<p style="text-align:center">($2\frac{1}{2}$ Hours)   **Total Marks: 75**</p>

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.

List of Constants:

1. (a) Attempt any **one:---**

    (i) Set up steady state Schrodinger equation for one dimensional harmonic   **10**
        oscillator. Solve it by raising and lowering operator.

    (ii) Set up the Schrodinger equation in spherical polar coordinates, for the   **10**
        electron in hydrogen atom. Show that how magnetic quantum number m_l
        takes discrete values.

   (b) Attempt any **one:---**

    (i) Explain radial probability density of electron in hydrogen atom.   **5**

    (ii) Applying the operator L_z to the hydrogen atom wave function, show that   **5**
        $L_z \Psi = ml\hbar\Psi$.

2. (a) Attempt any **one:---**

    (i) Describe symmetric and antisymmetric wave functions with suitable   **10**
        examples.

    (ii) Explain LS coupling and jj coupling.   **10**

   (b) Attempt any **one:---**

    (i) State and explain Pauli's exclusion principle.   **5**

    (ii) The term symbol of the ground state of sodium is $3^2S_{\frac{1}{2}}$ and that of its first   **5**

        excited state is $3^2P_{\frac{1}{2}}$. List the possible quantum numbers *n, l, j* and m_j of the

        outer electron in each case.

3. (a) Attempt any **one:---**

    (i) State the Normal Zeeman effect & give the quantum mechanical   **10**
        explanation of the same.

    (ii) What is Paschen-back effect? Explain it in the principal series doublet.   **10**

   (b) Attempt any **one:---**

    (i) Using the effective magnetic moment μ_J ,derive the Lande-g-Factor.   **5**

    (ii) What is Anomalous Zeeman effect?   **5**

4. (a) Attempt any **one:**---
  (i) For diatomic molecule as a simple harmonic oscillator, derive the frequency ν_0 and the energy E_ν. Using the energy level diagram, show the vibrational energy levels & allowed transitions for absorption spectrum. **10**
  (ii) Explain in detail, the classical theory of Raman effect. **10**

  (b) Attempt any **one:**---
  (i) Write a short note on Electronic spectra of diatomic molecules. **5**
  (ii) What are Stoke's lines & Antistoke's lines? Explain why the intensity of Stoke's lines is greater than intensity of Antistoke's lines. **5**

5. (a) Attempt any **one:**---
  (i) Find zero point energy of harmonic oscillator whose period is 1sec. **4**
  (ii) If $U_o(y)$ be the lowest possible eigen function, then by using lowering operator show that $U_0(y) = A_0 e^{-y^2/2}$. **4**

  (b) Attempt any **one:**---
  (i) If one of the states of the configuration is $^6H_{5/2}$, what are the other possible states? **4**
  (ii) A beam of electrons enters a uniform magnetic field of flux density 1.2 Tesla. Find the energy difference between the electrons whose spins are parallel and antiparallel to the field. **4**

  (c) Attempt any **one:**---
  (i) The Normal Zeeman shift is 0.03735 A^0 when a spectral line of 4000 A^0 is subject to the magnetic field of 0.5 Tesla. Determine the specific charge (e/m) of the electron. **4**
  (ii) Calculate the value of Lande's g –factor for $3\ ^2S_{1/2}$ state. **4**

  (d) Attempt any **one:**---
  (i) In CO molecule, the frequency of oscillations of atoms is 3×10^{13} Hz. Calculate the force constant K if reduced mass $\mu = 1.138 \times 10^{-26}$ k.g **3**
  (ii) Calculate the bond length of CO molecule if the reduced mass is 1.14×10^{-26} k.g & moment of Inertia is 1.44×10^{-46} k.g m^2 **3**