HW #1

1.a) @ $T = 650°C$ and $P = 2.5\ MPa$, $U_1 = 3378.2$, $H_1 = 3800.4$

@ $T = 200°C$ and $P = 0.4\ MPa$, $U_2 = 2647.2$, $H_2 = 2860.9$

$\therefore \Delta U = U_2 - U_1 = 2647.2 - 3378.2 = -731. \frac{kJ}{kg}$

$\Delta H = H_2 - H_1 = 2860.9 - 3800.4 = -940. \frac{kJ}{kg}$

1.b) $C_p/R = 4.04$, $R = 8.314 \frac{J}{mol \cdot K}$, $T_2 = 200°C$, $T_1 = 650°C$

$\Delta H = \int_{T_1}^{T_2} C_p dT \longrightarrow \Delta H = C_p \Delta T =$

$= 4.04 \cdot 8.314 \cdot -450 = -15114.9 \frac{J}{mol}$

$\rightarrow -15114.9 \frac{J}{mol} \cdot \frac{1\ mol}{18.015\ g} = -839. \frac{kJ}{kg}$

$C_v = C_p - R \quad \therefore \quad C_v = 4.04\left(8.314 \frac{J}{mol \cdot K}\right) - 8.314 \frac{J}{mol \cdot K}$

$C_v = 25.27 \frac{J}{mol \cdot K}$

$\Delta U = \int_{T_1}^{T_2} C_v dT \approx C_v \Delta T = 25.27 \frac{J}{mol \cdot K}(-450K)$

$= -11373.6 \frac{J}{mol} \cdot \frac{1\ mol}{18\ g} = -631. \frac{kJ}{kg}$

HW #1

2) $m = 25\ g$ $\quad n = \frac{25\ g}{78\ g/mol} = 0.321\ mol$ $\quad \Delta H_{vap} = 30.77$

@ 50% : $T_1 = 298.15 K$, $T_2 = 303.15 K$

$\frac{1}{2} n\ l$: 25°C → T_2
$\frac{1}{2} n\ l$: 25°C → 80°C
$\frac{1}{2} n\ \Delta H_{vap}$
$\frac{1}{2} n\ V$: 80°C → T_2

$$\Delta H_{30°C} = \frac{1}{2} n \left(\int_{298}^{303} C_{p,B,l}\, dT + \int_{298}^{353} C_{p,B,l}\, dT + \Delta H_{vap,B} + \int_{353}^{303} C_{p,B,V}\, dT \right)$$

$$\Delta H_{50°C} = \frac{1}{2} n \left(\int_{298}^{323} C_{p,B,l}\, dT + \int_{298}^{353} C_{p,B,l}\, dT + \Delta H_{vap B} + \int_{353}^{323} C_{p,B,V}\, dT \right)$$

@ 75% vap:

$T_1 = 298.15 K$
$T_2 = 303.15$ OR 323.15

$\frac{1}{4} n\ l$: T_1 → T_2
$\frac{3}{4} n\ l$: T_1 → 80
$\frac{3}{4} n\ V$: 80 → T_2
$\frac{3}{4} n\ \Delta H_{vap}$

$$\Delta H_{30°C} = \frac{1}{4} n \int_{298}^{303} C_{p,B,l}\, dT + \frac{3}{4} n \left(\int_{298}^{353} C_{p,B,l}\, dT + \Delta H_{vap} + \int_{353}^{303} C_{p,B,V}\, dT \right)$$

$$\Delta H_{50°C} = \frac{1}{4} n \int_{298}^{323} C_{p,B,l}\, dT + \frac{3}{4} n \left(\int_{298}^{353} C_{p,B,l}\, dT + \Delta H_{vap} + \int_{353}^{323} C_{p,B,V}\, dT \right)$$

	Total H	Molar H
50% vap @ 30°C :	5.58 KJ	17.4 KJ/mol
@ 50°C :	6.31 KJ	19.7 KJ/mol
75% vap @ 30°C :	8.26 KJ	25.8 KJ/mol
@ 50°C :	8.90 KJ	27.8 KJ/mol

$$\text{Molar H} = \frac{\text{Total H}}{n}$$

HW #1

2) Molar Enthalpy = $\frac{\Delta H}{n}$

50% @ 30°: 16.2 $\frac{kJ}{mol}$
@ 50°: 16.2 $\frac{kJ}{mol}$

75% @ 30°: 24.3 $\frac{kJ}{mol}$
@ 50°: 24.2 $\frac{kJ}{mol}$

3.) $P_1 = 550\ kPa$ $T_1 = 200°C$ $\dot{m} = 15\ \frac{kg}{min}$
$P_2 = 200\ kPa$ $T_2 = ?$

For throttle: $\Delta H = 0$ ∴ using steam tables:

$H_1 = 2853.2\ \frac{kJ}{kg} = H_2$

For 200 kPa, $H = 2853.2\ \frac{kJ}{kg}$ when $T = 191.$

$T = T_1 + (H_0 - H_1)\frac{(T_2 - T_1)}{H_2 - H_1}$

$T = 150 + (2853.2 - 2769.1)\frac{(200-150)}{(2870.7-2769.1)} = 191.°C$

$U_i = 2641.3$

$U_f = 2577.1 + (190-150)\frac{(2654.6-2577.1)}{200-50} = 2639.1$

$\Delta U = U_f - U_i = 2639.1 - 2641.3 = -2.20\ \frac{kJ}{kg}$

$-2.20\frac{kJ}{kg} \cdot 15\ \frac{kg}{min} = -33.0\ \frac{kJ}{min}$

HW #1

4.) ΔH°_{rxn} @ 298.15 K: $\sum_{\text{Products}} |\nu_i| \Delta H_f^\circ - \sum_{\text{reactants}} |\nu_i| \Delta H_f^\circ$

$\therefore Q = 2(-393.51) + 3(-285.83) - (-83.82) - \frac{7}{2}(0)$

$= -1.56 \times 10^3 \frac{kJ}{mol}$

@ 400k $\sum_{\text{Products}} \nu_i \left(\Delta H_f^\circ + \int_{T_R}^{400} C_p dT\right) - \sum_{\text{reactants}} |\nu_i| \left(\Delta H_f^\circ + \int_{T_R}^{400} C_p dT\right)$

$C_p = A + BT + CT^2 + DT^3$

$\therefore Q = 2(-393.51 + 4.003) + 3(-285.83 + 7.728) - (-83.82 + 6.054) - \frac{7}{2}(0 + 3.034)$

$= -1.55 \times 10^3$