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Tutorial 3

Ans.1 $P = 110\ kPa \Rightarrow 1.1\ bar$

$T_{sat} = 102.32°C$

$V_{specific} = V_g = 1.548$

$(V_{sp})_i = (V_{sp})_f$

→ Finally, for mixture at 25°C,

$P = P_{sat} = 0.03168\ bar = \boxed{3.169\ kPa}$

$\Rightarrow V = V_f + x\, V_{fg}$

$\Rightarrow 1.548 = 0.0010029 + x\,(43.401)$

$\boxed{x = 0.036}$

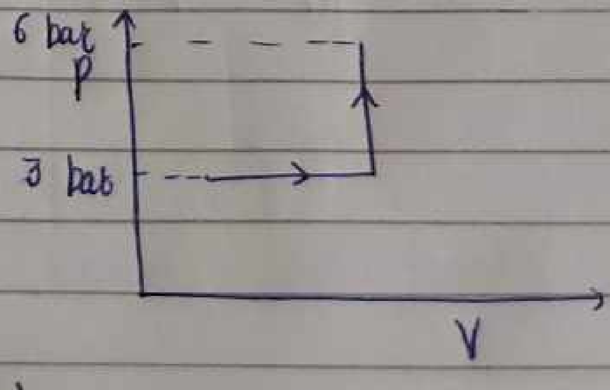
$\boxed{W = 0}$ $(\because$ Vol → fixed$)$

Ans. 2 Initially, $V_f = 0.0010017\ m^3/kg$

$V = mV_f = 0.0010017\ m^3$; $m = 1\ kg$

Finally, $V = 0.002\ m^3$

$\boxed{V_f = 2\ L}$



$W = \int_{P = 3\ bar} PdV + \cancel{\int_{V = 2L} PdV}^{\,0}$

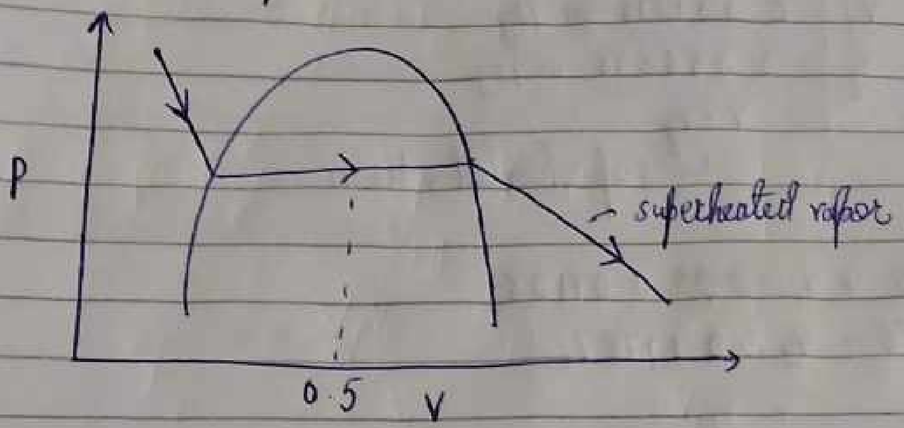
$= (300)(0.002 - 0.0010017)$

$\boxed{\approx 0.3\ kJ}$

Ans 3 $v_{sp} = 30 \, m^3/kg$

$v > v_g$ at $40°C$

$\Rightarrow$ superheated steam



At $40°C$, $v_g = 19.546 \, m^3/kg$

ideal gas: part 1: $W = nRT \ln \frac{V_2}{V_1}$

$$W_1 = \left(\frac{100}{18}\right)(8.3143)(273+40) \ln\left(\frac{19.546}{30}\right)$$

