St. Philomena's College (Autonomous), Mysore

Question Bank

Programme: M. Sc. Physics

III Semester

Course Title: Advanced Quantum Physics

Course Type: Hard Core

Q.P Code : 88321

Sl. No.	Module	Question	Marks
1.	2	Using Born's approximation Discuss low energy soft sphere scattering.	4
2.	2	Discuss the Rutherford scattering using Born's approximation.	4
3.	2	For the case of hard sphere scattering, obtain the expression for scattering angle as a function of impact parameter.	4
4.	2	For the case of hard sphere scattering, show that differential cross-section is independent of scattering angle.Using Born's approximation: Discuss low energy soft sphere scattering.	4
5.	2	Using Born's approximation: Rutherford scattering.	4
6.	2	For the case of hard sphere scattering, obtain the expression for scattering angle as a function of impact parameter.	4
7.	2	For the case of hard sphere scattering, show that differential cross-section is independent of scattering angle.	4
8.	2	In Rutherford scattering an incident particle of charge q_1 and kinetic energy E scatters off a heavy stationary particle of charge q_2: Determine the differential scattering cross section	4
9.	2	In Rutherford scattering an incident particle of charge q_1 and kinetic energy E scatters off a heavy stationary particle of charge q_2: Show that total cross-section for Rutherford scattering is infinite.	4

10.	1	Describe the underlying principle of Born-Oppenheimer approximation method.	6
11.	1	State Adiabatic theorem. Explain Adiabatic variation with examples.	6
12.	1	Write a note on non-holonomic processess.	6
13.	2	Describe quantum scattering theory and show that differential cross-section is equal to square of the scattering amplitude.	6
14.	2	Discuss the first Born's approximation and obtain the expression for scattering amplitude at low energy.	6
15.	3	Discuss the reasons for which Schrodinger equation and Klein Gordon equation of a particle fell into disgrace with the special theory of relativity.	6
16.	3	Obtain the covarient form of Dirac's equation in terms of γ matrices.	6
17.	3	Evaluate $(\sigma \cdot A)(\sigma \cdot B)$.	6
18.	3	Normalize the plane wave solutions of the Dirac equation.	6
19.	3	"Klein gordon equation represents a system of bosons whereas Dirac equation represents a system of fermions". Justify this statement giving theoretical reasons.	6
20.	1	Discuss the time dependent perturbation theory and hence deduce Fermi's Golden rule.	8
21.	1	Discuss the emission and absorption of radiation in the dipole approximation.	8
22.	2	In Rutherford scattering an incident particle of charge q_1 and kinetic energy E scatters off a heavy stationary particle of charge q_2: Derive the formula relating impact parameter to the scattering angle.	8
23.	2	Using the strategy of partial analysis: In the case of low energy scattering from a spherical delta function shell $V(r) = \alpha\delta(r\ a)$, where α and a are constants, calculate the scattering amplitude f	8

		(θ).	
24.	3	Discuss the non relativistic limit of the Klein Gordon Equation.	8
25.	3	Give the significance of negative energy states and hence explain the concept of antiparticles.	8
26.	3	Discuss the Hydrogen energy spectra according to Dirac's theory.	8
27.	1	Discuss time dependent perturbation theory for two level systems and obtain an expression for probability amplitudes at first and second order.	9
28.	1	Obtain an expression for the probability of transition of a particle from state a to state b when the perturbation is sinusoidal in nature.	9
29.	1	Develop time-dependent perturbation theory for a two-level system.	9
30.	1	Determine the zeroth, first and second order corrections for time dependent perturbation theory.	9
31.	1	Derive Einstein's co-efficients for spontaneous and stimulated emissions.	9
32.	1	Discuss selection rules for transitions from an excited state.	9
33.	1	State and prove Adiabatic theorem.	9
34.	1	For a non-holonomic system, show that net geometric phase change is a line integral around a closed loop in parameter space.	9
35.	2	Write short notes on classical and relativistic collisions.	9
36.	2	Calculate the threshold energy for the reaction $p + p^{-} \rightarrow p + p + p + p + p^{-}$ where a high energy proton strikes a proton at rest, creating a proton-antiproton pair.	9
37.	1	Show that the transition rate for stimulated emission from state b to state a for a two level system which is under the influence of incoherent, unpolarized light incident from all direction is $R_{a\rightarrow b} = \frac{\pi}{3\epsilon\hbar}\|p\|^2\rho_0$.	10

38.	1	Deduce an expression for the life time of an excited state and hence discuss selection rules for transitions from an excited state.	10
39.	2	Describe classical scattering theory and obtain the expression for differential cross-section.	10
40.	2	Using the strategy of partial analysis: Discuss the case of hard sphere scattering and show that scattering cross-section is four times the geometrical cross-section, in the low energy approximation.	10
41.	3	Write down the Dirac's equation in an external electromagnetic field and deduce an expression for the magnetic moment of electron.	10
42.	3	Obtain the plane wave solutions to the Klein -Gordon equation.	10
43.	3	Discuss the scattering of a particle by Yukawa potential.	10
44.	3	Derive the plane wave solutions to Dirac equation for a free particle	10
45.	2	Discuss the formalism of partial wave analysis and obtain the expression for total cross-section.	12
46.	2	Obtain the integral form of Schrodinger equation.	12
47.	3	Set up the Klein -Gordon equation for a free particle. Obtain the equation of continuity and hence define the probability and current densities.	12
48.	3	Derive the Dirac equation for a free particle and show that it decomposes into a set of four differential equations and that spin is a natural consequence in the wave equation.	12
49.	3	Solve the Dirac equation for a particle in a central field force and calculate the spin orbit coupling energy.	12
50.	3	Show that the orbital angular momentum operator **L** of a free Dirac particle is not a constant of motion. Describe how the addition of an appropriate spin operator **S** to **L** makes the sum a constant of motion.	12

For 3 and 4 credit Courses

St. Philomena's College(Autonomous), Mysuru			
I/II/III/IV Semester M.Sc. Examination Month – Year			
Subject:			
Title:			
Time: 3 hours			**Max. Marks:70**
Instruction: Answer any one full question from Section – A, Section-B and Section-C and any four questions from Section – D.			
Section - A			
1.	**a.**	Question to be asked from unit I	**18**
	b.	Question to be asked from unit I	
OR			
2.	**a.**	Question to be asked from unit I	**18**
	b.	Question to be asked from unit I	
Section - B			
3.	**a.**	Question to be asked from unit II	**18**
	b.	Question to be asked from unit II	
OR			
4.	**a.**	Question to be asked from unit II	**18**
	b.	Question to be asked from unit II	
Section - C			
5.	**a.**	Question to be asked from unit III	**18**
	b.	Question to be asked from unit III	
OR			
6.	**a.**	Question to be asked from unit III	**18**
	b.	Question to be asked from unit III	
Section - D			
7.	Question to be asked from unit I		**04**
8.	Question to be asked from unit I		**04**
9.	Question to be asked from unit II		**04**
10.	Question to be asked from unit II		**04**
11.	Question to be asked from unit III		**04**
12.	Question to be asked from unit III		**04**

Note : Marks of Section A, B and C can be any combinations of 18. For example (12+6), (10+8),(9+9),(10+4+4),(8+6+4) etc,.