U.G. 5th Semester Examination-2025

PHYSICS

[MAJOR-VI]

Course Code : PHY-M-T-6

(Classical and Statistical Mechanics)

[NEP-2020]

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.

1. Answer any **five** questions: 2×5=10

a) What do you mean by cyclic coordinate? Explain with example.

b) Explain the postulate of equal a` priori probability.

c) Write down the expressions of thermodynamic probability in MB and BE statistics.

d) What is meant by 'ultraviolet catasstrophe'? Explain.

e) The Fermi velocity of an electron in a metal is 0.7×10^{6} m/s. Calculate the Fermi temperature T_F.

[Turn over]

f) A particle is moving under the action of a generalized potential $V(q,\dot{q})=\frac{1+\dot{q}}{q^2}$. Find the magnitude of generalized force?

g) Define Poisson Bracket of two dynamical variables X and Y. Hence find $[q_i, p_j]$.

h) Write down Saha's Ionization formula. Explain the significance of this formula.

2. Answer any **two** questions: 5×2=10

a) State and explain principle of virtual work. Two masses m_1 and m_2 are located on a frictionless double incline plane and connected by an inextensible massless string passes over a smooth peg. Use the principle of virtual work to show that for equilibrium, we must have $\frac{\sin\theta_1}{\sin\theta_2}=\frac{m_2}{m_1}$. ($\theta_1$ and θ_2 are incline angles) 2+3

b) What is density of states? Derive an expression of density of states of an electron. 1+4

c) Derive an expression for the probability distribution of particles governed by Fermi-Dirac statistics. 5

d) Show that Lagrange's equations are unaltered if the total time derivative of a function is added to the Lagrangian. Write down Hamilton's canonical equations of motion in terms of Poisson brackets. 2+3

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

a) i) Derive Planck's formula for black body radiation using Bose-Einstein statistics. Using this result, deduce Stefan-Boltzmann law. (Given: $\int_0^\infty \frac{x^3}{e^x-1}dx = \frac{\pi^4}{15}$)

ii) There are two particles in three quantum states $g_i = 1, 2, 3$. Distribute the particles according to MB, BE and FD statistics.

(5+2)+3

b) i) Derive Hamilton's equation of motion for a system of particles.

ii) A particle is moving under action of a central force. Find the Hamiltonian and hence Hamilton's equations of motion.

iii) The Lagrangian of a charged particle in an electromagnetic field is given by $L = \frac{1}{2}mv^2 + q\vec{v}.\vec{A} - q\varphi$. Find the Hamiltonian of the particle. 3+4+3

c) i) The Lagrangian of a particle of mass m is given by $L = \frac{1}{2}m\dot{x}^2 - 2x$. Find the coordinate $x(t)$ of the particle at a time t.

ii) The Hamiltonian of a simple pendulum of mass, m, attached to a massless string of length, l is given by $H = \frac{p_\theta^2}{2ml^2} + mgl(1 - cos\theta)$. Find the Lagrangian L and hence evaluate $\frac{dL}{dt}$.

iii) Show that the shortest distance between two points in a plane is a 'straight line'.

3+4+3

d) i) Discuss the difference between FD and BE statistics. Under what conditions do FD and BE statistics yield the classical statistics? What is meant by 'Bose condensation'?

ii) Consider a system of four identical bosons each of which can occupy one of the three nondegenerate energy levels with energies 0, E and 2E. Find the number of states available to the system with total energy 5E.

iii) State and explain Kirchhoff's law for thermal radiation. (2+1+2)+3+2
