Please!

Be neat, write out equations before inserting numbers, and circle your answers.

If you cannot figure out one part, assume an answer and carry it through the other parts.

1. (~~35~~ 34%) A cylinder/piston arrangement contains 5 kg of water at 100°C with x = 20% and the piston mass is 75 kg. The piston is initially resting on the stops as shown in the figure. The outside pressure is 100 kPa, and the cylinder area is 24.5 cm^2. Heat is ~~now~~ added until the water reaches a saturated vapor state. Find:

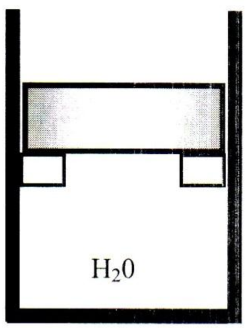
a) The initial volume

b) The final pressure (kPa)

c) The work

d) The heat transfer

e) Show a qualitative P-v diagram for the process.



5 a) $v = v_L + x\, v_{LV} = .001043 + .2(1.6726) = .336 \frac{m^3}{kg}$

$V = mv = 5(.336) = \boxed{1.68\ m^3}$

7 b) $P_p = \frac{F}{A} = \frac{m g/g_c}{A} = \frac{75\,kg\ 9.8\frac{m}{s^2} / 1\frac{kg\,m}{N s^2}}{24.5\,cm^2 / 10^4\frac{cm^2}{m^2}} \frac{1\ kN}{1000\ N} = 300\ kPa$

$P_2 = P_p + P_{atm} = 300 + 100 = \underline{400 kpa}$ assuming piston moves.

Problem 1 continued

7 c) @ 400 Kpa $v_v = .4625 \frac{m^3}{Kg}$

$V_2 = m v_v = 5(.4625) = \underline{2.3125 \, m^3} > V_1$

$W = P(V_2 - V_1) = 400 \text{Kpa}(2.315 - 1.68) = \underline{253 \text{ KJ}}$

10 d) $u_1 = u_L + x u_{LV} = 418.96 + .2(2087.1) = 836.4 \frac{KJ}{Kg}$

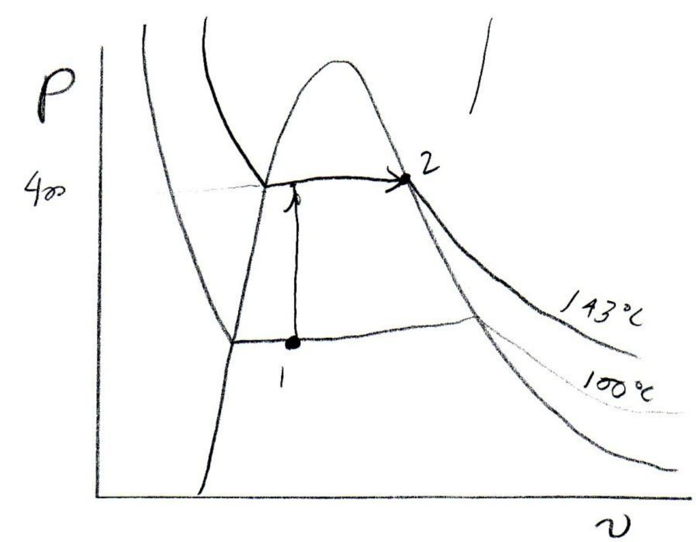
$u_2 = u_v = 2553.5$

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

$5(2553.5 - 836.4) = Q - (253)$

$\boxed{Q = 8838.6 \text{ KJ}}$

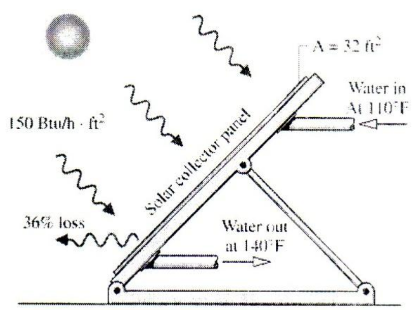
5 e)



2. (~~29%~~ 31%) A solar collector panel has a surface area of 32 ft². The panel receives energy from the sun at a rate of 150 BTU/hr per ft² of collector surface. Of the incoming solar energy 36% is lost to the surroundings. The remainder is used to heat a stream of high pressure (600 psia) water from 110 to 140°F. The water passes through the solar collector with negligible pressure drop. While the incoming velocity of the water is small, the flow leaves with a rather high velocity of 150 ft/s.

24 a) Determine the steady-state mass flow rate of water in lb_m/min.

