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

CLASS: I.MSC **SEMESTER : III**
BRANCH: PHYSICS **SESSION : MO/2023**

SUBJECT: PH301 QUANTUM MECHANICS AND APPLICATIONS

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)	What do you understand by Wave-particle duality? Calculate the wavelength associated with an electron subjected to a potential difference of 1.25 kV?	[5]	1	4
Q.1(b)	Calculate the expectation value of p^2 for the wave function $\psi(x)=\left(\frac{2}{L}\right)^{1/2}\sin\left(\frac{\pi x}{L}\right)$ in the region $0<x<L$ and $\psi(x)=0\ for\ \lvert x\rvert > L$	[5]	1	4
Q.2(a)	Discuss the physical significance of momentum wave function $\phi_p(r)=\phi(k)=Ae^{ik.r}$	[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	5
Q.3(a)	Derive the wavefunction and energy eigenvalues for a square well potential given by V=0 in the range x=0 to x=L, and V=∞ elsewhere.	[5]	3	2
Q.3(b)	Let u(ξ) be the solution to the Hermite differential equation $u''(\xi)-2\xi u'(\xi)+(\Lambda-1)u(\xi)=0,$ then find the recurrence relation using the Frobenius method, $u(\xi)=\sum_r c_r\zeta^{r+s}$.	[5]	3	2
Q.4(a)	Using the known commutation relation between position and momentum operators, prove that $\left[L_x,L_y\right]=i\hbar L_z$, where the symbols have their usual meanings.	[5]	4	3
Q.4(b)	The radial part of the wavefunction for the ground state of the hydrogen atom is given by $R_{10}(r)=\left(2/a_o^{3/2}\right)\exp\left(-r/a_o\right)$ Write down the full wavefunction $\psi_{100}(r,\theta,\phi)$. Show that the probability of finding the electron in the range $(r,r+dr)$ is proportional to $r^2R^2{}_{10}(r)$ and is maximized at $r=a_o$.	[5]	4	3
Q.5(a)	Discuss the Stern-Gerlach experiment and its significance?	[5]	5	1
Q.5(b)	Write down the Pauli spin matrices. Show that the square of each Pauli spin matrix is given by the identity matrix, while the determinant of each equals -1.	[5]	5	3

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