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Lab Section: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**CHEM 131 Lab Experiment: Evaluation of the Gas Law Constant**

**Background**

The presentation of the ideal gas law **PV = nRT**can be found in your textbook. This law will be used in this experiment to evaluate **R,**the gas law constant. If **R** is to be determined, the other parameters **P, V, n** and **T**in the equation must be available from the experiment, that is, it must be possible to measure them in the laboratory.

The procedure of this experiment is based on the chemical reaction between magnesium metal and hy­drochloric acid to produce hydrogen gas. The volume, pressure, and temperature under which the hydro­gen is collected will be measured. From the known quantity of magnesium used and the stoichiometry of the following reaction the number of moles of hydrogen produced can be calculated.

Mg(s) **+** 2 HCl(aq) **—>** MgCl2 (aq) + H2 (g)

Since the hydrogen is collected in a eudiometer tube over an aqueous solution (see following proce­dure), the gas pressure in the tube after the reaction has ceased is the sum of the hydrogen gas pressure and the vapor pressure of water. In order to obtain the pressure of the hydrogen gas, PH2, the vapor pressure of water, PH2O , at the temperature of the measurement must be subtracted from the atmospheric pressure, Patm***.*** Thus, the pressure of the hydrogen is given by

PH2 = Patm– PH2O

In case the liquid levels (step 3) cannot be equalized after the reaction has ceased, a further correction will be required since the pressure of the gases in the tube (hydrogen and water vapor) will not then be equal to the atmospheric pressure. If this is the case, the difference in levels must be measured with a me­ter stick as accurately as possible. Note that the gradations on the tube are in milliliters, not millimeters. *You must use a meter stick or ruler.* This difference, which represents the desired pressure difference, must be converted to mmHg. This can be accomplished by dividing the measured level difference in millimeters by 13.5 (the ratio of the densities of Hg and the aqueous solution). This difference must then be subtracted from the atmospheric pressure. Thus, if the levels cannot be equalized the pressure of hydrogen must be obtained from the following expression:

PH2 = Patm – PH2O – P level difference

Where *P* level difference = ( difference in height in mm as measured ) / 13.5

Several measurements are readily obtained within a 2- to 3-hour time period. Thus, the precision of this experiment may be readily determined as well as the accuracy since the accepted value of **R**is known. Proper evaluation of the data recorded for this experiment is an important and meaningful part of the ex­periments objectives of verifying the gas law constant and demonstrating a means of measuring it simply in the laboratory.

Vapor Pressure of water at various temperatures

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| T, (0 C) | P, mmHg | T, (0 C) | P, mmHg | T, (0 C) | P, mmHg | T, (0 C) | P, mmHg |
| 13.0 | 11.2 | 19.0 | 16.5 | 25.0 | 23.8 | 31.0 | 33.7 |
| 14.0 | 12.0 | 20.0 | 17.5 | 26.0 | 25.2 | 32.0 | 35.7 |
| 15.0 | 12.8 | 21.0 | 18.7 | 27.0 | 26.7 | 33.0 | 37.7 |
| 16.0 | 13.6 | 22.0 | 19.8 | 28.0 | 28.3 | 34.0 | 39.9 |
| 17.0 | 14.5 | 23.0 | 21.1 | 29.0 | 30.0 | 35.0 | 42.2 |
| 18.0 | 15.5 | 24.0 | 22.4 | 30.0 | 31.8 | 36.0 | 44.6 |

**Procedure**

This experiment will provide P, V, n, and T, thus leaving R to be determined.

Mg (s) + 2 HCl (aq) → MgCl2 (aq) + H2 (g)

Hydrogen is collected in eudiometer tube over an aqueous solution. The gas pressure in the tube after the reaction ceases is the sum of hydrogen gas pressure and the vapor pressure of water.

1. Measure 5 cm of Mg ribbon and then weigh out this Mg ribbon to the nearest mg on the top loading balance.

2. Add 8 ml of concentrated HCl to eudiometer tube. Wash the acid off walls with squirt bottle. Coil Mg ribbon in tube, 5-10 cm from open end (use copper wire wrap to keep in place). Fill tube with water and invert into suitable vessel (600 ml beaker) nearly filled with water. Clamp tube into position.

3. HCl will diffuse down to Mg and react with it. After reaction has ceased, adjust the liquid level in the tube to the liquid level in the vessel (meaning you have to measure the distance in mm between level of liquid in eudiometer and the level of liquid in beaker, **look at the fig!**). Also read the volume of H2 in the eudiometer tube.

4. Record the temperature of the water in the vessel at 1 minute intervals for 3 minutes. Take the average temperature.

5*.* Repeat two more times.

6. Calculate the # moles of Mg (n = Mass of Mg in g **/** 24.3 g/mol).

7. Calculate the corrected pressure using observed barometric pressure for the day, and the 2 corrections ( P H2O and P level difference ).

8. Calculate Rexp from the equation: PV = n Rexp T

9. Calculate relative error for R with the equation: % R = [( Rexp – Rtrue ) / Rtrue ] \* 100

R true = 0.0821 L atm /mol K



Collecting a Gas with the Use of an Eudiometer Tube

NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_

PARTNER: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ SECTION: \_\_\_\_\_\_\_\_\_\_\_

**Gas Law Constant**

**Data Sheet**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Trial 1** | **Trial 2** | **Trial 3** |  |
| Mass of Mg |  |  |  | g |
| Number moles of Mg |  |  |  | mol |
| Volume of gas |  |  |  | mL |
| Volume of gas |  |  |  | L |
| Barometric pressure |  |  |  | mm Hg |
| Difference in levels |  |  |  | mm solution |
| Difference in levels |  |  |  | mm Hg |
| Vapor pressure of water |  |  |  | mm Hg |
| Corrected H2 pressure |  |  |  | mm Hg |
| Corrected H2 pressure |  |  |  | atm |
| Temperature |  |  |  | K |
| Rexp |  |  |  | L atm/mol K |
| Average Rexp |  | l atm/mol K |  | |
| Relative Error |  | % R |

Sample Calculation:

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**Gas Law Constant**

**Post-lab Questions**

1. What would be the effect (increase, decrease, or no change) on the calculated value of **R**of each of the following? Please explain why in each case.

a. The initial reading on the eudiometer tube is not zero and no correction is made.

b. The level difference is recorded by reading the eudiometer tube volume (mistakenly assuming that this volume difference is a difference in height).

c. The volume of H2 is read when the liquid level in the eudiometer tube is above that in the beaker without making a correction for the level difference.

d. Some of the H2 gas escaped out of the bottom of the tube while it was produced

e. Some of the Mg broke loose and floated to the top of the tube, but at the end it was all reacted.

2. Why we didn’t take into account the amount of HCl used and include it in our calculations ?

3. Explain if your results are more precise or more accurate. ( Meaning are they closer to each other than they are to the true value.).

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**Gas Law Constant**

**Pre-lab Assignment**

1. What property of hydrogen gas allows it to be collected by water displacement ?

2. Why is it necessary to add conc. HCl, then water, rather than a solution of HCl to the eudiometer tube?

3. How is the atmospheric pressure corrected for the presence of:

a. Water vapor?

b. A level difference of liquid in the tube different from that in the beaker?

4. A student uses 0.086g of Mg and collects 89.9 mL H2 (g) over water at 23.1ºC on a day when theatmospheric pressure is 766.2 mmHg. The level of water in the eudiometer tube is 26.4 mm above the water level in the beaker. What value of R does the student obtain? Please be sure your value of *R* is expressed with proper units and the correct number of significant figures and that the **necessary corrections are made** for the vapor pressure of H2O.