4290

2008-2009
B.Sc.(HONS.) (PART-III) EXAMINATION
(PHYSICS)
QUANTUM MECHANICS
(PH-303)

Maximum Marks: 40   Duration : Three Hours.

All the questions are compulsory.
The marks are shown against the questions.

1.(a)   Qualitatively discuss the difference between intrinsic and orbital angular momentum.

Briefly discuss whether it would be correct to say that an angular momentum of $\hbar$
must be orbital and not intrinsic.   1+1

(b)   Briefly discuss whether the product of two hermitian operators is also hermitian.   02

(c)   Prove that

$$\frac{d}{dt} \langle P_x \rangle = \langle - \frac{\partial V}{\partial x} \rangle ,$$

where the symbols have their usual meaning.
Briefly say what the equation tells us.   2+1

2.(a)   Explain what is meant by a stationary quantal state?   01

(b)   Briefly point out that the free particle is spread out all over the space.   02

(c)   Calculate the particle flux associated with the free particle wave function Ae^{ikx} 02

(d)   Normalize the one- dimensional wave function $e^{-\alpha x}$ of a single particle, 'situated'
in the region $0 \leq x \leq + \infty$.   02

3.   Solve the one- dimensional time- independent Schrödinger equation for a one-
dimensional square well potential of a finite size and depth. Obtain the condition
for a bound state to occur. Tell how many levels are bound in the potential of
depth V_0 and size a   when $V_0 a^2 = \frac{\hbar^2}{2m}$, where m is the mass of the particle
inside it.   4+2

OR

3'.   What is the Zero-Point Energy of the oscillator? Relate it to the Uncertainty
Principle.   2+4

4.   Starting from the first principles, obtain the eigen functions and the energy eigen
values of the Rigid Rotator.

-1

....2

Where does the Rigid Rotator occur in physical problems? 5+1

OR

4'(a) What is meant by the degeneracy of an energy level? 01

(b) Discuss the degeneracy of the levels of the Rigid Rotator. 02

(c) Obtain the number of the degenerate levels of the hydrogen- like atom for n =2. Name an agency that can break the degeneracy of the levels of the hydrogen – like atom. 2 +1

5.(a) Briefly tell what first led to the picture of the 'spinning' electron. 02

(b) Write down all the relevant mutual commutators of the operators of the electron, spin components S_x, S_y and S_z as also of a component, say S_z and S^2. 03

(c) Briefly discuss whether the coordinate x commutes with S_x. 02

OR

5'(a) What is Zeeman Effect? Explain the terms Normal Zeeman Effect and Anomalous Zeeman Effect. 03

(b) With the help of the selection rules, discuss the transitions between two hydrogen atom levels when the system is placed in either a weak or a strong magnetic field (you may choose either the weak or the strong case). 04

6.(a) Define the terms : elastic scattering cross section, scattering amplitude and phase shift. 03

(b) If $f(\theta, \phi)$ is the unsymmetrized scattering amplitude; write down the cross section, for fermions, when the incident particle is identical with the target. Give one practical example. 3+ 1

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