Paper / Subject Code: 24241 / Physics: Atomic & Molecular Physics

T.Y. BSC Sem-V 23-24 1-11-23
Univ. exam.

(3 Hours) [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.

**Q1** Attempt any **two:---**

(i) Beginning with the time independent Schrodinger's equation for one electron atom, obtain three independent equations in spherical polar coordinates. **10**

(ii) Discuss quantization of orbital angular momentum with respect to magnitude and direction. **10**

(iii) Explain Radial probability density of an electron in hydrogen atom model using suitable graphs. Also discuss Azimuthal and Zenith probability densities. **10**

(iv) Describe the experimental setup of Stern Gerlach's experiment and explain how it was able to prove the existence of intrinsic spin of electron. **10**

**Q2** Attempt any **two:---**

(i) Show quantum mechanically that an electron undergoing transition from higher energy level $E_m$ to a lower energy level $E_n$ emits a radiation of frequency $\nu = \frac{E_m - E_n}{h}$. Also state selection rules for the allowed transition. **10**

(ii) Explain in detail, the experimental set up to observe Zeeman effect and comment on observed Zeeman components. **10**

(iii) Explain on the basis of vector atom model, simultaneous quantization of L, S and J vectors of one electron atom. **10**

(iv) Explain with classical theory Normal Zeeman effect. **10**

**Q3** Attempt any **two:---**

(i) Write the expression for vibration-rotation energy levels of a rigid diatomic molecule. Discuss features of P- branch and R-branch using suitable energy level diagram **10**

(ii) Write an expression for rotational energy of a single diatomic molecule. Explain in detail how the energy levels get modified if the effect of bond elongation is taken into consideration. Draw appropriate energy level diagram. **10**

(iii) Draw a labelled schematic diagram of an absorption IR spectrometer and explain its parts. **10**

(iv) State Franck-Condon Principle. Using the principle, explain the electronic spectra of diatomic molecule. **10**

**Q4** Attempt any **two:---**

(i) Define Raman shift and list the observations related to Raman effect. **10**

(ii) Explain the Raman activity of water molecules by considering various modes of vibrations **10**

(iii) Discuss pure vibrational Raman spectrum. Also explain stokes and antistokes lines that are observed **10**

(iv) Explain the parts of an ESR spectrometer and discuss its working. **10**

**Q5** Attempt any **four:---**

(i) Write Lz using spherical polar co-ordinates and obtain its eigen values. **20**

(ii) A beam of electrons enters a uniform magnetic field, of magnitude 1.2 T, Find the energy difference between electrons whose spins are parallel and anti parallel to the applied field. **05**
Given: h= 6.63 x $10^{-34}$ Js, c = 3 x $10^{8}$m/s, e = 1.6 x $10^{-19}$C , m = 9.11 x $10^{-31}$Kg **05**

(iii) Spectral lines from 3P-3S transition in sodium atom splits up into two components of wavelength 5890AU and 5896AU due to spin orbit interaction. Estimate the magnetic field experienced by the spinning electron in 3P state due to its orbital motion. **05**
Given: h= 6.63 x $10^{-34}$ Js, c = 3 x $10^{8}$m/s, e = 1.6 x $10^{-19}$C , m = 9.11 x $10^{-31}$Kg

(iv) Define Lande's 'g' factor and find its value for $^{2}P_{3/2}$. **05**

(v) In a CO molecule, the bond length is 1.13 AU, and the masses of C and O atoms are 1.99 x $10^{-26}$ Kg and 2.66 x $10^{-26}$ Kg respectively. Calculate the moment of inertia of the CO molecule and the energy of the first rotational energy level. **05**
Given: h= 6.63 x $10^{-34}$ Js

(vi) State the principle involved in microwave spectroscopy. Also draw block diagram for Microwave Spectrometer. **05**

(vii) A stokes line of wavelength 5540 AU was observed in a Raman spectrum when radiation of wavelength 5460AU was scattered by a medium. Calculate the Raman shift and wavelength of corresponding Anti-Stokes line. Given :- speed of light = 3 x $10^{8}$ m/s **05**

(viii) Calculate the resonance frequency in an NMR spectrometer experiment when a field of 2.3487 tesla is applied to a sample of hydrogen nuclei. Lande's g-factor for hydrogen is 5.585. **05**
Given: - h = 6.62 X $10^{-34}$ Js , $\mu_N$ = 5.05 x $10^{-27}$ $JT^{-1}$.

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