CBSE Test Paper - 05

Class - 12 Physics (Electronic Devices)

1. A p-type semiconductor can be obtained by adding
   a. phosphorus to pure germanium
   b. gallium to pure silicon
   c. arsenic to pure silicon
   d. antimony to pure germanium
2. An N-type Ge is obtained on doping the Ge-crystal with
   a. phosphorus
   b. gold
   c. aluminum
   d. boron
3. The potential barrier in the depletion layer is due to
   a. Holes
   b. Forbidden gap
   c. Electrons
   d. Ions
4. A hole in a semiconductor is defined as
   a. A free electron
   b. The incomplete part of an electron pair bond
   c. A free neutron
   d. A free proton
5. The input signal given to a CE amplifier having a voltage gain of 150 is v_i = 2cos (15t + 10°). The corresponding output signal is:
   a. 300 cos (15 t + 90°)
   b. 2 cos (15 t + 90°)
   c. 300 cos (15 t + 190°)
   d. 75 cos (15 t + 10°)
6. What is doping?
7. The current in the forward bias is known to be more (-mA) than the current in the

reverse bias (-μA). What is the reason, to operate the photodiode in reverse bias?

8. Distinguish between 'intrinsic' and 'extrinsic' semiconductors?

9. What is the main cause of Zener breakdown?

10. Write two characteristics features to distinguish between n-type and p-type semiconductors.

11. The ratios of number density of free electron to holes, $\left(\frac{n_e}{n_h}\right)$, for two different materials A and B, are equal to one and less than one respectively. Name the type of semiconductors to which A and B belong. Draw energy level diagram for A and B.

12. Explain, how a depletion region is formed in a junction diode?

13. In half wave rectification, what is the output frequency if the input frequency is 50 Hz. What is the output frequency of a full wave rectifier for the same input frequency.

14. Draw the (i) symbol and (ii) the reverse I-V characteristics of a zener diode. Explain briefly, which property of the characteristics enables us to use Zener diode as voltage regulator.

15.
    i. State briefly the processes involved in the formation of p-n junction, explaining clearly how the depletion region is formed.
    ii. Using the necessary circuit diagrams, show how the V-I characteristics of a p-n junction are obtained in (a) forward biasing (b) reverse biasing
    How are these characteristics made use of in rectification?

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Answers

1. b. gallium to pure silicon

   Explanation: In P-type doping, boron or gallium is the dopant. Boron and gallium each have only three outer electrons. When mixed into the silicon lattice, they form "holes" in the lattice where a silicon electron has nothing to bond to. The absence of an electron creates the effect of a positive charge, hence the name P-type.
   Holes can conduct current. A hole happily accepts an electron from a neighbor, moving the hole over a space. P-type silicon is a good conductor.

2. a. phosphorus

   Explanation: The addition of pentavalent impurities such as antimony, arsenic or phosphorous contributes free electrons, greatly increasing the conductivity of the intrinsic semiconductor.

3. d. Ions

   Explanation: When p-n junction is formed, the electrons from n-region diffuse through the junction into p-region provide positive ions in n-region similarly holes from p-region diffuse into n-region provide negative ions in p-region. Due to these ions, an electric field is set up across the junction from positive ions to negative ions. This electric field sets a potential barrier at the junction.

4. b. The incomplete part of an electron pair bond

   Explanation: A hole is the absence of an electron in a particular place in an atom. Although it is not a physical particle in the same sense as an electron, a hole can be passed from atom to atom in a semiconductor material.
   When a potential difference is applied across a semi conductor the valence shell electrons which are relatively loosely held to the nucleus come out of the orbit (get excited) leaving behind a vacancy, as the name suggests a hole corresponds to this vacancy created by the potential difference. A hole doesn't carry any charge (it is neutral), but by convention it is given a positive sign.

