

(4)

(OR)

8. (a) With the help of proper energy level diagram, explain how population inversion is achieved in He-Ne laser.
- (b) How do you obtain polarized output from a He-Ne laser?
- (c) Explain in detail why 'laser spiking' takes place in a Ruby laser.
- (d) Why is Ruby laser still considered an important practical laser? 3+2+3+2 (CO4/CO5)

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Ex/SC/PHY/PG/CORE/TH/109/2025

M. SC. EXAMINATION, 2025

[2nd Year 1st Semester (DAY)]

PHYSICS

PAPER : SC/PHY/PG/CORE/TH/109

(Atomic and Molecular Physics)

Time : Two Hours

Full Marks : 40

Answer ALL questions

1. (a) Considering the relativistic quantum mechanical corrections, derive an expression for the relativistic term shift for the fine structure of hydrogen like atom.
- (b) How do you calculate the energy degeneracy of hydrogen atom?
- (c) What are main reasons for hyperfine splitting of hydrogenic atoms? 5+2+3 (CO1)

(OR)

2. (a) Why did Dirac theory of atomic structure fail to explain the H_{∞} transitions in hydrogen atom? How does Lamb-Rutherford experiment resolve the experimentally observed H_{∞} transitions?

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- (b) Calculate the amount of energy splitting of $2p$ state of hydrogen atom due to spin-orbit interaction.

(2+5)+3 (CO1)

3. (a) What is the significance of electric dipole matrix?
- (b) Write down an expression for the transition rate for the absorption of radiation by one electron atom. What do you understand by absorption cross-section?
- (c) Derive an expression for the shift of energy level in the first excited state of one electron atom while interacting with a strong electric field. 2+(1+2)+5 (CO2/CO3)

(OR)

4. (a) Calculate the minimum magnetic field required to observe Zeeman splitting in a spectral line of wavelength of 600 nm using a spectrometer having a resolution of 0.02 nm.
- (b) What do you understand by exchange degeneracy?
- (c) Explain how the Pauli exclusion principle is connected with the symmetry of the wave function describing the two electron atoms. 3+2+5 (CO2/CO3)
5. (a) What is the standard procedure to obtain the expression for the energy states of asymmetric top molecules?
- (b) Discuss the consequences of breakdown of the Born-Oppenheimer approximation.

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[Continued]

(3)

- (c) Anti-Stokes lines are less intense than Stokes lines — Explain.
- (d) The $J = 1 \leftarrow 0$ transition in HCl occurs at 20.68 cm^{-1} . Considering the molecule to be a rigid rotator, calculate the wavelength of the rotational transition $J = 12 \leftarrow 11$. 3+3+2+2 (CO4)

(OR)

6. (a) What is spectral transition probability?
- (b) Obtain an expression for the intensity of purely rotational spectral lines.
- (c) What are sequence and progression in electronic spectroscopy of molecules?
- (d) Obtain an expression for Raman shift of rotating molecules following classical theory. 2+2+3+3 (CO4)
7. (a) How does the knowledge of centrifugal distortion constant D help us in infrared spectroscopy?
- (b) What is hot band? How can you identify it?
- (c) Discuss Fortrat parabola with necessary diagram.
- (d) The position of the lines in the fundamental band $\nu = 0 \rightarrow \nu = 1$ of HCl is $\bar{\nu} (\text{cm}^{-1}) = 2886.0 + 20.577m - 0.3034m^2$, $m = \pm 1, \pm 2, \dots$ Calculate B_0 and B_1 . 2+2½+3+2½ (CO4/CO5)

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[Turn Over]