Roll No. .....

(05/24)

15413

M.Sc. EXAMINATION

(For Batch 2021 & Onwards)

(Second Semester)

PHYSICS

MSc/Phy/2/CC8

Atomic and Molecular Physics

Time : Three Hours *Maximum Marks : 70*

Note : Attempt *Five* questions in all, selecting *one* question from each Unit. Q. No. **1** is compulsory.

1. (a) What is space quantization ? 2

   (b) What are normal and inverted multiplets ? Why is it impossible for 2 $^2D_{3/2}$ state to exist ? 2

(c) Explain, why are the absorption spectra continuous with edges ? 2

(d) How does the increase in the vibrational energy of a molecule affect its moment of inertia ? 2

(e) A $^3\Delta$ state has components of slightly different energies. What quantum number is used to indicate these components and how are its allowed values deduced ? Give the correct designation of the component. 2

Unit I

2. (a) Explain the effect of spin-orbit interaction on the structure of a spectral line. Discuss the fine structure of Hα line. 5

(b) In a Stern-Gerlach experiment, a beam of hydrogen atom moves a distance of 20 cm in a homogeneous magnetic field of gradient 2×10^2 T/m. If the velocity of hydrogen atom is 2×10^5 m/s, calculate the maximum separation between the two traces on the collector plates. 4

(c) What are symmetric and antisymmetric wave functions ? State and prove Pauli's exclusion principle on the basis of these functions. 6

3. (a) Derive an expression for the maximum number of electrons that can go into a shell with its principle quantum n. 4

(b) Explain Stern-Garlach experiment. Discuss, how it explained space quantization and electron spin ? 5

(c) Derive an expression for spin orbit interaction energy. How does the spin orbit interaction when combined with the relativity correction explain the hydrogen fine structure ? 6

Unit II

4. (a) What is normal and anomalous Zeeman effect ? Discuss the Zeeman pattern of the resonance line of sodium. 6

(b) Using L-S coupling scheme, find the spectral term for ground state electronic configuration of oxygen atom. Also find the ground energy state. 6

(c) The Lithium atom has one 2 *s* electron outside a filled inner shell. Its ground state is $^2S_{1/2}$. What are the term symbols of the other allowed states, if any ? Why would you think it is ground state ? 3

5. (a) Explain the spectra of He atom with appropriate energy level diagram. Explain the occurrence of ortho and para states of He atom. 5

(b) What is Stark effect ? Show that first order Stark effect for the ground state of hydrogen is zero. 6

(c) Explain Moseley's law in X-rays. 4

Unit III

6. (a) What is centrifugal distortion ? Explain the effect of centrifugal distortion on moment of inertia, energy levels and spectra of a diatomic molecule. 6

(b) Write down the expression of energy for anharmonic oscillator model of a diatomic molecule. Show how from the infrared absorption bands, the vibrational constants and anharominicity constant of the molecule can be determined. 5

(c) Calculate in units of B, the frequency of the rotational lines of H_2 resulting from the transition to the excited state characterized by the quantum number J = 4. If the bond length of H_2 is 0.007417 nm, determine the spacing between the lines. The mass of hydrogen is 1.673×10^{-27} kg. 4

7. (a) Find the number of vibrational energy levels below the dissociation limit and also the dissociation energy in eV of carbon molecule if the value of equilibrium frequency and anharmonicity constant in an excited electronic state are 1788.2 cm^{-1} and 0.000919 cm^{-1}. 5

(b) How would you obtain approximately the inter-nuclear distance from the separation of the band maxima of the P and R branch of an unresolved band, if T is known ? 3

(c) Discuss the fine structure of infra-red bands of diatomic molecule. Why are they all degraded toward longer wavelength side. 7

Unit IV

8. (a) State Franck-Condon principle and give its wave mechanical interpretation. How does it helps in understanding the intensity distribution in the vibrational coarse structure of electronic transition of diatomic molecule ? 8

(b) Discuss the vibrational coarse structure of electronic transition. What is the importance of absorption over emission spectra ? 7

(a) Explain the rotational fine structure of electronic vibrational transition. What is fortrat diagram ? 7

(b) Explain, how the vibrational structure of a band system in the electronic spectrum of a diatomic molecule is modified by the presence of an isotope. 4

(c) Explain the scheme for classifying the electronic states of a diatomic molecule. 4