열역학(다) Report #1

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[R1 - 1]

$$m = 1\,\text{kg}, \quad \mathsf{V} = 0.15\,\text{m}^3 = \text{const.},$$
$$P_1 = 2\,\text{MPa}, \quad T_2 = 40^\circ\text{C}$$

(a) Find T_1.
(b) Find P_2.
(c) Draw a T-v diagram.

[Solution]

Before cooling,

$$\mathsf{v} = \frac{\mathsf{V}}{m} = 0.15\,\text{m}^3/\text{kg}$$
$$\mathsf{v}_{f@P_1} = \mathsf{v}_{f@2000\,\text{kPa}} = 0.001177\,\text{m}^3/\text{kg}$$
$$\mathsf{v}_{g@P_1} = \mathsf{v}_{g@2000\,\text{kPa}} = 0.099587\,\text{m}^3/\text{kg}$$
$$\mathsf{v} > \mathsf{v}_{g,@P_1} \quad \Rightarrow \quad \text{superheated vapor}$$

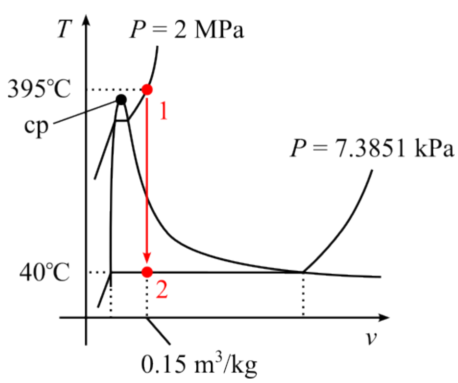
@ $P = 2\,\text{MPa}$

T [°C]	v [m^3/kg]
350	0.13860
T_1	0.15000
400	0.15122

$$T_1 = \frac{400 - 350}{0.15122 - 0.13860}(0.15 - 0.13860) + 350$$
$$= 395.1664025 \approx 395.17^\circ\text{C}$$

After cooling,

$$\mathsf{v}_{f@T_2} = \mathsf{v}_{f@40^\circ\text{C}} = 0.001008\,\text{m}^3/\text{kg}$$
$$\mathsf{v}_{g@T_2} = \mathsf{v}_{g@40^\circ\text{C}} = 19.515\,\text{m}^3/\text{kg}$$
$$\mathsf{v}_{f@T_2} \le \mathsf{v} \le \mathsf{v}_{g@T_2} \quad \Rightarrow \quad \text{wet vapor}$$
$$P_2 = P_{\text{sat}\,@\,40^\circ\text{C}} = 7.3851\,\text{kPa}$$



[R1 - 2]

$$T_1 = 300^\circ\text{C}, \quad P = 0.5\,\text{MPa} = \text{const.},$$
$$m = 0.6\,\text{kg}, \quad x = 0.48$$

(a) Find T_2, v_2, m_{f2}.
(b) Determine $\Delta\mathsf{V}$.
(c) Draw a T-v diagram.

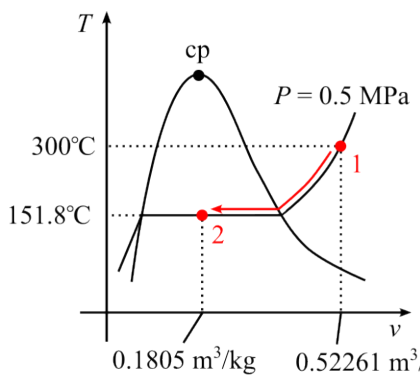
[Solution]

Before cooling,

$$P_{\text{sat}\,@\,300^\circ\text{C}} = 8587.9\,\text{kPa} > P = 500\,\text{kPa}$$
$$\Rightarrow \quad \text{superheated vapor}$$
$$\mathsf{v}_1 = \mathsf{v}_{@\,0.5\,\text{MPa},300^\circ\text{C}} = 0.52261\,\text{m}^3/\text{kg}$$

After cooling,

$$0 < x < 1 \quad \Rightarrow \quad \text{wet vapor}$$
$$m_{f2} = m(1-x) = (0.6)(1-0.48) = 0.312000$$
$$\approx 0.3120\,\text{kg}$$
$$T_2 = T_{\text{sat}\,@\,500\,\text{kPa}} = 151.83^\circ\text{C}$$
$$\mathsf{v}_{f2} = \mathsf{v}_{f@500\,\text{kPa}} = 0.001093\,\text{m}^3/\text{kg}$$
$$\mathsf{v}_{g2} = \mathsf{v}_{g@500\,\text{kPa}} = 0.37483\,\text{m}^3/\text{kg}$$
$$\mathsf{v}_2 = \mathsf{v}_{f2} + x(\mathsf{v}_{g2} - \mathsf{v}_{f2})$$
$$= 0.001093 + (0.48)(0.37483 - 0.001093)$$
$$= 0.18048676 \approx 0.18049\,\text{m}^3/\text{kg}$$
$$\Delta\mathsf{V} = m(\mathsf{v}_2 - \mathsf{v}_1)$$
$$= (0.6)(0.18048676 - 0.52261)$$
$$= -0.205273944 \approx -0.2053\,\text{m}^3$$



