TY BSc. Sem VI 23-24

Paper / Subject Code: 24210 / Physics: Mahtematical, Thermal & Statistical Physics

Time: 3 hrs. **M. M.: 100**

N.B.:

1. **All questions are compulsory.**
2. **Figures to the right indicate full marks.**
3. **Draw neat diagrams wherever necessary.**
4. **Symbols have usual meaning unless otherwise stated.**
5. **Use of non-programmable calculator is allowed.**

Constants: Boltzmann Constant k=1.38 x 10^{-23} J/K
Planck's Constants h= 6.26 x 10^{-34} Js

Q1. Attempt any **two**

(i) What is Bernoulli's trial? Explain the Binomial probability function and corresponding cumulative distribution function. **10**

(ii) Explain the terms with suitable example. **10**

A) Chebyshev's inequality
B) Laws of Large Number

(iii) Explain the Poisson distribution and derive the required relation. **10**

(iv) Explain in detail the methods of counting. **10**

Q2 Attempt any **two**

(i) Explain the trigonometric function of a complex number z. Using these **10**

a) Prove that $\sin 2z = 2 \sin z \cos z$

b) Find the value of $\cos(\pi - 2i ln 3)$

(ii) Find the impedance of z_1 and z_2 in series and in parallel if **10**

$$z_1 = 2\sqrt{3}e^{i\frac{\pi}{6}} \quad \text{and} \quad z_2 = 2e^{2i\frac{\pi}{3}}$$

(iii) State the second order non-homogeneous differential equation with constant coefficients and obtain its solution. Hence solve **10**

$$y'' + 3y' + 2y = e^{-x}$$

(iv) The vertical motion of a particle of mass m on a spring with spring constant k is described by the following differential equation: **10**

$$my'' = -ky + mg \qquad (y(0) = y_0 \text{ and } y'(0) = 0)$$

Solve this equation for the position of the particle as a function of time.

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Q3 Attempt any **two**

(i) Derive the relation between internal energy and the canonical partition function. For an ensemble consisting of 1.00 moles of particles having two energy levels separated by $h\nu = 1.0x10^{-20}J$, at what temperature will the internal energy of this system equal 1.00 kJ? **10**

(ii) What is degeneracy? State the equations for partition function and probability of occupying energy level for degenerate states. A system with single states has energy levels 0 and β^{-1}. Calculate its partition function and probability of occupying each energy level. How does its value change for another system having two states present at energy level β^{-1}? **10**

(iii) What is an entropy? Derive the relation $S = klog(W)$. For a temperature of 273 K and a $volume\ of\ 2.24x10^{-2}m^3$ determine the translational partition function for Argon gas (Given mass of Ar = 6.63x 10^{-26} kg). **10**

(iv) What is partition function? Derive an expression for translational partition function. **10**

Q4 Attempt any **two**

(i) Derive the Fermi-Dirac distribution law. **10**

(ii) Obtain the expression for most probable distribution of N identical balls thrown in a random manner, in a large box of area A, divided into k cells of area $a_1, a_2, \ldots, a_k$. **10**

(iii) Derive the Planck's radiation formula for black body cavity having volume V. **10**

(iv) Obtain the expression for Bose-Einstein distribution law. **10**

Q5. Attempt any **four**

(i) If 1500 people each select a number at random, between 1 and 500, what is the probability that 2 people selected the number 44? **05**

(ii) The number of particles emitted each minute by a radioactive source is recorded for a period of 10 hours; a total of 1800 counts are registered. During how many 1-minute intervals should we expect to observe no particles. **05**

(iii) Find the value of i^{-2i} **05**

(iv) Solve the equation **05**

$$\frac{\partial u(x,y)}{\partial x} = 9\frac{\partial u(x,y)}{dy}$$

and find the solution subject to $u(x,0) = 2e^{-3x}$

(v) What is Dominant Configuration? **05**

(vi) The vibrational frequency of I_2 is 208 cm^{-1}. What is the probability of I_2 populating the vibrational level n=2 if the molecular temperature is 298 K? **05**

(vii) Obtain the Stefan-Boltzmann law using the Planck's radiation formula. **05**

(viii) Consider an assembly of N molecules having energies $u_1, u_2, \ldots, u_k$. If there are n_i molecules of energy u_i, then obtain the Maxwell-Boltzmann distribution law. **05**

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