1. Derive (a) $dh = c_p dT + [v - T(\frac{\partial v}{\partial T})_p]dp$ (20%)

   (b) $ds = \frac{c_p}{T}dT - (\frac{\partial v}{\partial T})_p dp$

2. Explain the reason why any process must satisfy the first and second law of thermodynamics (20%).

3. A system undergoes a thermodynamic cycle while receiving energy by heat transfer from an incompressible body of mass *m* and specific heat *c* initially at temperature T_H. The system undergoing the cycle discharges energy by heat transfer to another incompressible body of mass *m* and specific heat *c* initially at a lower temperature T_C. Work is developed by the cycle until the temperature of each of the two bodies is the same. Show that the maximum theoretical amount of work that can be developed is

   (20%)

$$W_{\max} = mc[T_H + T_C - 2(T_H T_C)^{1/2}]$$

4. An isolated system of total mass *m* is formed by mixing two equal masses of the same liquid initially at temperatures T_1 and T_2. Eventually, the system attains an equilibrium state. Each mass is incompressible with constant specific heat *c*. show the amount of entropy produced is

   (20%)

$$\sigma = mc \ln\left[\frac{T_1 + T_2}{2(T_1 T_2)^{1/2}}\right]$$

5. Butane (C_4H_{10}) undergoes a process in a piston-cylinder assembly from p_1= 5 MPa, T_1= 500K to p_2= 3 MPa during which the relationship between pressure and volume is $pv^{1.05}$=constant. The mass of butane is 5 kg. Determine the final temperature, in K, and the work, in kJ. (20%)

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