Molar Mass Determination of a Volatile Liquid

A. Student
Lab partner: A. Friend
CH 222 Lab Manual page 23
February 11, 2003

Purpose:

To determine the molar mass of an unknown liquid. This was done by heating the liquid in a flask that was partially submerged in boiling water. Once the liquid had evaporated and was the same temperature as the water, the flask was taken out of the water and the gas allowed to condense back into a liquid. The liquid was weighed, the barometric pressure was taken, and all the numbers were plugged into the equation $PM=\frac{m}{V}RT$ and solved for M.

Data/Observations:

Unknown liquid: I

First Run
Temperature of gas: 100.5 ^{O}C (373.5 K)
Weight of flask (empty): 126.247 g
Weight of flask (with condensed gas): 127.168 g
Weight of condensed gas: 127.168g – 126.247g=.921 g
Barometric pressure: 759.32 mm Hg (.99911 atm)
Volume flask:

Mass of water (with flask): 391.20 g
Mass of water: 391.20g – 126.247g=264.95 g
Density of water at 17.5 ^{O}C: .998625 g/mL

$$.998625 g/mL=\frac{264.95g}{V}$$

V=265.31 mL (.26531 L)

$$(.99911 atm)(M)=\left(\frac{.921g}{.26531L}\right)(.082057 L \bullet atm/K \bullet mol)(373.5K)$$

M=106 g/mol

Second Run
Temperature of gas: 101 ^{O}C (374 K)
Weight of flask (with condensed gas): 127.144 g
Weight of condensed gas: 127.144g – 126.247g=.897 g
Pressure and volume same as first run

$$(.99911\text{atm})(M)=(\frac{.897g}{.26531L})(.082057\text{L}\bullet\text{atm/K}\bullet\text{mol})(374\text{K})$$

M=104 g/mol

<u>Parts Per Thousand</u>

Average molar mass: (106g/mol+104g/mol)/2=105 g/mol

Deviation$_1$: $|105 - 106| = 1$

Deviation$_2$: $|105 - 104| = 1$

Average deviation: (1+1)/2=1

$$\text{ppt}=\frac{1}{105}\bullet 1000 = 10$$

Conclusion:

Based on the data collected, the molar mass of unknown liquid I is approximately 105 g/mol. Both runs of the experiment and the parts per thousand indicate that this number is fairly accurate.

Post-Lab Questions:

1.
   - i. This would increase the molar mass (as mass increases, molar mass increases).
   - ii. This would increase the molar mass (since the temperature of the water is taken rather than directly taking the temperature of the gas, the value on the right hand side of the equation would be higher than it should be).
   - iii. This would increase the molar mass (when all else held constant, lower volume leads to a higher molar mass).
   - iv. This would have no effect on the molar mass (only weigh amount of gas condensed—initial volume is not plugged into equation).

2. Weight of condensed gas: 56.039g – 55.441g=.598 g

   100^{O}C=373 K

   752.2 mm Hg=.9900 atm

   $$(.9900\text{atm})(.2159\text{L})=n(.082057\text{L}\bullet\text{atm/K}\bullet\text{mol})(373\text{K})$$

   n=6.98 x 10^{-3} mol

   $$(.9900\text{atm})(M)=(\frac{.598g}{.2159L})(.082057\text{L}\bullet\text{atm/K}\bullet\text{mol})(373\text{K})$$

   M=85.6 g/mol