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(CBCS)

(5th Semester)

PHYSICS

EIGHTH (A) PAPER

(Atomic and Molecular Spectroscopy)

Full Marks : 75

Time : 3 hours

(PART : A—OBJECTIVE)

(*Marks* : 25)

The figures in the margin indicate full marks for the questions

SECTION—A

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. In the hydrogen spectrum, the wavelength corresponding to Paschen series of lines is given by

(a) $\bar{\nu} \quad R \left(\frac{1}{1^2} - \frac{1}{n^2}\right), \; n \quad 2, 3, 4, \ldots$ ( )

(b) $\bar{\nu} \quad R \left(\frac{1}{2^2} - \frac{1}{n^2}\right), \; n \quad 3, 4, 5, \ldots$ ( )

(c) $\bar{\nu} \quad R \left(\frac{1}{3^2} - \frac{1}{n^2}\right), \; n \quad 4, 5, 6, \ldots$ ( )

(d) $\bar{\nu} \quad R \left(\frac{1}{4^2} - \frac{1}{n^2}\right), \; n \quad 5, 6, 7, \ldots$ ( )

2. The value of spin quantum number of an electron in hydrogen atom is

(a) $\frac{1}{2}$ ( )

(b) $\frac{1}{2}$ ( )

(c) 1 ( )

(d) 0 ( )

3. The value of Lande's splitting factor for *s*-state is

(a) 0 ( )

(b) 1 ( )

(c) 2 ( )

(d) $\frac{1}{2}$ ( )

4. On which of the following levels of hydrogen the spin-orbit interaction has no effect?

(a) *s*-levels ( )

(b) *p*-levels ( )

(c) *d*-levels ( )

(d) *f*-levels ( )

5. The rotational energy levels of a molecule are

(a) equally spaced ( )

(b) unequally spaced ( )

(c) mixture of both ( )

(d) None of the above ( )

6. The velocity of the electron in the first Bohr orbit is

(a) $3 \quad 10^{8}$ m ( )

(b) $(1/57)\,c$ ( )

(c) $(1/3{\cdot}6)\,c$ ( )

(d) $(1/137)\,c$ ( )

7. The intensity of X-rays is determined by

(a) filament current ( )

(b) filament voltage ( )

(c) potential difference between the cathode and the anode ( )

(d) size of the anode ( )

8. The energy of hydrogen atom in the first excited state is

(a) 13·6 eV ( )

(b) 1·51 eV ( )

(c) 3·4 eV ( )

(d) 0·85 eV ( )

9. According to Born-Oppenheimer approximation, the molecular energy levels can be divided into electronic (E_e), vibrational (E_v) and rotational (E_r) energy levels. The order of magnitudes is

(a) E_e E_v E_r ( )

(b) E_v E_e E_r ( )

(c) E_r E_v E_e ( )

(d) E_r E_e E_v ( )

10. The transition zone for Raman spectra is

(a) between electronic levels ( )

(b) between magnetic levels of unpaired electrons ( )

(c) between magnetic levels of nuclei ( )

(d) between vibrational and rotational levels ( )

SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. If the Rydberg constant R $1{\cdot}097{\times}10^{7}$ m ^{1}, what are the wavelengths of the first three lines of the Paschen series?

OR

2. Write a short note on Rutherford's alpha particle scattering.

3. What is Zeeman effect? Distinguish between normal and anomalous Zeeman effects.

OR

4. State and explain Pauli's exclusion principle.

5. What is spin orbit coupling?

OR

6. Explain Stark effect.

7. Distinguish between pure rotational and rotational-vibrational spectrum.

OR

8. State and differences between the spectra of rigid diatomic rotator and non-rigid diatomic rotator.

9. Distinguish between continuous and characteristic X-ray spectra.

OR

10. Explain Franck-Condon in short.

(PART : B—DESCRIPTIVE)

(*Marks* : 50)

The figures in the margin indicate full marks for the questions

1. State Bohr's postulate of atom model and use them to determine the expression for radius of Bohr's orbit and the total energy of the electron in a hydrogen atom in the *n*th state. 2+4+4=10

OR

2. Explain the Sommerfeld's relativistic correction and fine structure of spectral lines of hydrogen-like atoms. Give the selection rule. (4+4)+2=10

3. Discuss the principle and the experimental arrangement of Stern-Gerlach experiment. How does it explain the assumptions of vector atom model? (2+6)+2=10

OR

4. Derive spin-orbit interaction energy/ factor. Calculate the energy shift from hypothetical term value of *s*, *p* and *d* orbitals. 4+(2+2+2)=10

5. What do you mean by Einstein *A* and *B* coefficients? Derive a relation between them. 4+6=10

OR

6. State and explain Paschen-Back effect using vector atom model. 3+7=10

7. *(a)* Give the general idea of Born-Oppenheimer approximation.

(b) Obtain an expression for the allowed energy levels of a vibrating diatomic molecule treated as a harmonic oscillator. 3+7=10

OR

8. Obtain an expression for rotational energy level of a diatomic molecule and the frequency of rotational spectra. State clearly the selection rule. (5+2)+3=10

9. What is Raman effect? How is it explained on the basis of quantum theory? Explain its importance. 2+5+3=10

OR

10. Discuss the rotational fine structure of electronic vibrational transitions. What is Fortrat diagram? 7+3=10

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