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B. Sc Course (CBCS) Ordinance Sem-VI
EXAMINATION APRIL 2023
PHYSICS - ATOMIC AND MOLECULAR PHYSICS

[Time: 2:00 Hours]

[Max. Marks: 80]

- Instructions:** 1) All questions are compulsory.
2) Figures to the right indicate marks.
3) Symbols have their usual meaning.
4) Use of non-programmable calculator is allowed
5) Draw neat diagrams wherever necessary.

Constants: $h=6.63 \times 10^{-34}$ J-S
 $m=9.1 \times 10^{-31}$ Kg.
 $e=1.6 \times 10^{-19}$ C
 $1 \text{ a.m.u.} = 1.67 \times 10^{-27}$ Kg.

1 Answer any four of the following.

(4×4=16)

- What do you mean by space quantization? What are the possible values of L_z for an electron in the d state? Draw the necessary diagram.
- What are Fermions and bosons?
- The term symbol of the ground state of sodium is $3^2S_{1/2}$ and that of the excited state is $3^2P_{1/2}$, list the possible value of quantum number n , l , m and m_j .
- Calculate the Lande g factor associated with the states $^2P_{1/2}$ and $^2P_{3/2}$
- Obtain an expression for orbital magnetic moment of an atomic magnet in terms of Bohr magneton. What is gyromagnetic ratio?
- What is Anomalous Zeeman effect? State the selection rule for Anomalous Zeeman effect. In what direction of the magnetic field π lines are observed?

2 Answer any four of the following.

(4×4=16)

- State the selection rule for rotational spectra & obtain an expression for frequencies of rotational spectral lines.
- State the selection rule for vibrational rotational spectra of a diatomic molecule and draw the energy level diagram to get P- branch and R branch spectral lines of a diatomic molecule.
- State and prove Duane-Hunt Law.
- Why anti-stokes lines are much weaker as compared to stokes lines? How one can increase the intensity of anti-stokes lines?

- e) State the selection rule for pure rotational Raman spectra. Draw the energy level diagram of rotational Raman spectra.
- f) Explain the diffused series of alkali spectra. State the selection rule for the transition to get the diffused series.
- 3 A) p) What is the shell and subshell capacities for a given value of l and n ? Give the electron configuration of Argon. Why it is chemically inactive? (03)
- q) Write the Schrodinger wave equation involving azimuthal wave function ϕ . What is the solution of this equation? What are the possible values of m_l to get this solution? (03)

OR

- A) x) Draw the space cones of L , S and J in the presence and absence of external magnetic field. (03)
- y) Calculate the Lande g factor for electron in the $^2D_{5/2}$ state. (03)
- B) Write the Schrodinger equation in spherical polar coordinates for the electron in hydrogen atom. Use the method of separation of variables to obtain three independent differential equations. (06)
- 4 A) p) Explain principle series of alkali spectra. Why shorter wavelength line is twice intense as the longer wavelength line of sodium doublet? (03)
- q) Calculate the orbital magnetic moment in terms of Bohr magneton for an electron in the D and F state (03)

OR

- A) x) What is meant by normal and inverted terms in the doublet fine structure? (03)
- y) Give any two features of Alkali spectra (03)
- B) Explain Normal Zeeman effect using quantum theory. (06)
- 5 A) p) What is Moseley's law? Give any two conclusions drawn from Moseley's law. (03)
- q) In observing a Raman spectrum of a sample using 2537 \AA as the exciting line one gets Stokes line at 2683 \AA , deduce the Raman shift. (03)

OR

- A) x) Draw the X-ray energy level diagram to get $K\alpha$, $K\beta$, and $K\gamma$ characteristic lines and explain Quantum mechanically how you get Characteristic $K\alpha$ line. (03)
- y) Explain in brief Raman activity of H_2O molecule in symmetric stretching. (03)

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- B) Explain quantum theory of Raman effect and obtain an expression for frequency of stokes and anti-stokes lines. (06)
- 6 A) p) Write the expression for vibrational rotational energy levels and obtain the expression for frequency of p-branch spectral lines. (03)
- q) Calculate the lowest rotational energy and angular velocity of CO molecule if its moment of inertia is $1.46 \times 10^{-26} \text{ Kg. m}^2$ (03)

OR

- A) x) Explain electronic spectra in brief where the inter nuclear distance remains the same in the electronic ground and excited state. (03)
- y) Calculate the frequency of vibration of the CO molecule and the spacing between the vibrational energy levels if the force constant $k = 187 \text{ N/m}$ and reduced mass $= 1.14 \times 10^{-26} \text{ kg}$. (03)
- B) Show that rotation of a diatomic molecule is equivalent to the rotation of a single particle and obtain an expression for rotational energy levels of a rigid diatomic molecule. What information pertaining to molecule can be deduced from the study of rotational spectra? (06)