Chemistry

Scarsdale High School

Reaction of Magnesium with Hydrochloric Acid

Objective:
Determine the value of the gas constant, R, from experimental data collected in this lab.

Task:
Perform the attached lab.

Materials:
1. See lab procedure

Lab Report:
PRESENTATION COUNTS
1. Abstract
2. Introduction
3. Experimental/Procedure
4. Results and Observations
5. Conclusion
6. References

Due Date: See Schedule

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Reaction of Magnesium with Hydrochloric Acid

Introduction

In this experiment, you will measure the volume of hydrogen gas produced at room temperature and pressure from the reaction of magnesium of known mass with excess HCl. The $H_{2\ (g)}$ will be collected by displacement of the solution from an inverted gas-measuring tube (eudiometer tube), which is calibrated to read volume. From the stoichiometry of the reaction between Mg and HCl, you will determine the moles of hydrogen that will be formed. From the eudiometer tube you will determine the volume of hydrogen produced. You will be given the barometric pressure and room temperature (which is the same temperature as the collected gas). With the values for n, V, P, and T, you will calculate the value of the gas constant.

Example calculation

Sodium (Na) metal reacts with a solution of hydrochloric acid (HCl) to produce hydrogen (H_2) gas and aqueous sodium chloride. In an experiment, 0.157 gram of Na reacts with excess HCl to produce 83.5 mL of H_2 gas, which is collected over water at 101.3 kPa and 25º C.

1. Using the table enclosed with this handout, calculate the partial pressure of the hydrogen by accounting for the vapor pressure of water.

   $P_{H2} = P_{total} - P_{H2O}$

2. Write the balanced chemical equation for the reaction between sodium and hydrochloric acid to form sodium chloride and hydrogen gas. Use this equation to determine the moles of hydrogen produced.

3. From the moles, volume, temperature and pressure of hydrogen gas, calculate the value of the gas constant, R, using the ideal gas law.

4. Compare the calculated value of R with the accepted value
   a. R = 8.31 L*kPa / K*mol
   b. R = 0.0821 L*atm / K*mol

Procedure

1. Obtain a piece of Mg ribbon and determine its mass on the digital scale

2. Obtain a piece of fine copper wire that is about 30 cm in length. Fold the magnesium ribbon and enclose it in a cage made from the copper wire. (see figure 1)

3. Set up a ring stand and utility clamp in position to hold a 50 mL gas measuring tube (eudiometer tube). Fill a 400 mL beaker about two-thirds full of tap water. (see figure 2)

4. Incline the eudiometer tube slightly and pour in about 10 mL of 6M HCl. Slowly fill the tube with tap water from the beaker. Avoid stirring up the acid layer in the bottom of the tube. Dislodge any bubbles clinging to the side by gently tapping the tube.

5. Insert the rubber stopper with copper cage hanging down into the filled eudiometer tube. A little bit of water will be displaced. (see figure 1)

6. With your finger on the hole in the stopper, invert the eudiometer tube into the 400 mL beaker of water (see figure 2). Hold the tube in place with either a clamp. After the reaction stops, wait a few minutes to allow the tube to come to room temperature. Dislodge any bubbles clinging to the side of the tube.

7. With your finger on the hole in the stopper, transfer the tube to a large graduated cylinder which is almost filled with water at room temperature (see figure 3). Move the eudiometer tube up and down until the level of the liquid in the eudiometer tube is identical to that in the graduated cylinder. Under this condition, the pressure of the gases in the tube is equal to room pressure. Read the gas volume to the nearest 0.1 mL.

8. Pour the acid solution from the tube down the sink. Rinse the tube with tap water. Record the water temperature in the graduated cylinder, the room temperature and the room pressure.

9. Repeat the experiment 2 more times

Vapor Pressure of Water at
Various Temperatures

Temperature (ºC)	Pressure (kPa)	Temperature (ºC)	Pressure (kPa)
15	2.00	23	3.07
16	2.13	24	3.20
17	2.27	25	3.33
18	2.40	26	3.47
19	2.53	27	3.60
20	2.67	28	3.73
21	2.80	29	3.87
22	2.93	30	4.00

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Calculations

1. Write the balanced equation for the reaction between magnesium and hydrochloric acid to produce hydrogen gas and magnesium chloride.

2. For each trial record or calculate the following:

Parameter	Trial 1	Trial 2	Trial 3
Moles of H_2 (mol)			
Atmospheric Pressure (kPa)			
Partial Pressure of H_2O (kPa)			
Partial Pressure of H_2 (kPa)			
Room Temperature (K)			
Volume (L)			
Calculated Gas Constant (L*kPa / K*mol)			
Percent Error (%)			

3. Compare your calculated value of R with the given value and calculate the % error

4. Compare your average values of R with the given value and calculate the % error

5. Explain what would happen if the following problems occurred during the experiment

   a. Some of the Mg slipped out of the copper cage and floated to the top of the liquid and remained unreacted. How will this effect the calculation of R? Explain.

   b. The volume of the gas in the eudiometer tube was read when the water level in the eudiometer tube was still several inches above the water level in the graduated cylinder. How would this error affect the calculation of R? Explain.

FIG. 1

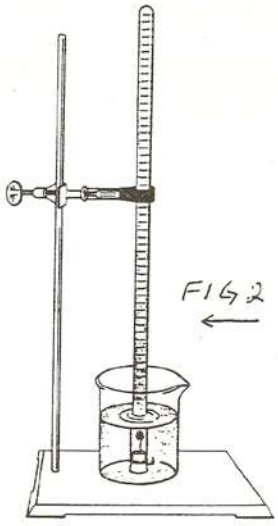

FIG 2

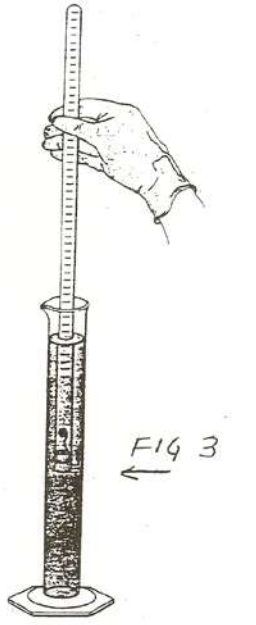

FIG 3

When the water level in the gas-collection tube is the same as that in the cylinder, the pressure of the gas in the tube is equal to the pressure of the atmosphere