[R1 - 3]

$$P_1 = P_2 = 3.5\,\text{MPa} \neq P_3, \quad T_2 = T_{\text{sat}\,@\,3.5\,\text{MPa}}$$
$$T_1 = T_2 + 5^\circ\text{C}, \quad T_3 = 200^\circ\text{C}, \quad \mathsf{v}_1 \neq \mathsf{v}_2 = \mathsf{v}_3$$

(a) Find T_1.
(b) Find $\Delta h_{1\to 2}$.
(c) Find P_3 and x_3.
(d) Draw a T-v diagram.

[Solution]

At the state 1, it is superheated vapor. Therefore,

$$T_1 = T_{\text{sat @ 3.5 MPa}} + 5°\text{C} = 242.56 + 5 = 247.56000$$
$$\approx 248°\text{C}$$

@ $P = 3.5\,\text{MPa}$

$T\,[°\text{C}]$	$h\,[\text{kJ/kg}]$
242.56	2802.7
247.56	h_1
250.00	2829.7

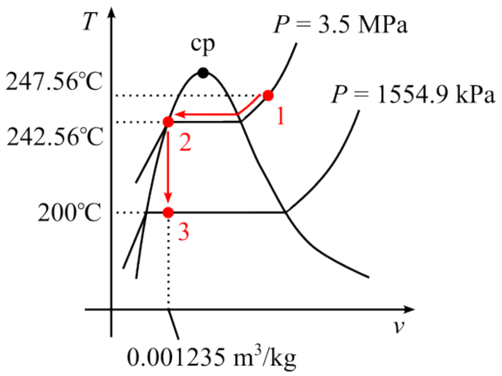
$$h_1 = \frac{247.56 - 242.56}{250 - 242.56}(2829.7 - 2802.7) + 2802.7$$
$$= 2820.845161 \approx 2821\,\text{kJ/kg}$$

At the state 2, it is saturated liquid water. Therefore,

$$h_2 = h_{f@3.5\,\text{MPa}} = 1049.7\,\text{kJ/kg}$$
$$\Delta h_{1\to 2} = h_2 - h_1 = 1049.7 - 2820.845161$$
$$= -1771.145161 \approx -1771.1/\,\text{kJ/kg}$$
$$\mathsf{v}_2 = \mathsf{v}_{f@3.5\,\text{MPa}} = 0.001235\,\text{m}^3/\text{kg}$$

At the state 3, it is wet vapor. Therefore,

$$\text{given :} \quad T_3 = 200°\text{C}$$
$$P_3 = P_{\text{sat @ 200°C}} = 1554.9\,\text{kPa}$$
$$\mathsf{v}_3 = \mathsf{v}_2 = 0.001235\,\text{m}^3/\text{kg}$$
$$\mathsf{v}_{f3} = \mathsf{v}_{f@200°\text{C}} = 0.001157\,\text{m}^3/\text{kg}$$
$$\mathsf{v}_{g3} = \mathsf{v}_{g@200°\text{C}} = 0.12721\,\text{m}^3/\text{kg}$$
$$x_3 = \frac{\mathsf{v}_3 - \mathsf{v}_{f3}}{\mathsf{v}_{g3} - \mathsf{v}_{f3}} = \frac{0.001235 - 0.001157}{0.12721 - 0.001157}$$
$$= 6.187873355 \times 10^{-4} \approx 0.0619\%$$



[R1 - 4]

$$T_1 = 20°\text{C}, \quad P_1 = 170\,\text{kPa}, \quad m_1 = 10\,\text{kg}$$
$$T_2 = 29°\text{C}, \quad P_2 = 300\,\text{kPa}, \quad \mathsf{V} = \text{const.}, \quad Z = 1$$

Determine Δm.

[Solution]

$$T_1 = (20 + 273.15)\,\text{K} = 293.15\,\text{K}$$
$$T_2 = (29 + 273.15)\,\text{K} = 302.15\,\text{K}$$
$$P\mathsf{V} = mRT \quad \Rightarrow \quad \frac{R}{\mathsf{V}} = \frac{P}{mT} = \text{const.}$$
$$\frac{P_1}{m_1 T_1} = \frac{P_2}{m_2 T_2} \quad \Rightarrow \quad m_2 = \frac{m_1 T_1 P_2}{T_2 P_1}$$
$$\Delta m = m_2 - m_1 = \frac{m_1 T_1 P_2}{T_2 P_1} - m_1$$
$$= \frac{(10)(293.15)(300)}{(302.15)(170)} - 10 = 7.1214141788$$
$$\approx 7.1214\,\text{kg}$$