$$= -6.193 \text{ kJ}$$

Part 2: $v = v_f + x v_{fg} = 9.7735$

$$W_2 = (7.375 \times 10^3)(-19.546 + 9.7735) \approx -72 \text{ kJ}$$

$$\boxed{W = W_1 + W_2 \approx -13.4 \text{ kJ}}$$

Ans 4 (a) $P = 30$ bar , ~~$v_1 = 0.00$~~

$v_1 = 0.0010017$ m^3/kg

$v = 0.1$ m^3/kg

$v_f = 0.001216$ m^3/kg

$v_g = 0.066596$ m^3/kg

$v > v_g$

↳ superheated steam

$400°C \rightarrow v_1 = 0.09936$

$450°C \rightarrow v_2 = 0.10787$

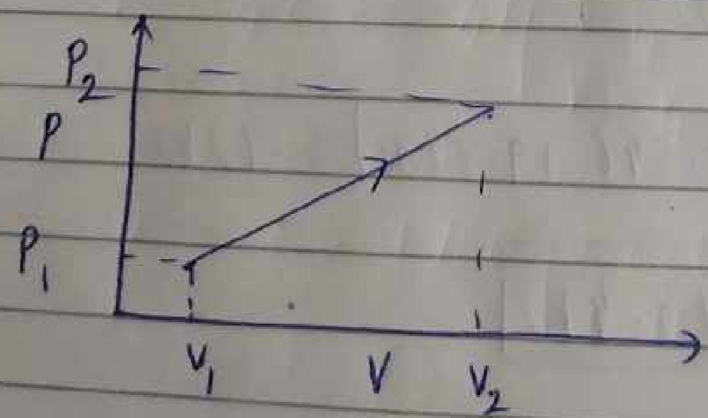
$$\rightarrow \frac{v_2 - v_1}{v - v_1} = \frac{T_2 - T_1}{T - T_1}$$

$$\rightarrow T = T_1 + \left(\frac{v - v_1}{v_2 - v_1}\right)(T_2 - T_1)$$

$$\rightarrow T = 400 + \left(\frac{0.1 - 0.09936}{0.10787 - 0.09936}\right)(450 - 400)$$

$$\boxed{T = 403.76 \approx 404°C}$$

(b)



(c) $W = \int P dV = \frac{1}{2}(P_1 + P_2)(V_1 - V_2)$

$= \frac{1}{2}(30+3)(10^5)(0.1 - 0.0010017)$

$\boxed{W = 163.35 \text{ kJ}}$

Ans 5 For Polytropic Process:

$P T^{\frac{n}{1-n}} = C$

$\Rightarrow (125)(325)^{\frac{n}{1-n}} = (300)(500)^{\frac{n}{1-n}}$

$\Rightarrow \frac{125}{300} = \left(\frac{500}{325}\right)^{\frac{n}{1-n}}$

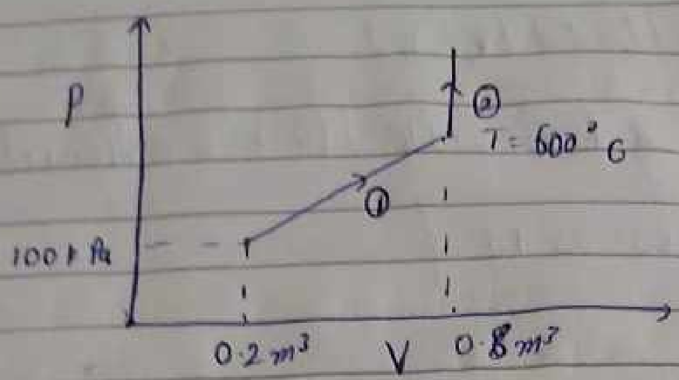
$\Rightarrow \frac{n}{1-n} = -2.03$

$\Rightarrow \boxed{n = 1.97}$

$W = \frac{P_2 V_2 - P_1 V_1}{1-n} = \frac{R(T_2 - T_1)}{1-n}$

$\boxed{W = -51.77 \text{ kJ/kg}}$

Ans.6



$v = 0.4\ m^3/kg$, $P = 12$ bar

$v_g = 0.162921\ m^3/kg$

$v > v_g$

↳ superheated steam

At 12 bar,

(T_1) $700°C \rightarrow 0.37294$ (v_1)

