(b) Discuss the fine structure of 3d → 2p line of Balmer series of hydrogen spectrum.

(c) Why is the sodium D line is a doublet? (10,5,3)

6. (a) What is meant by fine structure of hydrogen spectra? How is it explained on the basis of spin-orbit interaction?

(b) All diatomic molecules do not exhibit rotational spectra. Why?

(c) A hydrogen atom is placed in a magnetic field of 3 T. Compute the energy difference between $m_l = -1$ and $m_l = +1$ components in 2p-state (10,5,3)

Given:

Planck's Constant: 6.63×10^{-34} Joule sec

Electronic charge: 1.6×10^{-19} C

Rydberg's Constant: 1.097×10^{7} m^{-1}

Bohr magneton: 9.274×10^{-24} J/T

Mass of H-atom: 1.674×10^{-27} Kg

Mass of Chlorine atom: 5.81×10^{-26} Kg

Mass of Calcium atom: 6.65×10^{-26} Kg

Mass of electron: 9.1×10^{-31} Kg

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5136 **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.
3. **All** questions carry equal marks.
4. Question No. **1** is compulsory.
5. Non-programmable calculator is allowed.

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

(a) What do you mean by symmetric and anti-symmetric wavefunctions?

(b) 'No two electrons can have the same quantum state'. Explain.

(c) Explain whether the level $^4D_{1/2}$ can exhibit Zeeman splitting.

(d) What is Bohr-magneton? What is its physical significance?

(e) Explain potential energy curve for a diatomic molecule with the help of diagram.

(f) Discuss Frank Condon Principle.

(g) The moment of inertia of a rigid diatomic molecule A is 6 times that of another rigid diatomic molecule B. If the rotational energies of the two molecules are equal, find the corresponding values of the rotational quantum numbers J_A and J_B.

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

(b) A calcium atom emitting a spectral line of wavelength 4200 Å is brought into a magnetic field of 5×10^4 Gauss. Find the wavelength of the component lines observed in the spectrum.

(c) What is Pauli's exclusion principle? (10,5,3)

3. (a) Discuss the potential energy curve for diatomic molecule by considering harmonic and anharmonic potential.

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

(c) The ground state of chlorine is $^2P_{3/2}$. Find the magnetic moment in the units of Bohr Magneton. (10,5,3)

4. (a) Explain the principles nuclear magnetic resonance (NMR) and electron spin resonance (ESR). Why are the microwave source and techniques needed for the observation of ESR?

(b) The force constant for a vibrating HCl molecule is 470 N/m. Calculate the wavenumber corresponding to the vibrating HCl molecule. In which region of the electromagnetic spectra do the vibrational spectra lie?

(c) For l = 3, calculate the possible angles that L makes with the Z-axis. (10,5,3)

5. (a) What are non-equivalent and equivalent electrons? Is it possible to have two equivalent electrons in the same atom? Explain your answer.