19P209 (Pages: 2) Name……..……………….

Reg. No……..……………..

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, APRIL 2020

(CUCSS - PG)

CC19P PHY2 C07 - STATISTICAL MECHANICS

(Physics)

(2019 Admission – Regular)

Time: Three Hours Maximum: 30 Weightage

Part A

Answer ***all*** questions. Each question carries 1 weightage.

1. How the physical reason for reducing the number of microstates in resolving the Gibbs paradox is explained?
2. State and explain Liouville's theorem.
3. How the uncertainty principle plays an important role in finding the number of representative points in phase space?
4. Explain the *virial theorem* of Clausius. How can it be applied to classical ideal gas?
5. Write the expression which shows the entropy of a physical system is solely and completely determined by the probability values of its accessible dynamical states. What conclusions can be derived from it?
6. Why the postulate of *random a priori phases* is invoked in quantum statistics?
7. 'The ratio of specific heats C_p and C_v obtained in the case of classical ideal gas is not so in the case of ideal Bose gas'. Justify.
8. Distinguish between the approaches adopted by the Planck and Bose in describing the distribution of energy over the black-body spectrum.

(8 x 1 = 8 Weightage)

Part B

Answer any ***two*** questions. Each question carries 5 weightage**.**

9. Discuss in detail the problem of paramagnetism quantum mechanically by using classical ensemble theory and hence describe what happens when the quantum number $J \rightarrow \infty \; and \; J = \frac{1}{2}$. Is J = 0 possible in this case? Why?
10. Discuss the density and energy fluctuations in the grand canonical ensemble and hence find a correspondence with the other ensembles.
11. Describe the problem of ideal gas in both quantum mechanical canonical and grand canonical ensembles by considering M.B. case, B.E. case and F.D. case and hence arrive at a general equation for the q-potential, applicable to three cases.

12. Discuss in detail, Landau diamagnetism by quantum mechanical ensemble theory.

(2 x 5 = 10 Weightage)

Part C

Answer any ***four*** questions. Each question carries 3 weightage.

13. Write the Sackur-Tetrode equation and hence obtain an expression for chemical potential of classical ideal gas in terms of N, V and T. Check whether it is intensive or extensive.
14. From dimensional considerations, the fundamental volume ω_0 in the phase space must be in the nature of an 'angular momentum raised to the power of 3N'. Justify the statement by taking the classical ideal gas system.
15. Consider a system of classical ideal gas consisting of N number of particles having energy E enclosed in a volume V.
    (a) Write the expression for the number of microstates of $\sum(N, V, E)$,
    (b) Obtain the expression for density of states for energy in view of Gibbs correction factor and hence find out its canonical partition function and
    (c) Check whether the result is correct by invoking inverse Laplace transform.
16. The canonical partition function of a single particle in a classical ideal gas of N particles enclosed in a volume V is proportional to a function of temperature *f (T).*
    (a) Write the expression for grand partition function of the system,
    (b) Obtain the equation of state of the system and its specific heat capacity at constant volume and
    (c) Suppose if $f(T) \propto T^n$, obtain the energy density of the gas and also mention the peculiarity of the values for n = 3 and n = 3/2.
17. Prove that the expectation value of any given physical quantity G is manifestly independent of the choice of the basis $\{\Phi_n\}$. Find out the expectation value of the z - component of Pauli spin operator $\hat{\boldsymbol{\sigma}}$ in the case of a single electron in a magnetic field.
18. Discuss analytically and graphically the variation of specific heat capacity at constant volume with temperature at (a) $T < T_c$, (b) $T = T_c$ and (c) $T > T_c$ for an ideal Bose gas.
19. For an ideal Fermi gas, prove that

$$\frac{C_v}{Nk} = \frac{15 f_{5/2}(z)}{4 f_{3/2}(z)} - \frac{9 f_{3/2}(z)}{4 f_{1/2}(z)}$$

(4 x 3 = 12 Weightage)

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