Short Answer Type

1. Compare Intrinsic semiconductor and Extrinsic semiconductor.

Characteristic	Intrinsic Semiconductor	Extrinsic Semiconductor
Definition	Pure semiconductor material without intentional impurities	Semiconductor intentionally doped with specific impurities
Doping	Undoped	Doped with specific impurities
Conductivity	Lower conductivity	Higher conductivity
Temperature Dependence	Conductivity increases with temperature due to increased carrier generation	Less temperature-dependent conductivity compared to intrinsic semiconductors
Examples	Silicon (Si), Germanium (Ge)	Doped Silicon or Germanium (e.g., n-type or p-type)
Charge Carriers	Electron-hole pairs generated thermally	Additional carriers introduced by intentional doping (electrons or holes)
Purpose	Found in pure form, less commonly used in electronic devices	Widely used in electronic devices for controlled electrical properties

2. What is a pn junction and describe the formation of potential barrier in a pn junction.

When a P-type semiconductor and an N-type semiconductor are brought into contact, a PN junction is formed and it is a fundamental building block in semiconductor devices, such as diodes and transistors.

At the instant of pn-junction formation, the free electrons near the junction in the n region begin to diffuse across the junction into the p region where they combine with holes near the junction. The result is that n region loses free electrons as they diffuse into the junction. This creates a layer of positive charges (pentavalent ions) near the junction. As the electrons move across the junction, the p region loses holes as the electrons and holes combine. The result is that there is a layer of negative charges (trivalent ions) near the junction. These two layers of positive and negative charges form the depletion region (or depletion layer) and there exists a potential difference across the depletion layer is called barrier potential.

3. Write short notes on the following: (i) Knee voltage or cut-in voltage (ii) Breakdown voltage.

(i) Knee voltage:

It is the forward voltage at which the current through the junction starts to increase rapidly. For silicon diode is 0.7 V and 0.3 V for germanium diode.

(ii) Breakdown voltage:

It is the minimum reverse voltage at which pn junction breaks down with sudden rise in reverse current. Therefore, care should be taken that reverse voltage across a pn junction is always less than the breakdown voltage.

4. Compare Zener break down and Avalanche break down.

Zener Breakdown	Avalanche Breakdown
It occurs in diodes that are highly doped.	It occurs in diodes that are lightly doped.
This is observed when breakdown voltage V_z of **below 5V.**	This is observed when breakdown voltage **above 5V.**
The valence electrons are pulled into conduction due to the high electric field in the narrow depletion region.	The valence electrons are pushed to conduction due to the energy imparted by accelerated electrons, which gain their velocity due to their collision with other atoms.
The increase in temperature decreases the breakdown voltage.	The increase in temperature increases the breakdown voltage.
The V-I characteristics of a Zener breakdown has a sharp curve.	The V-I characteristic curve of the avalanche breakdown is not as sharp as the Zener breakdown.
Zener diodes and Zener voltage regulators utilize Zener breakdown.	Avalanche breakdown is commonly observed in high-voltage diodes and is undesirable in most low-voltage applications.

5. Explain the Zener diode equivalent circuit.

<u>(i) "On" state:</u>

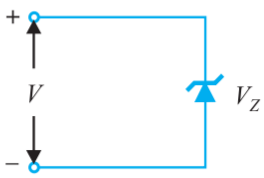
(*i*)
$V \geq V_Z$

(*ii*)
Equivalent circuit of zener for ''on'' state

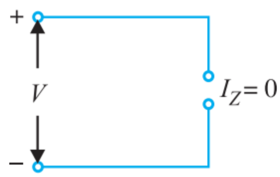
When reverse voltage across a zener diode is equal to or more than break down voltage V_Z, the current increases very sharply, is almost vertical. It means that voltage across zener diode is constant at V_Z even though the current through it changes. Therefore, in the breakdown region, an ideal zener diode can be represented by a battery of voltage V_Z as shown in Fig. (ii).

<u>(ii) "OFF" state:</u>

When the reverse voltage across the zener diode is less than V_Z but greater than 0 V, the zener diode is in the "OFF" state. Under such conditions, the zener diode can be represented by an open-circuit as shown in Fig.(ii).



