2023
M.Sc.
Third Semester
CORE – 10
PHYSICS
Course Code: MPHC 3.21
(Atomic & Molecular Spectroscopy)

Total Mark: 70 *Pass Mark: 28*
Time: 3 hours

Answer five *questions, taking* one *from each unit.*

UNIT–I

1. (a) Obtain the condition which determines Sommerfeld allowed elliptical orbits in hydrogen atom. 8
   (b) In case of Sommerfeld theory of elliptic orbit of hydrogen atom, show that the total energy expression is same as that obtained by Bohr model. 6

2. (a) Prove that in Stern-Gerlach experiment $D_x = \frac{\mu}{2M}\frac{dB}{dx}\left(\frac{d}{\upsilon}\right)^2$, where the symbols have their usual meaning. 7
   (b) Give detail description of the production of fine structure lines in H_α. 5
   (c) Write a short note on hyperfine structure of spectral lines. 2

UNIT–II

3. (a) Apply variation method of chemical bonding to find the ground state energy of hydrogen atom. 5
   (b) Describe hydrogen molecule and show that Pauli's exclusion principle is not contradicted. 9

4. (a) Discuss Born Oppenheimer approximation. 6

(b) What are the causes of excitation in a molecule? Discuss molecule as a rigid rotator. 4

(c) Describe how moment of inertia and bond length are determined in case of linear triatomic molecule. 4

UNIT–III

5. (a) Explain the salient features of a pure rotational spectra by considering a diatomic molecule as a rigid rotator. 5

(b) Explain diatomic molecule as a non rigid rotator. 6

(c) HCl molecule has a rotational constant B value of 1059.3 m^{-1} and a centrifugal distortion constant D of 5.3×10^{-2} m^{-1}. Estimate the vibrational frequency and force constant of the molecule. Given, mass of proton = 1.67×10^{-27} kg and mass of chlorine = 58.5×10^{-27} kg. 3

6. (a) What is a vibrational spectra? Prove that the vibrational energy levels are equally spaced. 5

(b) Describe vibrational-rotational spectra in detail. 5

(c) Discuss pure rotational Raman spectra. 4

UNIT–IV

7. (a) Show that electron spin spectra fall at considerable higher frequency as compared to nuclear spin spectra. 2

(b) Discuss nuclear magnetic resonance. 4

(c) Describe NMR instrumentation and explain the working of continuous wave mode NMR detector. 8

8. (a) Discuss the spin relaxation mechanisms in ESR spectroscopy. 4

(b) Explain how hyperfine structure of ESR spectroscopy is obtained. 7

(c) What is Doppler shift and how does it occur in ESR spectroscopy? 3

UNIT–V

9. (a) What is nuclear quadrupole resonance (NQR)? Briefly describe it. 4

(b) In NQR spectroscopy, derive the expression of frequency of transition for axially symmetric system. Calculate the frequencies of transition and energies associated with the transition for a nuclei having spin $I = \frac{5}{2}$. Illustrate with energy level diagram. 4 + 6 = 10

10. (a) What is Mössbauer effect? Briefly describe it. 4

(b) Discuss recoilless emission and absorption in Mössbauer spectroscopy. 7

(c) What is Auger electron spectroscopy? Briefly discuss Auger effect. 3
