SEAT No._____ **No. of Printed Pages : 3**

[125]

SARDAR PATEL UNIVERSITY

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M. Sc. (Physics) 2nd Semester Examination

Monday, 9th April, 2018

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) $\sum_{a,i} |ai\rangle\langle ai| =$

(a) $\hat{1}$
(b) δ_{ia}
(c) 0
(d) δ_{ai}

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

(a) $\left(\hat{B}\hat{A}\right)^{+} = A^{+} + B^{+}$
(b) $\left(\hat{B}\hat{A}\right)^{+} = A^{+}B^{+}$
(c) $\left(\hat{B}\hat{A}\right)^{+} = A^{+}B$
(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
(b) square of wave function
(c) perturbation
(d) potential

(4) The fine structure constant is eual to _____.
(a) 173
(b) 1/173
(c) 137
(d) 1/137

(5) The first order perturbation theory of degenerate level is equivalent of finding _____ with respect to which the perturbation is diagonal.
(a) orthogonal ket vectors
(b) Normalized ket vectors
(c) basis vectors
(d) null vectors

(6) If the eigen value E_n is non-degenerate, then $\upsilon^{(0)}$ _____ be defined uniquely.
(a) may not
(b) can not
(c) can
(d) may

(7) The term e^{-ikr} represents
(a) incoming spherical wave
(b) outgoing spherical wave
(c) incoming plane wave
(d) outgoing plane wave

(8) A barn is equal to
(a) $10^{-20} cm^2$
(b) $10^{-28} cm^2$
(c) $10^{-30} cm^2$
(d) $10^{-24} cm^2$

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 Explain Adjoint and self adjointness.
3 Explain basis in Hilbert space.
4 Define perturbation and degeneracy.
5 Explain WKB approximation.
6 What is a trial wave function? How is it selected?
7 What is exchange interaction?
8 Write phase shift δ_l for hard sphere scattering and give its interpretation.
9 What is scattering? Differentiate between elastic and inelastic scattering.

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

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

OR

(b) Define Hilbert space. 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 Stark effect. [6]

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

OR

(b) Using perturbation theory solve the problem of anharmonic oscillator. [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) On the basis of variation method explain how the problem of Hydrogen molecule can be worked out. [6]

OR

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

Q:6 (a) Define differential and total scattering cross sections using a suitable diagram. Explain the wave mechanical picture of scattering and obtain scattering amplitude. [6]

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

OR

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

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