Enrollment No: _____ Exam Seat No:_____

C.U.SHAH UNIVERSITY
Winter Examination-2018

Subject Name : Quantum Mechanics-I

Subject Code : 5SC01QUM1 **Branch: M.Sc. (Physics)**

Semester : 1 **Date :30/11/2018** **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 quantum numbers that are involved in spherical harmonics.
b. If the ground state energy of a hydrogen atom is given by E_0, what will be the energy of the excited states (having principle quantum number n)?
c. Why are spherical polar coordinates introduced to solve the Schrodinger equation of hydrogen atom?
d. What do you mean by removal of degeneracy?
e. Give an example of perturbation.
f. State the variational principle.
g. The problem of Helium atom is solved using the wave function of hydrogen atom. Why?

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

a. Resolve the Schrodinger equation of hydrogen atom in terms of spherical coordinates (r, θ, ϕ). **(08)**
b. Explain the concept of hydrogen spectrum. **(03)**
c. Find the normalized solution of the azimuthal part of wave function of hydrogen atom expressed by $\frac{d^2g}{d\phi^2} + gm_l^2 = 0$. **(03)**

OR

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

a. Prove that the Rodrigue's formula for Legendre polynomial leads to the same polynomial. **(06)**
b. If $\frac{d^2R}{dr^2} + \frac{2}{r}\frac{dR}{dr} + \frac{2m}{h^2}\left(E + \frac{kze^2}{r}\right)R = 0$ is the radial part of the wave function of hydrogen atom, where $R(r) = Ae^{-\alpha r}$; then derive the expression for the energy of hydrogen atom. **(08)**

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

a. Derive the expression for first order correction to i) energy and ii) wave function **(10)**

of a system subjected to perturbation.

b. 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. **(04)**

OR

Q-3 **a.** Determine the first order correction to energy of a system exhibiting Zeeman effect. **(08)**

b. For an equation $(H^0 - E^0)\Psi_n^2 = (E_n^2 - H^2)\Psi_n^0 + (E_n^1 - H^2)\Psi_n^1$; determine the second order correction to energy. **(06)**

SECTION – II

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

a. Give the condition for validity of WKB approximation method.

b. Which quantity in physics confirms the use of quantum mechanics and helps in distinguishing quantum from classical mechanics?

c. Name the different methods used to determine the wave function and energy of a system quantum mechanically.

d. Why is hydrogen atom preferred while solving the Schrodinger equation?

e. Give the Rodrigue's formula for Laguerre's polynomial.

f. Why are Rodrigue's formulas preferred while solving various differential equations?

g. Name the quantum numbers that were introduced while solving the schrodinger equation of a hydrogen atom.

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

a. 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)**

OR

Q-5 **a.** Name the integrals introduced while solving the hydrogen molecule ion problem. **(02)**

b. Determine the normalization constant, A for a triangular wave function given by $\Psi(x) = Ax \qquad 0 \le x \le \frac{a}{2}$ **(12)**

$$= A(a - x) \qquad a/2 \le x \le a$$
$$= 0 \qquad Otherwise$$

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

a. Explain the importance of connection formulae while solving a linear harmonic oscillator problem using WKB approximation method. **(12)**

b. What are Airy's equation and Airy's functions? **(02)**

OR

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

a. Determine the normalized first order solution to Airy's equation by identifying the expression for $F(x)$. **(06)**

b. Explain the process of tunneling using WKB approximation method. **(08)**