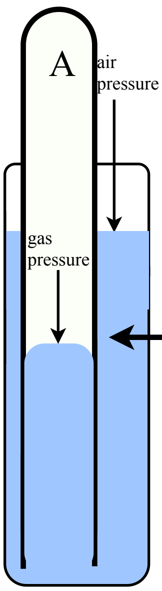
LAD D.1 (pg 1 of 4) Determining the Molar Mass of a Gas

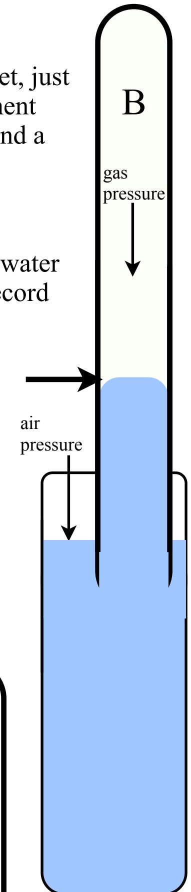
Name_______________Per___

In this LAD, as with any LAD, you must show work to support any calculations.

Introduction

Your objective in this LAD is to determine the molar mass of a gas, using the ideal gas law. You will measure mass, and use volume and pressure and temperature to calculate moles, which of course will allow the calculation of mass per moles. If you measure the mass of a gas and its corresponding number of moles, you can calculate its molar mass.





PreLAD - *to be turned in with your data table.*

1. Make a data/results table in your Google Sheets Lab Document. Use the same spreadsheet, just make a new sheet with the tab at the bottom. Be sure and make a row for each measurement and processing the data item. Be sure a title at the top which includes the LAD number and a descriptive title

2. Measure and record the volume of the gas in your eudiometer on the line in diagram A.

   a. Then raise the eudiometer up as far as possible without raising above the surface of the water in the cylinder as shown in diagram B. Read the volume of gas in the eudiometer and record it on the line in the diagram B.

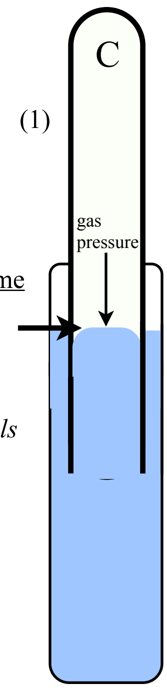
   ________Vol of gas in situation A

   Vol gas in situation B________

   b. Is the volume of gas in the eudiometer B <u>more or less</u> than in diagram A? (1)
   circle one

   c. Since you didn't let any air in or out and the temperature has not changed, yet the volume has changed, the pressure of the gas in the eudiometer in diagram B **must** be different than in the eudiometer A. Would you predict that the pressure of the gas in diagram B is <u>more or less</u> than in diagram A?
   circle one
   Put arrows on the equation below to justify your response. (1)

$$P_A V_A = P_B V_B$$



   d. In diagram A is the gas pressure inside the eudiometer, <u>more or less</u> than the air pressure? (1)
   circle one

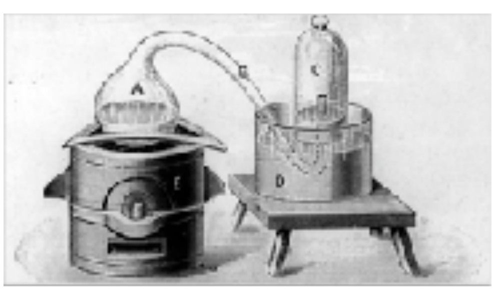
   e. In diagram B is the gas pressure inside the tube, <u>more or less</u> than the air pressure? (1)
   circle one

   f. Now, consider diagram C, is the gas pressure inside the tube <u>more than, less than, or the same</u> as the air pressure outside the tube? (1)
   circle one

