## SARDAR PATEL UNIVERSITY

M. Sc. (Physics) 3<sup>rd</sup> Semester Examination Friday, 21<sup>st</sup> October, 2016 Time: 02:00 pm to 05:00 pm

	Time: 02:00 pm to 0 Subject: PS03CPHY01 [Quanti	tum Mechanics-II]
	·	Total Marks: 70
Note: (1) F (2) S	igures to the right indicate marks. ymbols have their traditional meaning.	
Q:1 Atte	mpt all of the following Multiple choice	e type questions. [ 01 mark each ] [08]
(1)	For Pauli matrices $\sigma_+^2 = $ Take $\hbar =$	=1.
(a) (b)	0 -iσ+	(c) iσ- (d) -1
(2)	In the matrix representation of angular m	momentum $j = \frac{1}{2}$ , $J_+ = \frac{1}{2}$ . Take $h = 1$ .
(a) (b)	$\begin{pmatrix} 0 & 1 \\ 0 & 1 \\ 0 & 0 \\ 0 & 1 \end{pmatrix}$	(c) $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ (d) $\begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$
(2)	When the time variation of the Hamilton	onian is small we take
(3) (a) (b)	dipole approximation sudden approximation	<ul><li>(c) Born approximation</li><li>(d) adiabatic approximation</li></ul>
(4)	$a_f^{l}(t)$ provides a good approximation to transitions from i to all states $f \neq i$ is	
(a)	$\sum_{i} \left  a_f^{I}(t) \right ^2 \ll 1$ $\sum_{i} \left  a_f^{I}(t) \right ^2 \gg 1$	(c) $\sum_{i}  a_f^i(t) ^2 = 1$ (d) $\sum_{i}  a_f^i(t) ^2 = 0$
(b)	$\sum_{j=1}^{n} \left  a_f^{I}(t) \right ^2 \gg 1$	$(d)  \sum \left  a_f^1(t) \right ^2 = 0$
(5)	$V(t,t_1)V(t_1,t_0) =$	

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

(5)

In the transformation  $|\Psi\rangle \rightarrow U|\Psi\rangle$ , choosing U as  $V^{-1}(t,t_0)$  leads to (6) (c) Heisenberg picture Schrödinger picture (d) Interaction picture (a) Dirac picture (b)

In Natural units ( $\hbar = c = 1$ ), dimensional formula for electric charge is \_\_\_\_\_\_.  $M^{1}L^{0}T^{0}$  (c)  $M^{1}L^{0}T^{-1}$ (7) (a)

(c)  $V(t,t_0)$ 

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

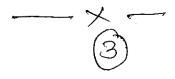
(	(8) (a)	The Klein-Gordon field is an example of spin $s = 0$ field.	
,	(b)	183 377	
Ç	):2	Answer any 7 of the following 9 questions briefly. [ 02 marks each ]	[14]
••	1 2	For $\tilde{J} = \tilde{J}_1 - \tilde{J}_2$ , prove that $\tilde{J}_1 - \tilde{J}_2$ does not represent angular momentum. Define Zeeman effect. Give difference between anomalous and normal	1 - 1
	3	Zeeman effect.  Draw the curve of transition probability as a function of energy difference between initial and final states, for fixed t in case of constant perturbation.  What is Dipole approximation?	
	<i>4</i> 5	Define and differentiate between elastic and inelastic scattering	
	6 7	Explain briefly the Schrödinger picture.  (i) Why is it necessary to consider Dirac's relativistic Hamiltonian?  (ii) Write down Pauli matrices.	
	8 9	For S.H.O., write lowering $(\hat{a})$ and $(\hat{a}^2)$ operators in terms of position and linear momentum operators. Prove that $[\hat{a}^2, \hat{a}] = -1$ . Define field. Write its coordinate.	
Q:	3 (a)	Derive total non-relativistic Hamiltonian for atomic system including spin in presence of external magnetic field. Write and interpret energy Eigen values expression for a case when spin-orbit interaction is neglected.	[6]
	(b)		[6]
•		OR	
	(b)	For $\langle j'm' J_+ jm\rangle = C_{jm}^+\hbar\delta_{j'j}\delta_{m',m+1}$ , obtain an expression for $C_{jm}^+$ .	[6]
		For two independent (non-interacting) angular momentum vectors $I_1$ and $I_2$ deduce addition of them, and show that it is equivalent to old 'vector model'. Define Clebsch-Gordan coefficients.	
Q:4	(a)	Obtain the general solution of time-dependent Schrödinger equation.	[6]
	(b)	Discuss in detail the interaction of an atom with electromagnetic radiation.	[6]
	(b)	OR Derive Fermi's golden rule and give its interpretation.	[6]
Q:5	(a)	Derive the Klein Gordon equation. Show that the relationship	[6]

## OR

- (b) Starting with Dirac's relativistic Hamiltonian  $H = c\vec{\alpha} \cdot \vec{p} + \beta mc^2$  derive the [6] Dirac equation.
- Q:6 (a) Derive Lagrangian classical field equation. Using the concept of functional [6] derivative, obtain classical field equation analogous to Langrange's equation for a system of particles.
  - (b) Derive Hamiltonian form of field equation. For a dynamical physical [6] quantity F as a functional of  $\psi$  and  $\Pi$ , obtain its time rate of change and introduce the definition of Poisson bracket for field coordinates.

## OR

(b) Explain the meaning of second quantization. Assuming following form for [6] Lagrangian density, viz;  $\mathcal{L} = i\hbar \psi^* \psi - \frac{\hbar^2}{2m} (\nabla \psi^*)(\nabla \psi) - V(\vec{r},t)\psi\psi^*$ , and using Hamiltonian form for field equation derive time dependent Schrödinger equation.



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