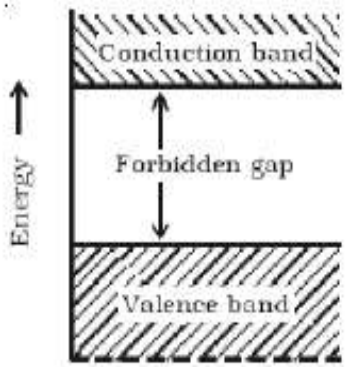
INDIAN SCHOOL MUSCAT

SENIOR SECTION

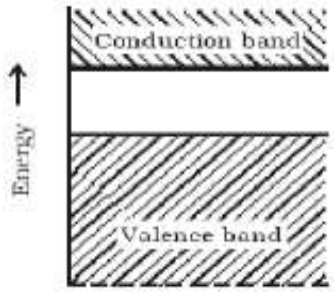
Solids and Semiconductor devices

1. Draw energy band diagram for a) insulator eg.diamond b)semiconductor $n_e = n_h$ eg. Si, Ge. C) conductor



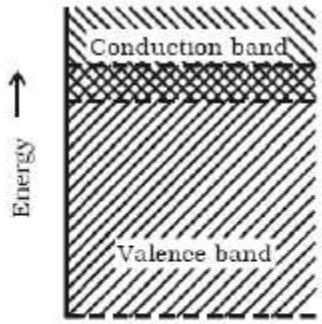
(a) Insulator

Energy gap > 3eV



(b) Semiconductor

Energy gap < 2eV. For Si 1.1 eV, Ge 0.7 eV



(c) Conductor

No energy gap conduction band and valance band over lap.

2.What is doping?
Deliberate addition of very small amount of desirable impurity into an intrinsic semiconductor is called **doping**. The impurity atoms are called dopants.

3. What are the characteristics of dopant atoms ?

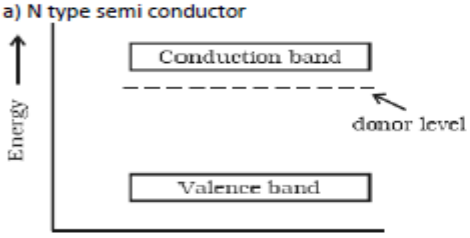
i. The dopant atom not must distort the original pure semiconductor lattice.
ii. The sizes of the dopant and the semiconductor atoms should be nearly the same.
iii. The dopant atoms must fit the place of few intrinsic atoms.

4. What is the relation between the concentrations of electrons and holes in a semi conductor at thermal equilibrium?
The electron and hole concentration in a semiconductor in thermal equilibrium is given by $n_e n_h = n_i^2$ where n_i is known as intrinsic carrier concentration.

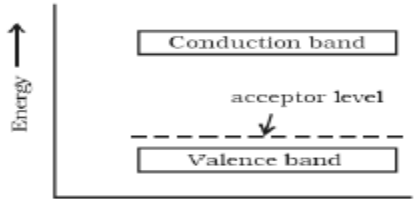
5. Draw energy band diagram for semiconductor in which a) $n_e > n_h$

b) $n_e < n_h$

a) N type semi conductor



b) P type semi conductor



6. *A pure Si crystal has 5×10^{28} atoms m^{-3}.*
It is doped by 1 ppm concentration of pentavalent As. Calculate the number of electrons and holes.
Given that $n_i = 1.5 \times 10^{16}$ m^{-3}.

