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PG (NEW) CBCS
M.Sc. Semester-I Examination, 2018
PHYSICS
PAPER: PHS-102

Full Marks: 40 **Time: 2 Hours**

Write the answer for each unit in separate sheet

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

PHS 102.1: QUANTUM MECHANICS - I

Marks: 20

Attempt Question number 1, 2 and any one from the rest.

1. Attempt any two of the following **(2 × 2 = 4)**
   a) The relation between angular frequency ω and wave number k for a given type of waves is $\omega = \alpha k + \beta k^2$.
   Find out the wave number k_0 for which the phase velocity (v_p) equalise the group velocity (v_g).
   b) Find the value of $[\hat{x}, e^{2\pi i p a/h}]$
   c) For the ground state of the hydrogen atom, evaluate the expectation value of the radius vector r of the electron where $\psi_0 = \frac{1}{\sqrt{\pi a_0^2}} e^{-\frac{r}{a_0}}$
   d) In a stationary state of rigid rotator, show that the probability density is independent of the angle φ.
2. Attempt any two of the following **(4 × 2 = 8)**
   a) The solution of the Schrodinger equation for a free particle of mass m in one dimension is ψ (x, t) at t=0,
   ψ (x,0) = A exp$[-\frac{x^2}{a^2}]$
   Find the probability amplitude in momentum space at t = 0 and time t.
   b) Evaluate $e^{\frac{2\pi i p a}{h}} \hat{x} e^{-\frac{2\pi i p a}{h}}$
   c) i) The operator e^A is defined by
   $$e^A = 1 + A + \frac{A^2}{2!} + \frac{A^3}{3!} + \cdots$$
   Show that $e^D = T_1$, where D = $(\frac{d}{dx})$ and T_1 is defined by T_1 f(x) = f(x+1).
   ii) Check whether the operator $-i\frac{h}{2\pi}x(\frac{d}{dx})$ is Hermitian.
   d) Consider a particle of mass m in the one-dimensional short range potential
   $$V(x) = -V_0\, \delta(x), \ V_0 > 0$$
   Where δ(x) is the dirac delta function. Find the energy of the system.
3. Answer any one of the following (1 × 8 = 8)
   i) Find the Hamiltonian operator of a charged particle in an electromagnetic field described by the vector potential A and scalar potential φ. **(3)**
   ii) Prove that $\Delta x \Delta p_n$ = (n+1/2)h for a one dimensional harmonic oscillator using operator method. **(5)**
4. a) Show that the zero point energy of (1/2) h$\omega/2\pi$ of a linear harmonic oscillator is a manifestation of the uncertainty principle. **(3)**
   b) If $\hat{H} = \frac{p^2}{2m} + \frac{1}{2} m\, \omega^2 x^2$
   Evaluate $[\hat{x}(t), \hat{x}(0)]$ using Heisenberg equation of motion. **(5)**

(Turn Over)

PHS 101.2: SOLID STATE – I

Marks: 20

Attempt Question number 1, 2 and any <u>one</u> from the rest.

1. Answer any two bits **($2 \times 2 = 4$)**
   a) Explain what is meant by single crystal and polycrystalline material and how can they be identified experimentally.
   b) Show the stereogram and matrix representation of e/m.
   c) The velocity of sound in metal ~ 3×10^3 ms^{-1}. Interatomic distance is 3 Angstrom. Estimate the order of magnitude of cut-off frequency assuming a linear lattice.
   d) A hypothetical semi-conductor crystal has a conduction bond that can be described by $E_{cl}=E_1-E_2Cos(ka)$. What is the effective mass of the electron at the bottom of the conduction band?
   e) What is meant by Brillion zone? How can you construct it?
2. Answer any two bits. **($2 \times 4 = 8$)**
   a) Find am experiment of density of states for a linear chain of atom. What is Van Hove Singularity? **(3+1)**
   b) Prove that `optical branch' does not arise in case of a monoatomic lattice.
   c) Prove that effective number of free electron in a solid is maximum when the outer most band is half-filled. What us meant by negative effective mass?
3. Derive the Laue equation assuming X-ray falling on a crystal. **(8)**
4. Describe in detail Debye Waller effect and hence find Debye Waller factor. Derive the vibrational modes of a diatomic linear chain of atom. **(4+4)**

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