

2024

(CBCS)

(5th Semester)

PHYSICS

EIGHTH (A) PAPER

(Atomic and Molecular Spectroscopy)

Full Marks : 75

Time : 3 hours

*The figures in the margin indicate full marks for the questions***(SECTION : A—OBJECTIVE)**

(Marks : 10)

Tick (✓) the correct answer in the brackets provided :

1×10=10

1. In hydrogen spectrum, the wave number limit corresponding to Balmer series is

(a) $R/4$ ()(b) $R/9$ ()(c) $R/16$ ()(d) $R/25$ ()where R is Rydberg constant.

2. The selection rule for Azimuthal quantum number (k) in Sommerfeld Atomic model is

(a) $\Delta k = 0$ ()

(b) $\Delta k = \pm 1$ ()

(c) $\Delta k = 0, \pm 1$ ()

(d) $\Delta k = \infty$ ()

3. The distance of the $^2d_{3/2}$ level from hypothetical term value for the centre of gravity of the doublet as a result of spin-orbit interaction is given by

(a) $\Gamma\left(j = \frac{3}{2}\right) = -\frac{3}{2}a$ ()

(b) $\Gamma\left(j = \frac{3}{2}\right) = a$ ()

(c) $\Gamma\left(j = \frac{3}{2}\right) = \frac{1}{2}a$ ()

(d) $\Gamma\left(j = \frac{3}{2}\right) = -a$ ()

(symbols have their usual meanings)

4. How many new energy levels are expected as a result of $4p3d$ interaction?

(a) 2 ()

(b) 6 ()

(c) 8 ()

(d) 12 ()

5. "Whatever be the anomalous Zeeman pattern of a given spectral line in a weak magnetic field, the pattern always approximates to the normal Zeeman triplet as the strength of magnetic field is progressively increased." This phenomenon is called

(a) Anomalous Zeeman effect ()

(b) Paschen-Back effect ()

(c) Planck's effect ()

(d) Stark effect ()

6. Due to spinning of electron consideration in X-ray spectra, the M state

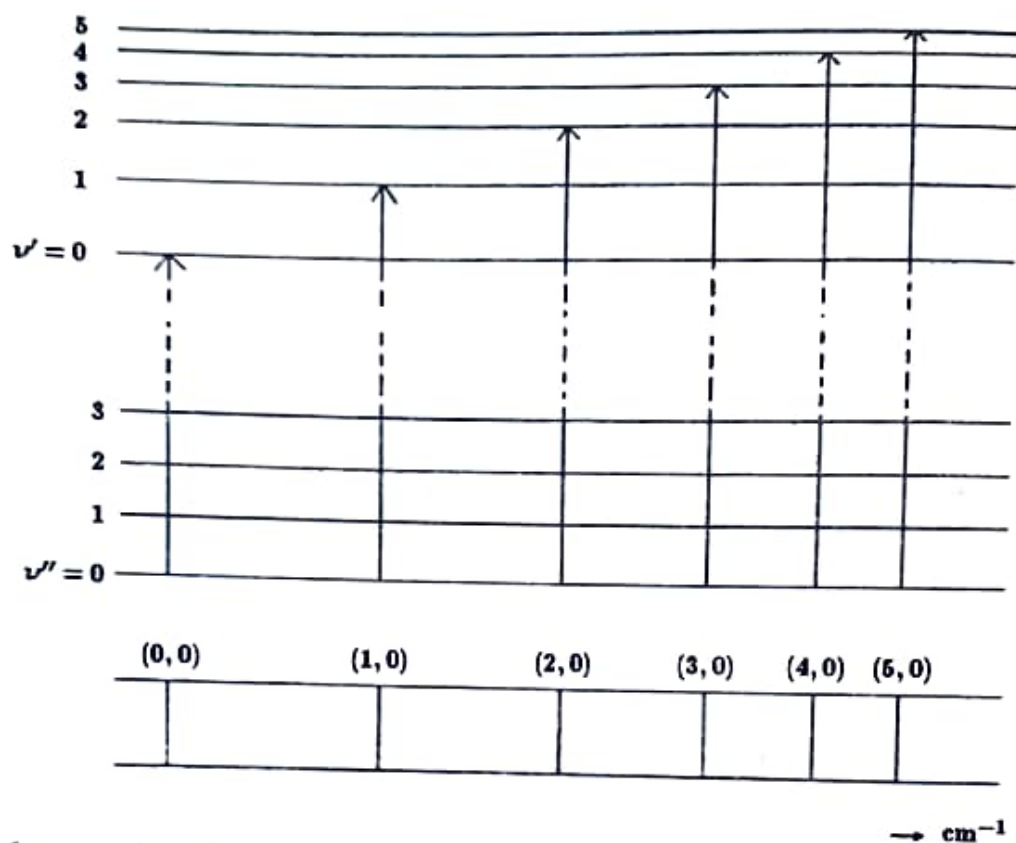
(a) does not split ()