$n_e \approx N_D$

$n_e = 5 \times 10^{28} / 10^6 = 5 \times 10^{22}$

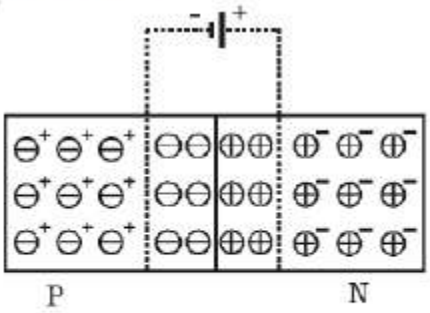
$n_e n_h = n_i^2$

$n_h = (2.25 \times 10^{32})/(5 \times 10^{22})$

$\sim 4.5 \times 10^9$ m^{-3}

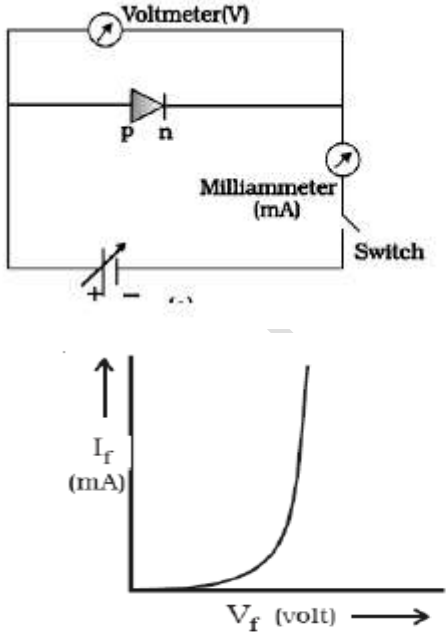
It will become N type semiconductor.

7. Draw diagram to show depletion layer and internal potential barrier in a PN junction Diode
And define them.



When a PN junction Diode is formed ,region near the junction is depleted of majority carriers and have only minority carriers called as depletion layer.
The potential due to minority carrier near the junction is known as internal potential barrier.

8. Explain the working of PN unction diode in forward bias .



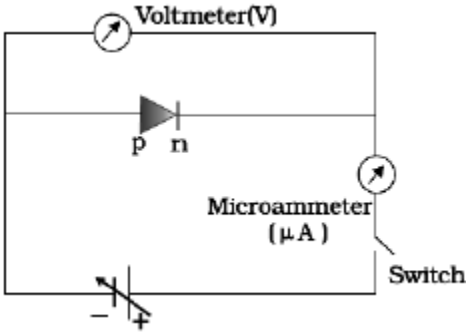
When the positive terminal of the battery is connected to P-side and negative terminal to the N-side , thePN junction diode is said to be forward biased.

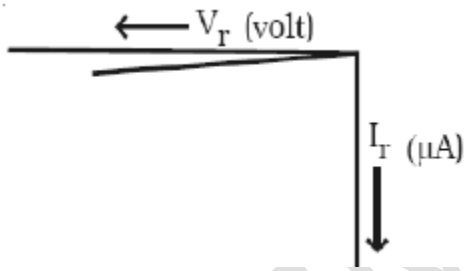
Above a particular value of applied voltage, called knee voltage, the majority carriers are repelled by the battery . As they cross the junction they neutralize the minority carriers at the depletion layer and , the **depletion region disappears** and the **potential barrier** also **disappears.** Hence, during FB, the majority charge carriers flow across the junction in opposite direction and constitute current flow in the forward direction.

9. Explain the working of PN unction diode in reverse bias .

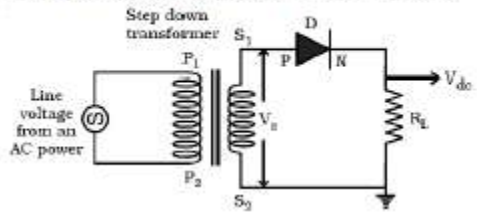
When the positive terminal of the battery is connected to N-side and negative terminal to the P-side , thePN junction diode is said to be reverse biased. The majority carriers are attracted away from the junction leaving more minority carriers at the depletion layer. The width of **depletion region increases** and the **potential barrier** also **increases .**

There is no flow of current due to majority carriers and a small current of micro amperes flow due to minority carriers.





9. Explain the working of a half wave rectifier.



Rectification is the process in which alternating emf or current is changed into direct emf or current.

Diode is used as a rectifier.

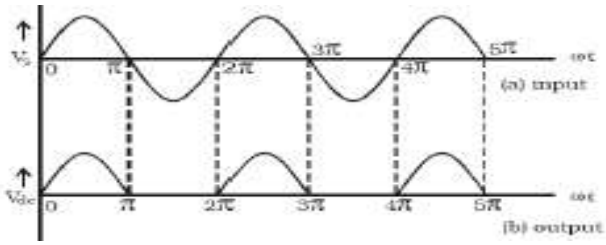
The circuit shows a half wave rectifier. During positive half cycles of stepped down AC voltage the diode D is forward biased and conducts. The forward bias current produces a pd across the load resistor R_L .

