Chapter -14
SEMICONDUCTOR

MULTIPLE CHOICE QUESTIONS

1. The semiconductors are generally

   (1) Monovalent (2) Divalent (3) Trivalent (4) Tetravalent

Sol. Answer (4)

Semiconductors are generally tetravalent like silicon and gallium.

2. The resistivity of a semiconductor depends upon

   (1) Size of the atom (2) The nature of atoms

   (3) Type of bonds (4) Size and types of motion

Sol. Answer (2)

The resistivity of a semiconductor depends mainly on the kind of atoms and the valence electrons they possess.

3. The impurity atoms with which pure silicon should be doped to make a *p*-type semiconductor are those of

   (1) Phosphorus (2) Antimony (3) Boron (4) Copper

Sol. Answer (3)

The impurities needed to make holes it should be a trivalent substance, of the third group which happens to be boron.

4. A pure semiconductor has

   (1) An infinite resistance at 0°C

   (2) A finite resistance which does not depend upon temperature

   (3) A finite resistance which increases with temperature

   (4) A finite resistance which decreases with temperature

Sol. Answer (4)A simple semiconductor has a finite resistance. An increase in temperature increases number of charge carries and increases conductivity.

5. The rate of recombination or generation are governed by the law(s) of

   (1) Mass conservation (2) Electrical neutrality (3) Thermodynamics (4) Chromodynamics

Sol. Answer (3)Carriers flow from higher to lower concentration like heat.

6. An n-type semiconductor is electrically

(1) Positive (2) Negative

(3) May be positive or negative (4) Neutral

Sol. Answer (4)

The presence of charge carries does not mean a semiconductors has any net charge.

7. A solid having uppermost energy band partially filled with electrons is called

(1) An insulator (2) A conductor (3) A semiconductor (4) None of these

Sol. Answer (2)

A solid which has uppermost energy band partially filled with electron is called a conductor

8. The energy gap for an insulator may be

(1) 1.1 eV (2) 0.02 eV (3) 6 eV (4) 0.7 eV

Sol. Answer (3)

The energy gap for an insulators is very high around 6 eV.

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9. If N_A is number density of acceptor atoms added and N_D is number density of donor atoms added to a semiconductor, n_e and n_h are the number density of electrons and holes in it, then

(1) $n_e = N_D, n_h = N_A$ (2) $n_e = N_A, n_h = N_D$ (3) $n_e + N_D = n_h + N_A$ (4) $n_e + N_A = n_h + N_D$

Sol. Answer (4)

Donor atoms increase number of conduction electron and must be added to

available electrons. Similarly for holes and acceptor atoms.

The equation is formed according to the law of electrical neutrality.

10. In an unbiased p-n junction which of the following is correct?

(1) p-side is at higher potential than n-side

(2) n-side is at higher potential than p-side

(3) Both p-side and n-side are at the same potential

(4) Any of the above is possible depending upon the carrier density in the two sides

Sol. Answer (2)In the depletion region n-side has positive ions and p-side is with negative ion. Hence n-side has longer potential.

11. In a full wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be

(1) 25 Hz (2) 50 Hz (3) 70.7 Hz (4) 100 Hz

Sol. Answer (4)

If mains frequency is 50 Hz after full wave rectification the frequency becomes double that of mains. So answer is 100 Hz.

12. In a semiconductor diode, the reverse biased current is due to drift of free electrons and holes caused by

(1) Thermal excitations only (2) Impurity atoms only

(3) Both (1) & (2) (4) Neither (1) nor (2)

Sol. Answer (1)

In case of reverse bias the reverse current is independent of reverse bias voltage but depends only on temperature of junction.

