

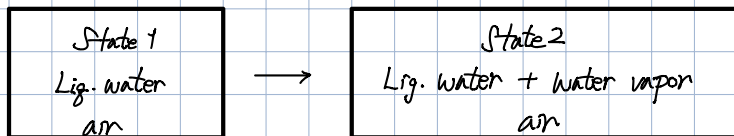
(b) During the compression: $pV^n = \text{constant}$

Determine the total amount of work during the compression

$$\begin{aligned}
 W &= \int_{V_1}^{V_2} p dV \quad \leftarrow pV^n = \text{const} = p_1 V_1^n = p_2 V_2^n, \quad p = \text{const} / V^n = \left(p_1 V_1^n / V^n \right) \\
 &= \int_{V_1}^{V_2} \frac{\text{const}}{V^n} dV \\
 &= \text{const} \cdot \left[\frac{1}{1-n} \cdot V^{1-n} \right]_{V_1}^{V_2} \quad 1 < n < k \\
 &= \frac{\text{const}}{1-n} \cdot (V_2^{1-n} - V_1^{1-n}) \\
 &= \frac{p_2 V_2^n \cdot V_2^{1-n} - p_1 V_1^n \cdot V_1^{1-n}}{1-n} = \frac{p_2 V_2 - p_1 V_1}{1-n} = \frac{(2471.9)(0.1) - (100)(1)}{1-1.393} = -374.53 \text{ kJ} \quad \text{Ans.}
 \end{aligned}$$

$$\begin{aligned}
 n? \quad p_1 V_1^n &= p_2 V_2^n \\
 (100)(1)^n &= (2471.9)(0.1)^n \\
 100 / 2471.9 &= 0.1^n \\
 n \log(0.1) &= \log(100 / 2471.9) \quad \rightarrow \underline{n = 1.393}
 \end{aligned}$$

(c) Determine the heat transfer from the surrounding into the piston-cylinder process



$$\Delta E = Q - W = \Delta U + \cancel{\Delta KE} + \cancel{\Delta PE}$$

$$Q - (-W_{in} + W_b) = \Delta U$$

$$Q = \Delta U + W_b - W_{in}$$

$$Q = \Delta H - W_{in}$$

$$\begin{aligned}
 H &= U + PV \\
 \Delta H &= \Delta U + \Delta(PV) \\
 dH &= dU + dP \cdot V + P \cdot dV \\
 &= \delta W_b
 \end{aligned}$$

$$Q = \Delta H - W_{in}$$

$$= (\Delta H)_{am} + (\Delta H)_{wv} + (\Delta H)_{wl} - W_{in}$$

$$= \{m C_p (T_2 - T_1)\}_{am} + \{m h_2 - m_1 h_1\}_{wv} + \{m h_2 - m_1 h_1\}_{wl} - W_{in}$$

$$\begin{aligned}
 (\Delta H)_{am} &= m_{am} C_p \cdot (T_2 - T_1) \quad \leftarrow C_p - C_u = R \\
 &= (1.13 \text{ kg}) (1.015 \text{ kJ/kg} \cdot \text{K}) \cdot (180 - 25) \text{ K} \\
 &= \underline{177.78 \text{ kJ}}
 \end{aligned}$$

$$m_{1, \text{liq. water}} = 1 \text{ kg}$$

if all liq. water turned into sat. vapor $v_2 = 0.1 \text{ m}^3/\text{kg}$

Table A-4 $T = 180^\circ\text{C} \rightarrow v_f = 0.001127 \sim v_g = 0.19384$

$$m_{2, \text{wv}} = \frac{V_2}{v_g} = \frac{0.1 \text{ m}^3}{0.19384 \text{ m}^3/\text{kg}} = 0.51589 \text{ kg}$$

$$m_{2, \text{wl}} = 1 - 0.51589 = 0.4841 \text{ kg}$$

$$\cdot (\Delta H)_{\text{wv}} = m_{2, \text{wv}} \cdot h_{2, \text{wv}} - m_{1, \text{wv}} \cdot h_{1, \text{wv}}$$

no water vapor at stage 1

$$= (0.5159 \text{ kg}) \cdot (1802.16) = 929.73 \text{ kJ}$$

$T = 180^\circ\text{C}$, Table A-4 $\rightarrow$

$$\begin{aligned} h_f &= 763.05 \\ h_g &= 2044.2 \\ h_g &= 2777.2 \end{aligned}$$

$$x_2 = \frac{0.5159}{1} \rightarrow h_{2, \text{wv}} = 1802.16$$

$$(\Delta H)_{\text{wl}} = m_{2, \text{wl}} \cdot h_{2, \text{wl}} - m_{1, \text{wl}} \cdot h_{1, \text{wl}}$$

$$* m_{2, \text{wl}} = 0.4841 \text{ kg} \quad h_{2, \text{wl}} = h_f = 763.05$$

$$m_{1, \text{wl}} = 1 \text{ kg} \quad h_{1, \text{wl}} = 104.83 \leftarrow \text{Table A-4, } T_i = 25^\circ\text{C}$$

$$= (0.4841) \cdot (763.05) - (1) (104.83) = 264.48$$

$$\therefore Q = (177.78) + (929.73) + (264.48) - 374.53$$

$$= 997.46 \text{ kJ}$$

~~~~~ Ans.