CMR
INSTITUTE OF
TECHNOLOGY

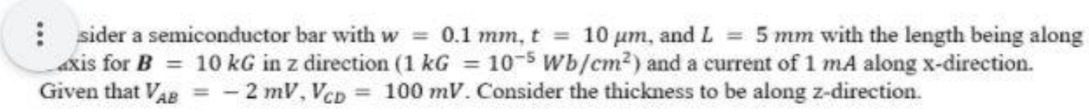
USN

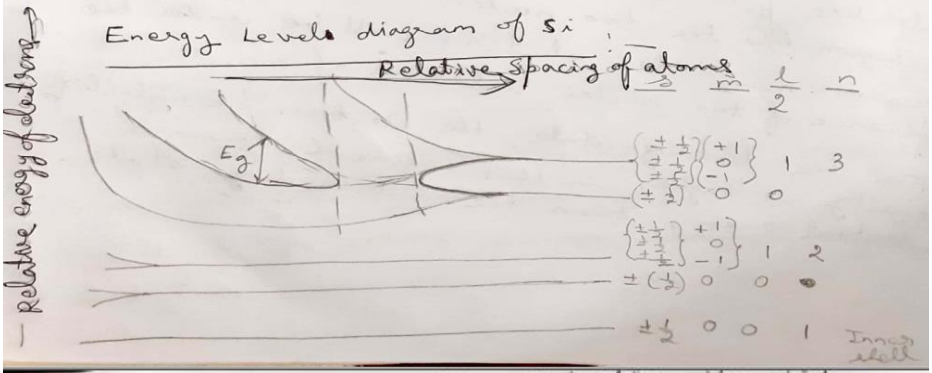
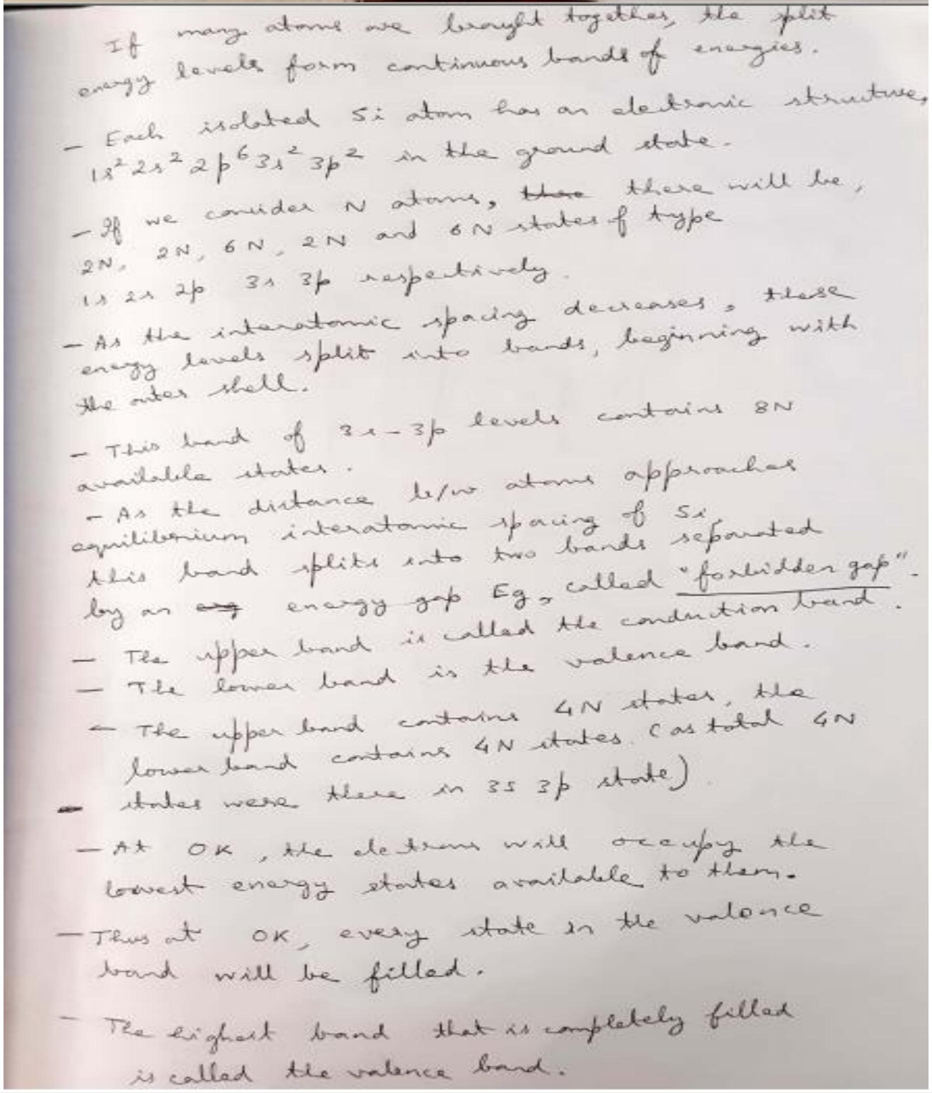
Internal Assesment Test - I

