CHE 260

QUIZ 1 SOLUTION – 2021.

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

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

For cylinder $\underset{0}{\cancel{Q}} + \underset{0}{\cancel{W}} = \Delta U = 0$

$$\Rightarrow \Delta U_A + \Delta U_B = 0$$

$$\Rightarrow m_A C_V (T_2 - T_{1A}) + m_B C_V (T_2 - T_{1B}) = 0$$

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

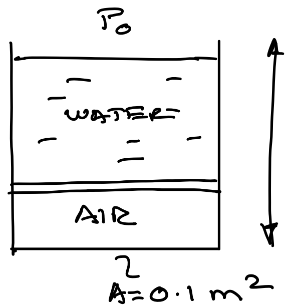
$$\Rightarrow T_2 = \frac{m_A T_{1A} + m_B T_{1B}}{(m_A + m_B)}$$

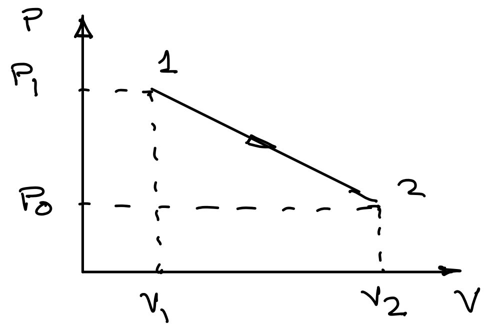
$$\Rightarrow T_2 = \frac{2.323\ \text{kg} \times 300\text{K} + 3.484\ \text{kg} \times 1000\ \text{K}}{(2.323 + 3.484)\ \text{kg}} = 720.0\ \text{K}$$

$$P_2 = \frac{(m_A + m_B) R T_2}{(V_A + V_B)} = \frac{(2.323 + 3.484)\ \text{kg} \times 0.287\ \frac{\text{kJ}}{\text{kg K}} \times 720\text{K}}{2\ \text{m}^3}$$

$$P_2 = 600\ \text{kPa}$$

2)





Volume of water $\quad V_w = V_{total} - V_{air}$

$$V_w = 10m \times 0.1m^2 - 0.3m^2 = 0.7m^3$$

Mass of water $\quad m_w = 0.7m^3 \times 1000 \frac{kg}{m^3} = 700\ kg.$

Initial air pressure $\quad P_1 = P_0 + \frac{m_w g}{A}$

$$= 101.3\ kPa + \frac{700 kg \times 9.81\ m/s^2}{0.1\ m^2 \times 1000 \frac{Pa}{kPa}} = 169.97\ kPa.$$

Mass of air $\quad m_a = \frac{P_1 V_1}{RT_1} = \frac{169.97 kPa \times 0.3m^3}{0.287 \frac{kJ}{kgK} \times 300K} = 0.592\ kg$

Final pressure $\quad P_2 = P_0 = 101.3\ kPa.$

$$V_2 = 10\ m \times 0.1\ m^2 = 1\ m^3$$

For process $\quad \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow T_2 = \frac{P_2}{P_1} \times \frac{V_2}{V_1} \times T_1$

$$\Rightarrow T_2 = \frac{101.3\ kPa}{169.97\ kPa} \times \frac{1m^3}{0.3m^3} \times 300K = 596.0\ K$$

$$W_{12} = -\int_{V_1}^{V_2} P dV = -\frac{1}{2}(P_1 + P_2)(V_2 - V_1)$$

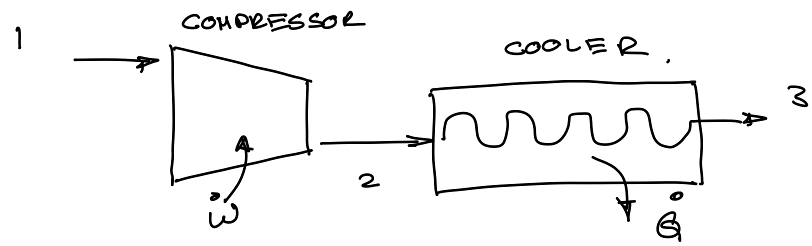
$$= -\frac{1}{2}(169.97 + 101.3) kPa (1 - 0.3m^3) = -94.94\ kJ$$

$$Q_{12} = \Delta U_{12} - W_{12} = mC_v(T_2 - T_1) - W_{12}.$$

$$= 0.592\ kg \times 0.7165\ kJ/kg\,K\ (596.0 - 300K) + 94.94\ kJ$$

$$Q_{12} = 220.5\ kJ$$

3)



In compressor

$$\dot{W} + \cancelto{0}{\dot{Q}} = \dot{m}\,(h_2 - h_1)$$

$$\dot{W} = \dot{m}\, c_p\, (T_2 - T_1)$$

$$w = \frac{\dot{W}}{\dot{m}} = c_p\,(T_2 - T_1)$$

$$w = 1.0035\ \frac{kJ}{kg\,K}\,(600 - 290)\,K = 311.1\ kJ/kg$$

In cooler.

$$\cancelto{0}{\dot{W}} + \dot{Q} = \dot{m}\,(h_2 - h_1)$$

$$\Rightarrow \quad q = \frac{\dot{Q}}{\dot{m}} = c_p\,(T_2 - T_1)$$

$$\Rightarrow \quad q = 1.0035\ \frac{kJ}{kg\,K}\,(300\,K - 600\,K)$$

$$q = 301.1\ kJ/kg.$$