HW 3.2)

4-5-19

13-1)

Mass fractions will be the same, but mole fractions will be different. In this case, the mass is the same between gasses. Since they are different gasses, it depends on the number of moles of each gas.

13-2)

The mole fraction for both ideal-gas mixtures and real-gas mixtures will be equal to 1.

13-3)

True. Both gasses have the same molar masses of 44 kg/mol

13-4)

It cannot be determined since each gas will have different molar masses

13-5)

The average molar mass of the gas mixture.
They will not since they will have different molar masses.

13-6)

Mass fraction — $mf_i = \frac{m_i}{m_m}$, Mole fraction — $y_i = \frac{N_i}{N_m}$

$$N_i = \frac{m_i}{M_i}, \quad m_i = m_m \times mf_i \Rightarrow N_i = \frac{m_m \times mf_i}{M_i}$$

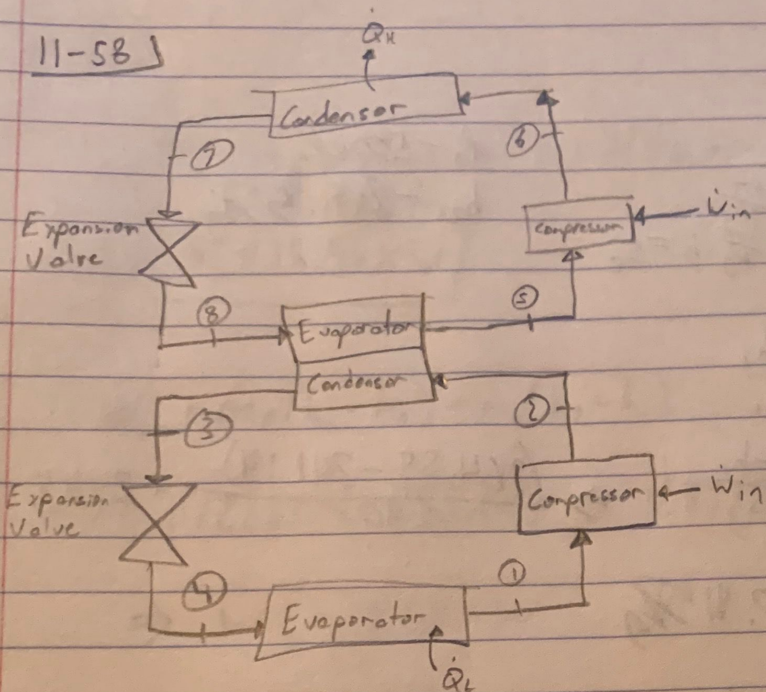
$$N_i = N_m \times y_i \Rightarrow N_m \times y_i = \frac{m_m \times mf_i}{M_i} \Rightarrow y_i = \frac{m_m \times mf_i}{N_m \times M_i}$$

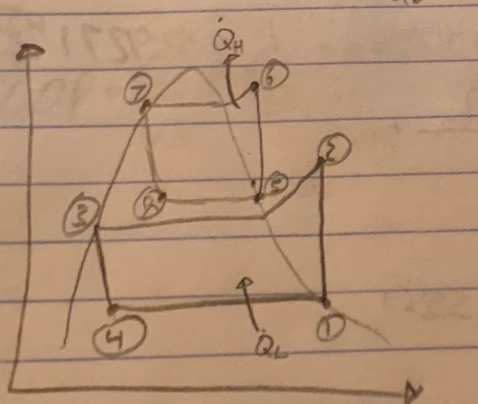
$$M_m = \frac{m_m}{N_m} \Rightarrow \boxed{y_i = \left(\frac{M_m}{M_i}\right)(mf_i)}$$

HW 3.2

4-5-19

11-58




T-s Diagram of the cycle

11-58

$P_1 = 160 kPa$
$h_1 = 241.14 \frac{kJ}{kg}$
$s_1 = 0.9420 \frac{kJ}{kg} \cdot k = s_2$

