[84] SEAT No._____ No. of Printed Pages : 2

SARDAR PATEL UNIVERSITY

M. Sc. (Physics) 2nd Semester Examination
Tuesday, 23rd October, 2018
Time: 10:00 am to 01:00 pm
Subject: PS02CPHY01 [Quantum Mechanics-I]

Total Marks: 70

Note: (1) Figures to the right indicate marks.
(2) Symbols have their traditional meaning.

Q:1 **Attempt all of the following Multiple choice type questions. [01 mark each]** [08]

(1) Eigen values of a Hermitian operator are
(a) real
(b) imaginary
(c) zero
(d) unity

(2) A unitary operator is define by
(a) $\hat{U}^{\dagger} = \hat{U}$
(b) $\hat{U}^{\dagger} = \hat{U}^{-1}$
(c) 1
(d) $\hat{U}^{\dagger} = \hat{U}^{-\dagger}$

(3) If the eigen value is non-degenerate then $|\upsilon^{(0)}\rangle$ _____be defined uniquely.
(a) can not
(b) can
(c) may
(d) may not

(4) The quantitative criterion for the smallness of a perturbation is given by
(a) $|E_n - E_m| \ll |\lambda H'_{nm}|$ for all $n \neq m$
(b) $|E_n + E_m| \ll |\lambda H'_{nm}|$ for all $n \neq m$
(c) $|\lambda H'_{nm}| \ll |E_n + E_m|$ for all $n \neq m$
(d) $|\lambda H'_{nm}| \ll |E_n - E_m|$ for all $n \neq m$

(5) At the classical turning point
(a) E=V(x)
(b) V(x)=0
(c) E=-V(x)
(d) E=0

(6) In the semi classical approximation
(a) $\hbar \to \infty$
(b) $\hbar \to \hbar\omega$
(c) $\hbar \to 0$
(d) $\hbar \to 1$

(7) At large distance from the target, the scattered particles appear radially outwards. The scattered particles are represented as _____waves.
(a) spiral
(b) cylindrical
(c) spherical
(d) plane

(8) In the case of spinless identical particles, the wave function must be
(a) constant
(b) zero
(c) anti symmetric
(d) symmetric

(P.T.O.)

Q:2 **Answer any 7 of the following 9 questions briefly. [02 marks each]** [14]

1 Define Hilbert space.
2 Show that the adjoint of the adjoint of an operator is the operator itself.
3 Prove that any observable is always diagonal in its own representation.
4 Write down the Hamiltonian for an anharmonic oscillator and a two dimensional harmonic oscillator.
5 Explain WKB approximation.
6 Explain the terms excited state and turning point.
7 What is exchange interaction?
8 Draw schematic diagram of a scattering event and explain scattering.
9 Explain differential and total scattering cross section.

Q:3 (a) Explain the unitary transformation induced by rotation of coordinate system. [6]

(b) Write a note on algebra of rotation generators. [6]

OR

(b) Deduce and discuss the relation $(\chi)_A = [F]_A (\psi)_A$. [6]

Q:4 (a) What is perturbation? Derive and discuss the relation $W^{(1)} = H'_{mm}$. [6]

(b) Write note on space inversion. [6]

OR

(b) Explain Stark effect deriving necessary expressions. [6]

Q:5 (a) Describe the basic procedure involved in the variation technique. For the ground state of two-electron atom, assuming effective charge as a variational parameter, obtain $W_{min} = -\left(Z - \frac{5}{16}\right)\frac{e^2}{a_0}$. Here, a_0 is the Bohr radius. [6]

(b) Discuss trial wave function linear in variational parameters. Take $\psi(x) = A \cdot \exp(-\alpha x^2)$ as a trial wave function and calculate ground state energy of a 1-d oscillator. [6]

OR

(b) Write a note the Bohr-Sommerfeld quantum condition. [6]

Q:6 (a) Define Green's function. Derive formal expression for scattering amplitude in terms of appropriate Green's function. [6]

(b) Explain the first Born approximation. Define screened Coulomb potential and evaluate $f_B(\theta)$ for it. [6]

OR

(b) Discuss the validity of Born approximation for square well potential. [6]

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