13. The value of form factor in case of half wave rectifier is

(1) 1.11 (2) 1.57 (3) 1.27 (4) 0.48

Sol. Answer (2)

$$\text{Form factor} = \frac{\text{RMS value of output voltage}}{\text{average value of output voltage}}$$

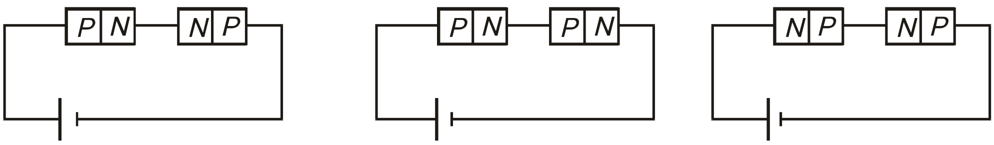
14. In a semiconductor diode, *P*-side is earthed and *N*-side is put at potential of –2 V, the diode shall

(1) Conduct (2) Not conduct (3) Conduct partially (4) Break down

Sol. Answer (1)

P side is put at higher potential than *N* side hence the diode will conduct.

15. Two identical *p-n* junctions may be connected in series with a battery in three ways as shown in the adjoining figure. The potential drop across the *p-n* junctions are equal in



(1) First and second circuits (2) Second and third circuits

(3) Third and first circuits (4) All of these

Sol. Answer (2)First is not bias second and third are bias and have same potential drop across diodes

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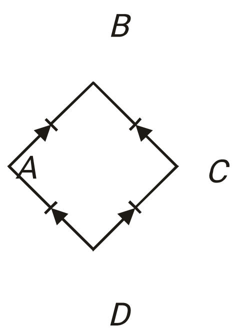
16. The zener diode is used for

(1) Rectification (2) Amplification (3) Stabilization (4) All of these

Sol. Answer (3) Zener diode is a reverse biased transistor used for voltage stabilisation.

17. In the diagram shown below, the input is across the terminals *A* and *C* and the output is across *B* and *D*. Then the output is



(1) Zero (2) Same as input (3) Full wave rectified (4)Half wave rectified

Sol. Answer (3)

The diagram is an example of a full wave rectifying circuit.

17. A junction diode, in which one of the *p* or *n*-sections is made very thin, can be used to convert light energy into electrical energy, then the diode is called

(1) Light emitting diode (2) Zener diode (3) Solar cell (4) Photo diode

Sol. Answer (3)

A diode used to convert light energy to electrical energy is called a photo diode.

18. The material suitable for making a solar cell is

(1) PbS (2) GaAs (3) CdSe (4) Ge

Sol. Answer (2)Ga As has a band gap close to 1.5 eV which in same as maximum intensity of solar radiation spectrum.

19. In which of the configurations of a transistor, the power gain is highest?

(1) Common base (2) Common emitter (3) Common collector (4) Same in all the three

Sol. Answer (2)

SHORT QUESTION ANSWER (3 Marks Question)

Q1: **Pure Si at 300 K has equal concentration of free electrons (n_e) and holes (n_h) as 2.8×10^{16} m^{-3}. Doping by trivalent impurity increases hole concentration to 5.0×10^{22} m^{-3}. Calculate n_e in doped silicon.**

Solution: Here $n_i = 2.5 \times 10^{16}\ m^{-3}, n_h = 5.0 \times 10^{22}\ m^{-3}$.

Using, $n_e = \frac{n_i^2}{n_h} = \frac{(2.8 \times 10^{16})^2}{5.0 \times 10^{22}} = 1.57 \times 10^{10}\ m^{-3}$.

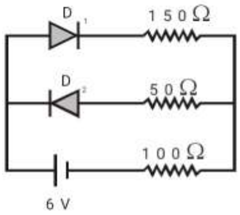
Q2: **Find the maximum wavelength of electromagnetic radiation, which can create a hole-electron pair in germanium. Given that forbidden energy gap in germanium is 0.72 eV**

Solution: **Here,** $E_g = 0.72\ eV = 0.72 \times 1.6 \times 10^{-19}\ J$

The maximum wavelength of radiation, which can create a hole electron pair in germination is given by

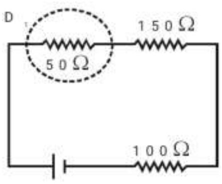
$$E_g = \frac{hc}{\lambda} \quad \text{or} \quad \lambda = \frac{hc}{E_g} = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{0.72 \times 1.6 \times 10^{-19}} = 1.724 \times 10^{-6}\ m$$

Q.3 The circuit shown in the figure contains two diodes each with a forward resistance of 50 ohm and with infinite reverse resistance. If the battery voltage is 6V, find the current through the 100 ohm resistance.