7 b) How many gallons of water at 140°F can eight collectors provide in a 30 min. time period?



system: solar heater

continuity: $\dot{m}_{in} = \dot{m}_{out}$

1st Law

$$\frac{dU}{dt} = 0 = \dot{Q} - \dot{W} + \dot{m}_{in} h_{in} - \dot{m}_{out}\left(h_{out} + \frac{\vec{V}_{out}^2}{2g_c}\right)$$

20
$$0 = (.64)\,150 \frac{BTU}{lbm\,ft^2}\left(\frac{1\ hr}{60\ m}\right) 32\ ft^2 + \dot{m}\left[79.8 - (109.8 + .45)\right]$$

$$\dot{m} = 1.68\ \frac{lbm}{min}$$

$$h_{in} = h_L + v_L(P - P_{sat}) = 78\ \frac{BTU}{lbm} + .01617\ \frac{ft^3}{lbm}\left(600 - 1.28\ \frac{lb_f}{in^2}\right)\left(144\ \frac{in^2}{ft^2}\right)\frac{1\ BTU}{778\ ft\,lb_f}$$

$$= 78 + 1.74 = 79.8\ \frac{BTU}{lbm}$$

$$h_{out} = h_L + v_L(P - P_{sat}) = 108 + 0.01629(600 - 2.9)(144)/778 = 109.8\ \frac{BTU}{lbm}$$

4) $$\frac{V^2}{2g_c} = \frac{(150\ ft/s)^2}{(2)\ 32.2\ \frac{lbm\,ft}{lbf\,s^2}}\ \frac{1}{778}\ \frac{BTU}{ft\text{-}lbf} = .45\ \frac{BTU}{lbm}$$

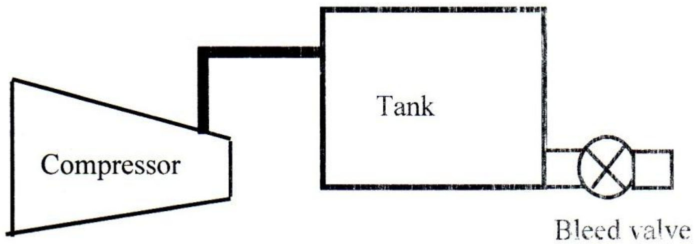
7 b) $\dot{V} = \dot{m} v * 8 * 30 \text{ min}$

$= 1.68 \frac{lbm}{min} (.01629 \frac{ft^3}{lbm})(8)(30) = 6.57 \ ft^3$

$6.57 \ ft^3 / (.1337) \frac{ft^3}{gal.} = 49 \text{ gal.}$

3. (~~35~~ 34%) In a two-step process air is first slowly bled from a tank having a volume of 2.5 m^3. The tank is un-insulated so the process can be considered iso-thermal; the temperature of the air is that of the surrounding, 25°C. The air is bled at a rate of 0.15 kg/min for 2 hrs at which point the tank pressure is equal to atmospheric pressure (100 kPa). In the second-step, the bleed valve is closed and an air compressor is turned on and fills the tank to a pressure of 350 kPa. The outlet temperature from the compressor is 300°C and the flow is isothermal. The final temperature of the air in the tank is 50°C.
assume variable Cp for air

a) What was the intial mass of air in the tank?
b) What was the initial pressure in the tank?
c) What is the final mass of air in the tank?
d) What was the total heat transfer to/from the tank (KJ)?



8 a) $P_2 V_2 = m_2 R T_2$

4 $100\,kPa(2.5m^3) = m_2 (\frac{8.314}{29})(298)$

$\rightarrow m_2 = 2.93\,Kg$

4 $m_{out} = .15 \frac{Kg}{min} * 60 \frac{min}{hr}\, 2\,hr = 18\,Kg$

$m_1 = m_2 + m_{out} = 2.93 + 18 = \boxed{20.93\,Kg}$

5 b) $P_1 V = m_1 R T_1$

$P_1(2.5m^3) = 20.93\ \frac{8.314}{29}\ 298$

$\rightarrow P_1 = \boxed{715.2\,KPa}$

Problem 3 continued

5 c) $P_3 V = m_3 R T_3$

$350(2.5) = m_3 \frac{8.314}{29} 323$

$\to$ $m_3 = 9.45$ Kg

system: tank

16 d) $u_3 m_3 - u_1 m_1 = Q - \cancel{W}^{0} + m_{in} h_{in} - m_{out} h_{out}$

$231.4(9.45) - 213.4(20.93) = Q + (9.45 - 2.93) 579.8 - 18(299)$

$-2279.7 = Q + 3780.3 - 5382$

$\to$ $Q = -678$ KJ

or) $u_2 m_2 - u_1 m_1 = Q - \cancel{W}^{0} + \cancel{m_{in} h_{in}}^{0} - m_{out} h_{out}$

$u_2 = u_1 \Rightarrow u(m_2 - m_1) = Q - m_{out} h_{out}$

$213.4(-18) = {}_1Q_2 - 18(299)$

$\to 1541$ KJ

$u_3 m_3 - u_2 m_2 = {}_2Q_3 + m_{in} h_{in}$

$231.4(9.45) - 213.4(2.93) = {}_2Q_3 + 6.52(579.8)$

$\to -2218.8$

$Q = {}_1Q_2 + {}_2Q_3 = 1541 + (-2219) = -678$ KJ