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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 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) k 0 ( ) *(b)* k 1 ( )

(c) k 0, 1 ( ) *(d)* k ( )

3. The possible quantum numbers n, l, j and m_j of the spectral notation $3^2 d_{3/2}$ are

(a) n 2, l 1, j 3 / 2, m_j 3/2 ( )

(b) n 2, l 2, j 3 / 2, m_j 3/2 ( )

(c) n 3, l 2, j 3 / 2, m_j 3/2 ( )

(d) n 3, l 1, j 3 / 2, m_j 3/2 ( )

4. The possible value of spin quantum number (s) of helium atom is

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

(c) 1 ( ) *(d)* 1 ( )

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

(a) $(j \quad 3/2) \quad \frac{3}{2} a$ ( ) *(b)* $(j \quad 3/2) \quad a$ ( )

(c) $(j \quad 3/2) \quad \frac{1}{2} a$ ( ) *(d)* $(j \quad 3/2) \quad a$ ( )

6. What is the need to achieve population inversion in LASER?

(a) To excite most of the atoms ( )

(b) To bring most of the atoms to ground state ( )

(c) To achieve stable condition ( )

(d) To reduce the time of production of LASER ( )

7. The spectral lines in rigid diatomic molecules are separated by a constant distance of

(a) $1B$ cm ^{1} ( ) *(b)* $2B$ cm ^{1} ( )

(c) $3B$ cm ^{1} ( ) *(d)* $4B$ cm ^{1} ( )

8. The selection rules for the anharmonic oscillator is

(a) 0 ( ) *(b)* 1 ( )

(c) 1, 2, 3,... ( ) *(d)* ( )

9. Raman shift generally lies within the range

(a) 100 cm ^{1}–3000 cm ^{1} ( ) *(b)* 200 cm ^{1}–4000 cm ^{1} ( )

(c) 100 cm ^{1}–2000 cm ^{1} ( ) *(d)* 200 cm ^{1}–2000 cm ^{1} ( )

10. The order of magnitude of electronic energy (E_e), vibrational energy (E_υ) and rotational energy (E_r) levels in molecular spectra is

(a) E_r E_υ E_e ( ) *(b)* E_e E_υ E_r ( )

(c) E_υ E_r E_e ( ) *(d)* E_υ E_e E_r ( )

SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. Show that the speed of orbiting electron is inversely proportional to the principal quantum number n and find the speed of electron in the first Bohr orbit.

OR

2. If the Rydberg constant is R 1097 10^{7}m ^{1}, find the wavelength of associated with H , H , H lines.

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

OR

4. The term of a particular atomic state is $^{2}d_{5/2}$. What are the values of L, S and J?

5. Explain the method of pumping in LASER.

OR

6. Explain the origin of characteristic X-ray spectra.

7. Classify the bands obtained in molecular spectra of a molecule.

OR

8. Differentiate between the spectra from the rigid diatomic rotator and non-rigid diatomic rotator.

9. The exciting line in an experiment is 5460 Å and the Stokes line is at 5520 Å. Find the wavelength of anti-Stokes line.

OR

10. Explain the terms 'sequence' and 'progression' in absorption and emission of vibrational spectra.

(PART : B—DESCRIPTIVE)

(*Marks* : 50)

The figures in the margin indicate full marks for the questions

1. Discuss the characteristics of Sommerfeld's elliptical orbits. Show that the *s*-electron orbit is most elliptic in any family of orbits having the same major axis. 5+5=10

OR

2. Deduce the famous Rutherford's alpha scattering formula. 10

3. *(a)* Derive an expression for the magnetic moment of hydrogen atom. Find the value of Bohr magneton. 5

(b) What is Larmor's precession? Derive an expression for the Larmor's precessional frequency. 1+4=5

OR

4. State and explain Pauli's exclusion principle. Apply it to determine the maximum number of electrons that can exist in a shell. 4+6=10

5. *(a)* What is population inversion? What do you mean by pumping process? How many types of pumping processes are employed while achieving population inversion? 1+1+5=7

(b) What do you mean by three-level laser? 3

OR

6. What are normal and anomalous Zeeman effects? Use classical ideas to explain normal Zeeman effect. 4+6=10

7. *(a)* Explain how diatomic molecule can behave as a harmonic oscillator. Hence find the energy levels. 4+4=8

(b) Write two applications of vibrational spectroscopy. 2

OR

8. Obtain an expression for the rotational energy levels of a diatomic molecule, taking it as a rigid rotator. Discuss its spectrum and the relevant selection rule. 5+5=10

9. *(a)* Describe Frank-Condon principle in emission and in absorption. 4

(b) What are sequence and progression in absorption and in emission for electronic spectrum? 6

OR

10. *(a)* How is Raman spectra used for structure determination of diatomic and triatomic molecules? 6

(b) Give the accounts of vibrational spectra. 4

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