Sub:	Electronic Devices							Code:	18EC33
Date:	11/09 / 2020	Duration:	90 mins	Max Marks:	50	Sem:	3rd	Branch:	ECE
Answer All Questions									

		Marks	OBE	
			CO	RBT
1.	**Q-1 n=p=ni is true for** Intrinsic Semiconductor Extrinsic Semiconductor P type semiconductor Semiconductor None of these **Ans - Intrinsic Semiconductor** **Q-2 At the minima of conduction band , electron has** Kinetic energy only Both kinetic energy and potential energy potential energy only None of these **Ans- potential energy only** **Q-3 Hall effect can be used to measure** Magnetic field intensity Electric field intensity Carrier concentration None of the above **Ans- Carrier concentration** **Q-4 In a PN junction with no external voltage, the voltage between acceptor and donor ions is called a** Peak voltage Barrier voltage Threshold voltage Path voltage **Ans- Barrier voltage** **Q-5 In a PN junction the potential barrier is due to the charges on either side of the junction created due to** diffusion of majority carriers diffusion of minority carriers diffusion of minority carriers drift of majority carriers **Ans- diffusion of majority carriers** **Q-6 By adding impurities in semiconductor, the bulk resistance of a**	[20]	CO1	L2

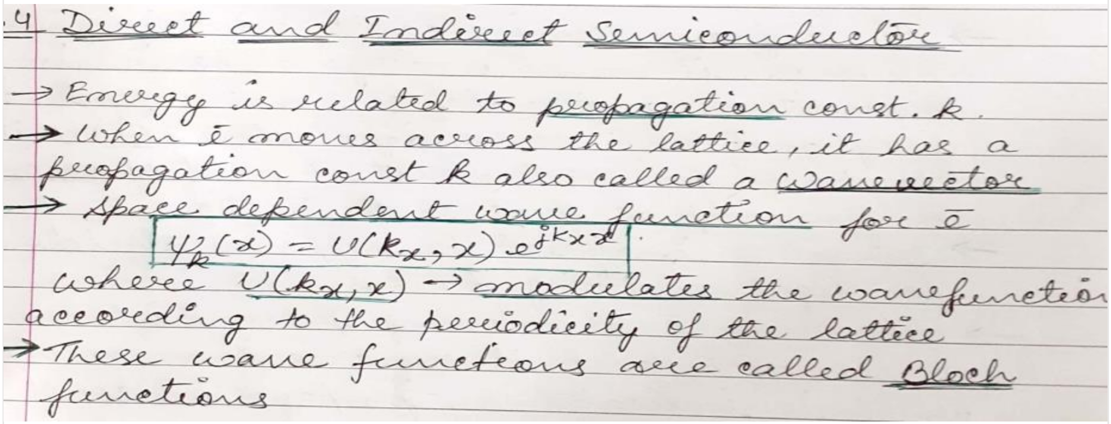
semiconductor_______
Decreases
Remain the same
Increases
None of the above
Ans- Decreases
Q-7 With forward bias to a PN junction the width of the depletion layer__________
Decreases
Increases
Remains the same
Remains the same
Ans- Decreases
Q-8 The space charge region in a junction diode contains charges that are
Fixed donor and acceptor ions
Majority carriers only
Minority carriers only
Mobile donor and acceptor ions
Ans- Fixed donor and acceptor ions
Q-9 The number of permitted electron states in outermost orbit of silicon is:
8
2
4
6
Ans- 8
Q-10 Electron-hole pairs are produced by
Recombination
Thermal energy
Ionization
Doping
Ans- Thermal energy
Q-11 The difference between an insulator and a semiconductor is
Wider forbidden gap
The number of free electrons
The atomic structure
All of the above
Ans- All of the above
Q-12 A pure semiconductor behaves like an insulator at 0 K because
There is no recombination of electrons with holes
Drift velocity of free electrons is very small
Free electrons are not available for current conduction
Energy possessed by electrons at that low temperature is almost zero
Ans- Free electrons are not available for current conduction
Q-13 Which of the following is a semiconductor
Diamond

