Determination of the Molecular Mass of a Volatile Compound

Objective: To calculate the molar mass of a volatile unknown compound from the mass of the vapor in a flask of known volume at a known temperature and pressure.

Theory: The molar mass of a gas equals its density X (RT/P). R = 0.0821 L-atm/mol-K

note: All observations, calculations and conclusions should be recorded directly in your laboratory notebook. Do not record data on loose paper and transfer it. USE YOUR NOTEBOOK.

Introduction

In this experiment a small amount of a volatile liquid will be placed in an Erlenmeyer flask and heated in a bath of boiling water to vaporize the liquid. This will drive out all of the air in the flask and fill the flask completely with vapor of the unknown liquid. The flask is then removed from the boiling water bath. The vapor inside the flask will condense back to the liquid state as it cools. The flask (that has previously been weighed) is weighed again.

The change in the mass of the flask is assumed to be due to the condensed vapor. The change in the mass of the air in the flask is assumed to be negligible. In this way it is possible to determine the mass of the volatile liquid at a known volume, temperature and pressure. The volume is the volume of the flask. The temperature is the temperature of the boiling water. The pressure is the atmospheric pressure in the room. To obtain the atmospheric pressure we will use a service such as National Oceanic and Atmospheric Administration (http://noaa.gov)

What does volatile mean? Please define this term in your laboratory notebook.

Using the data and the relationship between molar mass and density, the molar mass of the volatile unknown liquid can be determined.

Procedure

1. Clean and completely dry a 125mL Erlenmeyer flask. If the flask is even a little bit wet this will affect the mass of the flask so care should be taken to dry the flask well. The flask may be rinsed with a small amount of acetone and air dried for several minutes. Do not use the air jets in the laboratory as they are noisy and contain moist air.

2. Crimp a square of aluminum foil tightly over the top of the flask as a cover and secure it with a rubber band. (Figure 1)

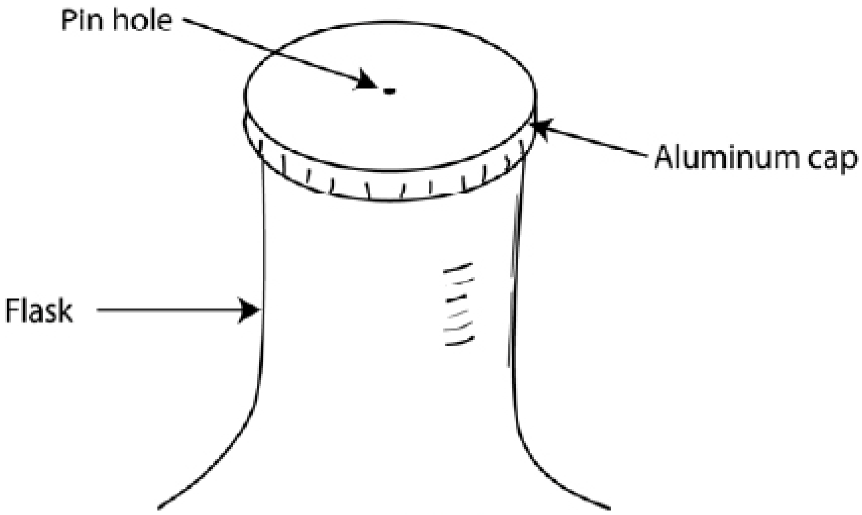

Figure 1

3. Punch a tiny pinhole in the foil to allow the air and excess vapor to escape.

4. Record the mass of a dry flask and foil cap and rubber band on an analytical balance to the nearest 0.001gram on the data sheet. Weigh the empty flask (without the foil and rubber band) on a triple beam balance because when the flask is filled with water to determine its volume it will be too heavy for the analytical balances.

5. Obtain a sample of a volatile liquid, your "unknown" , from the instructor. It is important that you record the number of your unknown sample in your laboratory notebook. You will use this sample for both trials.

CAUTION: Assume that the vapors of your unknown are toxic and flammable. Use good ventilation.

6. Fill a 1000 mL beaker about half full with water. (Figure 2) Place the beaker on a hot plate and secure the Erlenmeyer flask with a clamp. Add one-half of the unknown liquid to the flask. Cover with the foil. Place the flask with the volatile liquid in the beaker with the neck up. Use the clamp to keep the flask as deep in the beaker as possible.

7. Add water to the beaker until the water level is about 2 cm below the crimped foil cap on the flask. It is important that the cap remain dry and water is not trapped underneath it. Why?

