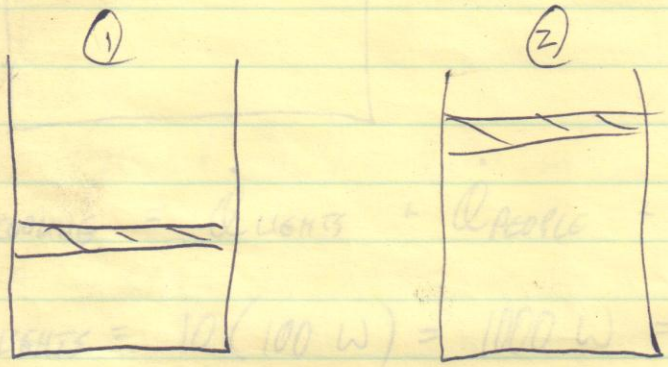
RETURN TO DR. THOMAS

HOMEWORK #4: ~~3-65E, 3-70, 3-74, 3-79, 3-101, 3-107, 3-123~~

4-6E, 4-7, 4-11, 4-18, 4-28, 4-34, 4-50

PROB. ~~3-65E~~ 4-6E



$Q_{IN} = 65$ Btu, $Q_{LOSS} = 8$ Btu

$W = 5$ Btu

FIND ΔU

FIRST LAW:

$Q - W = U_2 - U_1 = \Delta U$

$\Delta U = (65 - 8) - 5$ Btu $= 52$ Btu

PROB. 4-7

$\dot{Q}_{COOLING} = \dot{Q}_{LIGHTS} + \dot{Q}_{PEOPLE} + \dot{Q}_{HEAT\ GAIN}$

$\dot{Q}_{LIGHTS} = 10(100\ W) = 1000\ W = 1\ KW$

$\dot{Q}_{PEOPLE} = 40\left(360\ \frac{KJ}{HR}\right)\left(\frac{HR}{3600\ S}\right) = 4\ KW$

$\dot{Q}_{HEAT\ GAIN} = \left(15{,}000\ \frac{KJ}{HR}\right)\left(\frac{HR}{3600\ S}\right) = 4.167\ KW$

$\dot{Q}_{COOLING} = 9.167\ KW$

$NUMBER\ OF\ UNITS = \frac{(9.167\ KW)}{\left(\frac{5\ KW}{UNIT}\right)} = 1.83$ OR 2 UNITS

PROB. ~~BLOCK~~ 4-11

$V = (20\ L)\left(\frac{m^3}{1000 L}\right) = 0.02\ m^3$

$P_1 = 300\ kPa, \quad T_1 = 250°C$

$P_2 = 100\ kPa$

FIND Q_2, SHOW P-v DIAGRAM

$v_1 = 0.7964\ \frac{m^3}{kg}$

$v = \frac{V}{m}, \quad m = \frac{V}{v} = \frac{(0.02\ m^3)}{(0.7964\ \frac{m^3}{kg})} = 0.0251\ kg$

$v_2 = v_1 = 0.7964\ \frac{m^3}{kg}$

AT $P_{sat} = 100\ kPa, \quad v_f = 0.001043, \quad v_g = 1.694\ \frac{m^3}{kg}$

$x_2 = \frac{v_2 - v_g}{v_{fg}} = \frac{(0.7964) - (0.001043)}{(1.694) - (0.001043)} = 0.470$

4-11

PROB. CONT.

FIRST LAW:

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

RIGID CONTAINER, $W = 0$

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

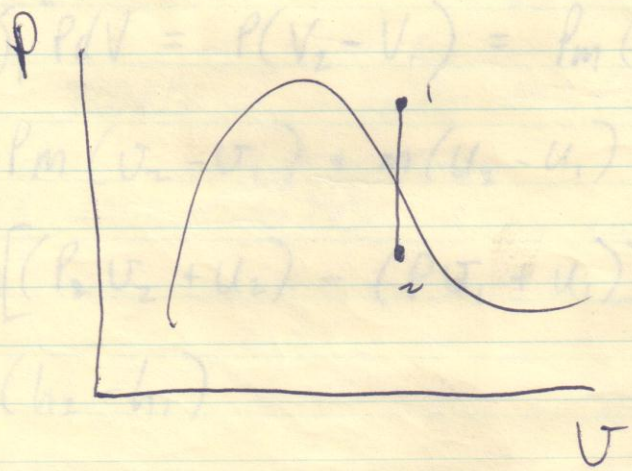
$$u_1 @ (300\ kPa, 150°C) = 2728.7\ \frac{kJ}{kg}$$