5. c. 300 cos (15 t + 190°)

   Explanation: Let output Singal of CE amplifier = V_o

Input signal of CE Amplifier $V_i = 2\ cos(15t + 10^{\circ})$
Voltage gain A_V = 150

As CE amplifier given phase difference of 90° between input and output signals,
So $A_v = \frac{V_o}{V_i}$
Then $V_o = A_v \times V_i$= $150 \times 2\ cos(15t + 10^{\circ} + 180^{\circ})$
= $300\ cos(15t + 190^{\circ})$

6. Doping is the process of adding impurities to intrinsic semiconductors to alter their properties. Normally Trivalent and Pentavalent elements are used to dope Silicon and Germanium. Depending on the type of doping material used, extrinsic semiconductors can be classified as:

   - **N-type semiconductors** : N-type semiconductors are created by doping an intrinsic semiconductor with donor impurities
   - **P-type semiconductors** : P-type semiconductors are created by doping an intrinsic semiconductor with acceptor impurities

7. When photodiode is illuminated with light then bonds get broken and additional electron hole pairs are created, it makes a significant change in minority carriers than in majority carriers . As the fractional change of minority carrier current is measurable significantly in reverse bias than that of forward bias. Therefore, photo diodes are always connected in reverse bias.

8.

Intrinsic semiconductor	Extrinsic semiconductor
It is a pure semiconductor and has no impurity atoms.	It is prepared by adding some impurity atoms in the pure semiconductor.
The number of free electrons and holes are always equal.	The number of free electrons and holes are not equal.

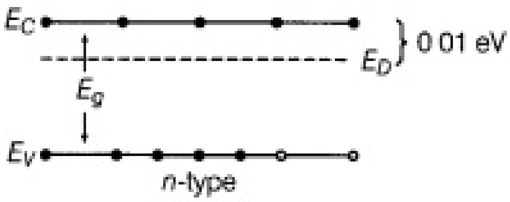
9. Internal field emission is the prime cause of Zener breakdown. When we increase the reverse voltage across the pn junction diode, what really happens is that the electric field across the diode junction increases (both internal & external). This results in a force of attraction on the negatively charged electrons at junction. This force frees electrons from its covalent bond and moves those free electrons to conduction band. When the electric

field increases (with applied voltage), more and more electrons are freed from its covalent bonds. This results in drifting of electrons across the junction and electron hole recombination occurs. So a net current is developed and it increases rapidly with increase in electric field.

10. **Characteristic features of n-type semiconductor**

    i. n-type semiconductor are doped with pentavalent impurity. In it the electrons are majority carriers and holes are minority carriers or ne >> n_h

    ii. The donor energy level E_D is slightly below the bottom of E_c conduction band so electron can easily jump to conduction band, with small supply of energy.

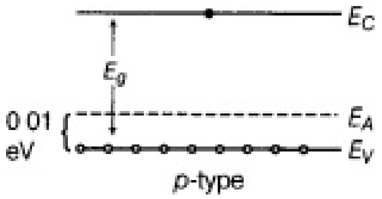


Characteristic features of p-type semiconductor

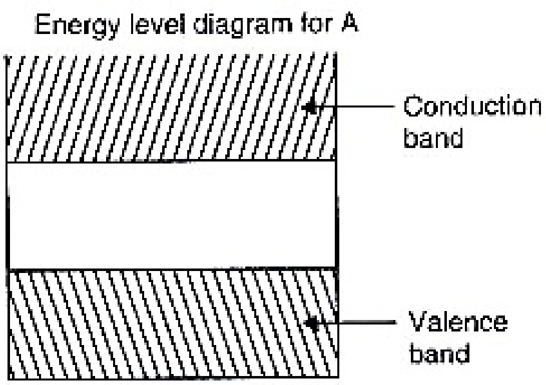
i. p-type semiconductor, are doped with trivalent impurity atoms. Holes are the majority carriers and electrons are the minority carriers i.e. n_h >> n_e

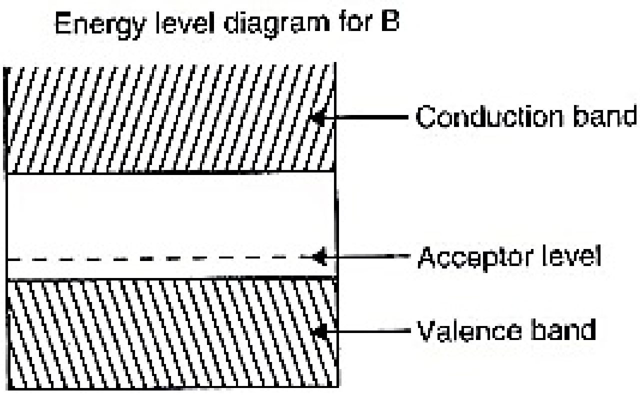
ii. The acceptor energy level is slightly above the valence band Ev. Thus, electron from valence band can easily jump to this level and holes are formed in the valence band.

iii.