	Arsenic Phosphorous Gallium arsenide **Ans- Gallium arsenide** **Q-14 The energy gap is much more in silicon than in germanium because** It has less number of electrons It has high atomic mass number Its crystal has much stronger bonds called ionic bonds Its valence electrons are more tightly bound to their parent nuclii **Ans- Its valence electrons are more tightly bound to their parent nuclii** **Q-15 In semiconductor the forbidden energy gap lies** Just below the conduction band Just above the conduction band Either above or below the conduction band Between the valence band and conduction band **Ans- Between the valence band and conduction band** **Q-16 In a N-type semiconductor, the positive of the Fermi level** Is at the centre of the energy gap Is lower than the centre of energy gap Is higher than the centre of energy gap Can be anywhere depending upon the doping concentration **Ans- Is higher than the centre of energy gap** **Q-17 As the temperature of a semiconductor increases its** Conductivity increases Resistivity increases Atomic number decreases Temperature co-efficient becomes zero **Ans- Conductivity increases** **Q-18 The conduction band** Is always above the forbidden energy level Is the region of free electrons Concentrates holes for the flow of current Is a range of energies corresponding to the energies of the free electrons **Ans- Is a range of energies corresponding to the energies of the free electrons** **Q-19 The movement of a hole results from.......** Excitation due to high temperature Change in number of protons in the atom The vacancy filled by a valence electron from the neighbouring atom none of the above **Ans- The vacancy filled by a valence electron from the neighbouring atom**			
2.	 sider a semiconductor bar with $w = 0.1\ mm$, $t = 10\ \mu m$, and $L = 5\ mm$ with the length being along axis for $B = 10\ kG$ in z direction ($1\ kG = 10^{-5}\ Wb/cm^2$) and a current of 1 mA along x-direction. Given that $V_{AB} = -2\ mV$, $V_{CD} = 100\ mV$. Consider the thickness to be along z-direction. N1. What is the type of the semiconductor bar (2+4+4)	[10]	CO1	L3

	Ans- n type N2. What is the concentration of the majority carriers? **Ans-3.125 x 10(^17)/cm^3** N3. What is the mobility of the majority carriers? **Ans- 10,000 cm^2/(VS)^(-1)**			
3.	With a neat diagram describe the formation of different energy levels in silicon atom as a function of inter atomic spacing. (2+5)  If many atoms are brought together, the split energy levels form continuous bands of energies. – Each isolated Si atom has an electronic structure, $1s^2 2s^2 2p^6 3s^2 3p^2$ in the ground state. – If we consider N atoms, ~~thae~~ there will be, 2N, 2N, 6N, 2N and 6N states of type 1s 2s 2p 3s 3p respectively. – As the interatomic spacing decreases, these energy levels split into bands, beginning with the outer shell. – This band of 3s – 3p levels contains 8N available states. – As the distance b/w atoms approaches equilibrium interatomic spacing of Si this band splits into two bands separated by an ~~erg~~ energy gap Eg, called "forbidden gap". – The upper band is called the conduction band. – The lower band is the valence band. – The upper band contains 4N states, the lower band contains 4N states (as total 4N states were there in 3s 3p state) – At 0K, the electrons will occupy the lowest energy states available to them. – Thus at 0K, every state in the valence band will be filled. – The highest band that is completely filled is called the valence band.	[05]	CO1	L2

4. What are direct and indirect band gap semiconductors? Explain with examples.

N1. What is the type of the semiconductor bar



4 Direct and Indirect Semiconductor

→ Energy is related to propagation const. k.

