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

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

S. No. of Question Paper : **6217**

Unique Paper Code : **222503** **D**

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

Name of the Course : **B.Sc. (Honours) 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.

(Constants are given at the end of the question paper)

1. Answer any *five* of the following :

   (*a*) An electron is accelerated through a potential difference of 300 V and then projected at right angles into a magnetic field of intensity 0.01 Wb/m^2. Calculate the velocity of the electron on entering the field and the radius of the path followed by the electron.

   (*b*) Determine the possible values of the total angular momentum of an *f*-electron using vector atom model.

P.T.O.

(*c*) Why is an inhomogeneous magnetic field used in Stern-Gerlach experiment ?

(*d*) With exciting line 2536 Å, a Raman line for a sample is observed at 2612 Å. Calculate the Raman shift in cm^{-1}.

(*e*) Do all the diatomic molecules exhibit rotational spectra ? Give reasons for your answer.

(*f*) Why anomalous Zeeman effect is more commonly observed than the normal Zeeman effect ?

(*g*) Explain the concept of optical pumping. 3×5=15

2. (*a*) Discuss the origin and mechanism of the production of continuous X-rays. Show that there is a minimum wavelength which is inversely proportional to the applied potential in case of continuous X-rays.

(*b*) Calculate the momentum of a photon corresponding to the minimum wavelength emitted from an X-ray tube operating at 120 kV. 12,3

3. (*a*) State and explain Hund's rule. Using this rule, find the ground state quantum numbers (L, S) of nitrogen (Z = 7).

(*b*) Explain *jj* coupling. Determine all the possible terms under *jj* coupling of an *s*-state electron with an *f*-state electron. 8,7

4. (*a*) Show that the total magnetic moment of an orbital electron in the state with total angular momentum **J** is given by :

$$\boldsymbol{\mu}_J = g\mu_B \, \mathbf{J}/\hbar$$

where $g = 1 + \dfrac{J(J+1) + S(S+1) - L(L+1)}{2J(J+1)}$

is the Lande *g*-factor and μ_B is Bohr magneton.

(*b*) The ground state of chlorine is $^2P_{3/2}$. Find its total magnetic moment in units of Bohr magneton. 12,3

5. (*a*) Discuss the principle and working of a He-Ne laser.

(*b*) Explain the formation of Rayleigh, Stokes' and anti-Stokes' lines in Raman spectra. 9,6

6. (*a*) Explain the concept of space quantization with respect to orbital and spin angular momentum.

(*b*) Obtain classically the relation between magnetic moment $\boldsymbol{\mu}$ and the orbital angular momentum **L** of an electron.

(*c*) Obtain an expression for the total energy of Hydrogen atom using Bohr's theory. Hence determine the wavelength range of Balmer series. 5,3,7

P.T.O.

7. (*a*) Discuss the vibrational-rotational spectra of diatomic molecules. Draw energy level diagram to explain the spectra. Also obtain the expression for the P, Q and R branches in the vibrational-rotational spectra.

(*b*) The force constant of CO bond is 187 N/m. Find the frequency of vibration of the CO molecule and the spacing between two consecutive vibrational energy levels. 10,5

Given :

Mass of carbon = 1.99×10^{-26} kg

Mass of oxygen = 2.66×10^{-26} kg

Planck's constant = 6.62×10^{-34} Js

Mass of electron = 9.11×10^{-31} kg

Rydberg constant = 1.09×10^{7} m^{-1}

Electronic charge = 1.6×10^{-19} C