Problem set 11

1) A gas mixture at 350 K and 300 kPa has the following volumetric analysis: 65% N₂, 20% O₂, and 15% CO₂. Determine the mass fraction and partial pressure of each gas.

\[ y_i = \frac{V_i}{V} \]
\[ m_i = \rho_i V_i \]
\[ P_i = \frac{m_i}{M_i} \]

\[ y_N = 0.65 \]
\[ y_O = 0.2 \]
\[ y_{CO_2} = 0.15 \]

\[ N_2 : 18.2 \]
\[ O_2 : 6.4 \]
\[ CO_2 : 6.6 \]

\[ P_N = 101.3 \text{ kPa} \]
\[ P_O = 20.1 \text{ kPa} \]
\[ P_{CO_2} = 44.4 \text{ kPa} \]

\[ P_i = P_{total} + y_i \]

\[ P_{total} = 300 \text{ kPa} \]

2) An insulated tank that contains 1 kg of O₂ at 15°C and 300 kPa is connected to a 2-m³ uninsulated tank that contains N₂ at 50°C and 500 kPa. The valve connecting the two tanks is opened, and the two gases form a homogeneous mixture at 25°C. Determine:

a) The final pressure of the tank.

b) The heat transfer.

c) The entropy generated during the process.

\[ V_2 = \frac{m_{O_2} R T_2}{P_2} \]
\[ m_{O_2} = \frac{(200 \text{ L/h})(2 \text{ kPa})}{(28.314 \text{ L/mol K})(25+273) \text{ K}} \]

\[ V_{O_2} = 0.25 \text{ m}^3 \]

\[ V_{N_2} = (10.42 \text{ kPa}) \frac{(28.314 \text{ L/mol K})(25+273) \text{ K}}{20.25 \text{ kPa}} \]

\[ P_{O_2} = \frac{m_{N_2} R T_2}{V_2} \]

\[ P_{N_2} = 44.4 \text{ kPa} \]

\[ (T_2 = -m_{O_2} \frac{(U(T_2) - U(T_1))_{O_2}}{m_{O_2}} + m_{N_2} \frac{(U(T_2) - U(T_1))_{N_2}}{m_{N_2}}) \]
\[ \Delta S = \Delta S_{N_2} + \Delta S_{O_2} \]

\[ \Delta S = \left[ m_{N_2} \left( \frac{S^0(T_2) - S^0(T_1)}{T_2} \right) - \frac{P_{N_2}}{R_{\text{L.m.}}} \right] - \left[ m_{O_2} \left( \frac{S^0(T_2) - S^0(T_1)}{T_2} \right) - \frac{P_{O_2}}{R_{\text{L.m.}}} \right] \]

\[ \Delta S = -101.0 \text{ kJ/mol} \]

\[ \Delta S = 10.42 \text{ kJ/mol} - \frac{1}{32} \left( 205.033 - 190.475 \right) \frac{34}{300} \]

\[ \Delta S = -0.263 \frac{\text{kJ}}{\text{mol}} + 1.02 \frac{\text{kJ}}{\text{mol}} \]

\[ \Delta S = 0.757 \frac{\text{kJ}}{\text{mol}} \]

\[ S_{\text{gen}} = \frac{\Delta S}{T_{\text{m.c.}}} = 0.757 \frac{\text{kJ}}{\text{mol}} \]

\[ S_{\text{gen}} = 1090 \frac{\text{kJ}}{\text{mol}} \]