Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2022

Course: Quantum Mechanics I
Semester: I
Program: M.Sc. Physics **Time : 03 hrs.**
Course Code: PHYS 7003 **Max. Marks: 100**

Instructions: Read all the below mentioned instructions carefully and follow them strictly:

1) Mention Roll No. at the top of the question paper.
2) Attempt all the parts of a question at one place only.
3) Section A has no choice while Sections B & C have internal choices.
4) Scientific calculator is allowed.

SECTION A
(5Q × 4M = 20 Marks)

S. No.	**(Attempt ALL questions)**	**Marks**	**CO**
Q 1	Mention the properties of Hermitian Operators.	**4**	**CO3**
Q 2	Define Ehrenfest's theorem.	**4**	**CO2**
Q 3	The work function of a metal is 3.45 eV. What is the maximum wavelength of a photon that can eject an electron from the metal?	**4**	**CO2**
Q 4	What is Compton effect? Give a schematic sketch of an experimental arrangement for observing this effect.	**4**	**CO1**
Q 5	The energy of an excited hydrogen atom is –3.4 eV. Calculate the angular momentum of the electron according to Bohr theory.	**4**	**CO1**
	SECTION B **(4Q × 10M = 40 Marks)**		
Q 6	Using the concept of motion of wave packets prove that $\frac{d}{dt}\langle r\rangle = \frac{\langle p\rangle}{m}$.	**10**	**CO3**
Q 7	A nucleon (neutron or proton) is confined to a nucleus of radius 5×10^{-15} m. Calculate the minimum possible values of the momentum and the kinetic energy of the nucleon.	**10**	**CO2**
Q 8	Calculate the most probable distance of the electron in the ground state of a hydrogenic atom. What is the radial probability density at that distance?	**10**	**CO2**

Q 9	Explain the alpha decay of a nucleus on the basis of the tunnel effect and obtain an expression for the lifetime of an alpha particle inside the nucleus. **OR** Derive the expression of Schrodinger time independent equation.	**10**	**CO2**
SECTION C **(2Q × 20M = 40 Marks)**			
Q 10	(a) Consider a particle moving in a one-dimensional infinite square well. Solve the time-independent Schrödinger equation for this system and obtain the energy eigenvalues and the normalized eigen functions. (b) Prove that the momentum operator $-i\hbar\nabla$ is Hermitian.	**15** **5**	**CO3** **CO2**
Q 11	Discuss the quantum mechanical scattering of a particle of mass m and energy E by the square potential well. $$V(x) = \begin{cases} 0 & x < 0 \\ -V_0 & 0 < x < a \\ 0 & x > a \end{cases}$$ Obtain the reflection and transmission coefficients and show that their sum is unity. **OR** Obtain the time-independent Schrödinger equation in spherical polar coordinates for a particle in a spherically symmetric potential. Carry out the separation of variables and solve the angular equation.	**20** **20**	**CO3**