2022

B.A./B.Sc.

Sixth Semester

CORE – 14

PHYSICS

Course Code: PHC 6.21

(Statistical Mechanics)

Total Mark: 70 *Pass Mark: 28*

Time: 3 hours

Answer five *questions, taking* one *from each unit.*

UNIT–I

1. (a) A particle of unit mass is executing simple harmonic motion. Determine its trajectory in phase space. 3
   (b) Define Maxwell-Boltzmann distribution law. Show that the lowest energy cell contains more molecules than the higher cells. 6
   (c) Consider a system of N identical particles which can occupy energy levels 0, ε. Find the partition function and also find Helmholtz free energy, average energy, entropy and specific heat of the system. 5

2. (a) State the law of equipartition of energy. Use the classical distribution law to prove that the average energy for each degree of freedom of a perfect gas molecule is $\frac{1}{2}KT$. 5
   (b) Explain the thermodynamic functions of a two energy level system. 3
   (c) Derive an expression for the partition function of a system of free particles. Deduce Sackur-Tetrode relation using partition function. 6

UNIT–II

3. (a) State and prove the Wien's distribution law of radiation 6
   (b) A black body at 500°C has a surface area of 0.5 m^2 and radiates heat at the rate of 1.02×10^4 J/s. Calculate Stefan's constant. 2

(c) Explain the terms emissive power and absorptive power. Deduce Kirchhoff's law of a black body radiation. 6

4. (a) Draw graphs showing the distribution of energy of a black body at different temperatures. Discuss briefly the different laws which try to explain the above energy spectrum. 7

(b) State and prove Saha's ionization formula. 7

UNIT–III

5. (a) Discuss the distribution of energy in the spectrum of a black body on the basis of the experiment performed by Lummer and Pringsheim. What are the salient features of black body radiation? 5

(b) What are the basic assumptions of Planck's theory of black body radiation? Deduce Planck's formula and explain the experimental verification of Planck's radiation law. 9

6. (a) Use Planck's formula to obtain expression for
(i) Stefan's constant and
(ii) Wien's constant
in terms of Planck's constant and Boltzmann's constant. 8

(b) Explain why radiation exerts pressure. 2

(c) Show that the Stefan's constant (σ) is related to Planck's constant

(h) by the formula $\sigma = \frac{2}{15}\frac{\pi^5 \kappa^4}{C^2 h^3}$. 4

UNIT–IV

7. (a) Compare the basic postulates of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. How do the Bose and Fermi distribution tend to the classical distribution? 5

(b) Deduce Bose-Einstein distribution formula and explain the phenomenon of Bose-Einstein condensation. 7

(c) Which distribution law will you use for the study of photon gas and why? 2

8. (a) What are bosons? Show that for Bose-Einstein gas, the relation between the total number of particles and the total energy is given by the expression $E = \frac{1}{2} nKT$. 9

(b) Explain qualitatively the properties of liquid He. 5

UNIT–V

9. (a) What is Fermi gas? Deduce an expression for the energy of a Fermi gas at absolute zero. 6

(b) Show that the mean energy of free electron at absolute zero is 3/5 times the Fermi energy. 4

(c) Deduce the expression for Fermi energy ε_F . 4

10. (a) What are the drawbacks of Einstein theory for the specific heat of solid? What was Debye's approach in this matter? Derive Debye's formula for specific heat of solid. 9

(b) Obtain the Chandrashekhar limit for white dwarf stars. 5

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