Chapter 5 – Problem Set 2

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October 22, 2020

1. Calculate the molecular mass of a liquid that, when vaporized at 99[°C] and 716[TORR] gave 225[mL] of vapor with a mass of 0.773[g]. (1)

$$\begin{aligned} n &= \frac{PV}{RT} \\ &= .00694[\text{mol}] \\ m_{molar} &= \frac{.773}{.00694} \\ &= 111.4\left[\frac{\text{g}}{\text{mol}}\right] \end{aligned} \tag{1}$$

2. Calculate the density of ammonium dichromate at STP. (2)

$$\begin{aligned} m_{molar} &= 252\left[\frac{\text{g}}{\text{mol}}\right] \\ \frac{n}{V} &= \frac{1}{.0821 \cdot 273} \\ &= .0446\left[\frac{\text{mol}}{\text{L}}\right] \\ 252 \cdot .0446 &= 11.2\left[\frac{\text{g}}{\text{L}}\right] \end{aligned} \tag{2}$$

3. At what pressure will nitrogen have a density of $0.985\left[\frac{\text{g}}{\text{L}}\right]$ at 25[°C]. (3)

$$\begin{aligned} \frac{1}{14} \cdot .985 &= \frac{P}{.0821 \cdot 298} \\ P &= .86[\text{ATM}] \end{aligned} \tag{3}$$

4. How many liters of CO_2 measured at 26[°C] and 767[TORR] are produced in the combustion of 125[mL] of propanol ($d = 0.804\left[\frac{\text{g}}{\text{mL}}\right]$)? (4)

$$\begin{aligned} 2\,C_3H_8O + 9\,O_2 &\longrightarrow 6\,CO_2 + 8\,H_2O \\ 125 \cdot .804 &= 100.5[\text{g}_{C_3H_8O}] \\ \frac{100.5}{60} &= 1.68[\text{mol}_{C_3H_8O}] \\ 1.68 \cdot 3 &= 5.04[\text{mol}_{CO_2}] \\ V &= \frac{5.04 \cdot .0821 \cdot 299}{1.009} \\ &= 123[\text{L}_{CO_2}] \end{aligned} \tag{4}$$

5. Oxygen is collected over water (vapor pressure of water = 31.8[MMHG]) at 30[°C] and a barometric pressure of 742[TORR]. What is the partial pressure and mole fraction of oxygen? (5)

$$\begin{aligned} 31.8[\text{MMHG}] &= .0418[\text{ATM}] \\ 742[\text{TORR}] &= .976[\text{ATM}] \\ .976 - .0418 &= .934[\text{ATM}] \\ \text{mol}_f &= \frac{.934}{.976} \\ &= .96 \end{aligned} \tag{5}$$

6. What volume is occupied by 1.25[g] of oxygen saturated with water vapor at 25[°C] (vp water = 23.8[MMHG]) and a total pressure of 749[MMHG]? (6)

$$\begin{aligned} 23.8[\text{MMHG}] &= .0313[\text{ATM}] \\ 749[\text{TORR}] &= .986[\text{ATM}] \\ .986 - .0313 &= .9547[\text{ATM}] \\ \frac{1.25}{32} &= .0391[\text{mol}_O] \\ V &= \frac{.0391 \cdot .0821 \cdot 298}{.9547} \\ &= 1[\text{L}_O] \end{aligned} \tag{6}$$

7. A quantity of nitrogen gas originally held at 3.8[ATM] in 1.0[L] container at 25[°C] is transferred to a 10.0[L] container at 20[°C]. A quantity of oxygen gas originally at 4.75[ATM] and 26[°C] in a 5.0[L] container is transferred to the same container. What is the total pressure in the new container? (7)

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\begin{aligned}
n_{\mathrm{O}} &= \frac{3.8 \cdot 1}{.0821 \cdot 298} \\
&= .155[\mathrm{mol_O}] \\
n_{\mathrm{N}} &= \frac{4.75 \cdot 5}{.0821 \cdot 299} \\
&= .967[\mathrm{mol_N}] \\
P_{\mathrm{O}} &= \frac{.155 \cdot .0821 \cdot 293}{10} \\
&= .373[\mathrm{ATM}] \\
P_{\mathrm{N}} &= \frac{.967 \cdot .0821 \cdot 293}{10} \\
&= 2.33[\mathrm{ATM}] \\
P_{total} &= 2.33 + .373 \\
&= 2.703[\mathrm{ATM}]
\end{aligned} \tag{7}
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8. Nitrogen gas is held in a 2.0[L] container at 1.0[ATM] and 25[°C]. Oxygen gas is held in another 3.0[L] container at 2.0[ATM] and 25[°C]. The containers are then put together to allow both gases to mix. What is the partial pressure of each gas and the total pressure in the combined container? (8)

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\begin{aligned}
n_{\mathrm{N}} &= \frac{2 \cdot 1}{.0821 \cdot 298} \\
&= .0817[\mathrm{mol_N}] \\
n_{\mathrm{O}} &= \frac{3 \cdot 2}{.0821 \cdot 298} \\
&= .245[\mathrm{mol_N}] \\
P_{\mathrm{N}} &= \frac{.0817 \cdot .0821 \cdot 298}{5} \\
&= .4[\mathrm{ATM}] \\
P_{\mathrm{O}} &= \frac{.245 \cdot .0821 \cdot 298}{5} \\
&= 1.2[\mathrm{ATM}] \\
P_{total} &= 1.2 + .4 \\
&= 1.6[\mathrm{ATM}]
\end{aligned} \tag{8}
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