Exam Code: 229002 **Paper Code: 2214**
(20)

Programme: Master of Science (Physics) Semester-II

Course Title: Quantum Mechanics-I

Course Code: MPHL-2391

Time Allowed: 3 Hours **Max Marks: 80**

Note: Attempt five questions in all, selecting at least one question from each section. Fifth question may be attempted from any section. Each question carries 16 marks.

SECTION A

1. a) Define the complex linear vector space, dimensionality basis in such a space. Discuss the representation of a vector and an operator such vector space.
   b) How two orthonormal basis are related. (10,6)
2. Explain in details of the Stern Gerlach experiment and its implications. (16)

SECTION B

3. Explain the properties of Time evolution operator and obtain the Schrodinger equation for the time evolution operator. (16)
4. Solve the one dimensional quantum mechanical harmonic oscillator for its eigen values and eigen kets using operator/ladder method approach. (16)

SECTION C

5. Discuss the symmetries in Quantum mechanics and the conservation laws associated with symmetries. (16)
6. Explain the term time reversal as discrete symmetry and discuss time reversal for spin half system. (16)

SECTION D

7. If $\vec{J_1} = 1, \vec{J_2} = \frac{1}{2}, \vec{J} = \vec{J_1} + \vec{J_2}$ find the Clebsch-Gordan (C.G.) coefficients. (16)
8. (a) Find the matrix representation for the operators $\hat{J}, \hat{J}^2, \hat{J}_{\pm}, \hat{J}_x, \hat{J}_y$ for J=1.
   (b) Evaluate $J_+ \ |Jm\rangle$ state. (10,6)

Exam Code: 229002 **Paper Code: 2215**
(20)

Programme: Master of Science (Physics) Semester-II

Course Title: Electrodynamics-I

Course Code: MPHL-2392

Time Allowed: 3 Hours **Max Marks: 80**

Note: Attempt five questions, selecting at least one question from each section. Fifth question may be attempted from any section. Each question carries 16 marks. Use of Non-programmable calculator is allowed.

Section-A

1. a) Define the polarizability of a material and derive the Clausis-Mossotti relation connecting this quantity with the dielectric constant of the material.

(12)

b) In a rectangular box with dimensions (a,d,c) in the (x,y,Z) direction if all surfaces of the box are at zero potential except for surface z=c which is at potential ϕ (x,y), then find potential everywhere inside the box.

(4)

2. Apply the method of electrical images to discuss the conducting sphere in a uniform electric field by the method of images. (16)

Section-B

3. A) Discuss and derive the expressions for microscopic equations. (12)

   B) State and prove Blot-Savart's Law. (4)

4. A) Derive an expression for magnetic moment and torque on a magnetic dipole in an external field. (10)

   B) Find the magnetic field due to an infinite current carrying wire. (6)

Section-C

5. A) Establish the Maxwell equations for the electromagnetic field. (10)

   B) A long straight Cu wire having an inside radius of 1cm and outside radius of 2cm carries a current of 200 amperes. Compute the magnetic field at a distance of 0.5 cm and 4 cm from the axis. (6)

6. Prove that in free space the EM waves travel with speed of light. Also find the relation between electrostatic and magnetic energy density. (16)

Section-D

7. a) What is total internal reflection? Differentiate between linear, elliptical and circular polarization of an electromagnetic waves with an expression. (10)
   b) Derive an expression for group velocity. (6)
8. Explain Reflection and Transmission at oblique incidence. Derive Fresnel's equations for the case of polarization in plane of incidence and prove that R+T=1, Where R and T are reflection and transmission constants. (16)

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EVE:- 18/05/2024

Exam Code: 229002 **Paper Code: 2216**
(20)

Programme: Master of Science (Physics)
Semester-II

Course Title: Condensed Matter Physics-I

Course Code: MPHL-2393

Time Allowed: 3 Hours **Max Marks: 80**

Note: Attempt five questions in all by selecting atleast one question from each section. Fifth question may be attempted from any section. Each question carries 16 marks.