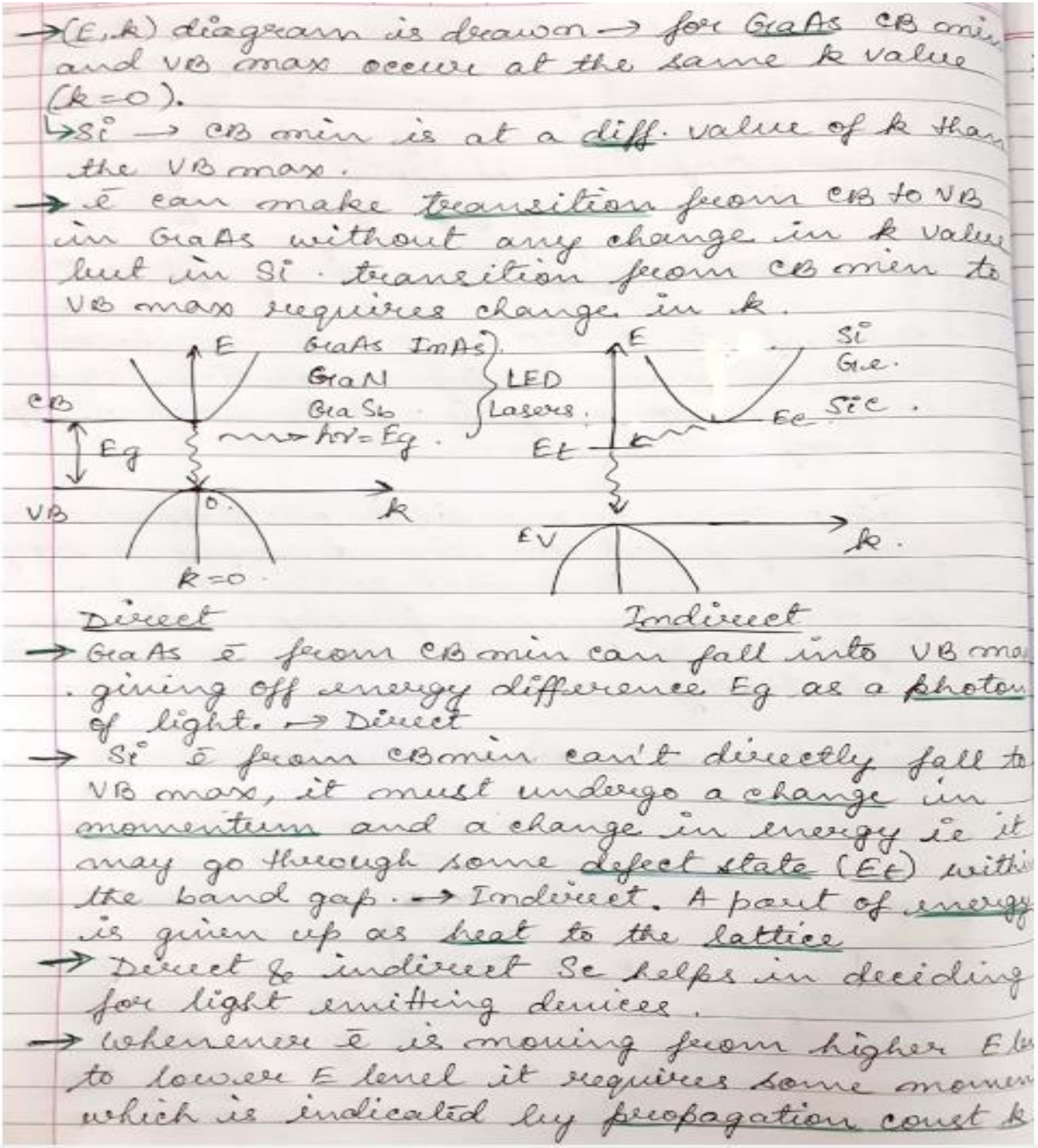
→ When ē moves across the lattice, it has a propagation const k also called a wavevector

