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EXPERIMENT 13: THE IDEAL GAS LAW AND THE MOLECULAR WEIGHT OF GASES

PRE-LABORATORY QUESTIONS

The following preparatory questions should be answered before coming to lab. They are intended to introduce you to several ideas important to aspects of the experiment. **You must turn in your work to your instructor before you will be allowed to begin the experiment.**

1. State the ideal gas law in equation form. What does each symbol in the equation stand for and what is its proper unit?

2. How can one determine the molecular weight of a gas from the ideal gas law?

3. A student determines the mass of an unknown gas to be 0.189 grams at 24^{o}C and 760 torr in a 100 mL container. What is the molecular weight of the unknown gas?

EXPERIMENT 13: THE IDEAL GAS LAW AND THE MOLECULAR WEIGHT OF GASES

INTRODUCTION

The ideal gas law states that PV = nRT where

P = pressure in atmospheres
V = volume in liters
n = number of moles
R = ideal gas constant = 0.08206 L·atm/mol K
T = absolute temperature in degrees Kelvin

The number of moles, n, can also be represented as m/MW where
m = the mass of the gas in grams
MW = the molecular weight of the gas in grams/mol

Substituting the alternate expression for n into the ideal gas law and rearranging gives

(Eqn 1) $$MW = \frac{mRT}{PV}$$

Thus, if one measures the mass of an ideal gas in a container of known volume at a known pressure and temperature, the molecular weight of the gas can be calculated.

During the experiment, you will go to the storeroom window and hand the attendant a 50 mL plastic syringe. He or she will slightly overfill the syringe with a gas for you. You will then take the syringe back to the laboratory, push the plunger on the syringe until there is exactly 50 mL of gas within it, and weigh it on the electronic balance. You will perform this procedure for each of three gases: carbon dioxide, nitrogen, and one unknown.

The mass of the gas in the syringe is determined in the following way:

(Eqn 2) $mass_{gas}$ = mass of gas-filled syringe - mass of air-filled syringe + $mass_{air}$

The mass of the air in the syringe, $mass_{air}$, is calculated by:

(Eqn 3) $mass_{air} = density_{air}$ (g/L) x volume of syringe (L)

The volume of the syringe is just 50 mL or 0.05 L and $density_{air}$ can be obtained from the table on the RESULTS page if the barometric pressure and the temperature of the room are measured.

EQUIPMENT NEEDED

a plastic 50 mL syringe (per pair of students)

PROCEDURE

1. Measure the temperature of the room with the thermometer in your locker and record this value on the RESULTS page.

2. Obtain the measured barometric pressure for the day from the sign outside the storeroom window. Record this value also on the RESULTS page.

3. Calculate the mass of air, $mass_{air}$, that is contained within the 50 mL syringe using equation 3 and the table on the RESULTS page (for the temperature and pressure readings you obtained in steps 1-2). Show your work on the RESULTS page.

4. Obtain a 50 mL plastic syringe from the center bench. **Always handle the syringe by the flange to avoid contamination by grease and moisture from your fingers and to avoid heating the gas with your hands.**

5. Push the plunger back on the syringe until it contains 50 mL of air. Then weigh the syringe on the electronic balance. Record this mass on the RESULTS page. You will obtain the best results if you position the rubber piece of the syringe in the center of the balance pan, make sure the syringe is not touching anything but the balance pan when weighing, use the cardboard box to cover the balance to keep out air drafts, and use the same balance throughout the experiment to minimize inconsistencies.

6. Take the syringe to the storeroom window and ask for carbon dioxide gas.

7. Take the gas-filled syringe back to the laboratory, push the plunger to the 50 mL mark, and weigh the syringe plus gas. Record this mass on the RESULTS page.

8. Use equation 2 to calculate $mass_{gas}$ and equation 1 to calculate the molecular weight of the gas. Show your work on the CALCULATIONS page.

9. Repeat steps 5-8 for the other 2 gases, nitrogen and the unknown. Record pertinent data on the RESULTS and CALCULATIONS pages.

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RESULTS

Table of Densities of Dry Air (in grams/liter)

Temperature of the Room _______ ^{o}C _______ ^{o}K

Barometric Pressure _______ mm Hg _______ atm

$Density_{air}$ (from table above) _______ g/L

$Mass_{air}$ (from equation 3) _______ g

Show your calculation here:

	mass of air-filled syringe	mass of gas-filled syringe
carbon dioxide		
nitrogen		
unknown		

Sign-out: All equipment is put away, and the student bench is clean and dry. TA___________________________Date_____________

CALCULATIONS

Carbon Dioxide Gas

$Mass_{gas}$ (from equation 2) _______ g

Show your calculation here:

Molecular Weight of the Gas (from equation 1) _______ g/mol

Show your calculation here:

Nitrogen Gas

$Mass_{gas}$ (from equation 2) _______ g

Show your calculation here:

Molecular Weight of the Gas (from equation 1) _______ g/mol

Show your calculation here:

Unknown Gas

$Mass_{gas}$ (from equation 2) _______ g

Show your calculation here:

Molecular Weight of the Gas (from equation 1) _______ g/mol

Show your calculation here:

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POST LABORATORY QUESTIONS

1. Using atomic weights from the periodic table, calculate the molecular weights of carbon dioxide and nitrogen. Compare your experimental values with the calculated values, i.e. calculate the percentage error for each gas as follows:

$$\% \text{ relative error} = \frac{\text{experimental value} - \text{accepted value}}{\text{accepted value}} \times 100$$

   Give a plausible reason why the experimental value might differ from the calculated value.

2. Based upon the following choices and your results, what is the most likely identity of the unknown gas?

<u>gas</u>	<u>MW</u>
He	4.0026
Ne	20.179
C_2H_2	26.02
NO	30.01
Ar	39.948
NO_2	46.01
SO_2	64.07

3. An organic compound had the following analysis: C = 55.8%, H = 7.03%, O = 37.2%. A 1.500 g sample was vaporized and was found to occupy 530 mL at 100^oC and 740 torr. What is the molecular weight and molecular formula of the compound?

4. Compute the approximate density of methane, CH_4, at 20^oC and 5.00 atm. The molecular weight of methane is 16.0.

5. If the density of carbon monoxide is 3.17 g/L at -20^oC and 2.35 atm, what is its approximate molecular weight?