MANIPAL ACADEMY of HIGHER EDUCATION (Institution of Eminence Deemed to be University)

Reg.No.									

DEPARTMENT OF SCIENCES, II SEMESTER M.Sc. (PHYSICS)
END SEMESTER EXAMINATIONS, MAY/JUNE 2023
Quantum Mechanics - II [PHY 5253]
(CHOICE BASED CREDIT SYSTEM - 2020)

Time: 3 Hours | Date: 26/05/2023 | MAX. MARKS: 50

Note (i) Answer ALL questions
(ii) Draw diagrams, and write equations wherever necessary

Q No	Question	Marks	CO	BL
1A	Differentiate between pure and mixed states.	3	1	4
1B	Evaluate the Zeeman splitting for the ground state of H-atom.	3	2	5
1C	Calculate the alpha decay lifetime of ${}_{84}Po^{212}$ isotope. Given: $m(Po) = 211.988842\,u$, $m(Pb) = 207.976627\,u$, $m(\alpha) = 4.002602\,u$ $1u = 931\,MeV/c^2$, $K_1 = 1.980\,MeV^{1/2}$, $K_2 = 1.485\,fm^{-1/2}$	4	2	3
2A	The general wave function for a two-level system subject to a time-dependent perturbation ($H'(t)$) is given by $\psi(t) = c_a(t)\psi_a e^{-iE_at} + c_b(t)\psi_b e^{-iE_bt}$, where $c_a(t)$ and $c_b(t)$ satisfies $\dot{c_a} = -\frac{i}{\hbar}H'_{ab}e^{-i\omega_0 t}c_b \quad ; \quad \dot{c_b} = -\frac{i}{\hbar}H'_{ba}e^{i\omega_0 t}c_a$. Using the time-dependent perturbation theory, derive the first and second order approximations to c_a and c_b.	3	3	3
2B	Apply time-dependent perturbation theory to a two-level system subjected to a harmonic perturbation and obtain the expression for transition probability.	4	3	3
2C	Derive the expressions for Einstein's coefficients.	3	3	3
3A	Write down the selection rules for electric dipole transitions. What are the decay routes possible for an electron in the $\vert 300\rangle$ state of H-atom to decay to the ground state $\vert 100\rangle$ via electric dipole transitions?	4	3	4
3B	For classical hard sphere scattering, the impact parameter is given by $b = R\cos(\theta/2)$. Evaluate the total cross-section. Comment on your results.	3	4	5
3C	Derive the optical theorem. Given: $f(\theta) = \frac{1}{k}\sum_l (2l+1)\exp(i\delta_l)\sin\delta_l\, P_l(\cos\theta)$.	3	4	3
4A	In the low energy Born approximation, evaluate $f(\theta)$ for the following potentials: i. Soft sphere, $V(r) = \begin{cases} V_0 & (r \le a) \\ 0 & (r > a) \end{cases}$ ii. Delta function, $V(r) = \alpha\,\delta(r-a)$	5	4	5
4B	Starting from the Klein-Gordon equation, derive the continuity equation. Discuss the problems associated with the Klein-Gordon theory.	5	5	3
5A	Calculate the differential scattering cross-section for scattering from Yukawa potential.	4	4	3
5B	Discuss some limitations of non-relativistic quantum mechanics.	2	5	2
5C	Starting from the Dirac Hamiltonian, arrive at the Dirac equation. Explain the Dirac hole theory.	4	5	4

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