SC

SEAT No.________ **No. of Printed Pages : 3**

[45/A-24]

SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar
M. Sc. (Physics) 3rd Semester Examination
Tuesday, 10th April, 2018
Time: 10:00 am to 01:00 pm
Subject: PS03CPHY01 [Quantum Mechanics-II]

Total Marks: 70

Note: (1) Figures to the right indicate marks.
(2) Symbols have their traditional meaning.

Q:1 **Attempt all of the following Multiple choice type questions. [01 mark each]** [08]

(1) For Pauli matrices $\sigma_+\sigma_- =$ _____.

(a) $2(1+\sigma_z)$ (c) $2(1-\sigma_z)$
(b) 0 (d) 1

(2) $(J_+ + J_-) =$

(a) 2 Jz (c) 2 Jx
(b) 0 (d) 2 Jy

(3) Induced absorption can be given by

(a) $\omega_{fi} - \omega = 0$ (c) $\omega_{fi} = 0$
(b) $\omega_{fi} + \omega = 0$ (d) $\omega_{fi} - \omega_{if} = 0$

(4) $a_f^1(t)$ provides a good approximation to the $a_f(t)$ if the total probability for transitions from i to all states $f \neq i$ is

(a) $\sum |a_f^1(t)|^2 = 1$ (c) $\sum |a_f^1(t)|^2 \ll 1$
(b) $\sum |a_f^1(t)|^2 \gg 1$ (d) $\sum |a_f^1(t)|^2 = 0$

(5) $V(t,t_1)V(t_1,t_0) =$

(a) $V(t_0,t_1)$ (c) 1
(b) $V(t,t_0)$ (d) $V(t_0,t)$

(6) The Pauli spin matrix $\sigma_y =$

(a) $\begin{pmatrix} 0 & i \\ i & 0 \end{pmatrix}$ (c) $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$
(b) $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ (d) $\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$

[P.T.O]

(7) In Natural units ($\hbar = c = 1$), dimensional formula for electric charge is _______.

(a) $M^1L^0T^0$ (c) $M^1L^0T^{-1}$

(b) $M^0L^0T^0$ (d) $M^1L^1T^0$

(8) **Klein-Gordon field corresponds to spin $s =$ _____ .**

(a) 3/2 **(c) 5/2**

(b) 1 **(d) 0**

Q:2 **Answer any 7 of the following 9 questions briefly. [02 marks each]** [14]

1 What are C-G coefficients?
2 Explain phase convention.
3 What is dipole approximation?
4 Explain selection rules.
5 Describe the scattering operator..
6 Explain the negative energy states.
7 Explain briefly the Schrödinger picture.
8 For S.H.O., write lowering ($\hat{a}$) and ($\hat{a}^{+}$) operators in terms of position and linear momentum operators. Prove that $[\hat{a}^{+}, \hat{a}] = -1$.
9 Define field. Write its coordinate.

Q:3 (a) Discuss the coupling of two spin-1/2 particles and obtain the spin wave function corresponding to the singlet and triplet states. [6]

(b) Derive eigenvalue spectrum for j_z and J^2, when $[J^2, j_z] = 0$. [6]

OR

(b) For $\langle j'm' | J_+ | jm \rangle = C^{+}_{jm} \hbar \delta_{j',j} \delta_{m',m+1}$, obtain an expression for c^{-}_{jm}. For two independent (non-interacting) angular momentum vectors J_1 and J_2 deduce addition of them, and show that it is equivalent to old '*vector model*'. Define Clebsch-Gordan coefficients. [6]

Q:4 (a) Obtain the general solution of time-dependent Schrödinger equation. [6]

(b) Write a note on Propagators. [6]

OR

(b) What is constant perturbation? For closely spaced states show that the transition probability per unit time is $\dot{w} = \frac{2\pi}{\hbar} |H'_{fi}|^2 \rho(E_f)$. [6]

Q:5 (a) Derive the Klein Gordon equation. Show that the plane wave solution of the equation gives $E = \pm(c^2\vec{p}^2 + m^2c^4)^{1/2}$. [6]

(b) Explain Dirac's relativistic Hamiltonian $H = c\vec{\alpha}\cdot\vec{p} + \beta mc^2$. Derive the equation $i\hbar\frac{\partial\psi}{\partial t} = -i\hbar c\alpha\psi + \beta mc^2\psi$. [6]

OR

(b) Write a plane wave solutions of the Dirac equation. [6]

Q:6 (a) What is *second quantization*? Derive the time dependent Schrödinger equation, using Hamiltonian form for field equation and the Lagrangian density as $L = i\hbar\psi^*\dot{\psi} - \frac{\hbar^2}{2m}(\nabla\psi^*)(\nabla\psi) - V(\vec{r};t)\psi\psi^*$. [6]

(b) Derive Hamiltonian form of field equation. For a dynamical physical quantity F as a functional of ψ and Π, obtain its time rate of change and introduce the definition of Poisson bracket for field coordinates. [6]

OR

(b) Derive the Lagrangian classical field equation. Deduce the classical field equation analogous to Langrange's equation for a system of particles. [6]