Model Question Paper

PHYSICS: MP 2.1- Classical Electrodynamics and Optics

Time: 3 Hours Max. Marks: 80

***Instructions**: Questions from 1 to 8 carry 15 marks each. Question No. 9 carries 20 marks*

1. (a) Define electromagnetic potentials. Express Maxwell's equations in terms of the electromagnetic potentials. (10)

   (b) Show that the gauge transforms A' and ϕ' satisfy the Lorentz condition if and only if the gauge functions satisfy the wave equation. (5)

OR

2. (a) Obtain an expression for Lienard-Wiechert potentials of a moving point charge. (10)

   (b) Show that under Lorentz gauge $\vec{E}$ and $\vec{B}$ also satisfy the wave equation. (5)

3. (a) Deduce the Abraham-Lorentz formula for radiation reaction and explain its significance. (10)

   (b) Show that the expression of power radiated by an oscillating electric dipole leads to Larmor's formula. (5)

OR

4. (a) Derive expression for the power radiated by an oscillating electric dipole. (10)

   (b) Write a note on Pinch effect. (5)

5. (a) Deduce an expression for Poynting vector and discuss the importance of Poynting theorem. (10)

   (b) Starting from Fresnel's equations obtain Brewster's law. (5)

OR

6. (a) Obtain an expression for Clausius- Mossotti equation for electric fields in solids. (10)

   (b) Write a note on retardation plates. (5)

7. (a) Give the theory of multiple reflections from a plane parallel film. (10)

   (b) Note down the conditions for sustainable interference. (5)

OR

8. (a) Give a detailed description of diffraction at a circular aperture. (10)

   (b) Discuss Fresnel's diffraction in brief. (5)

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9. Answer **any four** of the following: (4X5=20)

(a) Obtain an expression for electric quadrupole moment.

(b) Show that when the velocity is zero, the Lienard-Wiechert potentials generate electrostatic potential.

(c) Obtain an expression for power radiated by an accelerated charge when its acceleration is collinear to its velocity (bremsstrahlung).

(d) Show that $\vec{E}\cdot\vec{B}$ and $E^2 - c^2B^2$ are Lorentz invariant.

(e) Write a note on crystal polarizers.

(f) Obtain an expression for Alfven velocity of a plasma wave.

(g) Discuss in brief about spatial coherence.

(h) Discuss about resolving power of Fabry-Perot etalon.

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PHYSICS: MP 2.2- Quantum mechanics-1

Time: 3 Hours Max. Marks: 80

***Instructions**: Questions from 1 to 8 carry 15 marks each. Question No. 9 carries 20 marks*

1. a) Give a complete description of the sequential Stern-Gerlach experiment and comment on its results. 10

   b) Distinguish between ket space and bra space. 5

OR

2. a) Discuss the properties of commutators used in Quantum mechanics with examples. 10

   b) Discuss the five commutation relations used in Quantum mechanics. 5

3. a) Discuss the time evolution operator and its properties in quantum mechanics. 10

   b) State and prove Ehrenfest's theorem for the position coordinate. 5

OR

4. a) Arrive at the energy eigen values and eigen function of the linear harmonic oscillator by differential equation approach. 10

   b) What is meant by central potential? 5

5. a) Obtain the expressions for eigen values of the operators L^2 and L_z. 10

   b) Prove that $[J^2, J_x] = 0$. 5

OR

6. a) Obtain the angular momentum states arise for a system with two angular momentum $j_1=1$ and $j_2=1/2$? Specify the states. 10

   b) What are Clebsch-Gordon co-efficients? Explain their significance. 5

7. a) Explain the first order and second order correction to the energy and wavefunction for the non-degenerate energy levels. 10

   b) Discuss the first order correction for the anharmonic oscillator. 5

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OR

8. a) Discuss the general theory of the variational principle. Show that this method can be used to obtain the zero point energy of one dimensional harmonic oscillator. 10

   b) Write a short note on adiabatic approximation. 5

9. **Answer any four of the following:**

   (4X5=20)

   a) The position and momentum of 1 keV electrons are measured simultaneously. If its position is located within 1Å, what is the percentage uncertainty in its momentum? Is this consistent with the binding energy of electron in atom?

   b) Find the de Broglie wavelength of (i) electron moving with velocity 1000 m/s (ii) an object of mass 100 gm moving with the same velocity.

   c) Suppose $\psi(x) = \frac{1}{\sqrt{a}}\ for - a \le x \le a$, Find the momentum space wave function $\phi(p)$.

   d) A particle of mass m is in a one dimensional box of $0 \le x \le a$ is in the ground state. Find $\langle x \rangle and \langle p \rangle$

   e) Calculate the zero point energy of a system consisting of a mass of 1g connected to a fixed point by a spring which is stretched by 1 cm by a force of 0.1 N the particle being constrained to move only along x-axis.

   f) Prove that the parity of spherical harmonics $Y_{l,m}(\theta,\varphi)$ is $(-1)^l$.

   g) Evaluate the brackets $[J_z , J_{\pm}]$.

   h) Write a note on Interaction picture of the time dependent potentials.

