6. (a) What is Raman effect? Describe the pure rotational Raman spectrum of a diatomic molecule and obtain expression for frequency shift of rotational Raman lines as per quantum theory of Raman effect with suitable transition diagram. (5)

(b) In the rotational Raman spectrum of HCl the displacement from the exciting line are represented by $\Delta\nu = \pm (62.4 + 41.6\ J)\ cm^{-1}$. Calculate the moment of inertia of the HCl molecule. ($h = 6.62\times10^{-27}$ erg-sec, $c = 3.0\times10^{10}$ cm/sec). (5)

(c) The exciting line in an experiment is 4358 Å, a samples gives stokes line at 4458 Å. Deduce the wavelength of the anti-Stokes line. (5)

7. (a) Explain absorption and spontaneous and stimulated emission of radiation. Obtain a relation between transition probabilities for the two emissions. (5)

(b) Describe a He-Ne laser. How is population inversion achieved in this type of laser? (5)

(c) Write short note on any one

(i) Mosley's Law.

(ii) Stark effect. (5)

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December 2023

B.Sc. (Physics) - V SEMESTER

Atomic and Molecular Physics

(DECP–501A)

Time : 3 Hours] [Max. Marks : 75

Instructions :

1. *It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.*
2. *Answer any four questions from Part-B in detail.*
3. *Different sub-parts of a question are to be attempted adjacent to each other.*
4. *Use of scientific calculator is allowed.*

PART–A

1. (a) Calculate the two possible orientations of spin vector S with respect to a magnetic field along the z-axis. (1.5)

(b) Write the value of l, s and j for one electron term $^2D_{3/2}$. (1.5)

(c) Define spin-orbit interaction. (1.5)

(d) What is the difference between bosons and fermions? (1.5)

(e) Using j-j coupling, calculate the possible value of J for the configuration 'sf'. (1.5)

(f) What is the Paschen-back effect? (1.5)

(g) Calculate the total magnetic moment of the ground state of the term $^2P_{3/2}$. (1.5)

(h) Calculate the value of rotational constant if the transition J = 0 to 1 in HCl molecule occurs at 20.68 cm^{-1}? (1.5)

(i) What do you mean by X-ray line spectra? (1.5)

(j) What do you understand the term population inversion? (1.5)

PART–B

2. (a) Discuss about the Thomson method to determine e/m value of the electron with suitable diagram. (5)

(b) Drive an expression for the magnetic dipole moment of hydrogen atom and find the value of Bohr magneton. (5)

(c) Describe the Stern-Gerlach experiment and discuss how it explained space quantization and electron spin. (5)

3. (a) What do you mean by identical particles? State, explain and deduce Pauli's exclusion principle. (5)

(b) Deduce terms of '3p4d' configuration system using L-S coupling and after that arrange these terms in order of the increasing energy. (5)

(c) Determine the terms for the state obeying L-S coupling the component of a normal triplet state have separation 30 cm^{-1} and 60 cm^{-1} between adjacent components. (5)

4. (a) Distinguish between normal and anomalous Zeeman effects. Drive an expression for the magnetic interaction energy (Zeeman energy splitting) for a single valence electron for anomalous Zeeman effects. (10)

(b) Calculate the Zeeman pattern for the spectral line arising from $^3D_3$-$^3P_2$ transition in one electron atom. (5)

5. (a) The moment of inertia of the CO molecule is 1.46×10^{-46} kg-m^2. Calculate the energy (in eV) and the angular velocity in the lowest rotational energy level of the CO molecule. ($h = 6.63\times10^{-34}$ joule-sec) (5)

(b) What are P and R branches in the vibrational-rotational spectra? Explain their origin with suitable diagram. (5)

(c) Find the energy (eV) difference between the lowest and the first vibrational level of HCl, when the force constant of a vibrating HCl molecule is 4800 N/m.

Given : $h = 6.63\times10^{-34}$ Js, $N_A = 6.023\times10^{23}$ mol^{-1} (5)