Volatile Liquid Mystery Lab

(Determination of the Molecular Mass of a Volatile Liquid Lab)

Introduction: **(Lab Book… SUMMARIZE (3-4 sentences))**

It is often useful to know that molecular mass of a substance. This is one of the properties that helps characterize a substance. If the substance is a volatile liquid, one common way of determining its molecular mass involves using the ideal gas law

$$PV = nRT$$

Since the liquid is volatile, it can be easily converted to a gas. While it is in the gas phase, its volume, temperature and pressure are measured. The ideal gas law will then allow the calculation of the number of moles of the substance present.

$$n = \frac{PV}{RT}$$

where n is the number of moles of gas, P is the pressure (in atmospheres), V is the volume (in liters) and R is the ideal gas constant, and T is the temperature (in Kelvin). The number of moles of gas is related to the molecular mass, M, by the expression:

$$n = \frac{m}{M} = \frac{\text{grams of gas}}{\text{molecular mass of gas}}$$

The mass of the gas is found by first cooling the gas so that it condenses back into a liquid, and then determining the mass of that condensed liquid. The equations above can be combined into one equation that can be solved directly for molecular mass:

$$M = \frac{mRT}{PV}$$

In this experiment to determine the molecular mass of a volatile liquid, some of the liquid is placed into an Erlenmeyer flask. The flask is partially closed with a rubber stopper that has a small hole in it. The flask is heated in boiling water. The liquid vaporizes, the vapors fill the flask, and excess vapor leaves through the hole. Since the flask is open to air, the pressure of the vapor will be the same as the atmospheric pressure. The gas temperature will be that of the water bath. The volume of gas, which is the volume of the flask, can be easily found. The mass of the gas must be determined. To do this, the flask is quickly cooled so that the vapor condenses back into a liquid, and the mass of the flask, stopper, and liquid are found using an analytical balance.

Pre-Lab: **(Lab Book)**

The following data were obtained in an experiment to find the molecular mass of a liquid. Fill in the missing pieces of information and calculate the molar mass of the liquid.

Mass of condensed liquid in flask (g)	0.0326
Barometric Pressure (mm Hg)	742
Barometric Pressure (atm)	
Boiling Water Temperature (ºC)	99.2
Boiling Water Temperature (K)	
Volume of gas (mL)	8.23
Volume of flask (L)	

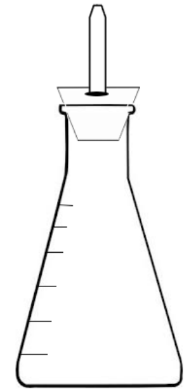
The following mistakes were made when carrying out the experiment. What specific effect will each have on the calculated molecular mass?

a. Only the bottom part of the flask was immersed in the water bath, so the temperature of part of the flask was less than that of the water bath.

b. Five milliliters of the liquid was initially placed in the flask instead of the recommended three milliliters.

c. The mass of the condensed liquid was not determined quickly. Instead, the flask was allowed to stand at room temperature for a while before its mass was measured.

Procedure: **(Lab Book… SUMMARIZE… split ¾ page with a blank observation column)**



1. ***Preparation:***
   a. Fill your 1000-mL beaker about two-thirds full with water. Add a couple of drops of food dye to the water. Start heating it on your hot plate.
   b. Place a medicine dropper tube into a 1-hole rubber stopper (pointy end towards the top of the stopper).
   c. Measure and record the exact mass of the flask, stopper, and dropper tube.
   d. Measure and record the barometric pressure.
   e. Pour about 3 mL of the unknown volatile liquid into the flask, and cover with the stopper.
   f. Clamp the flask to the ring stand using the utility clamp. Tilt the flask so it will be easier to see when all the liquid has vaporized.
2. ***Heating:***
   a. Immerse the flask in the hot water bath deep enough to cover the flask up to the neck. Keep the stopper above the water level to avoid getting water inside it. Be sure the flask's bottom is at least 0.5 cm away from the bottom of the beaker.
   b. Heat the beaker of water until boiling, and keep it at the boiling point while the liquid vaporizes. The expanding vapor will flush air out of the flask. As the liquid continues to vaporize, the excess vapor will escape out of the hole in the stopper. Keep the flask in the water bath for at least one minute after all of the liquid has vaporized.
   c. Measure and record the exact temperature of the boiling water. Put the end of the thermometer close to the middle of the flask.
3. ***Cooling:***
   a. Quickly, cool the flask and condense the vapors, by dunking it in an ice bath.
   b. Dry it off completely, being careful to not allow any liquid in the flask to escape.
   c. Measure and record the exact mass of the flask, stopper and condensed liquid.
   d. Repeat steps #1d-3 to get a second set of data.
   e. Finding the Volume of the flask:
   f. Clean the flask with soap and water. Rinse it well.
   g. Fill the flask to the very top with water, cover it with the stopper. Let any excess water come out.
   h. Measure and record the volume of water contained using a graduated cylinder.
4. Repeat steps #1d-3 to get a 2nd and 3rd set of data.
5. ***Finding the Volume of the flask:***
   a. Clean the flask with soap and water. Rinse it well.
   b. Mass the empty dry flask
   c. Fill the flask to the very top with water, cover it with the stopper. Let any excess water come out.
   d. Record the mass of the flask and water. Using water density values, determine the volume of the flask.

Data Table **(Lab Book)**

	Trial 1	Trial 2	Trial 3
Mass of flask and stopper			
Mass of flask, condensed liquid and stopper			
Mass of condened liquid in flask			
Barometric Pressure (atm)			
Boiling Water Temperature (K)			
Mass of flask and stopper (g) *(from above)*			
Mass of Flask and distilled water (g)			
Volume of Flask (L)			

Post-Lab Calculations and Analysis **(Lab Book)**

1. Show all calculations that are necessary to determine the molar mass of your unknown liquid (gas)
2. Calculate the molar mass of the liquid used in each run and the average of the two runs for the volatile liquid.
3. Identify the volatile liquid based on the molar mass that was determined.

   Options: Methanol: CH_3OH Ethanol: C_2H_5OH Acetone: C_3H_6O
4. Volatile liquids with lower boiling points often give better results than those with higher boiling points. Suggest a reason for this.
5. Some liquids have enough attractions between molecules to form dimers. (Dimers are molecules formed from the combination of the identical molecules, $A + A \rightarrow A_2$.) What effect would this have on the experimental molar mass?

Include a short conclusion discussing the collection of the data (variables) that are needed in this lab and the overall relationship between them. Please include any errors or improvements.