Jordan Whitaker

HW 3.3

(30) $M_{O_2} = 31.99$ kg/kmol, $M_{CO_2} = 44.01$ kg/kmol, $M_{N_2} = 28.013$ kg/kmol } Table A-1

$(C_{O_2})_{cv} = 0.657$ kJ/kg·K, $(O_2)_{cv} = 0.658$ kJ/kg·K, $(N_2)_{cv} = 0.743$ kJ/kg·K } Table A-2a

$P_{total} = P_{CO_2} + P_{O_2} + P_{N_2}$

$= 20 + 30 + 50$

$P_{total} = 100$ kPa

$y_{CO_2} = \frac{P_{CO_2}}{P_{total}} = \frac{20}{100}$

$y_{CO_2} = 0.20$

$y_{O_2} = \frac{P_{O_2}}{P_{total}} = \frac{30}{100}$

$y_{O_2} = 0.30$

$y_{N_2} = \frac{P_{N_2}}{P_{total}} = \frac{50}{100}$

$y_{N_2} = 0.50$

$m_{CO_2} = N_{CO_2} M_{CO_2}$

$= 20(44.01)$

$m_{CO_2} = 880$ kg

$m_{O_2} = N_{O_2} M_{O_2}$

$= 30(31.99)$

$m_{O_2} = 959.7$ kg

$m_{N_2} = N_{N_2} M_{N_2}$

$= 50(28)$

$m_{N_2} = 1400.65$ kg

$m_{total} = m_{CO_2} + m_{O_2} + m_{N_2}$

$= 880 + 959.7 + 1400.65$

$m_{total} = 3240.35$ kg

$mf_{CO_2} = \frac{m_{CO_2}}{m_{total}} = \frac{880}{3240.35}$

$mf_{CO_2} = 0.2716$

$mf_{O_2} = \frac{m_{O_2}}{m_{total}} = \frac{959.7}{3240.35}$

$mf_{O_2} = 0.296$

$mf_{N_2} = \frac{m_{N_2}}{m_{total}} = \frac{1400.65}{3240.35}$

$mf_{N_2} = 0.4322$

$M_m = \frac{m_{total}}{N_{total}} = \frac{3240.35}{100}$

$M_m = 32.40$ kg/mol

$C_v = mf_{CO_2}(C_{O_2})_{cv} + mf_{O_2}(O_2)_{cv} + mf_{N_2}(N_2)_{cv}$

$= (0.2716)(0.651) + (0.296)(0.658) + 0.4322(0.743)$

$C_v = 0.6943$ kJ/kg·K

$R = \frac{R_u}{M_m} = \frac{8.314}{32.40}$

$R = 0.2566$ kJ/kg·K

$C_p = C_v + R$

$= 0.6943 + 0.2566$

$\boxed{C_p = 0.9509 \text{ kJ/kg·K}}$

$k = \frac{C_p}{C_v}$

$= \frac{0.9509}{0.69415}$

$\boxed{k = 1.37}$

(3a)

