

(i) Printed Pages: 3

Roll No. ....

(ii) Questions : 7

Sub. Code :

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Exam. Code :

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B.A./B.Sc. (General) 3<sup>rd</sup> Semester  
(2122)

PHYSICS

(Quantum Physics—I)

Paper—C

Time Allowed : Three Hours]

[Maximum Marks : 44

Note :—Attempt five questions in all, selecting two questions from Units I & II. Question No. 7 (Unit III) is compulsory. Use of non-programmable calculator is allowed.

### UNIT-I

1. (a) Derive three-dimensional time dependent Schrodinger equation. 5
- (b) A particle is described by a wave function :

$$\Psi(x, t) = \left(\frac{2}{a}\right)^{\frac{1}{2}} \sin kx e^{\frac{-iEt}{\hbar}} \quad \frac{-a}{2} < x < \frac{a}{2} \text{ and } 0 \text{ elsewhere.}$$

Find the expectation value of momentum. 4

2. (a) What do you mean by phase velocity and group velocity ? Prove that phase velocity is one half of the particle velocity, whereas group velocity is equal to the velocity of the moving particle. 7



- (b) A photon of energy 1.02 MeV is scattered through  $90^\circ$  by a free electron. Calculate the energy of photon and electron after interaction. 2
3. What do you mean by expectation value of a quantity ? Give the exact definition of uncertainty. Also give the exact proof of Heisenberg's principle. 9

### UNIT-II

4. (a) Starting from the radial equation  $R(r)$  of the electron in the hydrogen atom, show that the orbital angular momentum  $L = \sqrt{\ell(\ell + 1)}\hbar$ . Where  $\ell$  is the orbital quantum number. 5
- (b) Calculate the expectation value of momentum of a particle trapped in a one-dimensional infinite square well potential. 4
5. Solve the radial part of the Schrodinger wave equation for hydrogen atom to obtain its energy levels. 9
6. What is harmonic oscillator ? Solve the Schrodinger equation for one-dimensional harmonic oscillator and obtain energy levels. 9

### UNIT-III

7. Attempt any **eight** parts :
- (a) What are laws of photoelectric emission ?
- (b) What do you mean by normalization of wave function ?
- (c) What is the meaning of a well-behaved wave function ?



- (d) Discuss non-existence of electrons within a nucleus using uncertainty principle.
- (e) What are Hermitian operators ?
- (f) What is energy operator ?
- (g) Normalize the wave function  $\Psi(x) = A e^{ikx}$  over the region  $-a \leq x \leq a$ .
- (h) What is a degenerate state ? Show that for a given value of  $n$ , the state of hydrogen atom is  $n^2$  fold degenerate.
- (i) What is physical significance of principal quantum number  $n$  ?
- (j) What is pair production ?  $8 \times 1 = 8$