B.Sc. 6th Semester (Honours) Examination, 2020-21

PHYSICS

Course ID: 62412 **Course Code: SH/PHS/602/C-14/T-14**

Course Title: Statistical Mechanics (T14)

Time: 1 Hour 15 Minutes **Full Marks: 25**

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Section-I

1. Answer any ***five*** questions: 1×5=5

a) Give an example of canonical and grand canonical ensemble.

b) How do you connect the statistical mechanics and thermodynamics?

c) What do you mean by statistical equilibrium?

d) Compare BE and FD distribution functions graphically.

e) Write down Sackur-Tetrode formula.

f) What do you mean by chemical potential of a system?

g) Does electron have zero energy at 0 K? If not why?

h) Calculate the number of ways of arranging 10 Fermions in 15 phase cells.

Section-II

2. Answer any ***two*** questions: 5×2=10

a) How can you determine the Fermi level from the knowledge of particle density in the system? Sketch the Fermi distribution function for T = 0K and T > 0K. (4+1)

b) What is Bose-Einstein condensation? Using BE statistics, describe Plank's law for black body radiation in terms of wavelength. (1+4)

c) (i) Define ensemble and partition function in the context of statistical mechanics.
(ii) A system of N particles obeying MB-statistics possesses three energy levels $E_1 = 0$, $E_2 = \in$, $E_3 = 10\in$. Find the temperature below which the levels E_1 and E_2 are occupied. What is the average energy <E> of the system at temperature T? (2+3)

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d) Discuss the temperature variation of Fermi level (E_f) . Show that the average KE per electron for a 3-D free electron gas at 0 K is $\bar{E}_0 = \left(\frac{3}{5}\right)\bar{E}_{f(0)}$. Under what limiting condition the FD and BE distribution functions tend to MB distribution? (3+1+1)

Section-III

3. Answer any ***one*** question: 10×1=10

a) (i) Write down the partition function for quantum harmonic oscillator and calculate the heat capacity.
(ii) Assuming the electrons to be free, calculate the total number of states below E = 5 eV in a volume $10^{-5}\ m^3$.
(iii) What is Gibb's Paradox? What is its origin? Discuss how this paradox can be resolved.
(4+3+3)

b) (i) Define Phase space. A particle moves in 1D space under a potential V = a|x| with some non-zero kinetic energy, where a>0. Draw the phase space trajectory.
(ii) Why the elementary volume of a cell in phase space for quantum particle cannot be zero?
(iii) Derive the equation for number of phase space cells in the energy interval E and E+dE.
(1+3)+2+4