$P_3 = 500 kPa$
$h_{2s} = 264.55 kJ/kg$

$$\eta_c = \frac{h_{2s} - h_1}{h_2 - h_1}$$

$$\Rightarrow h_2 = \frac{h_{2s} - h_1}{\eta_c} + h_1 \Rightarrow \frac{(264.55 - 241.14)}{0.80} + 241.14$$

$$\Rightarrow h_2 = 270.41 kJ/kg$$

$h_3 = 73.32 kJ/kg$ $\quad P_5 = 400 kPa$ $\quad h_5 = 0.9271 \frac{kJ}{kg} \cdot k$

$$\eta_c = \frac{h_{6s} - h_5}{h_6 - h_5} \Rightarrow h_6 = \frac{h_{6s} - h_5}{\eta_c} + h_5$$

$$\Rightarrow \frac{(281.56 - 255.61)}{0.80} + 255.61$$

$$h_6 = 288.04 kJ/kg$$

$$h_7 = 127.25 kJ/kg = h_8$$

$$\dot{m}_A(h_5 - h_8) = \dot{m}_B(h_2 - h_3) \Rightarrow \dot{m}_A = \dot{m}_B \frac{(h_2 - h_3)}{(h_5 - h_8)}$$

$$\Rightarrow 0.11 \frac{(270.41 - 73.32)}{(255.61 - 127.25)}$$

$$\boxed{\Rightarrow \dot{m}_A = 0.1689 kg/s}$$

MET 350

11-58)

$$\dot{Q}_L = \dot{m}_B(h_1 - h_4) \Rightarrow (0.11)(241.14 - 73.32)$$

$$\boxed{\dot{Q}_L = 18.46\ kW}$$

$$\dot{W}_{in} = \dot{m}_A(h_6 - h_5) + \dot{m}_B(h_2 - h_1)$$

$$\Rightarrow 0.11(288.04 - 255.61) + 0.1689(270.91 - 241.14)$$

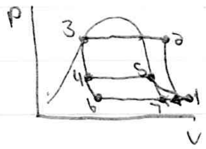
$$\Rightarrow \dot{W}_{in} = 8.511\ kW$$

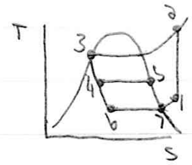
$$COP = \frac{\dot{Q}_L}{\dot{W}_{in}} \Rightarrow \frac{18.46}{8.511} \Rightarrow \boxed{COP = 2.14}$$

Jordan Whitaker

CH 11

(60)




$h_3(h_f) = 95.48\ kJ/kg$ } Ref-134a Pressure table

$h_5(h_g) = 250.50\ kJ/kg$ } Ref-134a Temp. Table

(using Ref-134a Temp. table)

$$h_7 = h_g@T=-28 + (h_g@T=-26 - h_g@T=-28)\left(\frac{T_7 - T@T=-28}{T@T=-26 - T@T=-28}\right)$$

$$= 233.44 + (234.70 - 233.44)\left(\frac{-26.4-(-28)}{-26-(-28)}\right)$$

$$\boxed{h_7 = 234.44\ kJ/kg}$$

$$\dot{Q}_L = \dot{m}_2(h_7 - h_6) \Rightarrow \dot{m}_2 = \frac{\dot{Q}_L}{(h_7-h_6)} = \frac{8}{(234.44-95.48)}$$

$$\boxed{\dot{m}_2 = 0.05757\ kg/s}$$

$$\dot{m}_1 = \dot{m} - \dot{m}_2 = 0.1 - 0.05757$$

$$\boxed{\dot{m}_1 = 0.04243\ kg/s}$$

$$\dot{m}_1 h_5 + \dot{m}_2 h_7 = \dot{m} h_1 \Rightarrow h_1 = \frac{\dot{m}_1 h_5 + \dot{m}_2 h_7}{\dot{m}} = \frac{(0.04243)(250.50) + (0.05757)(234.44)}{0.1}$$

$$\boxed{h_1 = 241.25\ kJ/kg}$$

(using Ref-134a Temp. Table)

$$P_1 = P@T=-28 + (P@T=-26 - P@T=-28)\left(\frac{T_1 - T@T=-28}{T@T=-26 - T@T=-28}\right)$$

$$= 92.76 + (101.73 - 92.76)\left(\frac{-26.4-(-28)}{-26-(-28)}\right)$$

$$\boxed{P_1 = 100\ kPa}$$

(using superheated Ref-134a Table)

$$s_1 = s@h=239.52 + (s@h=247.51 - s@h=239.52)\left(\frac{h_1 - h@h=239.52}{h@h=247.51 - h@h=239.52}\right)$$

$$= 0.9721 + (1.0031 - 0.9721)\left(\frac{241.25 - 239.52}{247.51 - 239.52}\right)$$

