(iv) What do you mean by mean free path of free electron ?

(v) What is Bloch theorem ?

(vi) What is concept of hole ?

(vii) Explain the term μ-space.

(viii) Define thermodynamic probability.

(ix) Calculate the r.m.s. velocity of H_2 at 27°C.

Given :

(1) k = 1.38 $\times 10^{-23}$ joule/deg and

(2) mass of H_2 molecule = 3.34 $\times 10^{-27}$ kg.

(x) What is black body ?

(xi) What are bosons ? Which statistics is used to study them ?

(xii) Find the Fermi temperature for the valence electrons in Copper.

Given :

(1) $E_{F(0)}$ for Cu = 7.03 eV and

(2) Boltzmann's constant, K = 1.38 $\times 10^{-23}$ J/K.

1×10=10

TKN/KS/16/5885

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

501 : ATOMIC PHYSICS, FREE ELECTRON THEORY AND STATISTICAL PHYSICS

Paper—I

(Physics)

Time—Three Hours] [Maximum Marks—50

N.B. :— (1) All questions are compulsory.

(2) Draw neat diagrams, wherever necessary.

EITHER

1. (A) Explain briefly :

(i) Spatial quantization and

(ii) Spin of electron.

Name the four quantum numbers of an electron. 3+2

(B) (i) Discuss quantum mechanically the normal Zeeman effect. 3

(ii) Find the separation between the adjacent components of wavelength 4500 Å if it is placed in a magnetic field of flux density 0.3 T. 2

OR

(C) Obtain an expression for energies of free electrons on the basis of Sommerfeld's quantum free electron model. 2½

(D) The density of aluminium is 2.7 gm/cm^3, atomic weight is 26.9 and the number of electrons per atom is 3. Calculate the Fermi energy. 2½

(E) Distinguish between conductors, semiconductors and and insulators on the basis of band picture of solids. 2½

(F) Write short notes on Hall effect. 2½

EITHER

3. (A) Write short notes on :

(i) Accessible and inaccessible states,

(ii) Macro and micro states. 2½+2½

(B) (i) Derive Maxwell-Boltzmann distribution law. 3

(ii) Find the most probable speed of Nitrogen molecules at 27ºC.

Given :

(1) molar mass of Nitrogen molecules = 28×10^{-3} kg/mol and

(2) gas constant, R = 8.31 J/mol K. 2

OR

(C) Derive Boltzmann's entropy relation for an ideal gas. 2½

(D) What are the limitations of Maxwell-Boltzmann method ? 2½

(E) On the basis of Maxwell Boltzmann distribution law show that for the molecules of an ideal gas the average speed is given by :

$$\overline{V} = \sqrt{\frac{8kT}{\pi m}}.$$ 2½

(F) At what temperature will the mean speed of hydrogen molecules be the same as that of Nitrogen molecules at 135ºC.

Given :

(i) Molecular weight of N_2 = 28 and

(ii) Molecular weight of H_2 = 2. 2½

EITHER

4. (A) Obtain an expression for Bose-Einstein distribution law and derive Planck's radiation formula from the law. 3+2

(B) (i) Discuss the postulates of quantum statistics and derive its formula. 3

(ii) Fermi energy of conduction electron in silver is 5.48 eV. Calculate the number of such electrons per cm^3.

Given :

(i) $h = 6.62\times10^{-27}$ erg–sec and

(ii) 1 eV = 1.62×10^{-12} erg. 2

OR

(C) Explain the Stern-Gerlach experiment and indicate its importance in atomic physics. 2½

(D) State and explain Pauli's exclusion principle. 2½

(E) What are the salient features of Stark effect ? 2½

(F) Calculate the magnetic field in order to observe the anomalous Zeeman effect of D lines of wavelengths λ_1 = 5896 Å and λ_2 = 5890 Å. 2½

EITHER

2. (A) Derive the equations for electrical conductivity and thermal conductivity. Prove that $\frac{K}{\sigma T} = \frac{\pi^2}{3}\left(\frac{k}{e}\right)^2$. 2+2+1

(B) (i) Explain qualitatively the formation of energy bands on the basis of Kronig-Penny model. 3

(ii) A rectangular metal slab of thickness 2 mm carries a current of 100 mA in the direction parallel to its length. A uniform magnetic field of flux density 0.5 Wb/m^2 applied to the slab perpendicular to its length produces a maximum Hall voltage of 8 mV. Calculate Hall coefficient and charge carrier density. 2

OR

(C) Explain Bose-Einstein condensation. 2½

(D) Distinguish between B–E and F–D statistics. 2½

(E) Write short notes on negative temperature state. 2½

(F) Treating liquid Helium (He–I) as an ideal B–E gas, find the critical temperature T_B at which there is a transmission of liquid He–I to liquid He–II.

Given :

(i) molar volume of liquid He at the critical temperature = 27.4×10^{-6} m^3,

(ii) mass of He atom = 6.65×10^{-27} kg.

(iii) Avogardro's number, N = 6.63×10^{23} per mole.

(iv) Planck's constant, h = 6.63×10^{-34} JS and

(v) Boltzmann's constant, k = 1.38×10^{-23} J/K. 2½

5. Attempt any **TEN** questions (1 mark each).

(i) What are shells and subshells ?

(ii) Calculate the value of spin magnetic moment from the given data :

e = 1.6×10^{-19} C, h = 6.62×10^{-34} J-S and

m = 9.1×10^{-31} kg.

(iii) Distinguish between π and σ components in Stark effect.