First Semester Examination-2017

M.Sc. PHYSICS

Paper Code: PHS-102

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

Use Separate scripts for Group A & Group B

Group A

[Assume] $\hbar = \frac{h}{2\pi}$

(Quantum Mechanics I)

Answer Question no 1 and any One from the rest.

1. **Answer any five bits.** 2×5

(a) If $\psi(x,t) = \frac{1}{\sqrt{2\pi\hbar}} \int a(p) e^{\frac{i}{\hbar}(px-Et)}\, dp$, prove that $\int |\psi(x)|^2 dx = \int |a(p)|^2\, dp$.

(b) The wave function of a particle in a one dimensional box at $t = 0$ is given by $\psi(x, t=0) = A \sin\frac{2\pi x}{l} \cos\frac{\pi x}{l}$.

Write down wave function at a later instant $t, \psi(x,t)$.

(c) Show that if $\hat{A}$ and $\hat{B}$ are Hermitian operators then $i[\hat{A}, \hat{B}]$ is also Hermitian.

(d) If $[\hat{A}, \hat{B}] = \hat{I}$, where $\hat{I}$ is the identity operator. Prove that $[e^A, B] = e^A$.

(e) In classical mechanics $H = wxp$. Find the Hamiltonian $\hat{H}$ in the quantum mechanics.

(f) Explain resonance scattering in rectangular potential barrier problem.

(g) A rigid rotator is constrained to rotate about fixed axis, find out its normalized eigen function and eigenvalues.

(h) Find the eigenfunction of the operator $(x + \frac{d}{dx})$.

2. (a) A particle is described by the wave function $\psi(x) = \frac{1+ix}{1+ix^2}$. Normalize $\psi(x)$. Where is the particle most likely to be found? 3+2

(b) The state of an oscillator of angular frequency w is $\psi(x) = e^{-\frac{mwx^2}{\hbar}}$. Find the probability that the magnitude is larger than $\sqrt{mw\hbar}$. 5

3.(a) A particle of mass m is in the potential $V(x) = \frac{1}{2}mw^2x^2 - bx$. Find the eigen function and eigen value. 5

(b) A particle is in one dimensional potential

$$V(x) = \begin{cases} \infty \, for \, x < 0 \\ -V_0 \, for \, 0 \leq x \leq l \\ 0 \, for \, x > l \end{cases}.$$

If there is at least one bound state, find the minimum depth of the potential. 5

Group B

(Solid State I)

Answer Question no 1& 2 and any One from the rest.

1. **Answer any two bit.** $2 \times 2 = 4$

   (a) Explain what is meant by glide symmetry element?

   (b) i) In a crystal, a plane cuts intercepts of $2a, 3b$ and $6c$ along the three crystallographic axes. Determine the miller indicesof the plane. $1\frac{1}{2}$

   ii) Convert the miller indices (110) into Miller Bravier Indices. $\frac{1}{2}$

   (c) Find the packing fraction of hcp lattice.

2. **Answer any two bit.** $3 \times 2 = 6$

   (a) The Debye temperature of diamond is 2000k. Calculate the mean velocity of sound in diamond, given the density and atomic mass of diamond as $3500 kgm^{-3}$and 12 amu respectively. If the interatomic spacing is 1.54 Å Estimate the frequency of dominant mode of lattice vibration.

   (b) What is meant by normal process and umclappprocess.

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

3. Find the density of states corresponding to linear chain of monoatomic lattice in vibration. What is Van Hove singularity? Find the Brillouin Zone of F.C.C. lattice? 5+2+3

4.(a) What is the physical origin of energy gap in solid and show that the magnitude of energy gap in solid and show that the magnitude of energy gap is determined by the strength of periodic potential. 8

(b) Show that the inclusion of anharmonic term is necessary to understand the phenomenon of thermal expansion. 2