Enrolment No: **Name:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Online End Semester Examination, May 2021

Course: Statistical Mechanics **Semester: VI**
Program: B.Sc (Honors) Physics **Time 03 hrs**
Course Code: PHYS 3004 **Max. Marks: 100**

SECTION A

Each Question carries 5 Marks.

S. No.	Questions	CO
Q.1	(a) In specific heat of solids at low temperature $C_v = T^3$ law is followed. It is explained by (i) Dulong and Petit;s theory (ii) B-E statistics [2] (iii) Debye's theory (iv) both (ii) & (iii) (b) The Debye's temperature is [1] (i) 273K (ii) $\frac{h\nu_m}{k_B}$ (iii) $\frac{h\nu_m}{2\pi k_B}$ (iv) 0K (c) The relative probability between two different energy states having difference of 1.1×10^{-20} Joules at 40K is [2] (i) e^{-1} (ii) e^{-2} (iii) e (iv) e^2	CO2
Q.2	What is the difference between bosons and fermions? Give some examples.	CO1
Q.3	True/False (a) In B-E statistics, the number of particles condensing into ground state are zero. [T/F] (b) In a quatum statistics the particles are identical and indistinguishable. [T/F] (c) For strongly degenerate fermi gas the specific heat is proportional to the absolute temperature. [T/F] (d) In the equilibrium state, the entropy is minimum. [T/F] (e) The relation between entropy and probability is S=k lnΩ. [T/F]	CO1
Q.4	(a) Two stars A and B radiate maximums energy at 360 nm and 480 nm respectively. The ratio of their absolute temperatures is: (i) 3:4 (ii) 4:3 (iii) 256: 81 (iv) 81:257 (b) The temperature of a piece of metal is raised from 27ºC to 512ºC. the rate at which metal radiates energy increases nearly: (i) 1.36 times (ii) 2 times (iii) 4 times (d) 8 times (c) A radiation of energy E and speed C fall normally on a perfectly reflecting surface. The momentum transferred to the surface is: (i) E/ C (ii) E/C^2 (iii) EC (iv) 2E/C (d) A piece of red glass when heated to red hot will appear to be (i) white (ii) red (iii) green (iv) invisible (e) A spherical black body with a radius 12 cm radiates 450W power at 500 K. if the radius were halved and temperature doubled the power radiated in watt would be: (i) 225 (ii) 450 (iii) 900 (iv) 1800	CO2
Q.5	A particle is moving in one dimension. If it is confined to 10^{-5} m of space and its momentum lies between -10^{-25} kg-m/sec and $+10^{-25}$ kg-m/sec, then the number of quantum states is	CO2

	(i) 1000 (ii) 2000 (iii) 3000 (d) 4000	
Q.6	Why He^3 is considered as Fermion and He^4 as Boson?	**CO1**
SECTION B **Each question carries 10 marks**		
Q.1	Demonstrate that neither Wien's law nor Rayleigh Jeans law are able to explain the experimental curve of black body radiation. [4] A spherical blackbody of radius 6 cm is kept at a temperature of 300K. Calculate the wavelength at which maximum energy is radiated. Also, calculate the power radiated. [Stefan's constant is 5.67×10^{-08} W/m^2/K] [6]	**CO2**
Q.2	What do you understand by Bose Einstein condensation? Explain by developing the analogy with normal condensation in Euclidian space. [6] Calculate the critical temperature for He^4 at which the condensation starts. Given that $\frac{N}{V} = 2.2 \times 10^{28} m^{-3}$ and $m = 6.65 \times 10^{-27}$kg. [4]	**CO4**
Q.3	Apply Bose-Einstein statistics to photon gas and derive the Planck's law for the spectral distribution of energy in black body radiation. [10]	**CO3**
Q.4	Given 3 states and 5 molecules. Calculate the thermodynamic probability for (a) $n_1 = 5,\ n_2 = 0,\ n_3 = 0$ (b) $n_1 = 4,\ n_2 = 1,\ n_3 = 0$ (c) $n_1 = 3,\ n_2 = 2,\ n_3 = 0$ (d) $n_1 = 3,\ n_2 = 1,\ n_3 = 1$ (e) $n_1 = 1,\ n_2 = 2,\ n_3 = 2$ Where $n_1,\ n_2,\ n_3$ be the occupation number of state 1, 2 and 3, respectively. [10]	**CO2**
Q.5	(a) Name the some of the amazing properties, which He^4 (He-II phase) possess below the temperature 2.17K. [5] (b) Differentiate between classical and quantum statistics. Under what condition quantum statistics gives same results as classical statistics. [5]	**CO4**
Section C **Each Question carries 20 Marks. There is an internal choice in this section.**		
Q.1	(a) For a system of indistinguishable N particles characterized by non-degenerate energy states, write the partition function and then find out the internal energy, heat capacity at constant volume and Helmholtz free energy for such a system. [10] (b) Consider a one level system having energy $\varepsilon = -k_B T \ln\left(\frac{V}{V_0}\right)$ where V_0 is a constant. Write down the partition function for this system and calculate the average pressure for this system as a function of volume and temperature. [5] (c) A stone at rest falls freely. Determine its phase trajectory. [5] **OR** (a) What do you understand by weakly degenerate, strongly degenerate and completely degenerate Fermion gas. [6] (b) Derive an expression for the Fermi energy at 0K for the completely degenerate F-D gas. Establish the relation between average energy and Fermi energy of an electron. [8] (c) Consider silver in the metallic state with one free (conduction) electron to per atom. Calculate the Fermi energy at 0K. The density of silver is 70.5 gm/cm^3, and its atomic mass is 108. [6]	**CO3**