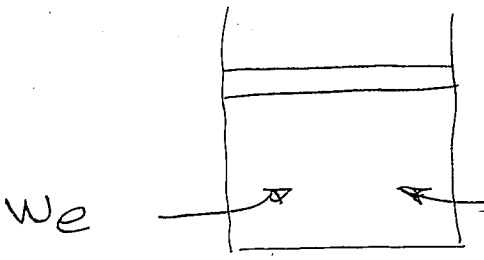
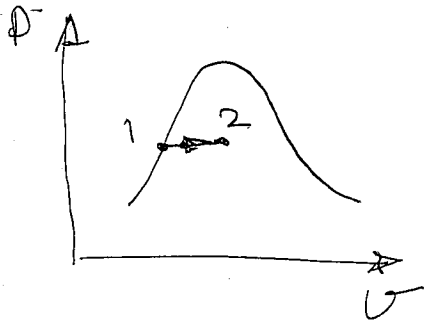
CHE 260 – MIDTERM 2016

(1)





For const pressure process

$$W_e + W_{sh} = \Delta H = m(h_2 - h_1)$$

At $P_1 = 175$ kPa, sat liq: $h_1 = h_f = 487.01$ kJ/kg; $v_1 = v_f = 0.001057$ m³/kg

$P_2 = 175$ kPa, $x_2 = 0.5$: $h_f = 487.01$ kJ/kg, $h_g = 2700.2$ kJ/kg

$$h_2 = h_f + x_2(h_g - h_f)$$
$$= 487.01 + 0.5(2700.2 - 487.01)$$
$$= 1593.6 \text{ kJ/kg}$$

$$m = \frac{V_1}{v_1} = \frac{5 \times 10^{-3} \text{ m}^3}{0.001057 \text{ m}^3/\text{kg}} = 4.730 \text{ kg}$$

$$V_e I \Delta t + W_{sh} = m(h_2 - h_1)$$

$$\frac{V_e (8A)(45 \times 60 \text{ s})}{1000 \text{ J/kg}} + 400 \text{ kJ} = 4.730(1593.6 - 487.01)$$

$$V_e = 223.8 \text{ V}$$

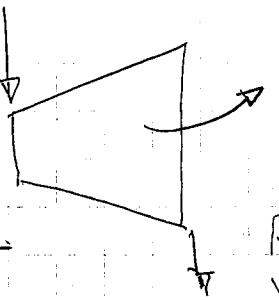
(2) Argon

$P_1 = 900\ kPa$

$T_1 = 450^\circ C$

$V_1 = 80\ m/s$

$A_1 = 60\ cm^2$



At inlet $v_1 = \frac{RT_1}{P_1} = \frac{0.2081\ \frac{kJ}{kg\,K} \times 723.15\ K}{900\ kPa}$

$\Rightarrow v_1 = 0.1672\ m^3/kg$

$\dot{m} = \frac{A_1 V_1}{v_1} = \frac{80\ m/s \times 60 \times 10^{-4}\ m^2}{0.1672\ m^3/kg} = 2.871\ kg/s$

Energy Balance

$\dot{W} + \cancel{\dot{Q}}^{\,0} = \dot{m}\left[(h_2 - h_1) + \frac{V_2^2 - V_1^2}{2}\right]$

$-250\ \frac{kJ}{s} = 2.871\ \frac{kg}{s}\left[0.5203\,(T_2 - 450^\circ C) + \frac{(150\ m/s)^2 - (80\ m/s)^2}{2 \times 1000\ J/kJ}\right]$

$\Rightarrow T_2 = 267.2^\circ C.$

(3)

A	B
200 kPa	2 MPa
$x = 0.8$	400°C

$V_A = V_B = 1\ m^3$

$P_2 = 1$ MPa.

At 200 kPa

$v_f = 0.001061\ m^3/kg \quad v_g = 0.88578\ m^3/kg$

$u_f = 504.50\ kJ/kg \quad u_g = 2024.6\ kJ/kg.$

$u_{A,1} = 504.50 + 0.8 \times 2024.6 = 2124.18\ kJ/kg$

$v_{A,1} = 0.001061 + 0.8(0.88578 - 0.001061)$

$= 0.70884\ m^3/kg$

At 2 MPa, 400° C.

$v_{B,1} = 0.15122\ m^3/kg \quad u_{B1} = 2945.9\ kJ/kg.$

$m_A = \frac{1}{v_{A,1}} = \frac{1}{0.70884\ m^3/kg} = 1.411\ kg$

$m_B = \frac{1}{v_{B,1}} = \frac{1}{0.15122\ m^3/kg} = 6.613\ kg.$

$m_{tot} = m_A + m_B = 1.411 + 6.613 = 8.024\ kg$

$v_2 = \frac{2\ m^3}{8.024\ kg} = 0.24925\ \frac{m^3}{kg}, \quad P_2 = 1\ MPa$

$\frac{T_2 - 250}{300 - 250} = \frac{0.24925 - 0.23275}{0.25799 - 0.23275} \Rightarrow T_2 = 289.2°C$

