**Exam. Code : 209003**
**Subject Code : 5346**

**M.Sc. Physics 3rd Semester**

**Phy—501 : QUANTUM MECHANICS—II**

Time Allowed—3 Hours] [Maximum Marks—100

**Note :—** Attempt ***five*** questions in all. Section-A is compulsory. Attempt at least ***one*** question each from Sections B, C, D and E.

## SECTION—A

1. (i) Show that with a time-dependent Hamiltonian the energy is not conserved.

   (ii) What are the advantages of the variational method over the other perturbation methods ?

   (iii) Explain the Ramsauer Townsend effect.

   (iv) What do you mean by anharmonic oscillator ? Write down its total Hamiltonian.

   (v) Define the particle exchange operator and show that its Eigen values are ±1.

   (vi) Write short note on adiabatic and sudden approximations.

(vii) Compare the state vectors and operators in Schrödinger, Heisenberg and Interaction pictures.

(viii) The condition that must be satisfied by two operators $\hat{A}$ and $\hat{B}$ if they are to share the same eigenstates is that they should commute. Prove the statement.

(ix) What is resonance scattering ?

(x) What do you mean by constant perturbation ?

2×10=20

## SECTION—B

2. Consider an electron inside an infinitely deep one-dimensional potential well. The normalized wave function is :

$$\psi_n = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right).$$

Assuming a perturbation of form H' = –eFx. Show that in first order perturbation theory, each level get shifted by $-\frac{1}{2}eFL$. 20

3. Show that the first order effect of a time-dependent perturbation, varying sinusoidally in time, leads to the emission or absorption in energy. Find the transition rate for emission and absorption. 20



## SECTION—C

4. Using the Born approximation, calculate the differential cross section for the scattering by a spherical square well potential defined by $V(r) = \begin{cases} -V_0, r < b \\ 0, r > b. \end{cases}$ 20

5. Show that the scattering amplitude by the method of partial wave analysis is given by :

$$f(\theta) = \frac{1}{k}\sum_{\ell=0}^{\infty} (2\ell+1)e^{i\delta_\ell} \sin\delta_l P_l(\cos\theta).$$ 20

## SECTION—D

6. Show that Dirac's wave equation automatically endows the electron a spin of $\hbar/2$. 20

7. The Pauli matrix $\sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$ :

(a) Show that the matrix is real whose Eigen values are real.

(b) Find the Eigen values of $\sigma_y$ and construct the Eigen vectors. 20

## SECTION—E

8. (a) What do you mean by para- and ortho-helium ? Why the spin-singlet state of helium lies higher than spin-triplet state ? 10

(b) The two electrons in a helium atom are in 2s state. Write the spin part of the wave function. 10

9. Describe how symmetric and antisymmetric wave-functions are constructed for a system of n identical particles. Show that an Eigen function of such a system corresponding to a non-degenerate level is either symmetric or antisymmetric. 20

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**M.Sc. Physics 3rd Semester**

**Phy-502 : ELECTRODYNAMICS—II**

Time Allowed—3 Hours] [Maximum Marks—100

**Note :—** Attempt ***all*** the questions from Section-A and attempt ***one*** question each from the Sections-B, C, D and E.

## SECTION—A

1. (i) Which mode has lowest cut off frequency for both TE and TM modes in a rectangular wave guide ?

   (ii) Differentiate between wave guide and cavity resonator.

   (iii) How the power losses occur in resonant cavity ?

   (iv) What is the origin of time dilation ?

   (v) Define field tensor and give its one example.

   (vi) Discuss proper velocity in terms of ordinary velocity.

   (vii) Give one practical application of radiation reaction.

   (viii) Compare the power radiated by electric dipole and magnetic dipole.

(ix) Can a stationary charge emit the fields and why ?

(x) What is retarded time and give its physical significance ? 2×10=20

## SECTION—B

2. Work out the theory of TM modes for a rectangular wave guide. Also find the longitudinal electric field, the cutoff frequencies and wave and group velocities. 20

3. (i) Find the resonant frequencies for both TE and TM modes in case of resonant cavity produced by closing off two ends of the rectangular waveguide. 12

(ii) Write the expression for fields at the surface of and within a conductor. Discuss their physical meaning. 8

## SECTION—C

4. (i) Show that in energy closed system, the total relativistic energy and momentum are conserved. 10

(ii) Prove that the symmetry of a tensor is preserved under Lorentz transformation. 10

5. (i) Describe the Lagrangian formulation for the covariant Maxwell's equations. Also discuss its physical significance. 10

(ii) Show that conservation of relativistic energy is consistent with the principle of relativity. 10



## SECTION—D

6. For an oscillating electric dipole system, find :

(a) the scalar and vector potentials

(b) electric and magnetic fields

(c) Poynting vector and power radiated

(d) also sketch the intensity profile as a function of θ. 20

7. (i) Describe the radiating fields due to localized oscillating sources. 10

(ii) Suppose a point charge is constrained to move along the x-axis. Find the electric and magnetic fields at a point on the x-axis to the right of the charge. What are the fields on the axis, to the left of the charge ? 10

