

Molar Mass of Butane Lab

Introduction

When a new substance is prepared in the laboratory, its identity must be determined. Knowing the molar mass of the substance limits the list of possible identities. To determine the molar mass, you need the mass of the sample and the number of moles of substance present in that particular mass. Knowing the pressure and volume of a gas at a specific temperature provides enough information to determine the number of moles present. One method of determining the volume of a gas sample at a known pressure is to collect it over water. If the volume (V), temperature (T) and total pressure (P) of the collected gas are measured, the ideal gas law can be used to determine the moles of gas in that sample.

Butane is a gas at normal room conditions, but it is a liquid in disposable lighters under high-pressure conditions. When the lighter is opened, the container is depressurized, allowing the butane to escape as a gas. In this experiment you will collect a butane gas sample in a container by the water displacement method, allowing direct measurement of the volume of butane gas collected.

Purpose

Based on the introduction above, determine the purpose of this lab and include it in your lab write-up.

Prediction

Do you think 100 mL of butane gas is enough to accurately determine the molar mass of butane? Why or why not?

Materials

butane lighter [C₄H₁₀]
tap water

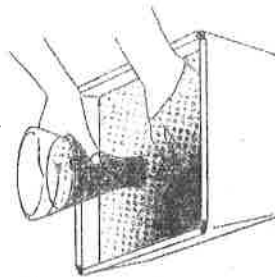
plastic trough or dishpan
thermometer
Vernier LabQuest

Safety Considerations

- Butane is toxic and highly flammable. No open flames should be used in this experiment!
- Sometimes chemicals from previous labs still remain in glassware and on other lab equipment; wash all lab equipment before and after performing this lab.
- Wash your hands thoroughly after completing this lab.

Procedure

1. Place the lighter under water. Remove the lighter, shake off the excess water, and dry the outside with a paper towel. Using the balance, determine the mass of the lighter and record.
2. Fill the plastic trough two-thirds full with water.
3. Fill a 100-mL graduated cylinder to the brim with water. Using the palm of your hand, completely cover the opening of the graduated cylinder and invert it into the trough. Once the opening is under water, remove your hand, keeping the opening of the graduated cylinder under water at all times. If there are any noticeable air bubbles in the graduated cylinder, you must remove the cylinder and repeat this step.



This diagram shows a similar setup using an Erlenmeyer flask; you will use a graduated cylinder instead.

4. Hold the lighter under the opening of the graduated cylinder and release the butane gas by depressing the lever. Collect exactly 96.0 mL of butane gas. Do not allow any bubbles of butane to escape outside the cylinder. Do not exceed 96.0 mL since this may prevent you from making an accurate volume measurement.
5. Determine the temperature of the water in °C and record.
6. Carefully raise or lower the graduated cylinder until the water level inside the cylinder is the same as the water level in the trough. Be careful not to pull the cylinder out of the water! While maintaining equal water levels, read the exact volume of the butane gas to the nearest 0.1 mL and record.
7. While keeping it upside down, remove the graduated cylinder and take it to the fume hood to release the collected butane gas safely.
8. Remove the lighter from the water, shake off the excess water, and dry the outside with a paper towel. Determine the mass of the lighter and record.
9. Record the barometric pressure from your faculty.

Additional Clean-up and Disposal

1. Return all used equipment and materials to the supplies table; return the lighter to your teacher.

Data – you should create a data table in your lab write-up that looks something like this:

Property	Value
mass of lighter before	
mass of lighter after	
water temperature	

Water Vapor Pressure Table

T (°C)	P (kPa)	T (°C)	P (kPa)	T (°C)	P (kPa)
0	0.61	12	1.40	24	2.98
1	0.66	13	1.50	25	3.17
2	0.71	14	1.60	26	3.36
3	0.76	15	1.70	27	3.56
4	0.81	16	1.82	28	3.78
5	0.87	17	1.94	29	4.00
6	0.93	18	2.06	30	4.24
7	1.00	19	2.20	31	4.49
8	1.07	20	2.34	32	4.75
9	1.15	21	2.48	33	5.03
10	1.23	22	2.64	34	5.32
11	1.31	23	2.81	35	5.62

Calculations (include these answers in your Conclusion!)

1. Determine the pressure of the butane gas by subtracting the water vapor pressure of the system from the atmospheric pressure.
2. Convert the volume of butane gas you collected from milliliters into Liters.

3. Convert the temperature of the system into Kelvins.
4. Using the ideal gas constant (R) and the pressure, volume, and temperature of the butane gas in your experiment, determine the number of moles (n) of butane gas you collected.
5. Determine the molar mass of butane by dividing the mass of gas released from the lighter by the number of moles (n) of you determined in Calculation #4.
6. Calculate the percent error for your experimental value of the molar mass of butane.

Questions

1. Explain how butane, which can be stored as a liquid in lighters, comes out as a gas.
2. Butane gas does not dissolve well in water. Why is this critical to performing this experiment?
3. The diagram on the first page shows this experiment being performed with an Erlenmeyer flask instead of a graduated cylinder.
 - a. Why is it preferable to use a graduated cylinder instead of a flask in this lab?
 - b. Imagine you performed this lab and collected the gas with a flask instead of a graduated cylinder. How might you attempt to accurately determine its volume?

Errors

Describe two possible errors you may have committed in this lab that may have somehow affected your results. Explain the specific steps you will take to avoid each of these errors in the future.

Conclusion

Write two or more paragraphs summarizing your results, examining the validity of your prediction, and explaining your calculations.