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

Se

SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

M. Sc. (Physics) 2nd Semester Examination

Monday, 18th March, 2019

Time: 02:00 pm to 05:00 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) If $\hat{F}$ is a self-adjoint operator, then $[F]_A$ is a _____ matrix.

(a) Hermitian (c) unit
(b) self-adjoint (d) null

(2) $\left(\hat{B}\hat{A}\right)^{+} =$

(a) $\left(\hat{B}\hat{A}\right)^{+} = A^{+} + B^{+}$ (c) $\left(\hat{B}\hat{A}\right)^{+} = A^{+}B$
(b) $\left(\hat{B}\hat{A}\right)^{+} = A^{+}B^{+}$ (d) $\left(\hat{B}\hat{A}\right)^{+} = AB^{+}$

(3) The first order change in the energy is the expectation value of the

(a) wave function (c) perturbation
(b) square of wave function (d) potential

(4) The criterion for smallness of the perturbation is given by for all $n \neq m$

(a) $|\lambda H'_{mn}| \ll |E_m|$ (c) $|\lambda H'_{mn}| \ll |E_n + E_m|$
(b) $|\lambda H'_{mn}| \ll |E_n$ (d) $|\lambda H'_{mn}| \ll |E_n - E_m|$

(5) Under rotations about z-axis, the x component of linear momentum is

(a) constant (c) not invariant
(b) linear (d) invariant

(6) At the turning point the kinetic energy of a classical particle becomes____.

(a) maximum (c) zero
(b) minimum (d) constant

(7) The screened Coulomb potential is given by $(-Ze^2/r)e^{-kr}$. The term $1/k$ has the dimensions of

(a) length inverse (c) length
(b) is dimensionless (d) potential

(8) The partial wave method leads to _____ approximation.

(a) Coulomb (c) high energy
(b) phase shift (d) low energy

(P.T.O)

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

1 Show that the eigenvalues of a Hermitian operator are real.
2 Using suitable example explain unitary operators.
3 Define Hilbert space.
4 Define perturbation and degeneracy.
5 Write Hamiltonians for (i) 2-d harmonic oscillator (ii) two electrons moving in the field of a fixed nuclear charge.
6 Explain WKB approximation.
7 What is exchange interaction?
8 Draw schematic diagram of a scattering event. Define differential and total scattering cross section.
9 What is Born series?

Q:3 (a) Explain the algebra of rotation generators. [6]

(b) Write a note on Degeneracy: labelling of commuting observables. [6]

OR

(b) Show that for a continuous basis $\langle x|\hat{p}|\psi\rangle = -i\hbar\frac{\partial\psi(x)}{\partial x}$. [6]

Q:4 (a) Discuss the effect of an electric field on the energy levels of the ground state of Hydrogen atom. [6]

(b) Write note on removal of degeneracy. [6]

OR

(b) Using perturbation theory solve the problem of anharmonic oscillator. [6]

Q:5 (a) Discuss the trial wave function linear in variational parameters. [6]

(b) Prove that the variation method gives an upper bound on ground state energy. How can this method be extended to excited sates of atoms? [6]

OR

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

Q:6 (a) Write a note on Eikonal approximation. [6]

(b) Obtain the scattering amplitude in terms of phase shifts. [6]

OR

(b) Using Green's function obtain formal expression for scattering amplitude. Explain how the first-Born approximation can be deduced from this result. [6]

—X—