1.

Stage	P (kPa)	T(C)	v (m^3/kg)	u (kJ/kg)	h (kJ/kg)	x
1	101.42	100	0.2851	773.85	802.76	0.17
2	101.42	100	0.4332	958.8	1002.76	0.2586
3	1000	100	0.001043	419.06	419.17	-
4	1000	600	0.40111	3297.5	3698.6	-
5	10	600	40.296	3303.3	3703.3	-

Process	Q (kJ)	W (kJ)
1 to 2	1000	75.25
2 to 3	-2917.9	-219.2
3 to 4	16397	2004.8
4 to 5	9315	9286

2.

	T [C]	P [kPa]	v [m^3/kg]	u [kJ/kg]	h [kJ/kg]	x [-]	State
1	80	1000	0.001029	334.97	335.02	-	Compressed liquid
2	160	618.28	0.1490	1589.9	1682	0.4834	Saturated mixture
3	350	800	0.35442	2878.6	3162	-	Superheated vapor
4	500	5	71.36	3132.9	3489.7	-	Superheated vapor
5	500	10	35.68	3133	3489.7	-	Superheated vapor
6	190	1255.2	0.1051	2000	2132.6	0.67	Saturated mixture

ME40 Spring 2017 MID #1

(1)

$T_1 = 100°C$

$x = 0.17 \rightarrow$ mixture

$\Rightarrow P_1 = 101.42$ kPa

$v_1 = v_f + x v_{fg} = 0.001043 + 0.17(1.6720 - 0.001043)$

$= 0.2851$ (m^3/kg)

$u_1 = u_f + x u_{fg} = 773.85$ kJ/kg

$h_1 = 802.76$ kJ/kg

$1 \rightarrow 2$: $q_{12} = \Delta u_{12} + w_{12} = \Delta h_{12}$

$\frac{1000\,kJ}{5\,kg} = h_2 - h_1$

$h_2 = 802.76 + 200 = 1002.76$ (kJ/kg) $\rightarrow$ mixture

$P_2 = P_1 = 101.42$ kPa

$\Rightarrow x_2 = \frac{h_2 - h_f}{h_{fg}} = \frac{1002.76 - 419.17}{2256.4} = 0.2586$

$v_2 = 0.4332$ m^3/kg

$u_2 = 958.8$ kJ/kg

$1 \rightarrow 2$: $Q_{12} = 1000$ kJ

$W_{12} = Q_{12} - \Delta U_{12} = Q_{12} - m(u_2 - u_1) = 75.25$ kJ

$T_3 = 100°C$

$P_3 = 1$ MPa $\rightarrow$ comp. liq.

$\Rightarrow v_3 \approx v_f @ 100°C = 0.001043$ m^3/kg

$u_3 \approx 419.06$ kJ/kg

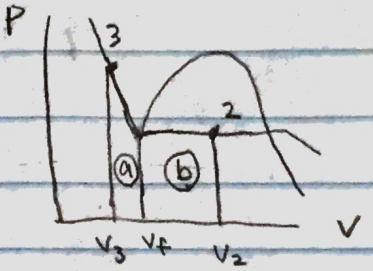
$h_3 \approx 419.17$ kJ/kg

$2 \to 3$: $W_{23} = \int_2^3 P dV$

$= ⓐ + ⓑ$

(since $V_3 \approx V_f$, ⓐ $\to 0$)

