SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

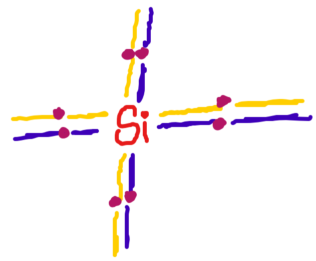
DEPARTMENT OF PHYSICS

PHYSICS: SEMICONDUCTOR PHYSICS (18PYB103J)

MODULE - 2

PART – A

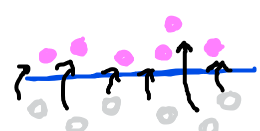
1. A semiconductor is formed by____bonds.
   (A) Covalent
   (B) Electrovalent
   (C) Co-ordinate
   (D) Oxidation



2. A semiconductor has _____temperature coefficient of resistance.
   (A) Positive
   (B) Zero
   (C) Negative
   (D) Large

3. When a pure semiconductor is heated, its resistance___.
   (A) Increases
   (B) Decreases
   (C) Remains the same
   (D) Increases then it decreases

temp ↑



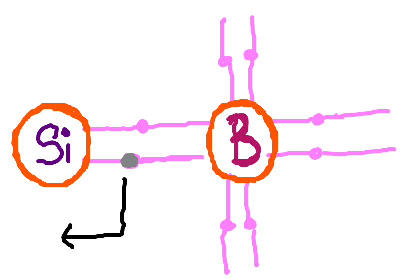
More e^- jump

4. An n-type semiconductor have______.
   (A)Holes as majority charge carriers
   (B)Electrons as majority charge carriers
   (C)Equal number of holes and electrons as charge carriers
   (D)None of the above

n type → electrons

p type → holes

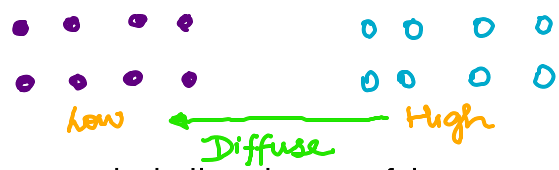
5. A hole in a semiconductor is defined as____.
   (A)A free electron
   (B)The incomplete part of an electron pair bond
   (C)A free proton
   (D) A free neutron



hole ←

Incomplete bond.

6. The random motion of holes and free electrons due to thermal agitation is called_.
   (A)Diffusion
   (B)Pressure
   (C)Ionization
   (D) Drift



7. As the doping to a pure semiconductor increases, the bulk resistance of the semiconductor____.........
   (A)Remains the same
   (B) Increases
   (C)Decreases
   (D) Decreases then increases

Doping
Decreases resistance
Increases conductance

8. The Fermi level in a p-semiconductor lies close to
   (A)The top of the valence band
   (B)The top of the conduction band
   (C)The bottom of the valence band
   (D)The bottom of the conduction band

Fermi Level
p type top of valence band
n type bottom of conduction band

9. Electron-hole pairs are produced due to___.
   (A)Recombination
   (B)Thermal energy
   (C)Ionization
   (D) Doping

10. The p-region has a greater concentration of_as compared to the n-region in a P-N junction.
   (A) Holes
   (B) Electrons
   (C) Both holes & electrons
   (D) Phonons

p → greater e^+
n → greater e^-

11. A p-type semiconductor material is doped with___impurities whereas a n-type semiconductor material is doped with__________impurities.
   (A) Acceptor, donor
   (B) Acceptor, acceptor
   (C) Donor, donor
   (D) Donor, acceptor

Acceptor ← p-type → Boron → 3 | 4
trivalent

Donor ← n-type → Phosphorous
pentavalent
5 | 4

12. The n-region has a greater concentration of__as compared to the p-region in a P-N junction diode.
   (A) Holes
   (B) Electrons
   (C) Both holes & electrons
   (D) Phonons

13. Which of the below mentioned statements is false regarding a p-n junction diode?
   (A)Diode are current control devices → Forward Bias / current is allowed   Reverse Bias / current is not allowed
   (B)Diodes are rectifying devices → They are not ohmic.
   (C)Diodes are unidirectional devices → Yes
   (D)Diodes have three terminals → 2 terminals   p | n