Solution: As per given circuit, diode D_1 is forward biased and offer a resistance of 50 ohm. Diode D_2 is reverse biased as a its corresponding resistance in infinite, no current flows through it. Thus the equivalent circuit is as shown in the figure. As all the three resistances are series, the current through them is

$$I = \frac{6}{50 + 150 + 100} = \frac{6}{300} = 0.02\ A$$



<u>LONG ANSWER TYPE QUESTION(5 Marks Q.)</u>

Q1.Distinguish between an intrinsic semiconductor and p-type semiconductor. Give reason, why, a p-type semiconductor crystal is electrically neutral although $n_h >> n_e$? (Delhi 2008)
Answer:

(i)

	Intrinsic semiconductor	p-type semiconductor
1.	The pure semiconductors (Ge or Si) in which the electrical conductivity is totally governed by electrons thermally excited from the valence bond to the conduction bond are called intrinsic semiconductors.	A tetravent semiconductor of Si or Ge doped with trivalent impurity atoms of B, Al or In is called a *p*-type semiconductor.
2.	They have equal number of densities of free electrons and holes *i.e.* $n_e = n_h$.	It has more density of holes than density of free electrons *i.e.* $n_h >> n_e$.

(ii) In a p-type semiconductor, the trivalent impurity atom shares its three valence electrons with the three tetravalent host atoms while the fourth bond remains unbounded. The impurity atom as a whole is electrical neutral. Hence the p-type semiconductor is also neutral.

Q.2 What is Zener diode? Give its symbol.

Ans : Zener diode : A specially designed diode which can operate in reverse breakdown region without being damaged are called Zener diode.

- Zener diode with different breakdown voltages (3 V to 200 V) can be obtained by changing the doping levels of P and n side.

  Formation :

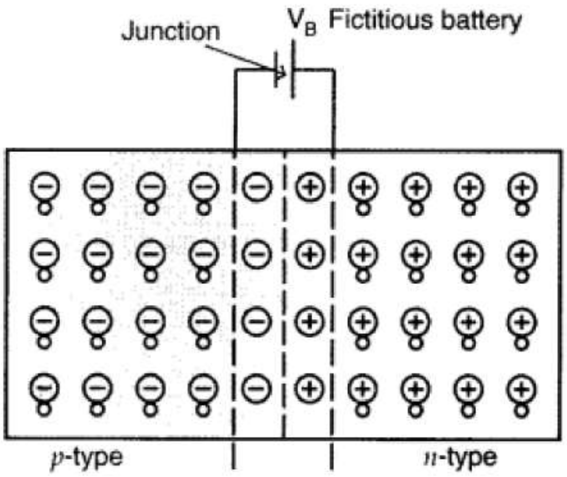
- Zener diode is made up of heavily doped p and n type semiconductor.

- P and n sides of diode are heavily doped by acceptor. and donar impurity respectively and are denoted by symbols p* and n‘*.

- Due to high doping densities of p and n regions, the depletion layer is small

  (10^{-7} m)
- When a large reverse field is applied across such a diode,due to small depletion region very high electric field(10^{7} V/m)

Q.3 Explain how a depletion region is formed in a junction diode. (Delhi 2011)
Answer:
As soon as a p-n junction is formed, the majority charge carriers begin to diffuse from the regions of higher concentration to the regions of lower concentrations. Thus the electrons from the n-region diffuse into the p-region and where they combine with the holes and get neutralised. Similarly, the holes from the p-region diffuse into the n-region where they combine with the electrons and get neutralised. This process is called electron-hole recombination.



p-region near the junction is left with immobile -ve ions and n-region near the junction is left with +ve ions as shown in the figure. The small region in the vicinity of the junction which is depleted of free charge carriers and has only immobile ions is called the depletion layer. In the depletion region, a potential difference VB is created, called potential barrier as it creates an electric field which opposes the further diffusion of electrons and holes.
(i) In forward biased, the width of depletion region is decreased.
(ii) In reverse biased, the width of depletion region is increased.