EXPERIMENT 8

Determination of Molecular Weight

by Gas Density Measurements

INTRODUCTION

One of the simplest methods for determining molecular weights is based on the ideal gas law,

$$PV = nRT$$

where P is the pressure in atmospheres, V is the volume in liters, n is the number of moles, T is the temperature in K of a gas sample, and R is the gas constant, which is equal to 0.0821 L atm/K mol. If P, V, and T for a gaseous sample can be measured, the gas law can be used to calculate the number of moles of gas present. If, in addition, the weight of the sample can be determined, its molecular weight can be calculated, since

$$MW = \frac{g}{n}$$

Dumas developed a simple procedure in which the pressure, volume, temperature, and weight of a gaseous sample could be easily measured, and its molecular weight calculated. In the procedure, an excess of a volatile liquid is placed in a flask of known weight and heated at constant temperature, in a water bath, until all of the liquid vaporizes. This drives both the air and any excess vapor out of the flask. The flask then contains vapor at a known T (temperature of the water bath), P (atmospheric pressure), and V (volume of the flask). To determine the mass of the vapor, the flask is cooled and reweighed. The increase in weight represents the weight of the vapor.

The Dumas method is used in this experiment to determine the molecular weight of an unknown volatile liquid.

RELEVANT PROBLEMS FROM THE TEXT (Chang, 10e): Example 5.9, Problems 5.43, 5.44, 5.47

PROCEDURE

1. Obtain a thermometer, flask, capillary stopper (or piece of foil), and supporting wire from the stockroom, and an unknown from the instructor. Record the unknown number on the data sheet.

2. Set up a hot water bath by supporting a 400 mL beaker of water with a ring, wire mesh, and ringstand. Heat the water to boiling with a Bunsen burner.

3. While waiting for the water to boil, weigh the flask and capillary stopper (foil) on the analytical balance to ±0.0001 g. Record the mass on the data sheet.

4. Pour about one third of the unknown into the flask. Replace the capillary stopper. Immerse the flask in the hot water bath and support it with the wire, cork, and clamp as demonstrated by the instructor. The flask should be immersed in the hot water up to the neck of the flask to prevent condensation of the liquid. Replace the water in the beaker as it evaporates. Measure and record the temperature of the boiling water.

5. When all the liquid has been vaporized, remove the flask from the water bath. Allow the flask to cool to room temperature.

6. When cool, dry off the outside of the flask.

7. Weigh the flask, capillary stopper, and condensed vapor to ±0.0001 g. on the analytical balance. Record the mass on the data sheet.

8. Repeat the experiment by adding half the remaining unknown to the flask, heating in the water bath, cooling, and reweighing. Repeat a third time with the remaining unknown.

9. The total volume of the flask is 50.0 mL. Record this volume. Record the atmospheric pressure from the barometer in the lab (or your instructor may give you the value to use).

10. Using the Ideal Gas Law, calculate the molecular weight of the liquid.

11. Clean the flask by rinsing thoroughly with acetone.

DETERMINATION OF MOLECULAR WEIGHT BY GAS DENSITY MEASUREMENTS

Name ______________________________

Section ____________________________

Unknown Number ____________________

DATA

	Sample 1	**Sample 2**	**Sample 3**
Weight of flask + wire + stopper			
Weight of flask + wire + stopper + condensed vapor			
Temperature of boiling water			
Atmospheric pressure			
Volume of flask			

RESULTS

Weight of condensed vapor			
Moles of vapor present			
Molecular weight			
Average molecular weight			

Sample Calculation of Moles and Molecular Weight: