STATISTICAL MECHANICS

NUMERICALS

1. Three distribution particles have a total energy of 9 units. But the particles are restricted to energy levels from 0 to 4. Calculate the numbers the macrostates and microstates.
2. 8 distinguishable particles are distributed in two compartments. The first compartment is divided into 4 cells and the second into 2 cells. Each cell is of equal a priori probability and there is no restriction on the number of particles that can be contained in each cell. Calculate the thermodynamics probability of a) the most prob. State b) the macrostate (8, 0).
3. Six distinguishable particles are distributed over three non-degenerate levels of energies 0, E and 2E. Calculate the numbers of microstates of the system and the energy of the distribution for which the prob. is a maximum.
4. 3 distinguishable particles each of which can be in one of the E, 2E, 3E, 4E energy states have total energy 6E. Find all possible numbers of distribution of all particles in the energy states.
5. Three distinguishable particles each of which can be in one of the non-degenerate states with 0, 1, 2, 3 energy of the system have total energy of 3 units. Find the microstates if the particles obey a) M-B, b) F-D, c) B-E statistics.
6. Four particles are distributed into three energy levels having energies 0, E, 3E so that the total energy is 4E. If the levels are degenerate with degeneracy 1, 2, 3 respectively, find out the macrostates and the corresponding microstates for M-B particles and B-E particles.
7. 2 particles are distributed into two energy levels with degeneracy 1, 2 respectively. Find the most probable state of the distribution of the particle sin the system, if the particles obey a) M-B, b) F-D, c) B-E Statistics.
8. A system has 7 particles arranged in two compartments. The 1^{st} compartment has 8 cells and the second has 10 cells, all cells are of equal size. Calculate the number of microstates in the macrostates (3, 4), when the particles are Fermions and Boson.
9. A system has two particles, each one of them can be in one of three quantum states. Find the possible number of microstates of the system according to the three statistics.
10. Find the Fermi energy at T=0K for sodium, Given that density of sodium=0.97×10^{3} kg/m^{3}, atomic weight 23, Avogadro's no. 6.023×10^{26}/kg –mol.
11. The Fermi energy of sodium at T=0K is 3.1 eV. Find its value for aluminium given that the free electron density in Al approximately 8 times that in Na.
12. Find the Fermi energy at T=0K for CU, given that $\rho=8.96\times10^{3}$ kg/mol, atomic wt. =63.5, N=6.023×10^{26}/kg –mol.
13. The numbers of conduction electron per CC is 24.2×10^{22} in Beryllium and 0.91×10^{22} in cesium. If the Fermi energy of conduction electrons in Beryllium is 14.44 eV, calculate that in cesium.
14. Fermi energy of conduction electron in silver is 5.48 eV, calculate the number of such electron per CC.
15. Calculation the occupation probability at 2KT units of energy above the Fermi energy E_F.
16. Assuming that in tungsten (at. Wt.=183.8, density=19.3 gm/cc) there are two free-electron per atom. Calculate the Fermi energy and electron density.
17. Find the average velocity of electrons at 0°C in a metal having 3×10^{22} electron per cm^{3}.
18. Consider a free electron gas at 0K and show that the de-Brogle wavelength associated with an electron is given $\lambda_F = 2\left(\frac{\pi}{3n_0}\right)^{\frac{1}{3}}$, where n_0= concentration of electron.

Questions

1. What do you mean by macrostate and microstate?
2. Define thermodynamic probability and most probable state of a system.
3. State the fundamental postulate of statistical mechanics.
4. State what are meant by occupation number, degenerate, non-degenerate energy levels.
5. What is phase space?
6. Define μ- phase space and Γ-phase space. Show that the volume of μ-phase corresponding to a single quantum state for particles with no spin is h^3, and the volume of momentum space corresponding to single quantum state for such particles is h^3/V, where h is Planck's constant , V is the physical volume of the system.
7. Derive the expression for the density of energy state of a system between E to E+dE.
8. Assuming the expression for the Maxwell-Boltzmann count for an isolated system of identical and distinguishable, non-interacting particles derive the M-B distribution law of energy among the molecules of an ideal gas.
9. Define equi -partition law of energy, also derive it from the M-B energy distribution law.
10. Derive Maxwell's law of distribution of molecular speeds.
11. Assuming Maxwell's law of distribution of molecular speeds, derive expressions for the most probable, average and root-mean Square speeds.
12. Define Fermi distribution function and Fermi level. Give a physical interpretation of Fermi level at T=0K and T>0K in metal
13. Sketch the Fermi distribution function for T=0K and T>0K in metal.
14. Verify that the fraction of unoccupied energy states in the energy level below the Fermi level is equal to the fraction of occupied energy states in the energy level above the Fermi level by the same value.
15. How does Fermi energy of free electron gas varies with electron density?
16. Can an electron have zero energy at 0K
17. What do you mean by Fermi temperature and Fermi velocity of an electron in Fermi level?
18. Derive Bose –Einstein energy distribution law and hence obtain Planck's formula for black body radiation.
19. Show that Wien's formula and Rayleigh Jeans formula can be deduced as particular cases of Planck's law.
20. Under what conditions do B-E and F-D statistics yield classical statistics, show it graphically.
21. Using F-D distribution function, derive the concentration of electrons in conduction band and the concentration of holes in valance band in intrinsic semiconductor.
22. Derive the expression of Fermi level in intrinsic semiconductor and also show that at T = 0K, Fermi level is exactly midway between the conduction band and valance band.
23. Derive the expression of carrier concentration in terms of temperature of intrinsic semiconductor.
24. State and establish the law of mass action in semiconductors. What is its significance?
25. What are p-type and n-type semiconductors?
26. Discuss the variation of Fermi level in n-type and p-type semiconductors with temperature.