$$u_2 = u_f + x_2 u_{fg} = (417.36) + (0.47)(2088.7)$$

$$u_2 = 1399\ \frac{kJ}{kg}$$

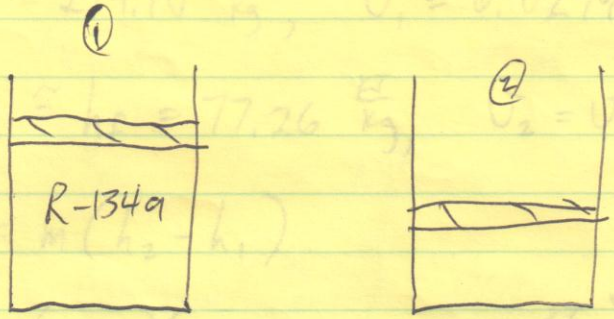
$$Q = (0.02511\ kg)(1399 - 2728.7\ \frac{kJ}{kg})$$

$$\boxed{Q = -33.4\ kJ}$$



4-18

PROB. [illegible]



$m = 5\ kg$

$P_1 = 800\ kPa, \quad T_1 = 60°C$

$P_2 = P_1 = 800\ kPa$ [illegible], $T_2 = 20°C$

FIND Q, SHOW T-v DIAGRAM

FIRST LAW:

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

$$W = \int_1^2 P\,dV = P(V_2 - V_1) = Pm(v_2 - v_1)$$

$$Q = Pm(v_2 - v_1) + m(u_2 - u_1)$$

$$Q = m[(P_2 v_2 + u_2) - (Pv_1 + u_1)] \qquad h = u + Pv$$

$$Q = m(h_2 - h_1)$$

PROB. 4-18

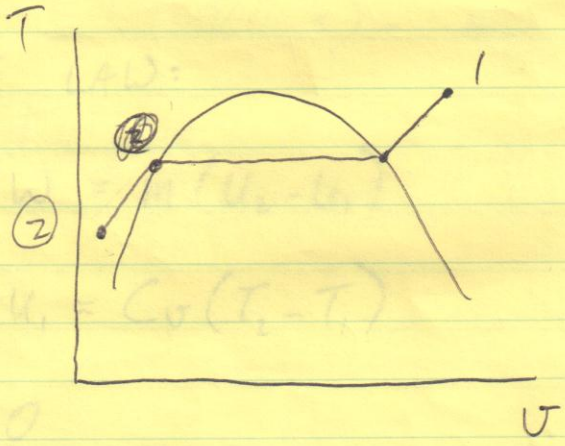
$h_1 = 294.98 \frac{KJ}{Kg}$, $v_1 = 0.02992 \frac{m^3}{Kg}$

$h_2 \cong h_f = 77.26 \frac{KJ}{Kg}$, $v_2 = v_f = 0.0008157 \frac{m^3}{Kg}$

$Q = m(h_2 - h_1)$

$Q = (5\ Kg)(77.26 - 294.98 \frac{KJ}{Kg})$

$Q = -1088.6\ KJ$



@ $P_2 = 800\ kPa$, $T_2 = 20°C \Rightarrow$ S.C.L.

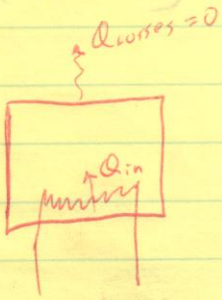
TAKE PROPERTIES OF SAT. LIQ. AT 20°C

PROB. BLOCK 4-28

$V = (4m)(5m)(6m) = 120\ m^3$ AIR

$T_1 = 7°C, \quad T_2 = 23°C$

$\Delta t = (15\ min)\left(\frac{60\ s}{min}\right) = 900\ s$



$P = 100\ kPa$

FIND POWER

FIRST LAW:

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

$u_2 - u_1 = C_v(T_2 - T_1)$

$W = 0$

POWER: $\dot{Q} = \frac{Q}{\Delta t} \quad \therefore \quad Q = \dot{Q}\Delta t$

$\dot{Q}\Delta t = mC_v(T_2 - T_1)$ C_v C_p

$\dot{Q} = \frac{mC_v(T_2 - T_1)}{\Delta t}$

$C_v = 0.718\ \frac{kJ}{kg\text{-}K}$

4-28

PROB. [illegible] CONT.

