6. (a) Describe the pure rotational Raman spectrum of a diatomic molecule with suitable transition diagram. (5)

(b) In the vibrational Raman spectrum of HF, there are adjacent Raman lines of wavelength 2670 Å and 3430 Å. What is the fundamental vibrational frequency of the molecules? ($c = 3.0 \times 10^{10}$ cm/sec) (5)

(c) The force constant of vibrating CO molecule is about 1870 newton/metre. Calculate the frequency of vibration of the molecule and the spacing between its vibrational energy levels in eV. Given : $h = 6.63 \times 10^{-34}$ Js, 1 eV = 1.6×10^{-19} J, $\mu_{CO} = 1.14 \times 10^{-26}$ kg. (5)

7. (a) Describe the principle features of the electronic band spectrum of a diatomic molecule. (5)

(b) What is Franck-Condon Principle? Explain the intensity distribution in Absorption Bands from Franck-Condon Principle. (5)

(c) Write short notes on any *one* :
(i) Intensity alternation in Raman Spectra. (5)
(ii) Stark effect.

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December 2023

M.Sc. (Physics) III SEMESTER

Atomic and Molecular Physics (MPH-301)

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) What do you understand the term spin-orpit interaction? (1.5)

(b) Calculate the possible orientations of the orbital angular momentum vector L corresponding to $\ell = 2$ with respect to a magnetic field along the z-axis. (1.5)

(c) Find the possible values of J for 'sd' configuration using j-j coupling. (1.5)

(d) What is the difference between normal and anomalous Zeeman effect? (1.5)

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(e) Calculate the magnetic moment of the ground state of the term $^3P_2$. Also find the how many sub-states the ground state will split in a weak as well as strong magnetic field. (1.5)

(f) What is the Paschen-back effect and how is it different from Zeeman effect? (1.5)

(g) The nuclear spin of bismuth atom is 9/2. Find the allowed values of hyperfine structure quantum number of the term $^2D_{5/2}$. (1.5)

(h) What is the difference between continuous and characteristics X-Rays? (1.5)

(i) What do you mean by Raman effect? (1.5)

(j) Define dissociation energy in molecular spectra. (1.5)

PART–B

2. (a) Drive an expression for the Larmor precessional frequency. What is its importance? (5)

(b) Briefly discuss about the Stern-Garlach experiment and why this experiment is used only for atoms not ions. (5)

(c) Determine the spectral terms configuration of carbon atom for the term '2p3p' using L-S coupling and then arrange these terms in order of the increasing energy. (5)

3. (a) Drive an expression for the magnetic interaction energy for a single valence electron for anomalous Zeeman effect. (5)

(b) Calculate the Zeeman pattern for the spectral line arising from $^2D_{5/2} - ^2P_{3/2}$ transition in one electron atom. (5)

(c) In an atom obeying L-S coupling, the component of a normal triplet state have separation 20 cm^{-1} and 40 cm^{-1} between adjacent components. There is a higher state for the separations are 22 cm^{-1} and 33 cm^{-1}. Determine the terms for the two states. (5)

4. (a) What is Moseley's law? Describe and explain the fine structure observations in X-ray emission spectrum. (8)

(b) Discuss the salient features of pure rotation spectra and write down the expression for the energy of a rigid-rotator model of a diatomic molecule and predict the pure rotational spectrum of the molecule. (7)

5. (a) In the far infra-red spectrum of HCl molecule, the first line falls at 20.68 cm^{-1}. Calculate the moment of inertia and bond length of the molecule. Given: h = 6.62×10^{-34} Js, c = 3.0×10^8 m/sec, and $N_A = 6.023 \times 10^{23}$ mol^{-1}. (5)

(b) Discuss the fine structure of infra-red bands of diatomic molecules with suitable diagrams. Why are they all degraded towards red (longer wavelength side)? (10)