M.Sc. 2nd Semester Examination, 2010

PHYSICS

(*Classical Mech.*)

PAPER—PH-1202

Full Marks : 40

Time : 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

Illustrate the answers wherever necessary

PAPER—1202 A

[*Marks* : 20]

Answer **all** questions

1. Answer any *two* questions : 2 x 2

(*a*) What kind of transformation is generated by the function $F = -\sum Q_i p_i$?

(*Turn Over*)

(*b*) The Lagrangian of a charged particle moving in crossed electric and magnetic fields is :

$$L = \frac{1}{2}mv^2 - q\phi + q\,(\vec{v}\,.\,\vec{\lambda})$$

where the symbols have usual meaning. Obtain Hamiltonian and equation of motion of the particle.

(*c*) Explain Exchange transformation and Identity transformation.

2. Answer any *two* questions : 3 x 2

(*a*) Show that the motion of a system in a small interval 'dt' can be described by an infinitesimal canonical transformation generated by the Hamiltonian of the system.

(*b*) Show that the transformation defined by,

$$Q = \tan^{-1}\left(\frac{\alpha q}{p}\right) \text{ and } P = \frac{1}{2}\alpha q^2\left(1 + \frac{p^2}{\alpha^2 q^2}\right)$$

is canonical.

(*c*) Show that :

$$\Delta\int_{t_1}^{t_2}\sum p_k \dot{q}_k dt = \delta\int_{t_1}^{t_2} L dt + (L+H)[\Delta t]_{t_1}^{t_2}$$

3. Answer any *one* question : 10 × 1

(*a*) (*i*) Explain Hamilton's principle.

(*ii*) For a dynamical system having q_k and p_k respectively the generalised co-ordinates and momenta and Hamiltonian H, derive the following relations :

$$\dot{q}_k = \frac{\partial H}{\partial p_k} \text{ and } \dot{p}_k = -\frac{\partial H}{\partial q_k}$$

(*iii*) For a system consisting of a single particle show that the principle of least action becomes

$$\Delta\int\sqrt{H-V}\cdot dS = 0$$

where dS=elementary path, H = Hamiltonian, and V = potential energy. 2 + 5 + 3 (*b*) Determine the oscillations of a system with two degrees of freedom whose Lagrangian is,

$$L = \frac{1}{2}(\dot{x}^2 + \dot{y}^2) - \frac{1}{2}w_0^2(x^2 + y^2) + \alpha xy.$$

For the Hamiltonian $H = \frac{(p^2 + q^2)}{2}$. Find $[\dot{p}, H]$ and $[\dot{q}, H]$ and find the values of p and q. Show that energy is a constant. 5 + 5

PAPER—1202 B

[*Marks* : 20]

Answer **Q. No. 1 & 2** and any **one** from the rest

1. Answer any *two* questions : 2 x 2

(*a*) Electrical resistivity of copper at room temperature is $1{\cdot}65 \times 10^{-8}\ \Omega$m. Find the thermal conductivity of the material.

(*b*) Estimate the fraction of electrons excited about the Fermi level at room temperature for Na. Fermi energy of Na = 3·1 eV.

(*c*) Find the depletion temperature corresponding to extrinsic to intrinsic transition in an *n*-type semiconductor.

2. Answer any *two* questions : 3 x 2

(*a*) The *E*-*k* relation in a particular semiconductor is given by $E = Ak^2 + Bk^3$. (*i*) Find the wave vector for which electron group velocity is zero. (*ii*) Determine the electron effective mass for these wavevector values. Here *A* and *B* are positive constants.

(*b*) Find an expression of ionization energy an electron in a semiconductor droped with donor atoms.

(*c*) Prove that electronic specific heat in a metal varies linearly with absolute temperature.

3. (*a*) Find an expression for density of states in the conduction band and hence find an expression of carrier concentration in a degenerate semiconductor.

(*b*) Find the position of the Fermi level with respect to the conduction band in an intrinsic Si at 300 K.
Given, $m_e^* = 1{\cdot}1$ m, $m_n^* = 0{\cdot}59$ m, $E_g = 1{\cdot}1$ eV.

(*c*) What is meant by Fermi sphere ? What is Mathison's rule ? 3 + 3 + 2 + 2

4. (*a*) What is the physical origin of energy gap ? Find an expression of band gap in terms of crystal potential.

(*b*) Assuming Boltzmann transport equation find an expression of electrical conductivity in a metal.

4 + 6

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