Exam Seat No:_____ Enrollment No:_____

C.U.SHAH UNIVERSITY

WADHWAN CITY

University (Winter) Examination -2013

Course Name :M.Sc(Physics) Sem-I **Subject Name: -Quantum Mechanics-I** **Marks :70**

Duration :- 3:00 Hours **Date : 20/12/2013**

Instructions:-

(1) Attempt all Questions of both sections in same answer book / Supplementary.
(2) Use of Programmable calculator & any other electronic instrument is prohibited.
(3) Instructions written on main answer Book are strictly to be obeyed.
(4) Draw neat diagrams & figures (If necessary) at right places.
(5) Assume suitable & Perfect data if needed.

SECTION-I

Q.1 Write answers of the following Questions.

1. What is zero point energy? 1
2. Prove that $J_-J_+= J^2-J_z^2-\hbar J_z$ 2
3. In the solution of Harmonic Oscillator $u_\infty = \exp(\pm\xi^2/2)$, the positive exponent is avoided, Why? 2
4. Prove that $[H,a]=-\hbar\omega a$ 2

Q.2 A. Discuss Harmonic Oscillator energy spectrum in brief and plot Eigen function for n=0 to n=5. 5

B. Discuss Spherical harmonics in detail and obtain Y_{00}, Y_{10} and Y_{20}. 5

C. Derive the Energy Eigen value of Hydrogen atom. 4

OR

Q.2 A. Derive the following equation using power series solution, 5

$$a_{n+2} = \frac{2}{n+2} a_n$$

B. Using the relations of rectangular and spherical polar coordinates, obtain 5

$$L_z = i \frac{\partial}{\partial \phi}$$

C. Using the solution of Schrodinger equation in three dimension, prove 4

$$\frac{\partial^2 \Phi}{\partial \phi^2} + \Phi m^2 = 0$$

Q.3 A. What is One dimensional Harmonic Oscillator ? Derive the following equation, 7

$$\frac{d^2h}{d\xi^2} - 2\xi\frac{dh}{d\xi} + h(\square - 1) = 0$$

B. Define Raising and Lowering operators in brief. 7

OR

Q.3 A. For attractive coulomb potential $V(r)=-\frac{c}{r}$, solve Schrodinger radial equation and prove that energy Eigen values are $E_n=-\frac{m z^2 e^4}{2\hbar^2 n^2}$. 7

B. Discuss the solution of Harmonic Oscillator in Polar Co-ordinates. 7

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SECTION-II

Q.4 Write answers of the following Questions.

1. Why WKB approximation is called semi-classical approximation? 1
2. What is Dirac's Bra and Ket Notation? 2
3. What are the applications of Fermi Golden Rule? 2
4. In the Time independent perturbation Theory in the following Equation 2

$(E_n-E_m)C_k^{(1)}+H'_{km}-W^{(1)}\delta_{km}=0$

H'_{km} suggests what? What are the E_n and E_m ?

Q.5

A. Explain WKB approximation. 5

B. Discuss the Variation method in terms of upper bound and ground state energy. 5

C. Define the Matrix Representation of an Operator. 4

OR

Q.5

A. Explain the Unitary operators. 5

B. Discuss the Dirac-delta function with necessary diagram. 5

C. What is Stark effect? Discuss it in brief. 4

Q.6

A. Explain the Periodic Perturbation in Brief. 7

B. Explain the Time dependent perturbation theory with general formulation and first order theory. 7

OR

Q.6

A. Explain the Interaction of Electromagnetic Field with atom. 7

B. Show that the perturbation removes degeneracy and obtain 7

$$w^{(1)}=\frac{1}{2}(h_{11}+h_{22})\pm\frac{1}{2}[(h_{11}-h_{22})^2+4h_{12}h_{21}]$$

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