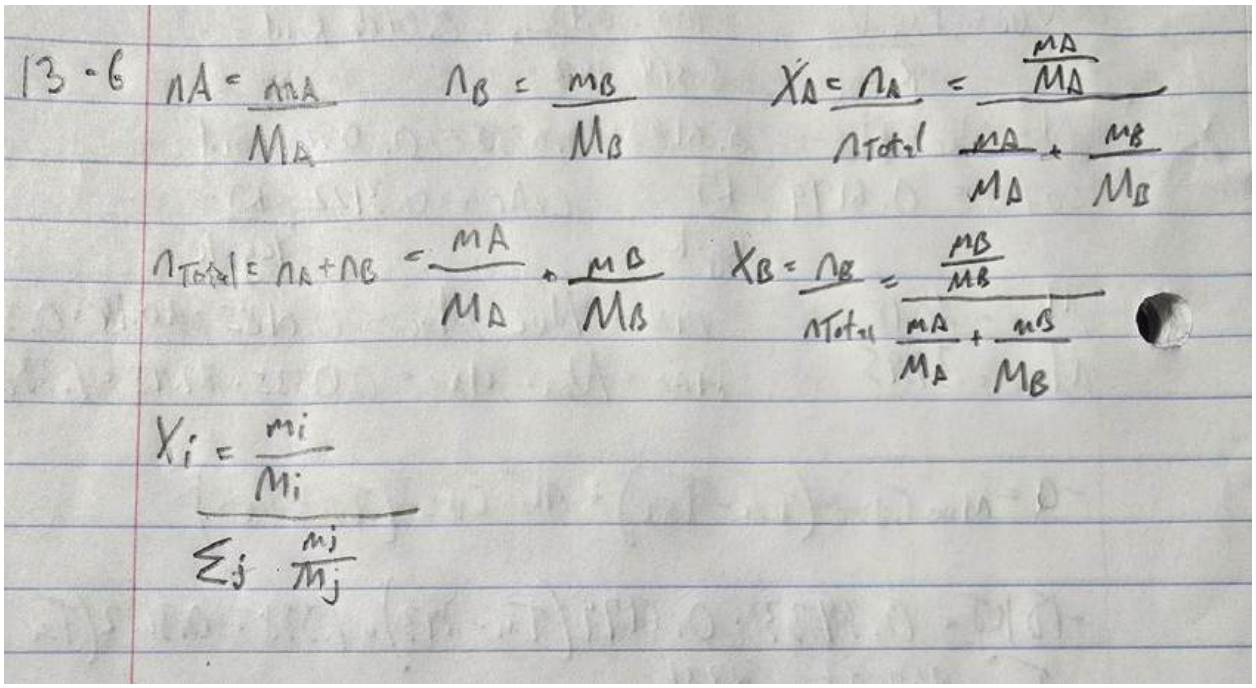
13-1: Mass fractions will be similar if they have the same mass. Mole fractions will not be because they depend on the number of moles
13-2: Yes. The sum of mole fractions is equal to one.
13-3: Yes, they are the same. Both CO2 and N2O's molar mass is 44.01 g/mol
13-4: No, molar mass is a mole-weighted average. The average only works when the mole fractions are equal.
13-5: No, molar mass is not an average. The mass of an individual molecule depends on its chemical identity, not on others.



13-9

$$mf_A = \frac{M_A}{M_A + M_B} \qquad y_A = \frac{\Delta_A}{\Delta_A + \Delta_B} \qquad \Delta_A = \frac{m_A}{M_A} \qquad \Delta_B = \frac{m_B}{M_B}$$

$$M_m = \frac{m_m}{N_m} \qquad m_m = N_A M_A + N_B M_B$$

$$M_m = \frac{N_A M_A + N_B M_B}{N_m} = \frac{N_A}{N_m} M_A + \frac{N_B}{N_m} M_B$$

$$M_m = y_A M_A + y_B M_B \qquad y_A + y_B = 1$$

$$y_B = \frac{M_B}{M_A\left(\frac{1}{mf_A} - 1\right) + M_B} \qquad y_B = 1 - y_A$$

