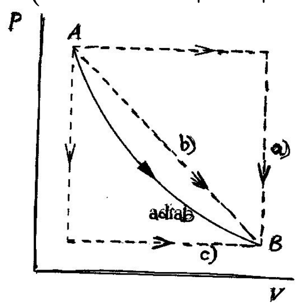
Physics II
ISI B.Math
Supplementary Midterm Exam: November 27, 2019

Total Marks: 40
Time: 3 hours
Answer all questions

1. **(Marks: 3 + 4 + 3 = 10)**



During a quasistatic reversible transformation from $A \to B$ during which no heat is exchanged with the environment, the pressure of a certain amount of gas is found to change with the volume according to the equation $P = \alpha V^{-\frac{5}{3}}$ where α is a constant. Find the work done on the system and the net amount of heat absorbed by the gas in each of the following three transformations which take the system from state A to state B as indicated in the diagram by a) , b) and c). You may assume that the transformations are quasi-static and reversible. Express your results in terms of P_A, P_B, V_A and V_B (the constant α should not appear in your results.)

2. **(Marks : 5 + 5 = 10)**

(a) Calculate the maximum work in Joules obtainable from a heat reservoir consisting of a mass M of iron heated initially to a temperature of T_1 , using the ocean, at temperature T_2 , as the second heat reservoir at a lower temperature. Assume that the specific heat capacity of iron is constant and is equal to C_I.

(b) Calculate the entropy change of the universe in this process.

3. **(Marks: 3 + 3 + 4 = 10)**

i) It is experimentally found that for a solid of volume expansion coefficient β at constant pressure P

$$\beta V = a + bP + cP^2$$

where a, b and c are constants for $P_A \leq P \leq P_B$. How much will the entropy increase when the solid is compressed from a pressure P_A to P_B at constant temperature ?
ii) Show that

$$\left(\frac{\partial U}{\partial V}\right)_P = T\left(\frac{\partial P}{\partial T}\right)_V - P$$

(iii) Radiation, which is a collection of photons can be modelled as a non-ideal gas. The internal energy u of a unit volume of such a photon gas is a function of T only and the equation of state for this gas is given by $p = \frac{1}{3}u(T)$. Determine the functional form of $u(T)$.

4. **(Marks: 3 + 3 + 4 = 10)**

(a) Is the infinitesimal quantity $dF = (x^2 - y)dx + xdy$ an exact differential ?
(b) Using the fact that the Gibb's potential $G = U - TS + pV$ is a function of state show that

$$\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$$

(c) Show that for an isothermal, isobaric process the Gibbs potential cannot increase.

Information you may (or may not) need

$$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$$

$$\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$$

$$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$$

$$\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$$