PH 571.3 Reg No :

ST ALOYSIUS COLLEGE (AUTONOMOUS) MANGALURU
SEMESTER III - P.G. EXAMINATION - M.Sc Physics
NOVEMBER/DECEMBER - 2023
QUANTUM MECHANICS II

Time : 3 Hours Max. Marks : 70

PART A

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

Unit I

1 a. Describe a Linear Vector Space. Define basis and dimension of a linear vector space. Also define a Hilbert space. 6

b. State and prove the general uncertainty relation. Using the same show that $\Delta\hat{x}\Delta\hat{p}_x \geq \frac{\hbar}{2}$. 9

OR

2. a. Consider a vector space spanned by the orthogonal basis $|e_1\rangle$, $|e_2\rangle$ and $|e_3\rangle$. Let there be two vectors in the space $|\alpha\rangle = i|e_1\rangle - 2|e_2\rangle - i|e_3\rangle$, $|\beta\rangle = i|e_1\rangle + 2|e_2\rangle$. Find all nine matrix elements of the operator $\hat{A} = |\alpha\rangle\langle\beta|$. Is this operator Hermitian? 9

b. Find the norm of the vectors $|V\rangle = \begin{bmatrix} 2i \\ 3 \\ 1 \end{bmatrix}$ and $|W\rangle = \begin{bmatrix} 4i \\ 3 \\ -2 \end{bmatrix}$. Find their inner product and also verify Schwartz inequality for the vectors. 6

Unit II

3. a. For a particle like electron, arrive at the matrices $\hat{\sigma}_x$, $\hat{\sigma}_y$ and $\hat{\sigma}_z$. Outline their properties. 9

b. Explain dynamical postulate. What is the dynamical postulate for Schrödinger picture. Write the equation of motion for Schrödinger picture. 6

OR

4. a. Find the Clebsch Gordan coefficients for the addition of spin of two electrons. 9

b. For the ladder operators $\hat{J}_+$ and $\hat{J}_-$, show that $\hat{J}_+|jm\rangle = \sqrt{(j-m)(j+m+1)}|jm+1\rangle$ and $\hat{J}_-|jm\rangle = \sqrt{(j+m)(j-m+1)}|jm-1\rangle$. 6

5. a. Prove that first order correction in energy for a non degenerate system is the expectation value of the perturbation in the unperturbed state. 6

b. Show that there will be splitting of spectral energies when external magnetic field is applied on atoms. Explain usiing perturbation theory. 9

OR

6. a. What are turning points? What is classically forbidden region? How does WKB approximation give a solution to the case of transmission probability. 6

b. Use variational method to arrive at the ground state energy for the bound state of hydrogen molecule ion. 9

Contd...2

Unit IV

7. a. Arrive at the continuity equation from the Dirac's equation. Write Dirac's Hamiltonian in covariant notation. 6

   b. Solve the Dirac's equation for a free particle at rest and for a free particle at motion. 9

OR

8. a. What are $\vec{\alpha}$ and β in Dirac's theory. What are their properties? 9

   b. What are qubits? Explain how they are different from the bits used in classical computers. Also explain the difference between classical and quantum computers. 6

PART - B

Answer any TWO questions. **(2x5=10)**

9. a. Show that operators that commute have simultaneous set of eigen vectors.

   b. Show that $\hat{a}^\dagger|\psi_n\rangle = \sqrt{n+1}|\psi_{n+1}\rangle$ and $\hat{a}|\psi_n\rangle = \sqrt{n}|\psi_{n-1}\rangle$ where $\hat{a}^\dagger$ and $\hat{a}$ are the raising and lowering operators respectively.

   c. Explain the concept of absorption, stimulated emission and spontaneous emission as an application of time dependent perturbation theory.

   d. Show that the Klein Gordon equation does not satisfy probability interpretation.

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St Aloysius College (Autonomous)

Mangaluru

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

November/December - 2023

CONDENSED MATTER PHYSICS II

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

PART - A

Answer all questions choosing one from each unit. **(15x4=60)**

UNIT -I

1. a) What is a Frenkel defect? Obtain an expression for its equilibrium number of such defects in a monoatomic crystal. **(9)**

b) Explain the following terms, Line defect, Dislocation and Burger's vector. **(6)**

OR

2. a) Discuss in detail Landau-Devonshire theory of first order phase transitions in ferroelectric crystals. **(9)**

b) Define the following
1. Thermoluminescence 2. Electro luminescence 3.Bioluminescence **(6)**

UNIT -II

3. a) Discuss hard and soft magnetic materials. Also mention two important applications of each. **(6)**

b) How do you differentiate diamagnetic and paramagnetic materials? Explain with the relevant theory. **(9)**

OR

4. a) Explain the Molecular Field Theory of ferrimagnetism. **(9)**

b) Briefly discuss relevant theory of paramagnetism. **(6)**

UNIT -III

5. a) What is Fourier transform? With the block diagram explain the working of a FTNMR spectrometer. **(8)**

b) Explain the influence of nuclear motion on NMR Spectra. **(7)**

OR

6. a) How MRI is used for imaging? Elaborate. **(6)**

b) What is chemical shift and how it is measured? Find how many signals are obtained when the following samples are used?
1) CH_3OH 2) CH_3CH_2OH. Find their relative peak areas. **(9)**

