SRM INSTITUTE OF SCIENCE AND TECHNOLOGY
RAMAPURAM

DEPARTMENT OF PHYSICS

PHYSICS: SEMICONDUCTOR PHYSICS (18PYB103J)

CHAPTER - 1

PART - A

1. Which of the following is responsible for electrical conduction in metal?
a) Electrons
b) Protons
c) Neutrons
d) Positrons

2. The electrons in inner shells are called as
a) Valence electrons
b) Core electrons
c) Conductions electrons
d) Free electrons

3. Conduction electrons in metal moves in _______
a) Positive direction
b) Negative direction
c) Random direction
d) Up and down

4. Free electrons move always in
a) Positive direction
b) Negative direction
c) Random direction
d) Up and down

5. The failures of classical theories were overcome by
a) Sommerfeld
b) Drude
c) Widmann
d) Lorentz

6. In Quantum theory electrons possess
a) Particle nature
b) Wave nature
c) Liquid nature
d) Gas nature

7. Free electrons in metals always obey
a) Fermi Dirac statistics
b) Wiedemann Franz law
c) Bose Einstein Statistics
d) Drude Lorentz theory

8. In real crystal at positive ion site, the potential of electrons will become
   a) Zero
   b) 1
   c) 2
   d) 3

9. According to Kronig Penney model, the shape of inner potential of crystal is
   a) Rectangular
   b) Triangular
   c) Spherical
   d) Sinusoidal

10. At low temperatures, semiconductors will become
   a) Conductors
   b) Insulators
   c) Ferroelectrics
   d) Superconductors

11. In semiconductors at low temperatures, the valence band will be
   a) Full
   b) Empty
   c) Partially full
   d) Partially empty

12. The conduction electrons always contribute to
   a) Electricity
   b) Conductivity
   c) Thermal effect
   d) Magnetic effect

13. The difference between metals, semiconductors and insulators is based on
   a) Value of bandgap
   b) No of electrons in valence band
   c) No of electrons in conduction band
   d) Magnitude of electric field applied

14. The free electron theory of metals was initiated by
   a) Pauli
   b) Sommerfeld
   c) Lorentz and Drude
   d) Fermi-Dirac

15. At any temperature T and for $E=E_F$ in metals, the Fermi-distribution function becomes
   a) 0
   b) Infinity
   c) 1
   d) ½

16. The value of Fermi-distribution function at absolute zero (T = 0 K) is 1, i.e., F(E)=1, under the condition

a) $E > E_F$
b) $E < E_F$
c) $E = E_F$
d) $E >> E_F$

17. With the increase in temperature, the resistance of a metal

a) Remains constant
b) Increases
c) Decreases
d) Becomes zero

18. A band or range of energy levels that an electron in a crystal is allowed to occupy is known as

a) Allowed energy bands
b) Energy bands
c) Forbidden energy bands
d) Energy Band-gap

19. A band or range of energy levels that an electron in a crystal is not allowed to occupy is known as

a) Allowed energy bands
b) Energy bands
c) Forbidden energy bands
d) Energy Band-gap

20. The principle stating that no two electrons can occupy the same quantum state is known as

a) Heisenberg Uncertainty principle
b) Pauli Exclusion principle
c) De Broglie principle
d) Quantum mechanical principle

21. The complex physical quantity which describes about the particle wave and helps deriving the probability density function is called as

a) Wave equation
b) Wave function
c) Schroedinger equation
d) Probability density function

22. The first Brillouin zone is defined between the region

a) $k = 0$ to π/a
b) $k = -2\pi/a$ to π/a
c) $k = -\pi/a$ to $2\pi/a$
d) $k = -\pi/a$ to π/a

23. The indirect bandgap semiconductors require a change in energy along with change in

a) Momentum
b) Velocity

c) Mass
d) Potential

24. The direct bandgap semiconductors have the requirement of
a) Change in energy & change in momentum
b) No change in energy & change in momentum
c) No change in energy & no change in momentum
d) Change in energy & No change in momentum

25. The position of fermi level E_F in an intrinsic semiconductor is given by
a) $E_F = E_C – E_V$
b) $E_F = E_V – E_C$
c) $E_F = (E_V – E_C) / 2$
d) $E_F = (E_C + E_V) / 2$

26. The donor atoms in extrinsic n-type semiconductors contribute
a) Electrons to conduction band
b) Electrons to valence band
c) Holes to conduction band
d) Holes to valence band

27. The acceptor atoms in extrinsic p-type semiconductor contribute
a) Holes to conduction band
b) Holes to valence band
c) Electrons to conduction band
d) Electrons to valence band

28. The carrier generation is the process by which
a) Electrons are created
b) Holes are created
c) Electrons and holes are created
d) Electrons and holes are annihilated

29. The carrier regeneration is the process by which
a) Electrons and holes are created
b) Electrons and holes are annihilated
c) Electrons are created
d) Holes are created

30. In thermal equilibrium, the concentrations of electrons and holes are
a) Dependent on time
b) Independent of time
c) Dependent on time and energy
d) Independent of time and energy

31. The quantum of energy in elastic wave is known as

a) Photon
b) Phonon
c) Electron
d) Magnon

32. The Phonons are particles that obey

a) Fermi Dirac statistics
b) Wiedemann Franz law
c) Bose Einstein Statistics
d) Drude Lorentz theory

PART – B

1. What are the merits and demerits of Classical free electron theory?
2. What are the merits and demerits of Quantum free electron theory?
3. Write short notes on direct bandgap semiconductors.
4. Write short notes on indirect bandgap semiconductors.
5. Define intrinsic semiconductors using bandgap in energy levels.
6. Explain the concept of phonons
7. Describe in brief about the First Brillouin zone.
8. How does the band theory differentiate the semiconductors and insulators?
9. What is the influence of dopant on n-type semiconductors?
10. What is the influence of dopant on p-type semiconductors?
11. Define Fermi level. Describe the Fermi Distribution function.
12. How does the *E*-*k* diagram explain the existence of bandgap in materials?
13. Write note on Effective mass.
14. Describe the concept of periodic potential in crystals.
15. Give the band structure diagram of GaAs and Si crystals.
16. Write down the Fermi distribution function. How does the function vary with temperature?
17. Differentiate between semiconductors and insulators based on band theory.

PART – C

1. Describe free electron theory using classical concepts. Also mention its merits and demerits.
2. Describe free electron theory using quantum concepts. Also mention its merits and demerits.
3. Derive the density of states equation for the concentration of charge carriers.
4. Derive the equation for the band structure of energy in solids using the assumptions of Kronig-Penney model.

1) The electrical resistivity of Copper at 27°C is $1.72\times10^{-8}\,\Omega m$. Compute its thermal Conductivity if the Lorentz number is $2.26\times10^{-8}\,W\Omega K^{-2}$

Given $(\rho) = 1.72\times10^{-8}\,\Omega m$

$T = 27^\circ c \Rightarrow 273+27 = 300\,k$

$L = 2.26\times10^{-8}\,W\Omega K^{-2}$

According to Wiedemann - Franz law using classical free electron theory

$$\frac{k}{\sigma} = LT$$

(or) $k = \sigma LT$

$$k = \frac{LT}{\rho} \qquad \left[\because \sigma = \frac{1}{\rho}\right]$$

Therefore thermal Conductivity $k = \dfrac{2.26\times10^{-8}\times 300}{1.72\times10^{-8}}$

$$k = \boxed{394.18\,Wm^{-1}K^{-1}}$$

---

2) Using Fermi dirac distribution function, obtain the Value of $F(E)$ for $E-E_F = 0.01\,eV$ at 200k

Given $E - E_F = 0.01\,eV$

Temperature $= 200\,k$

Boltzmann's Constant $(k) = 1.38\times10^{-23}\,JK^{-1}$

Using Fermi dirac distribution function $F(E) = \dfrac{1}{\left[e^{(E_i-E_F)/kT}\right]+1}$

Then $F(E) = \dfrac{1}{\left[e^{(0.01\times1.6\times10^{-19})/(1.38\times10^{-23}\times200)}\right]+1}$

$$F(E) \Rightarrow \frac{1}{e^{0.5797}+1}$$

$$F(E) = \frac{1}{1.7855+1} = \frac{1}{2.7855} = \boxed{0.359}$$

3) Free electron density of aluminium is $18.10 \times 10^{28}\ m^{-3}$. Calculate its Fermi energy at 0K. Planck's Constant and mass of free electron are 6.62×10^{-34} Js and 9.1×10^{-31} kg.

Given that Electron density of aluminium $(n) = 18.10 \times 10^{28}\ m^{-3}$
Planck's Constant $(h) = 6.62 \times 10^{-34}$ Js
Mass of electron $(m) = 9.1 \times 10^{-31}$ kg

For a given system, (E_F) at 0K is

$$E_F = \frac{h^2}{2m}\left[\frac{3n}{8\pi}\right]^{2/3}$$

$$E_F = \frac{(6.62 \times 10^{-34})^2}{2 \times 9.1 \times 10^{-31}}\left[\frac{3 \times 18.10 \times 10^{28}}{8 \times 3.14}\right]^{2/3}$$

$$\boxed{E_F = 1.869 \times 10^{-18}\ J}$$

---

4) Calculate the number of states lying in an energy interval of 0.01 eV above the fermi level for a crystal of unit volume with fermi energy $E_F = 3.0$ eV

Given $E_F = 3.0\ eV \Rightarrow 3 \times 1.6 \times 10^{-19} = 4.8 \times 10^{-19}\ J$

$\Delta E = 0.01$ eV

We know $(h) = 6.63 \times 10^{-34}$ Js & $(m) = 9.1 \times 10^{-31}$ kg

Let $\Delta E = E - E_F$

$$\Delta E + E_F = E = (3 + 0.01)\ eV = E$$
$$= (3.01 \times 1.6 \times 10^{-19})\ J = E$$
$$\Rightarrow 4.816 \times 10^{-19}\ J = E$$

Number of states per unit volume lying between E & E_F is given by

$$n = \frac{4\pi}{h^3} \times (2m)^{3/2} \times \int_{E_F}^{E} (E)^{1/2}\, dE$$

$$= \frac{4\pi}{h^3} \times (2m)^{3/2} \times \left[\frac{2}{3}(E)^{3/2}\right]_{E_F}^{E}$$

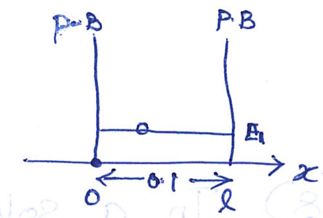
$$n = \frac{4\pi}{h^3} \times (2m)^{3/2} \times \frac{2}{3}\left[E^{3/2} - E_F^{3/2}\right]$$

$$n = \frac{4 \times 3.14 \times [2 \times 9.1 \times 10^{-31}]^{3/2}}{(6.63 \times 10^{-34})^3} \times \frac{2}{3}\left[(4.816)^{3/2} - (4.8)^{3/2}\right] \times [10^{-19}]^{3/2}$$

$$n = 3.74 \times 10^{55} \times (1.108 \times 10^{-30})$$

$$\boxed{n = 4.14 \times 10^{25}\ m^{-3}}$$

5) Find the Lowest energy of an electron Confined in One dimensional Potential box Seperated by distance 0.1 nm



Given $l = 0.1\ nm$ & we know $h = 6.62 \times 10^{-34}$

We know Energy of electron in 1-D Box is

$$E_n = \frac{n^2 h^2}{8 m l^2}$$

To find, Lowest energy of an electron $(n = 1)$

$$E_1 = \frac{(1)^2 \times (6.62 \times 10^{-34})^2}{8 \times (9.1 \times 10^{-31}) \times (0.1 \times 10^{-9})^2}$$

$$E_1 = \frac{4.38244 \times 10^{-67}}{7.28 \times 10^{-31} \times 10^{-18}} = \frac{4.38244 \times 10^{-67}}{7.28 \times 10^{-49}}$$

$$\boxed{E_1 = 6.0198 \times 10^{-19}\ J}$$

6) An electron is bound in One dimensional infinite well of width 1×10^{-10} m. Find the energy value in the ground state and first two excited states

Given $l = 1 \times 10^{-10}$ m & we know $h = 6.62 \times 10^{-34}$

We know $E_n = \frac{n^2 h^2}{8 m l^2}$

To find lowest energy of an electron $(n = 1)$

$$E_1 = \frac{(1)^2 \times (6.62 \times 10^{-34})^2}{8 \times (9.1 \times 10^{-31}) \times (1 \times 10^{-10})^2}$$

$$E_1 = 0.6031 \times 10^{-17}\ J$$

Energy of first excited state $= 4 \times 0.6031 \times 10^{-17}$
$= 2.412 \times 10^{-17}$ J

Energy of second excited state $= 9 \times 0.6031 \times 10^{-17}$
$\boxed{= 5.428 \times 10^{-17}\ J}$

7) Evaluate the fermi function for an energy kT above the fermi energy.

