Five-Year Integrated M.Sc. Examination 2022-2023
Semester: VII
Paper: PH-4-7-5
Subject: Physics (Spectroscopy-II)

Time: Three Hours **Full Marks: 40**

Questions are of value as indicated in the margin.
Answer Question number 1 and any three from the rest.

1. Answer any five questions: 5x2 = 10
   (a) Write down the empirical rules regarding the spin quantum number of nuclei.
   (b) What is the chemical shift in Hz of an NMR peak at 6.0 ppm, if the spectra are recorded at a frequency of 60 MHz?
   (c) Briefly explain Auger spectroscopy.
   (d) Draw the diagrams showing the precessions of orbital, spin and total angular momentum vectors of an atom in absence and in presence of an external magnetic field.
   (e) What is the standard notation of an atomic state? State and explain the notations for the possible states of an atom for n = 2.
   (f) Draw the energy level diagram showing Na D-lines. Explain briefly.
   (g) Write the expression of orbital energy for an atom according to Dirac's theory. Based on this expression, show that $2^2S_{1/2}$ and $2^2P_{1/2}$ states are degenerate.

2. (a) Starting from the interaction of an electron in presence of an external magnetic field B_z, calculate the separation between neighbouring spin energy levels. Draw the energy levels produced as a result of the interaction with increasing value of B_z. Also, calculate the Larmor frequency associated with the electron.
   (b) A free electron produces resonance at 9.3 GHz. If the value of g is 2.0023, calculate the strength of the magnetic field.
   7+3 = 10

3. (a) Explain the concept of hyperfine structure in ESR spectra. Give an example.
   (b) A particular NMR instrument operates at 30.256 MHz. Determine the magnetic fields necessary to bring ^1H and ^{13}C nuclei to resonate at that frequency. Given, $\beta_n = 5.05\text{x}10^{-27}$ J T^{-1}, $g_H = 5.585$, $g_C = 1.404$, $h = 6.62\text{x}10^{-34}$ J s.
   7+3 = 10

4. Describe Lamb-Retherford experiment to measure Lamb shift. Draw the necessary experimental set-up and energy level diagrams.
   10

5. (a) Draw the experimental set-up to study normal Zeeman effect and explain the effect mathematically by using energy level diagram,
   (b) What is the basic difference between normal and anomalous Zeeman effects?
   8+2 = 10