

Ex/SC/PHY/PG/CORE/TH/109/2024

MASTER OF SCIENCE EXAMINATION, 2024

(2nd Year, 1st Semester)

PHYSICS

PAPER : PG/CORE/TH/109

(Atomic & Molecular Physics)

Time : Two Hours

Full Marks : 40

Answer any four questions choosing **two** from Qs. Nos. 1 to 3 and the rest from Qs. Nos. 4 to 6.

1. (a) Using the quantum mechanical description of atom show that the ground state of hydrogen atom is spherically symmetric.
(b) Explain how the spin-orbit interaction leads to the splitting of energy levels of hydrogen atom.
(c) The effective spin-spin interaction between the electron spin $\vec{S}_e$ and the proton spin $\vec{S}_p$ in the ground state of the Hydrogen atom is given by $H' = b \vec{S}_p \cdot \vec{S}_e$. What will be splitting of energy levels due to this interaction?
3+4+3
2. (a) Explain the normal Zeeman effect. Considering the interaction of an atom with a strong magnetic field estimate the number of atomic spectral transitions between atomic levels $^1D_2 \rightarrow ^1P_1$.

PHY-327

[Turn Over]

(2)

- (b) Write down an expression for the transition probability for stimulated emission from one-electron atom.
- (c) What do you understand by symmetric and antisymmetric wave functions? Also explain *ortho* and *para* states for two-electron atom. 5+1+4
3. (a) Why does the linear Stark effect for a hydrogen atom in the ground state show no energy shift?
- (b) What do you understand by dipole approximation and how is it related to the spectral transition between different atomic energy levels? 4+6
4. (a) What is *Isotope effect*?
- (b) What is the role of Franck-Condon principle in connection with the intensity of vibrational electronic spectral lines?
- (c) What is polarizability ellipsoid?
- (d) In the infrared spectra of CO the fundamental and the first overtone transitions are observed at 2143.3 cm^{-1} and 4260.0 cm^{-1} respectively. Calculate the anharmonicity constant. 2+3+3+2
5. (a) Discuss the selection rule of anharmonic oscillator and its outcome with proper illustration.

(3)

- (b) The separation between consecutive rotational Raman lines in H_2 molecule is $4B$ whereas in O_2 molecule it is $8B$ —Justify.
- (c) The rotational and centrifugal distortion constants of HCl are 10.593 cm^{-1} and $5.3 \times 10^{-4} \text{ cm}^{-1}$ respectively. Obtain an estimate for vibrational frequency. Comment on the result. 4+3+3
6. (a) What is the consequence of neglecting Born-Oppenheimer approximation in studying the spectra of a vibrating rotator?
- (b) Both red and violet degraded bands are observed in electronic band systems while rotation-vibration spectra show bands degraded to red only— Explain.
- (c) Discuss the pumping mechanism of He-Ne laser with necessary energy level diagram. 3+4+3

★ ★ ★