Given $E - E_F = kT$

We know $F(E) = \dfrac{1}{e^{(E-E_F)/kT}+1}$

Therefore $F(E) = \dfrac{1}{e^{(kT/kT)}+1} = \dfrac{1}{e^{(1)}+1} = \dfrac{1}{2.718+1}$

$F(E) = \dfrac{1}{3.718} = \boxed{0.268}$

8) In a solid, consider the energy level lying 0.01 eV below Fermi level. What is the probability of this level not being occupied by an electron?

Given $E - E_F = 0.01\ eV$ & we know $k = 1.38 \times 10^{-23}\ JK^{-1}$

Assume $T = 300K \Rightarrow kT = 0.026\ eV$

To find probability of an energy level E not being occupied by an electron in given by

$$1 - F(E) = 1 - \frac{1}{1+e^{(E-E_F)/kT}} = \frac{1}{1+e^{(E_F-E)/kT}}$$

$$= \frac{1}{1+e^{0.01/0.026}} = \frac{1}{1+e^{0.385}} = \frac{1}{1+1.47}$$

$$= \boxed{0.405}$$

9) Find the temperature at which there is 1% probability of a state with an energy 0.5 eV above Fermi energy.

Given $E = E_F + 0.5\,eV$; $F(E) = 1\% = 0.01$

We know $F(E) = \dfrac{1}{1+e^{E-E_F/kT}}$ & $k = 1.38 \times 10^{-23}\ JK^{-1}$

Then $0.01 = \dfrac{1}{1+e^{0.5/kT}}$

$$1 + \exp\left(\frac{0.5}{kT}\right) = \frac{1}{0.01}$$

$$\exp\left(\frac{0.5}{kT}\right) = 99$$

$$\frac{0.5}{kT} = \ln(99)$$

$$T = \frac{0.5 \times 1.6 \times 10^{-19}}{\ln(99) \times 1.38 \times 10^{-23}}$$

$$\boxed{T = 1261\,k}$$

10) The Fermi level for potassium is 2.1 eV. Calculate the velocity of the electron at the Fermi level

Given $E_F = 2.1\,eV$

We know $E_F = \frac{1}{2} m v_F^2 \Rightarrow v_F = \left(\frac{2E_F}{m}\right)^{1/2}$

Then $v_F = \left[\frac{2 \times 2.1 \times 1.602 \times 10^{-19}}{9.11 \times 10^{-31}}\right]^{1/2}$

$\boxed{v_F = 8.6 \times 10^5\ m/s}$

---

11) Calculate the k-value for an electron in the Conduction band of GaAs having energy of 0.01 eV (measured from band edge). Compare this to the case where the electron in free space. The effective mass of electrons in GaAs is 0.067 m.

We know k-value is given by $k = \frac{\sqrt{2mE}}{\hbar}$

For GaAs appropriate mass in Conduction band is $0.067\,m_0$

This given $k = \frac{[2 \times (0.067 \times 9.1 \times 10^{-31}\,kg)(0.1 \times 1.6 \times 10^{-19}\,J)]^{1/2}}{1.05 \times 10^{-34}\ Js}$

$\boxed{k = 4.2 \times 10^8\ m^{-1}}$

In free space we get $k = 1.625 \times 10^9\ ms^{-1}$

The two values are quite different since the k-value in the crystal represents an effective momentum

---

12) Calculate the energy of an electron and of a hole in the heavy hole band of semi conductor at a k-value of 0.1 Å. The heavy hole mass is $0.5\,m_0$

The electron energy in the valence band is $E_e = E_V - \frac{\hbar^2 k^2}{2m_h^*}$

After using the parameter given we get

$E_e = E_V - 1.21 \times 10^{-20}\ J = \boxed{E_V - 0.0755\ eV}$

The hole energy is inverse of electron energy

$E_h = \boxed{E_V + 0.0755\ eV}$

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

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

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

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

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

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

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

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
   (B)Diodes are rectifying devices
   (C)Diodes are unidirectional devices
   (D)Diodes have three terminals

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

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^{+}

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
   (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

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

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

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

27. When a pure semiconductor is heated, its resistance ………….
   a. Goes up
   b. Goes down
   c. Remains the same
   d. Can't say

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)

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

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

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

d) $\mu \propto T^2$

35. The electronic configuration of silicon is

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

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

c) $\mathbf{1s^2, 2s^2, 2p^6, 3s^2, 3p^2}$

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

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

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

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

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

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 $\Delta\, n \; and \; \Delta\, p$ 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

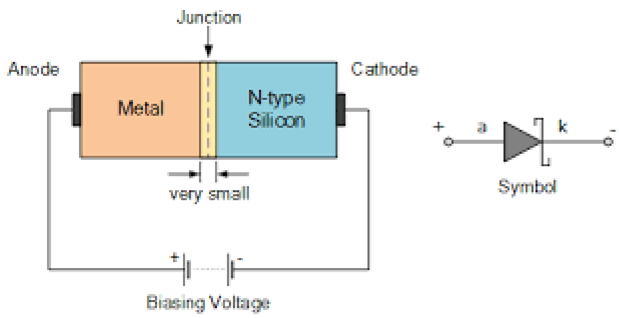
55. A p-n junction is fabricated from a semiconductor with band gap of 3.0 eV. The wavelength of the radiation which it can detect is
a) 600 nm
b) **400 nm**
c) 100 nm
d) 1000 nm

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

57. In an abrupt P – N junction, the doping concentrations on the P – side and N – side are $9\times16^{16}/cm^3$ and $1\times10^6/cm^3$ respectively. The P – N junction is reverse biased and the total depletion width is 3 μm. The depletion width on the P – side is

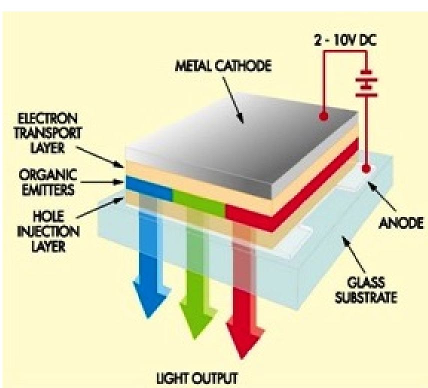
a) 2.7 μm
b) **0.3 μm**
c) 2.25 μm
d) 0.75 μm

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



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

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



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

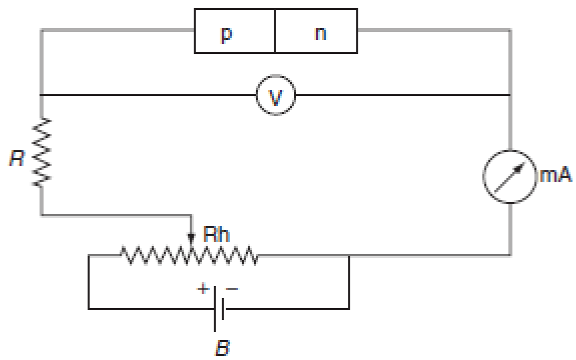
a) each of them increases

b) each of them decreases

c) copper increases and germanium decreases

d) **copper decreases and germanium increases**

61. The given circuit represents……….



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, $n_i=2.5\text{x}10^{19}/m^3$; $\mu_e=0.39\ m^2v^{-1}s^{-1}$ and $\mu_h=0.19m^2v^{-1}s^{-1}$ at 300K.

a) **4.31x10^3 ohm**

b) 0.131x10^3 ohm

c) 1.531x10^2 ohm

d) 2.131x10^{4}ohm

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

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

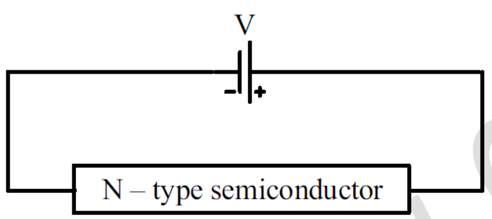
a) $dp/dt = n_o - n/\, n_o - (\mu_p E) dp/dx + (D_p) d^2p/dx^2 + G$

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

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

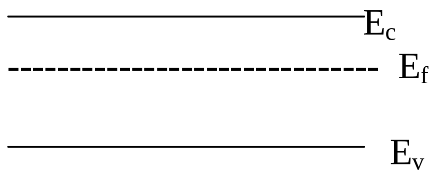
d) $dp/dt = P_o - P/\, P_o - (\mu_p E) dp/dx + (D_p) d^2p/dx^2$

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

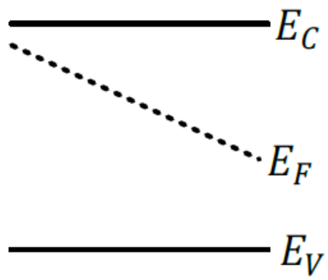


If E_c is the lowest energy level of the conduction band, E_V is the highest energy level of the valance band and E_F is the Fermi level, which one of the following represents the energy band diagram for the biased N – type semiconductor?

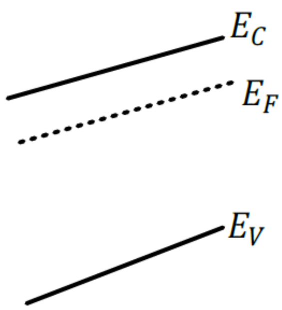
a)



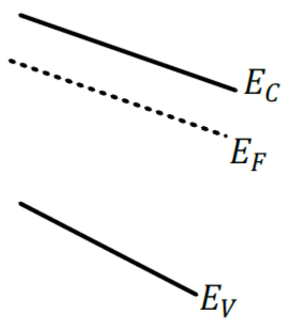
b)



c)

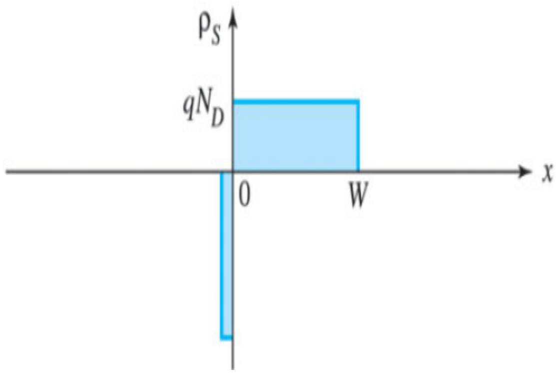


d)



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) $3.05\text{X}10^{14}$

b) $1.075\text{X}10^{14}$

c) **$4.075\text{X}10^{14}$**

d) $2.075\text{X}10^{14}$

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.

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY, RAMAPURAM CAMPUS, CHENNAI

DEPARTMENT OF PHYSICS

QUESTION BANK – I YEAR B.Tech.

18PYB103J- SEMICONDUCTOR PHYSICS

UNIT 3

PART A-ONE MARK QUESTIONS

1. ________ is the process where the energy due to recombination is dissipated as photons.
(A) Radiative transition
(B) Non-radiative transition
(C) Absorption
(D) Radiation

2. The maximum voltage generated across the terminals of solar cell when they are kept open is called _______.
(A) Short circuit voltage
(B) Open circuit voltage
(C) Fill factor
(D) Drift Voltage.

3. The _______ process is in which the electron-hole pairs are created and recombined radiatively.
(A) Luminescence
(B) Photon emission
(C) Phonon emission
(D) Radiation.

4. The average velocity acquired by the electrons in a particular direction during the presence of electric field is called _______.
(A) Relaxation time
(B) Drift velocity
(C) Collision time
(D) Diffusion current

5. The photons of energy value ____ that of the band gap values do not get absorbed in photovoltaic cell.
(A) Greater than
(B) Less than
(C) Nearly equal than
(D) Zero

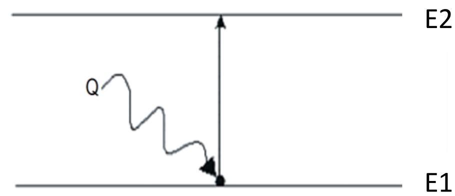
6. _____ is the process where the excess energy due to recombination is usually imported to phonons and dissipated as heat.
(A) Radiative transition
(B) Non-radiative transition
(C) absorption
(D) Radiation.

7. The radiative recombination of electron-hole pair created by injection of photons is called ________.
(A) Photoluminescence
(B) Photon emission
(C) Phonon emission
(D) Radiation

8. The maximum current flows in solar cell when its P-side & N-side terminal are shorted, such a current is called _____.
(A) Drift current
(B) Diffuse current
(C) Short-circuit current
(D) Alternative current

9. The ratio between E_g and charge of electron in photovoltaic cell is called _____.
(A) Current loss
(B) Voltage loss
(C) loss due to metal
(D) Optical loss.

