1. Please give the three methods to increase the Rankine cycle efficiency? (6%) for which is the best way to increase the efficiency? (2%) and why? (2%)

2. Give the brief description of the Kelvin-Planck Statement (5%) and Clausius Statement (5%) and write down the equation of the Inequality of Clausius. (5%)

3. A car engine with two inlets ad one outlet is shown as in figure 1, at time t while the piston is locate on state (1). When the spark start to ignite, a certain amount of heat Q is generated in the engine and the piston is pushing to the state (2) at time $t+\delta t$. During this period of time interval δt, a mechanical wok W_{shaft} has been done by the engine and the system internal energy is changed from $U_{sys,t}$ to $U_{sys,t+\delta t}$. This internal energy change is also represented as ΔU_{sys}. Please develop the 1st law equation of thermodynamic from the given data of the figure 1. Assume all the kinetic energy and the potential energy can be neglected. (20%)

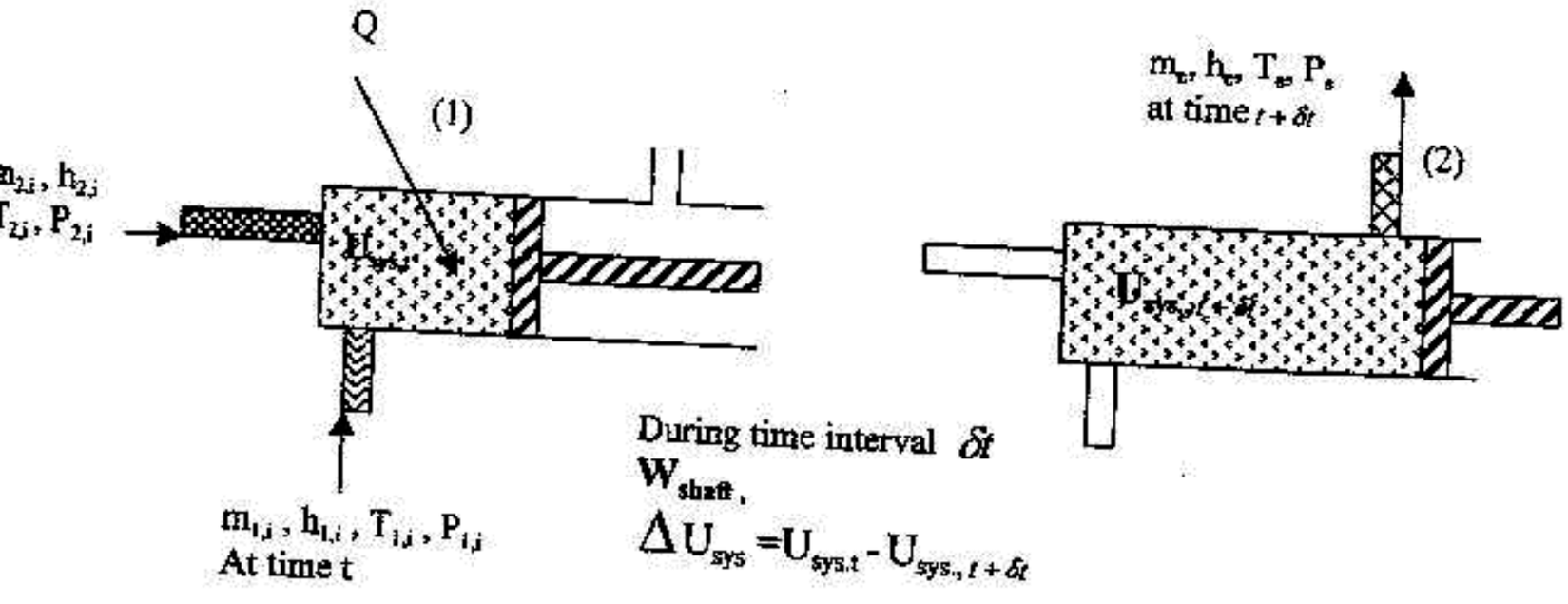

Figure 1

4. A cyclic machine is used to transfer heat from a higher to a lower temperature reservoir, as shown in figure 2. Determine whether this machine, with energy transfer values as shown in figure 2 reversible, irreversible, or impossible. (10%)

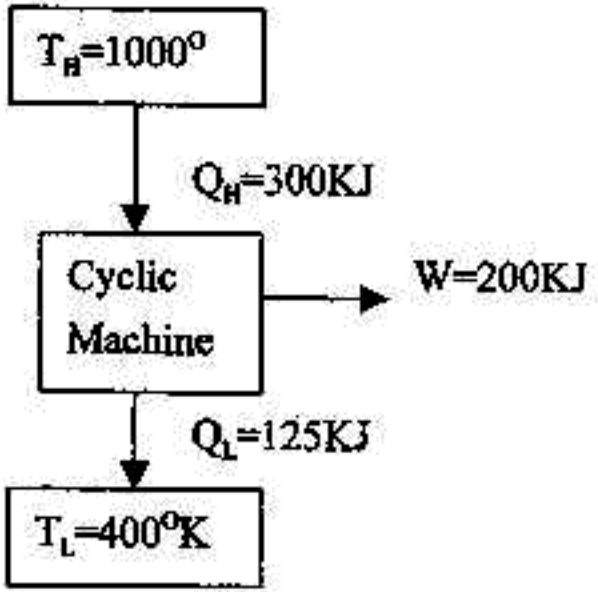

Figure 2

5. A simple ideal Rankine cycle engine is operating between 20°C and 100°C, the T-S diagram is shown as in figure 3

a) Determine the quality and the enthalpy at point (4) (4%)

