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May 2023
BSc (H) Physics Semester-VI
Statistical Mechanics (BPH-602)

Time: 3 Hours

Max. Marks:75

Instructions:
1. *It is compulsory to answer all the questions (1.5 marks each) of Part -A in short.*
2. *Answer any four questions from Part -B in detail.*
3. *Different sub-parts of a question are to be attempted adjacent to each other.*
4. *Use of non-programmable simple calculator is allowed.*

PART -A

Q1 (a) What do you mean by ultraviolet catastrophe. (1.5)

(b) Distinguish microstate and macrostate with the help of an example. (1.5)

(c) Explain Wein's displacement law. (1.5)

(d) Differentiate three types of ensemble. (1.5)

(e) The fermi energy for metal X is 3.15eV. Find the value of fermi energy for metal Y given that electron density in metal Y is 9 times that of X. (1.5)

(f) Consider a system of three non-interacting fermions having energy levels $-\epsilon$, 0, ϵ. Find the entropy of the system if the total energy of the system is zero. (1.5)

(g) Write the expression for density of phase space cells according to Classical Statistics. (1.5)

(h) Derive Rayleigh-Jeans law from Planck's law. (1.5)

(i) Define phase space and phase trajectory. (1.5)

(j) What do you mean by thermodynamic probability. (1.5)

PART -B

Q2 (a) What is relation between entropy and thermodynamic probability. Derive the expression for entropy, internal energy and chemical potential of a perfect gas, using thermodynamical relation. (10)

(b) Show that the partition function for translational motion of monoatomic gas molecule is given by (5)

$$Z_T = V.\left(\frac{1}{\lambda^3}\right),$$ where λ is thermal de Broglie wavelength.

Q3 (a) Derive condition for a strongly degenerate boson gas. How does the degeneracy depend upon the temperature, number density and mass of particles? (10)

(b) "The quantity and quality of radiation inside a non-conducting isothermal enclosure depends on its temperature and is entirely independent of both the nature of the walls and the nature of the bodies." Explain the statement with proof. (5)

Q4 (a) In context of Bose Einstein condensation show that " The fraction of particles condensed in ground state varies as temperature changes relative to transition temperature" ,with the help of appropriate diagram (10)

(b) What is Sackur-Tetrode equation? How it fixes Gibb's Paradox. (5)

Q5 (a) Explain how negative temperature can be attained in the system of N particles each having a magnetic moment μ, that can either be parallel or anti parallel to an external magnetic field B. (10)

(b) Derive thermodynamic proof of Stefan's law. (5)

Q6 (a) Find expression for fermi energy of free electrons gas. Also show that mean energy of Fermi gas at absolute zero temperature is $(3/5)E_{F(0)}$ (10)

(b) Plot and explain the variation of distribution function for a Fermi gas. (5)

Q7 (a) Find the expression for relative number of atoms in two ionization states in the interior of stars. (10)

(b) Evaluate the temperature at which there is 5% probability that a state with energy 0.1eV above fermi energy, will be occupied by an electron. (5)
