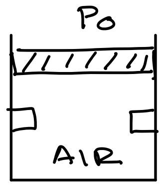
CHE 260

QUIZ 1 - 2022.

1)



$m = 0.5\ kg$

STATE 1: $P_1 = 2000\ kPa$, $T_1 = 1000\ K$

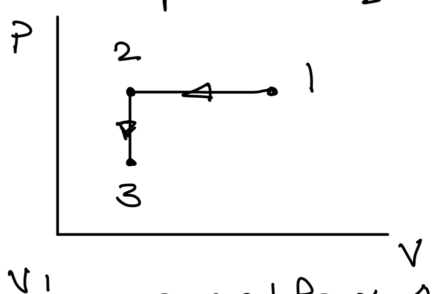
$$V_1 = \frac{mRT_1}{P_1} = \frac{0.5\ kg \times 0.287 \frac{kJ}{kg K} \times 1000 K}{2000\ kPa}$$

$$V_1 = 0.07175\ m^3$$

If we assume it has just reached the stops after cooling, but is not resting on them, then $P_2 = P_1$

$$T_2 = T_1 \frac{V_2}{V_1} = 1000 K \times \frac{0.03\ m^3}{0.07175\ m^3} = 418 K$$

However, we know that $T_2 = 400 K$, so it is resting on stops $\Rightarrow V_2 = V_3 = 0.03\ m^3$



$$> \quad P_3 = P_1 \times \frac{T_3}{T_1} \times \frac{V_1}{V_3} = 2000\ kPa \times \frac{400K}{1000K} \times \frac{0.07175\ m^3}{0.03\ m^3}$$

$$P_3 = 1913.3\ kPa.$$

$$W_{12} = -\int_1^3 P dV = -P(V_3 - V_1)$$

$$W_{12} = -2000\ kPa\,(0.03\ m^3 - 0.07175\ m^3) = 83.5\ kJ$$

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

$$Q_{12} = 0.5\ kg \times 0.790\ kJ/kg\,(418K - 1000K) - 83.5kJ = -313.4 kJ$$

(2)

$$Pv^{1.25} = \text{const}$$

$$\Rightarrow \quad P_2 = P_1 \left(\frac{v_1}{v_2}\right)^{1.25} = 90\,\text{kPa}\,(6)^{1.25}$$

$$P_2 = 845.15\ \text{kPa}$$

Ideal gas : $Pv = RT$

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)\left(\frac{v_2}{v_1}\right)$$

$$= 293\,\text{K}\left(\frac{845.15\,\text{kPa}}{90\,\text{kPa}}\right)\left(\frac{1}{6}\right) = 458.6\,\text{K}$$

$$m = \frac{P_1 V_1}{R T_1} = \frac{90 \times 0.2 \times 10^{-3}\,\text{m}^3}{0.287\,\text{kJ/kg K} \times 293\,\text{K}} = 2.14 \times 10^{-4}\,\text{kg}$$

$$W_{12} = \frac{P_2 V_2 - P_1 V_1}{n-1} = \frac{mR(T_2 - T_1)}{n-1}$$

$$W_{12} = \frac{2.14 \times 10^{-4}\,\text{kg} \times 0.287\,\frac{\text{kJ}}{\text{kg K}}(458.6\,\text{K} - 293\,\text{K})}{1.25 - 1} = 0.0407\,\text{kJ}$$

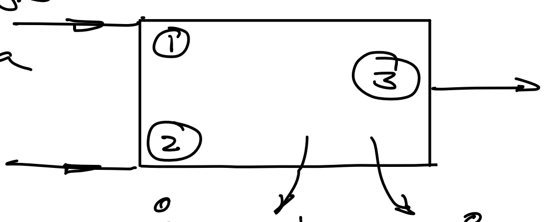
$$Q_{12} = m c_v (T_2 - T_1) - W_{12}$$

$$= 2.14 \times 10^{-4}\,\text{kg} \times 0.724\,\text{kJ/kg K}(458.6 - 293)\,\text{K} - 0.0407\,\text{kJ}$$

$$Q_{12} = -0.0150\ \text{kJ}$$

(3) 0.025 kg/s

350 kPa
150°C



100 kPa
−40°C

450 kPa
15°C

$\dot{Q} = -1\,\text{kW}$ $\quad \dot{W} = -4\,\text{kW}$

$$\dot{m}_1 + \dot{m}_2 = \dot{m}_3$$

$$\dot{m}_1 h_1 + \dot{m}_2 h_2 + \dot{Q} + \dot{W} = \dot{m}_3 h_3$$

$$\Rightarrow \dot{m}_1 h_1 + \dot{m}_2 h_2 + \dot{Q} + \dot{W} = (\dot{m}_1 + \dot{m}_2) h_3$$

$$\Rightarrow \dot{m}_1 (h_1 - h_3) + \dot{m}_2 (h_2 - h_3) = -\dot{Q} - \dot{W}$$

$$\Rightarrow \dot{m}_2 C_p (T_2 - T_3) = -\dot{Q} - \dot{W} - \dot{m}_1 C_p (T_1 - T_3)$$

$$\Rightarrow \dot{m}_2 = \frac{-\dot{Q} - \dot{W} - \dot{m}_1 C_p (T_1 - T_3)}{C_p (T_2 - T_3)}$$

Assume constant $C_p = 1.0035$ kJ/kgK

$$\Rightarrow \dot{m}_2 = \frac{1\,\text{kW} + 4\,\text{kW} - 0.025\,\frac{\text{kg}}{\text{s}} \times 1.0035\,\text{kJ/kgK}\,(150^\circ\text{C} + 40^\circ\text{C})}{1.0035\,\frac{\text{kJ}}{\text{kgK}}\,(15^\circ\text{C} + 40^\circ\text{C})}$$

$$\dot{m}_2 = 4.2 \times 10^{-3}\ \text{kg/s}$$