

13-1) Yes, the mass fraction will be identical because the masses of each gas are identical.

No, the mole fraction will not be identical because the number of moles vary between different gases and depend on their molar mass.

13-3.) CO_2 : $M = 44.01 \text{ kg/kmol}$

N_2O : $M = 44.01 \text{ kg/kmol}$

$\therefore$ Molar masses (M) are identical, as provided by table A-1. Therefore mole fraction is identical.

13-5.) Apparent molar mass is the average of molar masses in a mixture. It does not represent the mass of each molecule in the mixture since it is an average.

$$13-7.) \quad y_A = \frac{M_B}{M_A(1/m_{fA}-1) + M_B} \quad y_B = 1 - y_A$$

$$\text{Mass fraction: } m_{fA} = \frac{m_A}{m_A + m_B} \quad m_{fB} = \frac{m_B}{m_A + m_B} \quad m_{fA} + m_{fB} = 1$$

$$\text{Mole fraction: } y_A = \frac{N_A}{N_A + N_B} \quad y_B = \frac{N_B}{N_A + N_B} \quad y_A + y_B = 1$$

$$m = NM \quad \therefore m_A = N_A M_A \quad m_B = N_B M_B$$

Substitute:

$$m_{fA} = \frac{N_A M_A}{N_A M_A + N_B M_B}$$

$$(N_A M_A + N_B M_B) m_{fA} = N_A M_A$$

$$N_A M_A = m_{fA} (N_A M_A + N_B M_B)$$

$$N_A M_A (1 - m_{fA}) = m_{fA} N_B M_B$$

$$\frac{N_A}{N_B} = \frac{mf_A M_B}{(1-mf_A) M_A}$$

Substitute into mole fraction:

$$y_A = \frac{N_A}{N_A + N_B}$$

13-9.) N_2 60%

CO_2 40%

Table A-1: $M_{N_2} = 28.013 \text{ kg/kmol}$

$M_{CO_2} = 44.01 \text{ kg/kmol}$

$N_{N_2} = 0.60$

$N_{CO_2} = 0.40$

Gravimetric analysis and Molar mass:

~~$$M_m = M_{N_2} + M_{CO_2}$$~~
~~$$= 28.013 + 44.01$$~~

~~$$M_m = 72.023 \text{ kg/kmol}$$~~

$$M_m = m_{N_2} + m_{CO_2}$$

$$= .6(28.013) + .4(44.01)$$

$$m_m = 34.4118$$

$$mf_{N_2} = \frac{.6(28.013)}{34.4118} = .488 = 48.8\%$$

$$mf_{CO_2} = \frac{.4(44.01)}{34.4118} = .512 = 51.2\%$$

Gas Constant: $R_m = \frac{R_u}{M_m} = \frac{8.314}{34.4118} = 0.242 \text{ kJ/kg} \cdot K$

$$\begin{array}{lll}
 13-11.) & 2 \text{ kg } O_2 & M_{O_2} = 31.999 \text{ kg/kmol} \\
 & 5 \text{ kg } N_2 & M_{N_2} = 28.013 \text{ kg/kmol} \\
 & 7 \text{ kg } CO_2 & M_{CO_2} = 44.01 \text{ kg/kmol}
 \end{array}
 \left. \vphantom{\begin{array}{l} 13-11.) \\ 2 \text{ kg } O_2 \\ 5 \text{ kg } N_2 \\ 7 \text{ kg } CO_2 \end{array}} \right\} \text{Table A-1}$$

$$m_m = 2 + 5 + 7 = 14 \text{ kg}$$

$$a.) \quad m_{f_{O_2}} = \frac{m_{O_2}}{m_m} = \frac{2}{14} = 0.143$$

$$m_{f_{N_2}} = \frac{m_{N_2}}{m_m} = \frac{5}{14} = 0.357$$

$$m_{f_{CO_2}} = \frac{m_{CO_2}}{m_m} = \frac{7}{14} = 0.5$$

$$b.) \quad O_2 \rightarrow N_{O_2} = \frac{m_{O_2}}{M_{O_2}} = \frac{2}{31.999} = 0.063$$

$$N_2 \rightarrow N_{N_2} = \frac{m_{N_2}}{M_{N_2}} = \frac{5}{28.013} = 0.238$$

$$CO_2 \rightarrow N_{CO_2} = \frac{m_{CO_2}}{M_{CO_2}} = \frac{7}{44.01} = 0.159$$

$$N_m = 0.063 + 0.238 + 0.159 = 0.46$$

$$y_{O_2} = \frac{N_{O_2}}{N_m} = \frac{0.063}{0.46} = 0.137$$

$$y_{N_2} = \frac{N_{N_2}}{N_m} = \frac{0.238}{0.46} = 0.517$$

$$y_{CO_2} = \frac{N_{CO_2}}{N_m} = \frac{0.159}{0.46} = 0.347$$

$$c.) \quad M_m = \frac{m_m}{N_m} = \frac{14}{0.46} = 30.43 \text{ kg/kmol}$$

$$R_m = \frac{R_u}{M_m} = \frac{8.314}{30.43} = 0.273 \text{ J/mol} \cdot \text{K}$$