## SECTION—E

8. (i) What is the physical significance of Larmour's formula and describe its relativistic generalization. 15

(ii) Does a particle in hyperbolic motion experience a radiation reaction and give reason. 5

9. (i) Derive expression for Lienard-Wiechert's potentials and describe their applications. 15

(ii) Compare the electric fields of a point charge moving with constant velocity and an accelerated point charge. 5

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**Subject Code : 5348**

**M.Sc. Physics 3rd Semester**

**Phy-503 : CONDENSED MATTER PHYSICS—I**

Time Allowed—3 Hours] [Maximum Marks—100

**Note :—** Attempt ***all*** the questions from Section-A and attempt ***one*** question each from the Sections-B, C, D and E.

## SECTION—A

1. (i) Distinguish between elastic compliance and stiffness constants.

(ii) What is the significance of lattice specific heat of solids ?

(iii) Express stress and strain in terms of tensor notations.

(iv) State Wiedemann-Franz law and give its physical significance.

(v) Define hydration energy of ions.

(vi) Differentiate between F-centres and V-centres.

(vii) How the self diffusion takes place in solids ?

(viii) Draw the structure of $BaTiO_3$.

(ix) Distinguish between electronic and ionic polarizabilities.

(x) What are the objections against the dipole theory of ferroelectricity ? 2×10=20

## SECTION—B

2. Derive Debye model of Lattice specific heat. Also discuss its agreement with experimental results. 20

3. Describe the formation of elastic waves in cubic crystal. 20

## SECTION—C

4. (i) Explain the formation of Schottky and Frankel vacancies. 10

(ii) Find the number of Frenkel defects in a crystal in equilibrium state at a given temperature. 10

5. (i) Describe edge dislocations and screw dislocations in crystal lattice with suitable diagrams. 10

(ii) State the differences between high-angle and low-angle grain boundary and their relative effect on the materials. 10

## SECTION—D

6. State and derive the Boltzmann transport equation. Also describe its physical significance. 20



7. (i) Define activation energy for the formation of defects in ionic crystals. Also find expression for it. 10

(ii) How the ionic conductivity in pure alkali halides differ from conductivity of metals ? 10

## SECTION—E

8. (i) Explain the thermodynamics of ferroelectric transitions. 10

(ii) What are ferroelectric crystals ? Write their applications. 10

9. (i) State and derive Claussius-Mossotti relations. 10

(ii) Describe the frequency dependence of ionic polarizabilities. 10

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**Subject Code : 5349**

**M.Sc. Physics 3rd Semester**

**Phy-504 : NUCLEAR PHYSICS**

Time Allowed—3 Hours] [Maximum Marks—100

**Note :—** Section-A is compulsory. Attempt any ***four*** questions from Sections-B, C, D and E with at least ***one*** question from each section. All questions carry equal marks.

## SECTION—A

Attempt all ***ten*** parts.

1. (i) The binding energy per nucleon is low at low mass numbers and high mass numbers. Explain.

   (ii) What is LS coupling ? Write its advantages and disadvantages.

   (iii) Define Majorans forces and potential.

   (iv) Explain why beta spectrum is continuous.

   (v) What is the Q-value of a nuclear reaction ? Establish the Q-equation of a nuclear reaction by taking an example.

   (vi) Define Yukawa potential and define under what conditions it is used.

(vii) Explain with examples the phenomenon of isospin.

(viii) What do you mean by charge symmetry of nuclear forces ?

(ix) State Nilsson model briefly.

(x) What are stripping and pick up reactions ?

## SECTION—B

2. Explain p-p scattering. Experimentally the study of p-p scattering is capable of much higher accuracy than n-p scattering. Why ? What are the similarities of n-n and p-p forces ?

3. State clearly the definition of nuclear quadrupole moment and discuss the ground state of the deuteron in the light of the fact that it has small but finite quadrupole moment.

## SECTION—C

4. Give the main assumptions of liquid drop model of the nucleus. Derive the expression for the binding energy of a nucleus based on liquid drop model and explain all the parts of equation.

5. Discuss nuclear vibrational and rotational spectra of nuclei in collective model and explain the merits of this model over other models.



## SECTION—D

6. Give a brief account of Fermi's theory of beta-decay and show how it was necessary to postulate the existence of neutrino. What is Kurie plot ?

7. Describe the phenomenon of internal conversion. Obtain an expression for internal conversion coefficient for K-shell conversion in parity favoured transition.

## SECTION—E

8. Describe the conditions for direct nuclear reaction to occur and determine nuclear cross section for this reaction.

9. Explain in detail nuclear resonance scattering and find the cross sector in terms of partial wave amplitudes.