PHYS 430 - SUPPLEMENTARY EXAMINATIONS FOR GRADUATION
February 2007

Name and Surname:
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Department:
Signature:

1. Calculate the thermodynamical potentials $F,\ S,\ E,\ \mu,\ F$ of an ideal gas of pointlike particles confined to move in 2 dimesions on a surface A if they have the energy-momentum relation $\epsilon = \frac{p^2}{2m}$ using
   (a) Micro Canonical Ensemble
   (b) Canonical Ensemble
   (c) Grand Canonicle Ensemble
2. Consider two small systems in contact. Show that in equilibrium:
   (a) If the two subsytems are allowed to exchange energy, the temperatures of both systems are the same
   (b) If both systems are seperated by a movable piston so that they exchange volume, but no other exchange is possible, the pressures of both systems are the same in equilibrium
   (c) If the two system are seperated by a membrane which only allows the exchange of particles, then the chemical potential of both systems are the same
3. Consider two particles which can be only in 2 states, one with energy ϵ_1 and the other with energy ϵ_2. If the system is at temperature T, write the partition function of the system if the particles are:
   (a) Distinguishable particles
   (b) Identical particles satisfying the Boltzman distribution
   (c) Identical particles which are fermions
   (d) Identical particles which are bosons.

In each of these cases, calculate the energy $\langle E \rangle$ of the system and the fluctuations in the energy of the system, $\langle (\Delta E)^2 \rangle$

4. Consider the two single particles states in a metal which have energies ϵ_i ($i = 1,\ 2$) none of which is degenerate. If the metal is at temperature T and has a chemical potential μ, what is the average number of electrons in these states? What is the relative fluctuation in the number of particles in these states?

5. Consider a quantum harmonic oscillator that has a frequency ω (the energy levels are given by $\epsilon_n = \hbar\omega(n + \frac{1}{2})$). If the oscillator is at temperature T, calculate its free energy F. Calculate E and C_V for this harmonic oscillator.

6. Consider a mixture of N_1 molecules of a diatomic ideal gas and N_2 molecules of a monatomic ideal gas. Calculate C_V, C_P and $\gamma = \frac{C_P}{C_V}$ for this mixture.

7. Suppose that you have a gas of N identical particles entrapped in a sphere of radius R and are subject to a potential $V = \alpha r$ where α is some constant and r is the distance from the center of the sphere. Assume that the energy of the particles is relted to the momentum through $\epsilon = \alpha p^n$.

   (a) Calculate the the density of particles as a function of the radius from the center. Properly normalize the density so that the integral of the density over the whole sphere gives N, the total number of particles.

   (b) Calculate the partition function of the system.

   (c) Calculate the pressure the gas exerts on the sphere surface.