Seat No. : _____

JB-109

January-2018

M.Sc., Sem.-I

404 : Physics
(Solid State Physics and Electronics-I)

Time : 3 Hours] **[Max. Marks : 70**

Instructions : (1) Each questions carry equal marks.
(2) Symbols used have their usual meanings.

1. (A) Show that if in the potential model used in connection with the Kronig-Penney calculation V_0 is allowed to become infinitely large and b is allowed to approach zero, such that the product P remains fixed, then allowed energy values are given by the solution of equation $P\frac{\sin\alpha a}{\alpha a} + \cos\alpha a = \cos Ka$. Also show that this leads to allowed and forbidden energy bands. **7**

OR

(1) The two free-electron wave functions at the boundary of the first Brillouin zone, viz $k = \pm\pi/a$ are $\psi = \exp\left(\pm i\frac{\pi x}{a} - i\omega t\right)$. One of these wave function represents an electron travelling in the + *x* direction and other represents an electron travelling in the – *x* direction. If $\psi 1$ is the sum of these wave functions, calculate the probability function of $\psi 1$. **4**

(2) Prove that the energy gap for the monoatomic lattice is Fourier component of periodic potential. **3**

(B) Derive the wave equation of electron in a periodic potential. **7**

OR

Discuss in details Bloch theorem.

2. (A) Describe the tight binding method of band structure calculation and list its merits and demerits. **7**

OR

(1) Write notes on Pseudopotential theory. **4**

(2) In the tight binding method, the dispersion relation for BCC crystal is given by $E(K) = E_0 - \alpha - 8\beta \cos\frac{1}{2}k_x a \cos\frac{1}{2}k_y a \cos\frac{1}{2}k_z a$. Show that the energy bands are spherical at k=0 and deduce the effective mass of the electron. **3**

(B) Write the note on construction of fermi surface and free electron fermi surface in reduced zone scheme. **7**

OR

Show the quantization of orbits in a magnetic field.

3. (A) Differentiate between voltage amplifier and power amplifier. Draw circuit diagram of direct coupled resistive load power amplifier. Using graphical method of analysis, show that its maximum theoretical conversion efficiency is 25 %. **7**

OR

(i) Discuss advantages and disadvantages of single ended transformer coupled power amplifier. **4**

(ii) Write short note on: Cross over distortion **3**

(B) What are multivibrators ? What are its types ? Draw circuit diagram of an Astable multivibrator using BJT and obtain the equation for its frequency of oscillations. In an astable multivibrator circuit $Rc_1 = Rc_2 = 2\ K\Omega$, $R_1 = R_2 = 40\ K\Omega$, $C_1 = C_2 = 0.01\ \mu F$, $V_{CC} = 10$ V and h_{fe} of BJT = 100. Find the frequency of the square wave generated by the multivibrator. **7**

OR

Draw circuit diagram of bistable multivibrator using transistors and explain its working. Mention its applications.

4. (A) Draw an analog computer circuit to solve the following equations : **7**

$X - 4Y = 6.$

$3X - 2Y = 5.$

Indicate where voltmeters should be connected to read the solutions.

OR

Explain application of operational amplifier as Sine wave generator.

(B) Explain applications of op amp as : **7**

(i) AC amplifier

(ii) Differentiator

OR

Explain application of operational amplifier as triangular wave generator.

5. Answer the following questions : (Each question is of **one** mark) **14**

(i) Calculate the Fermi sphere volume of Aluminum (Al) which lattice constant a=4.0 Å.

(ii) Why Mg (Magnesium) fall in the category of metal ?

(iii) The simple cubic zone has $-\frac{\pi}{a} < k_x < \frac{\pi}{a}$, the zone volume is

(a) $\frac{16\pi^3}{a^3}$ (b) $\frac{8\pi^3}{a^3}$ (c) $\frac{4\pi^3}{a^3}$ (d) $\frac{\pi^3}{a^3}$

(iv) What is the solution of central equation if we consider the lattice potential vanishes ?

(v) The hole orbit is filled by electrons. (TRUE/FALSE)

(vi) What are the Landau levels ?

(vii) For an ideal Fermi gas in three dimensions, the electron velocity V_F at the Fermi surface is related to electron concentration n as,

(a) $V_F = n^{2/3}$ (b) $V_F = n$ (c) $V_F = n^{1/3}$ (d) $V_F = n^{1/2}$

(viii) What is the maximum conversion efficiency of an idealized class B push pull power amplifier ?

(ix) What do you understand by complementary symmetry pair of transistors ?

(x) Give at least two applications of monostable multivibrator.

(xi) Sketch the transfer characteristic of a Schmitt trigger circuit and indicate the hystersis.

(xii) Draw circuit diagram of current to voltage converter using op-amp.

(xiii) What is the difference between actual ground and virtual ground ?

(xiv) Define slew rate.