$$\boxed{s_1 = 0.9788\ kJ/kg\cdot K}$$

(using Superheated Ref-134a Table)

$$h_2 = h@s=0.9481 + (h@s=0.9803 - h@s=0.9481)\left(\frac{s_2 - s@s=0.9481}{s@s=0.9803 - s@s=0.9481}\right)$$

$$= 276.46 + (286.71 - 276.46)\left(\frac{0.9788-0.9481}{0.9803-0.9481}\right)$$

$$\boxed{h_2 = 286.23\ kJ/kg}$$

$$\dot{Q}_L = \dot{m}_1 (h_5 - h_4)$$

$$= (0.04243)(250.50 - 95.48)$$

$$\boxed{\dot{Q}_L = 6.578 \text{ kW}}$$

$$\dot{W}_{in} = \dot{m}(h_2 - h_1)$$

$$= (0.1)(286.23 - 241.25)$$

$$\boxed{\dot{W}_{in} = 4.498 \text{ kW}}$$

$$COP_R = \frac{\dot{Q}_L}{\dot{W}_{in}}$$

$$= \frac{(8+6.578)}{4.498}$$

$$\boxed{COP_R = 3.24}$$

CH 12

7. $h@410K = 11932$ kJ/kmol
$h@390K = 11347$ kJ/kmol
$u@410K = 8523$ kJ/kmol
$u@390K = 8104$ kJ/kmol
Ideal gas Nitrogen Table

$$C_{p@T=400K} = \left(\frac{\Delta h(T)}{\Delta T}\right)_{T=400K} = \frac{\frac{11932-11347}{28.013}}{(410-390)}$$

$$\boxed{C_{p@T=400K} = 1.0446 \text{ kJ/kg}\cdot K}$$

$$C_{v@T=400K} = \left(\frac{\Delta u(T)}{\Delta T}\right)_{T=400K} = \frac{\frac{8523-8104}{28.013}}{(410-390)}$$

$$C_{v@T=400K} = 0.748 \text{ kJ/kg}\cdot K$$

8. $h(820R) = 5704.7$
$h(780R) = 5424.2$
Table A-18E

$$C_p = \frac{h(820R) - h(780R)}{\Delta T} = \frac{5704.7 - 5424.2}{820-780}$$

$$C_p = 7.0125 \text{ Btu/lbmol}\cdot°R \Rightarrow \frac{7.0125}{28}$$

$$\boxed{C_p = 0.25 \text{ Btu/lbm}\cdot°R}$$

$u(820R) = 4076.3$
$u(780R) = 3875.2$
Table A-18E

$$C_v = \frac{u(820R) - u(780R)}{\Delta T} = \frac{4076.3 - 3875.2}{820-780}$$

$$C_v = 5.0275 \text{ Btu/lbmol}\cdot°R \Rightarrow \frac{5.0275}{28}$$

$$\boxed{C_v = 0.1795 \text{ Btu/lbm}\cdot°R}$$

(using Table A-2E)

$$\boxed{\begin{aligned} C_p &= 0.262 \text{ Btu/lbm}\cdot°R \\ C_v &= 0.191 \text{ Btu/lbm}\cdot°R \end{aligned}}$$

9. $$dz = \left(\frac{\partial z}{\partial x}\right)_y dx + \left(\frac{\partial z}{\partial y}\right)_x dy$$

a) $$dv = \left(\frac{\partial v}{\partial T}\right)_P dT + \left(\frac{\partial v}{\partial P}\right)_T dP \quad (1)$$

$$\Rightarrow dv = R\left(\frac{1}{P}dT - \frac{T}{P^2}dP\right) \quad (2)$$

air: 0.287 kJ/kg·K (gas Const. Table)

