PH571.3 Reg. No.

St Aloysius College (Autonomous)

Mangaluru

SEMESTER III – P.G. Examination – M.Sc. Physics

December - 2022

Quantum Mechanics II

Time: 3 hrs. **Max Marks: 70**

PART -A

Answer all questions choosing ONE from each unit. **(4x15=60)**

UNIT I

1. a. Explain Gram-Schmidt procedure for converting a linearly independent basis into an orthonormal one. Using this, from an orthogonal basis in two-dimension A= 3i+4j and B= 2i-6j generate another orthonormal. (10)

   b. What is Unitary operator? Show that a product of unitary operators is unitary (5)

OR

2. a. What is a linear vector Space? Show that any vector $|V\rangle$ in an n-dimensional space can be written as a linearl combination of n linearly independent vectors and it is a unique expression. (8)

   b. Show that the expectation values of operators do not change with unitary transformation. (7)

Unit II

3. a. Obtain the Clebsh- Gordan coefficients for a system having $j_1=1/2$ and $j_2= 1/2$. (8)

   b. State the eigenvalue-eigenvector relations for the operators $\mathbf{J^2}$ and $\mathbf{J_z}$. Hence obtain the matrices for $\mathbf{J^2}$ and $\mathbf{J_z}$. (7)

OR

4. a. What are Pauli's Matrices? Write the properties and also prove that $[\sigma_x, \sigma_y]=2i\,\sigma_z$ (7)

   b. Verify that $\psi= A \sin\Theta \exp(i\varphi)$, where A is a constant, is an eigenfunction of L^2 and L_z. Find the eigenvalues (8)

Unit III

5. a. Explain the WKB approximation method. (7)

   b. Explain briefly the principle of time-independent perturbation theory for non degenerate case. (8)

OR

6. a. Explain the Variational Principle. Outline the variation method used for obtaining approximate value of ground state energy of a system of linear harmonic oscillator. (7)

   b. Using time dependent perturbation theory arrived at an expression for transition probability for absorption. (8)

Contd...2

Unit IV

7. a. Obtain expression for probability density and probability current density in the Dirac formalism. (7)

   b. Set up the Klein-Gordon equation. Show how it fails to explain probability interpretation. (8)

OR

8. a. Give the energy spectrum of a free Dirac particle and solve Dirac's equation for the case of free particle in motion. (8)

   b. Give the physical interpretation of Dirac's $\vec{\alpha}$ and β matrix. (7)

PART B

Answer any <u>TWO</u> questions. **(2x5=10)**

9. a. Determine whether the vectors (1,1,1), (1,0,1) and (1,2,-1) are linearly independent or not

   b. Show that Dirac's Hamiltonian for a free particle commute with the operator $\boldsymbol{\sigma}.\boldsymbol{p}$

   c. Show that the raising and lowering operators L_+ and L_- are adjusts of each other.

   d. The matrices for the unperturbed (H^0) and perturbation (H') Hamiltonians in the orthonormal basis $|\varphi_1\rangle$ and $|\varphi_2\rangle$ are

$$\hat{H}^0 = \begin{pmatrix} E_0+\epsilon & 0 \\ 0 & E_{0-}-\epsilon \end{pmatrix}, \quad \hat{H}' = \begin{pmatrix} 0 & A \\ A & 0 \end{pmatrix}, \quad \text{Determine}$$

   (i) The first order correction to energy.

   (ii) Second order correction to energy.

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St Aloysius College (Autonomous)
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Semester III- P.G. Examination – M.Sc. Physics
December-2022
CONDENSED MATTER PHYSICS-II

Time: 3 hrs **Max. Marks:70**

PART-A

Answer all questions choosing ONE from each unit. **(4 x 15 =60)**

UNIT- I

1. a) Discuss the current transport mechanism in ionic crystals. (8)
   b) Derive an expression for the concentration of Frenkel defects in solids. (7)

OR

2. a) Discuss about different types of luminescence processes in solids. (8)
   b) What are dislocations? Explain edge and screw dislocations. (7)

UNIT- II

3. a) What are spin waves in ferromagnets? Derive dispersion relation for the magnons. (8)
   b) Derive Bloch $T^{3/2}$ law in ferromagnetism. (7)

OR

4. a) Explain the molecular field theory of ferrimagnetism. (9)
   b) Discuss hard and soft magnetic materials. Also mention two important applications of each. (6)

UNIT- III

5. a) Explain the following: (8)
   (i)Influence of nuclear motion on NMR line width, and
   (ii)Chemical shift with suitable examples.
   b) Illustrate the phenomenon of electron spin resonance using classical equation of motion. (7)

OR

6. a) With block diagrams explain the working principles of continuous wave and Fourier transform nuclear magnetic resonance spectroscopy. (8)
   b) Explain: i) spin-lattice and ii) spin-spin relaxation processes. (7)

