AP CHEMISTRY

Molar Mass of a Volatile Liquid

(125 Points)

Name, Date and Lab Partner (5 Points)

Procedure & Materials (15 Points)

Complete, step-by-step account

of actions performed

Data (35 Points)

Observation Table (15 Points)

Reagent Serial Number & Mass (5 Points)

Reagent Volume (5 Points)

Experimental T, P, & V (10 Points)

Calculations/Analysis (35 Points)

Comprehension (10 points)

Mass of Unknown (5 Points)

Moles of Unknown (10 Points)

Molar Mass of Unknown (5 Points)

%Error (5 Points)

Conclusion (25 Points)

Overall Neatness and Organization (5 Points)

Safety (5 Points)

This part is determined by proper lab safety which includes having your goggles and lab coat on properly at all times. Each reminder by the instructor will result in a deduction of 5 or 10 points. This component of the grade can be negative.

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**INTRODUCTION TO ANALYTICAL CHEMISTRY – LAB**

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**EXPERIMENT V**

**DETERMINATION OF MOLAR MASS FOR A VOLATILE LIQUID**

**INTRODUCTION**

It is often useful to know the molar mass of a substance as it is one of the properties that helps characterize the substance. It can aid in your determination of the elemental composition of a molecule, empirical and molecular formulas, rates of effusion, and molecular velocities.

If the substance is a volatile liquid, one way of determining the molar mass of the molecules composing the liquid is by analyzing how it behaves in a gaseous phase. Since the liquid is volatile, it can easily be converted to a gas by altering the pressure, volume, or temperature of the substance.

But in order to determine molar mass, a solid understanding of relationships between pressure, volume, moles, and temperature for a substance in the gaseous phase is required.

**THEORY PRE-LAB**

When gases behave ideally, there is a predictable relationship between the volume, pressure, moles and temperature of the gas.

1. Show that relationship below:

Given that the intent of this analysis is the determination of the molar mass for an unknown volatile liquid:

1. What is meant by the term volatile? Relate it to this lab.
2. What information must be known to determine molar mass (think units)? Which of the two units will be calculated experimentally and which can be directly measured for a sample of gas in a container?
3. Which of those variables may be obtained experimentally from the equation in question #1? Rearrange the equation from question #1 to solve for that variable.

**PROCEDURE PRE-LAB**

Read through the investigation instructions and answer the following questions prior to initiating the experiment.

1. If the mass of sample is to be measured, what must be taken into account to isolate this value from your system?
2. Discuss how you should vaporize your sample given the following parameters and diagram an experimental set-up that would accomplish the parameters below.
   * It is dangerous to apply direct heat to an “empty” glass system (one with only gas present, be it air or a sample).
   * The entire container should receive uniform heating.
   * A thermometer inside the flask would provide a condensation point as well as a point of escape for your vaporized sample.
3. How would you measure the unknown volume of a container?
4. A sample in a closed container is heated. Compare the pressure inside the container to that of the atmospheric pressure outside.
5. The same sample is heated in an unsealed container. Compare the pressure inside the container to that of the atmospheric pressure outside.

**Safety and Disposal**

The volatile liquid being evaporated in this experiment are toxic and flammable and should not be directly inhaled or exposed to flame. Their vaporization should be kept to a minimum (small volume) and should be performed in a well-ventilated area or in a fume hood.

**Investigation**

1. Obtain the following materials from the cart/lab drawer:

* 125mL Erlenmeyer
* 0.5mL glass syringe
* 2x – 600mL or larger beaker
* Heating Apparatus (Pre-Lab #6)

* Test tube tongs
* Vernier Interface and Laptop
* Ice (wait to get until later)

1. Assemble your heating apparatus per pre-lab question #6.
2. Obtain the assigned unknown liquid by filling your glass syringe to the 0.5mL mark from the assigned unknown reagent bottle. Record the serial number of the bottle you obtained the unknown from.
3. Inject and analyze your sample using the heating system.
4. Prepare an ice bath in a large beaker filled with cold tap water and ice, leaving enough room to fit your sample container.
5. Allow the sample container to stay in the heat source for 3 minutes ***after*** all of the volatile liquid has evaporated. Record any critical data/observations.
6. Quickly transfer the flask over to the ice bath. Record any critical data/observations.
7. Once equilibrated to the ice bath, remove and dry flask. Record any critical data/observations.
8. Determine the volume of the flask per pre-lab #7.
9. Research the current local barometric pressure.

**DATA ANALYSIS**

Comprehension

1. What variables of data were obtained during this experiment?
2. Explain the importance of determining the volume of the flask and the barometric pressure.
3. If a piece of warm metal is placed in water and allowed to sit for an infinite amount of time, what can eventually be said of the metal and water? Apply this principle to your experiment and solve for the temperature of your gas sample.
4. Although not directly measured, describe how effusion was used in this lab.
5. Why is it important to allow the flask to sit in the hot water bath for 3 minutes after complete vaporization has occurred? Discuss at least 2 lines of reasoning.

Calculations

1. Volume of unknown gas maintained in the flask at atmospheric pressure.
2. Barometric pressure in atmospheres.
3. Mass of unknown maintained in the flask at atmospheric pressure.
4. Moles of unknown maintained in the flask at atmospheric pressure.
5. Report your results as the molar mass and identity (serial number & name) of the unknown molecule.
6. %Error of your molar mass.
7. If air is a mixture of nitrogen, oxygen and argon gases, can you be confident only your sample was in the flask during analysis? Use effusion calculations to support your stance.

**CONCLUSION**

Write a conclusionary paragraph that highlights:

1. How the ideal gas law can be used to determine the molar mass of a volatile liquid.
2. The results of your experiment and how they may or may not have differed from the molar mass provided by the unknown liquid’s manufacturer.
3. A discussion on possible sources of error and potential improvements to experimental design that would increase your accuracy. Reference your analysis questions (comprehension and calculations) to support your stance.
4. Assumptions that were made during this experiment. (Does it matter how much volatile liquid is used initially? What gases are present in the flask? Is the gas behaving ideally? Did the entire volume of vapor recondense? Why did we record atmospheric pressure?)