**PG Odd Semester (CBCS) Exam., December—2016**

PHYSICS

**( 3rd Semester )**

Course No. : PH–302 (C)

**( Quantum Mechanics—II )**

*Full Marks* : 75
*Pass Marks* : 30

*Time* : 3 hours

*The figures in the margin indicate full marks for the questions*

Answer **five** questions, taking **one** from each Unit

UNIT—I

**1.** Obtain the first- and second-order energy corrections for a time independent perturbation in a non-degenerate system. Also obtain the first-order corrections to eigenstates. 15

**2.** An electric field $\mathscr{E}$ is applied for a time to a one-dimensional harmonic oscillator with





angular frequency $_0$ and electric charge $q$ so that the perturbation is

$$W(t) \quad q\mathscr{E}x \quad \text{for } 0 \quad t$$
$$0 \quad \text{otherwise}$$

The oscillator is in the ground state at $t$ 0. Using time dependent perturbation theory for first-order, calculate the probability of transition to the state $n$ 1. Also show that a transition to $n$ 2 is impossible. 12+3=15

UNIT—II

**3.** Discuss the validity conditions of WKB approximations. Show that the WKB approximation give the eigenvalues of the harmonic oscillator correctly. 5+10=15

**4.** Using variational method, estimate the ground state energy of hydrogen atom by choosing as a trial function the spherically symmetric functions $(r)$ whose $r$ dependence is given by

$$(r) \quad c \; 1 \; \frac{r}{} \quad \text{for } r$$
$$0 \quad \text{for } r$$

where $c$ is the normalization constant and is the variational parameter. Also find the extremum value of and compare it with Bohr radius $a_0$. 12+3=15

## UNIT—III

**5.** *(a)* Obtain the differential cross-sections

$$\frac{d\ (\ )}{d} \text{ and } \frac{d\ (\ _0)}{d}$$

in the centre of mass frame and laboratory frame respectively for scattering of two particles. 7

*(b)* Prove the optical theorem

$$_{\text{total}} \quad \frac{4}{k} \operatorname{Im} f(0)$$

where $\operatorname{Im} f(0)$ is the imaginary part of the forward scattering amplitude. 8

**6.** Discuss elastic scattering for a Gaussian potential. 15

## UNIT—IV

**7.** *(a)* Obtain the Klein-Gordon equation as a relativistic generalization of Schrödinger equation. Evaluate the equation of continuity and show that the probability density is not a positive definite quantity. 3+3=6

*(b)* Obtain the covariant form of Dirac equation and discuss the properties of the -matrices. 4+5=9





**8.** Obtain the Dirac equation for energy levels of hydrogen atom and discuss the terms therein describing the fine structure. 15

## UNIT—V

**9.** *(a)* Discuss the Lagrangian formalism for fields, using variational method and obtain the Euler-Lagrange equations. 7

*(b)* State and prove Noether's theorem. 8

**10.** Discuss the canonical quantisation of real scalar field. 15

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