13-12 $m_{CH_4} = 0.75\ kg$ $M_{CH_4} = 16\ kg/kmol$

$m_{CO_2} = 0.25\ kg$ $M_{CO_2} = 44\ kg/kmol$

$$n_{CH_4} = \frac{0.75}{16} = 0.046875\ kmol$$

$$n_{CO_2} = \frac{0.25}{44} = 0.005682\ kmol$$

$n_{total} = 0.046875 + 0.005682 = 0.052557\ kmol$

$$x_{CH_4} = \frac{0.046875}{0.052557} = 0.892$$

$$x_{CO_2} = \frac{0.005682}{0.052557} = 1.08$$

$M_{mix} = x_{CH_4} \cdot M_{CH_4} + x_{CO_2} \cdot M_{CO_2} = 0.892 \cdot 16 + 0.108 \cdot 44$

$M_{mix} = 19.02\ kg/kmol$

$$R_m = \frac{R}{M_{mix}} = \frac{8.314}{19.02} = 0.437\ kJ/kg \cdot k$$

13-13 $m_{H_2} = n_{H_2} \cdot M_{H_2} = 6 \cdot 2 = 12\ kg$ $m_{total} = 12 + 56 = 68\ kg$

$m_{N_2} = n_{N_2} \cdot M_{N_2} = 2 \cdot 28 = 56\ kg$ $n_{total} = 6 + 2 = 8\ kmol$

$$M_{mix} = \frac{m_{total}}{n_{total}} = \frac{68}{6} = 8.5\ kg/kmol$$

$$R_m = \frac{R}{M_{mix}} = \frac{8.314}{8.5} = 0.978\ kJ/kg \cdot k$$

13-1 Mass fractions will be similar if they have same mass
Mole fractions will not because they depend on number of moles

13-30 CO_2 - 20 kPa O_2 30 kPa N_2 50 kPa

$P_M = 20 + 30 + 50 = 100$ kPa

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

$M_{CO_2} = 44.01$ $M_{O_2} = 32.00$ $M_{N_2} = 28.01$ kg/kmol

$M_m = \sum y_i M_i = (0.2 \cdot 44.01) + (0.3 \cdot 32) + (0.5 \cdot 28.1) = 32.41$ kg/kmol

$mf_{CO_2} = \frac{y_i M_i}{M_m} = \frac{0.2(44.01)}{32.41} = 0.2716$

$mf_{O_2} = \frac{0.3(32)}{32.41} = 0.2962$ $mf_{N_2} = \frac{0.5(28.01)}{32.41} = 0.4322$

$R_m = \frac{R_u}{M_m} = \frac{8.314}{32.41} \approx 0.2565$ kJ/kg K

@ 300K $CO_2 = 0.657$ $O_2 = 0.658$ $N_2 = 0.743$

$C_{v,m} = \sum mf_i C_{v,i} = (0.2716 \cdot 0.657) + (0.2962 \cdot 0.658) + (0.4322 \cdot 0.743) = 0.6446$

$C_{p,m} = C_{v,m} + R_m = 0.6446 + 0.2565 = 0.9011$

$K_m = \frac{C_{p,m}}{C_{v,m}} = 1.369$

13-39 $M_{CH_4} = 16.04$ kg/mol $M_{air} = 28.97$ kg/kmol

$M_m = y_{CH_4} M_{CH_4} + y_{air} M_{air}$

$= (0.15)(16.04) + (0.85)(28.97) = 27.03$ kg/kmol

$\dot{V} = V_{disp} \cdot \frac{RPM}{2} \rightarrow 5\,L \cdot \frac{3500 \text{ rev/min}}{2} = 7.5\ m^3/min$

$P = \rho R_m T$ $P = 80$ kPa $T = 293.15$ K $R_u = 8.314$ kJ/kmol·K

$\rho = \frac{P \cdot M_m}{R_u T} = \frac{80 \cdot 27.03}{8.314 \cdot 293.15} = 0.887$ kg/m³

$\dot{m} = \rho \dot{V} = 0.887 \cdot 7.5 = 6.65$ kg/min

13-58 $V = 0.9\,m^3$ $P_{Ne} = 100\,kPa$ $T_{Ne} = 293\,K$

$Q = 15\,kJ$ $P_{Ar} = 200\,kPa$ $T_{Ar} = 323\,K$

$V_{Ne} = V_{Ar} = \frac{V}{2} = \frac{0.9}{2} = 0.45\,m^3$

$N_{Ar} = \frac{P_{Ar} V_{Ar}}{R T_{Ar}} = \frac{200 \cdot 0.45}{8.314 \cdot 323} = 0.0335\,kmol$