14. In the p & n regions of the p-n junction the____& the____are the minority charge carriers respectively.
   (A) holes, holes
   (B) electrons, electrons
   (C)holes, electrons
   (D) Electrons, Holes

	Minority	Majority
p region	e^-	e^+
n region	e^+	e^-

15. Let us assume that the doping density in the p-region is 10^{-9} cm^{-3} & in the n-region is $10^{-17}cm^{-3}$ as such the p-n junction so formed would be termed as a
   (A) $p^- n^-$
   (B) $p^+ n^-$
   (C) $p^- n^+$
   (D) $p^+ n^+$

There is nothing like p^- or n^+.
The only combi is $\boxed{p^+ \text{ and } n^-}$

16. Which of the following is true in case of an unbiased p-n junction diode?
   (A) Diffusion does not take place
   (B) Diffusion of electrons & holes goes on infinitely → $\vec{E}$
   (C)There is zero electrical potential across the junctions
   (D) Charges establish an electric field across the junction

17. Which of the following is true in case of a forward biased p-n junction diode?
   (E) The positive terminal of the battery attract electrons from the p-region
   (F) The positive terminal of the battery injects electrons into the p-region
   (G) The negative terminal of the battery attract electrons from the p-region
   (D) The negative terminal of the battery injects electrons into the p-region

Battery cannot inject !

18. What is the forward bias ideality factor of a Schottky barrier diode?
   (A) n = 1
   (B) n = 2
   (C) 1< n < 2
   (D) n > 2

19. The amount of radiance in planar type of LED structures is

(A) Low
(B) High
(C) Zero
(D) Negligible

planar → Low
Surface → High

20. In a basic OLED structure, the diamine layer is used as a_____.

(A) **HTL**
(B) ETL
(C)ITL
(D) CCL

21. In a basic OLED structure, the AlQ3 layer acts as a____.

(A) HTL
(B) ETL
(C)ITL
(D) CCL

22. . ______ is the condition for transport of charge carriers in Schottky barrier diode.

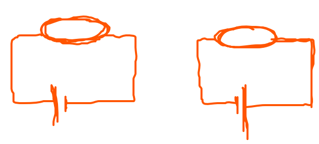
(A) $\phi m = \phi s$
(B) $\phi m > \phi s$
(C) $\phi m < \phi s$
(D) $\phi m = 0$

23. _______ is the condition for transport of charge carriers in Ohmic contact.

(A) $\phi m = \phi s$
(B) $\phi m > \phi s$
(C) $\phi m < \phi s$
(D) $\phi m = 0$

24. An Ohmic contact is a______providing current conduction in both directions.

(A) Low - resistance junction
(B)High - resistance junction
(C)Infinite – resistance junction
(D) Zero - resistance junction



Must be low R for both conditions.

25. In tunneling barrier, the space – charge width is a rectifying metal-semiconductor contact is inversely proportional to square root of_.

(A)Semiconductor doping
(B)Metal doping
(C)Carrier injection
(D)recombination.

26. LED is a semiconductor p-n junction diode which convert______under forward bias.

a. Light energy into Electrical energy

b. Electrical energy into Light energy

c. Thermal energy into electrical energy

d. Electrical energy into thermal energy

electrical
$\downarrow$
Light

27. When a pure semiconductor is heated, its resistance …………..

a. Goes up

b. Goes down

c. Remains the same

d. Can't say

Because more electrons jump to conduction band.