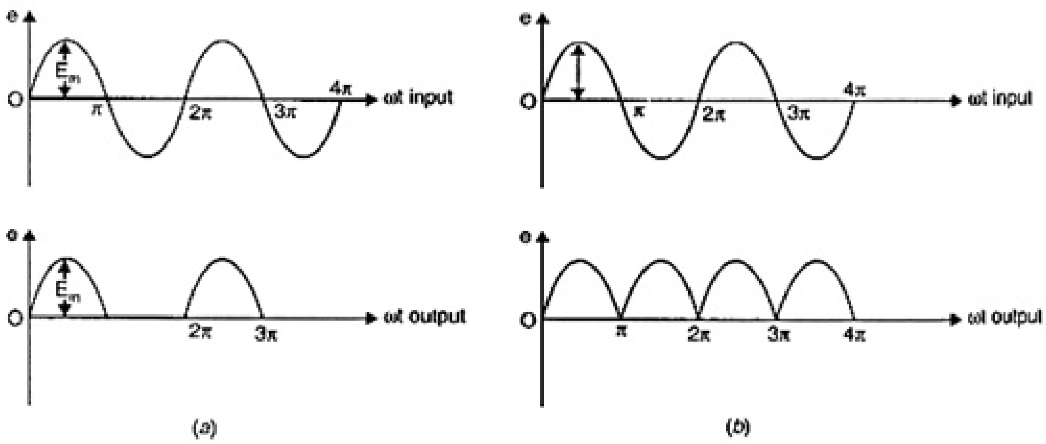


11. A is intrinsic semiconductor and B is p-type semiconductor.

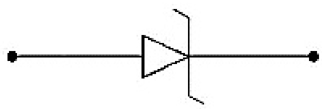




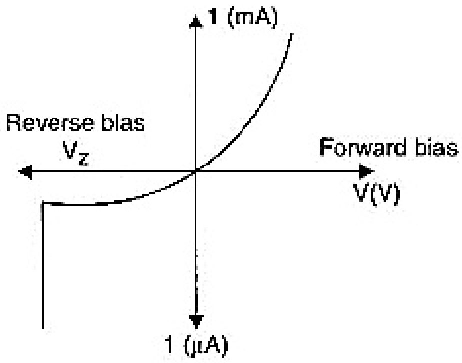
12. When p and n semiconductors are joined , the holes from p-region diffuse into the n-region and electrons from n-region diffuse into p-region and electron-hole pair combine and energy is released.
    This process develops layer of positive ions near the junction on n side and layer of negative ions on p side of junction it develops ,V_B across the junction which opposes the further diffusion through the junction. Thus, small region forms in the vicinity of the junction which is depleted of free charge carrier and has only immobile ions is called the depletion region.
13. Input frequency for half wave and full wave rectifier = 50 Hz.
    Input and output waveforms of half wave and full wave rectifier are shown in figure. Half wave rectifier conducts once during a cycle and full wave rectifier does so twice. Therefore, if input frequency is 50 Hz, output frequency for half wave and full wave rectifier are 50 and 100 Hz respectively.



14. i. Symbol of Zener diode:

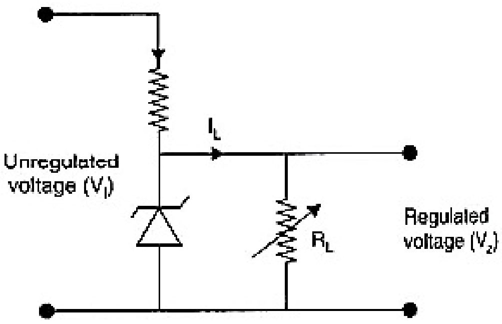


ii. I-V characteristics:



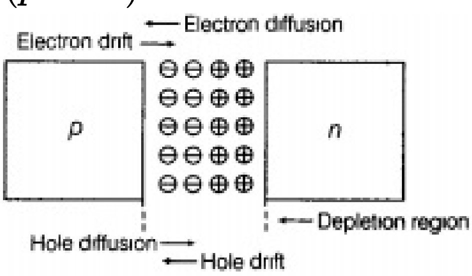
Zener diode as voltage regulator: For widely different Zener currents, the voltage across the Zener diode remains constant. On account of this fact we can use Zener diode as a d.c. voltage regulator.