→ Space dependent wave function for ē

$$\boxed{\psi_k(x) = U(k_x, x)\, e^{jk_x x}}$$

where $U(k_x, x)$ → modulates the wavefunction according to the periodicity of the lattice

→ These wave functions are called Bloch functions



→ (E, k) diagram is drawn → for GaAs CB min and VB max occur at the same k value (k=0).

↳ Si → CB min is at a diff. value of k than the VB max.

→ ē can make transition from CB to VB in GaAs without any change in k value but in Si transition from CB min to VB max requires change in k.

Direct

Indirect

→ GaAs ē from CB min can fall into VB max giving off energy difference Eg as a photon of light. → Direct

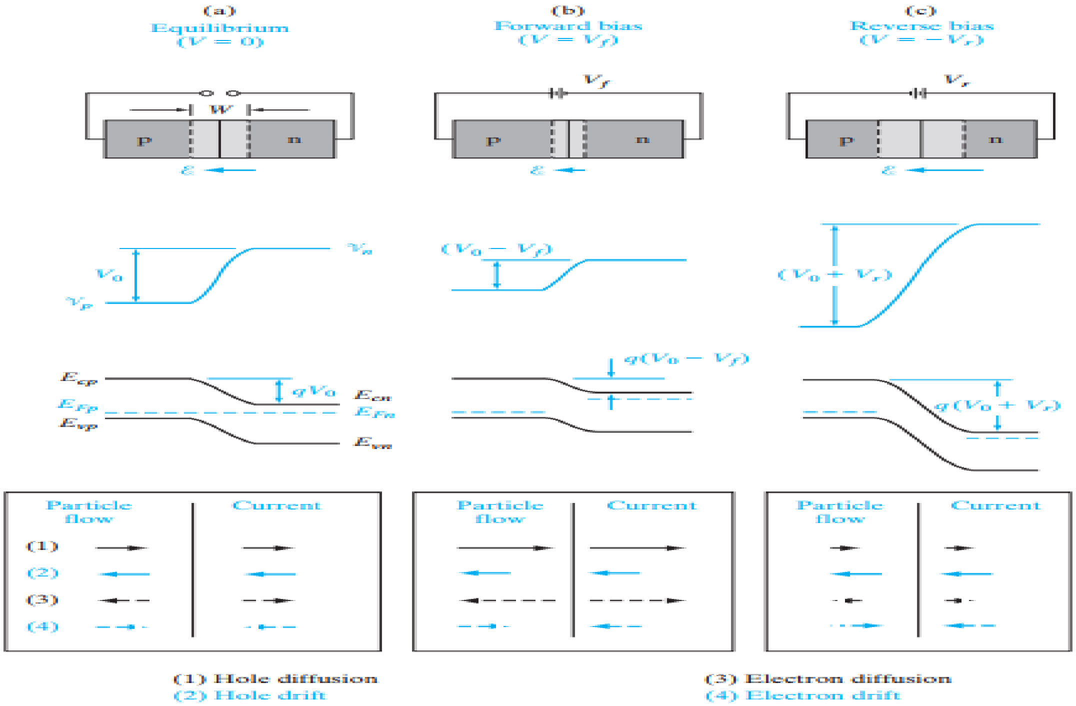
→ Si ē from CB min can't directly fall to VB max, it must undergo a change in momentum and a change in energy ie it may go through some defect state (Et) within the band gap. → Indirect. A part of energy is given up as heat to the lattice

→ Direct & indirect Sc helps in deciding for light emitting devices.

