M.E. Electronics and Tele-Communication Engineering, 2024
First Year First Semester

PHYSICAL ELECTRONICS

Time: **3 Hours** Full Marks: **100**

Answer ***any FIVE*** questions

Q1.a)	Define *Unit Cell* and mention how it is useful in analyzing crystalline solids.	6
b)	Show that in a cubic lattice, a body diagonal and a plane normal to it, both can be represented by the similar set of Miller indices.	6
c)	Determine the *Packing Factor* for a FCC lattice.	4
d)	Describe the *Sphalerite* or *Zinc Blende* crystal structure.	4
Q2.	Establish that – *Free electron energy spectrum gets converted into a set of allowed bands separated by forbidden zones in a crystalline solid.* Use a chain of equi-spaced, identical atoms as the model for 1D crystal.	20
Q3.a)	Define *Crystal Momentum* and explain its significance.	5
b)	Derive two different expressions for *carrier effective mass*. Which one is more useful for semiconductors characterized by parabolic *E-k* dispersion relation, and why?	5+2
c)	Comment on the conduction band structure of semiconductors for which the Conductivity effective mass and *DOS* effective mass are (i) equal and (ii) unequal. Give an example of each category.	8
Q4.a)	Determine the eigen functions and energy eigen values for an electron confined in an infinitely deep square quantum well (QW) of thickness *d*. Also determine the average location of an electron occupying the ground energy state in the above well.	12+3
b)	State and explain Bloch Theorem.	5

Q5.a) Determine the range of energy over which the *Fermi-Dirac distribution function* varies significantly. 6

b) Define Quasi Fermi Levels and mention their features. 4+4
Draw and explain the energy band diagram of a forward biased *p-n* junction.

c) Determine the difference between two quasi Fermi levels in an *n-Si* sample doped with $N_D = 10^{16}\ cm^{-3}$ and subjected to optical illumination causing 1% rise in majority carrier concentration. Take, for *Si* $n_i = 10^{10}\ cm^{-3}$ at 300 *K*. 6

Q6.a) Define *Phonon* and explain its origin. 7

b) Make a list of various lattice scatterings occurring in each of the following crystals: 6
(i) Silver (*Ag*)
(ii) Silicon (*Si*)
(iii) Gallium Arsenide (*GaAs*).

c) Explain the energy transfer mechanism in an *n*-type semiconductor subjected to (i) a weak and (ii) a strong electric field. 7

Q7.a) Derive the *Boltzmann Transport equation* for electrons undergoing scattering at non-equilibrium conditions. 15

b) Define *Debye Screening length* in context of Ionized Impurity scattering. How does it influence carrier mobility? 3+2

Q8. Write notes on ***any Two***: 2x10

a) Reduced Brillouin zone,
b) Experimental determination of Diffusivity of minority carrier,
c) Shockley-Read-Hall (SRH) Recombination and Surface Recombination,
d) Temperature dependence of carrier mobility.