10. The given diagram represents ……………..



(A)Spontaneous emission

(B) Stimulated emission

(C) Absorption process

(D) Temperature inversion

11. Which of the following is responsible for electrical conduction in metal?

(A) Electrons

(B) Protons

(C) Neutrons

(D) Positrons

12. The given diagram represents ……………..

(A) Photovoltaic Cell

(B) Fuel cell

(C) Two probe

(D) DMS

13. The ______ does not require any external energy for process to take place.

(A) Stimulated emission

(B) Spontaneous emission

(C) Stimulated absorption

(D) Stimulated radiation.

14. The light amplification is achieved by _____ from an atomic or molecular system.

(A) Spontaneous emission

(B) Stimulated emission

(C) Time inversion

(D) Temperature inversion

15. _____ is the process of radiative recombination of electron–hole pairs created by electron bombardment.

(A) Photoluminescence

(B) photon emission

(C) Phonon emission

(D) Cathodoluminescence

16. The open circuit voltage of a solar cell increases with _______.

(A) Increase in bandgap

(B) Decrease in band gap

(C) Increase of in holes

(D) Decrease in holes

17. The current density is directly proportional to the _________.

(A) Rest mass of electron

(B) Applied electric field

(C) density of core electron

(D) Collision time.

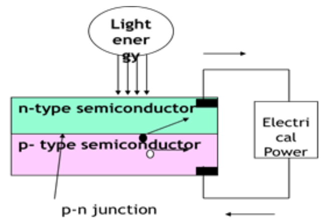
18. The given diagram represents …………… effect.

(A) Photovoltaic effect

(B) Compton effect

(C) Raman effect

(D) Zeeman Effect.



19. The ratio of the maximum power that can be extracted from a solar cell to the ideal power is called ___.

(A) Short circuit voltage

(B) Open circuit voltage

(C) Fill factor

(D) Drift Voltage

20. The sun light can be converted to electricity due to the _________.

(A) Photovoltaic effect

(B) Compton effect

(C) Raman effect

(D) Zeeman Effect.

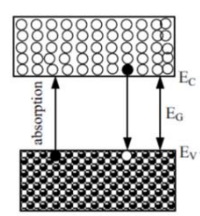
21. Which one of the following is related to the diagram?

(A) Band to band transition

(B) Impurity to band transition

(C) Free carrier Transition

(D) Photonic transition



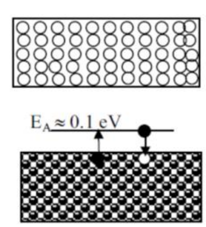
22. Which one of the following is related to the diagram?

(A) Band to band transition

(B) Impurity to band transition

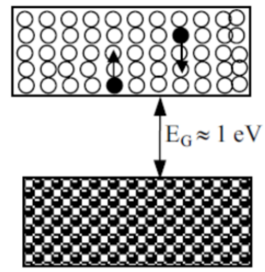
(C) Free carrier Transition

(D) Photonic transition



23. Which one of the following is not a postulate of Classical free electron theory?
(A) The valence electrons are freely moving about the whole volume of the metals
(B) The energy levels of the electrons moving inside the metal are discrete.
(C) The free electrons collide with each other positive ions
(D) When the electric field is applied all the valence electrons a drifted

24. Which one of the following is related to the diagram?



(A) Band to band transition
(B) Impurity to band transition
(C) Free carrier Transition
(D) Photonic transition

25. Illustrate the properties of Photoluminescence ………………

(I) The Principle of this method is based on the absorption of ultraviolet light or visible light by chemical compounds, which results in the production of distinct spectra. Spectroscopy is based on the interaction between light and matter.
(II) It is a process in which a molecule absorbs a photon in the visible region, exciting one of its electrons to a higher electronic excited state, and then radiates a photon as the electron returns to a lower energy state.
(III) This method is routinely used in analytical chemistry for the quantitative determination of different analytes, such as transition metal ions, highly conjugated organic compounds, and biological macromolecules.
(IV) It is the spontaneous emission of light from a material following optical excitation. It is a powerful technique to probe discrete energy levels and to extract valuable information about semiconductor sample composition, quantum well thickness or quantum dot sample mono dispersity.

(A) All the four Incorrect
(B) Both II and III correct
(C) Both III and I correct
(D) Both II and IV correct

26. The direct band to band absorption and emission can take place only at frequencies for which photon energy ______.
(A) $h\gamma > E_g$
(B) $h\gamma < E_g$
(C) $h\gamma = E_g$
(D) $h\gamma = 0$

27. The ratio between spontaneous and stimulated emission coefficients is called ________.

(A) Lorenz number
(B) Lorentz coefficient
(C) Absorption coefficient
(D) Einstein's coefficient

28. Analyse the device Photovoltaic Cell

I) The single photovoltaic cell constitute the *n-type* layer *sandwiched*with p-type layer.
(II) This is an electrical device that converts the energy of light into electricity.
(III) The operation of all optoelectronic devices is based on creation or annihilation of electron hole pairs.
(IV) These are the class of vacuum tubes, and more specifically vacuum phototubes, are extremely sensitive detectors of light.

(A) Both I and II correct
(B) Both I and III correct
(C) Both II and IV correct
(D) Both I and II correct

29. Analyse recombination process

(I) simplest way to achieve this phenomenon is to irradiate the semiconductor

(II) Recombination maybe radiative or non radiative.

(III) Pair formation essentially involves raising an electron in energy from the valence band to conduction band leaving hole behind in valence band.

(IV) The energy levels of the electrons moving inside the metal are discrete.

(A) Both I and IV correct
(B) Both I, II and III correct
(C) Both II and IV correct
(D) Both III and IV correct

30. Efficiency of single crystalline Silicone is about --------

(A) 14 – 17
(B) 1-7
(C) 13 – 15
(D) 5 - 7

31. Which one of the following is not a drawback of Classical free electron theory?
(I) It could not explain photoelectric effect and Compton effect.
(II) It verifies ohms law.
(III) Electrical conductivity of semiconductors and insulators could not explain.
(IV) Ferromagnetism could not explain by this theory.

(a) Both I and III correct

(b) All the four Incorrect

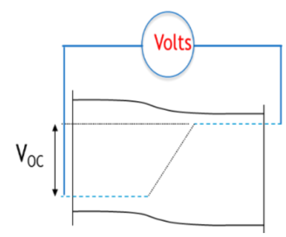
(c) II - correct

(d) Both I and IV correct

32. The average velocity acquired by the free electrons of a metal in aparticular direction by the application of electric field equal to ------------.

(I) eEτ / m
(II) eEτ m
(III) eE / m
(IV) eτ / m

33. Which one of the following is related to the diagram?



(A) Open circuit voltage
(B) Short circuit voltage
(C) Short circuit current
(D) Open circuit Current

34. Which one of the following is related to this expression?

$$W_{abs} = \frac{2\pi}{\hbar}|\langle f|H_{int}|i\rangle|^2\ \delta(E_f - E_i - \hbar\omega)$$

(A) Joint density of states
(B) Fermi's Golden Rule
(C) Energy density
(D) Fermi Energy

35. Fill factor of PV cell equal to ------------
(A) $(I_{mp}) / (I_{SC} \cdot V_{OC})$
(B) $(I_{mp} \cdot V_{mp}) / (I_{SC} \cdot V_{OC})$
(C) $(V_{mp}) / (I_{SC})$
(D) $(I_{mp} \cdot V_{mp}) / (V_{OC})$

36. Calculate the electrical resistivity of sodium at 0^0 C. It has 25.33 x 10^{27} unit volume and has a mean free time of 3.2 x 10^{14}s.

(A) 4.532 X 10^{-36} Ω m
(B) 5.431 X 10^{-36} Ω m
(c) 6.81 X 10^{-36} Ω m
(D) 3.12 X 10^{-36} Ω m

37. Efficiency of Amorphous Silicone is about --------
(A) 14 – 17
(B) 1-7
(C) 13 – 15
(D) 5 - 7

38. The spectral region where the material changes from being relatively transparent to strongly absorbing is known as ---------.

(A) Absorbing edge

(B) Conduction edge

(C) Valance edge

(D) Annihilation edge

39. In stimulated emission, the state at which the life time of atoms is extended is ---------.

(A) Metastable state

(B) Stable state

(C) Excited state

(D) Ground state

40. The absorption coefficient of semiconducting materials strongly depends on the……………
(A) Properties of material
(B)Wavelength
(C) Amount of light
(D) Amplitude

Unit -4

Part – A

1. In a ---- the electrons are ejected from a photoemissive surface and are amplified within the cell.
   (A) Photomultiplier tube (B) Bolometer (C) Electrode (D) Photodiode

2. Alkali metals and their oxides are best ------ materials.
   (A) Photoemissive (B) Conductig (C) Insulating (D)Semiconducting

3 .The crystallie solids absorbs energy and re-emits it the visible region of the spectrum is called -----.
   (A) Luminescence (B) Photon emission (C) Phonon emission (D) Radiation.

4. Find out the hall coefficient of an n type semiconductor having carrier concentration of 5 x 10^{15} cm^{-3}
   (A) 1150 (B). 1250 (C). 1350 (D) 1450

5. ------- Spectroscopy can be used to determine the concentration of absorbs in a solution.
   (A) UV Vis (B) IR (C) Microwave (D) Gamma

6. An ideal monochromator should have an ------ narrow effective bandwidth.
   (A) Infinitely (B) Small (C) Zero (D) finite

7. ------ is an instrumentation used for determine the concentration of impurities of a sample.
   (A) DLTS (B) TGA (C) DTA (D) IR

8. ------ is used for separating source radiation wavelengths.
   (A) Monochromator (B) Antenna (C) Detector (D) Display device.

9. The ------- method is generally employed in the system where crystals are not easily obtained.
   (A) Rotating crystal (B) Oscillating **(C) Powder Crystal** (D) Fixed Crystal

10. the method which provides information on bond length and angles I the molecule which helps I structure determination -------.
    (A) Thermal method **(B) X-ray diffraction method** (C) potentiometric method
    (D) Ammperometric method

11. The path difference is an integral multiple of wavelength is called --------.
    (A) Bragg law (B) Biotsavart’s Law (C) Ohms Law (D) Lambert’s law

Unit – 5

Part – A

1. In a quantum wire the material size is reduced-----.
   (A) 3 directions (B). **2 directions** (C). 1 directions (D). 0 directions

2. Tensile strength of CNT exceeds----.
   (A) 1KPa (B) 1 MPa **(C) 150 GPa** (D) 1TPa

3. Carbon nanotube reactivity is related to -----.
   (A) volume (B) length (C) **diameter** (D) Width

4. In CVD chamber the precursors are introduced to the reaction chamber in the ….. state.
   (A) Liquid (B) Solid (C) Gaseous (D) colloidal

5. Nano structures have dimensions in between ……
   (A) 1 to 100 Å (B) **1- 100 nm** (C) 100-1000 nm (D) 100- 1000 Å

6. AFM tip should have a radius of curvature of-----.
   (A) **greater than 20-50 nm** (B) lesser than 20-50 nm (C) around 100 nm
   (D) more than 100 nm

7. In a quantum dot the material size is reduced -------.
(A) **3 directions** (B) 2 directions (C) 1 directions (D) 0 directions

8. Electrons are caused by the de-energization of the specimen after a secondary electron is produced -----.
(A) **Auger** (B) Bragg (C) Lorenz (D) Kakuchi

9. The physical parameter that is propped in AFM resulting from different interaction is ----.
(A) Charge (B**) Force** (C) potential (D) temperature

10. In PVD chamber the precursors are introduced to the reaction chamber in the ….. state
    (A) Liquid (B) **Solid** (C) Gaseous (D) semisolid

11. In CVD Chamber, the precursors are introduced to the reaction chamber in the ____ state.
(A) Liquid (B) Solid (C) **Gaseous** (D) semisolid

12. Nanoparticles are special mainly because of their ____
(A) **Surface area** (B)surface charge (C) volume (D) force

13. Exciton can move freely in two directions only in

(A) **Quantum well** (B) quantum wire (C) quantum dot (D) bulk

14. Bands of alternating light and dark lines that are formed by inelastic scattering interactions that are related to atomic spacings in the specimen are called ____.

