Exam. Code : 209002
Subject Code: 5387

M.Sc. Physics 2nd Semester

STATISTICAL MECHANICS

Paper—Phy-453

Time Allowed—3 Hours] [Maximum Marks—100

Note :— Section A is compulsory. Attempt **ONE** question each from Sections B, C, D and E. All questions carry equal marks.

SECTION—A

(Each question carries 2 marks)

1. What is Langevin function and discuss its behaviour at low and high temperatures ?
2. For canonical ensemble, express specific heat at constant volume (C_v) and mean energy (U) in terms of Helmholtz free energy (A).
3. Write expression for the partition function for 1-D harmonic oscillator.
4. Write an expression for the energy fluctuation in the canonical ensemble.

5. How is grand canonical partition function related to the canonical partition function ?

6. What is expectation value of the σ_z for an electron in magnetic field ?

7. A system has three energy levels E_1, E_2 and E_3 with degeneracies 2,1,1 respectively. Write partition function and expression for mean value of energy.

8. What is Debye T^3 law in solids ?

9. How is Fermi energy fixed for the system having level density g(E) and particle number N ?

10. Differentiate between microcanonical ensemble and grand canonical ensemble.

SECTION—B

(Each question carries 20 marks)

1. What is Gibbs paradox and how was it resolved ?

2. Discuss the statistical mechanics of the classical ideal gas.

SECTION—C

(Each question carries 20 marks)

1. Derive the statistics of Pauli paramagnetism.

2. Discuss q-potential and how is it related to grand canonical partition function. How the thermodynamical quantities can be written in terms of q-potential ?

SECTION—D

(Each question carries 20 marks)

1. Discuss the quantum mechanical statistics of microcanonical, canonical and grand canonical ensembles.

2. What is the expectation value of the Hamiltonian for a free particle in a box ?

SECTION—E

(Each question carries 20 marks)

1. Discuss the quantum mechanical statistics of ideal gas in microcanonical ensemble.

2. Discuss Bose-Einstein condensation in ultra-cold atomic gases.

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M.Sc. Physics 2nd Semester

ATOMIC & MOLECULAR SPECTROSCOPY

Paper—Phy-454

Time Allowed—3 Hours] [Maximum Marks—100

Note :— Section A is compulsory. Attempt one question from each of the Sections B, C, D and E.

SECTION—A

1. (a) Which one term is possible out of the terms 3^2D_2 and 4^3F_4? Write the values of quantum numbers n, l, s and j for a possible term.

   (b) What are fundamental and hot bands ?

   (c) What do you mean by band centre, P and R branches ?

   (d) What are the conditions for a diatomic molecule to be infrared active ?

   (e) Write Morse formula for potential energy and draw Morse curve for a diatomic molecule.

   (f) What do you understand by the fine structure of atomic spectra ?

   (g) Distinguish between simple, compound and anomalous triplets.

(h) Express g-factor in terms of quantum numbers.

(i) What is spin-orbit correction factor in case of Paschen-Back effect ?

(j) What do you mean by normal and inverted triplet ?

2×10=20

SECTION—B

2. (a) What is the basis of origin of vector model of an atom ? What are its salient features ? How they can be experimentally verified ? 10

(b) Compute the terms for two equivalent d-electrons using Briet's scheme. Show that for a 3d4s electronic configuration, the total ^2D separation is same in both L-S and J-J couplings. 10

3. (a) Derive an expression for the interaction energy due to spin-orbit interaction in two valance electron system. 12

(b) What are qualitative and quantitative rules of relative intensity in case of doublet system ? Also determine the relative intensity of spectral lines arising from the transition $^2D_{5/2,\,3/2}$ to $^2P_{3/2,\,1/2}$. 8

SECTION—C

4. (a) Describe briefly the line broadening due to external effects like collision damping, asymmetry and pressure effects. 10

(b) Illustrate with the help of diagrams the splitting of ^2D levels of sodium when :

(i) a weak magnetic field

(ii) a strong magnetic field is applied. 10

5. (a) Define Lande's splitting factor. Derive its expressions under L-S and J-J coupling schemes in two valance electron system. 10

(b) Explain Stark effect under strong weak electric field for hydrogen atom. 10

SECTION—D

6. (a) How can electromagnetic radiations leads to change the rotational levels of a molecule ? What are the rotational selection rules ? What conditions determine the intensity of rotational spectral lines ? 10

(b) Discuss the spectra of CO molecule, when the bond is assumed to be non-rigid bond. 10

7. (a) What do you mean by the presence of anharmonicity in the actual vibrating molecules ? How it effects the vibrational levels and selection rules ? 10

(b) Discuss the IR spectra of a diatomic vibrating rotator. 10

SECTION—E

8. (a) Describe the chief characteristics of vibrational and pure rotational Raman spectra. 10

   (b) How the combined Raman and IR spectroscopy is useful in determining the structure of molecules ? Discuss with examples. 10

9. (a) Define Franck-Condon Principle. Discuss the intensity distribution in the absorption and emission bands from Frank-Condon Principle. 10

   (b) Write a note on dissociation energy and dissociation products. 10