NRT/KS/19/2137

Bachelor of Science (B.Sc.) Semester—V Examination

ATOMIC PHYSICS, FREE ELECTRON THEORY AND STATISTICAL PHYSICS

Optional Paper—1

(Physics)

Time : Three Hours] [Maximum Marks : 50

N.B. :— (1) **ALL** questions are compulsory.

(2) Draw neat diagrams wherever necessary.

EITHER

1. (A) What is Zeeman effect ? Explain with neat diagram experimental arrangement of Zeeman effect. 5

(B) (i) What is meant by space quantization of orbits in vector atom model ? 3

(ii) Compute the magnetic field gradient of 0.4 m long Stern-Gerlach experiment that would produce a 2 mm separation at the end of the magnet between two components of a beam of silver atoms emitted from an oven at 900ºC. The magnetic dipole moment of silver is due to single $\ell = 0$ electron. 2

OR

(C) What is meant by L-S coupling ? Explain with example 2½

(D) Calculate the values of L, S and J for p-electron in an atom. 2½

(E) Calculate the magnetic field in order to observe the anomalous Zeeman effect of D-lines of wavelengths. λ_1 = 5896Å and λ_2 = 5890 Å.

($c = 3\times10^{10}$ m/s ; $e/m = 1.76\times10^{11}$ c/kg) 2½

(F) State Hund's rule and explain it with the help of suitable example. 2½

EITHER

2. (A) State assumptions of Drude-Lorentz theory. Derive an expression for electrical conductivity of metal on the basis of free electron theory. 5

(B) (i) Define Fermi energy. Show that Fermi energy E_F is a function of density of free electrons. 3

(ii) Calculate the total number of free electrons present in 1 cm length of a monoatomic one-dimensional copper wire.

(Given : Fermi temperature $T_F = 8.1\times10^4$ K, Mass of electron = 9.1×10^{-31} kg) 2

OR

(C) Explain the concept of hole in solids. 2½

(D) Derive expression for density of states for a free electron gas in one dimension. 2½

(E) Explain how atomic energy levels split into bands when number of atoms brought together to form crystal. 2½

(F) The resistivity of a rectangular bar of p-type silicon is 2×10^5 Ω.cm. The magnetic field of 0.1 wb/m^2 is applied to bar of thickness 0.3 cm. If the measured values of current and Hall voltage are 10 μA and 50 mv respectively. Calculate the mobility of charge carriers. 2½

EITHER

3. (A) Derive Maxwell's law of distribution of speeds for the molecules of an ideal gas, using M.B. energy distribution formula, derive expression for most probable speed. 5

(B) (i) Explain Macro and Microstates. 3

(ii) Calculate the value of root mean square speed of a molecule of hydrogen at 27°C. (Given : Boltzmann's constant $k = 1.38\times10^{-23}$ J/molecule K, Mass of hydrogen molecule = 3.34×10^{-27} kg). 2

OR

(C) Explain accessible and inaccessible states. 2½

(D) Show that the smallest volume of unit cell in a phase space is h^3 (h is Planck's constant). 2½

(E) What are the limitations of Maxwell-Boltzmann's statistics ? 2½

(F) Four molecules are to be distributed in two compartments. Calculate possible number of macrostates and corresponding number of microstates. 2½

EITHER

4. (A) Derive an expression for most probable distribution by using Fermi-Dirac statistics. 5

(B) (i) Derive Planck's law of radiation for black body from Bose-Einstein energy distribution law. 3

(ii) Fermi energy of conduction of electrons in silver is 5.48 eV. Calculate the number of such electrons per cm^3.
(Given : $h = 6.62 \times 10^{-27}$ erg-sec, Mass of electron = 9.1×10^{-27} kg, 1eV = 1.62×10^{12} erg) 2

OR

(C) Explain Bose-Einstein condensation. 2½

(D) Derive an expression for Fermi-energy for free electrons in metal. 2½

(E) Distinguish between Bose-Einstein and Fermi-Dirac statistics. 2½

(F) Three particles are to be distributed in four energy levels a, b, c and d. Calculate all possible ways of this distribution when particles are (a) bosons and (b) fermions. 2½

5. Attempt any ***ten*** :

(i) State the Pauli's exclusion principle.

(ii) State any two drawbacks of Bohr's atomic theory.

(iii) Define Bohr Magneton. State its value.

(iv) State the importance of Hall effect.

(v) Calculate number of collisions per second of a molecule of a gas having mean free path 1.876×10^{-7} m if average speed of molecule is 511 m/s.

(vi) Calculate the mobility of charge carriers in a semiconductor having conductivity $2.04\times10^{-2}\ \Omega^{-1}m^{-1}$ and Hall coefficient is $5\times10^{-11}\ m^3/c$.

(vii) Define thermodynamic probability.

(viii) Explain phase space.

(ix) State the principle of priori probability.

(x) What is Fermi level ?

(xi) Calculate the number of ways of arranging 8 Fermions in 12 phase space cells.

(xii) What are Bosons and Fermions ? 1×10