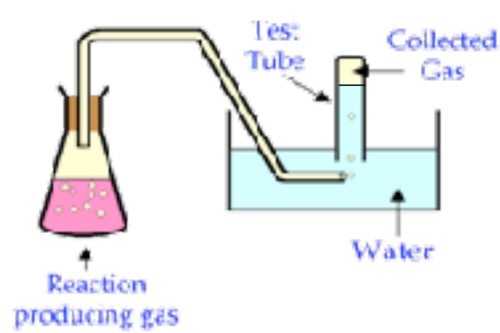
this sketch is not to scale

It is very important that when collecting gas over water, the volume must be measured when the levels of water inside and outside the gas collecting container must be equal, this is the only way we can know the pressure of the collected gas – by knowing the pressure of the air.

3. Consider the diagrams below in which gas from the reaction in the flask is collected over water. The containers collecting gas actually contains two gases. What is the other gas and how does it get into the container? (2)



Gas has been collected over water for many years.
This is a sketch of Lavoisier's gas collecting apparatus.



Some facts to help you nderstand vapor pressure of gas over a liquid in a sealed container.

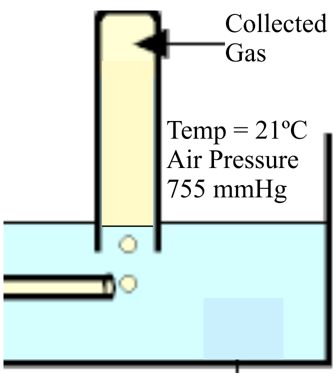
- When a liquid evaporates to a gas (vapor) in a closed container, the gaseous molecules cannot escape.
- Some of the vaporized molecules will strike the liquid phase and condense back into it.
- When the rate of condensation of the vapor becomes equal to the rate of evaporation of the liquid, the amount of vapor will have reached a maximum and the vapor pressure will no longer change.
- The gas in the sealed container is said to be in ***equilibrium*** with the liquid.
- The pressure exerted by the water vapor in equilibrium with the liquid water in a closed container at a given temperature is called the vapor pressure.
- ***Vapor pressure is dependent only on temperature***: at a higher temperature, more molecules have enough energy to escape from the liquid or solid. At a lower temperature, fewer molecules have sufficient energy to escape from the liquid or solid.

4. Let's take a closer look at two gases in a container. Dalton's Law of Partial Pressures says that each gas will independently cause pressure and that each gas will contribute to the total pressure. $P_{total} = P_{gas1} + P_{gas2}$
Calculate the total pressure in container Z in which the two gases in X and Y have been combined in container Z. (1)

H_2O Pressure 16 mmHg **X**	+	O_2 Pressure 739 mmHg **Y**	=	H_2O O_2 Total Pressure ?? atm **Z**

Total pressure (in mm)______________ and (in atm)______________

5. Consider the scenario in the diagram below. Use the Equilibrium Water Vapor Pressure Table to the right to calculate the pressure of the collected gas.
Show your work in the space below. (2)



Equilibrium Water Vapor Pressure

Temp (ºC)	Pressure (mm Hg)	Temp (ºC)	Pressure (mm Hg)
0	4.58	30	31.82
5	6.54	35	42.2
10	9.21	40	55.3
11	9.80	45	71.9
12	10.52	50	92.5
13	11.20	55	118.0
14	11.99	60	149.4
15	12.80	65	187.5
16	13.63	70	233.7
17	14.53	80	355.1
18	15.48	90	525.8
19	16.48	92	567.0
20	17.54	94	610.9
21	18.65	96	657.6
22	19.83	98	707.3
23	21.07	100	760.0
24	22.38	102	815.9
25	23.76	104	875.1
26	25.21	106	937.9
27	26.74	108	1004.4
28	28.35	110	1074.6
29	30.04		

6. Write the Ideal Gas Law in the space below,
   - and then substitute for moles: n = mass/molar mass
   - and then manipulate the variables and solve for molar mass. (2)