28. What is the continuity equation in words?

a. Rate of increase = (inflow – outflow) + drift – diffusion

b. Rate of increase = (inflow – outflow) + generation - recombination

c. Rate of increase = (inflow - outflow)

d. Rate of increase = (inflow + outflow)

! Very important

29. The forward bias current in a typical Schottky barrier is due to what physical mechanism?

a) Drift

b) Diffusion

c) Recombination

d) Thermionic emission

30. The amount of radiance in planer type of LED structures is

a) Low

b) High

c) Zero

d) Negligible

31. The InGaAsP is emitting LEDs are realized in terms of restricted

a) Length strip geometry

b) Radiance

c) Current spreading

d) Coupled optical power

32. When p-n junction is unbiased, the junction current at equilibrium is

(a) Zero as no crosses the junction

(b) Zero as equal number of carriers crosses the barrier in opposite direction

(c) Mainly due to diffusion of majority carriers

(d) Mainly due to diffusion of minority carriers

Only biasing creates current

Forward Bias

Reverse Bias

33. Intrinsic concentration of charge carriers in a semiconductor varies as

a) T

b) T^2

c) $T^{3/2}$

d) 1/T

34. The dependence of the mobility of charge carriers in a semiconductor is given by

a) $\mu \propto 1/T$

b) **$\mu \propto 1/T^{3/2}$**

c) $\mu \propto T^{3/2}$

d) $\mu \propto T^2$

35. The electronic configuration of silicon is

Si → 14

Ge →

a) $1s^2, 2s^2, 2p^6, 3s^2, 3p^4$

b) $1s^2, 2s^2, 2p^6, 3s^1, 3p^6$

c) **$1s^2, 2s^2, 2p^6, 3s^2, 3p^2$**

d) $1s^2, 2s^2, 2p^6, 3s^0, 3p^2$

36. The Femi level in an n-type semiconductor at 0 K lies

a) below the donor level

b) **half way between the conduction band and donor level**

c) coincides with intrinsic Fermi level

d) above the donor level

37. Room temperature resistivity of pure germanium in Ω-m is

a) 47

b) 4.7

c) **0.47**

d) 0.047

My View:

Ge → 0.7

So can't be above 1. or below 0.01.

For 0.47

38. When a free electron recombines with a hole, there results

a) generation of energy

b) **release of energy**

c) no change in energy

d) forbidden energy

→ energy

(photon (or) phonon + photon)

39. The density of carriers in a pure semiconductor is proportional to
a) exp $(- E_g/k_BT)$
b) exp $(- 2E_g/k_BT)$
c) exp $(- E_g/k_BT^2)$
d) **exp $(- E_g/2k_BT)$**

40. The energy needed to detach the fifth valence electron from the arsenic impurity atoms surrounded by germanium atoms is approximately
a) 0.001 eV
b) **0.01 eV**
c) 0.1 eV
d) 1.0 eV

41. The diffusion current is proportional to
a) square of applied electric field
b) applied electric field
c) **concentration gradient of charge carriers**
d) mobility of charge carriers

More charge carriers → More diffusion

42. The depletion region in an open circuited p-n junction contains
a) electrons
b) holes
c) **uncovered immobile impurity ions**
d) neutralized impurity atoms

43. The reverse saturation current in a p-n diode
a) increases
b) decreases
c) **remains constant with increase of reverse bias**
d) Moderate

Saturation → constant

44. If an atom loses one or more electrons, it becomes ________.
a) Electrically neutral
b) **Electrically positive**
c) Electrically negative
d) A neutral ion

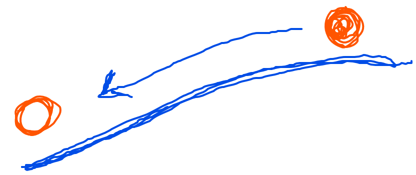
45. The excess carriers move from the region of higher density to region of lower density tending to produce a uniform distribution is called

a) **diffusion current**

b) drift current

c) carrier concentration

d) recombination



46. In a LED, the number of radiative recombination is proportional to

a) **carrier injection**

b) carrier rejection

c) resistance

d) resistivity

47. The minority carriers storage time in the Schottky diode is

think of a resistor

a) 0.15 ms

b) **Zero**

c) Infinite

d) 1.5 ms

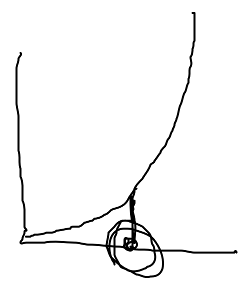
48. The knee voltage of a diode approximately is equal to the