$N_{Ne} = \frac{P_{Ne} V_{Ne}}{R T_{Ne}} = \frac{100 \cdot 0.45}{8.314 \cdot 293} = 0.0185\,kmol$

$N = N_{Ar} + N_{Ne} = 0.0185 + 0.0335 = 0.052\,kmol$

$C_v Ar = 0.6179\ \frac{kJ}{kg \cdot k}$ $C_v Ar = 0.3122\ \frac{kJ}{kg \cdot k}$

$M_{Ne} = 20.18$ $m_{Ne} = N_{Ne} \cdot M_{Ne} = 0.0185 \cdot 20.18 = 0.3733\,kg$

$M_{Ar} = 39.95$ $m_{Ar} = N_{Ar} \cdot M_{Ar} = 0.0335 \cdot 39.95 = 1.338\,kg$

$-Q = m_{Ne} C_{v Ne} (T_m - T_{Ar}) + m_{Ar} C_{v Ar} (T_m - T_{Ar})$

$-15\,kJ = 0.3733 \cdot 0.6179 (T_m - 293) + 1.338 \cdot 0.3122 (T_m - 323)$

$T_m = 269.2\,k = 273\,k$

$T_m = 16.2°C$

$P_m = \frac{N R T_m}{V} = \frac{0.052 \cdot 8.314 \cdot 289.2}{0.9} = 138.92\,kPa$

13-59 $N_{CH_4} = 3.75\,kmol$

$N_{C_3H_8} = 0.5682\,kmol$ $M_{mix} = \frac{100}{3.75 + 0.5682 + 0.2586}$

$N_{C_4H_{10}} = 0.2586\,kmol$

$R_m = \frac{R}{M_{mix}} = \frac{8.319}{21.85} = 0.3805$ $M_{mix} = 21.85\ \frac{kg}{kmol}$

13.59 cont

$$W_{in} = R_m T \ln\left(\frac{P_2}{P_1}\right) = 0.3805 \cdot 293 \ln\left(\frac{1000}{100}\right)$$

$W_{in} = 257$ kJ/kg

$W_{in} = Q_{out}$

13-3

$n_{N_2} = 78$ kmol $M_{N_2} = 28.01$ kg/kmol $m_{N_2} = 2184.28$ kg

$n_{O_2} = 20$ kmol $M_{O_2} = 32$ $m_{O_2} = 640.00$ kg

$n_{H_2O} = 2$ kmol $M_{H_2O} = 18.02$ $m_{H_2O} = 36.04$ kg

$m_{tot} = 2184.28 + 640.00 + 36.04 = 2860.32$

$mf_{N_2} = \frac{m_i}{m_m} = \frac{2184}{2860} = 0.7637$ $mf_{O_2} = 0.2237$ $mf_{H_2O} = 0.0126$

13-4

$y_{N_2} = 0.6$ $y_{CO_2} = 0.4$

$M_{mix} = \sum y_i M_i = 0.6(28.01) + (0.4)(44.01) = 34.41$

$R_m = \frac{R_u}{M_m} = \frac{8.314}{34.41} = 0.2416$ $mf_{O_2} = \frac{0.6(32)}{34.41} = 0.489$ $mf_{CO_2} = \frac{0.4(44.01)}{34.41} = 0.512$

13-10

$(0.6)(32) + (0.4)(44.01) = 36.80$

$R_m = \frac{8.314}{36.8} = 0.2259$ kJ/kg·K $mf_{O_2} = \frac{(0.6)(32)}{36.80} = 0.522$ $mf_{CO_2} = \frac{0.4(44.01)}{36.80} = 0.478$

13-11

$M_{O_2} = 2$kg $M_{N_2} = 5$kg $M_{CO_2} = 7$kg

$mf_{O_2} = 0.143$ $mf_{N_2} = 0.357$ $mf_{CO_2} = 0.5$

$n_{O_2} = \frac{2}{32} = 0.0625$ $n_{N_2} = \frac{5}{28.01} = 0.1785$ $n_{CO_2} = \frac{7}{44.01} = 0.1591$ $n_{tot} = 0.4001$ kmol

$y_{O_2} = 0.156$ $y_{N_2} = 0.446$ $y_{CO_2} = 0.398$

$M_{avg} = \frac{M_{tot}}{n_{tot}} = \frac{14}{0.4001} = 34.99$ $R_m = \frac{8.314}{34.99} = 0.2376$