B. I. T. SINDRI

B. Tech. 2nd Semester , 2nd Mid Semester Examination: 2019

SUBJECT: PHYSICS-II (Introduction to Quantum Mechanics for Engineers) Branch: - EE,CSE & IT)

TIME: 1.5 HOUR **F.M. 20**

Answer five Questions. Question No. 1 is compulsory

All questions are of equal marks

1. *Answer any four questions*

(I) The zero point energy of harmonic oscillator is:

(a) $\hbar\omega$ (b) $\frac{\hbar\omega}{2}$ (c) $2\hbar\omega$ (d) $\frac{\hbar\omega}{4}$

(II) In the case of a potential step of height V_0 . If a particle of energy $E < V_0$ the transmittance is

(a) zero (b) finite non –zero (c) infinite (d) 1

(III). According to the quantum mechanics, for a free particle (V=0)

(a) The energy levels are discrete and equispaced
(b) The energy levels are continuous
(c) The energy levels are discrete but not equispaced
(d) The energy is always zero

(IV). If $\psi = Ae^{\frac{-\alpha x^2}{2}} e^{iEt/\hbar}$ is a normalized wave function, the value of A will be

(a) 1 (b) 0 (c) $\left(\frac{\pi}{\alpha}\right)^{-1/4}$ (d) $\frac{\alpha}{2}$.

(V). Which one of the following pairs of phenomena illustrates the particle aspect of wave particle duality?

(a) Compton effect and Bragg's law (b) Compton effect and Photoelectric effect (c) Compton effect and Pauli's principal(d)Photoelectric effect and Bragg's law

(VI).The correct relation is:

(a) $v_g = v_p - \lambda \frac{dv_p}{d\lambda}$ (b) $v_p = v_g - \lambda \frac{dv_g}{d\lambda}$

(c) $v_g = v_p + \lambda \frac{dv_p}{d\lambda}$ (d) $v_p = v_g - \frac{1}{\lambda}\frac{dv_p}{d\lambda}$.

2 .Obtain Schrodinger time dependent wave equation and separate it into space and time dependent parts. Give the probability interpretation of the wave function and show that the probability density ρ and the probability current density J satisfy the continuity equation $\frac{d\rho}{dt} + \nabla . J = 0$.

3. A beam of particles with energy E is incident on a potential barrier with potential function

$V(x) = 0$ for $x<0$

$= V_0$ for $0<x<a$

$= 0$ for $x>a$

Show that there is a finite probability of transmission even if $E<V_0$.

4. A particle of mass m is in a 3D cube with side L. It is in the third excited state, corresponding to $n^2 = 11$.

(a) Calculate the energy of the particle.

(b) The possible combination of n_x, n_y and n_z

(c) The wave functions for these states.

5. (a) Use uncertainty principle to prove that electrons cannot exist in the nucleus.

(b) Calculate the minimum energy of the harmonic oscillator by the help of the uncertainty principle.

6. (a) What do you mean by expectation values of dynamical quantities?

(b) Normalise the wave function $\psi = Ae^{\frac{-ax^2}{2}} e^{iEt/\hbar}$ for $x=-\infty$ to $x=+\infty$ and find the expectation values of x and x^2, given that $\int_{-\infty}^{+\infty} e^{-ax^2} dx = \sqrt{\frac{\pi}{a}}$, $\int_{-\infty}^{+\infty} xe^{-ax^2} dx = 0$ and $\int_{-\infty}^{+\infty} x^2 e^{-ax^2} dx = \frac{1}{2}\sqrt{\frac{\pi}{a^3}}$

7. Give an outline of quantum mechanical description of a simple harmonic oscillator. Discuss the properties of the oscillator in the lowest three energy states.