(A) Auger bands (B) Bragg bands (C) Lorentz bands (D) **Kakuchi bands**

15. Nanotechnology deals with ___ of nanostructures into useful nanoscale devices such as electronic circuits and mechanical devices at the molecular level
(A) the design (B) manufacturing (C) applications (D) **engineering**

1.What do you mean by Density of states?
• The density of states function describes the number of energy states that are available in a system and is essential for determine the carrier concentrations and energy distributions of carriers within a semiconductor.
• In semiconductors, the free motion of carriers is limited to two, one and zero spatial dimensions. When applying semiconductor statistics to systems of these dimensions, the density of states in quantum well (2D), quantum wires (1D) and quantum dots (0D) must be known.
2. What are low dimensional systems?
•A low-dimensional system, also called confined system, is any way quantum system in which the carriers are free to move in two, one, or zero dimensions in these systems, the spatial dimensions are of the order of De Broglie wavelength of the carriers and therefore the carrier energy states and density of states become quantized. As a result, the electronic, electrical, and optical behaviour of the carriers are governed by quantum mechanical principles or mechanisms
• A low-dimensional system is one where the motion of microscopic degrees-of-freedom, such as electrons, phonons or photons, is restricted from exploring the full three dimensions of the present world.
• In the low dimensional quantum systems such as Quantum well, Quantum wire and Quantum dot, the charge carriers are free to move in two, one and zero dimensions respectively.
• The main advantages of these low dimensional semiconductor systems are in the realizations of important devices, like the double heterostructure lasers with low threshold at room temperature, high effective LEDs, bipolar transistors, p-n-p-n switching devices, high electron mobility transistors (HEMT) and many other optoelectronic devices.
3. Brief the DOS in low dimensional systems?
• A low-dimensional system is one where the motion of microscopic degrees-of-freedom, such as electrons, phonons or photons, is restricted from exploring the full three dimensions of the present world.
• In the low dimensional quantum systems such as Quantum well, Quantum wire and Quantum dot, the charge carriers are free to move in two, one and zero dimensions respectively.
• The main advantages of these low dimensional semiconductor systems are in the realizations of important devices, like the double heterostructure lasers with low threshold at room temperature, high effective LEDs, bipolar transistors, p-n-p-n switching devices, high electron mobility transistors (HEMT) and many other optoelectronic devices.

4. Compare the DOS in OD,1D and 2D systems. ************
in zero-dimensional (0D) nanomaterials all the dimensions are measured within the nanoscale (no dimensions are larger than 100 nm). Most commonly, 0D nanomaterials are nanoparticles.
In one-dimensional nanomaterials (1D), one dimension is outside the nanoscale. This class includes nanotubes, nanorods, and nanowires.
In two-dimensional nanomaterials (2D), two dimensions are outside the nanoscale. This class exhibits plate-like shapes and includes graphene, nanofilms, nanolayers, and nano coatings.
5. Discuss about quantum well, quantum wire and quantum dot.
<u>Quantum well: -</u>
•If one dimension is reduced to the nano-range while the other dimensions remain large, then we obtain a structure known as quantum well. In these systems the particles are confined in one direction and are free to move in two directions.

•The conduction electrons are confined in a narrow dimension and such a configuration is referred as quantum well.

Quantum wire: -

•If two dimensions are reduced the nano-range and one remain large, the resulting structure is referred to as a quantum wire. In these systems the particles are confined in two directions and are free to move in one direction

•A quantum wire is a structure such as a copper wire that is long in one dimension, but has a nano-meter size as its diameter. In this case, the electrons move freely along the wire but are confined in the transverse directions.

Quantum dot: -

•The extreme case of this process of size reduction in which all three dimensions reach the low nano-meter range is called a quantum dot. In these systems the particles are confined in all three directions and can not move freely in any spatial direction.

•The quantum dot may have the shape of a tiny cube, a short cylinder or a sphere with low nanometre dimensions.

6. What are the different allotropes of carbon?

•Diamond, graphite and fullerenes (substances that include nanotubes and 'buckyballs', such as buckminsterfullerene) are three allotropes of pure carbon.

7. Write the properties of CNT.

CNT exhibits extraordinary mechanical properties:

•The Young's modulus is over 1 Tera Pascal. It is stiff as diamond.

•The estimated tensile strength is 200 GPa. These properties are ideal for reinforced composites, Nano electromechanical systems (NEMS)

•Apart from remarkable tensile strength, CNT nanotubes exhibit varying electrical properties (depending on the way the graphite structure spirals around the tube, and other factors, such as doping), and can be superconducting, insulating, semiconducting or conducting (metallic)

•CNT Nanotubes can be either electrically conductive or semi conductive, depending on their helicity (shape), leading to nanoscale wires and electrical components.

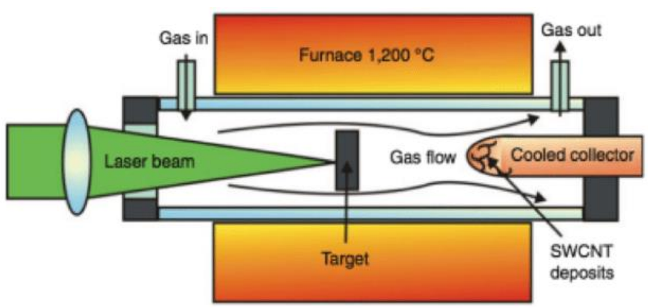
Chemical reactivity:

•The chemical reactivity of a CNT is very high as compared with a graphene sheet because of its curved surface.

•A Nanotube with smaller diameter results in increased reactivity.

8. How will you synthesize CNT by Laser ablation?

Process: -



Process: -

•Vaporizes graphite at 1200 0C with Helium or argon gas

• A hot vapor plume forms and expands and cools rapidly

• Carbon molecules condense to form large clusters

• Yield of up to 70%

9. Give any 3 Applications of CNT.

•Carbon Nanotube can be used as a conducting channel in Field emission Transistor
•Because of their flexibility, Nanotubes can also be used in scanning probe instruments.
•High Strength Composites
•Conductive Composites
•Medical Applications

10. Brief on the working of CVD

A basic CVD process consists of the following steps: -

•A predefined mix of reactant gases and diluent inert gases are introduced at a specified flow rate into the reaction chamber;
•The gas species move to the substrate;
•The reactants get adsorbed on the surface of the substrate;
•The reactants undergo chemical reactions with the substrate to form the film; and
•The gaseous by-products of the reactions are desorbed and evacuated from the reaction chamber.

11. Differentiate heterogenous and homogenous reactions in CVD

s.no	Homogeneous reactions	Heterogeneous reactions
1	Reactions that take place in the gas phase are known as homogeneous reactions	Reactions that take place at the substrate surface are known as heterogeneous reactions
2	selectively occur on the heated surface of the wafer where they create good-quality films.	Homogeneous reactions form gas phase aggregates of the depositing material, which adhere to the surface poorly and at the same time form low-density films with lots of defects.

•heterogeneous reactions are much more desirable than homogeneous reactions during chemical vapor deposition.

12. Differentiate Hot wall reactor and cold wall reactor in CVD

s.no	Hot wall reactor	cold wall reactor
1	a reactor is said to be 'hot-wall' if it uses a heating system that heats up not only the wafer	In cold wall reactors, the substrate itself is heated
2	In hot-wall reactors, films are deposited on the walls in much the same way as they are deposited on wafers.	'Cold-wall' reactors use heating systems that minimize the heating up of the reactor walls while the wafer is being heated up
3	Example: - radiant heating from resistance-heated coils.	Example: - of which is heating via IR lamps inside the reactor.

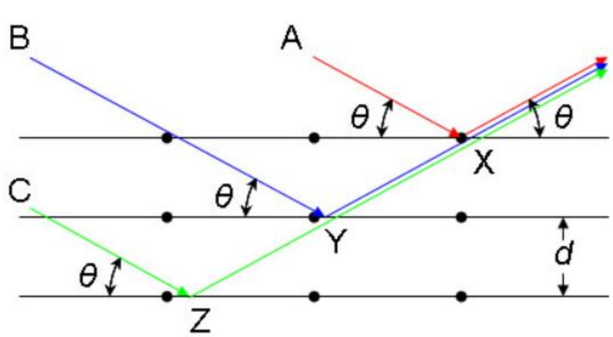
13. Classify CVD based on the operating pressure
•These are classified into 3 types based it on the range of their operating pressure.
1) Atmospheric pressure CVD
•Reactors operate at atmospheric pressure, and are therefore the simplest in design.
2) Low-pressure CVD
•reactors operate at medium vacuum (30-250 Pa) and higher temperature than APCVD reactors.
3) Plasma Enhanced CVD
•reactors also operate under low pressure, but do not depend completely on thermal energy to accelerate the reaction processes.

14. Brief on the working of PVD.
• Physical vapour deposition (PVD) is fundamentally a vaporisation coating technique, involving transfer of material on an atomic level. It is an alternative process to electroplating
• The process is similar to chemical vapour deposition (CVD) except that the raw materials/precursors, i.e. the material that is going to be deposited starts out in solid form, whereas in CVD, the precursors are introduced to the reaction chamber in the gaseous state.

15. What are the four 4 processes in PVD?
• PVD processes are carried out under vacuum conditions. The process involved four steps:
1.Evaporation
2.Transportation
3.Reaction
4.Deposition

<u>Evaporation</u>
During this stage, a target, consisting of the material to be deposited is bombarded by a high energy source such as a beam of electrons or ions. This dislodges atoms from the surface of the target, 'vaporising' them.
<u>Transport</u>
This process simply consists of the movement of 'vaporised' atoms from the target to the substrate to be coated and will generally be a straight-line affair.
<u>Reaction</u>
The atoms of metal will then react with the appropriate gas during the transport stage.
<u>Deposition</u>
This is the process of coating build up on the substrate surface. Depending on the actual process, some reactions between target materials and the reactive gases may also take place at the substrate surface simultaneously with the deposition process.

16. State Bragg's law?
<u>Bragg's law: -</u> The law states that when the x-ray is incident onto a **crystal** surface, its angle of incidence 'θ', will reflect back with a same angle of scattering 'θ'. And, when the path difference, d is equal to a whole number, n, of wavelength, a constructive interference will occur.



$n\lambda = 2d\sin\theta$

where:

- λ is the wavelength of the x-ray,
- d is the spacing of the crystal layers (path difference),
- θ is the incident angle (the angle between incident ray and the scatter plane), and
- n is an integer

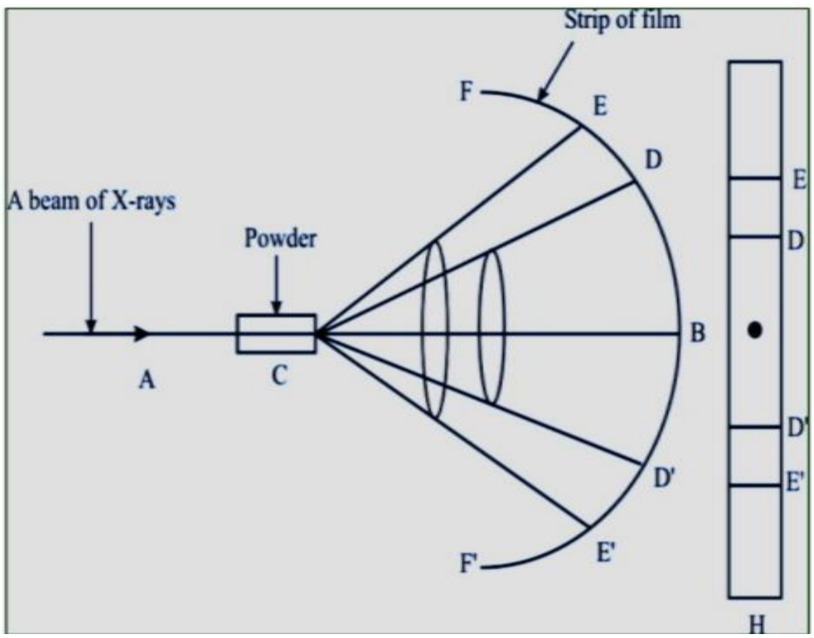
17. What is the method of Powder XRD?

The powder method:

•A narrow beam of monochromatic X-rays fall on the finely powdered specimen to be examined, and the diffracted rays are passed on to a strip of film which almost completely surrounds the specimen.

•The random orientation of crystals produces diffraction rings. This method is commonly used for identification purposes by comparing the data with the standard files available.

•For a cubic crystal the identification of lines in the powder photograph is simple compared to other types.



18. What is the principle of SEM?

• Scanning electron microscopes (SEMs) use an electron beam to image samples with a resolution down to the nano-meter scale. The electrons are emitted from a filament and collimated into a beam in the electron source. The beam is then focused on the sample surface by a set of lenses in the electron column.

• “Scanning Electron Microscopy”, or SEM analysis, provides high-resolution imaging useful for evaluating various materials for surface fractures, flaws, contaminants or corrosion

19. How are backscattered, secondary and Auger electrons utilised in SEM?

Backscattered Electrons: -

•The production of backscattered electrons varies directly with the specimen's atomic number.