b) Determine the isentropic turbine work (4%)

c) Determine the isentropic pump work (4%)

d) Determine the enthalpy at point (1) (2%)

e) Determine the heat absorption at boiler (2%)

f) Find the efficiency of the simple ideal Rankine Cycle (2%)

g) If it is the carnet operating between 20 °C and 100 °C, find the Carnot efficiency. (2%)

Steam Table

State	P_i(kPa)	T_i(°C)	V_i(m^3/kg)	h_i(kJ/kg)	S_i(kJ/kg °K)	χ
1	101.32		—	—	—	—
2	101.32	100	0.001043	418.9	1.3062	0
3	101.32	100	1.6699	2675.8	7.3554	1.0
4	2.34	20	—	—	—	—
5	2.34	20	0.001002	83.9	0.2965	0
6	2.34	20	57.8	2538.1	8.6672	1.0

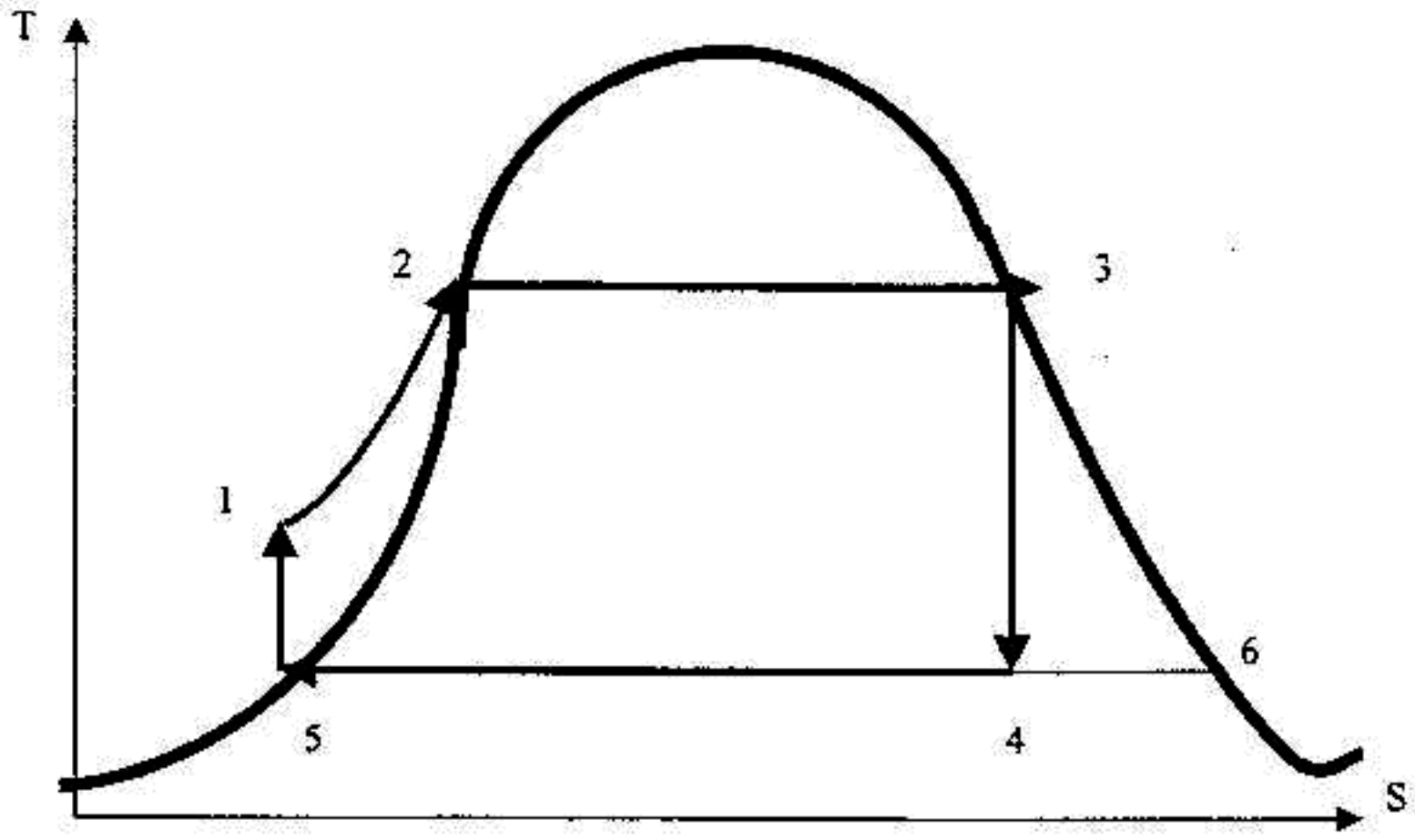

Figure 3

6. Water is compressed from state (1) to state (5). Shown as in Fig. 4. Assume the specific volume of water v_f and its volume expansivity α_p are constant, the values of v_f and α_p are changing with respect to the changes of the pressure only. Water in liquid phase is following the state equation P=AlnT+C, where A, C are constant, and the steam in vapor phase is following the state equation P(v-b)=RT, where b