PHYSICS – II
(PHYS 2001)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) A generalized coordinate q_j is absent in the lagrangian of a system. The corresponding conserved quantity is
(a) energy (b) momentum (c) velocity (d) force.

(ii) Which of the following functions is an eigen function of the operator d^2/dx^2?
(a) $\Psi = c\cos(x)$ (b) $\Psi = cx^2$ (c) $\Psi = c / x$ (d) $\Psi = cx$.

(iii) The expected average of momentum of a particle in an infinite well is
(a) 0 (b) $\hbar$ (c) $\hbar/2$ (d) $k\hbar$

(iv) The number of macrostate for 2 distinguishable particles in 2 compartments obeying MB statistics are
(a) 4 (b) 3 (c) 1 (d) 2.

(v) Which one of the following is a Boson?
(a) α-particle (b) photon (c) electron (d) none of these.

(vi) The dimension of polarizability in SI unit is
(a) Fm^2 (b) Fm^{-1} (c) Fm (d) Fm^{-2}

(vii) Ferrites are example of
(a) diamagnetism (b) paramagnetism
(c) ferromagnetism (d) ferrimagnetism

(viii) Paramagnetic susceptibility depends on
(a) temperature and directly proportional to temperature
(b) temperature and inversely proportional to temperature
(c) temperature and inversely proportional to the square of the temperature
(d) does not depend on temperature.

(ix) Superconducting material must be
(a) diamagnetic (b) paramagnetic
(c) ferromagnetic (d) none of these.

(x) The density of free electron states in a metal varies with energy E as
(a) $\sqrt{E}$ (b) E^2 (c) E (d) E^{-1}.

Group – B

2. (a) What are the advantages of Lagrange's equation over the Newtonian equation of motion?

(b) Write down the Lagrangian and Lagrange's equation defining all the terms.

(c) Using Lagrangian method, derive the equation of motion of a system of two masses connected by an inextensible string passing over a small smooth pulley.

(d) The Lagrangian of a system is given by $L = \frac{1}{2}m\dot{x}^2 - mg(h - x)$, where $m, g \text{ and } h$ are the constants. Obtain the Hamiltonian of the system.

3 + 3 + 3 + 3 = 12

3. (a) What is a wave function? Mention three points on its physical significance. How is wave function related to the probability of finding a particle at any point in space at a given time?

(b) Show that $[\widehat{p_x}, \widehat{x^n}] = -i\hbar n x^{n-1}$

(c) A particle is moving in 1D potential box of infinite height and width 25Å. Calculate the probability of finding the particle within an interval of 5Å at the centres of the box when it is in its state of least energy.

(1 + 3 + 2) + 3 + 3 = 12

Group – C

4. (a) Define macrostates and microstates. Three distinguishable particles each of which can be in one of the E, 2E, 3E, 4E energy states have total energy 6E. Find the number of macrostates.

(b) What do you mean by Fermi energy in metal? Calculate the total number of free electron in a metal in terms of the fermi energy at absolute zero temperature.

(c) Calculate the Fermi energy in electron volts for sodium assuming that it has one free electron per atom. Given that density of sodium = 0.97gm/cm^3, atomic weight of sodium = 23.

(2 + 2) + (2 + 3) + 3 = 12

5. (a) Sketch the Fermi distribution curve for T = 0K and T > 0K in metal and explain.

(b) Write down the Bose-Einstein energy distribution law and hence obtain the expression for Planck's formula for black body radiation.

(c) A black body emits radiation at a temperature of 1500K. Calculate the energy density per unit wavelength at 6000Å of black body radiation.

(d) Compare Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics.

3 + 3 + 3 + 3 = 12

Group – D

6. (a) What are dielectrics? Differentiate between polar and non-polar dielectrics.

(b) Define electronic polarizability in atoms and obtain an expression for electronic polarizability in terms of radius of the atom.

(c) Find out the average radius of the atom of an air molecule if the polarizability of atoms in the air molecules is 9×10^{-41} Fm^2.

(d) If an ionic crystal is subjected to an electric field of 2000V/m and the resulting polarization is 6.4×10^{-8} C/m^2, then calculate the relative permittivity or the dielectric constant of the crystal.

(1 + 3) + (1 + 3) + 2 + 2 = 12

7. (a) Define magnetization. Obtain the relation $\mu = \mu_0(1 + \chi_m)$, where symbols have their usual meaning.

(b) Explain the origin of magnetic moment in magnetic materials. What are diamagnetic, paramagnetic and ferromagnetic substances?

(c) What is hysteresis? Draw the B-H curve for ferromagnetic materials.

(1 + 3) + (2 + 3) + (2 + 1) = 12

Group – E

8. (a) Write down an expression for effective mass of an electron. Is it different from the free electron mass? What information does one obtain about the effective mass of electron in a periodic potential?

(b) The energy of a free electron in a crystal is a following function of wave number E(k) = A–Bsin(ka), where A, B are constants and a is distance between adjacent atoms. Find out the value of effective mass.

(c) State the Bloch theorem and explain.

(1 + 2 + 2) + 3 + (2 + 2) = 12

9. (a) What do you mean by superconductivity? What are the two types of superconductors? Distinguish between them.

(b) Write the mathematical expression for how the critical magnetic field for a superconductor vary with temperature. Draw the graph.

(c) Establish London equation of superconductivity in terms of magnetic field induction.

(1 + 2 + 2) + (2 + 2) + 3 = 12

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Department & Section	Submission Link
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