UNIT 10 - GASES

DETERMINING MOLAR MASS USING THE IDEAL GAS EQUATION LAB

DISCUSSION & OBJECTIVE

Gases are one of the major products and/or reactants in many chemical reactions. Of all the states of matter, gases are the most affected by changes in temperature and pressure. The method of collecting the gas also affects the pressure of the gas. The relationship between the density of a gas and the pressure and temperature at which it is collected can be used to determine the molecular weight of the gas.

This lab activity will use the Ideal Gas Equation to experimentally determine the molar mass of a common gas - butane. Since real gases do not behave ideally at room temperature, the results will be expected to vary from the calculated molar mass. The idea of a dry gas versus one collected over water will also be involved.

MATERIALS

- butane lighter, large container, large graduated cylinder, thermometer, balance

SAFETY PRECAUTIONS

- basic safety precautions apply; **Do not try to ignite the gas after collecting it!**

PROCEDURE

1. Immerse the lighter completely in water. Then use a paper towel to dry the lighter as best as possible. Then weigh the butane lighter to the nearest hundredth of a gram. Record this value in the data table.
2. Fill the container about two-thirds to three-fourths full with water.
3. Place the graduated cylinder in the container and fill it with water also. Invert the cylinder and keep the opening of the cylinder under the surface of the water to prevent any water from leaving the cylinder. (You should not have any air bubbles at the top of the graduated cylinder.)
4. Check the lighter to be certain it is open as much as possible to allow gas to escape rapidly.
5. Place the top of the lighter up into the opening of the cylinder and depress the striker to allow the gas to bubble up into the cylinder. (Butane is not very flammable under water!)
6. Allow the gas to escape until about 250 mL of gas are collected. Quickly read the volume of the gas because butane is more soluble in water than most hydrocarbons. Record this volume.
7. Dry the lighter **completely** and weigh it again. Record this value.
8. Read the temperature of the water to the nearest tenth of a degree. Record this temperature.
9. Your instructor will provide you with the barometric pressure reading.

DATA TABLE

Mass of the lighter before collecting gas	_____ g
Mass of the lighter after collecting gas	_____ g
Mass of gas collected	**_____ g**
Volume of gas collected	_____ mL
Volume measurement in Liters	**_____ L**
Temperature of the water (and gas)	_____ ^{o}C
Temperature measurement in Kelvins	**_____ K**
Barometric pressure	_____ inches Hg
Barometric pressure conversion (1 inch = 25.4 mm)	_____ mm Hg
Vapor pressure of water at certain temperature *	_____ mm Hg
Pressure of the "dry" gas	_____ mm Hg
Dry gas pressure measurement in atm	**_____ atm**

* See table of water vapor pressures on next page.

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CALCULATIONS

The ideal gas equation is P V = n R T

where P = pressure, V = volume, n = moles, R = ideal gas constant, and T = temperature.

Make sure that your calculations are clearly shown in #3 below! (Please note that clearly implies not only legibility, but also a logical progression of calculations. Numbers written haphazardly all over your paper is not a logical progression.)

Experimental molar mass = _____g/mole

The formula for butane is C_4H_{10}. Calculate the theoretical molar mass based on this formula.

Theoretical molar mass = _____ g/mole

Calculate the % error: $\frac{|\text{theoretical value} - \text{experimental value}|}{\text{theoretical value}} \times 100$

LAB QUESTIONS

1.) Identify at least three (3) possible sources of experimental error. (The errors you include should stem from either an assumption that was made about the gas or lab conditions or something that you did or did not do during the lab. Remember, I know that you're intelligent young adults. "We read the insert name of measuring device here wrong." is not an acceptable source of experimental error. Think about your answers!) Explain how your calculated molar mass would be affected by these errors.

2.) Read Step 6 in the PROCEDURE. What effect would leaving the gas in contact with the water for an excessive amount of time have on the experimental molar mass? (Would the experimental molar mass be higher or lower if you did this? Why? Think about your calculations.)

3.) Show **in detail** how you determined the experimental molar mass of butane, the theoretical molar mass of butane, and your percent error.

Temperature (°C)	**Water Vapor Pressure (mm Hg)**
17.0	14.5
17.5	15.0
18.0	15.5
18.5	16.0
19.0	16.5
19.5	17.0
20.0	17.5
20.5	18.1
21.0	18.6
21.5	19.2
22.0	19.8
22.5	20.4
23.0	21.1
23.5	21.7
24.0	22.4