Sr. No. 321602

December 2023

B.Sc.VI SEMESTER

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 scientific calculator is allowed.*

PART -A

Q1 (a) What do you mean by the term phase space? (1.5)

(b) What is Gibb's paradox? How this paradox is solved? (1.5)

(c) What are the main constituents of white dwarf stars? What prevent the gravitational collapse of white dwarf stars? (1.5)

(d) Calculate the surface temperature of the sun, given that λ_m = 4753 Å and Wien's constant = 0.2898. (1.5)

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

(f) Three particles are to be distributed in four energy levels. Calculate all possible ways of this distribution when particles are Fermions. (1.5)

(g) What is black body radiation? Explain its temperature dependence. (1.5)

(h) Explain the ultraviolet catastrophe according to Rayleigh-Jeans distribution law. (1.5)

(i) What do you mean by photon gas? (1.5)

(j) Differentiate the term microstate and macrostate in classical statistics. (1.5)

PART -B

Q2 (a) Explain concept of ensemble. Differentiate between micro-canonical, canonical and grand-canonical ensembles. Where they are used. (10)

(b) A three-state system with energies E= $-E_0$, 0, $+E_0$ is in thermal equilibrium at a temperature T. If $\beta E_0 = x$, Find the probability of finding the system with E=0. (5)

Q3 (a) What is Bose-Einstein statistics? What are the basic postulates used? Derive an expression for the most probable distribution of the particle obeying B.E. statics. (10)

(b) Show that the single partition function for an ideal monoatomic gas is given by (5)

$$Z = V\left[\frac{2\pi mkT}{h^2}\right]^{3/2}$$

Q4 (a) Using Maxwell's law of distribution of speeds of molecules in a gas, obtain expressions for most probable speed, average speed and root- mean square speed. (8)

(b) Write down the postulates of Fermi-Dirac Statistics. Derive an expression for the probability distribution of particle governed by Fermi-Dirac statistics. (7)

Q5 (a) Derive Planck's law of black body radiation? Under what condition does this law reduce to Rayleigh Jean's law and Wien's law? (10)

(b) Calculate the radiant emittance of a black body at a temperature of (i) 400 K (ii) 4000 K. [Given: $\sigma = 5.672 \times 10^{-8}$ M.K.S. units] (5)

Q6 (a) What do you understand by thermodynamics probability? How is it related with the entropy of the system? Establish the necessary relation. (10)

(b) Evaluate the temperature at which there is 1% probability that a state with energy 0.5eV above Fermi energy will be occupied by an electron. (5)

Q7 (a) Define Fermi energy and Fermi Temperature. Explain the significance of Fermi energy. (5)

(b) Prove that the pressure due to diffuse radiation on a surface is u/3, where u is energy density of radiation. (5)

(c) Write short note on any one (i) Statistical equilibrium (ii) Kirchhoff's law of black body radiation (5)

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