a) Breakdown voltage

b) **Barrier potential**

c) Applied voltage

d) Forward voltage



49. Thermionic emission of electrons results from

a) Photovoltaic effect

b) Electrostatic fields

c) **High temperatures**

d) Strong magnetic fields

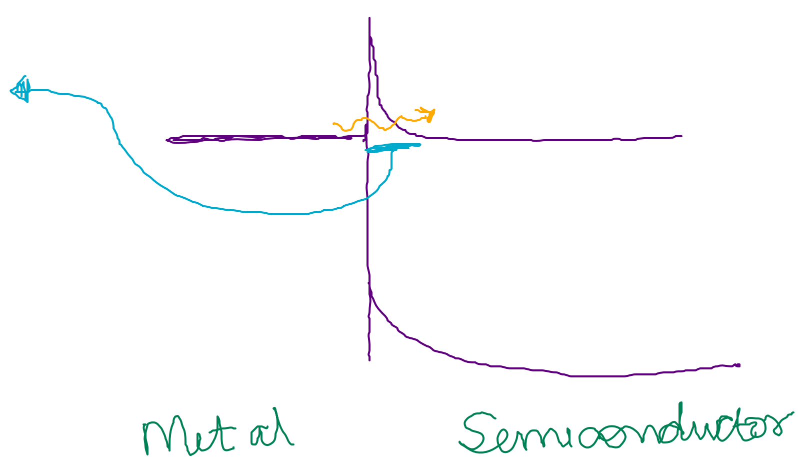
50. The main reason why electrons can tunnel through a PN junction is that

a) Barrier potential is very low

b) high energy

c) Impurity level is low

d) **Depletion layer is extremely thin**

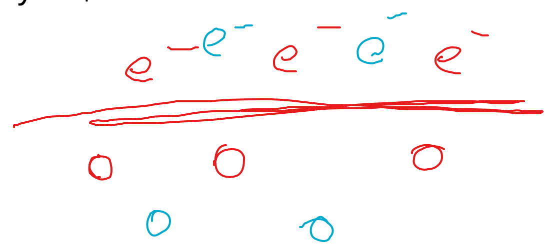


51. The static VI characteristics of a junction diode can be described by the equation called
a) Child's three half-power law
b) **Boltzmann diode equation**
c) Einstein's photoelectric equation
d) Richardson-Dushman equation

52. The drift velocity of the conductor
a) Increase with an increase in temperature
b) Decrease with Decrease in temperature
c) Increase with Decrease In the temperature
d) **Decrease with the increase in temperature**

?

53. Due to illumination by light, the electron and hole Concentrations in a heavily doped N type semiconductor increases by Δn *and* Δp respectively if n_i is the intrinsic concentration then
a) $\Delta n < \Delta P$
b) $\Delta n > \Delta P$
c) $\boldsymbol{\Delta n = \Delta P}$
d) $\Delta n \times \Delta P$



54. A reverse voltage of 20 V is across the diode. What is the voltage across the depletion layer?
a) 0V
b) 0.7 V
c) **20 V**
d) 5 V

reverse voltage = V(depletion layer)

55. A p-n junction is fabricated from a semiconductor with band gap of 3.0 eV. The wavelength of the radiation which it can detect is
a) 600 nm
b) **400 nm**
c) 100 nm
d) 1000 nm

$E = \frac{hc}{\lambda} \Rightarrow \frac{hc}{E} = \lambda \Rightarrow \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{3 \times 1.6 \times 10^{-19}}$

