**Introduction to Determination of the Molar Mass of Gases and Volatile Liquids**

Problem

The molar masses of compounds are used daily in the chemistry profession. The molar mass is defined as the mass, in grams, of 1 mole of any element or compound. How is molar mass determined and how is the molar mass of an unknown found? In this experiment, the molar masses of sample gases are determined directly and the molar masses of several volatile liquids will be calculated based on measurements of their vapor density.

Background

The ideal gas law relates the four measurable properties of a gas (P, V, n, T). In this experiment, the ideal gas law will be used to determine the molar mass of gases and volatile liquids.

**PV = nRT Equation 1**

The number of moles (n) of any pure substance is equal to its mass divided by its molar mass

**n = grams given/ molar mass Equation 2**

Substituting for n in Equation and then rearranging produces the equation of the molar mass of a gas.

**Molar mass (g/mol) = mass (g) X RT Equation 3**

**P(atm) X V (L)**

The molar masses of several volatile liquids with boiling points well below the boiling point of water are determined. A small sample of the liquid is placed in a tared 15 ml plastic pipet and the pipet is then heated in boiling water to vaporize the liquid. The air and excess vapor escape, leaving the pipet filled only with the volatile liquid vapor at atmospheric pressure and at the temperature of boiling water. The pipet is then removed and cooled to condense the vapor.

Once cooled, the pipet is weighed. By massing the same pipet filled with deionized water, the volume of the pipet is calculated. The molar mass of the volatile liquid is then determined from Equation 3 using the mass of the condensed vapor, the volume of the pipet, the atmospheric pressure, and the temperature of the boiling water.

**Determination of the Molar Mass of Gases and Volatile Liquids**

Overview

The purpose of this experiment is to determine the molar masses of various gases and volatile liquids. In this lab liquids are volatilized and condensed in a fixed volume. The condensed vapor is massed and liquid’s molar mass is calculated from experimental data.

Safety Precautions

Acetone, ethyl alcohol and isopropyl alcohol are all flammable liquids and fire risks. Acetone and isopropyl alcohol are slightly toxic by ingestion and inhalation. Ethyl alcohol is made poisonous by the addition of a denaturant. Wear chemical splash goggles, chemical resistant gloves, and a chemical resistant apron. Exercise care when working with the hot water bath. Wash hands thoroughly with soap and water before leaving the laboratory.

Revised Procedure

1. Mass each pipet to the nearest 0.001g and record this mass in the data table.

2. Draw a small amount of the liquid from the labeled bottle into each of the previously prepared and labeled pipets.



Volume should not exceed this amount.

3. Insert the tips of the pipets containing your liquid into the short piece of plastic tubing, then secure the tubing with a test tube clamp. See Figure 2



4. Lower the pipets into the boiling water bath. Make sure the entire

bulb of each pipet is below the water line.

5. Heat for at least five minutes.

6. Carefully remove the pipets from the water. Inspect each pipet. If

any liquid remains in a pipet bulb, heat the entire assembly for another minute.

7. Cool the pipets by lowering the pipet assembly into a bath of cold water in a 400 ml beaker.

8. Record the temperature of the boiling water bath and barometric pressure of the room in the Data Table.

9. Dry the pipets with paper towels and mass each pipet which now contains only the condensed vapor, to the nearest 0.001g. Record these values in the Data Table.

10. Fill each pipet completely with water, then expel the water into the sink to flush the remaining volatile liquid from the pipet. Repeat this process several times.

11. To determine the volume of pipet: Fill the pipet completely with water, (draw as much up as possible, flip pipet upside down. Squeeze out air. Maintain pressure on pipet and invert into water again. Pipet should completely fill). Dry the outside, and mass the pipet and water. Record the mass in the data table.

12. Repeat step 16 for pipets #2 and #3.

Data Table:

Temperature of boiling water bath \_\_\_\_\_\_\_\_\_\_◦C

Barometric Pressure \_\_\_\_\_\_\_\_\_\_ mm Hg

Temperature of room temp. water bath \_\_\_\_\_\_\_\_\_\_ ◦C

Density of water at room temperature \_\_\_\_\_\_\_\_\_\_ g/ml

Jumbo pipets

|  |  |  |  |
| --- | --- | --- | --- |
|  | Jumbo Pipet #1 | Jumbo Pipet #2 | Jumbo Pipet #3 |
| Mass of empty pipet |  |  |  |
| Mass of pipet and water (step 11) |  |  |  |
| Mass of water in filled pipet |  |  |  |
| Volume of pipet (calculate from density) |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Pipet #1 | Pipet #2 | Pipet #3 |
| Mass of pipet and condensed volatile liquid(step 9) |  |  |  |
| Mass of condensed volatile liquid |  |  |  |
| Molar mass of volatile liquid |  |  |  |
| Accepted molar mass of volatile liquid |  |  |  |
| Percent error |  |  |  |

Calculations: volume of pipet, mass of liquid, molar mass of liquid, percent error.

Discussion: Also includes possible sources of error, the impact the errors had on the results

1. Volatile liquids with lower boiling points often give better results than those with higher boiling points. Suggest a reason for this.

2. What effect would vapor condensation in the neck of the jumbo pipets have on the reported molar mass?

Conclusion: Write one. Include the identity of each pipet.