2015

M.Sc. 1st Seme. Examination

PHYSICS

PAPER—PHS-102

Full Marks : 40

Time : 2 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 Answer-scripts for Group-A & Group-B

Group-A

[Marks : 20]

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

1. Answer any *five* bits : 5×2

(a) Show that the linear momentum is not quantized.

(b) Find the de-Broglie wave length of a electron with K.E. 1 GeV.

(c) If an orthonormal set of kets

$\{|e_i\rangle,\ i = 1, 2, 3, \ldots\}$ form a basis,

then prove that $\sum_i |e_i\rangle\langle e_i| = I$.

(d) Show that the zero point energy of a linear Harmonic oscillator is a manifestation of the uncertainty principle.

(e) If $\hat{H} = \frac{\hat{p}x^2}{2\mu}$, Evaluate $\left[\hat{x}, \hat{H}\right], \hat{x}\right]$.

(f) Show that the probability of finding the particle outside the classical limit is only 16%.

(g) If the wave function $\psi = \frac{e^{ikr}}{r}$, Find the probability current density.

(h) Show that $\left(\frac{d}{dx}\right)^+ = -\frac{d}{dx}$.

2. (a) Electrons with energies 1 eV are incident on a barrier 5 eV high 0·4 nm wide. (i) Evaluate the transmission probability. What would be the probability (ii) if the height is doubled (iii) if the width is doubled and (iv) comment on the result. 2+3

(b) In a Harmonic oscillator, the creation (a^+) and annihilation (a) operator in dimensionless unit are defined by

$$a^+ = \frac{x - ip}{\sqrt{2}} \; ; \; a = \frac{x + ip}{\sqrt{2}}$$

An unnormalized energy eigen function

$$\psi_n = \left(2x^2 - 1\right) \exp\left(-\frac{x^2}{2}\right).$$

What is its state ? Find the eigen functions corresponding to the adjacent states. 1+2+2

3. (a) A particle of mass m is subjected to a spherically symmetric attractive square well potential defined by

$$V(r) = -V_0 \; ; \; 0 < r < a$$

$$= 0 \quad ; \; r > a$$

Find the minimum depth of the potential well needed to have (i) one bound state of zero angular momentum and (ii) two bound states of zero angular momentum.

3+2

(b) An electron of mass m and charge e moves in a region where a uniform magnetic field $\vec{B} = \vec{\nabla} \times \vec{A}$ exists in the z-direction.

(i) Write down the Hamiltonian of the system.

(ii) Prove that $\hat{p}_y$ and $\hat{p}_z$ are constants of motion.

(iii) Obtain the schrödinger equation in Cartesian co-ordinates and solve the same to obtain the energy eigen states. 1+2+2

Group-B

[Marks : 20]

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

1. Answer any *two* bits : 2×2

(a) Find the matrix representation of point group 2 for rotation about C axis and mirror plane perpendicular to C.

(b) Why C face centered lattice is not possible for cubic structure ?

(c) Find the structure factor of a C-face centered lattice & hence find the condition for systematic absence.

2. (a) Show that for hexagonal lattice

$$\frac{1}{d_{nkl^2}} = \frac{4\left(h^2 + k^2 + hk\right)}{3a^2} + \frac{b^2}{c^2}.$$

(b) Bragg angles are observed at 12.3°, 14.1°, 20.2° and 24.0° of X-ray powder photograph of a cubic structure taken with λ = 1.54A°. Assign Miller indices to these lines and find the lattice constant.

(c) Prove that 'Optical Branch' does not arise in case of monoatomic lattice.

3. (a) Derive Laue equation considering the scattering of X-ray from a crystal.

(b) Find the Brillouin zone shape of a F.C.C crystal.

8+2

4. (a) Find the density of states corresponding to a linear monoatomic chain. What is Van Hove singulatiry ?

   (b) What is the physical origin of energy gap in a solid ? Explain your answer considering a nearly free electron model.

4+1+5