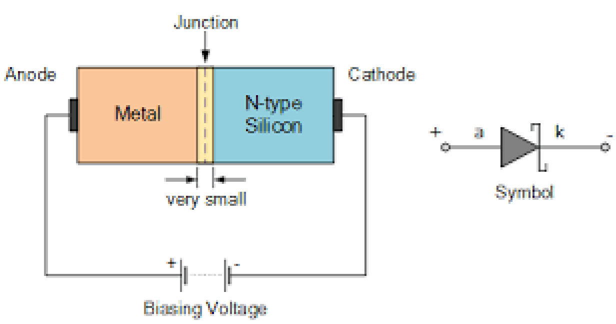
$= 414 nm \approx 400 nm$

56. In which of these diode the reverse recovery time is nearly zero.
a) Diode
b) Tunnel Diode
c) **Schottkey Diode** → Near Ohmic.
d) PIN Diode

57. In an abrupt P – N junction, the doping concentrations on the P – side and N – side are $9 \times 16^{16} / cm^3$ *and* $1 \times 10^6 / cm^3$ respectively. The P – N junction is reverse biased and the total depletion width is 3 μm. The depletion width on the P – side is

a) 2.7 μm
b) **0.3 μm**
c) 2.25 μm
d) 0.75 μm

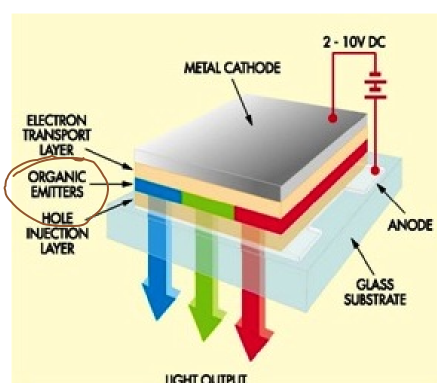
58. The given diagram represents ……………..



Metal + Semiconductor
⇓
Schottky diode

a) Photo diode
b) **Schottky diode**
c) PIN Diode
d) Zener diode

59. The given diagram represents ……………..



organic ⇒ OLED

a) Surface-mount LED
b) Gallium Arsenide LED
c) Polymer LED
d) **Organic LED**

60. A piece of copper and another of germanium are cooled from room temperature to 80˚C. The resistance of

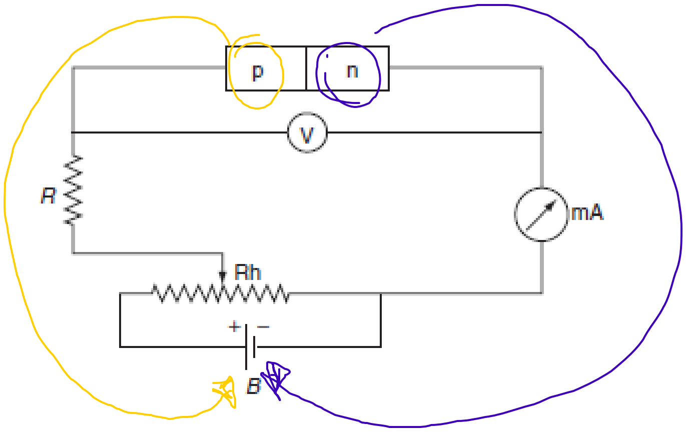
a) each of them increases

b) each of them decreases

c) copper increases and germanium decreases

d) **copper decreases and germanium increases**

61. The given circuit represents……….



p → +
n → −
} Forward Bias

a) reverse biased p-n diode

b) **forward biased p-n diode**

c) V–I characteristics of p-n diode

d) p-n diode rectifier

62. Find the resistance of an intrinsic germanium rod 1cm long, 1mm wide,1mm thick at 300K. For Ge, n_i=2.5x10^{19}/m^3; μ_e =0.39 m^{2}v^{-1}s^{-1} and μ_h=0.19m^{2}v^{-1}s^{-1} at 300K.

