Time: (3 hrs) **Total Marks: 100**

N.B. : (1) **All** questions are **compulsory**.
(2) **Figures** to the **right** indicate **full** marks.
(3) Draw **neat** diagrams wherever **necessary**.
(4) Symbols have usual meaning unless otherwise stated.
(5) Use of **non-programmable** calculator is allowed.

1. Attempt any two:---

(a) Set up steady state Schrodinger's equation for H-atom in spherical polar co-ordinates. Solve it by the method of separation of variables. Explain how magnetic quantum numbers m_l arises in solving ϕ equation. **10**

(b) State Pauli's exclusion principle. Show that particles obeying Pauli's Exclusion principle are described by antisymmetric wave functions. **10**

(c) Describe experimental set up of Stern-Gerlach experiment with the help of labelled diagram. **10**

2 Attempt any two:---

(a) Explain LS and jj coupling schemes to obtain resultant angular momentum in case of two electron atoms. **10**

(b) Explain quantum mechanically origin of spectral lines and derive expression for frequency emitted when an electron makes transition from higher energy level E_m to lower energy level E_n. **10**

(c) Give classical explanation of normal Zeeman effect and obtain an expression for normal Zeeman shift. **10**

3. Attempt any two:---

(a) Assuming linear harmonic oscillator model, derive an expression for the frequency of oscillation of a diatomic molecule in terms of force constant and its reduced mass. Find the energy spacing of the vibrational energy levels. **10**

(b) State Frank – Condon principle and hence explain in detail intensity of vibrational electronic spectra of a diatomic molecule. **10**

(c) Discuss in detail instrumentation of IR Spectrometer and draw its block diagram. **10**

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4. Attempt any two:---

(a) What are the observations made in the Raman effect? Explain the Raman effect on the basis of Quantum theory. State various applications of Raman Effect. **10**

(b) Discuss a Raman Spectrometer in detail. What are the advantages of Raman spectroscopy over IR spectroscopy? **10**

(c) Explain the Phenomenon of Electron Spin resonance (ESR). Discuss in detail about the ESR spectrometer. **10**

5. Attempt any four:---

(i) Write note on radial probability density of electron in H-atom. **05**

(ii) Show that **05**

$\Theta_{20} = \frac{\sqrt{10}}{4}\,[3\mathrm{Cos}^2\theta - 1]$ is a solution of Θ equation:

$$\frac{1}{\sin\theta}\,\frac{d}{d\theta}\left(\sin\theta\,\frac{d\Theta_{l,m_l}}{d\theta}\right) + \left[\ell\,(\ell+1) - \left(\frac{m_l^2}{\sin^2\theta}\right)\right]\Theta_{l,m_l} = 0.$$

(iii) What are the terms arising out of ss configuration of non-equivalent electrons. **05**

(iv) What is normal Zeeman shift in terms of wavelength? A sample of an element is placed in a magnetic field of 0.3 weber/m^2. Determine the normal Zeeman shift in terms of wavelength for a spectral line of wavelength 4500 A^0. **05**

(v) Write a short note on electronic spectra of diatomic molecule **05**

(vi) In CO molecule, the difference in wave numbers of consecutive absorption lines of rotational spectrum is 3.28 x 10^2 m^{-1}. Calculate the moment of inertia of CO molecule **05**

(vii) Calculate resonance frequency in NMR spectrometer experiment when a field of 2.3487 tesla is applied to a sample hydrogen nulei. Lande's g factor (g_l) is 5.585. **05**

(viii) An ESR spectrometer operates at 9000 MHz. Calculate the field required to bring a sample of free electrons to resonance. Given: g = 2.0043 **05**

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