2022

(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. According to Bohr's postulate, an electron of mass m moving in a circular path of radius r with velocity v will satisfy the relation

(a) $\frac{mv}{r} \quad \frac{nh}{2}$ ( )

(b) $\frac{mv}{r} \quad \frac{2}{nh}$ ( )

(c) $mvr \quad \frac{2}{nh}$ ( )

(d) $mvr \quad \frac{nh}{2}$ ( )

Where n 1, 2, 3... is called the principal quantum number.

2. The distance of closest approach of an -particle fired towards a nucleus with momentum p, is r. What will be the distance of closest approach when the momentum of -particle is $2p$?

(a) $2r$ ( )

(b) $4r$ ( )

(c) $\frac{r}{2}$ ( )

(d) $\frac{r}{4}$ ( )

3. Which of the following sets of quantum numbers is not possible?

(a) n 4, l 1, m_l 0, m_s $\frac{1}{2}$ ( )

(b) n 4, l 3, m_l 3, m_s $\frac{1}{2}$ ( )

(c) n 4, l 1, m_l 2, m_s $\frac{1}{2}$ ( )

(d) n 4, l 0, m_l 0, m_s $\frac{1}{2}$ ( )

4. If an atom is in the $^3D_3$ state, the angle between L and S is

(a) $\cos^{1}\frac{1}{\sqrt{3}}$ ( )

(b) $\cos^{1}\frac{2}{\sqrt{3}}$ ( )

(c) $\cos^{1}\frac{1}{\sqrt{2}}$ ( )

(d) $\cos^{1}\frac{\sqrt{3}}{2}$ ( )

5. The most energetic photon in a continuous X-ray spectrum has an energy approximately equal to

(a) the kinetic energy of an incident-beam electron ( )

(b) the total energy of a k-electron in the target atom ( )

(c) the rest energy mc^2 of an electron ( )

(d) the energy of all the electrons in a target atom ( )

6. The number of splitting levels in $2p$ orbital is

(a) 1 ( )

(b) 2 ( )

(c) 3 ( )

(d) 4 ( )

7. For a rigid diatomic molecule, if B is the rotational constant, the spectral lines are separated by a distance

(a) B cm ^{1} ( )

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

(c) $3B$ cm ^{1} ( )

(d) $4B$ cm ^{1} ( )

8. For transition from initial state of quantum number J to J 1, the frequency of absorbed photon is

(a) $\frac{2\hbar^2}{I}(J \quad 1)$ ( )

(b) $\frac{1}{2 \quad \hbar^2 I}(J \quad 1)$ ( )

(c) $\frac{\hbar^2}{2 \quad I(J \quad 1)}$ ( )

(d) $\frac{\hbar^2}{2 \quad I}(J \quad 1)$ ( )

9. The zero-point energy of a vibrating diatomic molecule is

(a) $\frac{1}{4} h_{\ os}$ Joule ( )

(b) $h_{\ os}$ Joule ( )

(c) $\frac{1}{2} h_{\ os}$ Joule ( )

(d) $2h_{\ os}$ Joule ( )

Here, $_{os}$ is oscillating frequency.

10. Raman spectra is appeared 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 ANSWER)

(*Marks* : 15)

Answer the following : 3×5=15

UNIT—I

1. The wavelength of the Balmer series in hydrogen is 3646 Å. Calculate Rydberg constant in cm ^{1}.

OR

2. Using the Sommerfeld's elliptical model of an atom, discuss the fine structure of H line.

UNIT—II

3. Calculate the Lande's g-factor and total magnetic moment for $^{2}D_{3/2}$.

OR

4. State and proof the Larmor's theorem.

UNIT—III

5. What is Auger effect? Explain the emission of Auger electron.

OR

6. Explain the population inversion in laser action.

UNIT—IV

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

OR

8. Calculate the moment of inertia and inter-nuclear distance of CO molecule. (Rotational constant B 1 921 cm ^{1} and the masses of carbon and oxygen are respectively 12·011 amu and 15·99 amu, N_a 6 024 10^{23} mole ^{1})

UNIT—V

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

OR

10. Discuss the main comparison of Raman scattering and IR scattering. Write the intensity curve for the two.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following : 10×5=50

UNIT—I

1. Derive the formula for Rutherford's scattering cross-section and discuss its limitations. 6+4=10

OR

2. State and explain the basic postulates of Bohr's atomic model and derive the expression for total energy of an electron. 5+5=10

UNIT—II

3. State and explain Pauli's exclusion principle. On the basis of this principle, how do you calculate the number of electrons that can occupy in a sub-shell inside an atom? 2+3+5=10

OR

4. Show how the concept of spinning of electron accounts for the doubling of levels in atomic spectra. Find the shift of fine structure from the hypothetical term value for *p* and *d* orbitals. 10

UNIT—III

5. What is Zeeman effect? Give the classical theory of normal Zeeman effect and derive the expression for Zeeman shift. 3+4+3=10

OR

6. What is Einstein's coefficient in LASER system? Derive the necessary equations to express the Einstein's *A* and *B* coefficients. 3+7=10

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 harmonic oscillator. 10

OR

8. With necessary diagram, obtain 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 rotators. 7+3=10

UNIT—V

9. Explain the 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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