Materials – on trays to be shared by two lab groups

- 2× 100 ml glass graduated cylinder
- 2× gas containers
  (lighter, butane canister, and/or Dust-Off)
- matches
- thermometer
- 2× "hot hands" grippers
- sink drain stop
- tissues & paper towels
- bucket and sponges for bench clean-up

Center Lab Bench

- Analytical (0.0001) balance

PreLAD

- 2× 1000 ml graduated cylinder and 2× eudiometer

 Determining the Molar Mass of a Gas Name______________Per___

Procedure

A. Weigh the gas container. (You will use either a butane refill or a Dust-Off canister.).

B. Prepare the graduated cylinder to collect gas by filling the cylinder with water and inverting the cylinder mouth down into the sink. Try not to get any air bubbles. Place the hose under water and allow gas to flow out of the canister until you have collected almost a full graduated cylinder of gas (DO NOT GO BEYOND FULL, or you will not have any markings to read the volume).

C. Measure the volume of gas when you have raised or lowered the graduated cylinder so that the level of water inside the tube and the surface of water in the sink are the same. At that moment, read the volume of gas inside the graduated cylinder.

D. Making sure your canister is not wet (from wet hands) weigh the canister.

E. Use the thermometer to record the temperature of water in the sink and the temperature of the air in the room - we hope that they are the same. (If they are not, take an average, since you can use only one value in your calculation.)

F. Using the vapor pressure chart, record the equilibrium vapor pressure of water for the temperature of water/air in the room on your data table.

G. Record the air pressure in the room. It has been checked on-line and recorded on the whiteboard.

Process the Data – ***Be sure and record your data and embedded formulas to calculate these results on your Google sheet. Be sure you record the mystery gas data from the board during class. This data should be an extra trial in your Google sheet.***

1. Calculate the mass of butane that was released into the cylinder.
2. Calculate the partial pressure of the butane in the cylinder. Use the water vapor pressure table given in the PreLAD.
3. Using your literal equation in which you solved for molar mass in the preLAD, calculate the molar mass of butane.
4. Write out the chemical formula of butane. Use the periodic table to calculate the molar mass.
5. Calculate the percent error for your experimental molar mass calculation.

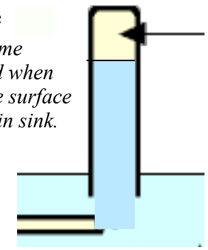
Post-LAD Questions - ***to be answered on this sheet in the spaces provided. Calculations must be shown.***

1. For the following questions (a-d), justify your response by stating the error's effect on any measurements and following those effects through the resulting calculations. Be specific by stating if the measurements and calculations would be *higher* or *lower* as a result of the source of error. You may want to use your literal equation from PreLAD #6 to help justify.

   a. If the canister were wet when you measured the canister's mass after letting out the gas, would the calculated molar mass be larger, smaller, or no change? (3)

   b. If you had a goofy lab partner who decided to open the gas canister's valve and let out some gas on the way to the balance before the final weighing of the canister, would the calculated molar mass be larger, smaller, or no change? (3)

c. If you measured the volume of your butane when the graduated cylinder looked like the diagram to the right, would the calculated molar mass be larger, smaller, or no change? (3)



Gas volume measured when above the surface of water in sink.

d. Some gases are more soluble than others. If a gas used in this lab procedure were quite soluble, would the calculated molar mass be larger, smaller, or no change? (3)

2. Most *Bic* lighters hold 5.0 ml of liquified butane (density = 0.60 g/ml) Calculate the minimum size container you would need to "catch" all of the butane (from a lighter) at room conditions , if you released all of the butane from the lighter. (3)

3. Write a balanced equation for the combustion of butane. (3)

4. What volume of air at room conditions (20ºC,760 torr) would be required to combust a full lighter of butane. Remember that air is only ~20% oxygen. *Show your work.* (3)

5. What would be the total volume of gases produced at room conditions (20ºC,760 torr) by the combustion described in the previous question. *Show your work.* (3)