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PHYSICS: MP 2.3- Thermal Physics and Statistical Mechanics

Time: 3 Hours Max. Marks: 80

***Instructions**: Questions from 1 to 8 carry 15 marks each. Question No. 9 carries 20 marks*

1. (a) What are thermodynamic variables? Derive Maxwell's relations. (10)

   (b) What are thermodynamic potentials? Explain. (5)

OR

2. (a) Explain the Seebeck, Joule, Peltier and Thomson effects of a thermocouple. (10)

   (b) State and explain Fourier's law, Fick's law and Ohm's law. (5)

3 .(a) Define phase space of a molecule. State and explain the postulate of equal apriori probability. (10)

   (b) Write a note on equipartition of energy. (5)

OR

4 .(a) Obtain the Boltzmann distribution at equilibrium for an isolated system of N distinguishable particles capable of occupying non-degenerate energy levels using Lagrange's method of undetermined multipliers. (10)

   (b) Show that chemical potential is constant throughout a system in the equilibrium. (5)

5. (a) State and explain the basic postulates of quantum statistical mechanics. (10)

   (b) Express the average value of observable using density matrix formalism. (5)

OR

6 .(a) Deduce BE and FD distributions starting with a grand canonical ensemble. (10)

(b) Discuss about the Rotational partition function. (5)

7. (a) Describe the Landau levels in diamagnetism. (10)

(b) Discuss Boss-Einstein condensation. (5)

OR

8. (a) Apply Bose-Einstein statistics to the photon gas and derive Planck's formula. (10)

(b) Show that in the long wavelength limit the Planck‘s law leads to Rayleigh-Jean‘s law. (5)

9. Answer **any four** of the following (4X5=20)

(a) Find the work done in an isothermal expansion of an ideal gas when its volume increases by a factor of two.

(b) Obtain an expression for the internal energy of a Vander Waal's gas using Maxwell's relations.

(c) Justify the Stirling approximation for ln (*n!*) by the graphical method.

(d) Calculate the probability of head and tails in tossing a coin ten times.

(e) Given two particles and three cells: How do you arrange them in various states according to M-B, B-E and F-D statistics?

(f) The atomic weight of Lithium is 6.94 and its density 0.53 g/cm^3. Calculate Fermi energy and Fermi temperature.

(g) Find the mean energy of particles at absolute zero for a system obeying Fermi-Dirac statistics.

(h) A body at 1500 K emits maximum energy at a wavelength 1800 nm. If the sun emits maximum energy at a wavelength of 560 nm, what is the temperature of the sun?

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Model Question Paper

PHYSICS: MP 2.4- Spectroscopy

Time: 3 Hours Max. Marks: 80

***Instructions**: Questions from 1 to 8 carry 15 marks each. Question No. 9 carries 20 marks*

1. (a) Discuss the relativistic correction to the energy levels of the hydrogen atom. (10)

   (b) Explain Doppler effect on spectral lines. (5)

OR

2. (a) Explain the anomalous Zeeman effect and obtain an expression for the transition between the D_1, D_2 lines of Sodium and deduce Lande's g_j factor. (10)

   (b) Write a note on breadth of spectral lines. (5)

3 .(a) Mention the principles involved in NMR spectroscopy and explain with neat diagrams the basic requirements in NMR spectroscopy. (10)

   (b) Explain the factors influencing the chemical shift. (5)

OR

4 .(a) What is microwave spectroscopy? Distinguish between the infrared and microwave spectroscopy. (10)

   (b) Mention the applications of NMR in medicine. (5)

5. (a) Discuss with theory the vibrations of polyatomic molecules. (10)

   (b) Explain Born-Oppenheimer approximation. (5)

OR

6 .(a) Explain the working principle of FTIR spectrometer with block diagram. (10)

   (b) Write the characteristic properties of Raman lines. (5)

7. (a) Describe the spectro-fluorimeter and discuss its applications. (10)

   (b) Deduce inverse square law relating to brightness and luminosity. (5)

OR

8. (a) Explain the basic principle of mass spectroscopy and write its applications. (10)

   (b) Obtain the relation for stellar time scale. (5)

9. Answer **any four** of the following: (4X5=20)

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(a) The spin-orbit effects splits $3P \rightarrow 3S$ transition into two lines – 5890Å corresponding to $2P_{3/2} \rightarrow 2S_{1/2}$ and 5896 Å corresponding to $2P_{1/2} \rightarrow 2S_{1/2}$. Calculate the effective magnetic induction experienced by outer electron in Sodium atom as a result of its orbital motion.

(b) Evaluate the Lande's g-factor for the $^3P_1$ level in the 2p3s configuration of the carbon atom, and use the result to predict the splitting of the level when the atom is in an external magnetic field of 0.1 tesla.

(c) Calculate the chemical shift in ppm for a proton that has resonance at 126 Hz down field from TMS on spectrometer that operates at 60 MHz.

(d) For a given organic compound two kinds of protons exhibit signals at 50 and 200 Hz using a 60 MHz NMR spectrometer. What will be their relative positions using 90 MHz spectrometer? Also convert the position of signal at 50 Hz into δand τ units.

(e) A sample of a certain element is placed in a magnetic field of flux density 0.3 tesla. How far apart is the Zeeman component of a spectral line of wavelength 4500 Å? Given: e/m = 1.76 X 10^{11} C/kg, c = 3 X 10^8 ms^{-1}.

(f) Calculate the wave number of stretching vibration of a carbon-carbon double bond (Atomic force constant k = 10 X 10^5 dynes/cm).

(g) Calculate the energy in joules per quantum calories per mole and electron volts of photons of wavelength 3000 Å.

(h) Explain the structure of the sun.

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