2015

M.Sc. Part–I Examination

PHYSICS

PAPER—I

Full Marks : 75

Time : 3 Hours

The figures in the margin indicate full marks.

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

Illustrate the answers wherever necessary.

Use separate Answerscripts for Gr. A & Gr. B.

Group—A

[*Marks : 30*]

1. Answer any *four* of the following : 4×2

(a) In Rutherford's α-particles scattering experiment 10^{-3} α-particles are scattered at an angle 4°, calculate the number of α-particles, scattered at an angle 15°.

(b) The potential energy of a particle is given as

$$v(y) = y^4 - 4y^3 - 8y^2 + 48y$$

Find out the stable and unstable equilibrium position of the particle.

(c) Find the Lagrangian's equation of motion for a electrical circuit consisting an inductor L and capacitor C. The capacitor is charged to q coulomb and current flowing in the circuit is i amp.

(d) Prove that total energy (E) of a particle in a rotating frame is related to E_o in the fixed frame by the rotation $E = E_o - \vec{\omega}.\vec{L}$, where $\vec{\omega}$ is the angular velocity of the rotating frame and $\vec{L}$ is the angular momentum of the particle in the same frame.

(e) What do you mean by Fast Top and Sleeping Top ? Write the difference between them.

(f) When a torque $(\vec{\tau})$ is applied to a body, then prove that $\vec{\omega}.\vec{\tau} = \frac{dT}{dt}$.

where $\vec{\omega}$ is the angular velocity of the body and T is the kinetic energy of the body.

(g) Find out the equation of motion of one dimensional harmonic oscillator using Hamilton's Principle.

2. Answer any *two* of the following : 2×3

(a) The Lagrangian of a system is given as

$$L = \frac{1}{2}\alpha_1\dot{\phi}^2 + \frac{1}{2}\alpha_2\dot{\Psi}^2 + \alpha_3\dot{\phi}\dot{\Psi} - \frac{1}{2}\alpha_4\phi^2 - \frac{1}{2}\alpha_5\Psi^2$$

where α_1, α_2, α_3, α_4 and α_5 are constants. Find out the expressions of P_ϕ, P_ψ, H and Hamilton's cannonical function.

(b) Using Variational Principle, prove that the shortest distance between any two points in a plane is a straight line.

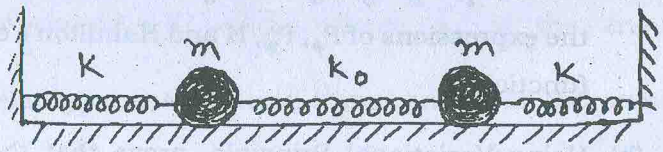
(c) Deduce the expression of normal mode frequencies of a linear triatomic molecule of the type AB_2. Consider only the vibrational motion along the line joining the atoms.

(d) Deduce Lagrange's equation of motion from Hamilton's principle for a Conservative Systems.

3. Answer any *two* of the followings : 2×8

(a) (i) State principle of least action. Deduce Jacobi's form of the principle of least action.

(ii) If KE of a system is conserved, then show that out of all paths between two points, the system moves along the particular path for which the time of transit is an extreme. (2+3)+3

(b) 

Find out the frequencies of normal modes of the small oscillation of the above spring mass system. Consider only longitudinal oscillation. Here K and K_0 are the Spring Constants.

What do you mean by Symmetric and anti-Symmetric mode in this case ?

What will happen if the spring between the masses

of spring constant K_0 is replaced by :

(i) an another spring of spring constant K ;

(ii) a rod of fixed length and of negligible mass. 4+2+2

(c) (i) Deduce the solution of one dimensional harmonic oscillator problem by Hamilton-Jacobi method.

(ii) Prove that for Harmonic Oscillator, the Hamilton's Principal function is the time integral of Lagrangian. 5+3

Group—B

[Marks : 45]

Answer *Q. No. 1* and any *three* from the rest.

1. Answer any *three* from the following : 3×3

(a) Explain what is meant by center of symmetry and mirror plane.

(b) Cu has Fcc structure and atomic radius is 0·1278 nm. Calculate the interplanar spacing for 110 plane.

(c) Ignoring the difference between transverse and longitudinal velocity show that Debye Temperature is given by $\theta_D = \frac{h\lambda}{2\pi k}\left[6\pi^2 \frac{N}{V}\right]^{\frac{1}{3}}$.

(d) Find the average energy of the electron at absolute zero assuming 3-dimensional Fermi gas in a metal.

(e) Prove that effective mass can be expressed as $m^* = \frac{\hbar^2}{d^2E/dk^2}$.

What is meant by negative effective mass?

(f) What is meant by Single crystal and Poly crystal. How can you identify than by Lave Diffraction Method?

2. (a) Derive Lave equations considering the scattering of X-rays from a small crystal.

(b) Find the condition for systematic absence in a B.C.C. crystal. 10+2

3. (a) Derive the dispersion relation assuming vibration in an one-dimensional monoatomic lattice.

(b) What is Van-Hove Singularity?

(c) Sound velocities in solids are of the order of $3\times10^3 mS^{-1}$. Interatomic distances in solid is 3×10^{-10}m. Estimate the order of magnitude of cut off frequency assuming a linear lattice. 7+2+3

4. (a) Prove that average energy of electron in a metal increases as temperature increases.

(b) Find an expression of electronic specific heat.

(c) Explain what is Hall effect? 7+2+3

5. (a) Find the energy of electron in a solid according to Tight Binding Approximation.

(b) Assuming Tight Binding Approximation find the Bandwidth of a Simple Cubic Lattice along [111]. 9+3

6. (a) Define polarization in a dielectric & hence derive $P = \frac{(\epsilon_s - 1)E}{4\pi}$ where ϵ_s is the static dielectric constant.

(b) Suppose a solid contains N atom per cm^3, each atom

containing Z electron, the diamagnetic susceptibility may be expressed as,

$$X_{dia} = -NZ\left(\frac{e^2}{6mc^2}\right)\left\langle r^2\right\rangle$$

where $\left\langle r^2\right\rangle$ represents mean square distance of the electrons from the nucleus.

(c) What is Meissner Effect? 4+6+2