$\approx ⓑ$



$W_{23} = m P_2 (V_f - V_2) = -219.2$ KJ

$Q_{23} = \Delta U_{23} + W_{23} = -2917.9$ KJ

$T_4 = 600°C$, $P_4 = 1$MPa $\to$ superheated vapor

$\Rightarrow v_4 = 0.40111$ m^3/kg

$u_4 = 3297.5$ KJ/kg

$h_4 = 3698.6$ KJ/kg

$3 \to 4$: $Q_{34} = \Delta H_{34} = m(h_4 - h_3) = 16397$ KJ

$W_{34} = Q_{34} - \Delta U_{34} = 2004.8$ KJ

$T_5 = 600°C$, $P_5 = 10$KPa $\to$ Superheated vapor

$\Rightarrow v_5 = 40.296$ m^3/kg

$u_5 = 3303.3$ KJ/kg

$h_5 = 3703.3$ KJ/kg

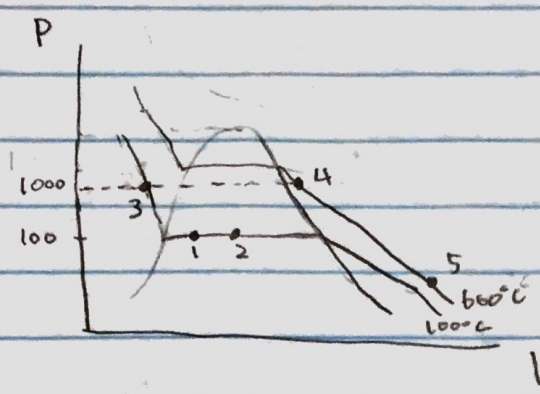
$4 \to 5$: approximately ideal gas

$W_{45} = \int_4^5 P dV = mRT \ln\left(\frac{V_f}{V_4}\right)$

$= (5)(0.4615)(873) \ln\left(\frac{40.296}{0.40111}\right)$

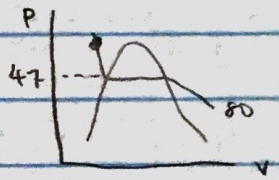
$= 9286$ (KJ)

$Q_{45} = \Delta U_{45} + W_{45} = m(u_5 - u_4) + W_{45} = 9315$ (KJ)



(2)

1)



$v = 0.001029\ m^3/kg$

$u = 334.97\ kJ/kg$

$h = 335.02\ kJ/kg$

comp. liq

2)

$h_f = 675.47 \quad h_g = 2757.5$

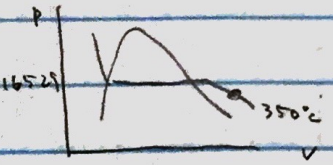
$x = \frac{h - h_f}{h_{fg}} = 0.4834$

$u = u_f + x u_{fg} = 1589.9\ kJ/kg$

$P = 618.28\ kPa \quad v = 0.1490\ m^3/kg$

Sat. mix

3)



$h_f = 25639$

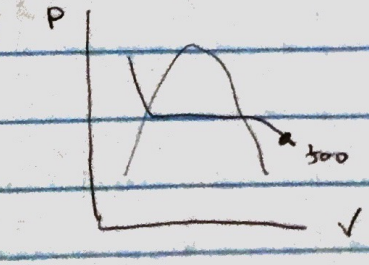
S.h.vap

$P = 0.8\ MPa$

$v = 0.354462\ m^3/kg$

$u = 2878.6\ kJ/kg$

4)



S.h.vap → ideal gas $u, h = f(T)$

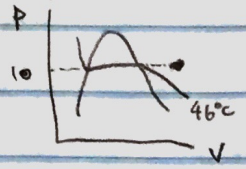
$[PV]_{\substack{10\,kPa \\ 500°C}} = [PV]_{\substack{5\,kPa \\ 500°C}} \Rightarrow v = 71.36\ m^3/kg$

$u = 3132.9\ kJ/kg$

$h = 3489.7\ kJ/kg$

4

5)



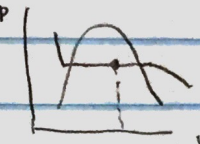
s: h. vap

T = 500°C

h = 3489.7 kJ/kg

v = 37.68 m³/kg

6)



Sat. mix

$u = u_f + x u_{fg}$

$2000 = u_f + 0.67\, u_{fg}$

$u_{fg} = \frac{2000 - u_f}{0.67}$

Trial & error

T = 190°C

P = 1255.2 kPa

$v = 0.001141 + 0.67\,(0.15636 - 0.001141)$

$= 0.1051$ m³/kg

h = 2132.6 kJ/kg