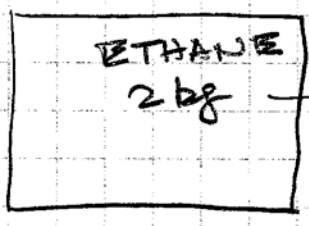
$\frac{u_2 - 2710.4}{2793.7 - 2710.4} = \frac{0.24295 - 0.23275}{0.25799 - 0.23275} \Rightarrow u_2 = 2764.9\ \frac{kJ}{kg}$

$Q_{1-2} = U_2 - U_1 = m_{tot} u_2 - (m_A u_{A,1} + m_B u_{B,1})$

$= 8.024 \times 2764.9 - (1.411 \times 2124.18 + 6.613 \times 2945.9)$

$= -292.9\ kJ$

4)



$$Q + W = \Delta U = m c_v (T_2 - T_1)$$

$$\Delta S = \frac{Q}{T_{surr}} + S_{gen}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad \text{and} \quad P_1 V_1^{1.3} = P_2 V_2^{1.3}$$

$$\Rightarrow \quad P_2 = P_1 \left(\frac{T_2}{T_1} \right)^{\frac{1.3}{0.3}}$$

$$= 500\ kPa \left(\frac{293\ K}{373\ K} \right)^{\frac{1.3}{0.3}} = 175.7\ kPa$$

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

$$= \frac{0.276\ (293 - 373)}{1.3 - 1} = -73.6\ kJ/kg$$

$$q = c_v (T_2 - T_1) - w = 1.490\ (293 - 373) + 73.6 = -45.6\ \frac{kJ}{kg}$$

$$\Delta s = c_p \ln \left(\frac{T_2}{T_1} \right) - R \ln \frac{P_2}{P_1}$$

$$= 1.766 \ln \left(\frac{293}{373} \right) - 0.276 \ln \left(\frac{175.7}{500} \right)$$

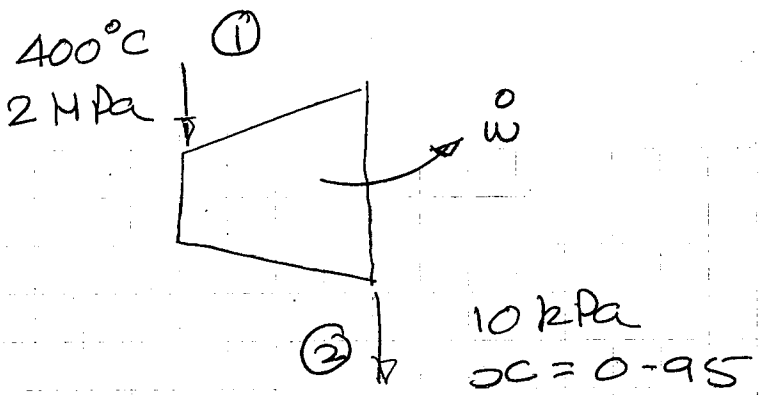
$$= -0.1376\ kJ/kg\,K$$

$$\Delta S = m \Delta s = 2\ kg \times (-0.1376)\ \frac{kJ}{kg\,K} = -0.2753\ \frac{kJ}{K}$$

$$S_{gen} = \Delta S - \frac{Q}{T_{surr}} = -0.2753 - \frac{(2 \times (-45.6))}{293}$$

$$= 0.0360\ \frac{kJ}{K}$$

(5)



$$w = \frac{\dot{W}}{\dot{m}} = h_2 - h_1$$

at 400°C, 2 MPa $\quad h_1 = 3248.4 \frac{kJ}{kg} \quad s_1 = 7.1292 \frac{kJ}{kgK}$

at 10 kPa $\quad h_f = 191.81 \text{ kJ/kg} \quad h_{fg} = 2392.1 \text{ kJ/kg}$

a) $h_2 = h_f + x_2 h_{fg}$

$= 191.81 \text{ kJ/kg} + 0.95 \times 2392.1 \frac{kJ}{kg} = 2464.3 \frac{kJ}{kg}$

$w = 2464.3 \text{ kJ/kg} - 3248.4 \frac{kJ}{kg} = -784.1 \text{ kJ/kg}$

b) For isentropic expansion $s_2 = s_1 = 7.1292 \frac{kJ}{kgK}$

at 10 kPa $\quad s_f = 0.6492 \text{ kJ/kgK} \quad s_{fg} = 7.4996 \text{ kJ/kgK}$

$$x_2 = \frac{s_2 - s_f}{s_{fg}} = \frac{7.1292 - 0.6492}{7.4996} = 0.8640$$

$h_2 = h_f + x_2 h_{fg}$

$= 191.81 \text{ kJ/kg} + 0.8640 \times 2392.1 \frac{kJ}{kg}$

$= 2258.6 \text{ kJ/kg}$

$w = h_2 - h_1 = 2258.6 \frac{kJ}{kg} - 3248.4 \text{ kJ/kg}$

$w = -989.8 \text{ kJ/kg}$