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Determining the Gas Constant “R”

PRE-LAB DISCUSSION

The basis of this experiment is the following reaction in which you will react a known mass of Magnesium with excess hydrochloric acid to produce the substances shown:

$Mg + 2\,HCl \rightarrow MgCl_2 + H_2$

The hydrogen gas is the product that is of interest to you in this experiment. You will make an experimental determination of the number of moles of hydrogen molecules produced and the volume occupied by these molecules. The number of moles of hydrogen will be determined indirectly. The balanced equation for this reaction shows that the molar ratio of magnesium reacted to hydrogen gas produced is 1:1. Therefore, by determining the mass of magnesium that reacts and the number of moles that this mass is equal to, you will also determine the number of moles of hydrogen gas produced. The volume of hydrogen gas produced will be measured directly on the scale of a gas-measuring tube. The gas laws of Boyle and Charles will be used to correct this volume, measured under laboratory conditions, to the volume the sample of gas would occupy at STP. The collected data (number of moles and volume at STP) will be used to calculate the molar volume of the hydrogen gas. This experiment should aid in the understanding of the mole concept and the concept of molar volume of a gas.

PURPOSE

Determine the volume of 1 mole of hydrogen gas at STP using experimental data, known mathematical relationships, and a balanced chemical equation.

EQUIPMENT

gas-measuring tube and stopper, beaker 400-mL, ring stand, graduated cylinder, utility clamp, metric ruler, thermometer, and safety glasses.

CHEMICALS: magnesium ribbon (Mg); 3 M hydrochloric acid (HCl) CAUSTIC !

PROCEDURE

1. Obtain 2.3 – 2.6cm a piece of magnesium ribbon from your teacher. Measure the length in millimeters. Record the length in your data table.
2. Obtain a 50.00mL gas collection tube. Remove the rubber stopper with copper metal loop from the tube. Wrap the piece of magnesium around the copper loop so that it will fit easily into the gas-measuring tube.3. Add about 300 mL of water to a 400-mL beaker. Set up a ring stand and utility clamp, and place the beaker of water in the position shown in Fig. 29-2
4. Obtain 10 mL of 3 M hydrochloric acid (HCI). (CAUTION: Handle this acid with care.) Carefully pour the HCI into a gas-measuring tube. Don't spill. 5. Tilt the gas-measuring tube slightly. Using a beaker, SLOWLY fill the gas- measuring tube with water. Try to avoid mixing the acid and water as much as possible.
6. Insert the one-hole rubber stopper firmly into the tube as shown in Figure 29-1.
7. Place your finger over the hole in the rubber stopper and invert the gas- measuring tube. Lower the stoppered end of the tube into the beaker of water. Clamp the tube in place so that the stoppered end rests on the bottom of the beaker (Figure 29-2).
8. Let the apparatus stand about five minutes after the magnesium has completely reacted. Carefully measure the volume of gas produced to the tenth of a milliliters.

9. Place a thermometer in the 400ml beaker for 5 minutes and measure the water temperature.

OBSERVATIONS AND DATA TABLE

(a) length of Mg ribbon________ mm (b) mass of 1000 mm of Mg = (c) volume of H2 gas in tube ______ ml (d) water temperature ________ [illegible] C (e) barometric pressure ______________ (from your instructor)

f. water vapor pressure at room temperature __________ (see table in book)

Lab for Finding Gas Constant R

Title Purpose List equipment needed Step by step procedure Data table Calculations

1. Determine the moles of Mg used.
2. Show reaction and then determine the moles of H2 in the gas collecting tube.
3. Determine the volume of gas in the gas collecting tube.
4. Determine the Kelvin temperature of the gas in the tube.
5. Determine the pressure of H2 in the gas collecting tube.(NOTE – you will need to know the partial pressure of H2O(g) at the temperature in #4)
6. Determine the ideal gas constant R 7. Find you personal % error 8. Plot a graph to find the class average value of R. 9. Calculate the class average % error.

Discussion of results paragraph Conclusion paragraph

Calculation Section PUT UNITS EVERYWHERE

1. Finding mass of Mg reacted in Mg

24.5mm Mg (1.414/1000.mm)=.0346g Mg

2. Find moles of H_2 formed

$Mg(s)+HCl(aq) \rightarrow MgCl_2+H_2$

.0346g Mg(1 mol Mg/24.305g)(1 mol H_2/ 1 mol Mg)=.00142 mol H_2

3. Finding Vapor Pressure of water at 23.1°C.
From http://intro.chem.okstate.edu/1515sp01/database/vpwater.html
P_{H_2O} @ 23.0°C = 21.1 mm Hg
P_{H_2O} @ 24.0°C = 22.4 mm Hg
Assume the increase from 23.0°C--> 24.0°C is constant, increase per 1/10°C is:
For temp increase of 1°C pressure increased by 1.3mm Hg.
P_{H_2O} @ 23.1°C =21.2 mm Hg.
4. Finding Partial pressure of H_2
P_{H_2O} = P_{Total}-P_{H_2O}
=751.6mm Hg-21.2mm HG
=730.4mm Hg(1.000atm/760.0mmHg)
=.9611atm
5. Temperature of H_2
Temperature=23.1°C + 273.2

$=296.3K$

6. Volume of H_2

Volume= 36.60mL (1L/10^3mL)= .03660L

7. Finding Gas constant “R”

$$R = \frac{PV}{nT}$$

$$= \frac{.9611atm \times .03660L}{.00142mol \times 296.3K}$$

$$= .0836 \frac{atm \times L}{mol \times K}$$

8. Finding % Error

$$\% \text{ Error} = \frac{| acc - ex |}{acc} \times 100\%$$

$$= \frac{.08206 - .0836}{.08206} \times 100\%$$

$$= \frac{.0015}{.08206} \times 100\ \%$$

$=1.9\%$

description	
Mass of Mg(g)	.0346g
Moles of H_2	.00142 mol H_2
Partial pressure H_2O(g) (mm Hg)	21.2 mm Hg
Partial pressure H_2(g) (atm)	.9611 atm
Temperature of H_2(g) (K)	296.3K
Volume of H_2	.03660L
Finding gas constant *R* (atm L) (mole K)	.0836 (atm x L)/(mol x K)
Error %	1.9%

The results should have been .08206 (atm x L)/(mol x K). The result was .0836 (atm x L)/(mol x K) and was lower than expected. Trapped air bubbles could have caused a change in the end result. This is because trapped air bubbles in the water would be measured as less gas in the gas collecting tube, therefore having a lower answer. The meniscus was lower than the water level, therefore having a higher volume which made the final answer higher than it should have been. The Magnesium was cut at a 90° angle, so there was not an angled end. The Magnesium could have floated to the top and didn't all react, making there be less gas in the gas collecting tube.

Conclusion

The basis of this experiment is the following reaction in which a known mass of Magnesium was reacted with excess hydrochloric acid to produce substances. A brief procedure of the lab was to fill a gas collecting tube with 10 mL of hydrochloric acid, and then tying a strip of Magnesium to the bottom. Next, the gas collecting tube was flipped upside down in the water in the graduated cylinder, and the meniscus was put at the exact line of the water in the graduated cylinder, the measurement was recorded. The result should have been .08206 (atm x L)/(mol x K). The result was .0836 (atm x L)/(mol x K), which was lower than expected. The major source of error were the trapped air bubbles that didn't get to the other gas in the gas collecting tube which caused the equation to have a lower answer. The results were supported by the theoretical result.