(a) True

(b) False

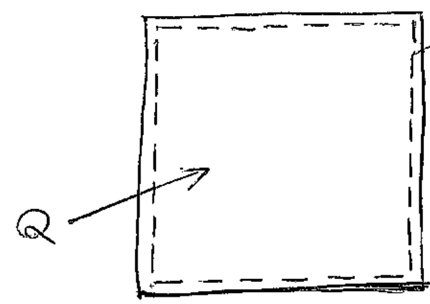
(c) False

(d) True

(e) decreases

(f) saturated liquid-vapor mixture
saturated vapor
superheated vapor

System



Assumptions
- Closed system (m = constant)
- Quasi-equilibrium process
- Rigid tank : $W_{boundary} = 0$
- Ignore change in KE and PE

Basic Equations

$$Q - \cancel{W}^{0} = \Delta E = \Delta U + \cancel{\Delta KE}^{no} + \cancel{\Delta PE}^{no}$$
$$\hookrightarrow (\cancel{W_{boundary}}^{0} + \cancel{W_{other}}^{0})$$

Solution

(a) State 1 $T_1 = 20°C$, $\boxed{v_1 = \frac{V}{m} = 0.0444 \frac{m^3}{kg}}$

$v_f(T_1) < v_1 < v_g(T_1) \Rightarrow$ $\boxed{\text{saturated liquid-vapor mixture}}$

$P_1 = P_{sat}(T_1) \Rightarrow \boxed{P_1 = 8.3654 \text{ bar}}$

(b) State 2 $T_2 = 60°C$, $\boxed{v_2 = v_1 = 0.0444 \frac{m^3}{kg}}$

$v_2 > v_g(T_2) \Rightarrow$ $\boxed{\text{superheated vapor}}$

$\boxed{P_2 \cong 12 \text{ bar}}$

(c) Considering energy balance, heat transfer during the process: $Q_{12} = U_2 - U_1 = m(u_2 - u_1)$

State 1

$$x_1 = \frac{v_1 - v_f(T_1)}{v_g(T_1) - v_f(T_1)} = \frac{0.0444 - 0.0019996}{0.055317 - 0.0019996} = 0.795$$

$$x_1 = \frac{u_1 - u_f(T_1)}{u_g(T_1) - u_f(T_1)} \Rightarrow 0.795 = \frac{u_1 - 145.37}{445.25 - 145.37}$$

