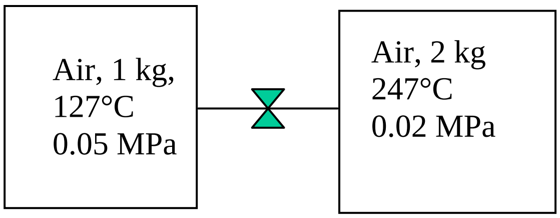
Two tanks filled with air are connected by a valve as shown. If the valve is opened and the gases are allowed to mix while receiving heat from the surrounding. The final temperature is 227°C. Determine (a) the final pressure of the mixture, (b) the amount of heat transfer during the mixing process. Assume ideal gas model is valid and little change of KE & PE. Both the initial and the final states are in equilibrium



From table A-1, T_C=132.5 K, P_C=3.77 MPa, T_R=3, P_R=0.0133 for tank 1
From Figure 3-51, compressibility factor Z=1, good ideal gas assumption. The same can be said about tank 2 ⇒ can be treated as ideal gas

$$P_f = \frac{mRT_f}{V}, \text{ where } \mathrm{V} = \mathrm{V}_1 + \mathrm{V}_2 \text{ is the total volume of both tanks.}$$

$$\mathrm{m} = \mathrm{m} + \mathrm{m} \text{ is the total mass of both tanks.}$$

$$V_1 = \frac{m_1 R T_1}{P_1}, V_2 = \frac{m_2 R T_2}{P_2}$$

$$P_f = \frac{(m_1 + m_2) R T_f}{\dfrac{m_1 R T_1}{P_1} + \dfrac{m_2 R T_2}{P_2}} = \frac{(1+2)(273+227)}{\dfrac{(1)(400)}{0.05} + \dfrac{(2)(520)}{0.02}} = 0.025(MPa)$$

(b) The heat transfer can be found from the energy balance

$$\mathrm{E}_\mathrm{f} - E_i = U_f - U_i = Q - W$$

$$Q = U_f - U_i = (m_1 + m_2)u(T_f) - \left[m_1 u(T_1) + m_2 u(T_2)\right]$$

$$Q = m_1[u(T_f) - u(T_1)] + m_2[u(T_f) - u(T_2)]$$

$$= m_1 C_{v,avg,f-1}(T_f - T_1) + m_2 C_{v,avg,f-2}(T_f - T_2) \text{ (see eq 3-44, p.110)}$$

where $C_{v,avg,f-1} = (1/2)(0.726 + 0.742) = 0.734(kJ/kgK)$

can be found using averaged $\mathrm{C_v}$ and table A - 2 (p.1084)

$$C_{vf} = 0.742(@\,500°C), \quad C_{v1} = 0.726(@\,400°C)$$

$$C_{v2} \approx 0.746 \text{ (kJ/kg K)}$$

interpolating between T = 500K & 600K

since $\mathrm{T}_2 = 520K$

$$C_{v,avg,f-2} \approx 0.744 \text{ (kJ/kg K)}$$

$$\mathrm{Q} = (1)(0.734)(500 - 400) + (2)(0.744)(500 - 520) = 43.8(\mathrm{kJ})$$