(b) split into 2 levels ()

(c) split into 3 levels ()

(d) split into 5 levels ()

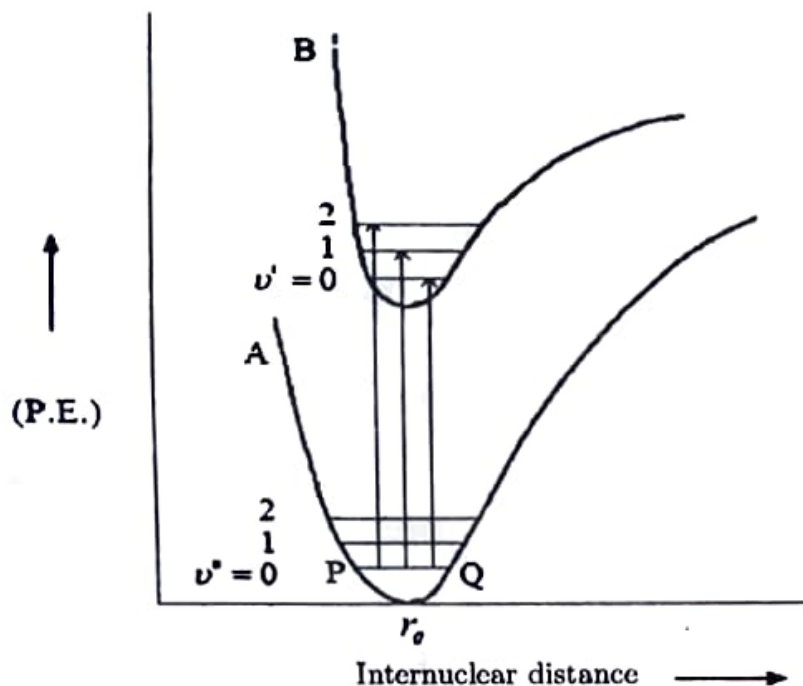
7. In the figure, according to their vibrational quantum number of (v' , v'') i.e., (0, 0), (1, 0), (2, 0), ... (upper state first), such a set of transition is called



- (a) band ()
 (b) spectrum ()
 (c) sequence ()
 (d) progression ()
8. For transition from initial state of quantum number J to $J + 1$, the frequency of absorbed photon is

- (a) $\frac{2\hbar^2}{\pi I} (J + 1)$ ()
 (b) $\frac{1}{2\pi\hbar^2 I} (J + 1)$ ()
 (c) $\frac{\hbar^2}{2\pi I (J + 1)}$ ()
 (d) $\frac{\hbar^2}{2\pi I} (J + 1)$ ()

9. During absorption or emission of radiation, the inter-nuclear distance in a molecule does not change appreciably; the electronic transition should then be represented by



- (a) vertical line ()
- (b) horizontal line ()
- (c) curve A ()
- (d) curve B ()
10. Raman spectra appear due to the scattering of radiation by the
- (a) dipole moment of molecule ()
- (b) rotating molecules ()
- (c) vibrating molecules ()
- (d) absorption of molecules ()

(SECTION : B—SHORT ANSWERS)

(Marks : 15)

Answer the following :

$$3 \times 5 = 15$$

UNIT—I

1. Electron transitioned from 2nd to 1st orbit of hydrogen. Find the frequency of radiation emitted in terms of Rydberg constant.

