**EXPERIMENT 18:**
**DETERMINATION OF THE IDEAL GAS LAW CONSTANT**

Introduction: You will experimentally verify the numerical value of the ideal gas law constant **R**, as used in the ideal gas law:

$$P V = n R T$$

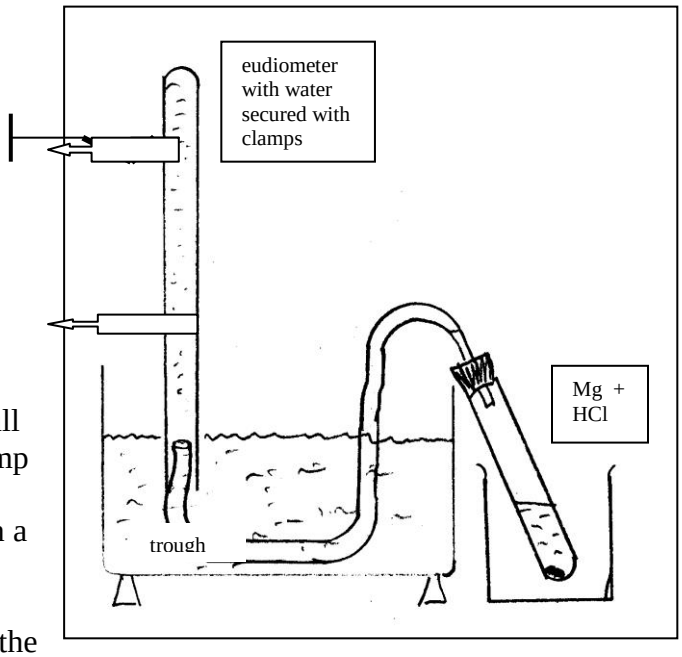
Background: Pressure and volume of a gas are proportional to the temperature and the amount of gas used. This proportionality constant is "R," which is constant to 3 significant figures for most simple gases at temperatures and pressures close to standard temperature and pressure ("STP"). The accepted value is 62.4 L torr $mole^{-1}K^{-1}$. The pressure is found by measuring the atmospheric pressure and subtracting **two** correction factors (for humidity and differences in water levels). The volume is measured in a gas collection tube called a *eudiometer*. Temperature must be equalized between the test tube and eudiometer. The moles of gas, n, are determined by stoichiometry from the amount of Mg used in the reaction to produce the hydrogen gas.

$$Mg + 2\,HCl \longrightarrow H_2\,(g) + MgCl_2\,(aq)$$

.

Materials Needed:

| Equipment | Chemicals |
|---|---|
| Brass metal trough<br>Eudiometer (gas tube)<br>8-inch test tube<br>Stopper w/ rubber hose<br>Thermometer,<br>400 mL Beaker<br>Watch glass, tweezers | 6 M HCl (aq)<br>Mg ribbon<br>Gelatin capsule<br>tweezers |




Procedure: Fill a eudiometer completely with water and invert it into a trough filled about ¾ full with water. Secure the eudiometer to a buret clamp or 2 utility clamps.

· Obtain a rubber hose attached to a glass tube in a one-hole stopper. Insert the free end of the hose into the eudiometer. The presence of air in the hose before and after the reaction will not affect the results.

· Place an 8-inch test tube in a 400 mL beaker next to the trough and pour about 20 mL of 6 M HCl into the test tube.

· Obtain a 6-7 cm piece of Mg ribbon. You may have to clean it with steel wool. On the analytical balance, weigh a 6-7 cm piece of Mg ribbon. to 4 decimal places. Use clean tweezers to handle the Mg. The Mg will weigh about 0.07 g Curl the ribbon into a small spiral.

·Obtain a gelatin capsule. Separate the capsule and insert the Mg which can be curled up into a small spiral. (You can handle the Mg with your fingers since you've already weighed it.) Reconnect the two halves of the capsule

· Drop the gelatin capsule into the 6 M HCl in the test tube and insert the rubber stopper into the tube as shown in the diagram – a tight fit is essential. The HCl will slowly dissolve the gelatin capsule and the reaction between the Mg and HCl will start quickly generating $H_2$ gas. If pieces of Mg are stuck in the upper part of the test tube, swirl the HCl so as to bring it into

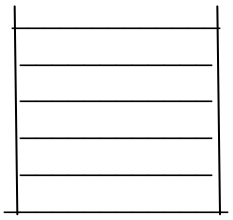
contact with the Mg. The foam from the gelatin capsule should subside, and the reaction slows down over the next several minutes. After the reaction stops, pour some water into the 400 mL beaker in order to allow the temperature of the gas to equilibrate with the room T. If you get more than 100 mL of gas – you'll have to start over !!! (use a smaller piece of Mg).

