

(c) For a rigid rotor, calculate the frequency (in cm^{-1}) of the transition from $J = 1 \rightarrow J = 2$ for a molecule with $B = 2.0 \text{ cm}^{-1}$. (10,5,3)

6. (a) Derive the expression for rotational energy states for a diatomic molecule and state corresponding selection rules for rotational transitions.

(b) Define Larmor frequency. The angular momentum vector L never points in the Z -direction. Why?

(c) A diatomic molecule does not rotate in the ground state. Why? (10,5,3)

Given:

Planck's Constant: $6.63 \times 10^{-34} \text{ Joule sec}$

Electronic charge: $1.6 \times 10^{-19} \text{ C}$

Rydberg's Constant: $1.097 \times 10^7 \text{ m}^{-1}$

Bohr magneton: $9.274 \times 10^{-24} \text{ J/T}$

Mass of H-atom: $1.674 \times 10^{-27} \text{ Kg}$

Mass of Chlorine atom: $5.81 \times 10^{-26} \text{ Kg}$

Mass of electron: $9.1 \times 10^{-31} \text{ Kg}$

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4825

J

Unique Paper Code : 2224002011

Name of the Paper : Atomic and Molecular Physics (GE Paper)

Name of the Course : **B.Sc. Hons. - (Physics)_NEP: UGCF-2022**

Semester : IV / VI

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all. **All** questions carry equal marks.
3. Question No. 1 is compulsory.
4. Non-programmable calculator is allowed.

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1. Attempt any **six** of the following : (6×3)

- (a) Difference between stroke's and anti-stroke's lines.
- (b) Explain the reason of non-existence of He_2 molecule.
- (c) Determine the possible values of the total angular momentum of an f-electron.
- (d) What is Lamb-shift?
- (e) Spin-orbit coupling splits all the states except s-state. Why are s-states exception to this rule?
- (f) Explain why a molecule having net dipole moment zero does not show rotational spectra.
- (g) What is Born-Oppenheimer approximation?

2. (a) Describe and explain L-S and J-J coupling with the help of vector diagram. Give the selection rules for L, S and J.

(b) In a rigid rotator of mass M, if the energy of the first excited state is 1 meV, Find the fourth excited state energy in meV.

(c) What are para and ortho helium? (10,5,3)

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3. (a) Consider the hydrogen-deuterium molecule HD. If the mean distance between two atoms is 0.08 nm and the rest mass of the hydrogen atom is 938 MeV/c², find the energy difference between the two lowest rotational states?

(b) Deduce an expression for the Lande's g-factor of an atom.

(c) Given the bond length of HCl is 127.5 pm and the reduced mass is $\mu = 1.626 \times 10^{-27}$ kg, calculate the rotational constant B in cm⁻¹. (10,5,3)

4. (a) Explain the difference between singlet and triplet states. Also discuss the physical significance of these states.

(b) What is Raman effect? What is the importance of Raman effect?

(c) Explain the term exchange degeneracy. (10,5,3)

5. (a) Describe and explain spin-orbit coupling. What happens when a magnetic-field is applied?

(b) Why do molecules show band spectra than line spectra.

P.T.O.