OR

2. With the introduction of elliptical orbit by Sommerfeld, show that the orbit with principal quantum number $n = 3$ split into three sub-orbits.

UNIT—II

3. Find the maximum number of electrons with all the shells fill up to principal quantum number $n = 4$.

OR

4. For a particular atomic state $^2P_{3/2}$, what are the different possible orientations of inner angular momentum in space (angle between inner angular momentum and vertical axis)?

UNIT—III

5. Write a short note on Stark effect.

OR

6. Explain the method of pumping in LASER.

UNIT—IV

7. Explain the general idea of Born-Oppenheimer approximation.

OR

8. Calculate the moment of inertia and inter-molecular distance of HCl molecule. Given, atomic weight of hydrogen = 1.00794 a.m.u. and chlorine = 35.453 a.m.u., $h = 6.62 \times 10^{-27}$ erg.sec and $c = 3 \times 10^{10}$ cm sec⁻¹.

UNIT—V

9. What is Fortrat diagram? What information is observed in the principle?

OR

10. What is Raman effect? Give the quantum mechanical explanation of Raman effect.

(SECTION : C—DESCRIPTIVE)

(Marks : 50)

Answer the following :

10×5=50

UNIT—I

1. Discuss Rutherford's atomic model and its failure. Derive the formula for Rutherford's scattering cross-section. $4+6=10$

OR

2. Derive the energy expression for electrons after the introduction of Sommerfeld relativistic mass correction. Up to what extent does it help in explaining the fine structure of H_{α} line? $7+3=10$

UNIT—II

3. (a) State and prove Larmor's theorem. $2+4=6$

(b) What is the effect of space quantization introduced by vector atom model? Does it result in the formation of new energy level? $2+2=4$

OR

4. (a) Discuss Stern-Gerlach experiment. How does it help in explaining the vector atom model? $4+4=8$

(b) Find the Γ -factor for the p -orbital. Show it in a diagram with spectral notation. $1+1=2$

UNIT—III

5. (a) What are the normal and anomalous Zeeman effect? Explain anomalous Zeeman effect with vector atom model. $2+5=7$

(b) Illustrate with diagrams the splitting of 2D level of sodium in weak and strong magnetic field. 3

OR

6. (a) Explain X-ray fluorescent and an Auger effect. 4

(b) Derive the rate equation for three-level LASER system. 6

UNIT—IV

7. With necessary diagram, obtain an expression for the energy level, frequency of spectral line and the selection rule in vibrating diatomic molecule as anharmonic oscillator. 10

OR

8. Derive an expression for the energy level, frequency of spectral line and the selection rule in non-rigid rotator. Discuss the general comparison of rigid and non-rigid rotator. $7+3=10$

UNIT—V

9. Explain sequence and progression in electronic spectra and hence derive the frequency of the spectrum due to a change in total energy of the molecule. 10

OR

10. (a) Define the *P*, *Q* and *R* branches in the spectrum of rotational fine structure in electronic vibrational transition. 5

