REV-01
MSP/35/40

2022/07

M.Sc. PHYSICS
FOURTH SEMESTER
STATISTICAL PHYSICS
MSP – 401

(Use Separate Answer Scripts for Objective & Descriptive)

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

(PART-A: Objective)

Time: 20 min. Marks: 20

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

1. The Γ-space may be considered as a superposition of -------.
   a. μ-space b. π-space
   c. phase-space d. none of these

2. Which of the following particles follow Fermi Dirac Statistics
   a. Photon b. Kaons
   c. Proton d. None of the options

3. If the cells are of equal size then they have the same ---------.
   a. thermodynamic probability b. a priori probability
   c. density d. none of these

4. How many possible numbers of ways to arrange 3 indistinguishable particles into four spaces?
   a. 20 b. 32
   c. 8 d. 16

5. Which among the following has fluctuation in energy?
   a. Micro-canonical ensemble b. Canonical ensemble
   c. Grand-canonical ensemble d. Both options b.& c.

6. In the case of strong degeneracy of an ideal Fermi-Dirac gas, which condition is necessary for the constant α
   a. α is small b. α is large
   c. $0 < \alpha < 1$ d. None of the options

7. The probability of finding a phase point in any particular region of phase space is directly proportional to the ---------.
   a. accessible states b. density
   c. thermodynamic probability d. volume

8. What is the formulation for the spin degeneracy g_s
   a. 2s+1 b. 3s+2
   c. s+1 d. None of the options

9. 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. $\partial\left(\frac{\partial \Gamma}{\partial t}\right) = 0$

c. $\partial\left(\frac{\delta N}{\partial t}\right) = 0$

d. $\rho\frac{d}{dt}(\delta\Gamma) = 0$

10. Which condition holds true for the implementation of Stirling's Approximation?
    a. N±1 ~ N
    b. N > 1
    c. N < 1
    d. None of the Options

11. Many different microstates may correspond to ---------- .
    a. the same macrostate
    b. different macrostate
    c. indefinite macrostate
    d. no macrostate

12. Which energy is usually used for calculation of thermodynamic states?
    a. Potential
    b. Kinetic
    c. Chemical
    d. Gravitational

13. The Helmholtz free energy in terms of partition function can be expressed as ----------.
    a. $F = kTlogZ$
    b. $F = klogZ$
    c. $F = \sigma TlogZ$
    d. $F = \sigma logZ$

14. In which form of statistics is the number of particles limited?
    a. Bose-Einstien
    b. Maxwell-Boltzmann
    c. Fermi-Dirac
    d. None of the options

15. In a grand canonical ensemble, the grand potential can be expressed as ---------.
    a. $\Omega = Ts - U - \mu N$
    b. $\Omega = U - TS - \mu N$
    c. $\Omega = U + TS - \mu N$
    d. $\Omega = U - TS + \mu N$

16. The probability of getting 7 heads and 4 tails in tossing a coin 10 times is ---------.
    a. 1/1024
    b. 12/1024
    c. 120/1024
    d. 124/1024

17. Which among the following obey Maxwell-Boltzmann statistics?
    a. photon
    b. neutron
    c. oxygen molecule
    d. hydrogen-molecule

18. The compounded probability of two occurrences is always
    a. Additive
    b. Subtractive
    c. Multiplicative
    d. Divisive

19. The instantaneous position of a particle in the phase-space is represented by a point known as,
    a. phase point
    b. representative point
    c. both (i) & (ii)
    d. none of these

20. The total thermodynamic probability is given by:
    a. $\Omega = \sum\frac{\omega_j}{N}$
    b. $\Omega = \sum\omega_j$
    c. $\Omega = \frac{\sum\omega_j}{N}$
    d. None of the options

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PART-B : Descriptive

Time : 2 hrs. 40 min. **Marks : 50**

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

1. a. Which Liouville's theorem is related to establish the Gibb's principle of conservation of extension in phase space and Why? **5+5=10**

   b. Express entropy in terms of partition function.

2. a. Explain the importance of the Partition function. **5+5=10**

   b. Explain the case of degeneracy in an ideal Bose Einstein gas

3. a. Deduce the Maxwell-Boltzmann distribution law. **5+3+2=10**

   b. Show that the internal energy of harmonic oscillator of frequency γ are

   $$E = h\gamma\left(\frac{1}{2} + \frac{1}{e^{\theta}-1}\right), where\ \theta = \frac{h\gamma}{kT}$$

   c. Calculate entropy at absolute zero.

4. a. Define the exchange symmetry for Fermi-Dirac and Bose-Einstein particles. **6+4=10**

   b. Explain how the Fermi-Dirac Statistical distributions can be used for practical applications like electronics

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

   b. Show that the entropy of a system in canonical ensemble can be expressed as

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

   where P_r is the probability of the system to be found in i^{th} state.

6. a. Derive the Energy of an ideal Fermi-Dirac Gas. 7+3=10

b. Explain the cases of degeneracy for an ideal Fermi-Dirac Gas.

7. a. Show that for grand canonical ensemble, the Gibb's free energy is $G = \mu\bar{n}$ 7+3=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.

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

8. Deduce the Bose Einstein statistical Distribution function 10

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