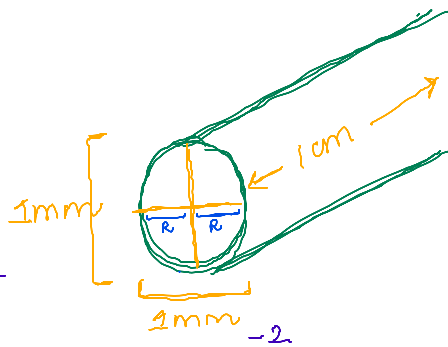
?

a) **4.31x10^3 ohm**

b) 0.131x10^3 ohm

c) 1.531x10^2 ohm

d) 2.131x10^{4}ohm



$\sigma = ne(\mu_e + \mu_h)$

$= 2.5 \times \cancel{10^{19}} \times 1.6 \times \cancel{10^{-19}} (0.39 + 0.19)$

$= 2.32$

$\rho = \frac{1}{\sigma} = 0.431$

$R = \rho \frac{l}{A}$

$= \frac{0.431 \times 1 \times 10^{-2}}{\pi \times (0.5 \times 10^{-3})^2}$

$= 5.48 \times 10^3 \,\Omega$

$\neq 4.31 \times 10^3 \,\Omega$

63. Which one of the following expression gives the Fermi energy for p-type semiconductor

a) **$E_f = (E_v + E_a/2) + kT/2 \ln (N_a/N_y)$**

b) $E_f = (E_d + E_c/2) + kT/2 \ln (N_a/N_y)$

c) $E_f = (E_d + E_f/2) - kT/2 \ln (N_a/N_y)$

d) $E_f = (E_v + E_f/2) - kT/2 \ln (N_a/N_y)$

$$E_F = \left(\frac{E_v + E_a}{2}\right) + \frac{kT}{2} \ln\left(\frac{N_y}{N_a}\right)$$

64. Which one of the following expression gives the Continuity equation

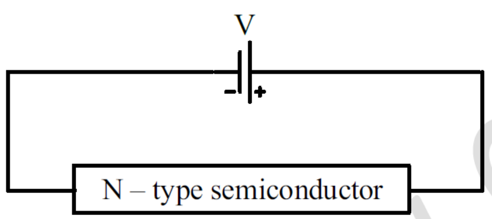
a) $dp/dt = n_o - n/\ n_o - (\mu_p E)dp/dx + (D_p)d^2p/dx^2 + G$

b) **$dp/dt = P_o - P/\ \tau_p - (\mu_p E)dp/dx + (D_p)d^2p/dx^2 + G$**

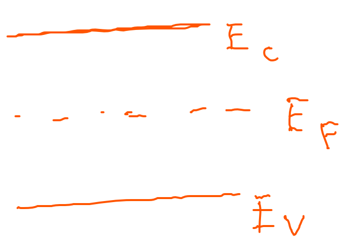
c) $dp/dt = P_o - P/\ P_o - dp/dx + (D_p)d^2p/dx^2$

d) $dp/dt = P_o - P/\ P_o - (\mu_p E)dp/dx + (D_p)d^2p/dx^2$

65. An N – type semiconductor having uniform doping is biased as shown in the figure

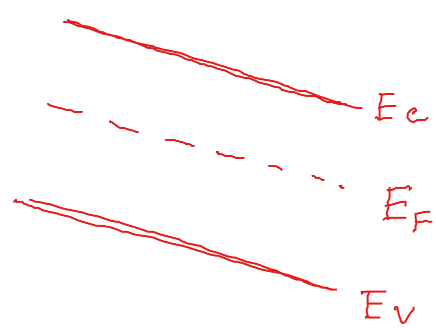


If E_c is the lowest energy level of the conduction band, E_V is the highest energy level of the valance band and E_F is the Fermi level, which one of the following represents the energy band diagram for the biased N – type semiconductor?

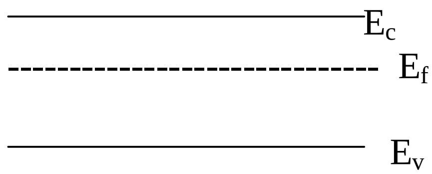


−ve potential is higher

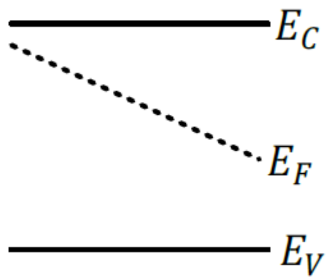
+ve potential is lower.



