B.Sc. PHYSICS
SIXTH SEMESTER
STATISTICAL MECHANICS
BSP – 602

(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. From which statistics, Planck's formula of black body radiation can be derived?
   a. Maxwell-Boltzmann
   b. Bose-Einstein
   c. Fermi-Dirac
   d. Rayleigh-Jeans

2. Which amongst the following is used to convert microscale temperature to macroscale temperature?
   a. ε_0
   b. Both
   c. k_B
   d. None of the options

3. The spin of a photon is
   a. 0
   b. $\hbar/2$
   c. $\hbar/3$
   d. $\hbar$

4. Planck's Law reduces to which law for shorter wavelengths?
   a. Stefan's Law
   b. Rayleigh Jeans Law
   c. Wein's Displacement Law
   d. None of the Options

5. Free electrons in a metal obey ..... Statistics.
   a. Bose-Einstein
   b. Maxwell-Boltzmann
   c. Fermi-Dirac
   d. None

6. What is the minimum number of coordinates in phase space, that can be used to define the location of an electron in an atom?
   a. 2
   b. 1
   c. 3
   d. 6

7. Which of the of following is the low-temperature (T) dependence of specific heat as per Debye's theory?
   a. T^3
   b. $T^{3/2}$
   c. $T^{-1/2}$
   d. T

8. Which of the following parameters can be allowed for transfer between the systems in a micro-canonical ensemble?
   a. Energy
   b. Mass
   c. Both Energy and Mass
   d. None of the Options

9. Below which temperature, He-4 exhibits no viscosity?
   a. 1.85 K
   b. 3.47 K
   c. 2.77 K
   d. 2.17 K

10. If the surface temperature of a star is hotter, then what will be the nature of the mean wavelength emitted by the star?
    a. Mean wavelength is shorter
    b. Depends upon the size of the star
    c. Mean wavelength is longer
    d. None of the Options

11. The wavelength λ at which a black body emits maximum amount of radiation is proportional to
    a. T^3
    b. $1/T$
    c. $T^{1/2}$
    d. T^2

12. Stirling's Approximation is applied under which condition?
    a. N+a ~ N (a is an integer)
    b. N = 0
    c. N <<< 1
    d. None of the Options

13. Which of the following is the rest mass of a photon?
    a. Finite
    b. Infinite
    c. Equal to that of electron
    d. Zero

14. Kirchoff's Law is a relation between any body and which type of physical standard?
    a. Thermal Equilibrium
    b. Black Body
    c. Both Black Body and Thermal Equilibrium
    d. None of the Options

15. At 0K, the average velocity of an electron in a Fermi gas is (v_F is Fermi velocity)
    a. $0.75v_F$
    b. $0.65v_F$
    c. $0.9v_F$
    d. v_F

16. Which of the following can be applied to a system of boilers?
    a. Micro-Canonical Ensemble
    b. Canonical Ensemble
    c. Grand-Canonical Ensemble
    d. None of the Options

17. What is the occupation index of an electron in a Fermi gas at the Fermi energy and T> 0K?
    a. 0
    b. 0.5
    c. 0.75
    d. 1

18. The relation between the radiation pressure and the total energy density is
    a. P = U/2
    b. P = 3*U
    c. P = U/3
    d. None of the Options

19. At 0K, the average energy of an electron in a Fermi gas is
    a. $0.5E_F$
    b. $0.6E_F$
    c. $0.4E_F$
    d. $0.7E_F$

20. Bose-Einstein statistics is for the _____
    a. Distinguishable particles
    b. Symmetrical Particles
    c. Particles with half integral spin
    d. Particles with integral spin

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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. Obtain the expression for the occupation index following the Bose-Einstein distribution law. 1

2. a. Differentiate between Microstates & Macrostates. 4+6=1
   b. Define Ensembles and state how ensembles are related to the microstates and macrostates.

3. a. Explain the need for quantum statistics. 4+2+
   =1
   b. What is Bose-Einstein condensation?
   c. How will you explain BE condensation for liquid helium?

4. a. Derive the Planck's Law. 7+3=1
   b. Show that the Planck's law reduces to Wein's law for shorter wavelengths

5. a. Explain the concept of a 'photon gas'? 3+7=1
   b. How will you obtain Planck's law of black body radiation from Bose-Einstein distribution law?

6. a. A black body at 500^0C has a surface area of $0.5m^2$ and radiates heat at the rate of 1.02×10^4 J/s. Calculate the Stefan's Constant. 5+5=1
   b. Enunciate Kirchoff's Law and derive the mathematical form of the statement.

7. a. What is a degenerate Fermi gas? 2+1+
   =1
   b. Define Fermi energy.
   c. How did Debye explain correctly the behavior of specific heatof metals at both temperatures citing Einstein theory deficiencies.

8. Deduce the Maxwell Boltzmann statistical Distribution function 1

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