$dT = T_1 - T_2$
$= 305 - 300$
$\boxed{dT = 5K}$
$dP = P_1 - P_2$
$= 96 - 100$
$\boxed{dP = -4 \text{ kPa}}$

$$dv = 0.287\left(\frac{1}{98}(5) - \frac{302.5}{(98)^2}(-4)\right)\left(\frac{1 \text{ kPa}\cdot m^3}{\text{kJ}}\right)$$

$$\boxed{dv = 0.0508 \text{ m}^3/\text{kg}}$$

b) $V_1 = \frac{RT_1}{P_1}$

$= \frac{(0.287)(300)}{100}\left(\frac{1 kPa \cdot m^3}{1 kJ}\right)$

$\boxed{V_1 = 0.8610 \; m^3/kg}$

$V_2 = \frac{RT_2}{P_2}$

$= \frac{(0.287)(305)}{96}\left(\frac{1 kPa \cdot m^3}{1 kJ}\right)$

$\boxed{V_2 = 0.9118 \; m^3/kg}$

$\Delta V = V_2 - V_1$

$= 0.9118 - 0.8610$

$\boxed{\Delta V = 0.0508 \; m^3/kg}$

⑪ $P(v-a) = RT$

$P = \frac{RT}{v-a}$

$V = \frac{RT}{P} + a$

$T = \frac{P(v-a)}{R}$

a) $\left(\frac{\partial P}{\partial v}\right)_T \left(\frac{\partial v}{\partial T}\right)_P \left(\frac{\partial T}{\partial P}\right)_v = -1$

$\left(\frac{\partial P}{\partial v}\right)_T = \left(\frac{\partial}{\partial v}\left(\frac{RT}{v-a}\right)\right)_T$

$\boxed{\left(\frac{\partial P}{\partial v}\right)_T = -\frac{P}{v-a}}$

$\left(\frac{\partial v}{\partial T}\right)_P = \left(\frac{\partial}{\partial T}\left(\frac{RT}{P} + a\right)\right)_P$

$\boxed{= \frac{R}{P}}$

$\left(\frac{\partial T}{\partial P}\right)_v = \left(\frac{\partial}{\partial P}\left(\frac{P(v-a)}{R}\right)\right)$

$\boxed{= \frac{v-a}{R}}$

$$\boxed{\begin{gathered}\left(-\frac{P}{v-a}\right)\left(\frac{R}{P}\right)\left(\frac{v-a}{R}\right) = -1 \\ -1 = -1\end{gathered}}$$

b) $\left(\frac{\partial P}{\partial T}\right)_v = \frac{1}{\left(\frac{\partial T}{\partial P}\right)_v}$

$\left(\frac{\partial P}{\partial T}\right)_v = \left(\frac{\partial}{\partial T}\left(\frac{RT}{v-a}\right)\right)$

$\boxed{= \frac{R}{v-a}}$

$\frac{R}{v-a} = \frac{1}{\frac{v-a}{R}}$

$\boxed{\frac{R}{v-a} = \frac{R}{v-a}}$

(11) $T = \frac{1}{R}\left(P + \frac{a}{v^2}\right)(v-b)$

$\left(\frac{\partial T}{\partial P}\right)_v = \frac{1}{R}(1+0)(v-b)$

$\boxed{\left(\frac{\partial T}{\partial P}\right)_v = \frac{(v-b)}{R}}$

(12) $\left(\frac{\partial s}{\partial P}\right)_{@T=50^\circ C} = \left(\frac{s_{0.7mpa} - s_{0.6mpa}}{0.7\,mpa - 0.6\,mpa}\right)_{@T=50^\circ C}$

$LHS = \left(\frac{s_{0.7mpa} - s_{0.6mpa}}{800 - 600}\right)_{@T=50^\circ C}$

$s_{@0.8mpa} = 0.9802\ kJ/kg \cdot k$ } Superheated Ref-134a Table

$s_{@0.6mpa} : 1.0121\ kJ/kg \cdot k$

$\left(\frac{\partial s}{\partial P}\right)_{@T=50^\circ C} = \left(\frac{0.9802 - 1.0121}{800 - 600}\right)_{@T=50^\circ C}$

$\boxed{= -1.595 \times 10^{-4}}$

$RHS = -\left(\frac{v_{@60^\circ C} - v_{@40^\circ C}}{(60-40)^\circ C}\right)_{P=700kPa}$

$v_{@60^\circ C} = 0.034875\ m^3/kg$ } Superheated Ref-134a Table

$v_{@40^\circ C} = 0.031696\ m^3/kg$

$-\left(\frac{\partial v}{\partial T}\right)_P = -\left(\frac{v_{333k} - v_{313k}}{333k - 313k}\right)_{P=700kPa}$

$= -\left(\frac{0.034875 - 0.031696}{333 - 313k}\right)_{P=700kPa}$

$\boxed{= -1.5895 \times 10^{-4}}$

$\boxed{-1.595 \times 10^{-4} = -1.5895 \times 10^{-4}}$