During negative half cycles

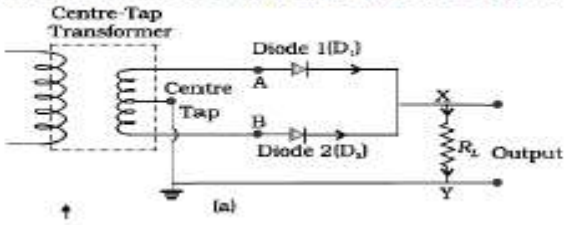
of AC the diode D is reverse biased and does not conduct.

Thus only positive half cycles of AC are rectified and the arrangement is known as half wave rectifier.

Efficiency of a half wave rectifier is 40.6%

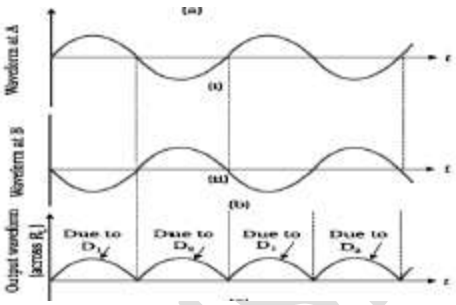


10. . Explain the working of a full wave rectifier.

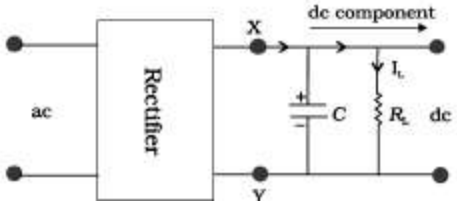


The step down transformer is centre tapped and a bridge of two diodes D1 and D2 are used in a full wave rectifier.
During positive half cycles the diode D1 is forward biased and conducts but the diode D2 is reverse biased and does not conduct.

During negative half cycles the diode D2 is forward biased and conducts but the diode D1is reverse biased and does not conduct.
Thus during both the half cycles there is a dc out put across the load resistor. Thus the full wave of AC is rectified.



To get a steady dc a filter circuit is used . capacitor of the filter circuit filters out the ac ripple part and steady dc output is available across R_L



Efficiency of a full wave rectifier is 81.2%

11. Explain the working of a zener diode as a voltage regulator.

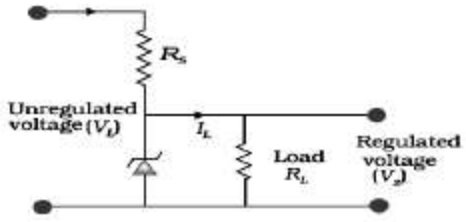
Zener diode is designed to operate under reverse bias in the breakdown region and used as a voltage regulator, it is heavily doped.

To get a constant dc voltage from the dc unregulated input, we use a Zener diode.

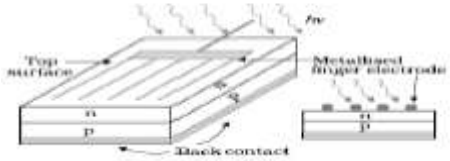
The unregulated dc voltage is connected to the Zener diode through a series resistance R_s such that the Zener diode is reverse biased.

When the input voltage increases, the current through R_s and Zener diode also increases. This increases the voltage drop across R_s without any change in the voltage across the Zener diode. This is because in the breakdown region, Zener voltage remains constant even though the current through the Zener diode changes.

When the input voltage decreases, the current through R_s and Zener diode also decreases. The voltage drop across Rs decreases without any change in the voltage across the Zener diode. Thus any increase/decrease in the input voltage does not produce any change in voltage across the Zener diode.



12. Explain the working of solar cell .



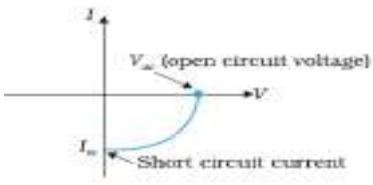
In a solar cell the junction area is kept much larger for more solar radiation to be incident to get more power.