•This differing production rates causes higher atomic number elements to appear brighter than lower atomic number elements.

•This interaction is utilized to differentiate parts of the specimen that have different average atomic number.

Secondary Electrons: -

• Production of secondary electrons is very topography related.
• Due to their low energy, 5eV, only secondaries that are very near the surface (<10nm,) can exit the sample and be examined.
• Any changes in topography in the sample that are larger than this sampling depth will change the yield of secondaries due to collection efficiencies.
• Collection of these electrons is aided by using a "collector" in conjunction with the secondary electron detector.

Auger Electrons: -

• Auger Electrons have a characteristic energy, unique to each element from which it was emitted from.
• These electrons are collected and sorted according to energy to give compositional information about the specimen

20. What is the principle of TEM?

•TEM Principle: -The TEM operates on the same basic principles as the light microscope but uses electros instead of light. ... Because the wavelength of electrons is much smaller than that of light, the optimal resolution attainable for TEM images is many orders of magnitude better than that from a light microscope

21. How does unshattered, elastically scattered and inelastically scattered electrons provide information in TEM?

•When a specimen is a crystal, elastically scattered electrons become diffracted waves that travel in specific directions given by the Bragg condition. ... As a specimen is thinner, the intensity of a TEM image or a diffraction pattern is explained by elastically scattered electrons.

22. What is the principle of AFM?

•AFM Principle: -

•Surface Sensing: -

an AFM uses a cantilever with a very sharp tip to scan over a sample surface. As the tip approaches the surface, the close-range, attractive force between the surface and the tip cause the cantilever to deflect towards the surface. However, as the cantilever is brought even closer to the surface, such that the tip makes contact with it, increasingly repulsive force takes over and causes the cantilever to deflect away from the surface.

• Detection Method: -

A laser beam is used to detect cantilever deflections towards or away from the surface. By reflecting an incident beam off the flat top of the cantilever, any cantilever deflection will cause slight changes in the direction of the reflected beam. A position-sensitive photo diode (PSPD) can be used to track these changes. Thus, if an AFM tip passes over a raised surface feature, the resulting cantilever deflection (and the subsequent change in direction of reflected beam) is recorded by the PSPD.

•Imaging: -

An AFM images the topography of a sample surface by scanning the cantilever over a region of interest. The raised and lowered features on the sample surface influence the deflection of the cantilever, which is monitored by the PSPD. By using a feedback loop to control the height of the tip above the surface— thus maintaining constant laser position—the AFM can generate an accurate topographic map of the surface features.

23. Comment on the working concept of AFM.

•The Atomic Force Microscope works on the principle measuring intermolecular forces and sees atoms by using probed surfaces of the specimen in nanoscale. ... The Atomic Force Microscope (AFM) takes the image of the surface topography of the sample by force by scanning the cantilever over a section of interest.

24. Define Diffusion.

•Diffusion is the process of movement of molecules under a concentration gradient. It is an important process occurring in all living beings. Diffusion helps in the movement of substances in and out of the cells. The molecules move from a region of higher concentration to a region of lower concentration until the concentration becomes equal throughout.

25. Define ion implantation.

•Ion implantation is a low-temperature process by which ions of one element are accelerated into a solid target, thereby changing the physical, chemical, or electrical properties of the target. Ion implantation is used in semiconductor device fabrication and in metal finishing, as well as in materials science research. The ions can alter the elemental composition of the target (if the ions differ in composition from the target) if they stop and remain in the target. Ion implantation also causes chemical and physical changes when the ions impinge on the target at high energy. The crystal structure of the target can be damaged or even destroyed by the energetic collision cascades, and ions of sufficiently high energy (10s of MeV) can cause nuclear transmutation.

26. Define epitaxial growth

•Epitaxial growth is broadly defined as the condensation of gas precursors to form a film on a substrate. Liquid precursors are also used, although the vapor phase from molecular beams is more in use.

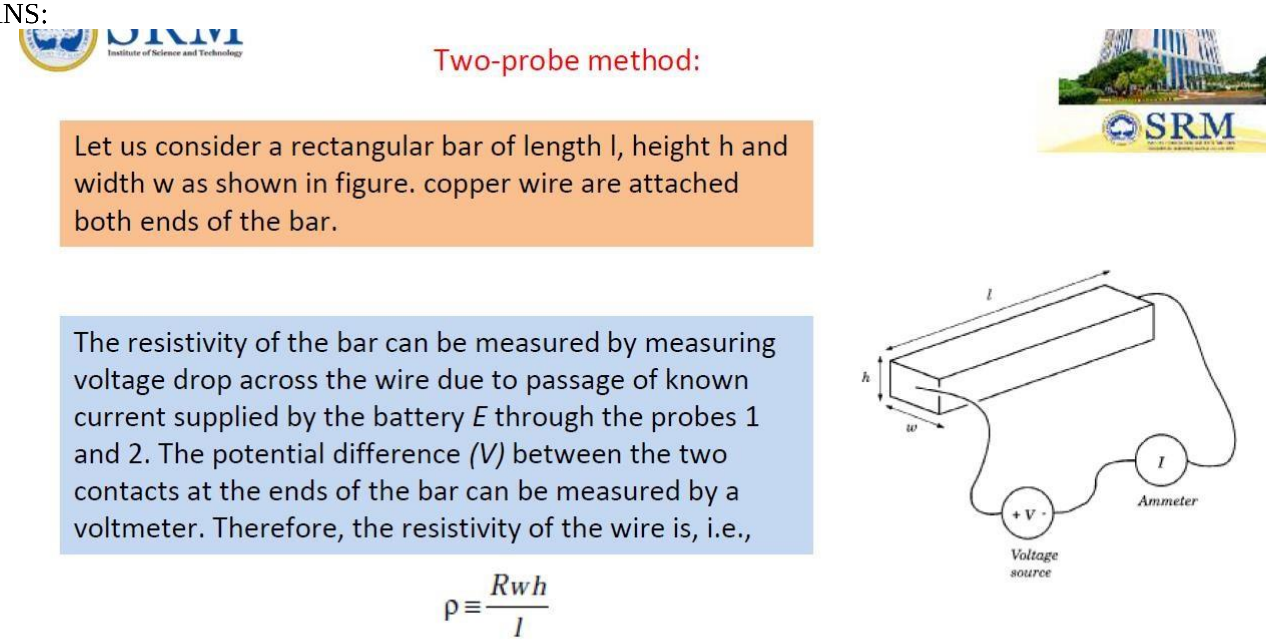
27. Shortly discuss the band diagrams of dissimilar single layer p-n junction.

28. Shortly discuss the band diagrams of dissimilar double layer p-n junction.

Module-IV

1. Explain resistivity of a given material determined using two probe method.

ANS:



2. Mention any three advantages of Four Point Probe over two point probe method.

ANS:

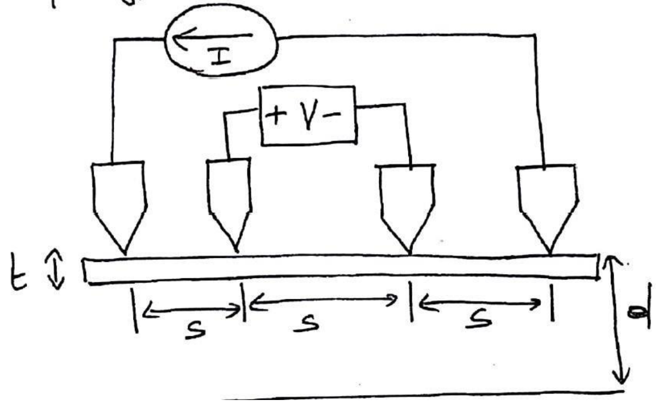
Advantage of four probe method over two probe method

Four point probe is preferred than two-point probe as the contact and spreading resistances in two point probe are large and the true resistivity cannot be actually separated from measured resistivity. In the four probe method, contact and spreading resistances are very low with voltage probes and hence accuracy in measurement is usually very high. To measure very low resistance values, four probe method is used. The resistance of probe will be not be added to that of sample being tested. It uses two wires to inject current in the resistance and another two wires to measure the drop against the resistance.

3. Explain how the sample is connected to the probes in Four Point Probe method.

ANS:

→ The four-point probe method, has four equally spaced in-line probes with probe tip diameters small compared to the probe spacing, "s".



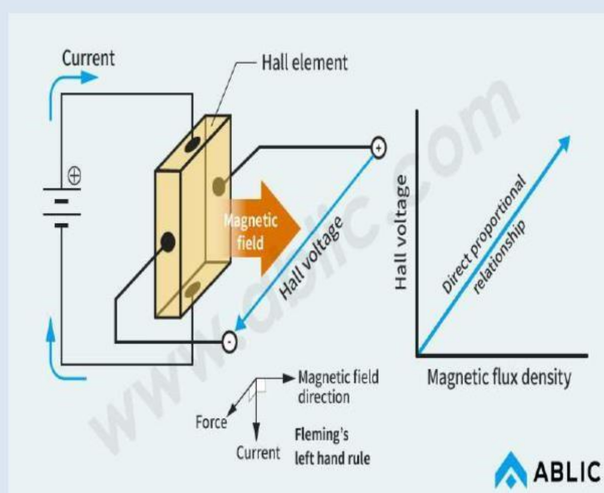
In-line four-point probe measurement of a conductive film of thickness t, uses a known current source, high-impedance voltmeter, spring loaded sharp probes.

4. State Hall Effect with diagram.

ANS:

Definition

When a piece of conductor (metal or Semiconductor) carrying current is placed in a transverse magnetic field, an electric field is produced inside the conductor in a direction normal to both the current and the magnetic field. This phenomenon is known as the Hall Effect and the generated voltage is called the Hall voltage.



5. Derive the expression for the Hall coefficient of n type semiconductor

ANS;

At equilibrium , $eE_H = Bev$ (or) $E_H = Bv$ (1)

If J is the current density, then , $J= -nev$ (2)

Where 'n ' is the concentration of current carriers,

From equ. (2)

$v= J/-ne$ (3)

Substituting the value of v in equ. (1) we get,

$E_H = BJ/-ne$ (4) .

- The Hall Effect is described by means of the Hall coefficient 'R_H ' in terms of current density ' J' by the relation,

$E_H = R_HBJ$

(or) $R_H = E_H / BJ$ (5)

By substituting the value of E_H from equ. (4) we get,

$R_H = BJ/ -neBJ = - 1/ne$ (6)

- Since all the three quantities E_H, J and B are measurable , the Hall coefficient R_H and hence the carrier density 'n' can be found out.

6. Write any three applications of Hall Effect.

ANS:

Applications of Hall effect:

(1) Determination of type of semiconductor

For a N-type semiconductor, the Hall coefficient is negative whereas for a P-type semiconductor, it is positive. Thus from the direction of the Hall voltage developed, one can find out the type of semiconductor.

(2) Calculation of carrier concentration

Once Hall coefficient R_H is measured, the carrier concentration can be obtained from,

$n = 1/eR_H$ or $p = 1/eR_H$

(3). Determination of mobility

We know that, conductivity, $\sigma_n = ne\mu_e$ (or) $\mu_e = \sigma_n /ne = - \sigma_n R_H$

Also $\sigma_p = pe\mu_h$ or $\mu_h = \sigma_p /pe = \sigma_p R_H$. Thus by measuring σ and R_H, μ can be calculated.

(4) Measurement of magnetic flux density:

Using a semiconductor sample of known 'R_H' the magnetic flux density can be deduced from $R_H = V_H t/ BI$ or $B = V_H t / R_H I$

7. A silicon plate of thickness 1 mm, breath 10mm and length 10mm is placed in a magnetic field of 0.5 Wb/m^2 acting perpendicular to its thickness. If 1×10^{-3}A current flows along its length, calculate the Hall voltage developed if the Hall coefficient is 3.66×10^{-4} m^3/C.

ANS:

4. A silicon plate of thickness 1 mm, breath 10mm and length 100mm is placed in a magnetic field of 0.5 Wb/m^2 acting perpendicular to its thickness. If 10^{-2} A current flows along its length, calculate the Hall voltage developed if the Hall coefficient is 3.66x 10^{-4} m^3 / coulomb.

Given Data:

t= 1mm; w= 10mm ; L = 100 mm ; B = 0.5 Wb/m^2 ; I = 10^{-2} A ; R_H = 3.66x 10^{-4} m^3 / coulomb.

Solution:

Hall coefficient R = V_H t/ IB

$V_H = R_H IB/t$

$= 3.66\times 10^{-4} \times 10^{-2} \times 0.5 / 1\times10^{-3}$

$= 1.83\times 10^{-3}$ V = 1.83 mV

8. An n-type semiconductor has Hall coefficient = 4.16 x10^{-4} m^{3}C^{-1}. The conductivity is 10^8 ohm^{-1}m^{-1}. Calculate its charge carrier density and electron mobility at room temperature.