$$PV = mRT$$

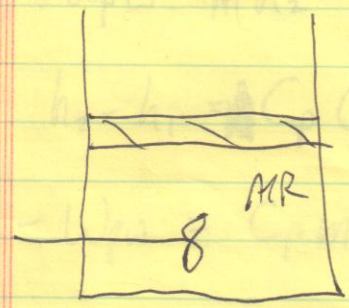
$$m = \frac{PV}{RT} = \frac{(100\ kPa)(120\ m^3)}{\left(0.287\ \frac{kJ}{kg-K}\right)(22+273\ K)} = 141.7\ kg$$

$$\dot{Q} = \frac{m\,C_v(T_2 - T_1)}{\Delta t}$$

$$\dot{Q} = \frac{(141.7\ kg)\left(0.718\ \frac{kJ}{kg-K}\right)(23-7\ K)}{(900\ s)}$$

$$\dot{Q} = 1.81\ kW$$

PROB. 4-34



INSULATED: $Q = 0$

$V = (100\ L)\left(\frac{m^3}{1000\ L}\right) = 0.1\ m^3$

$P_1 = 400\ KPa, \quad T_1 = 25°C$

$W_{PW} = -15\ KJ$

$P_2 = P_1$

FIND T_2

FIRST LAW:

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

$W_{net} = W_{PW} + P(V_2 - V_1) \quad = W_{PW} + Pm(v_2 - v_1)$

$-W_{PW} - Pm(v_2 - v_1) = m(u_2 - u_1)$

PROB. 4-34 CONT.

$$-W_{pw} = m(h_2 - h_1)$$

$$h_2 - h_1 = C_p(T_2 - T_1)$$

$$-W_{pw} = C_p m(T_2 - T_1)$$

$$T_2 = T_1 - \frac{W_{pw}}{C_p m}$$

$$PV = mRT$$

$$m = \frac{PV}{RT}$$

$$T_2 = T_1 - \frac{W_{pw} RT}{C_p PV}$$

$$T_2 = (25°C) - \frac{(-15\ kJ)\left(0.287 \frac{kJ}{kg-K}\right)(25°C + 273\ K)}{\left(1.005 \frac{kJ}{kg-K}\right)(400\ kPa)(0.1\ m^3)}$$

$$\boxed{T_2 = 56.9°C}$$

PROB. BLUZB 4-50

$\rho = 7833 \frac{kg}{m^3}$, $C_p = 0.465 \frac{kJ}{kg-K}$

$D = 8\,mm = 0.008\,m$, $T_1 = 900°C$, $T_2 = 100°C$

$\dot{N} = \left(2500 \frac{BALLS}{HR}\right)\left(\frac{HR}{3600S}\right) = 0.6944 \frac{BALLS}{S}$

FIND $\dot{Q}$

FIRST LAW:

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

FOR SOLIDS AND LIQUIDS, $C_v = C_p = C$

$$\therefore u_2 - u_1 = C(T_2 - T_1)$$

$W = 0$

$$Q = mC(T_2 - T_1)$$

AS A RATE EQUATION:

$$\frac{Q}{\Delta t} = \frac{m}{\Delta t} C(T_2 - T_1)$$

$$\dot{Q} = \dot{m} C (T_2 - T_1)$$

4-50
PROB. BALLS CONT.

FIND MASS FLOW RATE OF BALLS:

$\dot{m} = \dot{N} \cdot \text{MASS OF ONE BALL} = \dot{N} \cdot m_B$

$m_B = \rho V$

$m_B = \rho \frac{\pi D^3}{6} = \frac{\pi}{6}\left(7833 \frac{kg}{m^3}\right)(0.008\ m)^3 = 2.1 \times 10^{-3} \frac{kg}{BALL}$

$\dot{m} = \dot{N} \cdot m_B = \left(0.6944 \frac{BALLS}{s}\right)\left(2.1 \times 10^{-3} \frac{kg}{BALL}\right)$

$\dot{m} = 0.001458 \frac{kg}{s}$

$\dot{Q} = \dot{m} C (T_2 - T_1)$

$\dot{Q} = \left(0.001458 \frac{kg}{s}\right)\left(0.465 \frac{kJ}{kg\text{-}K}\right)(100 - 900\ K)$

$\boxed{\dot{Q} = -0.542\ kW = -542\ W}$