$(2\,{}^1\!/_2$ Hours) **Total Marks: 75**

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) State Schrodinger equation for linear simple harmonic oscillator. Using appropriate operator, solve it to obtain zero point energy. **10**

   (ii) Using radial part of Schrodinger's equation for hydrogen atom R(r), Show that the angular momentum of electron is quantized. **10**

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

   (i) Describe space quantization of orbital angular momentum of an electron. **5**

   (ii) By using azimuthal probability density $|\phi|^2$, find the value of normalized azimuthal function Φ. **5**

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

   (i) Explain Goudsmith and Ulhenbeck hypothesis in case of spinning of electron. Describe Stern-Gerlach experiment. **10**

   (ii) Give a brief account of the vector atom model. **10**

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

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

   (ii) A beam of electrons enters a uniform magnetic field of induction 1.8Wb/m^2. Find the energy difference between the states of the electrons whose spins are parallel to the field and those whose spins are antiparallel to the field. **5**

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

   (i) What is Zeeman effect? Write the classical explanation of Normal Zeeman effect. **10**

   (ii) Write a detailed note on Paschen back effect. What are the selection rules for Paschen back effect? **10**

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

   (i) Write a note on Anomalous Zeeman effect **5**

   (ii) Define and explain what is Lande g-factor. **5**

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

    (i) Considering the diatomic molecule as a rigid rotator, derive the rotational **10** energy terms E_J and show that the rotational energy levels are not equispaced.

    (ii) What is Raman effect? What are Stoke's & Antistoke's lines? Give the **10** quantum theory of Raman effect.

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

    (i) Write note on Frank Condon principle. **5**

    (ii) Explain the Raman activity of vibrations with the example of H_2O molecule. **5**

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

    (i) Calculate the zero point vibrational energy for NaCl molecule, if its **4** fundamental vibrational frequency is 1.5×10^{13} Hz. (h= 6.63×10^{-34} J.s).

    (ii) If $U_0(y) = e^{-y^2/2}$, Find $U_1(y)$. **4**

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

    (i) Calculate the values of L, S. and J for 'd' electron in one-electron atomic **4** system.

    (ii) Find the values of S, L and J that correspond to each of the following states: **4** $^2D_{3/2}$, $^2S_{1/2}$

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

    (i) If a sample of an element is placed in magnetic field of strength 0.3wb/m. **4** Find how far apart are the Normal Zeeman components of a spectral line of wavelength $4500A^0$?

    (ii) For $3\,^2P_{3/2}$ state, Calculate the value of Lande's g-factor. **4**

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

    (i) Calculate the moment of inertia of CO molecule if the first absorption line **3** in CO rotational spectrum occurs at 1.153×10^{11} Hz.

    (ii) When radiation of $\lambda = 5460A^0$ was scattered by a medium, A stokes line of **3** $\lambda = 5440A^0$ was observed. Calculate the Raman shift Δv.