1. Describe a process that would satisfy the conservation of energy principle, but does not actually occur in nature. (10%)

2. Show that $(dG)_{T,P} = 0$ is a valid equilibrium criterion, where $G=H-TS$ is the Gibbs function. (15%)

3. Derive $dh = c_P dT + \left[v - T\left(\frac{\partial v}{\partial T}\right)_P \right] dP$ (15%)

4. For an ideal gas, what is the value of the Joule -Thomson coefficient? $\mu_J = \left(\frac{\partial T}{\partial P}\right)_h$ (15%)

5. The pressure-volume diagram of a Carnot power cycle executed by an ideal gas with constant specific heat ratio k is shown in Fig. 1. Demonstrate that
   (a) $V_4V_2 = V_1V_3$ (20%)
   (b) $T_2/T_3 = (p_2/p_3)^{(k-1)/k}$
   (c) $T_2/T_3 = (V_3/V_2)^{k-1}$

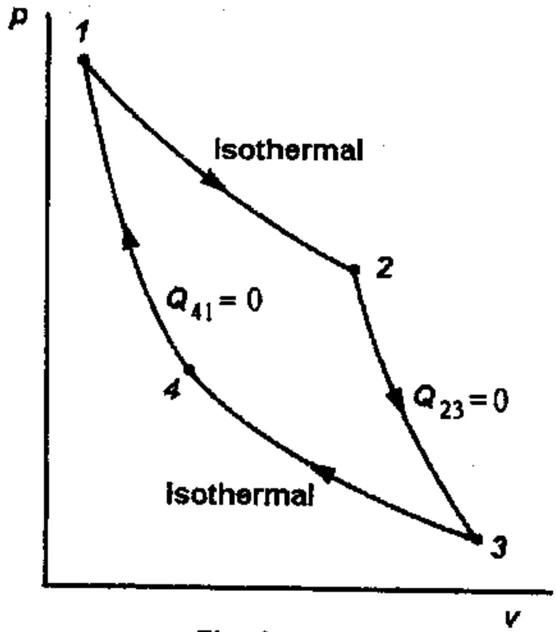

Fig. 1

6. Water initially a saturated liquid at 100℃ is contained in a piston-cylinder assembly. The water undergoes a process to the corresponding saturated vapor state, during which the piston moves freely in the cylinder. For each of two processes described below, determine on a unit of mass basis the work, the heat transfer, and the change in availability (exergy), the availability transfer accompanying work, the availability transfer accompanying heat, and the availability destruction, each kJ/kg. Let $T_0 = 20\,℃$, $p_0 = 1.014\,\text{bar}$.

   (a) The change in state is brought about by heating the water as it undergoes an internally reversible process at constant temperature and pressure.

   (b) The change in state is brought about adiabatically by the stirring action of a paddle wheel.

(25%)

Temp ℃	Press bar	Specific Volume m^3/kg Sat. Liquid $v_f \times 10^3$	Specific Volume Sat. Vapor v_g	Internal Energy kJ/kg Sat. Liquid u_f	Internal Energy Sat. Vapor u_g	Enthalpy kJ/kg Sat. Liquid h_f	Enthalpy Sat. Vapor h_g	Entropy kJ/kg·K Sat. Liquid s_f	Entropy Sat. Vapor s_g
100	1.014	1.0435	1.673	418.94	2506.5	419.04	2676.1	1.3069	7.3549