(b) State and explain Franck-Condon principle. $2+3=5$

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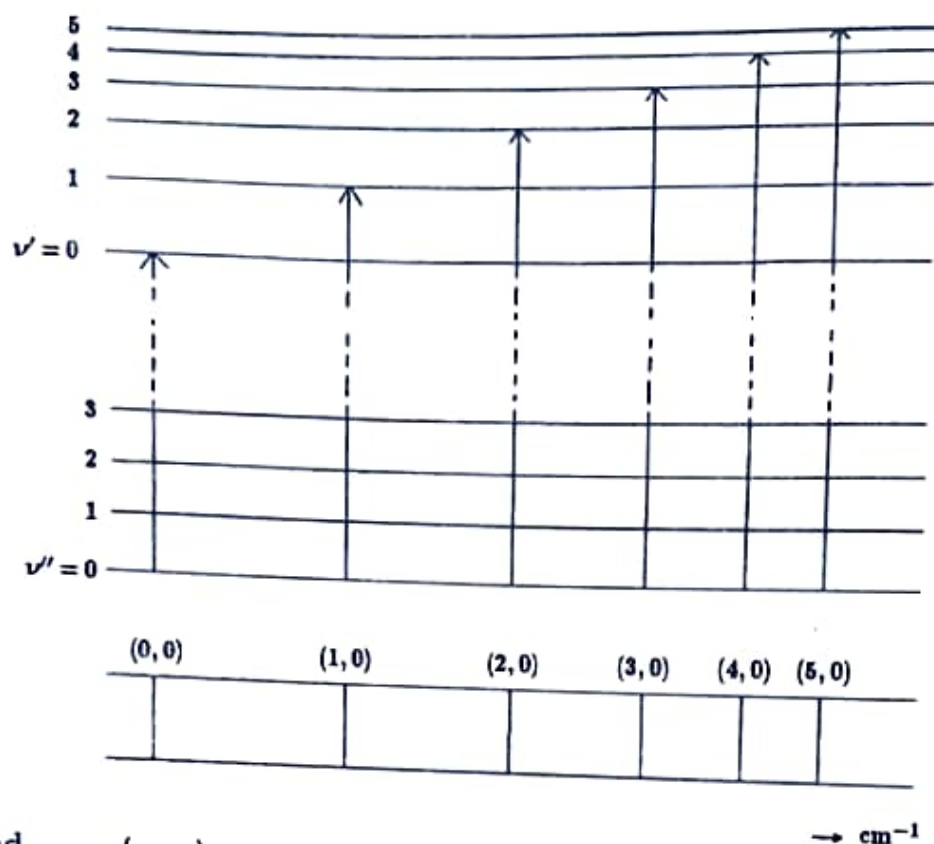
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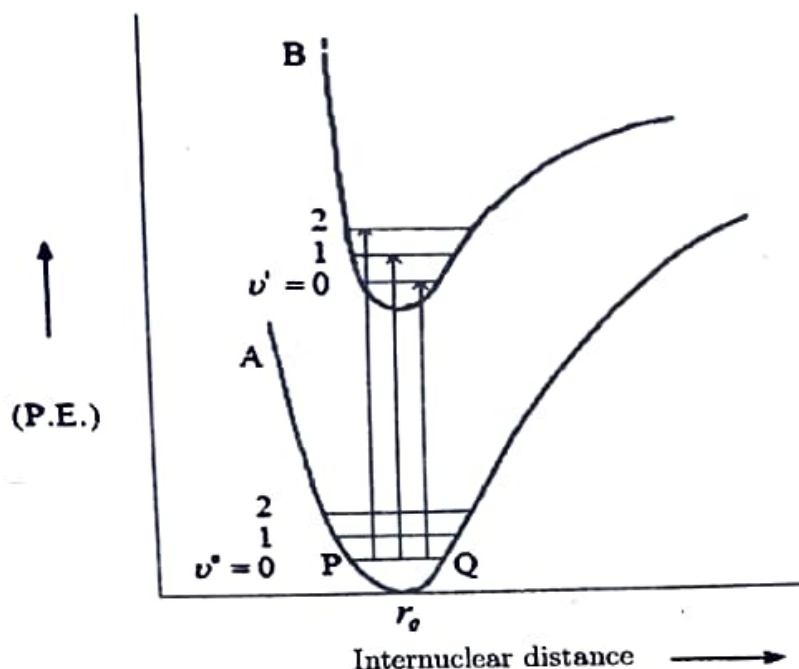


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