# mae 204 J THERMODYNAMICS Summer 2010 Quiz 1

4 lbs of liquid water and 1 lb of water vapor are contained in a piston cylinder device at 60 psia. Heat is added until all the water is vaporized and the temperature has been increased to 320 F. Determine the heat requires and the work done. Sketch a temperature-volume property diagram for the process.

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ave = 64

$$x = \frac{\text{gas mass}}{\text{total mass}} = \frac{1}{5} = .2$$

$$u_1 = u_f = x \times u_{fg} = 262.02 + .2 \times 836.13 = 429.24 \text{ Btu/lb}$$

$$h_1 = h_f + x \times h = 262.2 + .2 \times 915.61 = 445.32$$

$$v_1 = v_f + x \times \left(v_g - v_f\right) = .01738 + .2 \times (7.1766 - .01738)$$

$$v_1 = 1.449 \text{ ft}^3\text{/lb}$$

Superheat Table @ 60 psia, 320 F

$$u_2 = 1109.6 \text{ Btu/lb}$$

$$h_2 = 1192.7 \text{ Btu/lb}$$

$$v_2 = 7.4863 \text{ ft}^3\text{/lb}$$

$$Q = m \times (h_2 - h_1) = 5 \times (1192.7 - 445.32) = 3736.9 \text{ Btu}$$

$$W = Q - m \times (u_2 - u_1)$$

$$W = 3736.9 - 5 \times (1109.6 - 429.24)$$

$$W = 3836.9 - 3402.$$

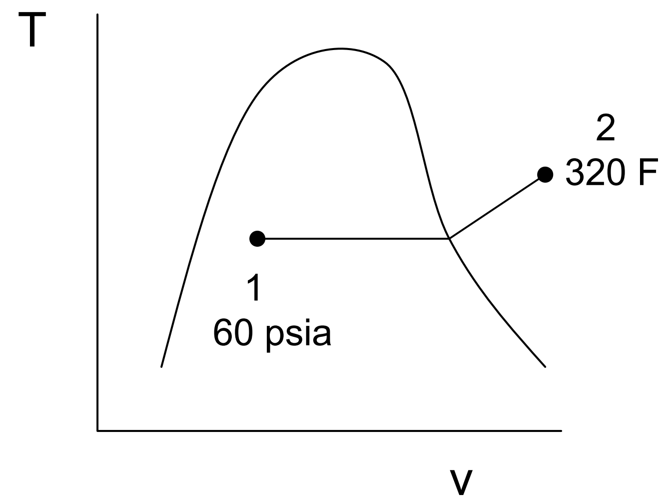
$$W = 335.1 \text{ Btu}$$

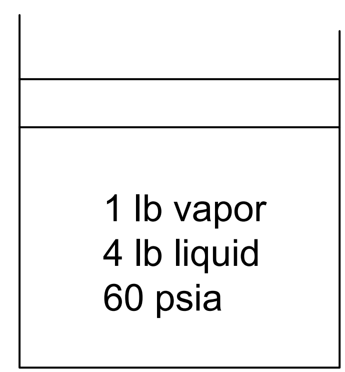
$$W = \int p\,dv = m \times p \times (v_2 - v_1)$$

$$W = 5 \times 60 \times 144 \times (7.4863 - 1.449)$$

$$W = 260811.36 \text{ ft} - \text{lb}$$

$$W = \frac{260811.36 \text{ ft} - \text{lb}}{778 \text{ ft - lb/Btu}} = 335.2 \text{ Btu}$$



# mae 204 J THERMODYNAMICS Summer 2010 Quiz 2

Liquid water is heated with water vapor in a mixing vessel maintained at 500 kPa. Water vapor at 1MPa, 300 C flows at a rate of 100 kg/min through a control valve into the mixing vessel. Liquid water at 1.5 MPa and 50 C flows at a rate of 200 kg/min through a control valve into the vessel. What is the volume flow rate and temperature of the leaving water? Sketch a property diagram of the process.

