CHE 260 QUIZ 1 2018

1) $P_1 = 200\ kPa \quad V_1 = 0.1\ m^3 \quad T_1 = 30^\circ C$

$P_2 = 225\ kPa.$

$P = P_0 + cV^{1/2}$ where $P_0 = 100\ kPa.$

At initial conditions

$$200 = 100 + c\,(0.1)^{1/2}$$

$$\Rightarrow \quad c = 316.23 \quad kPa/m^{3/2}$$

At final conditions

$$225 = 100 + 316.23\,V_2^{1/2}$$

$$V_2 = 0.156\ m^3$$

Assuming ideal gas $\quad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$$\Rightarrow \quad T_2 = \frac{P_2V_2}{P_1V_1}T_1 = \frac{225\ kPa \times 0.156\ m^3}{200\ kPa \times 0.1\ m^3}\ 303.15K$$

$$T_2 = 532\ K = 259^\circ C.$$

$$W_{12} = -\int_{V_1}^{V_2} P\,dV = -\int_{V_1}^{V_2} (P_0 + cV^{1/2})\,dV$$

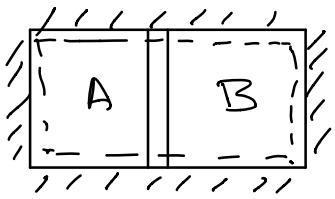
$$= -\left[P_0V + \frac{2}{3}cV^{3/2}\right]_{V_1}^{V_2}$$

$$= -\left[P_0(V_2 - V_1) + \frac{2}{3}c\left(V_2^{3/2} - V_1^{3/2}\right)\right]$$

$$W_{12} = -\left[100\,(0.156 - 0.1) + \frac{2}{3} \times 316.23\left(0.156^{3/2} - 0.1^{3/2}\right)\right]$$

$$= -(5.60 + 6.32) = -11.9\ kJ$$

(2)



At equilibrium, $P_A = P_B$

$T_A = T_B$

$$m_A = \frac{P_A V_A}{R T_A} = \frac{200\ kPa \times 1\ m^3}{0.287\ kJ/kg\,K \times 300} = 2.323\ kg$$

$$m_B = \frac{P_B V_B}{R T_B} = \frac{1000\ kPa \times 1\ m^3}{0.287\ \frac{kJ}{kg\,K} \times 1000\,K} = 3.484\ kg$$

First law $\quad \cancel{Q}^{\,0} + \cancel{W}^{\,0} = \Delta U$

$$\Rightarrow \quad \Delta U = m_A C_v (T_{A,2} - T_{A,1}) + m_B C_v (T_{B,2} - T_{B,1}) = 0$$

Since $\quad T_{A,2} = T_{B,2} = T_2$

$$\Rightarrow (m_A + m_B) T_2 = m_A T_{A,1} + m_B T_{B,1}$$

$$\Rightarrow \quad T_2 = \frac{2.323 \times 300 + 3.484 \times 1000}{2.323 + 3.484}$$

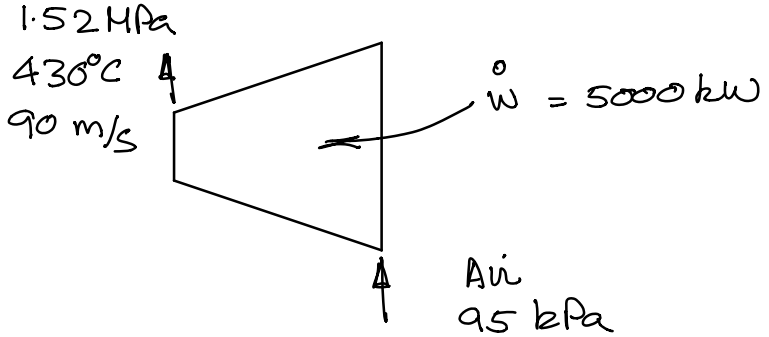
$$= 720\,K$$

$$P_2 = \frac{(m_A + m_B) R\ T_2}{(V_A + V_B)}$$

$$P_2 = \frac{(2.323 + 3.484)\ kg \times 0.287\ kJ/kg\,K \times 720\,K}{2\ m^3}$$

$$= 600\ kPa$$

3)



$$\dot{Q}^{\,0} + \dot{W} = \dot{m}\left[(h_2 - h_1) + \frac{V_2^2 - V_1^{2\,0}}{2}\right]$$

$$\dot{W} = \dot{m}\left[C_p(T_2 - T_1) + \frac{V_2^2}{2}\right]$$

$$5000\ \text{kW} = \dot{m}\left[1.0035\ \frac{\text{kJ}}{\text{kg K}}\,(430^\circ\text{C} - 20^\circ\text{C}) + \frac{(90\ \text{m/s})^2}{2 \times 1000}\right]$$

$$\Rightarrow \dot{m} = 12.0\ \text{kg/s}$$