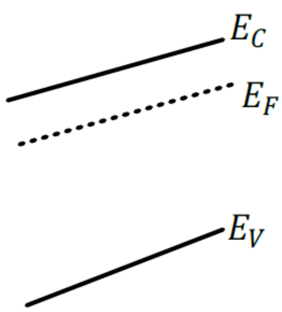
a)



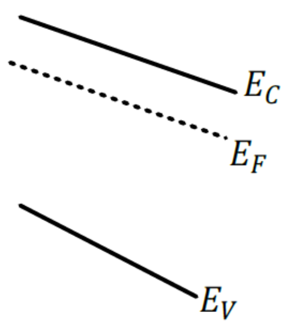
b)



c)

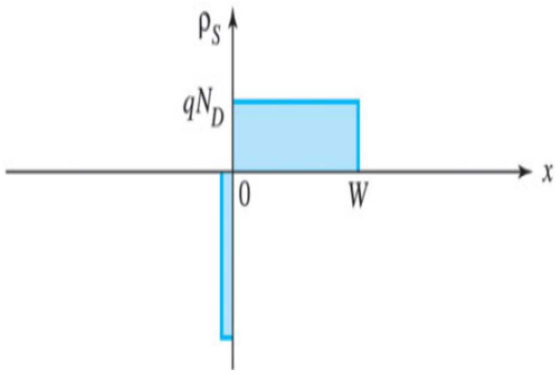


d)



Answer (d)

66. Which one of the following is related to the diagram



a) electric-field distribution in a metal-semiconductor contact

b) **Charge distribution in a metal-semiconductor contact**

c) Photocurrent in a P-N junction

d) field distribution in semiconductor

67. Which one of the following expression gives the equation of drift and diffusion current?

a) $n\mu_n eE$; $eD_n\, d(\Delta n)/dx$

b) $n\mu_n e$; $eD_n\, d(\Delta n)/dx$

c) $n\mu_n eE$; $eD_n\, \Delta n$

d) $n\mu_n eE$; eD_n

68. A cadmium sulphide (Eg=2.4eV) photodetector is illuminated with light of wavelength 3000Å. The intensity of radiation falling on the detector is 30 W/m^2. The area of the detector is 9mm^2. Assuming that each quantum generates an electron-hole pair, calculate the number of pairs generated per second.

a) 3.05×10^{14}

b) 1.075×10^{14}

c) **4.075×10^{14}**

d) 2.075×10^{14}

PART - B

1. What is meant by Fermi level in semiconductor? Where does the Fermi level lie in an intrinsic semiconductor?
2. Describe the difference between P-type and N-type semiconductor materials.
3. Explain the concept of drift current.
4. Explain the concept of diffusion current.
5. Discuss in detail about the of p-n junction.
6. Write notes on the forward and reverse bias p-n junction.
7. What happens to the bands when a junction is formed between metals and semiconductors?
8. What is a rectifying contact? Explain with diagram.
9. Explain the working concept of Ohmic contact.
10. Write notes on photocurrent in p-n junction.
11. Write a short note on Organic LED.
12. Write a short note on optoelectronic materials and its applications.
13. Explain about carrier generation and recombination.
14. Write note on intrinsic semiconductor.

PART -C

1. What is intrinsic semiconductor? Explain atomic structure and energy level diagram of intrinsic semiconductor? Where does the Fermi level lie in an intrinsic semiconductor?
2. What is Extrinsic semiconductor? Explain N-type semiconductor and the variation of Fermi level with temperature with the diagram.
3. What is Extrinsic semiconductor? Explain P-type semiconductor and the variation of Fermi level with temperature with the diagram.
4. Explain in detail about the rectifying and non-rectifying contacts using band diagram.
5. Explain in detail (i) Ohmic contacts, and (ii) Schottky contacts.
6. Explain principle, construction, working of LED? Mention its merits, demerits and applications.
7. Explain principle, construction, working of OLED? Mention merits, demerits and applications.
8. Using the concept of carrier drift and diffusion current, derive and explain the concept of continuity equation.