Thermodynamics Practice Problems of Unit I

1. a) For ideal gas, $d\underline{U} = nC_v dT$, delta($\underline{U}$) = $3R(T_2 - T_1)$ = 124.7 J

$\underline{W}s$ = delta($\underline{U}$) - $\underline{Q}$ = delta($\underline{U}$) = 124.7 J

b). Delta ($\underline{S}$) = $n\,[C_v \ln(T_2/T_1) + R \ln(V_2/V_1)\,] = n\,C_v \ln(T_2/T_1)$ =0.422 J/K

2. a). Carnot Cycle provides the maximum thermal efficiency,

eta = $Ws/Q_h = (Q_h - Q_c)/Q_h = (T_h - T_C)/T_h$ = (300 –279)/300 = 7%

b). Q_c = - $C_P \times$ (T change of cold water) = - 4.6 kJ/kg

$Ws = Q_h - Q_c = Ws$ /eta - Q_c → Ws = - Q_c/(1-1/eta) = - 0.346 kJ/kg

$\underline{W}s = m\,Ws$

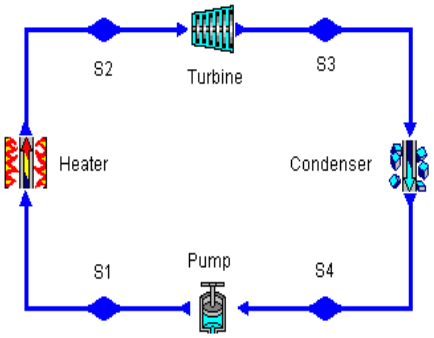
m = 50 (kJ/s) / 0.346 (kJ/kg) = 144.5 kg/s

3. Rankine Cycle.

eta = $Ws/Q_h = (H_3 - H_2)/(H_2 - H_1)$

State properties

State point	T (°C)	P (MPa)	S (kJ/kg K)	H (kJ/kg)
1		2 (=P2)		274 (calculated)
2		2 (given)	7.8296 (= S3; rev. turb.)	3803 (calculated)
3 (Sat V)	65 (given)	0.025 (from table)	7.8296 (from table)	2617.5 (from table)
4 (Sat. L)		0.025 (=P3)	0.8937 (from table)	272.12 (from table)



Calculation:

Interpolation for H_2:

H_2 = 3803 kJ/kg

Calculation for H_1:

$H_1 = H_4 + V(\text{delta P})$

= 272 + 1.02 × (2-0.025) = 274 kJ/kg

Ans. eta = 34%

4. For compartment (A): $(n_A/n_o) = (T_A / T_o)^{Cv/R}$ ----------(1)

For Compartment (B): $(n_A U_A - n_o U_o) = n_B U_B + \text{Integ.}\,(RT\,dn)$

$= n_B U_B + CvRT_o n_B^{Cp/Cv}/(C_P n_o^{R/Cv})$

Choose reference state: $T^R = T_o$, $U^R = 0$

we have: $n_A(T_A - T_o) = n_B(T_B - T_o) + RT_o n_B^{Cp/Cv}/(C_P n_o^{R/Cv})$ ------(2)

From material balance: $n_o = n_A + n_B$ --------(3)

where $n_o = P_o V_A/T_o$ ----------(4)

$n_A = P^f V_A/T_A$ ----------(5)

$n_B = 2\,P^f V_A/T_B$ ----------(6)