

SEAT No. _____

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Sardar Patel University
Vallabh Vidyanagar

M Sc (Physics)- I Semester Examination (NE)
PS01CPHY22 Atomic & Molecular Spectroscopy and Statistical Mechanics
Day and Date: Thursday, 12 April 2018

Time: 2:00 to 5:00 pm

Max marks: 70

I Choose the best possible answer from the given choices. (8x1=8)

- The ground state wave function of hydrogen atom is given by.
(a) $\exp(-Zr^2/a_0)$ (b) $\exp(-Zr/a_0)$
(c) $(1-Zr) \exp(-Zr)$ (d) $a_0 r \exp(-Zr/a_0)$
- Typically, the molecular vibrational transitions lie in the
(a) U-V range (b) Optical range
(c) Infrared region (d) X-ray region
- The process of scattering of light from a conduction band electron spin is reversed is known as
(a) CARS (b) SFRS
(c) CSRS (d) HFRS
- According to the Thomas-Fermi model of the atom, the total number of individual electrons states for energies up state E is proportional to
(a) $E^{3/2}$ (b) $E^{1/2}$
(c) E^2 (d) $E^{2/3}$
- The scaling laws can help us to express all the critical exponents in terms of
(a) only two independent ones (b) Critical temperature only
(c) four independent ones (d) all the critical field values.
- A pure state is represented by
(a) $Tr(\hat{\rho}) = 0$ (b) $Tr(\hat{\rho}) = 1$
(c) $\hat{\rho} = \hat{\rho}^2$ (d) $\hat{\rho} = \hat{\rho}^\dagger$
- If a system of bosons undergoes a phase transition to BEC state, its fugacity approaches to
(a) zero (b) 2.162
(c) 2 (d) one
- The stability of neutron stars are understood as its gravitational pressure balances with the
(a) Radiation pressure (b) Electron degeneracy pressure
(c) Neutron degeneracy pressure (d) Proton degeneracy pressure

C.P.T.O.)

II Attempt any seven of the following short answer questions.

(7x2=14)

1. Show that the total number of degenerate states in the case of hydrogen atom are proportional to square of the principal quantum number.
2. List the physical factors involved in Fine structure, Lamb shift and Hyper fine structure.
3. What is auto-ionization? Explain.
4. Explain the difference between Rayleigh and Raman Scattering
5. Derive the partition function corresponds to the translational motion of free particles.
6. How density operator for canonical ensemble is written?
7. Discuss the behaviour of the fugacity of ideal boson gas at very low temperatures.
8. Illustrate the diagrammatic representation of a typical Cluster integral.
9. Explain the physical interpretation of Boltzmann H-Theorem.

- III A. What was the major assumption in the Thomas Fermi model for many electron systems? What was the major source of error in calculation of energy of many electron systems using this model? (6)
- B. Write the expression for linear expansion of i^{th} molecular orbital using LCAO approximation. Briefly explain (qualitatively) the procedure used to determine the coefficients used here. (6)

OR

- B. Discuss the Schrödinger equation for two electron atoms by taking into account of the spin of the two electrons and Pauli exclusion principle. (6)

- IV A. What are Einstein coefficients? Explain the parameters A_{21} , B_{12} , and B_{21} . Explain in brief the working mechanism of two and three level laser systems with diagrams. (6)
- B. What are the symmetry issues while employing Raman spectra of vibrational spectra of molecules? How is it solved using hyper Raman spectra? Explain in brief. (6)

OR

- B. Explain the working principle of a free electron laser. (6)

- V A. Derive density matrix and the partition function for a system of free particles in momentum space. (6)
- B. Discuss in detail Mayer's cluster expansion for a real classical gas. (6)

OR

- B. What is Fermion degeneracy? Explain how a white dwarf star gets into a steady state condition. (6)

- VI A. Explain critical phenomenon. Discuss the behaviour of physical parameters near the critical points. Deduce the various scaling relations among the critical exponents. (6)
- B. Discuss the theory of Brownian motion. What important conclusion that you can draw from Brownian motion? (6)

OR

- B. How the phase transitions are classified? Explain in detail Landau's theory of second order phase transition. (6)

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