REV-01
BSP/10/15

2024/05

B.Sc. PHYSICS
SIXTH SEMESTER
STATISTICAL MECHANICS
BSP – 602
[USE OMR FOR OBJECTIVE PART]

SET A

Duration: 3 hrs. **Full Marks: 70**

(Objective)

Time: 30 min. **Marks: 20**

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

1. The Gibbs potential in terms of partition function of an equilibrium system is given by____
   a. $G = RT + NkT(\ln Z)$ b. $G = -NkT(\ln Z)$
   c. $G = RT^2 - NkT(\ln Z)$ d. None of these

2. The classical statistics failed to explain---?
   a. Temperature b. Pressure
   c. Energy d. Electron gas

3. The equilibrium state is the state of ---?
   a. Minimum entropy and maximum thermodynamic probability b. Maximum entropy and maximum thermodynamic probability
   c. Minimum entropy and minimum thermodynamic probability d. Maximum entropy and minimum thermodynamic probability

4. In grand canonical ensemble, which one of the following remains constant?
   a. (T, N, V) b. (N, E, V)
   c. (T, μ, V) d. (T, E, V)

5. The mean energy in terms of partition function is given by
   a. $\frac{\partial}{\partial \beta}(\ln Z)$ b. $-\frac{\partial}{\partial \beta}(\ln Z)$
   c. $\frac{\partial}{\partial \alpha}(\ln Z)$ d. $-\frac{\partial}{\partial \alpha}(\ln Z)$

6. The total energy in terms of partition function of an equilibrium system is given by____
   a. $E = NkT^3 \frac{\partial}{\partial \beta}(\ln Z)$ b. $E = NkT \frac{\partial}{\partial T}(\ln Z)$
   c. $E = -NkT^2 \frac{\partial}{\partial T}(\ln Z)$ d. $E = NkT^2 \frac{\partial}{\partial T}(\ln Z)$

7. Root mean square speed is given by
   a. $\sqrt{\frac{kT}{2m}}$ b. $\sqrt{\frac{kT}{m}}$
   c. $\sqrt{\frac{3kT}{2m}}$ d. $\sqrt{\frac{3kT}{m}}$

8. In classical statistics, which of the following statement is true?
   a. The wave functions overlap.
   b. The wave functions do not overlap.
   c. There is no wave function.
   d. The wave functions vanish.

9. The Kirchoff's law of black body radiation is E_λ =?
   a. $\frac{e_\lambda}{a_\lambda}$
   b. $\frac{a_\lambda}{e_\lambda}$
   c. $\frac{e_{\lambda+1}}{a_\lambda}$
   d. $\frac{e_{\lambda-1}}{a_\lambda}$

10. Which of the following statement is false?
   a. According to Planck's hypothesis, the resonators absorb or emit energy continuously.
   b. A black body radiation chamber is also filled with Planck oscillators.
   c. Rayleigh-Jeans law cannot explain the shorter wavelength region.
   d. The energy distribution of black body spectrum is not uniform over a wide range of wavelength.

11. In Bose-Einstein statistics, the occupancy of energy levels:
   a. Can exceed unity
   b. is always less than unity
   c. is equal to unity
   d. Depends on the temperature only

12. Fermi energy is the energy at which:
   a. The occupation probability is 1
   b. The occupation probability is 0
   c. The occupation probability is 0.5
   d. The occupation probability is maximum

13. Which of the following particles obey Bose-Einstein statistics?
   a. Electrons
   b. Neutrons
   c. Photons
   d. Protons

14. Quantum statistics are crucial for understanding the behavior of particles in:
   a. Classical gases
   b. Degenerate gases
   c. Classical liquids
   c. Classical solids

15. Which statistics is relevant for understanding the behavior of white dwarf stars?
   a. Bose-Einstein statistics
   b. Fermi-Dirac statistics
   c. Both Bose-Einstein and Fermi-Dirac statistics
   d. Neither Bose-Einstein nor Fermi-Dirac statistics

16. In which temperature regime does the distinction between Bose-Einstein and Fermi-Dirac statistics become less pronounced?
   a. High temperatures
   b. Low temperatures
   c. Very low temperatures
   d. Intermediate temperatures

17. At what temperature does helium-4 undergo a phase transition to become a superfluid?
   a. 0 K
   b. 2.168 K
   c. 4.2 K
   d. 10 K

18. Which of the following is not a property of superfluid helium?
    a. Zero viscosity
    b. Infinite thermal conductivity
    c. Ability to climb up walls of a container
    d. Ability to sustain a temperature gradient without experiencing a temperature difference

19. What is the significance of Pauli Exclusion Principle in quantum statistical mechanics?
    a. Describes the behavior of identical particles in quantum systems
    b. Ensures the stability of electrons in atoms and molecules
    c. Determines the probability distribution of particles in different energy states
    d. Determines the average energy of a system

20. What does the chemical potential in Bose-Einstein statistics represent?
    a. The energy of the particles
    b. The total number of particles
    c. The temperature of the system
    d. The ability of the system to exchange particles with its surroundings

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Descriptive

Time : 2 hrs. 30 mins. **Marks : 50**

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

1. a. Derive the Maxwell-Boltzmann distribution law ofenergy substituting the values of g_i, α and β. **5+5=10**
   b. Derive the Bose-Einstein distribution law for continuous variation of energy.

2. What is partition function? Find out the relation between entropy and partition function. Derive any five of the thermodynamic properties using partition function. **1+4+5 =10**

3. a. Explain black body radiation and its construction in classical statistics. **3+7=10**

b. State Planck's hypothesis and derive Planck's formula for black body radiation in terms of wavelength and frequency in classical statistics.

4. State and derive Wein's displacement law in classical statistics. **10**

5. **a.** Derive the Maxwell distribution law of velocities and describe its temperature variation. **5**

b. Write the basic postulates of Bose-Einstein and Fermi Dirac statistics. How does FD statistics differ from the BE statistics? **2+2+1 =5**

6. **a.** Explain the concept of Bose-Einstein condensation in a gas of bosonic particles. What conditions are necessary for BEC to occur? Describe the significance of the critical temperature in the context of BEC. **2+2+2 =6**

b. Explain why behaviour of liquid helium cannot be described by the classical statistics. How it is overcome by quantum statistics? **2+2=4**

7. **a.** What is photon gas? Starting from BE energy distribution law, derive Plancks' law of black body radiation. **1+5=6**

b. Define Fermi energy. Calculate the value of Fermi energy at absolute zero temperature. **1+3=4**

8. Discuss the free electron gas model for metals. Obtain the distribution law for the electron gas in a metal. **10**

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