$y_{CH_4} = 15\% = 0.15$

$V_d = 5\text{ L} = 0.005 \text{ m}^3$

$T_m = 20^\circ\text{C} = 20^\circ\text{C} + 273.15$

$= 293.15 \text{ K}$

$M = 28.97 \text{ kg/kmol}$
$M = 16.043 \text{ kg/kmol}$ } Table A-1

$y_{air} = 1 - y_{CH_4}$

$= 1 - 0.15$

$\boxed{y_{air} = 0.85}$

$M_m = \frac{m_m}{N_m}$

$= \frac{\sum N_i M_i}{N_m}$

$= \sum_{k=1}^{k} y_i M_i$

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

$= 0.15(16.043) + (0.85)(28.97)$

$\boxed{M_m = 27.031 \text{ kg/kmol}}$

$\dot{V} = \frac{N V_d}{2}$

$= \frac{3000(0.005)}{2}$

$\boxed{\dot{V} = 7.5 \text{ m}^3/\text{min}}$

$P_m V_m = \frac{R_u}{M_m} T_m \Rightarrow V_m = \frac{R_u T_m}{M_m P_m}$

$= \frac{8.314(293.15)}{27.031(800)}$

$\boxed{V_m = 1.1271 \text{ m}^3/\text{kg}}$

$\dot{m} = \frac{\dot{V}}{V_m}$

$= \frac{7.5}{1.1271}$

$\boxed{\dot{m} = 6.654 \text{ kg/min}}$

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$M_{CH_4} = 16.043\ kg/kmol$
$M_{C_3H_8} = 44.097\ kg/kmol$
$M_{C_4H_{10}} = 58.124\ kg/kmol$

$N_{CH_4} = \frac{m_{CH_4}}{M_{CH_4}} \Rightarrow N_{CH_4} = \frac{60\,kg}{16.043\,kg/kmol}$ $N_{CH_4} = 3.74\ kmol$

$N_{C_3H_8} = \frac{m_{C_3H_8}}{M_{C_3H_8}} \Rightarrow N_{C_3H_8} = \frac{25\,kg}{44.097}$ $N_{C_3H_8} = .567\ kmol$

$N_{C_4H_{10}} = \frac{m_{C_4H_{10}}}{M_{C_4H_{10}}} \Rightarrow N_{C_4H_{10}} = \frac{15\,kg}{58.124}$ $N_{C_4H_{10}} = 0.258\ kmol$

$N_m = N_{CH_4} + N_{C_3H_8} + N_{C_4H_{10}} = 4.565\ kmol$

$M_m = \frac{m_m}{N_m} \Rightarrow \frac{100\,kg}{4.565} = 21.905\ kg/kmol$

$R = \frac{R_u}{M_m} = \frac{8.314}{21.905} = 0.3795\ kJ/kg \cdot K$

$W_{in} = RT \ln\left(\frac{P_2}{P_1}\right) \Rightarrow (0.3795)(293) \cdot \ln\left(\frac{1000}{100}\right)$

$= 256.03\ kJ/kg$ $W_{in} = Q_{out}$

13-54

$$P_{mix} = \frac{n_{mix} R_u T_{mix}}{V_{mix}}$$

$$\Rightarrow P_{mix} = \frac{(0.052)(8.314)(289.2)}{(0.9)}$$

$$= 138.9 \text{ kPa}$$

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Molar Masses

$M_{Ne} = 20.18 \frac{kg}{mol}$

$M_{Ar} = 39.95 \frac{kg}{mol}$

$T_{Ne} = 20°C = 293K$

$T_{Ar} = 50°C = 323K$

$N_{Ne} = \left(\frac{P_1 V_1}{R_u T_1}\right)$

$\Rightarrow \frac{(100kPa)(0.45m^3)}{(8.314 kPa\cdot m^3/kmol\cdot K)(293K)}$

$N_{Ne} = 0.0185 kmol$

$N_{Ar} = \left(\frac{P_1 V_1}{R_u T_1}\right)$

$\Rightarrow \frac{(200)(0.45)}{(8.314)(323)}$

$N_{Ar} = 0.0335 kmol$

$N_{mix} = N_{Ne} + N_{Ar}$

$N_{mix} = 0.0520 kmol$

$\Delta E = E_{in} - E_{out}$

$\Rightarrow -Q_{out} = \Delta U_{Ne} + \Delta U_{Ar}$

$\Rightarrow -Q_{out} = [mc_v(T_m - T_1)]_{Ne} + [mc_v(T_m - T_1)]_{Ar}$

$\Rightarrow -Q_{out} = [NMc_v(T_m - T_1)]_{Ne} + [NMc_v(T_m - T_1)]_{Ar}$

$\Rightarrow -15kJ = [(0.0185)(20.18)(0.6179)[T_m - 20°C)] +$

$[(0.035)(39.95)(0.3122)[T_m - 50°C)]$

$\boxed{\Rightarrow T_m = 16.2°C}$