13-13.) 6 kmol H_2 $H_2 = 2.0 \text{ kg/kmol}$
 2 kmol N_2 $N_2 = 28 \text{ kg/kmol}$

a.) $m_{H_2} = N_{H_2} M_{H_2} = (6)(2) = 12 \text{ kg}$
 $m_{N_2} = N_{N_2} M_{N_2} = (2)(28) = 56 \text{ kg}$

b.) $m_m = m_{H_2} + m_{N_2} = 12 + 56 = 68 \text{ kg}$
 $N_m = N_{H_2} + N_{N_2} = 6 + 2 = 8$
 $M_m = \frac{m_m}{N_m} = \frac{68}{8} = 8.5 \text{ kg/kmol}$

$$R_m = \frac{R_u}{M_m} = \frac{8.314}{8.5} = 0.978 \text{ kJ/kg} \cdot \text{K}$$

13-30.) CO_2 20 kPa Find y_i R_m
 O_2 30 kPa mfi $C_{v,m}$
 N_2 50 kPa M_m K_m

a.) $y_i = \frac{P_i}{P_m}$ $P_m = 100 \text{ kPa}$

$$y_{CO_2} = \frac{20}{100} = \boxed{0.2} \quad y_{O_2} = \frac{30}{100} = \boxed{0.3} \quad y_{N_2} = \frac{50}{100} = \boxed{0.5}$$

Table A-1: $CO_2 = 44.01 \text{ kg/kmol}$
 $O_2 = 31.999 \text{ kg/kmol}$
 $N_2 = 28.013 \text{ kg/kmol}$

$$M_{CO_2} = y_{CO_2} \times M_{CO_2} = 0.2(44.01) = 8.802$$

$$M_{O_2} = y_{O_2} \times M_{O_2} = 0.3(31.999) = 9.5997$$

$$M_{N_2} = y_{N_2} \times M_{N_2} = 0.5(28.013) = 14.0065$$

$$M_m = 32.4082 \text{ kg/kmol}$$

$$mf_{CO_2} = \frac{m_{CO_2}}{m_m} = 0.272$$

$$mf_{O_2} = \frac{m_{O_2}}{m_m} = 0.296$$

$$mf_{N_2} = \frac{m_{N_2}}{m_m} = 0.432$$

b.) $M_m = 32.4082 \text{ kg/kmol}$

$$R_m = \frac{R_u}{M_m} = \frac{8.314}{32.4082} = 0.257 \text{ kJ/kg} \cdot \text{K}$$

Used table A-2 for C_p, C_v at 300K

$$C_{v,m} = \sum mf_i C_{v,i}$$

$$= (0.272)(0.657) + (0.296)(0.658) + (0.432)(0.743)$$

$$C_{v,m} = 0.6944 \text{ kJ/kg} \cdot \text{K}$$

$$C_{p,m} = \sum mf_i C_{p,i}$$

$$= (0.272)(0.846) + (0.296)(0.918) + (0.432)(1.039)$$

$$= 0.9507 \text{ kJ/kg} \cdot \text{K}$$

$$k = \frac{C_{p,m}}{C_{v,m}} = \frac{0.9507}{0.6944} = 1.369$$

13-54.)

Ne	Ar
$T=20^\circ\text{C}$	$T=50^\circ\text{C}$
$P=100\text{kPa}$	$P=200\text{kPa}$

$$Q_{\text{out}} = 15 \text{ kJ}$$

$$V = 0.9 \text{ m}^3$$

$$M_{\text{Ne}} = 20.183 \text{ kg/kmol}$$

$$M_{\text{Ar}} = 0.2081 \text{ kg/kmol}$$

$$P_{\text{Ne}} V_{\text{Ne}} = N_{\text{Ne}} R_u T_{\text{Ne}}$$

$$N_{\text{Ne}} = \frac{P_{\text{Ne}} V_{\text{Ne}}}{R_u T_{\text{Ne}}} = \frac{(100)(0.45)}{(8.314)(20+273)} = 0.0185 \text{ kmol}$$

$$N_{\text{Ar}} = \frac{P_{\text{Ar}} V_{\text{Ar}}}{R_u T_{\text{Ar}}} = \frac{(200)(0.45)}{(8.314)(50+273)} = 0.0335 \text{ kmol}$$

$$N_m = N_{\text{Ne}} + N_{\text{Ar}} = 0.052 \text{ kmol}$$

a) $-Q_{\text{out}} = \Delta U$

(Used table A-2 for C_v)

(Assume 300K)

$$-15 = (m C_v (T_m - T_1))_{\text{Ne}} + (m C_v (T_m - T_2))_{\text{Ar}}$$

$$-15 = (0.373 \cdot 0.6179 (T_m - 20)) + (0.0069 \cdot 0.3122 (T_m - 50))$$

$$-15 = 0.2305 T_m - 4.6095 + 0.00215 T_m - 0.1077$$

$$T_m = 44.19^\circ\text{C}$$

$$m_{\text{Ne}} = N_m = (0.0185)(20.183) = 0.373$$

$$m_{\text{Ar}} = N_m = (0.0335)(0.2081) = 0.0069$$

b) $P_m V_m = N_m R_u T_m$

$$P_m = \frac{N_m R_u T_m}{V_m} = \frac{(0.052)(8.314)(44.19+273)}{0.9} = 152.37 \text{ kPa}$$