurred in this experiment and other possible error the results were highly suspect. With calculations preformed the percent error was high because 22.4 liters of hydrogen should have been obtained. This experiment is very relevant to all of chemistry because it proves or shows how the mole for a gas (22.4 L) was obtained.