ISI B.Math Physics II
Problem Set II
Total Marks =50

1. Use the second law of thermodynamics to show that two adiabatic curves cannot intersect . (5)

2. (a) Show that the entropy S increases with the volume V for a gas whose pressure P is known to be proportional to the absolute temperature when the volume is kept constant. (5)

(b) It is desired to cool a gas by expansion through a porous plug (Joule- Thomson method). Should the initial conditions be chosen so that $\left(\frac{\partial H}{\partial P}\right)_T$ is greater than, equal to, or less than zero ? Explain. (5)

3. The internal energy u of a unit volume of a gas is a function of T only and the equation of state for this gas is given by $p = \frac{1}{3}u(T)$.

(i)Determine the functional form of $u(T)$. (5)

(ii) Calculate the entropy density for this gas using the boundary condition that the entropy vanishes at absolute zero.(5)

(iii) If a Carnot engine is operated with the above gas as a working substance, draw the Carnot cycle on a PV diagram showing the isothermals and adiabatics composing it (5)

4. The heat capacity of nonmetallic solids at sufficiently low temperatures is proportional to T^3, as $C = aT^3$. Assume it were possible to cool a piece of such a solid to $T = 0$ by means of a reversible refrigerator that uses the solid specimen as its low-temperature (variable!) reservoir, and for which the high temperature reservoir has a fixed temperature T_h equal to the initial temperature T_i of the solid. Find an expression for the electrical energy required.(10)

5. A room air conditioner operates as a Carnot cycle refrigerator between an outside temperature T_h and a room at lower temperature T_i. The room gains heat from the outside at the rate $A(T_h - T_i)$; this heat is removed by the air conditioner. The power supplied to the cooling unit is P. Find the steady state temperature of the room T_i in terms of P and T_h.(10)