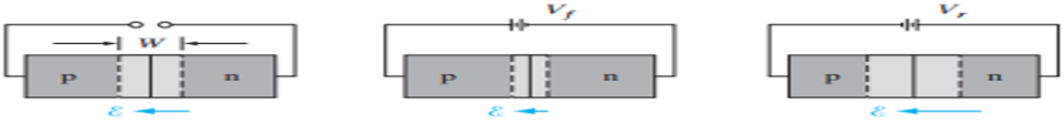
→ Whenever ē is moving from higher E level to lower E level it requires some momen which is indicated by propagation const k

[05] CO1 L2

5. Explain the description of current flow under equilibrium, Forward and Reverse bias for PN Junction



- Applied bias ***V*** appears across the transition region of the junction rather than in the neutral n and p regions - ***V*** drop in the neutral material, if a ***I*** flows through it.
- As applied ***V*** changes the electrostatic potential barrier & EF within the transition region.
- Applied bias affects energy bands separation along the ***W***.
- ***Electrostatic potential barrier V0 – at the junction***
  - ***FB*** - electrostatic potential decreases by -***Vf*** and becomes (***V0*** – ***Vf***) – as FB raises the electrostatic potential on the p side relative to the n side.
  - ***RB*** - (***V*** = -***Vr***) electrostatic potential increases by +***Vr*** and becomes larger (***V0*** + ***Vr***).
- ***Electric field ε*** - within the transition region
  - ***FB*** – EF decreases with applied ***Vf***, ***opposite*** to built-in field ε.
  - ***RB*** - EF increases with applied ***Vr,*** same direction of built-in field.
- ***Transition region width W*** - change in EF at the junction changes width ***W***.
  - ***FB***- ***W*** decrease due to reduced EF.
  - **RB** - ***W*** increase due to increased EF.



[10] CO1 L2

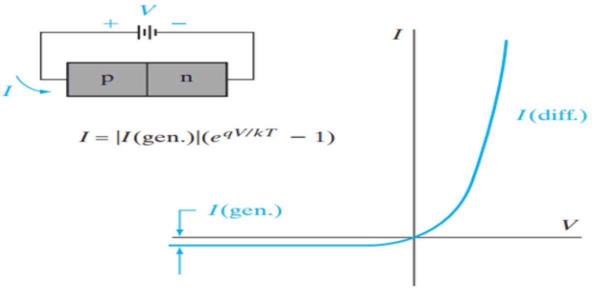
- ***Separation of the energy bands*** **-** is a direct function of the electrostatic potential barrier at the junction - q times the height of the electrostatic potential barrier.
  - ***FB*** - less separation $q(V_0 - V_f)$
  - ***RB*** – more separation $q(V_0 + V_r)$

- ***Fermi level E_F***- shifting of the energy bands under bias implies a separation of the Fermi levels on either side of the junction,
  - ***FB*** - fermi level on the n side E_{Fn} *is above* E_{Fp} by the energy qV_f
  - ***RB*** – fermi level E_{Fp} *is above* E_{Fn} by qV_r.

- ***Diffusion current I_{diff}*** – diffusion of charge particles
  - ***FB*** – ***I_{diff} increases***. Lower barrier ***(V_0-V_f)*** cause more ***e-*** to diffuse from n to p side – ***I(ndiff)*** increases. More ***h+*** diffuse from p to n - ***I(pdiff)*** increases.
  - ***RB*** – large barrier **(V_0 + V_r)** no ***e- & h+*** can't diffuse – ***I_{diff} decreases.***

- ***Drift current I_{drift} -***

not related to the height of the potential barrier.



$$I = |I(\text{gen.})|(e^{qV/kT} - 1)$$

- Minority carriers participates in ***I_{drift}*** are generated by ***thermal excitation of electron–hole pairs (EHPs).***
  - ***I*** due to drift of generated carriers across the junction - ***generation current I_g* -** magnitude depends on the *rate of generation of EHPs*.

- ***Total current*** crossing the junction = ***I_{diff}*** + ***I_{drift}*** = ***0*** at equilibrium – as ***I_{diff} & I_{drift}*** cancel.
  - Under RB - ***both I_{diff} components =0*** due large barrier at the junction, only ***I*** = small ***I_g*** from n to p.