ANS:

i) Carrier density(n) = $\frac{1}{R_H q}$ cm^{-3}

R_H = Hall coefficient
q = Charge of the e^- or hole (C)

$= \frac{1}{4.16\times10^{-4}\times1.6\times10^{-19}}$

Carrier density(n) = 1.502×10^{22} m^{-3},

ii) Carrier mobility (μ) = $R_H \sigma$ cm^{2}V^{-1}s^{-1}

R_H = Hall coefficient
σ = conductivity (C V^{-1} s^{-1} cm^{-1})

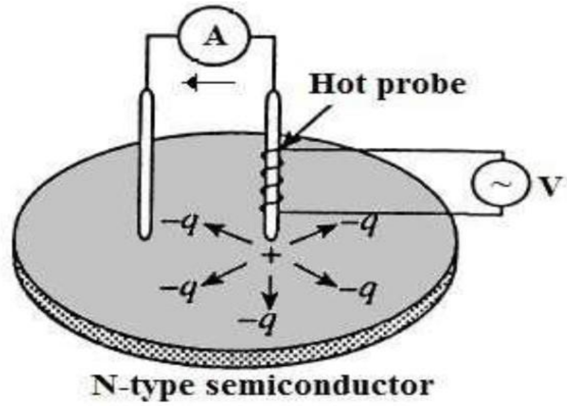
$= 4.16\times10^{-4}\times10^{8}$
$= 4.16\times10^{4}$ m^{2}V^{-1}s^{-1}

9. Explain the working principle of hot point probe method.

ANS:

Principle:

•A conventional Hot-Probe experiment enables a simple and efficient way to distinguish between n-type and p-type semiconductors using a hot probe and a standard multi- meter.



While applying the cold and hot probes to an n-type semiconductor, positive voltage readout is obtained in the meter, whereas for a p- type semiconductor, negative voltage is obtained.

10. Explain the principle of capacitance-voltage measurement method.

ANS:

Principle:

- The capacitance at an p-n or metal –semiconductor junctions depends on the properties of the charge- depletion layer formed at the junction
- The depletion regions is the vicinity of the PN junction and is " depleted" of free carriers due to the drift field required to maintain charge neutrality.

Capacitance-Voltage measurements

- Hillibrand and Gold (1960) first described the use of capacitance –voltage (C-V) methods to determine the majority carrier concentration in semiconductors.
- C-V measurements are capable of yielding quantitative information about the diffusion potential and doping concentration in semiconductor materials.
- The technique employs PN-junctions, metal- semiconductor junctions (Schottky barriers), electrolyte –semiconductor junction MIS field effect semiconductors.
- C-V measurements yield accurate information about the doping concentrations of majority carriers as a function of distance (depth) from the junction.

11. How does the capacitance of p-n junction diode vary in forward bias and reverse bias.

ANS:

Deep-level transient spectroscopy(DLTS)

DLTS Principle:

- Emission of trapped charge carriers change the depletion capacitance of a PN-junction or Schottky diode. The transient measurement provides information on the defect levels in the band gap.

- Deep-level transient spectroscopy is a method of determining the concentration and thermal emission rate of semiconductor deep levels by measuring capacitance transients as a function of temperature.

- A Schottky or p-n diode is first forward biased to fill the traps, then the capacitance transient caused by carrier emission from filled traps in the depletion region is measured at the quiescent reverse bias.

- A DLTS peak is generated when the thermal emission rate of the trap is the same as that of the rate window. Because of the strong temperature dependence of the trap emission rates, it is possible to resolve the emission from different traps using an appropriate emission rate window.

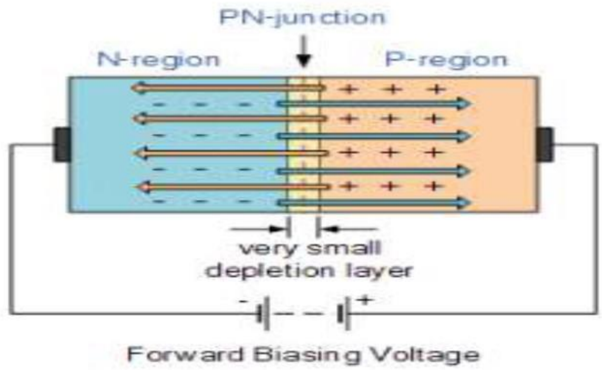
- When voltage across a p-n junction is changed, there is a corresponding change in the depletion region width. This change in width causes a change in the number of free charge carriers on both sides of the junction, resulting in a change in the capacitance.

- This change has two contributions; a) the contribution due to change in depletion width known as the junction capacitance and b) the contribution due to change in minority carrier concentration called the diffusion capacitance.

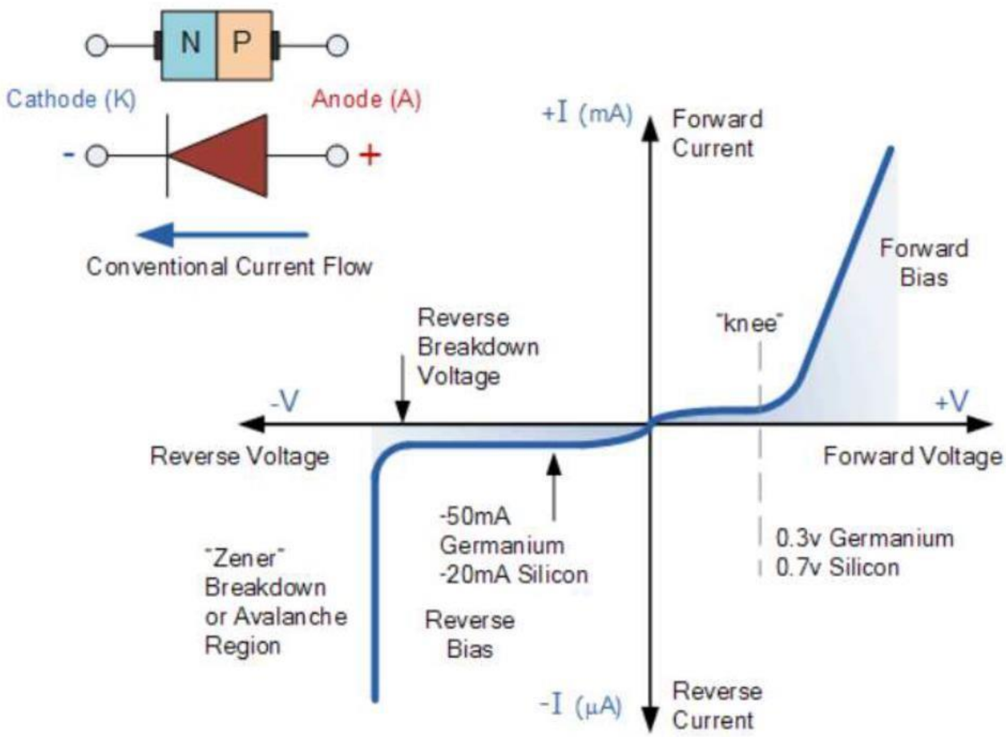
- Junction capacitance is dominant under reverse biased conditions while diffusion capacitance is dominant under forward biased conditions.

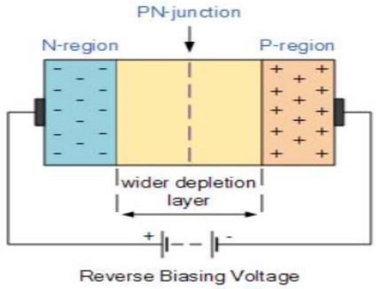
12. Explain forward biasing and reverse biasing of p-n junction diode.

ANS;



➢When a diode is connected in a **Forward Bias** condition, a negative voltage is applied to the N-type material and a positive voltage is applied to the P-type material. If this external voltage becomes greater than the value of the potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the potential barriers opposition will be overcome and current will start to flow.





- When a diode is connected in a **Reverse Bias** condition, a positive voltage is applied to the N-type material and a negative voltage is applied to the P-type material.

- The net result is that the depletion layer grows wider due to a lack of electrons and holes and presents a high impedance path, almost an insulator. The result is that a high potential barrier is created thus preventing current from flowing through the semiconductor material.

- This condition represents a high resistance value to the PN junction and practically zero current flows through the junction diode with an increase in bias voltage. However, a very small **leakage current** does flow through the junction which can be measured in micro-amperes, (μA).

13. Write a short note on I-V characteristics of p-n junction diode in reverse bias.

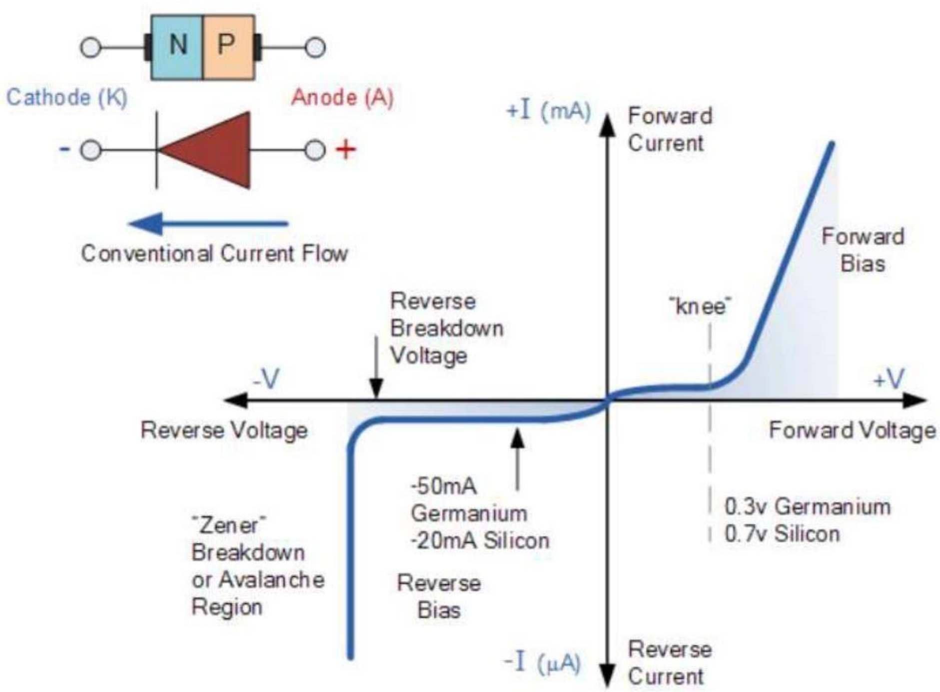
ANS:

I-V Characteristics in a Diode

- A *PN Junction Diode* is one of the simplest semiconductor devices around, and which has the characteristic of passing current in only one direction only. However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage as the diode has an exponential current-voltage (I-V) relationship and therefore we can not described its operation by simply using an equation such as Ohm's law.

- If a suitable positive voltage (forward bias) is applied between the two ends of the PN junction, it can supply free electrons and holes with the extra energy they require to cross the junction as the width of the depletion layer around the PN junction is decreased.

- By applying a negative voltage (reverse bias) results in the free charges being pulled away from the junction resulting in the depletion layer width being increased. This has the effect of increasing or decreasing the effective resistance of the junction itself allowing or blocking current flow through the diode.



14. What are Shallow Level Traps and Deep Level Traps?

ANS;

Introduce energy level in the band structure

•Shallow level

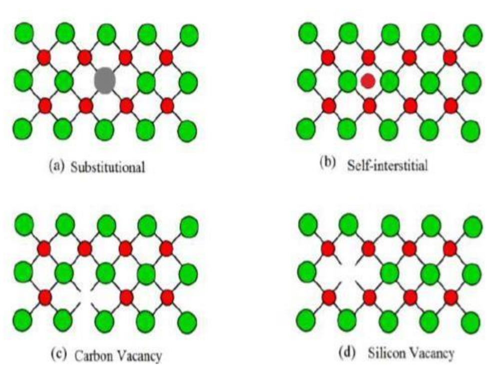
–Close to the edges of the bandgap

–Use mainly as a dopant

•Deep level

–Close to the middle of the bandgap

–Act as generation/recombination or trap center.



15. State combined Beer Lambert Law.

ANS;

The **Beer-Lambert law** is the linear relationship between **absorbance** and concentration of an **absorbing** species. The **Beer-Lambert law** implies that both the type and the concentration of the molecules are important in the process of radiation **absorption**.

- When the light beams are passed through a dilute sample, the absorption will be less since there is only less number of absorbing particles presented.

- The light beam was passed through a concentrated sample.

