(OR)

8. *(a)* Consider a collection of atoms and let a near monochromatic radiation of energy density u at frequency ω pass through the medium. In such a condition, obtain the differential equation that governs the rate of change of intensity of the radiation as it passes through the medium bounded by two planes each of area A situated at x and $x + dx$, x being the direction of propagation of the radiation. Comment from the expression about the factor that decides the gain or attenuation in intensity of the beam as it leaves the medium.

(b) For a two-level system comprising of energy levels E_1 and E_2 with N_1 and N_2 atoms per unit volume respectively, estimate the rate at which the populations of N_1 and N_2 atoms per unit volume change in presence of external pumping, stimulated and spontaneous transitions. What is the ratio of $N_2 : N_1$ in steady state condition? If the intensity of the incident radiation (I) is far less than the saturation intensity (I_s), show that the density of population difference between energy levels E_1 and E_2 is almost independent of the intensity of the incident radiation (I). 3+2+2+1+2=10

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BACHELOR OF SCIENCE EXAMINATION, 2024

(3rd Year, 1st Semester)

PHYSICS

PAPER : DSE/TH/02/A2

(Atomic, Molecular & Laser Physics)

Time : *Two Hours* *Full Marks* : 40

*Answer **all** questions.*

The figures in the margin indicate full marks.

1. *(a)* Define Larmor frequency. What important role does it play in atomic physics?

(b) Write down the Pauli Exclusion Principle and discuss its implications.

(c) What is magnetic moment? Derive an expression for Bohr magneton. Comment on the role/use of Bohr magneton. 3+3+4=10

(OR)

2. What is the basic idea behind Born-Oppenheimer (BO) approximation? Write the general Hamiltonian for a molecule. How are the Hamiltonian of the electrons and the nuclei of a molecule represented separately following BO approximation? Write the corresponding Schrödinger equations in terms of electronic and nuclear wave functions. Hence, show how the total molecular wave function is estimated from the electronic and nuclear wave functions. 2+2+3+2+1=10

3. *(a)* Discuss about the outcome of the Stern-Gerlach experiment in connection with the concept of space quantization. Comment on the sample gas used in this experiment.

(b) Calculate the total number of electronic energy levels for a given principle quantum number n.

(c) Express **L.S** in terms of J, L and S and hence find its possible values for $L = 1$ and $S = ½$. 4+3+3=10

(OR)

4. When do *LS*-coupling and *jj*-coupling occur? What is Zeeman effect? Distinguish between normal and anomalous Zeeman effect. Based on 'Vector Atom Model', give an account of anomalous Zeeman effect. 2+1+2+5=10

5. *(a)* For a rigid diatomic molecule, show the energy dispositions of various rotational energy levels. Draw the corresponding spectral lines. Discuss about the relative intensities of these spectral lines.

(b) Microwave spectra of H^1Br^{79} show series of rotational transitions spaced 17 cm^{-1} apart. Estimate the internuclear distance of the molecule. (Assume the molecule to behave as a rigid rotator) 2+2+3+3=10

(OR)

6. *(a)* Explain the doublet structure of sodium D-lines.

(b) What are the features of Morse potential?

(c) Distinguish between the characteristics of vibrational spectra of a diatomic molecule considering it as harmonic and anharmonic oscillator. 4+3+3=10

7. The active centers of a material containing special system of energy levels E_1, E_2 and E_3, ($E_3 > E_2 > E_1$) are somehow excited to the highest energy level E_3. Explain the fate of the active centres along the decay path towards the lowest energy level E_1. To achieve the lasing action, what role does the energy level E_2 play? Explain the concept of spontaneous and stimulated emission of photons with reference to the above energy levels. What is an optical resonator? How is high degree of coherency achieved in laser? 3+1+3+1+2=10