[This question paper contains 2 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1754 **L**

Name of the Course	: B.Sc. Hons.–(Physics)_NEP: UGCF-2022
Semester	: VI- Semester
Name of the Paper	: DSC Atomic, Molecular and Nuclear Physics
Unique Paper Code	: 2222013602

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. **Question No. 1 is compulsory.**
4. Attempt ***four*** questions from the rest of the paper
5. Non- programmable scientific calculators are allowed.

1. Answer any **six** of the following: **(6X3=18)**

   (a) What causes the fine structure of hydrogenic atoms?

   (b) State and explain Larmor's theorem.

   (c) In the near infrared spectrum of $^{12}C^{16}O$ molecule there is an intense band at $2144 cm^{-1}$. Calculate the zero point energy of the molecule.

   (d) Distinguish between Raman scattering and Rayleigh scattering.

   (e) What is the role of neutrino in the phenomenon of β- decay?

   (f) Write the law of conservation of momentum for the Gamow-Teller transitions.

   (g) Show how each line belonging to Lyman series splits into a doublet in Hydrogen atom.

2. (a) Derive an expression for the fine structure splitting of an (n, l) level of a hydrogenic system due to spin-orbit interaction. Calculate the magnitude of this shift in cm^{-1} for $2p_{1/2}$ and $2p_{3/2}$ states of the Hydrogen atom.

   (b) In a Stern-Gerlach experiment, a beam of silver atoms moves a horizontal distance of 1m in a region with vertical magnetic field gradient 0.387 T/m. If the speed of silver atoms is 100 m/s, calculate the maximum separation between the traces on the detector plates. [Given: Mass of silver atoms =1.79×10^{-25}kg] **(12+6)**

3. (a) Give main features of the pure rotational band spectrum of a heteronuclear diatomic molecule. How are they explained, treating molecule as a rigid rotator. Also, discuss rotational spectrum of a diatomic molecule, treated as a non-rigid rotator.

(b) In rigid rotator approximation for CO, the $J = 0 \rightarrow J = 1$ absorption line occurs at a frequency of 1.15×10^{11}Hz. What is the (i) Moment of inertia and (ii) bond length of the CO molecule. **(10+8)**

4. (a) Explain the classical theory of the observed Raman spectrum of a diatomic molecule. How is it used to explain the structure of a diatomic molecule?

(b) Distinguish between Normal and Anomalous Zeeman Effects. Show that the total magnetic moment of an orbital electron in weak magnetic fields for the state with total angular momentum J is given by: $\mu_J = g\mu_B J/\hbar$

Where $g = 1 + \frac{J(J+1)+S(S+1)-L(L+1)}{2J(J+1)}$ **(8+10)**

5. (a) State and explain the Geiger–Nuttall law. Outline a barrier penetration model for α-decay and explain the concept of quantum tunneling.

(b) Give any three evidences indicating the presence of shell structure in nuclei.

(c) Predict the ground state spins and parities based on the shell model for the following nuclei: (i) ${}^{11}_{5}B$ (ii) ${}^{17}_{8}O$ **(8+6+4)**

6. (a) Give a brief account of multipole radiation associated with the process of γ- decay. Consider a γ transition from an initial excited state of angular momentum 3/2 and even parity to a final state 5/2 with even parity. What are the possible values of angular momentum for the multipole radiation emitted in the process? Determine the type of corresponding multipole radiation as electric or magnetic.

(b) Describe the process of electron capture. Under what conditions is it more likely to occur than the beta decay?

(c) Draw and discuss the characteristic Morse potential energy curve for anharmonic vibrations of a diatomic molecule. **(7+6+5)**

Useful information:

$\langle \frac{1}{r} \rangle = \frac{Z}{n^2 a_0}$; $\langle \frac{1}{r^2} \rangle = \frac{Z^2}{(l+1/2)n^3 a_0^2}$; $\langle \frac{1}{r^3} \rangle = \frac{Z^3}{l(l+\frac{1}{2})(l+1)n^3 a_0^3}$

a_0 is the Bohr radius, Z is nuclear charge, l is the orbital quantum number and n is the principal quantum number

Bohr Magneton $\mu_B = 9.27 \times 10^{-24} J$; Fine structure constant $\alpha = \frac{1}{137}$

$h = 6.625 \times 10^{-34} Js$; $1U = 1.66 \times 10^{-27} kg$