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MPHY-503

Statistical Mechanics and Foundation Of Quantum Mechanics

M.Sc. Physics (MSCPHY-20)

IstSemester, Examination, June 2022

Time : 2 Hours Max. Marks : 40

Note : This paper is of Forty (40) marks divided into two (02) Sections A and B. Attempt the questions contained in these sections according to the detailed instructions given therein.

SECTION – A

(Long-answer – type questions)

Note : Section 'A' contains Five (05) long-answer-type questions of Ten (10) marks each. Learners are required to answer any Two (02) questions only.

(2×10=20)

P.T.O.

1. What is meant by micro canonical, canonical and grand canonical ensembles? Show that for a perfect gas represented by a grand canonical ensemble, the probability of finding the system with n atoms is given by Poisson distribution

   $\omega(n) = \frac{1}{n!} (\bar{n})^n \exp(-\bar{n})$

   where n is the mean number of atoms present.

2. Obtain partition function for grand canonical ensemble. What is the effect of (a) shifting the zero level of energy, (b) decomposition of the system, on partition function?

3. Deduce Maxwell – Boltzmann law for the distribution of molecules in a gas. Use the law to prove the theorem of equipartition of energy among various degrees of freedom of the molecules.

P.T.O.

4. Describe Bose-Einstein condensation for an ideal gas. For a strongly degenerate Boson gas, show that:

Condensation temperature $T_B = \frac{0.084h^2}{\gamma^{2/3}mk}\left(\frac{N}{V}\right)^{2/3}$

Where N and V are number of atoms and volume of the gas and γ = 2S + 1, S is spin of particle

5. Explain the different postulates of quantum statistical mechanic. Describe eigen functions and eigen values.

SECTION – B

(Short – answer – type questions)

Note : Section 'B' contains Eight (08) short – answer type questions of Five(5) marks each. Learners are required to answer any Four (04) questions only. (4×5 = 20)

P.T.O.

1. Describe postulates of classical statistical mechanics.

2. Establish relation between statistical and thermodynamical quantities. Show that

   $F = - kT \log Z,$

   Where Z is the partition function and F is Helmholtz free energy.

3. A system consisting of 3 independent particles localized in space. Each particle has two states of energy 0 and $\in$. When the system is in thermal equilibrium with a heat reservoir at temperature T calculate its partition function.

4. In a linear vector space describe Dirac's bra and ket vectors.

P.T.O.

5. Describe Liouville's theorem in terms of the principle of conservation of density and extension in phase space.

6. What is the canonical ensemble of systems? For a system in thermal contact with a heat reservoir, prove that :

$$\bar{U} = - \frac{\partial lnz}{\partial \beta},$$

Where $\bar{U}$ and Z are average and partition function of the system and β is temperature parameter.

7. Explain the concept of eigen functions and discuss uncertainty principle. Use it to explain why electrons cannot exist inside the nucleus.

8. What do you mean by degeneracy of system? Find the equation of state of a weakly degenerate Fermion gas.