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$@\,1\text{ MPa, }300\text{ C}$

$h_1 = 3051.6$

$@\,1.5\text{ MPa, }50\text{ C}$

$h_2 = 209.34$

mass balance

$m_1 + m_2 = m_3$

$100 + 200 = 300\text{ kg} = m_3$

energy balance

$m_1h_1 + m_2h_2 = m_3h_3$

$100\times 3051.6 + 200\times 209.34 = 300\times h_3$

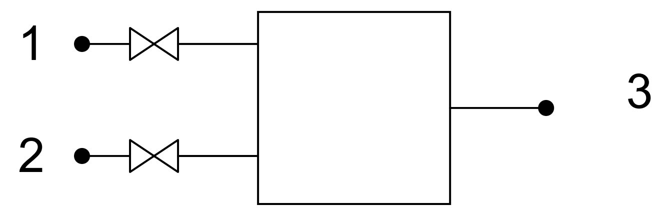
$h_3 = 1156.8$

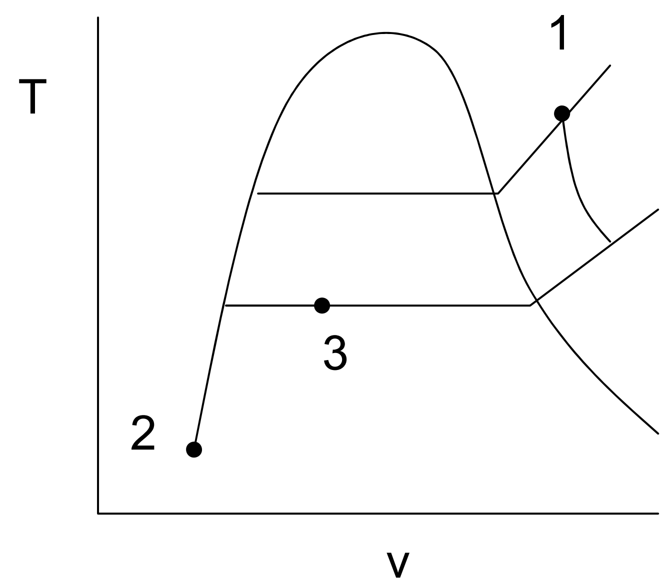
$$x_3 = \frac{1156.8 - 640.09}{2108} = .245$$

$v_3 = .001093.245\times(.37483) = .0929$

$V_3 = m_3\times v_3 = .0929\times 300 = 27.88\text{ m}^3/\text{min}$

$T_3 = T_{saturation}\ @\,500\text{ kPa} = 151.83\text{ C}$



# mae 204 J THERMODYNAMICS Summer 2010 Quiz 3

An insulated piston cylinder device initially contains .2 $m^3$ of air at 200 kPa and 22 C. At this state a linear spring touches the piston but exerts no force on it. The cylinder is connected by a valve that supplies air at 800 kPa and 22 C. The valve opens and air from the high pressure line is allowed to enter the piston cylinder. The valve is turned off when the pressure inside the cylinder reaches 600 kPa. If the enclosed volume inside the cylinder doubles during the process, determine a) the mass of air that entered the cylinder and b) the temperature of the air inside the cylinder.

# mae 204 J THERMODYNAMICS Summer 2010 Quiz 3

$$m_1 = \frac{pV}{RT} = \frac{200\,\mathrm{kPa}\times .2\mathrm{m}^3}{.286\left(273.15+22\right)} = .4739\,\mathrm{kg}$$

$$m_2 = \frac{pV}{RT} = \frac{600\times .4}{.287\times T_2} = \frac{839.2}{T_2}$$

$$W_b = p_{ave}(V_1 - V_2) = \frac{200+600}{2}\times .2 = 80\,\mathrm{kJ}$$

$$Q = 0$$

$$m_2 u_2 + W_b = m_1 u_1 + (m_2 - m_1)\,h_o$$

$$\frac{839.2}{T_2}\times .718 T_2 + W_b = .4739\times 211.92 + \left(\frac{839.2}{T_2} - .4739\right)\times 296.63$$

