(c) Draw the 1st and 2nd Brillouin zone of a 2-dimensional square lattice. (2)

3. (a) Find out an expression for atomic form factor from the scattering of X-rays by an atom. What is value of atomic scattering factor at low value of θ (5+2)

(b) Suppose that the electron density for each of three electrons in neutral Li can be represented by $C = \frac{e^{-2r/a}}{\pi a^3}$. Find out the atomic scattering factor for Li. (3)

…….

Internal Assessment-10

2017

M.Sc.

1st Semester Examination

PHYSICS

PAPER – PHS-102 (Gr. – A + B)

Full Marks : 50

Time : 2 Hours

(Quantum Mechanics I – PHS 102A)

Answer Q1 and any one from Q2 and Q3

1. Answer any five bits: 5X2 = 10

(a) Consider a 1D particle which is confined within the region $0 \le x \le a$ and whose wavefunction is $\psi(x,t) = \sin(\pi x/a)\exp(-i\omega t)$. Find the potential $V(x)$.

(b) Estimate the lifetime of the excited state of an atom whose natural width is $3\text{x}10^{-4}$ eV. Given, $h = 6.626\text{x}10^{-34}$J-s = $4.14\text{x}10^{-15}$ eV-s.

(c) Show that the operator $i\frac{\partial}{\partial x}$ is Hermitian under suitable boundary condition.

(d) A system is initially in the state $\psi_0 = \left[\sqrt{2}\varphi_1 + \sqrt{3}\varphi_2 + \varphi_3 + \varphi_4\right]/\sqrt{7}$, where φ_n are eigenstates of the system's Hamiltonian such that $\hat{H}\varphi_n = n^2\varepsilon_0\varphi_n$, ε_0 being a constant. If the energy is measured, what values will be obtained and with what probabilities?

(e) A harmonic oscillator moves in a potential $V(x) = (1/2)kx^2 + cx$, where c is a constant. Find the energy eigenvalues.

(Turn Over)

(f) A particle of mass m is inside a one-dimensional infinite well with walls at $x = 0$ and $x = L$. One of the walls is suddenly moved by a distance L so that the wall separation becomes $2L$. The wall moves so suddenly that the particle wave function has no time to change during the motion. Suppose that the particle is originally in the ground state. If we measure the energy after the width is doubled, what is the probability that it will not have changed?

(g) Write down the postulates in Quantum mechanics.

(h) What is the degeneracy of the third excited state of an isotropic three-dimensional harmonic oscillator?

2. (a) Define raising and lowering operators showing the reason of nomenclature analytically. (2)

(b) Show that for a harmonic oscillator, $|\psi_n\rangle = \frac{(a^+)^n}{\sqrt{n!}}|\psi_0\rangle$, where all symbols have usual meanings. (2)

(c) Compute $< x >, < p >, < x^2 >, < p^2 >$ for the harmonic oscillator ground state $\psi_0 = \alpha e^{-\xi^2/2}$. (4)

(d) What types of potentials are responsible for *l* and *m* degeneracies in Hydrogen atom? How such degeneracies can be removed? (2)

3. (a) Show that the transformation matrix which transforms one basis set to the other is unitary. (2)

(b) What is interaction picture? Find the equations of motion for the state vectors and operators in the said picture. (2)

(c) Define Projection operator. Consider a system whose Hamiltonian, $\hat{H} = a\left[|\varphi_1\rangle\langle\varphi_2| + |\varphi_2\rangle\langle\varphi_1|\right]$, where *a* is a real number having the dimension of energy and $|\varphi_1\rangle$, $|\varphi_2\rangle$ are normalized eigenstates. Is $\hat{H}$ a projection operator? Justify. (1+2)

(*Continued*)

(*Solid State Physics 1 – PHS 102B*)

Answer Q1 and any one from Q2 and Q3

1. Answer any five bits: 5X2 = 10

(a) Calculate geometrical structure factor for NaCl crystal.

(b) Explain: TA and TO phonon with diagram.

(c) Polonium has cubic unit cell of side 3.42 Å. If the atomic weight of Po is 210 and density be 8.27 g/cm^3 show whether the crystal is SC, BCC or FCC.

(d) The energy near the valence band edge of a crystal is given by $E = (-10^{-39}\ k^2)\ Jm^2$. An electron with wave vector $(10^{10}\ k_x)m^{-1}$ is removed from an orbital in the completely filled valence band. Determine its effective mass and momentum.

(e) How can the *n* glide be represented vectorially?

(f) Copper has fcc structure and atomic radius is 0.1278 nm. Calculate the interplanar spacing for (111) and (321) planes.

(g) Show that Face-Centered tetragonal lattice should not exist.

(h) What is Brillouin Zone? What will be its nature in case of bcc lattice?

2. (a) Prove that in one dimensional diatomic lattice, the two kinds of atoms oscillates with amplitude related to each other by $B = A\left(1 - \frac{M\omega^2}{2C}\right)\sec ka$, where, *C* is the force constant and *k* is the wave vector. (5)

(b) The unit cell parameter of NaCl crystal is *5.6 Å* and the modulus of elasticity along *[100]* direction is $5\times10^{10}\ N/m^2$. Estimate the wavelength at which an electromagnetic radiation is strongly reflected by the crystal. Given: Atomic weight of *Na=23* and *Cl=37*. (3)

(Turn Over)