REV-01
MSP/41/21/26

2023/01

M.Sc. PHYSICS
FIRST SEMESTER
STATISTICAL PHYSICS
MSP – 102
[USE OMR SHEET FOR OBJECTIVE PART]

SET B

Duration : 3 hrs.

Full Marks : 70

(Objective)

Time: 30 min.

Marks: 20

Choose the correct answer from the following: ***1X20=20***

1. During the density fluctuations in grand canonical ensemble, the fugacity is denoted by --------.
   a. $z = exp(-\frac{\mu}{K_B T})$ b. $z = exp(\frac{\mu}{K_B T})$
   c. $z = exp(\frac{\mu}{2K_B T})$ d. $z = exp(-\frac{\mu}{2K_B T})$
2. According to Gibb's, which of the following expression represents the principle of conservation of density in phase-space?
   a. $\frac{\partial \rho}{\partial t} = 0$ b. $\frac{\partial \rho}{\partial t} = 0$
   c. $\partial\left(\frac{\delta N}{\partial t}\right) = 0$ d. $\partial\left(\frac{\delta N}{\partial t}\right) = 0$
3. In which of the following ensemble systems, the internal energy is given by $U = U = \frac{3}{2}\overline{n}$KT? [2]
   a. Microcanonical ensemble b. Canonical ensemble
   c. Grand canonical ensemble d. None of these
4. Which of the following is the correct representation of grand partition function?
   a. $\Omega = n - \tau log\ Z$ b. $\Omega = \tau log\ Z$
   c. $\Omega = -\tau log\ Z$ d. $\Omega = n + \tau log\ Z$
5. For a canonical ensemble, the probability distribution is given by ----------.
   a. $\rho(E) = Ae^{-\frac{E}{KT}}$ b. $\rho(E) = Ae^{\frac{E}{KT}}$
   c. $\rho(E) = Ae^{-\frac{E}{2KT}}$ d. $\rho(E) = Ae^{\frac{E}{2KT}}$
6. The priori a probability G or the distribution is based upon the properties of the --------
   a. phase-point b. representative point
   c. cell d. none of these
7. For isothermal isochoric transformation, which of the following is the correct expression for energy of an ensemble in terms of partition function?
   a. $E = NKT^2\left[\frac{\partial(log\ Z)}{\partial T}\right]_P$ b. $E = NKT^2\left[\frac{\partial(log\ Z)}{\partial P}\right]_V$
   c. $E = NKT^3\left[\frac{\partial(log\ Z)}{\partial T}\right]_V$ d. $E = NKT^2\left[\frac{\partial(log\ Z)}{\partial T}\right]_V$

8. The state of a system in a phase space is represented by:
   a. n independent position coordinates
   b. 2n combined coordinates
   c. n independent momentum coordinates
   d. n combined coordinates
9. The Helmholtz free energy in terms of partition function can be expressed as ----------.
   a. $F = kTlogZ$
   b. $F = kTlogZ$
   c. $F = \sigma TlogZ$
   d. $F = \sigma TlogZ$
10. Which among the following obey Maxwell-Boltzmann statistics?
   a. photon
   b. neutron
   c. oxygen molecule
   d. hydrogen-molecule
11. Which among the following has fluctuation in temperature?
   a. Canonical ensemble
   b. Grand canonical ensemble
   c. Micro-canonical ensemble
   d. Both a and b
12. Phase coexistence curve is defined as
   a. Line separating two phases
   b. Line fusing two phases
   c. Both (a) and (b)
   d. None of these
13. The photon energy for a 900 nm light is
   a. 2.21×10^{-20} eV
   b. 2.21×10^{-19} J
   c. 2.21×10^{-19} eV
   d. 2.21×10^{-20} J
14. Pauli Exclusion Principle is strictly followed by
   a. Particles following Fermi-Dirac Distribution
   b. Particles following Bose-Einstein Distribution
   c. Superfluid He
   d. Both b and c
15. Bose-Einstein Condensate is responsible for
   a. Superfluidity
   b. Superconductivity
   c. Both a and b
   d. None of the above
16. Triple point in phase transition is defined as the unique pressure and temperature where
   a. Solid, liquid and gas have same number of particles.
   b. Solid, liquid and gas have different densities.
   c. Solid, liquid and gas have same energies.
   d. Both (a) and (c)
7. Particles for which wave function is symmetric under interchange of any two of the particles are called
   a. Fermions
   b. Bosons
   c. Both b and c
   d. All of the above
18. Micro canonical ensemble has
   a. Same energy, volume and number of particles.
   b. Same energy, temperature and volume.
   c. Same energy, temperature and chemical potential
   d. Same temperature, volume and chemical potential
19. Energy transmission in conduction
   a. Transfers heat energy by molecular vibration
   b. Transfers heat energy by actual motion of material
   c. Do not require a material medium for propagation
   d. Both (a) and (b)
20. The formula for radiation power given by Wein's is valid for
   a. Very long wavelengths
   b. Long wavelengths
   c. Both (a) and (b)
   d. Short wavelengths

Descriptive

Time : 2 hrs. 30mins. Marks : 50

[Answer question no.1 & any four (4) from the rest]

1. a. Explain Gibb's paradox. How is it resolved? **5+5=10**

   b. Show that for a perfect gas represented by a grand canonical ensemble, the probability of finding the sub-system with n atoms is given by Poisson's distribution.

   $$w(n) = \frac{1}{n_!}(\bar{n})^n exp. - (\bar{n})^n$$

2. a. Show that the probability that a phase point for a system chosen at random from an ensemble at time $t$would be given by **5+5=10**

   $$d\omega = \rho_N(q,p,t)\prod_{i=1}^{f} dq_i dp_i$$

   b. State both the principles of Liouville's theorem. Which Liouville's theorem is the related to establish the Gibb's principle of conservation of extension in phase space and why?

3. a. Deduce the expression of entropy in terms of partition function for a canonical ensemble. **7+3=10**

   b. $$\sigma = -\sum' \rho_r \log \rho_r$$

4. a. Prove that the dependence of particle number on chemical potential is proportional to the density fluctuations in a grand canonical ensemble. **5+2+3 =10**

   b. Calculate entropy at absolute zero.

   c. Showthat the result$\delta\Omega = \sum E_r \delta p_r$ is consistent with$\delta\Omega = \tau\delta\sigma$if$\sigma = -\sum p_r log\ p_r$where$p_r$is the probability that ther^{th}eigen state is occupied.

5. Define density matrix and state its properties. Define Ising model with example. **5+5=10**

6. Define black body radiation and state its properties. Explain Planck's hypotheses of black body radiation. Explain deviations of Rayleigh & Jeans, Wein's and Stefan & Boltzmann's Laws from Planck's theory. **3+4+3 =10**

7. Derive the wave functions for fermions and bosons. **6+4=10**
Define non-equilibrium processes and states its applications and differences from equilibrium processes.

8. Define superfluidity. Explain in details the properties exhibited by superfluid Helium. **2+6+2 =10**
Briefly explain the Bose-Einstein Condensate.

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