QP CODE: 20000683

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Reg No : ....

Name : ....

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MSc DEGREE (CSS) EXAMINATION , NOVEMBER 2020

Second Semester

M Sc PHYSICS

CORE - PH010203 - STATISTICAL MECHANICS

2019 Admission Onwards

BB74DED3

Time: 3 Hours

Weightage: 30

Part A (Short Answer Questions)

Answer any **eight** questions.

Weight **1** each.

1. How do you represent a microstate for an N particle system in classical phase space?
2. Calculate the number of microstates $g(p)dp$ for a free particle confined to a volume V whose momentum is lying in between p and $p + dp$.
3. "Energy fluctuations of the systems are related to the ability of the system to lose or absorb energy". Explain.
4. State and explain virial theorem.
5. Illustrate grand canonical ensemble with an example.
6. Obtain the grand partition function for system of independent localized particles, if the single particle canonical partition function is $Q_1(V,T) = kT/\hbar\omega$.
7. Explain how the classical systems and quantum systems with distinguishable particles are different from quantum systems with indistinguishable particles.
8. Deduce Wein's formula for black body radiation.
9. Plot the variation of specific heat capacity with temperature for solids for the different models.
10. Discuss the concept of thereshold frequency in photoelectic effect. How is it related to the work function of the metal?

(8×1=8 weightage)

Part B (Short Essay/Problems)

Answer any **six** questions.

Weight **2** each.

11. Show that for an ideal gas composed of monatomic molecules the chamge in entropy between any two temperatures atconstant pressureis $5/3$ times the corresponding chamge in entropy change at constant volume.

12. Suppose there are four non-degenerate energy levels with energies $0,\ 1.9\times 10^{-20}J,\ 3.6\times 10^{-20}J$ and $5.2\times 10^{-20}J$. The system is observed repeatedly and it is found that the probabilities of being in these levels are $p_0 = 0.498,\ p_1 = 0.264,\ p_2 = 0.150$, and $p_3 = 0.088$. Is the system in thermal equilibrium and if so what is the temperature.

13. Show that for an ideal gas, $\frac{S}{Nk} = \ln\left(\frac{Q_1}{N}\right) + T\left(\frac{\partial \ln Q_1}{\partial T}\right)_P$, where Q_1 is the single particle cannonical partition function.

14. Show that $\mathrm{Tr}(\hat{H}\hat{\rho}) = \frac{3}{2}kT$ for a free particle of mass m in a cubical box of side L in canonical ensemble.

15. Argue that the statistical weight factor for the distribution $\{n_i\}$ for a system of bosons $W_{BE}\{n_i\} = 1$.

16. Discuss the statistics of occupational number for the three distributions and show that they converge to the same value in the classical limit.

17. Given the grand partition function of a charged particle in an external magnetic field In $Q = \frac{-V}{6h^3}(2\pi m)^{3/2}(\mu_{eff}B)^2\sqrt{\beta}f_{1/2}(z)$. show that $(\chi_\infty)_{dia} = \frac{1}{3}(\chi_\infty)_{para}$(take $\mu^* = \mu_{eff}$).

18. Calculate under what pressure water would boil at 120^0C. One gram of steam occupies a volume of 1677 cm^3 . Latent heat of steam = 540cal/g, $J = 4.2\times 10^7$ erg/cal. Atmospheric pressure = $1.0\times 10^6 dyne/cm^3$.

(6×2=12 weightage)

Part C (Essay Type Questions)

Answer any **two** questions.

Weight **5** each.

19. Derive the thermodynamic properties of classical ideal gas by explicitly computing the number of microstates $\Omega(N,V,E)$. (Treating Ideal gas as particles confined in a cubical box of volume $V = L^3$ with single particle energy $\epsilon_{n_x,n_y,n_z} = \frac{h^2}{8mL^2}(n_x^2 + n_y^2 + n_z^2)$).

20. Discuss the energy and particle number fluctuations in grand canonical ensemble.

21. Explain Bose-Einstein Condensation . Deduce the expression for critical temperature.

22. Discuss the nature of Fermi gas at finite but low temperatures and arrive at the equation of state . Show that the specific heat capacity is proportional to the temperature.

(2×5=10 weightage)