Reg. No ..... Name **18P219**

M Sc DEGREE END SEMESTER EXAMINATION - APRIL 2018

SEMESTER 2 : PHYSICS

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

(Common for Regular - 2017 Admission & Supplementary 2016 Admission)

Time : Three Hours Max. Marks: 75

Section A
Answer any 5 (1 marks each)

1. If $|+\rangle$ denotes the spin up state and $|-\rangle$ denote the spin down state, $|+\rangle\langle+| + |-\rangle\langle-|$ is
   a) $|+\rangle\langle+|$ b) $|-\rangle\langle-|$ c) 0 d) 1
2. If a is an annihilation operator then $a|0\rangle =$
   a) $|0\rangle$ b) 0 c) $|1\rangle$ d) a
3. An electron in the $|+\rangle$ state is in the magnetic field $B_z\hat{k}$, then $\frac{dSz}{dt}$ is
   a) $\frac{e}{mc}$ b) 0 c) μ d) constant in z
4. If σ_x, σ_y and σ_z are the Pauli matrices then
   a) $\sigma_x = \sigma_y$ b) $\sigma_x^2 = \sigma_y^2$ c) $\sigma_x = -\sigma_y$ d) $\sigma_y^2 = \sigma_z^2$
5. The energy of the electron in the nth(n=principal quantum number) orbit of hydrogen atom is given by
   a) $\frac{13.6}{n^2}eV$ b) $\frac{13.6}{n^2}J$ c) $-\frac{13.6}{n^2}J$ d) $-\frac{13.6}{n^2}eV$

(1 x 5 = 5)

Section B
Answer any 7 (2 marks each)

6. Give the significance of momentum representation.
7. Show that for a free particle the linear momentum is a constant of motion.
8. Write the time evolution operator for a spin half system with magnetic moment subjected to a static external magnetic field of B_z.
9. Describe a stationary state and a nonstationary state.
10. Write the expression for the finite rotation operator and infinitesimal rotation operator.
11. Show that $\{\sigma_x, \sigma_y\} = 0$.
12. Write down the commutation relation between L^2, L_x, L_y and L_z.
13. Give the commutation relations of J^2. Where J is the total angular momentum.
14. State the criterion for the validity of WKB approximation.
15. Explain briefly the principle of time independent perturbation theory.

(2 x 7 = 14)

Section C
Answer any 4 (5 marks each)

16. Find the commutation [A,[B,C]]+[B,[C,A]]+[C,[A,B]].
17. The normalized wavefunction of a particle is $\Psi(x) = Ae^{iax-ibt}$, where A, a and b are constants. Evaluate the uncertainity in its momentum.
18. If a and a^+ are the annihilation and creation operator of a quantum mechanical simple harmonic oscillator show that

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

19. Show that $[J_x, J_y] = i\hbar J_z$.
20. A simple harmonic oscillator of mass m and angular frequency ω is perturbed by an additional potential $\frac{1}{2}bx^2$. Obtain the first and second order corrections to the ground state energy.
21. Estimate the ground state energy of a Harmonic oscillator of mass m and angular frequency ω using a Gaussian trial wave function $\phi(x) = Ae^{-\alpha x^2}$ where A and α are constants.

(5 x 4 = 20)

Section D
Answer any 3 (12 marks each)

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

OR

23. What are the properties of the infinitesimal translation operator? Show that $1 - iK \cdot dx'$ can be used to represent the infinitesimal translation operator and hence derive the commutation relation between momentum and position operators.
24. 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.

OR

25. Derive the Schrödinger equation for the time evolution operator after arriving at the expression for the infinitesimal time evolution operator. Also find the formal solutions to the Schrodinger equation thus treating the three cases for the Hamiltonian.
26. Obtain the fundamental commutation relations of angular momentum operators.

OR

27. Discuss hydrogen atom problem. Obtain the ground state wave function and the ground state energy.

(12 x 3 = 36)