(T_2) $800°C \rightarrow 0.4177$ (v_2)

$$\Rightarrow \frac{v_2 - v_1}{v - v_1} = \frac{T_2 - T_1}{T - T_1}$$

$$\Rightarrow T = T_1 + (T_2 - T_1)\left(\frac{v - v_1}{v_2 - v_1}\right)$$

$$\Rightarrow T = 700 + 100\left(\frac{0.4 - 0.37294}{0.4177 - 0.37294}\right)$$

$$\Rightarrow \boxed{T \approx 770°C}$$

$W = \int P dV$

$= \frac{1}{2}(1 + 10.03246)(10^5)(0.6)$

$\boxed{W \approx 330 \text{ kJ}}$

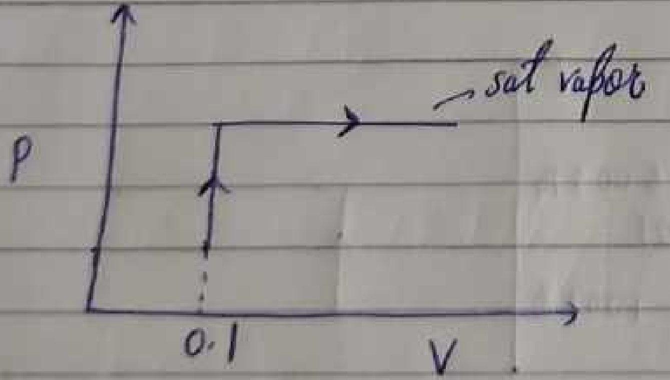
Ans 7 1 kg, 20°C, 0.1 m^3

$P = 400 \text{ kPa} = 4 \text{ bar}$

$v = \frac{0.1}{1} = 0.1 \ m^3/kg$

At 4 bar, $v_f = 0.001084$
$v_g = 0.460444$
$v_f < v < v_g$
$\Rightarrow$ Saturated mixture

$T = T_{sat} = 143.63°C$



$m = 1 kg, \ v_1 = 0.1, \ v_2 = 0.460444$

$\Rightarrow W = m(P)(v_2 - v_1) \Rightarrow W = (4 \times 10^5)(0.360444) \approx \boxed{144.18 \text{ kJ}}$

Ans. 8 $m = 0.1\ kg$, $P_1 = 100\ kPa$

$x = 0.25$, $v = v_f + x v_{fg} = 0.42$

$v = 0.42\ m^3/kg$

At 5 bar, $v_f = 0.001093$, $v_g = 0.36812$

$v = 0.42$

$\because v > v_g \Rightarrow$ superheated steam

$T_{sat} = 151.86°C$

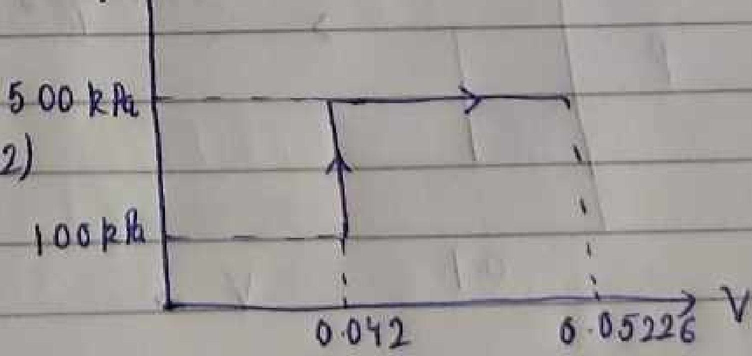
Now, at $T = 300°C$

$v = 0.52256$

$\boxed{P_{final} = 500\ kPa}$

$V_f = (0.1)(0.52256)$

$\boxed{V_f = 0.052256\ m^3}$



$W = mP(v_2 - v_1)$

$= (0.1)(5\times10^5)(0.5226 - 0.42)$

$\boxed{W \approx 5.13\ kJ}$