2021
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 form each unit.*

UNIT–I

1. (a) How is fine structure produced in H_α spectrum? 4
   (b) Obtain the condition which determines Sommerfeld allowed elliptical orbits in hydrogen atom. 10
2. (a) Describe the spectra of alkali atoms. 4
   (b) Explain how Sommerfeld introduced relativistic correction to show that the path of electron in an atom is a rosette. 10

UNIT–II

3. (a) Obtain the expression of moment of inertia and bond length of linear triatomic molecule. 6
   (b) Discuss Born Oppenheimer approximation. 8
4. (a) Using variation method, obtain the expression for ground state energy of hydrogen atom. 6
   (b) Discuss the molecular orbital theory of hydrogen molecule ion and obtain the expression of energy in the symmetric and anti-symmetric state. 8

UNIT–III

5. a) *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 4
   (b) Discuss vibrational-rotational spectra and explain how P-branch and Q-branch of the spectra are obtained. 4

(c) Discuss pure rotational spectra of a molecule as rigid rotator. 6

6. (a) The lines in the pure rotational spectrum of *HCl* are spaced as 20.8×10^2 per *metre*. Calculate the moment of inertia and the internuclear distance. Given that mass of proton = $1.67 \times 10^{-27}\,kg$ and mass of chlorine = $58.5 \times 10^{-27}\,kg$. 4

(b) Describe diatomic molecule as a non rigid rotator. 10

UNIT–IV

7. (a) When a nucleus interact with magnetic field, what is the interaction energy? Given that for a nucleus $g_I = 5.585$, $\mu_N = 5.05 \times 10^{-27}\,JT^{-1}$ and $B = 2.3487\,T$, find the interaction energy and the ratio of population in the two states. 5

(b) Discuss nuclear magnetic resonance and the different modes of NMR instrumentation. 9

8. (a) Calculate the Larmor frequency of a nucleus when it is placed in a magnetic field of 1.0 *T*. Given that $g_I = 5.256$, $\mu_N = 5.0504 \times 10^{-27}\,JT^{-1}$. Also calculate relative population in the two spin states. 5

(b) Discuss the basic principle and theory of electron spin resonance. Explain how hyperfine structure is obtained in ESR spectroscopy. 9

UNIT–V

9. (a) Explain the principle of NQR. 5

(b) Derive the expression of frequency of transition for NQR spectroscopy. Calculate the frequencies of transition and energies associated with the transition for a nuclei having spin $I = \frac{5}{2}$ 9

10. (a) The spin of ^{59}Co nucleus is $\frac{7}{2}$. Assuming axial field gradient, obtain the expressions for frequencies of the quadrupole transitions. 5

(b) Discuss recoilless emission and absorption in Mössbauer spectroscopy and explain the experimental techniques of Mössbauer spectrometer. 9
