

Roll No.

(05/25)

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. Write short notes on the following : $5 \times 2 = 10$

(i) Why is $^4D_{1/2}$ term not split in a magnetic field ? Explain.

(ii) What led to the assignment of quantum number $1/2$ to the spin of an electron ?

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- (iii) What are the consequences of nuclear spin on IR spectra of diatomic molecules ?
- (iv) The force constant of HCl molecule is 480N/m . Find the energy required to increase the nuclear separation by 1\AA .
- (v) What is the origin of formation of Q-branch in the fine structure of electronic spectra ?

Unit I

- 2. Discuss the quantum states of an electron in Hydrogen like atoms and reduce the required wave function. Also, discuss the physical significance of quantum numbers. 15
- 3. (a) Explain the Stern-Garlach experiment. Discuss how it explained space quantization and electron spin. 12
- (b) Find the two possible orientations of spin vector S with respect to magnetic field B . 3

Unit II

4. Describe L-S and $j-j$ coupling scheme. Derive spectral terms for calcium element ($Z = 20$) arising from the configurations :
- (a) two equivalent s electrons
 - (b) one s and p electrons. 15
5. (a) What is Paschen Back Effect ? Explain the Zeeman pattern of resonance (D_1 , D_2) lines of sodium. 10
- (b) The Zeeman pattern of a line consists of six equidistant components. The upper state term is known to be $^2P_{3/2}$. Determine the lower state term and draw a schematic diagram showing the transitions. 5

Unit III

6. Discuss the vibrating rotator model of the diatomic molecules. Why in spectrum, the bands are degraded towards red ? 15

7. Describe the origin of formation of stoke and anti-stoke lines with the help of well-known quantum theory. Point out the similarity and difference in infra-red and Raman spectra. 15

Unit IV

8. (a) "The molecular wave function can be written as a product of electronic and nuclear wave functions". Elucidate this statement and discuss it with the help of the Born-Oppenheimer approximation. 10
- (b) The fine structure lines of the CN band is, $\nu = 25798 + 3.85m + 0.068 m^2 \text{ cm}^{-1}$. Calculate the separation between the null line and the band head. Also, state the direction of degradation of the band. 5
9. (a) State Franck-Condon Principle. Discuss its use in explaining the intensity distribution in absorption taking the examples of O_2 , CO , and I_2 molecules. 10

- (b) How Condon parabola is formed and what information could be reduced from the Condon parabola ? Also, differentiate between the Fortrat parabola and the Condon parabola.

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