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[130/A16]

SARDAR PATEL UNIVERSITY

M. Sc. (Physics) – I Semester Examination

Day: Friday **Date:** 26-10-2018 **Time:** 10.00 AM to 1.00 PM

Paper code: PS01CPHY03 **Subject:** Atomic Molecular and Laser Physics

Max. Marks: 70

Q.1 Choose the correct answer from the given choices. Only one choice is allowed. **(08)**

(1) For the Rydberg atoms, the difference of energies of adjacent levels ($\Delta E = E_{n+1} - E_n$ in eV) is equal to

(A) $13.6\left(\frac{1}{n^2} - \frac{1}{(n+1)^2}\right)$ (B) $13.6\left(\frac{1}{n} - \frac{1}{n+1}\right)$ (C) $\left(\frac{13.6}{(n+1)^2}\right)$ (D) $\left(\frac{13.6}{n^2}\right)$

(2) The ground state term for lithium is

(A) $^2S_0$ (B) $^2S_{1/2}$ (C) $^2P_0$ (D) $^2P_{1/2}$

(3) The number of non-degenerate Σ states for a homonuclear diatomic molecule is

(A) one (B) two (C) three (D) four

(4) Frank-Condon principle refers to

(A) transition between vibrational energy levels of two electronic states of a molecule
(B) transition between rotational energy levels of two electronic states of a molecule
(C) transition between vibrational energy levels of single electronic state of a molecule
(D) transition between rotational energy levels of single electronic state of a molecule

(5) Which of the following laser uses optical pumping?

(A) He-Ne laser (B) CO_2 laser (C) Ruby laser (D) Semiconductor laser

(6) In Raman scattering, anti-Stokes lines are obtained when the energy of the emitted photon is

(A) greater than the incident photon
(B) less than the incident photon
(C) same as the incident photon
(D) not related to the incident photon

(7) In a He-Ne laser, the lasing action takes place in

(A) Ne atoms (B) He atoms (C) Both He and Ne atoms (D) impurity atoms

(8) If ν is the frequency of the incident photon in an active medium of a laser, the ratio of Einstein coefficients A and B proportional to

(A) ν^4 (B) ν^3 (C) ν^2 (D) ν

Q.2 Answer any SEVEN of the following questions briefly. **(14)**

(1) What is Pauli's principle? Explain its physical significance?

(2) Explain the difference between the hyperfine structure effects and isotope shifts.

(3) For two-electron atoms, prove that: (i) $S^2\chi_-(1,2) = 0$ and, (ii) $S^2\chi_+(1,2) = 2\,\chi_+(1,2)$

(4) Which of the following will have identical electronic configuration? He, He^+, Ar, K^+ Write the electronic configuration for all of them.

(5) What is ESR? What type of molecules exhibit this phenomenon?

(6) Is it possible to obtain the condition of population inversion in a two-level system? Explain your answer.

(7) Draw a completely labelled energy level diagram for He-Ne laser. If the wavelength of the light emitted by this laser is 632.9 nm, calculate the difference in energies of the energy levels between which lasing action takes place.

(PTO)

(8) What is MASER? How is it different from LASER?

(9) Explain the phenomenon of Raman scattering.

Q.3 (a) Write the total Hamiltonian that accounts for the fine structure of hydrogenic atoms. Describe the terms in involved and its physical significance. **(06)**

Q.3(b) Describe the Lamb shift in detail. **(06)**

OR

Q.3(b) Explain the model to obtain the Schrodinger equation for two-electron atoms. Write the equation and explain the ortho and para states. Draw a properly labelled complete energy level spectrum of helium. **(06)**

Q.4(a) Describe the assumptions involved in the Thomas-Fermi model for many-electron atoms. Derive the Thomas-Fermi equation in terms of dimensionless function $\chi(x)$, where x is a dimensionless variable. Discuss the solutions of this equation corresponding to different limiting values of x. **(06)**

Q.4(b) Describe the Born-Oppenheimer separation of nuclear and electronic degrees of freedom for the case of diatomic molecules. Derive the electronic wave equation and the nuclear wave equation. **(06)**

OR

Q.4(b) What is LCAO method? Describe the use of this method to solve the Schrodinger equation for hydrogen molecular ion. **(06)**

Q.5(a) Describe the principle of LASER. Which are the essential components of a LASER? Describe each in brief. **(06)**

Q.5(b) Describe the process of absorption, spontaneous emission and stimulated emission of photon on its interaction with molecules. Derive the expressions for the Einstein coefficients and discuss the conditions under which lasing action takes place. **(06)**

OR

Q.5(b) With the help of an appropriate example, describe the three-level pumping scheme in LASER. What are the advantages and disadvantages of this scheme? **(06)**

Q.6(a) Describe the hyper-Raman effect using classical as well as quantum mechanics. **(06)**

Q.6(b) Describe the principle, construction and working of a CO_2 laser. Draw necessary diagrams with proper labels. **(06)**

OR

Q.6(b) Describe NH_3 maser in detail. **(06)**

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