Name KEY Section

Experiment 9

Advance Study Assignment: Molar Mass of a Volatile Liquid

1. A student weighs an empty flask and stopper and finds the mass to be 54.868 g. She then adds about 5 mL of an unknown liquid and heats the flask in a boiling water bath at 100°C. After all the liquid is vaporized, she removes the flask from the bath, stoppers it, and lets it cool. After it is cool, she momentarily removes the stopper, then replaces it and weighs the flask and condensed vapor, obtaining a mass of 55.496 g. The volume of the flask is known to be 235.7 mL. The barometric pressure in the laboratory that day is 738 mm Hg.

a. What was the pressure of the vapor in the flask in atm?

same as the lab's barometric P (since the flask is open to the atmosphere when heating)

$738 \text{ mm Hg} \left(\frac{1 \text{ atm}}{760 \text{ mm Hg}}\right) = 0.9711 \text{ atm}$ (3 sig figs)

$P =$ 0.971 atm (3 s.f.'s)

b. What was the temperature of the vapor in K? the volume of the flask in liters?

$T = 100° + 273.15°$

$T =$ 373 K

(assume 3 sig figs.) $V = 235.7 \text{ mL} \left(\frac{1 \text{ L}}{10^3 \text{ mL}}\right) = 0.2357 \text{ L}$

$V =$ 0.2357 L

c. What was the mass of vapor that was present in the flask?

55.496 g (flask + condensed vapor)

− 54.868 g (flask alone)

$g =$ 0.628 grams

d. How many moles of vapor are present?

$PV = nRT \Rightarrow n = \frac{PV}{RT} = \frac{(0.9711 \text{ atm})(0.2357 \text{ L})}{(0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1})(373.15 \text{ K})}$

$= 0.007475 \text{ mol}$

$n =$ 7.47×10^{-3} moles

e. What is the mass of one mole of vapor (Eq. 2)?

molar mass $M = \frac{0.628 \text{ g}}{0.007475 \text{ mol}} = 84.01 \text{ g mol}^{-1}$

$MM =$ 84.0 g/mole

2. How would each of the following procedural errors affect the results to be expected in this experiment? Give your reasoning in each case.

a. All of the liquid was not vaporized when the flask was removed from the water bath.

Our analysis assumes the mass of condensed vapor is the mass that was required to exert 738 mm Hg of P. Vapor should leave the flask until $P_{inside} = 738 \text{ mm Hg}$. But in this case, extra liquid remains ⇒ mass too high ⇒ M too high.

b. The flask was not dried before the final weighing with the condensed vapor inside.

Again, final mass too high ⇒ M too high.

c. The flask was left open to the atmosphere while it was being cooled, and the stopper was inserted just before the final weighing.

This allows some of the vapor to escape ⇒ final mass too low ⇒ M too low.

d. The flask was removed from the bath before the vapor had reached the temperature of the boiling water. All the liquid had vaporized.

Since the actual T of the vapor was lower than the T used to calculate the number of moles, n_{calc} is too low ⇒ M is too high.