T.Y.BSc
Sem V

Subject: Physics : P: III
Automic and Molecular Physics (old)
2016-17.

QP Code : 77043

(2½ 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 their usual meaning unless otherwise stated.
(5) Use of logtable and nonprogrammable calculator is allowed.

1. (a) Attempt **any one.** **10**

(i) Write the Schrodinger equation for linear harmonic oscillator. Reduce it to dimensionless form. Solve it by operator method.

(ii) Show that the operators L_z and L^2 have the eigenvalue $m_l\hbar$ and $l(l+1)\hbar^2$ respectively.

Given : $L_z = -i\hbar\frac{\partial}{\partial\phi}$ and

$$L^2 = -\hbar^2\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial}{\partial\theta}\right)+\frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\phi^2}\right]$$

(b) Attempt **any one.** **5**

(i) What is zero point energy of linear harmonic oscillator? Explain it by using Heisenberg Uncertainty principle.

(ii) Draw the space quantisation diagram for f electron. Calculate the cosine of the angle between L and z-axis.

2. (a) Attempt **any one.** **10**

(i) Discuss Stern Gerlach experiment, which demonstrates the existence of magnetic moment associated with electron spin.

(ii) Show quantum mechanically that, when electron undergoes a transition between two states having energies E_m and E_n respectively, its average position oscillates with frequency

$$\nu = \frac{E_m - E_n}{h}$$

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(b) Attempt **any one.**

(i) State Hund's rule and show that ferromagnetism of $^{57}_{26}Fe$ is a consequence of Hund's rule. 5

(ii) Draw neat vector diagram indicating LS coupling for two electron atoms. Find the values of **S, L & J** corresponding to state $^2D_{3/2}$. 10

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

(i) What is Lande g-factor? Obtain an expression for it.

(ii) What is Paschen-Back effect? Discuss the theory of Paschen-Back effect using vector atom model. State selection rules for Paschen-Back effect. 10

(b) Attempt **any one.**

(i) Write a short note on Anomalous Zeeman effect.

(ii) A spectral line of 4000 angstrom is subjected to 0.5 tesla of magnetic field. The normal Zeeman shift is found to be 0.03735 angstrom. Determine the specific charge of the electron. 5

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

(i) Obtain an expression for the energies of rotational levels in a diatomic molecule, treating it as a rigid rotator. Draw energy level diagram. Show that though the rotational energy states are not equispaced, the rotational spectral lines are equispaced. 10

(ii) What is Raman Effect? Give its quantum theory. Why are antistoke's lines weaker than Stoke's lines?

(b) Attempt **any one.**

(i) Give an account of the intensity pattern observed in case of vibrational electronic spectra. Name the principle that can explain it. Give it's statement. 5

(ii) Show that a vibrating diatomic molecule can be reduced to an equivalent simple harmonic oscillator.

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

(i) Show that the electron probability density about z-axis is constant. 4

(ii) The wavefunction for a linear harmonic oscillator for n = 2 is given by $U_2(y) = 2A_2(2y^2 - 1)e^{-y^2/2}$. Using the lowering operator find wavefunctions U_1 and U_0.

(b) Attempt **any one.** 4

(i) Define symmetric and antisymmetric wavefunctions. Which of these wavefunctions obeys Pauli's exclusion principle? Justify your answer.

(ii) State selection rules for allowed transitions and find whether $\psi_{200} \rightarrow \psi_{100}$ is allowed or forbidden transition.

(c) Attempt **any one.** 4

(i) An atom with spin zero, emits a spectral line of frequency υ_0 when transition takes place from an $L_2 = 2$ to $L_1 = 1$ level. Show the splitting of energy levels and of the spectral line in the presence of an external magnetic field B.

(ii) Determine Lande's g-factor for ^3P, ^5D and ^7F states. Comment.

(d) Attempt **any one.** 3

(i) In pure rotational Raman spectrum of CO gas, the Raman shift for the first Stoke's line is observed to be 0.35×10^{12} Hz. Hence calculate the bond length of CO molecule. The reduced mass of CO molecule is 1.14×10^{-26} kg. and Planck's constant $h = 6.63 \times 10^{-34}$ j-s.

(ii) Which of the following exhibit pure vibrational spectrum? HCl vapour, liquid HCl, H_2, N_2. Justify your answer.