For input voltage $V_i > V_Z$, Zener diode is in the breakdown condition. Thus, for wide range of values of load (R_L), current through the Zener diode may change but the voltage across it remains constant.



15. i. **p-n Junction:** A p-n-junction diode is formed when a p-type semiconductor is fused to an n-type semiconductor creating a potential barrier voltage across the diode junction

Formation of Depletion Region in p-n Junction: In an n-type semiconductor $n_e > n_h$ Similarly, in a p-type semiconductor, $n_e < n_h$ During formation of p-n junction and due to the concentration gradient across p and n-sides, holes diffuse from p-side to n-side $(p \rightarrow n)$ and electrons diffuse from n-side to p-side $(n \rightarrow p)$



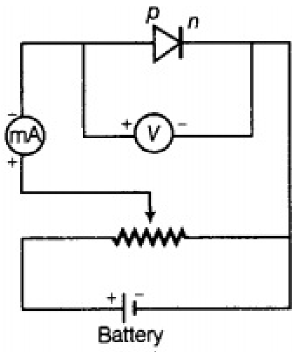
The diffused charge carriers combine with their counterparts in the immediate vicinity of the junction and neutralise each other.

Thus, near the junction, positive charge is built on n-side and negative charge on p-side. This sets up potential difference across the junction and an internal electric field E_1 directed from n-side top-side. The equilibrium is established when the field E_1 becomes strong enough to stop further diffusion of the majority charge carriers (however, it helps the minority charge carriers to diffuse across the junction). The region on either side of the junction which becomes depleted (free) from the mobile charge carriers is called depletion region or **depletion layer**.

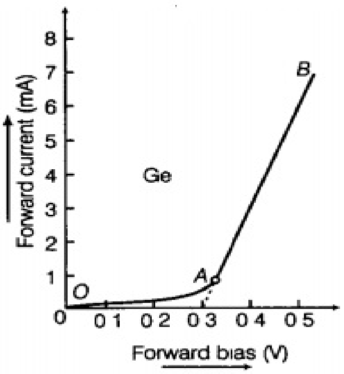
The width of depletion region is of the order of 10^{-6} m.

ii. a. **Forward Biased Characteristics**

The circuit diagram for studying forward biased characteristics is shown in the figure. Starting from a low value, forward bias voltage is increased step by step (measured by voltmeter) and forward current is noted (by ammeter). A graph is plotted between voltage and current. The curve so obtained is the forward biased characteristic of the diode.



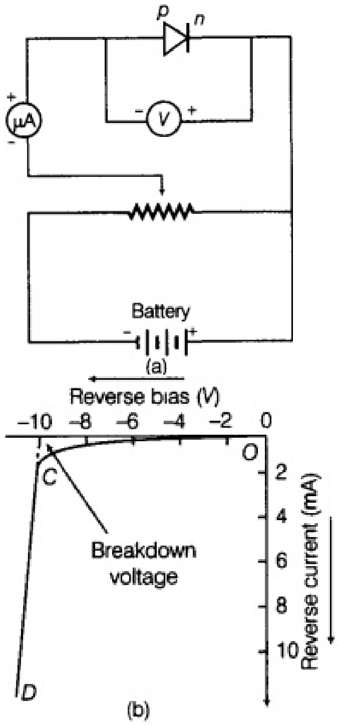
a,



b,

At the beginning, when applied voltage is low, the current through the diode is almost zero. It is because of the potential barrier, which opposes the applied voltage. Till the applied voltage exceeds the potential barrier, the current increases very slowly with increase in applied voltage (OA portion of the graph) With further increase in applied voltage, the current increases very rapidly (AB portion of the graph), in this situation, the diode behaves like a conductor. The forward voltage beyond which the current through the junction starts increasing rapidly with voltage is called knee voltage. If line AB is extended back, it cuts the voltage axis at potential barrier voltage.

b. **Reverse Biased Characteristics** The circuit diagram for studying reverse biased characteristics is shown in the figure.



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 positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrode.

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.

Therefore, the small reverse current remains almost constant over a sufficiently long range of reverse bias, increasing very little with increasing voltage (OC portion of the graph). This reverse current is voltage independent upto certain voltage known as breakdown voltage and this voltage independent current is called reverse saturation current.