ME 209 – BASIC THERMODYNAMICS
Assignment 3

1. Find the state of a closed system containing 1 kg of water substance. Specify h, v, x, s as appropriate.

a). Saturated liquid at 5 bar ($T=151.9\,^{o}C$, h=640.2 kJ/kg, v= 0.001093 m^3 /kg, s = 1.861 kJ/kg-K)
b). Saturated vapor at 10 bar ($T=179.9\,^{o}C$, h=2776.2 kJ/kg, v = 0.1632 m^3 /kg, s= 6.5194 kJ/kg-K)
c). 5 bar, 200 ^{o} C (h= 2855.4 kJ/kg, v= .425 m^3/kg, s= .059 kJ/kg-K)
d). 100 bar, 200 ^{o} C (u = 850.6 kJ/kg, h = 862.1 kJ/kg, v = 0.001157 m^3/kg, s = 2.331 kJ/kg-K)

2. Classify the following states of 1 kg of water substance as wet, dry saturated, superheated steam, subcooled liquid as appropriate,

a). 1 bar, 150 ^{o} C (Superheated)
b). 2 bar, 200 ^{o} C (Super heated)
c). 2 bar, S = 6.2 kJ/K (Wet steam)
d). 2 bar, 0.1 m^3 (Wet steam)
e). 0.5 bar, H = 2700 kJ (Superheated)
f). H = 2100 kJ, T = 50 ^{o} C (Wet steam)

3. For the following processes, find the changes in h, s, v, T and X as appropriate. The initial pressure is 5 bar and the final state is as specified,

a). Constant Volume; $v_1 = 0.3$ m^3 /kg, $P_2 = 3$ bar (Δh = -695 kg, (Δs = 1.526 kJ/kg-K)
b). Constant entropy; $s_1 = 6.3$ kJ/kg-K, $P_2 = 1.5$ bar (Δh = -188.6 kJ/kg, (Δv = 0.6336 m^3 /kg)
c). Constant Volume; $h_1 = 2500$ kJ/kg, $p_2 = 2.0$ bar (Δh = -1174.6 kJ/kg, (Δs= 2.618 kJ/kg-K)
d). Constant entropy; $s_1 = 6.4$ kJ/kg-K, $p_2 = 2.0$ bar (Δs = 0.279 kJ/kg-K, (Δv= 0.4876 m^3 /kg)
e). Constant Volume; $T_1 = 200^{o}$ C, $P_2 = 2.0$ bar ((Δh = -1295.9 kJ/kg-K, (Δ s 2.848 kJ/kg-K)
f). Constant Pressure $X_1 = 0.5$, $T_2 =400\,^{o}$ C ((Δ h =-1577.4 kJ/kg, (Δ s = 3.363 kJ/kg-K)

4 2 Kg of steam at critical conditions is sealed in a rigid container. It is then placed in an oven at 349.9 ^{o} C, and allowed to come to thermal equilibrium. Determine the masses of the water and steam in the final state, and the heat transferred. (m_{water} = 1.6008 kg, m_{steam}= 0.3992 kg, Q=-466.1 kJ

5. A closed system contains saturated liquid water at 20^{o} C. Heat is added to it at constant pressure. Determine the final state, if the amount of heat added is 2000 kJ/kg. (x= 0.815, u = 1973.9 kJ/kg)

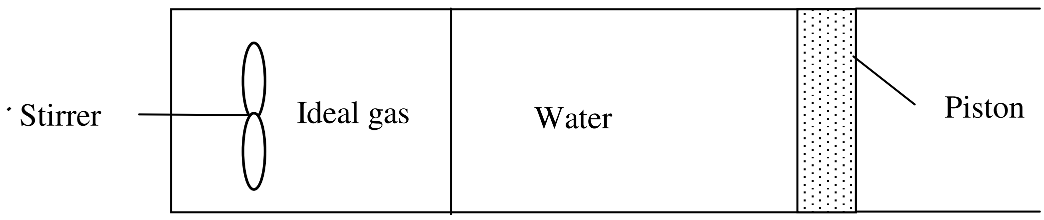
6. 2.5 kg of saturated liquid water at 10 bar is mixed with 1 kg of superheated steam at 10 bar and 250^{o} C adiabatically and at constant pressure. Determine the changes in volume and internal energy. Also compute the dryness fraction at the final state and work done (ΔV = -0.02328 m^3, (ΔU = 23.28 kJ, x = 0.309, W= -23.28 kJ)

7. Compute the change in the internal energy, enthalpy and the work done when 1 kg of water at 100^{0} C evaporates isothermally into dry saturated steam. (ΔU= 2087.6 kJ, (Δ H = 2257 kJ/kg, W = 169.4 kJ)

8. Water at 100^{0} C and 5 bar is supplied 1200 kJ/kg of heat at constant pressure. Determine the final state of the system, if the system is a closed one. (T = 151.9^{0} C, x = 0.4645)

9. A rigid metallic container is separated into two equal parts by a thin partition. One part contains 1 kg of saturated liquid water at 100^0 C. The other part is evacuated. The partition is broken, and equilibrium is established. During the process the temperature of the system is maintained at 100^0 C by an oil bath. Determine the final state of steam, work done and the heat transferred. (T= 100^0 C, x 6.244 X 10^{-4}, W = 0 kJ, Q = 1.304 kJ)

10. Consider an adiabatic piston cylinder assembly as shown in the figure. The cylinder is partitioned into two parts by a thin fixed diathermic wall. The left chamber contains an ideal gas. The right chamber contains 2 kg saturated liquid water at 30^0 C. The gas is stirred and the steam is allowed to expand at constant pressure till it becomes dry saturated. Determine a) change in internal energy of the ideal gas, b) heat transferred across the diathermic wall, c) Stirrer work and d) Work done by the steam



(Δ U = 0, Q = 4861 kJ, W = -4861 kJ, W_{steam} = 2799.3 kJ)

11. A rigid, insulated vessel is divided into two chambers by an adiabatic partition wall. One chamber contains 1 kg of wet steam at 2 bar and x = 0.6, while the other chamber contains 0.5 kg of dry saturated steam at a pressure of 5 bar. If the partition between the chambers is removed and the fluids allowed to mix, find the specific volume, specific internal energy, pressure and the dryness fraction at the final state, (v = 0.480 m^3 /kg, u = 2000.1 kJ/kg, p = 2.746 bar, x = 0.7287)