- The intensity of the transmitted beam was considerably low, which leads to violation of Beer Lambert's law.

- The law thus states that for a dilute solution, A = Kcl

  Where,

  A – absorbance

  K – molar absorbance coefficient

  c– molar concentration

  l - Path length

16. Write any three applications of U-V spectroscopic technique.

ANS:

Applications of UV Spectroscopy

- UV absorption spectroscopy can characterize those types of compounds which absorbs UV radiation thus used in qualitative determination of compounds. Identification is done by comparing the absorption spectrum with the spectra of known compounds.

- This technique is used to detect the presence or absence of functional group in the compound. Absence of a band at particular wavelength regarded as an evidence for absence of particular group.

- Kinetics of reaction can also be studied using UV spectroscopy. The UV radiation is passed through the reaction cell and the absorbance changes can be observed.

17. What is Photoluminescence? And how it is classified in to?

ANS:

• Luminescence is an electromagnetic (EM) radiation phenomenon due to excessive thermal radiation or incandescence in physical system.

• With regard to luminescent semiconductors, when energy of incident photon is equal or beyond the energy band gap, it will excite the electron of valence band into conduction band through band gap.

Luminescence of semiconductors can divide two types:

(1) Radiative transition

When an electron drops to lower energy state from higher energy state, it will probably occur radiative transition regardless of intrinsic state or energy state formed by impurities. Therefore, the system is not a balanceable condition and we assume that excited phenomena will generate electron-hole pairs in semiconductors. Firstly, we consider some basic transitions:

(a)Band-to-band transition:

Band-to-band transition is the relationship of free-electrons and holes. Those transitions usually occur in direct band gap materials such as Ⅲ-Ⅴ compounds where the electron-hole pairs will generate radiation recombination effectively between conduction band and valence band.

(b)Free exciton transition

If the material is very pure, an electron and a hole will attract each other to form exciton. Then, they will recombine to generate a very narrow spectrum. In Ⅲ-Ⅴ compounds, free exciton energy state usually describes Wannier-Mott approximation. The energy of free exciton can be expressed as Equation 1.

$$E_n = 2\pi^2 m^* e^4 / h^2 \varepsilon^2 n^2 \qquad (1)$$

In this equation, m* is effective mass, h is Planck constant, ε is dielectric constant, and n is quantum number.
However, there are probably several mechanisms to result in non-radiative transition. Those transitions will compete with radiative transition to result in lower luminescence.

(c)Free-to-bound transition

The transition is free-to-bound transition between energy bands of materials and impurity energy level. This transition is between the impurity and one of energy bands such as from conduction band to acceptor or from donor to valence band. The energy of radiative photon is E_g-E_b and E_b is bound energy of shallow impurity energy level.

(d)Donor-acceptor pair recombination

The transition is between donor and acceptor. After optical pumping, the electrons and holes will be bounded at D+ and A- locations to generate neutral D_0 and A_0 centers. Some neutral donor electrons will recombine with neutral acceptor holes radiatively.

Non-radiative transition

Some opportunities which cause non-radiative transition will compete with radiative recombination transition and influence luminescent efficiency negatively. They can describe as below:

a) Because of thermal oscillation to generate phonons;

a) Recombination on the surface state includes two dimensional dislocation, and agglomerative boundary et al. through step-wise transition which causes loss energy. It also calls cascade process;

a) Impurity locations are often not radiative recombination centers;

a) Loss energy of trapped carriers will excite other carriers in the lattice and emit non-radiative loss energy by Auger process.

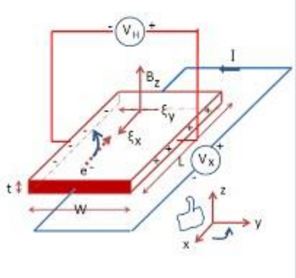
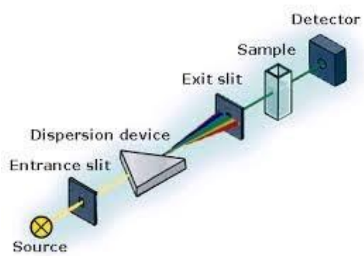
UNIT 4

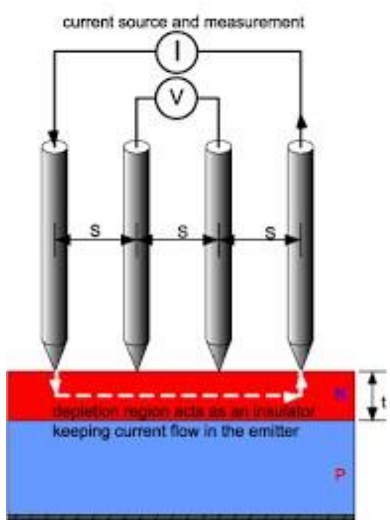
PART A-ONE MARK QUESTIONS

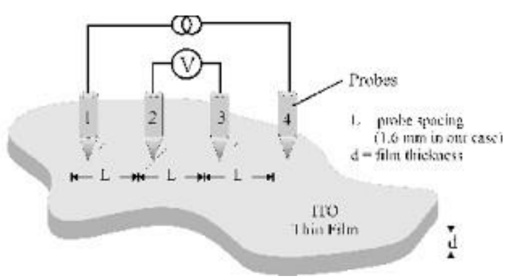
QUESTION NO.	QUESTIONS
1	In a …………, the electrons are ejected from photosensitive surface and are amplified within the cell. (A) Photodiode (B) Bolometer (C) Electrode (D) **photomultiplier tube**
2	Alkali metals and their oxides are best ………… materials. **(A) Photo emissive** **(B)** Conducting **(C)** Insulating **(D)** Semiconducting

3	The crystalline solids absorbs energy and re-emits it in the visible region of the spectrum is called …………….. (A) **Luminescence** (B) Photon emission nn (C) Phonon emission (D) Radiation
4	……………….. Spectroscopy can be used to determine the concentration of absorbs in a solution. (A) Gamma (B) IR (C) Microwave (D) **UV Vis**
5	An ideal monochromator should have an ………… narrow effective bandwidth. **(A) infinitely** **(B)** Small **(C)** Zero **(D)** finite
6	……………….. is an instrumentation used to determine the traps in semiconductors (a) TGA **(B) DLTS** **(C)** DTA **(D)** IR

7	………… is used for separating source radiation wavelengths. (A) Detector (B) Antenna (C) **Monochromator** (D) Display device
8	In …………… the conductivity increases with increasing temperature (A) IR (B) DTA (C) Phonos (D) **Semiconductors**
9	In ……………… semiconductor, the Hall coefficient is negative (A) P-type (B) Dilute (C) **N-type** (D) Magnetic

10	The given diagram represents …………….. effect  **(A) Hall effect** **(B)** Thermoelectric effect **(C)** Faradays effect **(D)** Photoelectric effect
11	The given diagram represents instrumentation of …………… spectroscopy  (A) IR (B) NMR (C) Gamma ray (D) **UV**

12	The given diagram represents …………….. experimer  **(A) Four probe** **(B)** Hall effect **(C)** Two probe **(D)** DMS

13	………………… law states that, when a beam of monochromatic light passes through an absorbing medium, the rate of decrease in intensity with the thickness of the medium, is proportional to the intensity of light. (A) Snell’s (B) Beer’s (C) **Lambert’s** (D) Photoelectric
14	A ……………….. is a method of determining quickly whether a semiconductor sample is n (negative) type or p (positive) type (A) Electrolysis (B) **Hot probe method** (C) Hydrogenation (D) Rectification
15	The ……………….. method is used to measure the resistance (A) Hydrogenation (B) Rectification (C) **Vander Pauw** (D) Electolysis
16	The energy gap in a semiconductor is also called as ………… **(A) Forbidden gap** **(B)** Large gap **(C)** Narrow gap **(D)** Electrical gap
17	The ……………… is the ratio of the voltage measured across the sample to the current driven through the sample (A) Capacitance (B) **resistance** (C) Inductance (D) capacitor
18	 The given diagram represents …………… method **(A) Vander Pauw** **(B)** Electolysis **(C)** Hydrogenation **(D)** Rectification

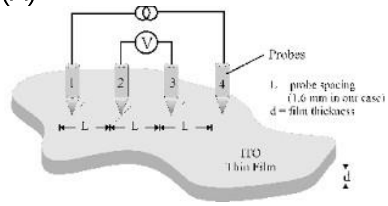
19	For determining the resistivity of a semiconductor, the diameter of contacts between the probe and the semiconductor should be ………………………. the gap between the probes. **(A)** **Smaller Than** **(B)** Greater than **(C)** Equal to **(D)** Double
20	……………….. is a technique for characterizing semiconductor materials and device, where the applied voltage is varied, and the capacitance is measured and plotted as a function of voltage. **(A)** **Capacitive – voltage profiling** **(B)** Current profiling **(C)** Voltage profiling **(D)** Baising

QUESTION NO.	QUESTIONS

21

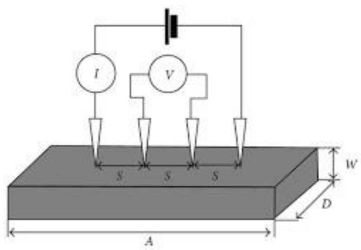
Identify the resistivity measurement by four probe linear method

(A)



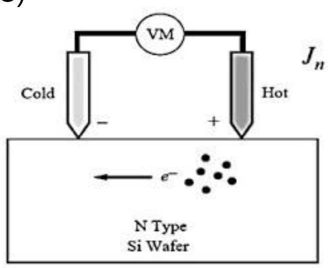
This technique is commonly used to measure the resistivity and the Hall coefficient of a sample

(B)



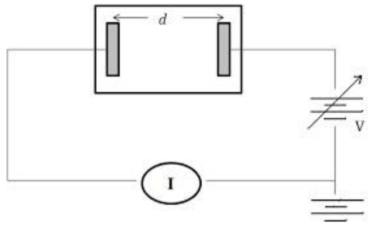
This technique involves using four equally-spaced,known as a four-point probe to make electrical contact with the material.

(C)



The method of determining quickly whether a semiconductor sample is n type or p type. A voltmeter or ammeter is attached to the sample, and a heat source, such as a soldering iron, is placed on one of the leads.

(D)

	 This Method is one of the standard and most commonly used method for the measurement of resistivity of very high resistivity samples like sheets/films of polymers
22	Illustrate the properties of Photoluminescence …………….. (I) The Principle of this method is based on the absorption of ultraviolet light or visible light by chemical compounds, which results in the production of distinct spectra. Spectroscopy is based on the interaction between light and matter. (II) It is a process in which a molecule absorbs a photon in the visible region, exciting one of its electrons to a higher electronic excited state, and then radiates a photon as the electron returns to a lower energy state. (III) This method is routinely used in analytical chemistry for the quantitative determination of different analytes, such as transition metal ions, highly conjugated organic compounds, and biological macromolecules. (IV) It is the spontaneous emission of light from a material following optical excitation. It is a powerful technique to probe discrete energy levels and to extract valuable information about semiconductor sample composition, quantum well thickness or quantum dot sample mono dispersity. (A) All the four Incorrect (B) Both II and III correct (C) Both III and I correct (D) **Both II and IV correct**
23	Analyse the device Photoemissive cell I) This cell is commonly known as a phototube, makes use of the photoelectric effect, the phenomenon whereby light-sensitive surfaces give off electrons when struck by light. These cells are sometimes called photocells or electric eyes. (II) This is is an electrical device that converts the energy of light directly into electricity by the photovoltaic

	effect, which is a physical and chemical phenomenon. (III) In this cell the photons passed their energy in fixed quantities to atoms inside the metal, knocking some of their electrons out of them, so producing an electric current. The photons need a minimum threshold frequency to free electrons and produce an effect, known as the work function. (IV) These are the class of vacuum tubes, and more specifically vacuum phototubes, are extremely sensitive detectors of light in the ultraviolet, visible, and near-infrared ranges of the electromagnetic spectrum. These detectors multiply the current produced by incident light by as much as 100 million times or 108 (i.e., 160 dB)[1], in multiple dynode stages (A) Both I and II correct (B) **Both I and III correct** (C) Both II and IV correct (D) Both I and II correct
24	Point out the applications of Uv- Vis Spectroscopy. (I) Quantitative and not Qualitative analysis. (II) Determination of molecular weight. (III) Determination of molar absorbance coefficient. (IV) Determination of known compound. (V) Detection of non-functional group. (VI) Detection of isomers and geometrical isomers. (VII) Detection of impurities. (a) The statements I, II, VII and V are correct (b) The statements I, II, VI and V are correct (c) The statements II, III,VI and VII are correct (d) The statements I, V, VI and VII are correct
25	If the drift velocity of holes under a field gradient of 100v/m is 5m/s, the mobility is **A. 0.05** **B.** 0.55 **C.** 500 **D.** 50