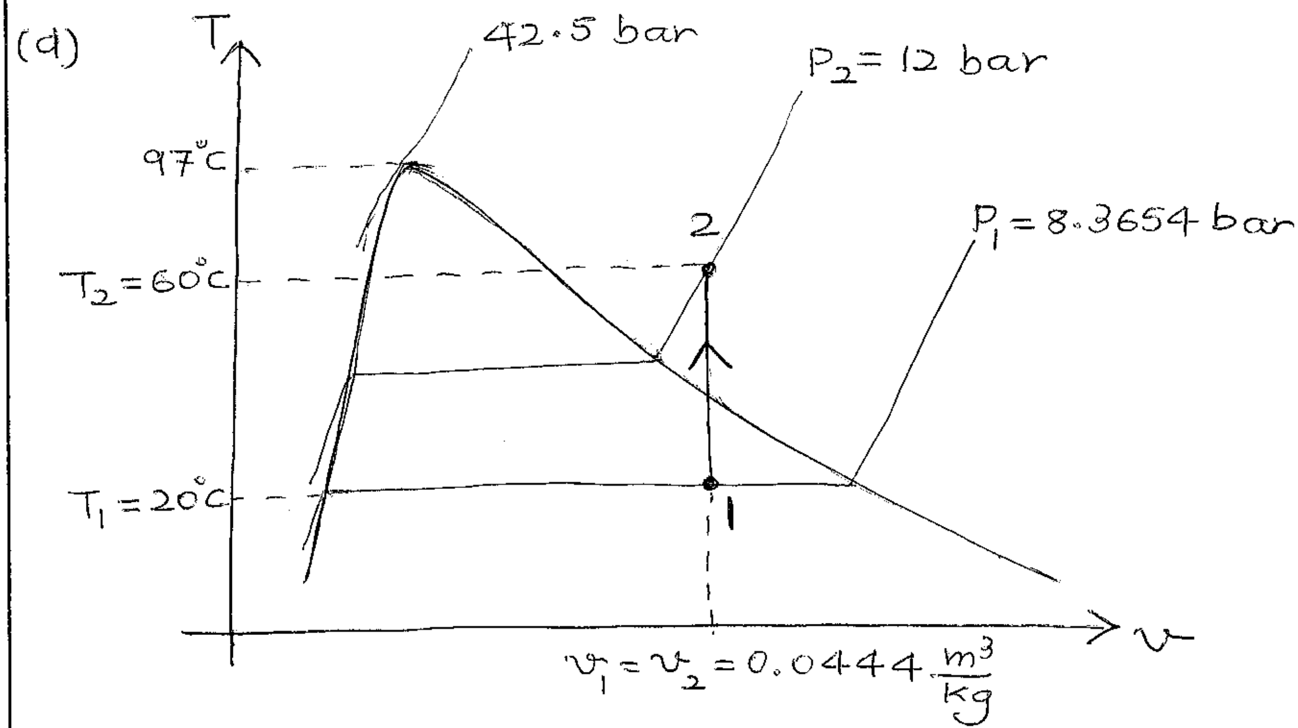
$$u_1 = 383.77 \ \frac{kJ}{kg}$$

State 2 $\quad u_2 \cong 505.77 \ \frac{kJ}{kg}$

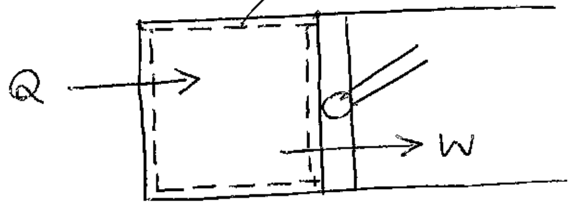
$$Q_{12} = 5 \ kg * (505.77 - 383.77) \frac{kJ}{kg}$$

$\boxed{Q_{12} = +610 \ kJ}$ $\quad Q > 0$ heat transfer into the system

(d)



System



Assumptions
- Closed system (m = constant)
- Quasi-equilibrium process
- Ignore change in KE and PE
- Air behaves as an ideal gas

Basic Equations

$$W_{boundary} = \int P\,dV$$

$$Q - W = \Delta E = \Delta U + \underbrace{\cancel{\Delta KE}}_{no} + \underbrace{\cancel{\Delta PE}}_{no}$$

$$W \rightarrow (W_{boundary} + \underbrace{\cancel{W_{other}}}_{0})$$

Solution

(a) Ideal gas equation: $P_1 V_1 = m_1 R_{air} T_1$

$$R_{air} = \frac{\bar{R}}{M_{air}} = \frac{8.314 \frac{kJ}{kmol\text{-}K}}{28.97 \frac{kg}{kmol}} = 0.287 \frac{kJ}{kg\text{-}K}$$

Mass of air: $$m_1 = \frac{P_1 V_1}{R_{air} T_1} = \frac{(3\times100)\,kPa * 0.2\,m^3}{0.287 \frac{kJ}{kg\text{-}K} * 350\,K}$$

$$\boxed{m_1 = 0.597\ kg}$$

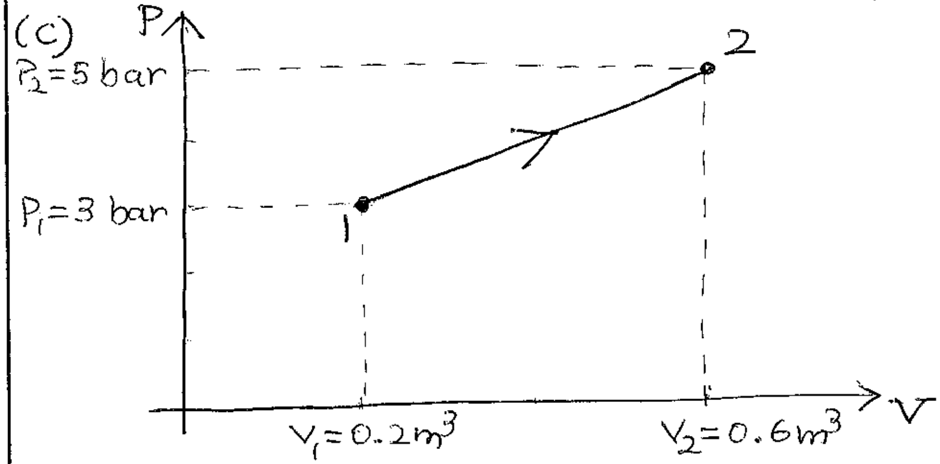
(b) Ideal gas equation: $P_2 V_2 = m_2 R_{air} T_2$

Temperature of air at State 2: $$T_2 = \frac{P_2 V_2}{m_2 R_{air}}$$

$$T_2 = \frac{(5\times100)\,kPa * 0.6\,m^3}{0.597\,kg * 0.287 \frac{kJ}{kg\text{-}K}}$$

$$\boxed{T_2 \cong 1750\ K}$$

(c)



(d) Boundary work during the process:

$$W_{12} = \int_{V_1}^{V_2} P\,dV = \text{Area under the process curve}$$

$$= \frac{1}{2}(P_1 + P_2)(V_2 - V_1)$$

$$= \frac{1}{2}(300+500)\text{ kPa} * (0.6-0.2)\text{ m}^3$$

$\boxed{W_{12} = +160 \text{ kJ}}$ W>0 work done by the system

(e) Considering energy balance, heat transfer during the process: $Q_{12} = W_{12} + (U_2 - U_1)$

$$Q_{12} = W_{12} + (m_1 = m_2)(u_2 - u_1)$$

$$u_1 = u_{air}(T_1) = 250 \frac{\text{kJ}}{\text{kg}}$$

$$u_2 \overset{*}{=} u_{air}(T_2) \cong 1439 \frac{\text{kJ}}{\text{kg}}$$

$$Q_{12} = 160\text{ kJ} + 0.597\text{ kg} * (1439 - 250)\frac{\text{kJ}}{\text{kg}}$$

$\boxed{Q_{12} = +869.8 \text{ kJ}}$ Q>0 heat transfer into the system