Name: ___________________________

Lab 17. Molar Mass of a Volatile Liquid

Overview

In this lab, you will determine the molar mass of a vapor from the mass of a sample at a known volume, temperature, and pressure.

Principle

This technique, the Dumas method, uses Avogadro's law, that the volume of a gas sample is determined by its pressure, temperature, and number of moles, but is independent of the identity of the gas. In this lab, you will fill a flask of known volume with the vapor of a volatile liquid by heating a sample of the liquid in the flask to a known temperature until all of the liquid converts to vapor, displacing the air from the flask. When the flask is cooled to condense the vapor, measuring the mass of the flask and condensate allows you to find the mass of vapor.

The volatile liquids provided are isopropyl alcohol and denatured ethyl alcohol. Both of these substances are moderately toxic, so use them sparingly.

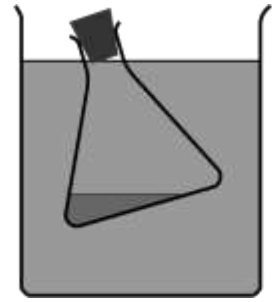
Materials

Aluminum foil\
Pin
Fine copper wire
Cutters
600-mL beaker
125-mL Erlenmeyer flask
1-hole stopper
Beral pipets
Ring stands and clamps
Thermometer
Weather station display
Isopropyl alcohol and denatured ethyl alcohol

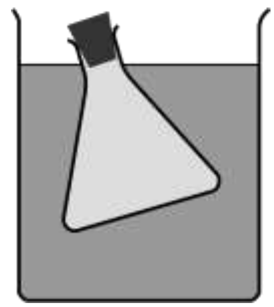
Procedure

1. The rubber stopper for the Erlenmeyer flask has a hole in it, but it is so large that it will allow too much vapor to escape the flask as it cools. You will need to fashion a pinhole cover for the stopper from aluminum foil. Shape the foil around the small end of the stopper, and mold it to the stopper by fitting the lined stopper into the mouth of the flask. Punch a small pinhole through the foil over the hole in the stopper. Cut the excess foil at the neck of the flask with a sharp blade. Remove the excess thoroughly, so that it does not provide a place for water vapor to condense.
2. Measure the mass of the empty flask with stopper.
3. Introduce the liquid sample with a beral pipet. Use just one or two squirts from the pipet; liquids expand a lot when they evaporate at atmospheric pressure. Cap the flask.

4. Add enough water to the beaker to cover the flask up to the stopper when the flask is in the beaker.
5. Place the beaker on the hot plate and heat the water to boiling. Place the flask containing the liquid sample into the boiling water so that it is immersed in the water up to its neck. You may use a ring stand and clamp to hold the flask under water.



6. Bring the water bath to a gentle boil, and continue it at a gentle boil until all the liquid sample evaporates.



7. Observe the liquid in the flask. It will reduce in volume as it evaporates. Once it is all gone, measure and record the temperature of the water in the beaker. Remove the flask from the water bath and allow it to cool to room temperature. All water must be completely removed from the outside of the flask. Be especially careful to remove all water from the mouth of the flask and the stopper. As the flask cools, some of the vapor should condense to liquid.

8. Measure and record the mass of the stoppered flask containing condensate.
9. Additional trials may be done by adding more solvent to the flask and repeating the heating-cooling procedure. Try to run two trials with isopropyl alcohol and two trials with denatured ethanol.
10. After the final trial, remove the stopper and rinse the flask with water. Fill the flask up to the stopper with water. Make sure the outside of the flask is completely dry, and measure the mass of the water-filled flask. This measurement, together with the mass of the empty stoppered flask and the known density of water, allows you to calculate the volume of the flask precisely.

Calculations

1. Calculate the volume of the flask.

2. Calculate the moles of each sample from its known volume, temperature, and pressure.
3. Calculate the mass of each vapor sample from the difference between the mass of the flask containing condensed vapor and the mass of the empty flask.
4. Calculate the molar mass of each liquid from the mass and number of moles of the vapor.

Questions

1. What are the sources of measurement error in this experiment?

2. What assumptions are made in the calculations? Are they justified?

3. What changes could be made to the procedure, apparatus, or calculations to make the results of this experiment more trustworthy?