Enrollment No: ________________________Exam Seat No:________________________

C.U.SHAH UNIVERSITY

Summer Examination-2018

Subject Name : Introduction to Quantum Mechanics

Subject Code : 4SC06QMC1 **Branch: B.Sc. (Physics)**

Semester : 6 **Date : 23/04/2018** **Time : 02:30 To 05:30** **Marks : 70**

Instructions:
(1) Use of Programmable calculator & 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.

Q-1		**Attempt the following questions:**	**(14)**
	a)	Which kind of energy is possessed by the free particle?	01
	b)	Define a Wave packet.	01
	c)	What is Heisenberg's uncertainty principle? Write its equation.	01
	d)	What do you mean by the normalization of a wave function ψ with finite norm?	01
	e)	What are the Admissibility Conditions of a wave function?	01
	f)	Define the Stationary States.	01
	g)	What is a momentum Eigen function? How can it be normalized?	01
	h)	Write the formula for the reflection probability $\mathfrak{R}$ at potential barrier and walls.	01
	i)	Define the adjoint of an operator.	01
	j)	What is self adjoint operator?	01
	k)	What are the properties of a self adjoint operator?	01
	l)	What is the Dirac Delta function?	01
	m)	Fill in the blanks from Ehrenfest theorem: $m\frac{dr}{dt} = \_\_\_$ and $\frac{<dP_r>}{dt} = \_\_$	01
	n)	Write the formula for the energy eigen values of the simple harmonic oscillator.	01

Attempt any four questions from Question No. 2 to Question No. 8

Q-2		**Attempt all questions**	**(14)**
	A	Obtain Schrödinger's equation for free particle in one dimension. From that, obtain it for three dimensions.	**06**
	B	Obtain Schrödinger's equation for a particle in a force field.	**04**
	C	Derive : Time dependent Schrödinger Equation.	**04**

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

A Discuss about the Physical interpretation for a wave function $\Psi(r,t)$ and probability interpretation for finding a particle in three dimensional space. **07**

B Write a short note on the Normalization of a wave function ψ. **04**

C Normalize the given wave functions. **03**

$\Psi = a.\exp i(kx - wt)$ where $-2 \leq x \leq 2$

$\chi = \exp(-i\,\theta)$ where $0 < \theta < 2\pi$

$\Psi'(\phi) = A\sin(mn\phi)$ where $0 < \phi < 2\pi$

Q-4 **Attempt all questions** **(14)**

A Explain giving example: Normalization of wave function with infinite norm by the method of Box Normalization. **07**

B Explain the conservation of probability for normalizable wave functions. **07**

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

A Write a short note on Expectation Value derive necessary formulas for the expectation value of (i) Energy (ii) Potential Energy and (iii) Momentum. **07**

B Derive : Time Independent Schrödinger Equation. **07**

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

A Give a brief explanation of Eigen Function and its Eigen Values. Show that the wave functions $\psi(x) = \sin 2x$ and $\phi(z) = e^{3x}$ are eigen functions of $\partial^2/\partial x^2$. **05**

B Describe the Square-Well Potential with one dimensional Schrödinger equation for different regions. **03**

C Discuss the particle under bound state ($\vec{E} < 0$) in a square well and derive its solutions. **06**

Q-7 **Attempt all questions** **(14)**

A Give a detailed account for Energy Eigen Function for Even & Odd Parity with graphical representation. **08**

B Write the statements of three fundamental postulates for the particle waves in quantum mechanics. Discuss any one of them. **06**

Q-8 **Attempt all questions** **(14)**

A For a given wave function $\psi = (\pi a^3)^{-1/2}.e^{-r/a}$ in spherical polar coordinate system (r, θ, ϕ), prove that $< r > = \frac{3a}{2}$;where a = constant. **04**

B For a wave function $\psi = \sqrt{\frac{2}{L}}\sin\left(\frac{n\pi x}{L}\right)$, prove that the expectation value of x for a particle in a box with volume L^3 is $< x > = \frac{L}{2}$. **04**

C Prove that : **04**

$[x, P_x^n] = n\,i\,\hbar\,P_x^{n-1}$ $[L_x, L_y] = i\hbar L_z$

$[y, P_y^n] = n\,i\,\hbar\,P_y^{n-1}$ $[L_y, L_z] = i\hbar L_x$

$[z, P_z^n] = n\,i\,\hbar\,P_z^{n-1}$ $[L_z, L_x] = i\hbar L_y$

D Prove that the commutator of the position and momentum do not vanishes for a particle; as $[x, P_x] = [y, P_y] = [z, P_z] = i\,\hbar$ **02**