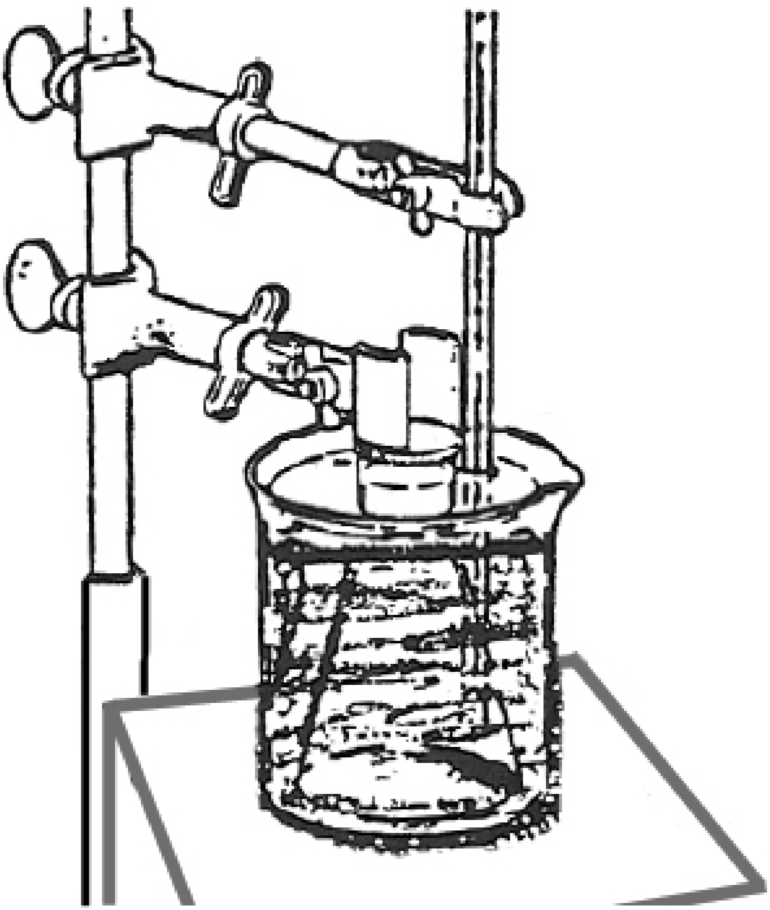

Figure 2

8. Bring the water bath to a gentle boil. Continue boiling until the last trace of unknown liquid has evaporated. You may need to move the flask a little bit to see if any liquid remains in the flask. Watch how light reflects from the surface of the liquid.

9. When you observe that all of the liquid has vaporized use crucible tongs to remove the Erlenmeyer flask from the boiling water. Take care that the aluminum cap remains in place.

10. Dry the outside of the flask with paper towels and allow it to cool to room temperature. You should observe a liquid condensate. Describe what you see in your laboratory notebook.

11. Carefully weigh the cool flask and its contents to the nearest 0.001 gram. Record this mass in your laboratory notebook.

12. Repeat this entire procedure to obtain a second set of data using the same volumetric flask and the second half of your unknown sample.

13. Determine the volume of the flask by filling it to the top with water and weighing it on a triple beam balance. Using the density of water at the temperature of the water you used to fill the flask you will be able to determine the volume of the flask.

14. Use the Ideal Gas Law to determine the moles of gas from your unknown liquid that filled the flask while it was in the water bath.

15. Determine the molar mass of this gas by dividing its mass by the moles determined in step 14. Do this for each trial.

16. The unknown liquid has the same molar mass as the molar mass of the gas. Report this value in your laboratory notebook. Determine the average and the percent difference. To determine the percent difference divide the difference between trial one and trial two values by the average value and multiply this result by 100. Report this number as a percentage.

17. The instructor will provide you with identity of your unknown so you can calculate the actual molar mass (true value) of your liquid. Finally, calculate the percent error in your result. To do this use the formula:

$$\frac{|\text{true value - actual value}|}{\text{true value}} \text{ X } 100\%$$

18. To finish this laboratory you will need to write a conclusion and a reflection. The conclusion should summarize the results of the laboratory and comment on these results. (For example you might state that the results were satisfactory or unsatisfactory and say why.) The reflection should be a statement about possible sources of error and how you might carry out the laboratory differently to obtain better results. If the laboratory was highly successful then a reflection might state techniques that worked well and explain why they were so successful.