

Experiment 9 - Molar Mass by Vapor Density

Vapor is the term for a gas produced from the vaporization of a liquid. If it is assumed that the resulting vapor is an ideal gas, then we can use the *ideal gas law*:

$$PV = nRT$$

By substituting moles for mass and molar mass the following equation is derived after some simple rearrangements:

$$PM_m = \left(\frac{m}{V}\right)RT \quad \text{or} \quad PM_m = dRT$$

$$M_m = \frac{dRT}{P}$$

The molar mass of the compound is represented by M_m and d is the vapor density in g per liter. Another way to calculate the molar mass of the sample is to determine the moles of the gas produced. The number of moles can be determined from the measured volume, pressure, and temperature of the gas. From the mass of the liquid sample used and the moles calculated from experimental measurements, the molar mass of the sample can be determined.

$$\text{Molar Mass} = M_m = \frac{\text{mass of sample (g)}}{\text{moles of sample}}$$

Many organic compounds are liquids that vaporized below the boiling point of water. A boiling water bath will be used as a constant temperature (100 °C or 373 K) heat source to convert your unknown liquid to a gas. The pressure of the gas will be the barometric pressure of the room and the volume is the volume of the gas inside the container (flask). In this experiment, you will be given an unknown liquid and you will determine the molar mass of the liquid.

Equipment and Reagents

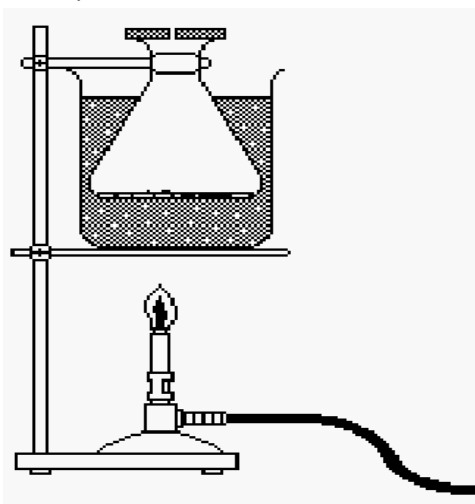
Analytical balance	unknown liquid	high capacity balance
200 mL flask	tap water	thermometer
Aluminum foil	stand w/ iron ring	barometer
Pin	wire gauze	
600 mL beaker	buret clamp	

Procedure

1. On an analytical balance weigh a 200 mL Erlenmeyer flask with a piece of aluminum foil large enough to cover the mouth of the flask.

2. Add enough of the unknown liquid to cover the bottom of the flask. Crimp the foil over the mouth of the flask and use a pin to puncture a small hole. Make sure to record the unknown ID.
3. Set up a stand with an iron ring and wire gauze. Place a 600 mL beaker about half full of tap water on the gauze. Submerge the flask as far as possible into the beaker. *Make sure the tap water does not enter the flask.* Clamp the flask securely to the stand and heat the water bath to boiling. Record the temperature of the boiling water. Keep the bath at a gentle boil and observe the liquid until all of it has been vaporized. This should take about 5 minutes.

Set Up



4. Remove the flask from the bath and allow it to cool to room temperature. The vapor that remained in the flask during the heating (vaporization) phase will condense in the flask to give back a liquid. Dry the outside of the flask and weigh it on the analytical balance. *You will get a stable mass when the flask is at room temperature.*
5. Repeat the above procedure with the same unknown sample so you have a total of 2 trials.
6. Fill the flask to the top with tap water and weigh it with the foil cap on a high capacity balance (a triple beam balance may work). Measure the temperature of the water in the flask and look up the density of water at that temperature.
7. Record the barometric pressure of the room.

Report

Determine the mass of the vapor in the flask for each trial

Determine the mass of water in the flask and use the density to calculate the volume of water in the flask. This will be equal to the volume of the vapor in the flask.

Calculate the molar mass for the gas for both trials and calculate the average value.

Include the unknown ID for the sample.