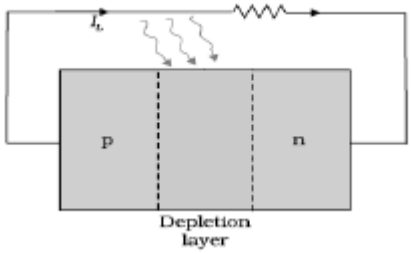
The generation of emf by a solar cell, when light falls on, it is due to the following three basic processes: generation, separation and collection—

(i) generation of e-h pairs due to light (with $h\nu > E_g$) close to the junction;

(ii) separation of electrons and holes due to electric field of the depletion region. Electrons are swept to n-side and holes to p-side;

(iii) the electrons reaching the n-side are collected by the front contact and holes reaching p-side are collected by the back contact. Thus p-side becomes positive and n-side becomes negative giving rise to photo voltage.





13.Mention the Uses of solar cell

i) in calculators and watches

ii) an array of solar cells is called as solar panel

which can be used in artificial satellites, and houses to generate electricity.

14. Explain the working of LED (Light Emitting Diode)

When a junction diode is forward biased, electrons from N-side and holes from P-side move towards the depletion region and recombination takes place. When an electron in the conduction band recombines with a hole in the valence band, energy is released.

If the semiconductor material is transluscent, light is emitted and the junction becomes a light source. By using **gallium arsenide phosphide** and **gallium phosphide**, a manufacturer can produce LEDs that radiate **red, green, yellow and orange. GaAs (Eg ~ 1.4 eV) is used for making infrared LED.**

15. State the similarity and differences between Solar Cell and Photo diode

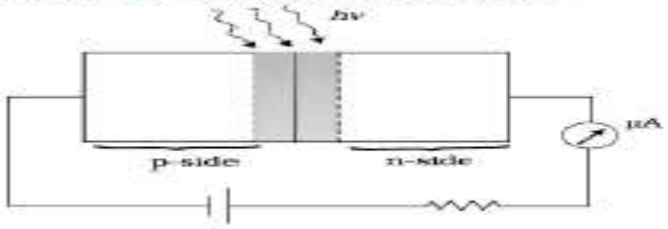
Similarity : both convert light energy into electrical energy.

Differences :

1. Solar Cell is self biased that is it acts as voltage source whereas Photo diode is operated under reverse bias.

2. Solar Cell is used in watches , calculators etc, Photo diode is used as a sensor in fire alarm burglar alarm ,automatic opening and closing of doors.

16.Explain the working of Photo diode.



A Photodiode is again a special purpose p-n junction diode fabricated with a transparent window to allow light to fall on the diode. It is operated under reverse bias.

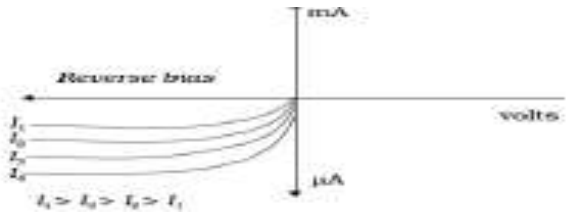
When the photodiode is illuminated with light (photons) with energy greater than the energy gap (Eg) of the semiconductor, then electron-hole pairs are generated due to the absorption of photons.

The diode is fabricated such that the generation of e-h pairs takes place in or near the depletion region of the diode.

Due to electric field of the junction, electrons and holes are separated before they recombine.

The direction of the electric field is such that electrons reach n-side and holes reach p-side.

Electrons are collected on n-side and holes are collected on p-side giving rise to an emf. When an external load is connected, current flows. The magnitude of the photocurrent depends on the intensity of incident light falls on the diode.



17. Why a photodiode is always operated under reverse bias.
It is easier to observe the change in the current
with change in the light intensity, if a reverse bias is applied , so detection of optical signals is easy.

18.Even though energy gap for GaAs is more than that of Si GaAs is better than Si to make solar cell
why?
GaAs is better Si because of its relatively higher light absorption coefficient.

19.Mention uses of LED

LEDs are used for instrument displays, calculators and digital watches. remote controls, burglar alarm systems, optical communication,

they replace incandescent lamps. used in LED televisions.

Mention the advantages of LED over incandescent lamps.

(i) Low operational voltage and less power.

(ii) Fast action and no warm-up time required.

(iii) The bandwidth of emitted light is 100 Å to 500 Å or in other words it is nearly (but not exactly) monochromatic.

(iv) Long life and ruggedness.

(v) Fast on-off switching capability.