(ii) Calculate the average energy, specific heat and entropy of the above system and discuss your result. (5)

3. (a) Evaluate the density matrix ρ_{mn} of a free particle (in the canonical ensemble) of mass m, in a cubical box of side L. (5)

(b) A circular cylinder of height L, cross-sectional area A is filled with a gas of classical point particles whose mutual interactions can be ignored. The particles, each of mass m, are acted by gravity. The system is maintained in thermal equilibrium at absolute temperature T. Compute the canonical partition function q as a function of T and other parameters. What are the values of q as $T \to 0$ and $T \to \infty$? (3+2)

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Internal Assessment-10

PKC/PG/IIIS/PHS-301/18

2018

M.Sc.

3rd Semester Examination

PHYSICS

PAPER – PHS-301 (Gr. – A + B)

Full Marks : 50

Time : 2 Hours

(Quantum Mechanics III – PHS 301A)

Answer Q1 and any one from Q2 and Q3

1. Answer any five bits: 5X2 = 10

(a) Explain why the ground state of the He exists in para-form whereas the excited states come in both forms.

(b) Justify-In case of potential scattering Green's function acts as a propagator.

(c) Discuss the applicability of the Thomas-Fermi approximation. Why is it called a semi-classical approximation?

(d) What do you mean by exchange degeneracy? How this degeneracy could be removed?

(e) Show that in an electromagnetic radiation field, the electric field interacts more strongly with the atom than the magnetic term and the perturbing Hamiltonian is $E_0 \cos \omega t (\hat{\epsilon}.\vec{r})$, $\hat{\epsilon}$ is the polarization vector.

(f) Two non-interacting distinguishable spin ½ particles are placed in a one dimensional potential well. Find the possible two particle wave functions, degeneracies associated with the first excited state.

(Turn Over)

(g) For a given energy, for a spherically symmetric potential having range a, up to what value of l should one consider?

(h) Assuming L-S coupling, list the possible spectral terms from the electronic configurations $nsn'd$.

2. (a) Outline in brief the Hartree Approximation for many electron system. (5)

(b) Show that for low energy scattering from a weak potential the S-wave phase shift $\delta_0 = -ka,$ a being the scattering length and k being the wave vector. (3)

(c) Explain in brief the Lande Interval rule. (2)

3. (a) What do you mean by the Fermi Golden rule? Deduce the rule for the case of a time periodic perturbation. (1+4)

(b) The perturbing Hamiltonian for a one dimensional harmonic oscillator in a laser electromagnetic field is given by $H' = \frac{e\hat{p}}{2m\omega} E_0 \sin \omega t$, where ω_0, m and e are the angular frequency, mass and the charge of the oscillator and ω is the angular frequency of radiation. Assume, the laser is turned on at $t = 0$ with the oscillator in its ground state $|0>$. Within the 1st order perturbation find the probability for any time $t > 0$ that the oscillator will be found in one of its excited states $|n>$. Oscillator states have the property $\hat{p}\ |n> = i\sqrt{\hbar m\omega_0}/2\left(\sqrt{n+1}\,|n+1> - \sqrt{n}\,|n-1>\right)$ (5)

(***Continued***)

(Statistical Mechanics I – PHS 301B)

Answer Q1 and any one from Q2 and Q3

1. Answer any five bits: 5X2 = 10

(a) Consider a system of three fermions which can occupy any of the four available energy states with equal probability. Calculate the entropy of the system.

(b) For a system of two bosons each of which can occupy any of the two energy levels: *0* and *E,* calculate the mean energy of the system at temperature *T*.

(c) Two drunks start out together at the origin, each having equal probability of making a step simultaneously to the left or right along the *x*-axis. What is the probability that they meet after *n* steps.

(d) A monoatomic crystalline solid comprises of *N* atoms, out of which *n* are in interstitial positions. If the available interstitial sites are n_I, then calculate the number of possible microstates.

(e) Consider a system of *N* localized weakly interacting particles, each of spin half and magnetic moment μ, located in an external magnetic field *H*. Under what circumstances is *T* negative?

(f) What is chemical potential? Calculate its value for photons.

(g) What is Liouville's theorem? Is it applicable both in equilibrium and non-equilibrium statistical mechanics?

(h) Calculate the density of states of free electrons in three dimensions.

2. (a) Under what condition Fermi-Dirac and Bose-Einstein distributions reduce to Maxwell-Boltzmann distribution? (2)

(b)(i) Calculate the partition function of a monoatomic ideal gas in the classical limit. (3)

(***Continued***)