Section A

1. (a) Explain in detail Debye Model of specific heat. (8)
   (b) Write a note on Born cut off procedure (8)
2. (a)Explain in detail about Einstein model of specific heat for solids (8)
   (b) What are elastic stress and strain components of a crystal? Show how these constants are reduced for cubic crystals. (8)

Section B

3. Explain different types of defects in a crystal and hence derive an expression for concentration of Schottky and Frenkel defects (16)
4. Write a note on the following
   (a) Edge and screw dislocations
   (b) Burger vectors and V- centres
   (c) Grain Boundaries
   (d) Dislocations multiplications and slips (16)

Section C

5. Write a note on each
(a) Sommerfeld theory of conductivity
(b) Boltzmann transport equation (16)
6. Explain in detail
   (a) Ionic conductivity in pure alkali halides
   (b) Mathieson's rule and Wiedemann-Franz law. (16)

Section D

7. Derive an expression for local field and Claussius-Mossotti reelation (16)
8. Write a note on dipole theory of ferroelectricity and objections against dipole theory. (16)

Exam Code: 229002 **Paper Code: 2217**
(20)

Programme: Master of Science (Physics)
Semester-II

Course Title: Atomic and Molecular Spectroscopy

Course Code: MPHL-2394

Time Allowed: 3 Hours **Max Marks: 80**

Note: Attempt five questions in all, selecting at least one question from each section. The fifth question may be attempted from any section. Each question carries 16 marks.

Section A

1. a) Derive an expression for the magnetic dipole moment of hydrogen atom, and find the value of Bohr magneton. 4

   b) Evaluate the possible angles between $\vec{L}$ and $\vec{S}$ for a 'd' electron in one electron atom. 4

   c) How does the spin orbit interaction when combined with the relativity correction, explain the hydrogen fine structure. 8

2. a) Find an expression for triplet separation for two valence electrons in L—S coupling. 12

b) Find the values of l, s, j and L, S, J for an atom having electronic configuration $1s^2 2s^2 2p^1$. 4

Section B

3. a) Define Anomalous Zeeman Effect. Deduce the expression for the weak field interaction energy of a single valence electron system. 12

b) The ground state of chlorine is $^2P_{3/2}$. Find its magnetic moment and the number of sub-states into which the ground state will split in the presence of weak magnetic field. 4

4. a) Calculate the Zeeman pattern arising from the transition $^3D_3 - {}^3P_2$. Stark Broadening and Pressure Broadening 8

b) Discuss ~~Stark effect~~ and show that the first order stark effect for the ground state of Hydrogen is zero. 8

10

06

Section C

5. a) Discuss the salient features of the vibrational-rotational spectra of diatomic molecules. Explain its P and R branches. 8

b) What are the effects of isotopic substitutions on rotational levels? 4

c) The far infra-red spectrum of H^1Br^{79} consists of a series of lines spaced 17 cm^{-1} apart. Find the inter nuclear distance of H^1Br^{79}. (Given h = 6.63 X 10^{-34}Js, c = 3 X 10^8 m/s, NA = 6.023 X 10^{23} per mol) 4

6. a) Explain diatomic molecule as 'symmetric top'. Derive an expression for the rotational energy levels of a symmetric top molecule. Also explain the structure of their vibrational bands. 10

b) Write a short note on relative intensities of spectral lines. 3

c) What are the advantages of Fourier transform technique. 3

Section D

7. a) Discuss the origin of Raman Effect. Describe briefly the characteristics of vibrational and pure rotational Raman spectra. Give the necessary theory. 8

b) A substance shows a Raman line at 4567 Å when exciting line 4358 Å is used. Deduce the Positions of Stokes and anti-Stokes lines for the same substance when exciting line 4047 Å is Used. 6

c) What is Isotope effect? 2

8. a) Discuss rotational fine structure of electronic vibrational transitions. What is Fortrat diagram? 8

b) The bands of a system are given by the relation $v = 19221.2 + (1611.3\ u' - 40.7\ u'^{2}) - (1495.7\ u'' - 31.5\ u''^{2})\ cm^{-1}$, where $u = v + \frac{1}{2}$. Calculate the position of the 0,0 band. 8