Enrollment No: _____ Exam Seat No:_____

C.U.SHAH UNIVERSITY

Summer Examination-2019

Subject Name: Quantum Mechanics-1
Subject Code: 5SC01QUM1 Branch: M.Sc. (Physics)
Semester: 1 Date: 16/03/2019 Time: 02:30 To 05:30 Marks: 70

Instructions:

(1) Use of Programmable calculator and any other electronic instrument is prohibited.
(2) Instructions written on main answer book are strictly to be obeyed.
(3) Draw neat diagrams and figures (if necessary) at right places.
(4) Assume suitable data if needed.

SECTION – I

Q-1 **Attempt the Following questions** **(07)**

a. Name the three parts in which the wave function of a hydrogen atom is resolved in terms of the spherical polar coordinates.
b. What do you mean by perturbation?
c. Give the statement of Variational Principle.
d. Justify why hydrogen atom has been preferred to determine the wave function.
e. Give the Rodrigue's formula for Laguerre's polynomials.
f. State the normalization condition.
g. What is the condition for the validity of WKB approximation method?

Q-2 **Attempt all questions** **(14)**

a) Resolve the Schrodinger equation of hydrogen atom in terms of spherical polar coordinates (r, θ ,Ø). **(08)**

b) Normalize the solution of the Azimuthal part of the wave function of a hydrogen atom and also prove that the quantum number m_l takes values from -1 to +1. **(06)**

OR

Q-2 **Attempt all questions** **(14)**

a) Taking $v = x^n e^{-x}$; prove that Rodrigue's formula for Laguerre's polynomial leads to the same polynomial. **(07)**

b) Prove that the Rodrigue's formula for Legendre polynomial leads to the same polynomial. **(07)**

Q-3 **Attempt all questions** **(14)**

a) Using Perturbation Theory; derive the expressions for the first order correction to Energy and Wave function. **(09)**

b) Determine the general expression for second order correction to energy. **(05)**

OR

Q-3 a) Calculate the first order correction to the energy of the n^{th} state of a harmonic oscillator whose centre of potential has been displaced from 0 to a distance l. **(05)**

b) Name the electric analogue of Zeeman effect. **(09)**

Using perturbation theory, solve a system exhibiting Zeeman effect.

SECTION – II

Q-4 **Attempt the Following questions** **(07)**

a. Name the approximation methods used to determine the wave function and energy of various systems quantum mechanically.

b. Give an example where perturbation theory could be used.

c. What are classical turning points?

d. Define tunneling.

e. Name the quantum numbers that are involved in spherical harmonics.

f. The presence of which quantity in physics confirms the use of quantum mechanics?

g. What do you mean by removal of degeneracy?

Q-5 **Attempt all questions** **(14)**

Find an upper bound for the ground state energy of a one dimensional harmonic oscillator whose Hamiltonian is given by $H= -\hbar^2/2m\ d^2/dx^2 + ½\ m\omega^2x^2$ **(14)**

OR

Q-5 Based on the variational principle, find the expectation value of Hamiltonian <H> of a system given by $H = \frac{h^2}{2m}\frac{d^2}{dx^2} - \alpha\delta(x)$ **(14)**

Q-6 **Attempt all questions** **(14)**

a) Explain the importance of connection formulae taking the example of a linear harmonic oscillator. **(09)**

b) Take Gamow's theory of alpha decay to explain the process of tunneling using WKB approximation **(05)**

OR

Q-6 **Attempt all Questions**

a) Prove that the WKB method follows a semi classical treatment. **(05)**

b) Determine the WKB solutions for a second order differential equation $d^2\psi/dx^2 + k^2\psi(x) = 0$; where k could be any continuous function. Explain the exponentially amplifying and decaying solutions. **(09)**