This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **854**

Unique Paper Code : **222503** **G**

Name of the Paper : **Atomic and Molecular Physics (PHHT-517)**

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all.

Question No. **1** is compulsory.

1. Answer any *five* of the following : 5×3=15

   (*a*) Two non-relativistic electrons move in a circle under the influence of uniform magnetic field B. If the ratio of their orbital radii is 1/3, then calculate the ratio of their speeds.

   (*b*) Find the precessional frequency of an electron orbit when placed in a magnetic field of 6 T.

   (*c*) Explain the significance of Critical Potentials.

   (*d*) What is Paschen-Back effect ?

P.T.O.

(*e*) A substance shows a Raman line at 4567 Å when an exciting line of 4358 Å is used. Find the position of Stokes and anti-Stokes line for the same substance when an exciting line of 4047 Å is used.

(*f*) Estimate the value of the wavelength of K_α line of silver (Z = 47).

(*g*) What is meant by space quantization ?

2. (*a*) Derive the expression of radius and velocity of an electron in the *n*th Bohr orbit of Hydrogen atom.

(*b*) Calculate the ratio of the wavelengths of the de-Broglie waves in the second and third Bohr orbit of Hydrogen atom.

(*c*) What is the difference between the photons of continuous X-rays and characteristic X-rays ?

7,4,4

3. (*a*) Describe the principle, theory and significance of Stern-Gerlach experiment.

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

10,5

4. (*a*) Explain the origin of spin-orbit coupling in atom. Compute the shift in the energy level due to spin-orbit coupling.

(*b*) Assuming jj coupling, find all possible values of J for two valence electrons having orbital quantum number $l_1 = 3$ and $l_2 = 1$.

10,5

5. (*a*) What is Normal Zeeman effect ? On the basis of quantum theory, explain the effect of magnetic field on the energy levels of the atom.

(*b*) Explain the splitting of spectral lines in Normal Zeeman effect for the $2p \rightarrow 1s$ transition.

(*c*) When hydrogen atoms with their electrons in $4d$ state are placed in strong magnetic field (Normal Zeeman effect), the degenerate level ($4d$) split into various levels. What is the maximum energy difference between the levels when atoms are placed in a magnetic field of 2.5 T. 6,6,3

6. (*a*) Evaluate the Lande's g factor for $^2D_{3/2}$ state.

(*b*) Find all possible orientations of total angular momentum vector J corresponding to $j = 3/2$ with respect to a magnetic field along the z-axis.

(*c*) Using Hund's rule find ground state quantum numbers for carbon (Z = 6). 5,5,5

7. (*a*) Distinguish between Raman scattering and Rayleigh scattering.

(*b*) Obtain the expression for the vibrational frequency of a diatomic molecule.

(*c*) The force constant for a vibrating HCl molecule is 470 N/m. Calculate the wavelength corresponding to the vibrating HCl molecule. In which region of the electromagnetic spectra do the vibrational spectra lie ? 5,5,5

8. (*a*) Explain the working of He-Ne Laser with the help of suitable energy level diagram.

(*b*) What is population inversion in a Laser ? How can we achieve a higher probability of stimulated emission as compared to that of spontaneous emission ?

(*c*) For a system in thermal equilibrium, calculate the temperature at which the spontaneous emission rate is equal to that of stimulated emission for a wavelength of 500 nm.

5,5,5

Given :

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

Electronic Charge : 1.6×10^{-19} C

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

Bohr magneton : 9.274×10^{-24} J/T

Mass of hydrogen atom : 1.674×10^{-27} kg

Mass of chlorine atom : 5.81×10^{-26} kg

Mass of electron : 9.1×10^{-31} kg.