UNIT- IV

7. a) Explain the polarization in a dielectric. Establish Clausius-Mosotti between dielectric constant and polarizability of the dielectric material. (8)
   b) Discuss the optical properties of ionic crystals. (7)

OR

8. a) Discuss orientational polarizability. Obtain an expression for Langevin function (8)
   b) Explain how elastic constants for cubic crystal are determined experimentally? (7)

PART-B

Answer any TWO questions. **(2 x 5 =10)**

9. a) Explain the formation of polorons and excitons in ionic solids.
   b) Explain hysteresis loop of a ferromagnetic material using domain concept.
   c) Write a note on ferromagnetic resonance.
   d) Assuming that the polarizability of Kr atom is 2.18×10^{-40} Fm^2, calculate its dielectric constant at 0^0C and 1 atmosphere.

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St Aloysius College (Autonomous)
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Semester III – P.G. Examination – M.Sc. Physics
December - 2022
THERMODYNAMICS AND STATISTICAL PHYSICS

Time: 3 hrs. **Max. Marks: 70**

PART-A

Answer all questions choosing ONE from each unit (4x15=60)

UNIT - I

1. a) What is entropy? Obtain an expression for the entropy of an ideal gas. (7)
   b) Using Maxwell's thermodynamic relations obtain heat capacity equations and internal energy equations. (8)

OR

2. a) Define and explain the thermodynamic potentials. (6)
   b) Explain the variation of entropy in reversible and irreversible process with suitable example. (5)
   c) Starting from Helmholtz's function, obtain Maxwell's second thermodynamic relation. (4)

UNIT – II

3. a) Obtain the rotational partition function for a system consisting of N diatomic molecules. (7)
   b) Describe Maxwell-Boltzmann distribution law for velocities of gas molecules. (8)

OR

4. a) What is Gibb's paradox? Explain. Discuss how it was resolved. (10)
   b) Define partition function. List its properties. (5)

UNIT – III

5. a) Outline the concept of Bose-Einstein condensation. Obtain an expression for the temperature below which the condensation happens. (10)
   b) Write a note on Fermi-Dirac statistics. (5)

OR

6. a) Arrive at the Bose-Einstein distribution for a system with fixed number of particles. (10)
   b) Give a brief description of different types of ensembles. (5)

UNIT –IV

7. a) Give the Langevin theory of Brownian motion and discuss its significance. (10)
   b) Explain how Nyquist theorem is helpful in the reduction of noise in electrical circuits. (5)

OR

8. a) State and prove Weiner-Khinchin theorem. (6)
   b) Arrive at Fokker-Planck equation and explain its significance. (9)

PART - B

Answer any TWO questions. (2x5=10)

9. a) Obtain heat capacity equations at constant pressure and constant volume.
   b) State and prove Boltzmann equipartition theorem.
   c) What is degenerate gas? When does the Bose-Einstein and Fermi-Dirac distributions tend to the classical distribution?
   d) Explain in brief the one dimensional random walk problem.

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St Aloysius College (Autonomous)

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SEMESTER III- PG Examination- MSc Physics

December-2022

Relativity and Cosmology

Time:3 hrs **Max Marks:70**

PART-A

Answer ONE full question from each Unit **(3x18=54)**

UNIT I

1. a) Compare & contrast Galilean relativity with Special relativity and hence, outline the significance of the latter. (8)

   b) Arrive at the Lorentz transformations starting from the postulates of relativity. Show that they reduce to Galilean transformation under "certain" condition. (10)

OR

2. a) What are the consequences of Lorentz transformations? Give examples. (8)

   b) Define a geodesic & hence, arrive at the geodesic equation of motion for a free particle in space-time. How does it compare to Newtonian equations? (10)

UNIT II

3. a) From empirical facts, arrive at the Einstein field equations & hence, discuss their nature & properties. (10)

   b) Mention a few experimental validations of General Relativity. (8)

OR

4. a) Outline the steps in arriving at Schwarzschild's solution of field equations. (10)

   b) Write a note on gravitational red shift & its experimental proof. (8)

UNIT III

5. a) What is Big Bang theory? Mention a few experimental evidences in support of this theory. (9)

   b) Justify expansion of the Universe & give supporting evidence. (9)

OR

6. a) What is Cosmic Microwave Background Radiation? How was it discovered & what are its implications? (10)

   b) Write a note on alternate theories for origin of the Universe. (8)

PART-B

Answer any FOUR questions. **(4x4=16)**

7. a) What are inertial & non-inertial reference frames? Give examples.

   b) What are 4-vectors? How are they different from ordinary vectors? Give examples.

   c) Arrive at the energy-momentum relation.

   d) Define metric tensor & mention its properties & significance.

   e) What is Schwarzschild radius? What is its significance?

   f) Briefly discuss Olber's paradox.

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