UNIT -IV

7. a) Write a note on: **(9)**
1. Electronic polarization 2. ionic polarization 3. Dielectric strength.

b) Write a note on Elastic compliance and stiffness constant. **(6)**

OR

8. a) Obtain Lyddane-Sachs Teller relation. **(9)**

b) Write a note on local field. **(6)**

PART - B

Answer any TWO questions: **(2x5=10)**

9. a) Write a note on Whiskers.

b) Explain hysteresis loop of a ferromagnetic material using domain concept.

c) ESR spectrum of methyl radical occurs at 330 mT in a spectrometer operating at 9250 MHz. Calculate the 'g' value for the radical.

d) What are polar dielectrics?

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PS 573.3

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St Aloysius College (Autonomous)

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

November/December - 2023

THERMODYNAMICS AND STATISTICAL PHYSICS

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

PART - A

Answer all questions choosing one from each unit. **(15x4=60)**

UNIT -I

1. a) State and explain the principle of increase of entropy. Show that the entropy change of a system between two equilibrium states is independent of path. **(9)**

b) What is enthalpy? Explain its properties. **(6)**

OR

2. a) For a pure substance, obtain a relation for the change in temperature for a reversible adiabatic change of pressure using the second TdS equation. **(6)**

b) Obtain the heat capacity equation for pure substance and explain its importance. Write the heat capacity equation in terms of isentropic and isothermal compressibility. **(9)**

UNIT -II

3. a) Derive Maxwell-Boltzman distribution function. **(8)**

b) State and prove equipartition theorem. **(7)**

OR

4. a) State and prove Liouville's theorem. **(6)**

b) Obtain the expressions for thermodynamical quantities of a monoatomic ideal gas using classical partition function. **(9)**

UNIT -III

5. a) Determine the equation of motion for density matrix. Explain it. **(6)**

b) Discuss the thermodynamic properties of an ideal Bose gas. **(9)**

OR

6. a) Obtain the expression for Bose-Einstein distribution function. **(9)**

b) Write a note on Lambda transition. **(6)**

UNIT -IV

7. a) State and prove Winer-Khinchine theorem for time-dependent fluctuations. **(8)**

b) Derive Einstein relation for mobility. **(7)**

OR

8. a) What is the spectral density of mean square fluctuation? **(7)**

b) Obtain Fokker-Plank equation. **(8)**

PART - B

Answer any TWO questions: **(2x5=10)**

9. a) A gas obeys the equation P(V-b)=RT, where b and C_v are constants, show that 'u' is a function of T only.

b) Write a note on ensembles.

c) Under what conditions do BE and Fermi-Dirac distributions approach Maxwell-Boltzmann distribution? Represent graphically.

d) Write a note on Fluctuations.

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ST ALOYSIUS COLLEGE (AUTONOMOUS) MANGALURU
SEMESTER III - P.G. EXAMINATION - M.Sc. PHYSICS
NOVEMBER/DECEMBER - 2023
RELATIVITY AND COSMOLOGY

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

PART A

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

Unit I

1 a. Show that relativistically, mass is not a constant. Hence derive the mass energy equivalence and energy momentum relation. 9

b. Show that $ds^2 = \Delta x_\mu \Delta x^\mu$ is invariant. Hence explain the same. Also find the scalar product of momentum four vector with itself. 9

OR

2. a. Arrive at $E = mc^2$ and $E^2 = p^2c^2 + m_0^2c^4$ for a relativistic particle. 8

b. Derive Lorentz transformation equations from the postulates of special relativity. Show that for $v \ll c$ the equations reduce to Galillean transformation equations. 10

Unit II

3. a. Arrive at the Einstein field equation from first principles. 10

b. Arrive at the geodesic equation using principle of equivalence and hence define Christoffel symbols. 8

OR

4. a. From the Einstein field equation, arrive at the Schwarzschild solution. What is Schwarzschild radius? 10

b. What is principle of equivalence? Explain gravitational red shift using the principle. Explain how it was demonstrated by Rebka and Pound. 8

Unit III

5. a. How does Robertson Walker model explain the concept of red shift and expansion of universe. 8

b. Discuss various models of universe highlighting the explanation and proofs for the same. 10

OR

6. a. What is Hubble's law? How does it support the concept of expanding universe? 8

b. What were the conditions that were prevalent in the early universe and also explain the various concepts like leptogenesis, baryogenesis and nucleosynthesis. 10

Contd...2

PART - B

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

7. a. Explain the motivation behind the formulation of theory of special relativity.

   b. Explain the concepts spacetime, spacetime curvature.

   c. Explain steady state cosmology .

   d. What are four vectors? What is the temporal component of momentum and force four vectors.

   e. Explain gravitatioal red shift.

   f. What is the cosmological principle? What is the difference between Newtonian and Einstein's cosmology?

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