

Subject: PHYSICS
Paper Code: MPH-C302
Paper Name: Atomic & Molecular Physics

Time: 3 hours

Max. Marks: 70

Note: Question paper is divided into two sections A & B. Attempt all sections as per instructions.

SECTION – A
(Short Answer Type Questions)

Note: Answer any five questions in about 150 words each. Each question carries **six** marks.

- Q.1. Show how the conception of spinning electron accounts for the doubling of levels in spectra of alkalis.
- Q.2. Define Lande's splitting factor and discuss its values for L-S and j-j coupling in a two-electron system.
- Q.3. The doublet splitting of the first excited state $P_{3/2}^2 \rightarrow P_{1/2}^2$ of Hydrogen atom is 0.365cm^{-1} . Calculate the corresponding separation for He^+ and Li^{++} respectively.
- Q.4. The moment of inertia of the CO molecule is $1.46 \times 10^{-46} \text{ kg-m}^2$. Calculate the energy in eV, and the angular velocity in the lowest rotational energy level of the CO molecule.
- Q.5. Describe the Frank-Condon principle in emission and absorption in brief. Also comment on the utility of this principle.
- Q.6. Calculate the anomalous Zeeman splitting of the $^2D_{3/2}$ and $^2D_{5/2}$ states in hydrogen in a field of 0.05 T.
- Q.7. The $J = 0 \rightarrow 1$ transition in HCl occurs at 23.78 cm^{-1} . Regarding the molecule to be a rigid rotator, calculate the wavelength of the transition $J = 14 \rightarrow 15$.
- Q.8. With exciting line 4358 \AA a sample gives Stokes line at 4458 \AA . Find the wavelength of the anti-Stokes line.
- Q.9. Explain the construction and operation of Ruby laser with a neat diagram in brief.

Q.10. Define the terms, spontaneous emission, and stimulated emission. What do you understand by the population inversion in a Laser?

SECTION – B
(Long Answer Type Questions)

Note: Answer any **four** questions in detail. Each question carries **ten** marks.

Q.1. How is the helium spectrum explained quantum mechanically? Show that the Helium in the ground state can exist only in singlet state.

Q.2. What are K, L and M series in X-ray spectra? What is their origin? Discuss the difference between emission and absorption spectra of X-ray. Compare this difference with that in the optical region.

Q.3. What do you mean by the term spin-orbit interaction? Calculate the expression for spin-orbit interaction for a single non-penetrating valance electron.

Q.4. Distinguish between normal and anomalous Zeeman effects. Also discuss the Zeeman pattern of the resonance (D_1 and D_2) lines of Sodium.

Q.5. Discuss why the occurrence of Raman spectrum depends on the polarizability of the molecule but is entirely independent of the presence of a permanent dipole moment.

Q.6. Discuss the theory of vibrational-rotational spectrum of a diatomic molecule in detail. The force constant of the bond in a CO molecule is 1870 N/m. Calculate the frequency of vibration of molecule and the spacing between its vibrational energy levels in eV. Given that the reduced mass of CO molecule is 1.14×10^{-26} kg.

Q.7. Discuss three level and four level lasers with suitable examples. Why two-level system is not appropriate for laser production? What is the importance of the metastable state?

Q.8. Write notes in detail on any two of the following: (i) Temporal and spatial coherence (ii) Helium-Neon Laser and (iii) GaAs Laser.