26	A silicon sample is uniformly doped with 10^{16} phosphorus atoms/cm^3 and 2 × 10^{16} boron atoms/cm^3. If all the dopants are fully ionized, the material is: A. n-type with carrier concentration of 3 × $10^{16}/cm^3$ B. **p-type with carrier concentration of $10^{16}/cm^3$** C. p-type with carrier concentration of 4 × $10^{16}/cm^3$ D. Intrinsic
27. 28.	In Photoluminescence process, electrons change energy states by either resonantly gaining energy from absorption of a ……………. or losing energy by emitting ………………. A. Mesons B. Phonons C. Baryons D. **Photons** In hot probe technique, ……………….. probe is connected to the positive terminal of the meter while the ………………… probe is connected to the negative terminal. A. Cold, Hot B. Thick, Thin C. Thin, Thick D. **Hot, Cold**
29 30	The wavelength range used in UV – Vis. Spectrophotometer is ………………………… **A. 200 nm to 2500 nm** **B.** 200 nm to 3500 nm **C.** 200 nm to 4000 nm **D.** 400 nm to 700 nm The Lambert law and Beer law may be combined single relationship which shows the effect of b ……………….. and ……………of absorbing substance A. Composition, Refractive Index B. **Thickness, Concentration** C. Elasticity, Plasticity D. Hardness, Isotropy

31. What is the unit of absorbance which can be derived from Beer Lambert’s law?

A. $Lmol^{-1}cm^{-1}$

B. $gm^{-1}cm^{-1}$

C. cm

D. **No unit**

32. In conventional DLTS the capacitance transients are investigated by using a ……………………………

A. Hartley oscillator

B. Cathode Ray Oscilloscope

C. **Lock-in- Amplifier**

D. Intermediate frequency amplifier

33. The temperature range of the most of the semiconductors to characterize in DLTS is ………………**..**

A. 77 K to 380 K

B. 87 K to 380 K

C. 77 K to 383 K

D. 77 K to 400 K

34. The DLTS is used to characterize ………………….

A. Conductors

B. **Semiconductors**

C. Insulators

D. Superconductors

35. To characterize the material in DLTS, it is necessary to form ……………………

A. Thin film

B. Nano particles

C. **PN junction**

D. Solution of the material

36. ……………….. is not taking part in CV measurement

A. Accumulation

B. Depletion

C. Inversion

D. **Emission**

37.	The leakage current occurs in ………………………. A. Forward Bias B. **Reverse Bias** C. Both forward and reverse bias D. LDR
38.	C-V measurements are capable of yielding information about the ………………………. and concentration of charge carriers A. Drift potential B. **Diffusion potential** C. Bonding D. Crystal structure
39.	The exponential ………………….. in current steeps as the diode current becomes limited by the resistance of undepleted region of diode A. Increase B. Decrease C. Zero D.equals
40.	In linear four probe method the tip of probe diameter is usually ………………….. than the probe spacing A. Larger B. Cooler C. Hotter D. **Smaller**
41.	Van der Pauw technique measures the resistivity and ………………. of the sample A. Coefficient of Friction B. Absorption C. **Hall coefficient** D. Emission
42.	To identify the nature of semiconductor (p-type or

	n–type) …………….. methods will be used, A. Two-point method B. Linear four-point method C. Van der Pauw four-point method D. **Hall effect**
43.	The leakage current occurs in ……………………… A. Forward Bias B. **Reverse Bias** C. Both forward and reverse bias D. LDR

QUESTION NO.	QUESTIONS
44	Hall Effect is defined as (I) The production of a voltage difference across an electrical conductor, transverse to an electric current in the conductor and to an applied magnetic field perpendicular to the current. (II) The production of a magnetic field across an electrical conductor, transverse to an electric current in the conductor and to the applied voltage perpendicular to the current. (III) The production of a current across an electrical conductor, transverse to voltage in the conductor and to an applied magnetic field perpendicular to the current. (IV) The production of a potential difference across an electrical conductor when a magnetic field is applied in a direction perpendicular to that of the flow of current.. (a) Both I and III correct (b) All the four Incorrect (c) Both II and III correct (d) **Both I and IV correct**
45.	The Hall coefficient of sample (A) of a semiconductor is measured at room temperature. The hall coefficient of (A) at room temperature is $4 x 10^{-4}$ m^3 $coulomb^{-1}$ .The carrier concentration in sample A at room temperature is A. ~ 10^{21} m^{-3}

B. ~ 10^{20} m^{-3}

C. **~ 10^{22} m^{-3}**

D. ~ 10^{23} m^{-3}

46. Applications of Hall effect

(I) The probes are often used as magnetometers, i.e. to measure magnetic fields, or inspect materials (such as tubing or pipelines) using the principles of magnetic flux leakage. These devices produce a very low signal level and thus require amplification.

(II) This converts mechanical energy into electrical energy, which is why it's useful during a power outage. This is when a current flows through a coil on a stovetop, which produces a magnetic field.

(III) These sensors are used to time the speed of wheels and shafts. These are used to detect the position of permanent magnet in brushless electric DC motors. The sensors are embedded in digital electronic devices along with linear transducers.

(IV) This can be used to solve complex electrostatic problems involving unique symmetries like cylindrical, spherical or planar symmetry. This can be used to simplify evaluation of electric field.

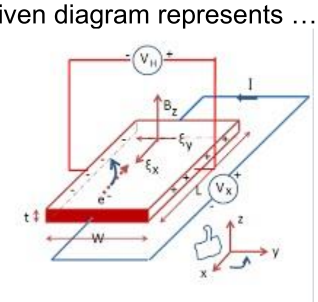
(A) Both III and IV are correct

(B) **Both I and III are correct**

(C) All the four correct

(D) Both II and III are correct

47. The given diagram represents ……………… effect



(a) Hall effect

(b) Thermoelectric effect

(c) Faradays effect

(d) Photoelectric effect

48.	Hot probe method (I) This method is routinely used in analytical chemistry for the quantitative determination of different analytes, such as transition metal ions, highly conjugated organic compounds, and biological macromolecules. (II) This method of determining quickly whether a semiconductor sample is n (negative) type or p (positive) type. A voltmeter or ammeter is attached to the sample, and a heat source, such as a soldering iron, is placed on one of the leads. (III) This technique is commonly used to measure the resistivity and the Hall coefficient of a sample (IV) The conventional characterization method enables only the definition of a semiconductor type, P or N, by identifying the majority of the charged carriers **(A)** **Both II and IV correct** **(B)** Both III and IV correct **(C)** Both I and IV correct **(D)** All the four correct
49.	Vander paw method. (I) This Method is a technique not commonly used to measure the resistivity and the Hall coefficient of a sample. (II) The doping type i.e. whether it is a P-type or N-type material (III) The sheet carrier density of the majority carrier cannot be determined. (IV) The charge density and doping level can be found (V) The mobility of the majority carrier can be found (VI) This method involves applying a current and measuring voltage using four small contacts on the circumference of a flat, arbitrarily shaped sample of uniform thickness. (VII) This method is particularly useful for measuring very small samples because geometric spacing of the contacts is unimportant. (A) All are correct (B) All are Incorrect (C) **II,IV,V,VI and VII are correct** (D) I, II, III, VI and VII are correct

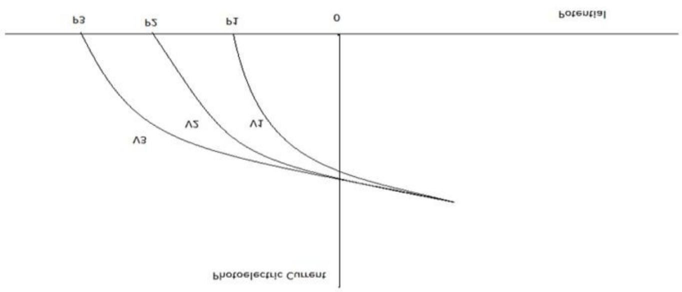
50.	Two probe method (I) This converts mechanical energy into electrical energy, which is why it's useful during a power outage. This is when a current flows through a coil on a stovetop, which produces a magnetic field. (II) The production of a voltage difference across an electrical conductor, transverse to an electric current in the conductor and to an applied magnetic field perpendicular to the current. (III) This method is one of the standard and most commonly used method for the measurement of resistivity of very high resistivity samples like sheets/films of polymers. (IV) 1. Remote sensing areas. 2. Resistance thermometer. 3. Induction hardening processes. 4. Precise estimation of geometrical factors. 5. Characterization of fuel cells bipolar plates (A) Both II and IV correct (B) **Both III and IV correct** (C) Both I and IV correct (D) All the four correct
51.	The basic components of UV-Vis Spectrometer. (A) They have three basic parts: (1) a large magnet, which is responsible for the static magnetic field H0, (2) a transmitter, which provides the alternating field H1, and (3) a receiver. (B) This consists of three basic components: radiation source, monochromator, and detector.The common radiation source for the spectrometer is an inert solid heated electrically to 1000 to 1800 °C. (C) **They have five main components: the light source, monochromator, sample holder, detector, and interpreter. The standard light source consists of a deuterium arc (190–330 nm) and a tungsten filament lamp (330–800 nm), which together generates a light beam across the 190–800 nm spectral range.** (D) A LASER source is needed to excite the target species. A filter collects the scattered light (Stokes) and filters out the Raleigh and Anti Stokes light. What is the unit of molar absorptivity or absorptivity which is used to determine absorbance A in Beer Lambert's
52.	

	formula? **i) L mol^{-1} cm^{-1}** ii) L gm^{-1} cm^{-1} iii) Cm iv) No unit
53.	Transmittance is given as T = P/Po. If Po is the power incident on the sample, what does P represent? **i) Radiant power transmitted by the sample** ii) Radiant power absorbed by the sample iii) Sum of powers absorbed and scattered iv) Sum of powers transmitted and reflected
54.	Which of the following is not true about Absorption spectroscopy? i) It involves transmission ii) Scattering is kept minimum **iii) Reflection is kept maximum** iv) Intensity of radiation leaving the substance is an indication of concentration

55.	The representation of Beer Lambert's law is given as A = abc. If 'b' represents distance, 'c' represents concentration and 'A' represents absorption, what does 'a' represent? a) Intensity b) Transmittance c) **Absorptivity** d) Admittance Which of the following is not a limitation of Beer Lambert's law, which gives the relation between absorption, thickness, and concentration? a) Concentration must be lower b) **Radiation must have higher bandwidth** c) Radiation source must be monochromatic d) Does not consider factors other than thickness and concentration that affect absorbance In which of the following ways, absorption is related to transmittance? a) Absorption is the logarithm of transmittance b) Absorption is the reciprocal of transmittance c) **Absorption is the negative logarithm of transmittance** d) Absorption is a multiple of transmittance Beer Lambert's law gives the relation between which of the following? a) Reflected radiation and concentration b) Scattered radiation and concentration c) **Energy absorption and concentration** d) Energy absorption and reflected radiation
56.	
57.	
58.	
59.	In photo emissive transducers, electrons are attracted by ………………… a) Cathode

	b) Anode **c)** Grid **d)** Body
60.	During Einstein's Photoelectric Experiment, what changes are observed when the frequency of the incident radiation is increased? a) The value of saturation current increases b) No effect c) **The value of stopping potential increases** d) The value of stopping potential decreases
61.	What is the time lag between the incidence of photons and the ejection of photoelectrons? a) Greater than 10^{-5} s b) Between 10^{-5} s and 10^{-9} s c) **Less than 10^{-9} s** d) 1 second
62.	How does the intensity affect the photoelectric current? **a) As intensity increases, the photoelectric effect increases** **b)** As the intensity increases, the photoelectric effect decreases **c)** As the intensity decreases, the photoelectric effect becomes twice **d)** No effect

63. Identify the correct order of frequencies.



a) $v_1 > v_2 > v_3$

b) $v_2 > v_3 > v_1$

c) **$v_3 > v_2 > v_1$**

d) $v_1 > v_3 > v_2$

64. The work function of lithium is 2.5 eV. The maximum wavelength of light that can cause the photoelectric effect in lithium is ………………..

a) 3980 Å

b) **4980** Å

c) 5980 Å

d) 6980 Å

65. Light of wavelength 3500 Å is incident on two metals A and B. Which metal will yield more photoelectrons if their work functions are 5 eV and 2 eV respectively? a) A

b) B

c) A & B

d) C

66. The Kinetic energy of a photoelectron emitted on shining a light of wavelength 6.2×10^{-6} m on a metal surface of work function 0.1 eV is ………………..

a) 0.01 eV

b) 0.02 eV

c) **0.1 eV**

d) 1 eV