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SARDAR PATEL UNIVERSITY
M.Sc. (Physics) (I Semester) Examination
Day & Date: Saturday   , 25/4/2015.
Time:10.30 a.m. to 1.30 p.m.
Subject: Atomic, Molecular and Laser Physics
Paper No. PS01CPHY03

Instructions:

(a) Figure to the right indicates marks.   **Total Marks :70.**

(b) All questions are compulsory.

Q.1   Write answer of all questions by showing your choice against the   (8)
question number.

1. The hydrogen Lamb shift corresponds to small energy difference between $2s_{1/2}$ with respect to

    (a) $1s_{1/2}$ (b) $2s_{1/2}$ (c) $2p_{1/2}$ (d) $2p_{3/2}$

2. Identify the pair of meta-stable states of Helium atom.
    (a) 2^3S and 2^1S (b) 2^3S and 2^3P (c) 2s and 2p
    (d) 1s and 2s

3. In atomic units, the kinetic energy operator of an electron is given by
    (a) $-k^2/2$ (b) $-\nabla^2/2$ (c) $mv^2/2$ (d) $kx^2/2$

4. The ground electronic state of Lithium atom is spin
    (a) Triplet   (b) Doublet   (c) Singlet   (d) multiplet

5. The Morse potential for molecules, is repulsive at a distance
    (a)   Much below R_0 (b) equal to R_0 (c) more than R_0
    (d)   all of these

6. In the rotational Raman spectrum the spacing between the 1st Stokes line and the 1st anti-Stokes line is

    (a) 4B   (b) 6B   (c) 12 B   (d) hv

7. Which of the following does not fall in the microwave region?

    (a) ESR   (b) hyperfine structure   (c) Lamb shift

    (d) Lyman–α line

Q.2 Attempt **any SEVEN** of the following: (14)

    (i) Sketch the first three energy levels (in eV) of hydrogen atom, and mark them with proper symbols.

    (ii) Which of the following will have an identical electronic configuration? Also write the configuration of all.
He, He^+, Ar, K^+

    (iii) What is the difference between isotopic shift and hyperfine structure?

    (iv) Write the symbols of the three Einstein coefficients and define them.

    (v) What is holography?

    (vi) What do you mean by optimum out- put coupling?

    (vii) What is the fundamental difference between free-electron laser and other lasers?

    (viii) Sketch the experimental arrangement for studying the absorption spectrum of a sample.

    (ix) With exciting line 2536Å a Raman line for a sample is observed at 2612Å. Calculate the Raman shift in cm^{-1}.

Q.3(a) Explain the simplest models you will use to explain the combined (6) rotational-vibrational spectra assuming small oscillations in a diatomic molecule.

Q.3(b) Set up the 3 dimensional Schrödinger equation for two- electron atom. How (6) do you include the spin in its solution? Define ortho- and para-states for two electron system. With usual notation, for two electron system, prove that
$$S_z\chi_1(1,2) = \chi_1(1,2).$$

OR

Q.3(b) State the assumptions used in the Thomas-Fermi equation for a high- Z (6) atom. Derive Thomas-Fermi equation. Write limitations of TF treatment.

Q.4(a) What are σ and π electrons in a molecule? State and explain the term (6) symbol for the ground state of H_2.

Q.4(b) With neat diagrams explain the '*up*' and '*down*' configurations of NH_3 (6) molecule, indicating its dipole moment vector in both the cases.

OR

Q.4(b) Write detailed note on Lamb shift. Describe the origin of fine structure (6) of hydrogenic atoms.

Q.5(a) Deduce the necessary equations in case of transitions of electrons in two level atoms. **(6)**

Q.5(b) Explain in detail the mechanism involved in three atom model in lasers. **(6)**

<div align="center">**OR**</div>

Q.5(b) Outline some of the applications of NMR. **(6)**

Q.6(a) Discuss in detail the He-Ne laser. **(6)**

Q.6(b) Explain the operation of CO_2 laser. **(6)**

<div align="center">**OR**</div>

Q.6(b) Distinguish in detail between the Rayleigh and Raman scattering. **(6)**

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