Con. 1338–13. **CG–2385**

(2½ Hours) **[Total Marks :60**

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 **logtable** and **non-programmable** calculator is allowed.

1. (a) Attempt any **one** :— **8**
   (i) Write Schrödinger's equation for Hydrogen atom in spherical polar co-ordinates. Using method of separation of variables, obtain independent equations for each co-ordinate.
   (ii) Define creation and annihilation operators. Using them, show that energy eigen values are quantized in case of simple harmonic oscillator. Represent eigen functions, eigen values and probability graphically. **8**

   (b) Attempt any **one** :—
   (i) Show that in Hydrogen atom, the electron probability density about 'Φ' axis is constant. **4**
   (ii) Show that eigen value of operator $\hat{L}_z$ is $m_\ell \hbar$. **4**

2. (a) Attempt any **one** :—
   (i) State and explain Pauli's exclusion principle, How did Pauli arrive at it ? **8**
   (ii) Explain on the basis of vector atom model, simultaneous quantization of L, S and J vectors of one electron atom. **8**

   (b) Attempt any **one** :—
   (i) State Hund's rule and apply it to $^{25}M_n$. **4**
   (ii) Describe experimental set up of Stern-Gerlach experiment with the help of labelled diagram. **4**

3. (a) Attempt any **one** :—
   (i) Explain quantum theory of normal Zeeman effect and obtain the expression for Zceman shift. **8**
   (ii) Derive an expression for Lande's 'g' factor. **8**

   (b) Attempt any **one** :—
   (i) Compare Zeeman effect and Paschen–Back effect. **4**
   (ii) Calcium sample is placed in magnetic field intensity of 3T. Calculate wavelengths of Zeeman components of a spectral line having wavelength, 4227 Å. **4**

Given : $\frac{e}{m} = 1 \cdot 7588 \times 10^{11}$ c / kg

$c = 3 \times 10^8$ m/sec

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4. (a) Attempt any **one** :—
   (i) State and explain Frank-Condon principle for vibration electronic spectra. **8**
   (ii) Discuss the classical theory of Raman Effect. **8**

   (b) Attempt any **one** :—
   (i) State the characteristics of Raman lines. **4**
   (ii) The J = 0 to J = 1 rotational absorption line occurs at $1{\cdot}153 \times 10^{11}$ Hz in $C^{12} O^{16}$ and at $1{\cdot}102 \times 10^{11}$ Hz in $C^{x} O^{16}$. Find the value of x. Assume bond length to be same in both the molecules. **4**

5. (a) Attempt any **two** :—
   (i) Determine the value of zero point energy in ev for a quantum oscillator having period 0·0004 sec. Given : $h = 6{\cdot}63 \times 10^{-34}$ JS. **3**
   (ii) Discuss the space quantization of orbital angular momentum for P state of an electron. **3**
   (iii) Find the possible values of L, S and J for configuration of two electron system having quantum numbers $l_1 = 1$ and $l_2 = 2$. Use LS coupling. **3**
   (iv) State selection rules, and find whether $\psi_{320} \rightarrow \psi_{111}$ is allowed or forbidden transition. **3**

   (b) Attempt any **two** :—
   (i) Consider the state in which $l = 3$ and $s = \frac{1}{2}$ for the state with largest possible j and largest possible m_j. Calculate the angle between $\vec{J}$ and positive Z axis. **3**
   (ii) Draw vector diagram to represent anomalous Zeeman effect in two electron atom obeying L–S coupling. **3**
   (iii) The first absorption line in CO rotational spectrum occurs at $1{\cdot}153 \times 10^{11}$Hz. Calculate the moment of inertia of CO molecule. **3**
   (iv) Determine the force constant of HCl-molecule if its vibrational frequency is 9×10^{15} Hz. **3**

   Given : m (H) = $1{\cdot}67 \times 10^{-27}$ kg
   m (Cl) = $5{\cdot}81 \times 10^{-26}$ kg