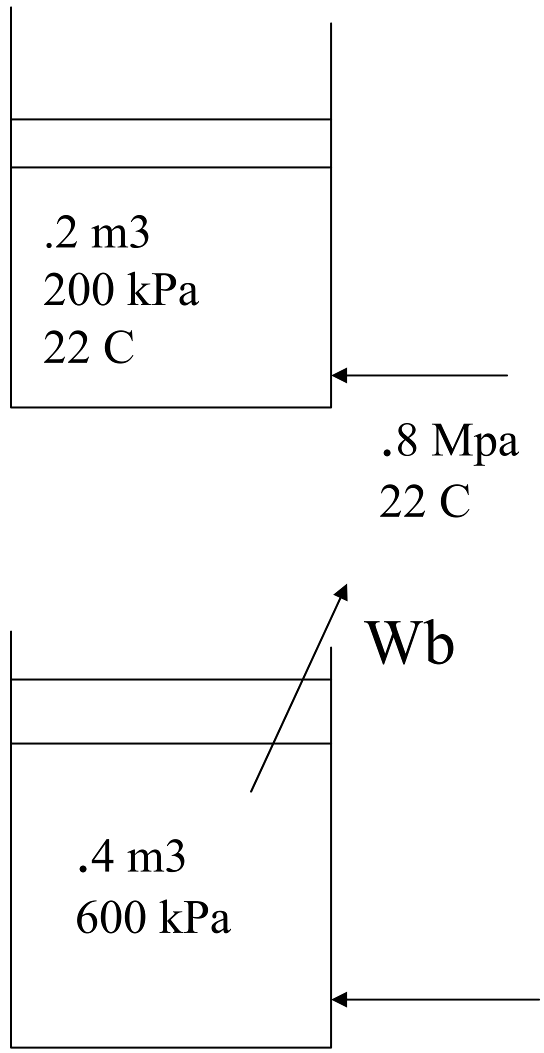
$$602.5 + 80 = 100.43 + \frac{248{,}932}{T_2} - 104.57$$

$$722.2 T_2 = 248{,}932.$$

$$T_2 = 344.5^{o}\,\mathrm{K}$$

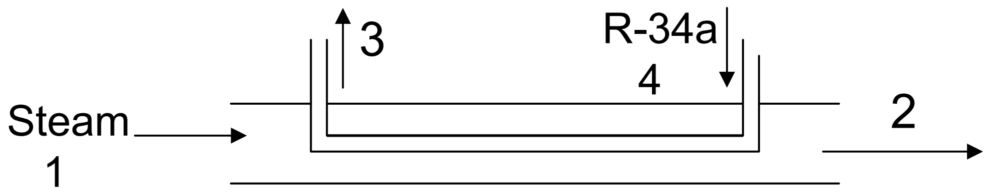
$$m_2 = \frac{839.2}{T_2} = \frac{839.2}{344.5} = 2.43\,\mathrm{kg}$$

$$\left(m_2 - m_1\right) = 2.43 - .4739 = 1.95\,\mathrm{kg}$$



# mae 204 J THERMODYNAMICS Summer 2010 Quiz 4

R-134a is heated in a heat exchanger with steam. 10 lb/min of steam enter the heat exchanger at 60 psia, 360 F. 50 lb/min of R-134a is heated from saturated liquid to saturated vapor at 90 psia. Determine the entropy generated by the process. Sketch a temperature entropy diagram for the steam process and for the refrigerant process.



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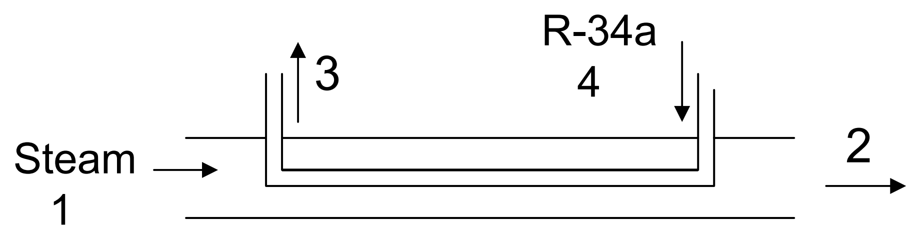


$$Q_{steam} = Q_{R\text{-}134a}$$
$$m_{steam} \times (h_1 - h_2) = m_{R\text{-}134a} \times (h_3 - h_4)$$
$$h_1 = h\ @\ (360\ F, 60\ psia) = 1213.5$$
$$s_1 = s\ @\ (360\ F, 60\ psia) = 1.6897$$
$$h_3 = h\ @\ (p = 90, x = 0) = 113.06$$
$$h_4 = h\ @\ (p = 90, x = 1) = 35.715$$
$$10 \times (1213.5 - h_2) = 50 \times (113.06 - 35.715) = 3867.25$$
$$h_2 = 826.78$$
$$x = \frac{826.78 - 262.2}{915.61} = .6166$$
$$s_2 = .4273 + .6166 \times 1.21697 = 1.1777$$
$$s_3 = s\ @\ (90\ psia, x = 1) = .22006$$
$$s_4 = s\ @\ (90\ psia, x = 0) = .07481$$
$$\Delta S = m_{steam} \times (s_2 - s_1) + m_{R\text{-}134a} \times (s_3 - s_4)$$
$$\Delta S = 10 \times (1.1777 - 1.6897) + 50 \times (.22006 - .07481)$$
$$\Delta S = -5.12 + 7.2625 = 2.1425\ \text{Btu/lb R}$$