

Thermodynamics Practice Problems of Unit I

1. a) For ideal gas, $dU = nC_v dT$, $\Delta(U) = 3R(T_2 - T_1) = 124.7 \text{ J}$
 $W_s = \Delta(U) - Q = \Delta(U) = 124.7 \text{ J}$
 b). $\Delta(S) = n [C_v \ln(T_2/T_1) + R \ln(V_2/V_1)] = n C_v \ln(T_2/T_1) = 0.422 \text{ J/K}$

2. a). Carnot Cycle provides the maximum thermal efficiency,
 $\eta = W_s/Q_h = (Q_h - Q_c)/Q_h = (T_h - T_c)/T_h = (300 - 279)/300 = 7\%$
 b). $Q_c = -C_p \times (\text{T change of cold water}) = -4.6 \text{ kJ/kg}$
 $W_s = Q_h - Q_c = W_s/\eta - Q_c \rightarrow W_s = -Q_c/(1 - 1/\eta) = -0.346 \text{ kJ/kg}$
 $W_s = m W_s$
 $m = 50 \text{ (kJ/s)} / 0.346 \text{ (kJ/kg)} = 144.5 \text{ kg/s}$

3. Rankine Cycle.
 $\eta = W_s/Q_h = (H_3 - H_2)/(H_2 - H_1)$

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 :

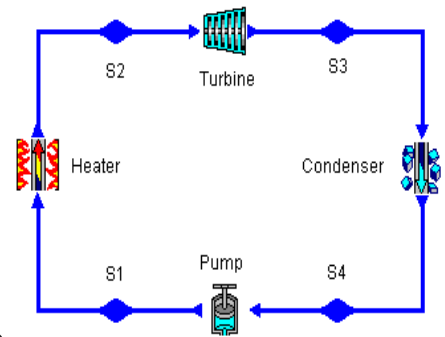
$$H_2 = 3803 \text{ kJ/kg}$$

Calculation for H_1 :

$$H_1 = H_4 + V(\Delta P)$$

$$= 272 + 1.02 \times (2 - 0.025) = 274 \text{ kJ/kg}$$

Ans. $\eta = 34\%$



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

For Compartment (B): $(n_A U_A - n_o U_o) = n_B U_B + \text{Integ. } (RT dn)$
 $= n_B U_B + C_v R T_o n_B^{C_p/C_v} / (C_p n_o^{R/C_v})$

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

we have: $n_A(T_A - T_o) = n_B(T_B - T_o) + RT_o n_B^{C_p/C_v} / (C_p n_o^{R/C_v})$ -----(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)

