Reg. No .... Name 19P2019

MSc DEGREE END SEMESTER EXAMINATION - MARCH/APRIL 2019

SEMESTER 2 : PHYSICS

COURSE : **16P2PHYT06 : QUANTUM MECHANICS -1**

(For Regular - 2018 Admission and Supplementary - 2017/2016 Admissions)

Time : Three Hours Max. Marks: 75

Section A

Answer all the following (1 marks each)

1. The wavefunction of a particle in one dimension is denoted by $\Psi(x)$ in the coordinate representation and by $\Phi(p) = \int \Psi(x)e^{-ipx/\hbar}dx$ in the momentum representation. If the action of an operator T on $\Psi(x)$ is given by $T\Psi(x) = \Psi(x+a)$, where a is a constant, then $T\Phi(p)$ is given by
   a. $-\frac{i}{\hbar}ap\Phi(p)$ b. $e^{-iap/\hbar}\Phi(p)$ c. $e^{iap/\hbar}\Phi(p)$ d. $\left(1+\frac{i}{\hbar}ap\right)\Phi(p)$.
2. The canonical commutation relation, [H,N], between the Hamiltonian (H) and the number operator (N) of a quantum mechanical simple harmonic oscillator is
   a) 1 b) a^+ c) a d) 0
3. If σ_x, σ_y and σ_z are the Pauli matrices
   a) $\{\sigma_i, \sigma_j\} = 2\delta_{ij}$ b) $\{\sigma_i, \sigma_j\} = \delta_{ij}$ c) $\{\sigma_i, \sigma_j\} = 2$ d) $\{\sigma_i, \sigma_j\} = 0$
4. In WKB approximation the first power of $\hbar$ gives
   a) The classical result b) quantum result c) the connection formulae d) e/m ratio
5. The first order correction to energy E_n^1 in time independent perturbation theory is given by
   a) $\langle\psi_n^0|H'|\psi_n^0\rangle$ b) $\frac{|\langle\psi_n^0|H'|\psi_n^0\rangle|^2}{(E_n^0-E_m^0)}$ c) $\langle\psi_n^0|H_0|\psi_n^0\rangle$ d) $\frac{|\langle\psi_n^0|H_0|\psi_n^0\rangle|^2}{(E_n^0-E_m^0)}$

(1 x 5 = 5)

Section B

Answer any 7 (2 marks each)

6. Show that commuting operators possess simultaneous eigen functions
7. What is meant by Schrödinger picture? Explain
8. Why does the angular momentum operators of different no-interacting particles commute.
9. Show that $\{\sigma_x, \sigma_y\} = 0$.
10. Write down the commutation relation between L^2, L_x, L_y and L_z.
11. If $|jm\rangle$ denotes the simultaneous eigenkets of J^2 and J_z then write the eigen value equation of J^2 and J_z.
12. The WKB method is suitable for problems that are one dimensional or which could be resolved into forms that are one dimensional why?

13. Write Ritz variational principle.

14. Explain the principle of variational method.

15. State the criterion for the validity of WKB approximation.

(2 x 7 = 14)

Section C

Answer any 4 (5 marks each)

16. If $|+>$ is represented by $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ in the matrix notation find the matrix representation for 1) $|->$ 2) $|Sx;+>$ 3) $|Sx;->$ 4) $|Sy;+>$ 5) $|Sy;->$

17. If a and a^+ are the annihilation and creation operator of a quantum mechanical simple harmonic oscillator show that

$$a|n\rangle = \sqrt{n}|n-1\rangle \text{ and } a^+|n\rangle = \sqrt{n+1}|n+1\rangle.$$

18. Show that $[J_x, J_y] = i\hbar J_z$.

19. Show that a state ket returns to its original state only through a rotation of 4π.

20. Evaluate the first and second order corrections to the energy of the $n = 1$ state of an oscillator of mass m and angular frequency ω subjected to a potential given by

$$V(x) = \frac{1}{2}m\omega^2x^2 + bx$$ Here b is independent of x and b and $\frac{1}{2}m\omega^2x^2 >> bx.$

21. Outline the method of variational method of approximation.

(5 x 4 = 20)

Section D

Answer any 3 (12 marks each)

22.1. (a) Derive the general uncertainity relation (b) Show that linear momentum is a generator of translation

OR

2. Calculate the expectation value of x, x^2 and p for a Gaussian wave packet.

23.1. Obtain the eigen kets and eigenvalues of a simple harmonic oscillator.

OR

2. For a one – dimensional simple harmonic oscillator (SHO), using creation and annihilation operators, show that

$(\Delta x)(\Delta p) = \left(n + \frac{1}{2}\right)\hbar$. Also draw the $\psi(x)$ and $|\psi(x)|^2$ for the first three states of the SHO.

24.1. (i) Obtain the expression for the rotation matrix in the two component (matrix) formalism. (ii) If $\hat{n}$ were a unit vector characterized by β and α the polar and azimuthal angles, then find the eigenspinor χ of $\sigma \cdot \hat{n}$.

OR

2. Discuss the first order time independent perturbation theory for non degenerate stationary case. Obtain the corrected eigenvalues and Eigen vectors.

(12 x 3 = 36)