BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: IMSc **SEMESTER : V**
BRANCH: Physics **SESSION : MO/2024**

SUBJECT: PH301 QUANTUM MECHANICS AND APPLICATIONS (QMA)

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Establish time dependent Schrodinger wave equation?	[5]	1	1
Q.1(b)	Find the expectation value of position and momentum of a particle whose normalized wave function is $$\psi(x) = Ne^{-(x^2/2a^2)+ikx}$$	[5]	1	3
Q.2(a)	What is the significance of the momentum wave-function. Write down its forms in terms of propagation constant?	[5]	2	2
Q.2(b)	For a Gaussian function f(x) represented by $f(x) = \frac{1}{\sqrt{(\sigma\sqrt{\pi})}} e^{-x^2/2\sigma^2}$ where ▫ determines the width of the wave-packet. Using Fourier transform derive the amplitude function A(k)?	[5]	2	3
Q.3(a)	For a quantum particle undergoing harmonic oscillation, show that the energy Eigen values are expressed as $E_n = \left(n + \frac{1}{2}\right)\hbar\omega$	[5]	3	2
Q.3(b)	Calculate the energy difference between the ground state and first excited state for an electron in one dimensional rigid box of length 10^{-10} m? (m_e=9.1×10^{-31} Kg, h = 6.626 × 10^{-34} joule-sec)	[5]	3	3
Q.4(a)	For the radial part of Hydrogen atom given by $$\frac{\partial^2 R}{\partial r^2} + \frac{2}{r}\frac{\partial R}{\partial r} + \left[\frac{-l(l+1)}{r^2} + \frac{2\mu}{\hbar^2}\{E - V(r)\}\right]R = 0$$ Setup the recursion relation $$a_{k+1} = \frac{k+l+1-\lambda}{(k+1)(2l+k+2)}a_k$$ Given $\alpha^2 = -\frac{2\mu E}{\hbar^2}$ *and* $\lambda = \frac{\mu Z e^2}{\hbar^2\alpha}$ and show energy eigen-values are given by $$E_n = -\frac{\mu Z^2 e^4}{2\hbar^2 n^2}$$	[5]	4	2
Q.4(b)	The wave function of Hydrogen atom for the *1s* sate is $\psi(1s) = \frac{1}{\sqrt{\pi}}\left(\frac{1}{a_0}\right)^{3/2} e^{-r/a_0}$, *Where*, $a_0 = \frac{\hbar^2}{me^2}$ is the Bohr's radius. Calculate the expectation value of the potential energy of electron in *1s* state.	[5]	4	3
Q.5(a)	Derive the expression for the Larmor's Precession frequency?	[5]	5	2
Q.5(b)	Discuss the Stern-Gerlach experiment and its significance?	[5]	5	1

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