- With a ruler, measure the distance in mm (millimeters !!) from the surface of the water (h) in the trough to the level of the water in the eudiometer.
- Obtain the barometric pressure (instructor will instruct you on the proper use of a barometer).
- Measure the volume of gas collected in the tube after the temperature has equilibrated.

Note: each mark on the eudiometer = 0.2 mL .

- Measure the temperature of the water in the trough. (Assume this is the T of the gas).

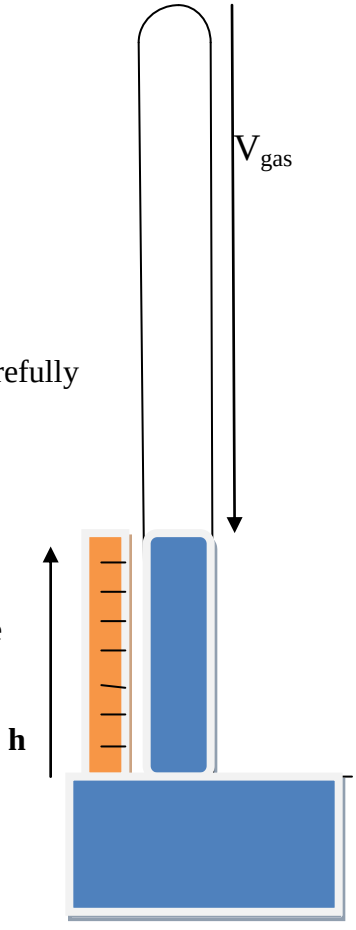
Amadeo Avogadro (1776-1856). His hypothesis in 1811 that equal volumes of gases at constant temperature and pressure, contained equal numbers of particles, was not generally accepted until 1860 at a great convention of chemists when his countryman the great chemist S. Cannizzarro, presented the idea and it came to be accepted. Too late for Avogadro – who had already passed away.



0 ( 0 is not labeled – it is at the top !)
each mark is **0.2** mL

so this third mark is 0.6 mL
marks are close together – read the meniscus carefully
the odd # mL marks are not labelled

Only even # ml are labeled,




Read the height of the Water column with a Ruler in cm. Start at The water level in The tub.
convert cm to mm

**EXPERIMENT 18: REPORT** **Name: _____**
**THE IDEAL GAS LAW CONSTANT** Section: _____ Date _____

| **Data and Calculations**: | Run 1 | Run 2 | |
|---|---|---|---|
| mass of Mg……..... | | | g |
| volume of gas in eudiometer..... (convert mL to L) | | | L |
| temperature, Kelvin ($^oC$ + 273) …. | | | K |
| moles of Mg used = moles $H_2$ ..... | | | mol |
| Barometric pressure (mm Hg or torr**) .....** (mm Hg is same unit as torr – instructor will provide this value) | | | mm Hg ( $P_{bar}$) |
| height of water (**h**) in gas tube…….. | | | mm $H_2O$ |
| Vapor pressure…… (at the $^oC$ temperature of the water; | | | mm Hg* (torr) this is found in a table in the CRC Handbook) |

Calculation of pressure of $H_2$**:** First, convert the height difference of the water levels in the eudiometer**, h**, from mm $H_2O$ to mm Hg by dividing by 13.6 (the density of Hg).

height of $H_2O$ / 13.6 = _____ (run 1) _____ (run 2) mm Hg **

Then, subtract **both** the vapor pressure (*)**,** and the converted water pressure difference (**) from the barometric pressure to obtain the actual pressure of dry hydrogen. This is the value that will be used in the ideal gas law.

$P_{H2}$ = $P_{bar}$ - mmHg* (vapor P) - mmHg** (height / 13.6) = _____ (run 1) _____ (run 2) mm Hg

Calculation of R**:** Using PV = nRT, calculate R from each run. Use the corrected $P_{H2}$
Show setup for one run below. Show the rest in your copy sheet – attach to report.

Make sure you use the pressure of only hydrogen in the formula !

R = _____ run1 _____ run 2

mean experimental value of R _____
(include the units)

## Conclusions and Questions:

1. Compare your mean value for R to the accepted value of 62.4 L-torr/mol-K. Calculate the % error.

_____% error

2. Try to explain why the % error may be high or low – i.e. what <u>systematic</u> factors in the experiment itself may lead to an answer that is not exactly correct. (Do not include student errors such as "I forgot to set the balance to 0 ", etc. We assume the student is a perfect experimenter and errors result only from the experiment itself.) Think about how the T and V were measured.

3. Using your mean experimental value of R, and a value of n = 1.00, calculate the molar volume of your $H_2$ at STP (standard T = 273 K, P = 760 mm Hg), using the ideal gas law.

4a) Why are **two** correction factors subtracted from the barometric pressure?

4b) If you had not used the correction factors, what would your calculated value of R have been?