U.G. 6th Semester Examination-2024

PHYSICS

[HONOURS]

Course Code : PHY-H-CC-T-14

(Statistical Mechanics)

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.
Candidates are required to give their answers in their own words as far as practicable.

Value of constants

Mass of electron $m = 9.1 \times 10^{-31}$ Kg

Planck's constant $h = 6.6 \times 10^{-34}$ Joule-S

Boltzmann constant $k = 1.38 \times 10^{-23}$ Joule / K

GROUP–A

1. Answer any **five** questions: $2 \times 5 = 10$

a) Which statistics (Bose-Einstein or Fermi-Dirac) will apply to the following particles? (i) phonon, (ii) tritium, (iii) muon, (iv) proton. Justify your answer.

b) What is meant by a strongly degenerate system?

c) In how many ways can 5 Bosons be arranged in three quantum states?

d) What is meant by the term 'equal a priori probability'?

e) What do you mean by microstate and macrostate?

f) Calculate the density of states for an electron with energy 5eV constrained to move in a cubical box of length 0.5mm.

g) Draw a phase space trajectory of a simple harmonic oscillator of energy E.

h) The temperature of the human body is 37^0C. At what wavelength the intensity of radiation emitted by the human body is maximum?

GROUP–B

2. Answer any **two** questions: $5\times2=10$

a) In a thermodynamic system in equilibrium each molecule can exist in three possible states with probabilities $\frac{1}{2}, \frac{1}{3}$ and $\frac{1}{6}$ respectively. Calculate entropy per molecule.

b) Calculate the surface temperature of the Sun considering it to be a perfect black body.

[Radius of Sun $R = 6.928\times10^8$ m,

Mean distance from Sun to earth $r = 1.5\times10^{11}$ m

Stefans constant $\sigma = 5.7\times10^{-8}\ Wm^{-2}K^{-4}$

Total heat radiated from Sun per unit area per second $S = 1.388\times10^3\ Wm^{-2}$]

c) Consider 4.2×10^{21} electrons are confined in a box of volume 1 cm^3. Calculate their Fermi wavelength and Fermi energy.

d) State and explain Wien's distribution law. What is the drawback of Wien's distribution law?

3+2

GROUP–C

3. Answer any **two** questions: 10×2=20

a) i) Consider a system of N indistinguishable, non-interacting particles obeying Pauli's exclusion principle. Find out the probability of finding a fermion with energy E_i.

ii) Calculate Fermi energy of the system of nucleons in a large nucleus with radius 1.3fm.

5+5

b) i) What is Saha ionization equation?

ii) Derive an expression for Saha ionization equation. Describe some applications of Saha's ionization formula. 2+(6+2)

c) i) State and explain Planck's Quantum Postulates in blackbody radiation.

ii) Calculate the number of modes of oscillation of electromagnetic radiation possible in a cavity. Hence calculate the energy per unit volume of the radiation in the cavity.

2+(3+5)

d) i) What is Bose-Einstein condensation? Derive the expression of critical temperature of Bose-Einstein condensation.

ii) Show that chemical potential μ can take zero or negative values for a system of bosons. (2+5)+3