is constant. The heat capacity of water is constant; $C_{p(f)}$, and the heat capacity of steam is constant too; $C_{p(v)}$. Given the saturated liquid enthalpy at state(2); $h_{f,2}$, and the saturated vapor enthalpy at state (3), $h_{g,3}$, P_1, P_2, P_5, are the isobaric lines, $T_4=T_5$, $T_3=T_2$,

Define volume expansivity:

$$\alpha_p = \frac{1}{v_f}\left(\frac{\partial v_f}{\partial T}\right)_P$$

(a) Please evaluate enthalpy change Δh_{12} and entropy change ΔS_{12}, from state (1) to state (2) with function of $C_{p(f)}$ T_1, T_2, P_1, P_2, α_p and A. (8%)

(b) Evaluate the enthalpy change Δh_{23} and entropy change ΔS_{23} from state (2) to state (3) with function of $h_{f,2}$, $h_{g,3}$, and T_2 (5%)

(c) Evaluate the entropy change Δh_{34} and the entropy change ΔS_{34} from state (3) to state (4) with function of $C_{p(v)}$, T_3 and T_4. (6%)

(d) Evaluate the enthalpy change Δh_{45} and the entropy change ΔS_{45} from state (4) to state (5) with function of R, b, P_2 and P_5 (6%)

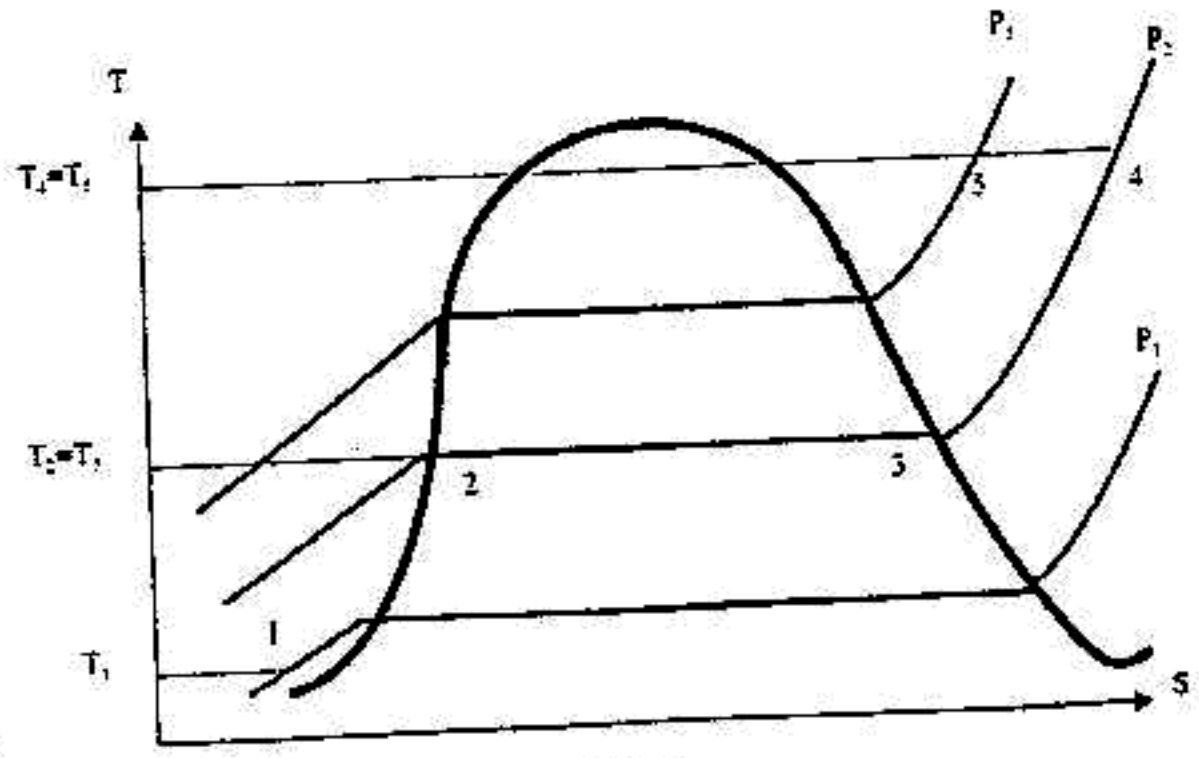

Figure 4