(*i*)
$V_Z > V > 0$



(*ii*)
Equivalent circuit of zener for ''off'' state

6. List the applications of normal diode and Zener diode.

Normal Diode (Rectifier Diode):

1. Rectification:
2. Signal Demodulation
3. Clipping and Clamping
4. Logic Gates
5. Light Emitting Diodes (LEDs)

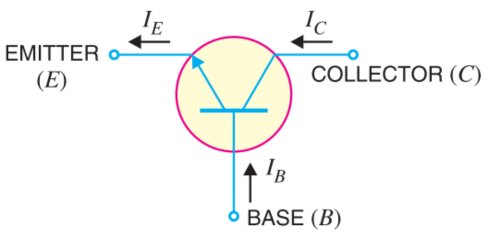
Zener Diode:

1. Voltage Regulation
2. Voltage Reference
3. Overvoltage Protection
4. Voltage Clipping
5. Temperature Compensation
6. Waveform Clipping
7. Voltage Detection

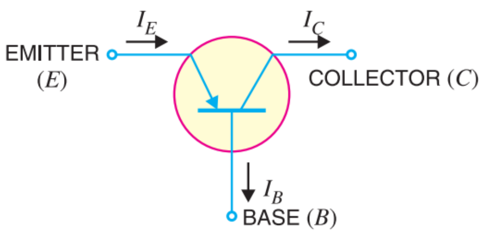
7. What is a transistor? Why is it so called?

The word "transistor" is a combination of two terms: "transfer" and "resistor." The name reflects the device's primary function, which involves transferring an electrical signal from one circuit to another while controlling the flow of current. The transistor acts as a switch or an amplifier, allowing it to control the flow of electric current in a circuit.

8. Draw the symbol of npn and pnp transistor and specify the leads.

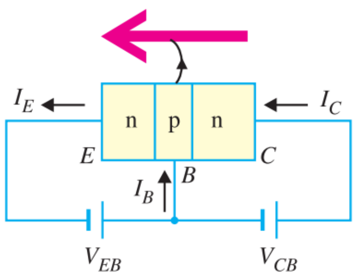


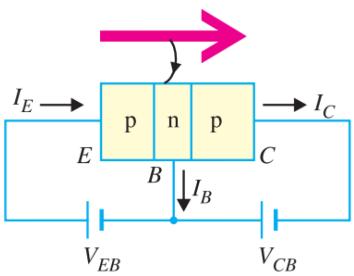
NPN



PNP

9. Describe the connecting process of external batteries to transistor terminals/leads.





(i) **Emitter (E):** The section on one side that **emits or supplies charge carriers** (electrons or holes) is called the emitter. The **emitter is always forward biased** w.r.t. base so that it can supply a large number of majority carriers.

(ii) **Collector (C):** The section on the other side that **collects the charges carriers** is called the collector. The **Collector is always reverse biased**. Its function is to remove charges from its junction with the base.

(iii) **Base (B):** The middle section which forms two pn-junctions between the emitter and collector is called the base. The **base-emitter junction is forward biased**, allowing low resistance for the emitter circuit. The **base-collector junction is reverse biased** and provides high resistance in the collector circuit.

10. What is amplification? What are the conditions to be fulfilled to achieve faithful amplification in a transistor amplifier.

The process of raising the strength of a weak signal without any change in its general shape is known as amplification.

To ensure this, its input circuit (i.e. base-emitter junction) remains forward biased and output circuit (i.e. collector-base junction) remains reverse biased at all times.

Subjective Type

1. Explain Intrinsic semiconductor and extrinsic semiconductor in detail.

2. Explain the effect of temperature on semiconductors.

The effect of temperature on semiconductors is significant and plays a crucial role in determining their electrical properties.

1. **Carrier Generation:**
    - As temperature increases, more electrons gain sufficient energy to break free from their atomic bonds, creating electron-hole pairs (generation of carriers).
    - This phenomenon is more pronounced in intrinsic semiconductors, where carriers are primarily generated through thermal excitation.
2. **Carrier Concentration:**
    - In intrinsic semiconductors, the number of carriers (both electrons and holes) increases with temperature due to increased thermal excitation.
    - Extrinsic semiconductors (doped with impurities) also experience changes in carrier concentration with temperature, but the effect is less prominent than in intrinsic semiconductors.
3. **Band Gap Energy:**
    - The energy gap between the valence band and the conduction band (band gap) tends to decrease slightly with increasing temperature.
    - The decrease in the band gap affects the semiconductor's electrical conductivity.
4. **Intrinsic Carrier Concentration:**
    - The intrinsic carrier concentration (ni) in an intrinsic semiconductor increases exponentially with temperature, following the relationship described by the intrinsic carrier concentration equation.
5. **Conductivity:**
    - As carrier concentration increases with temperature, so does the electrical conductivity of the semiconductor.
    - Higher temperatures generally lead to better conductivity in both intrinsic and extrinsic semiconductors.
6. **Mobility of Carriers:**
    - The mobility of carriers, which describes how quickly they can move in response to an electric field, is influenced by temperature.
    - Carrier mobility tends to decrease with increasing temperature due to increased lattice vibrations and scattering events.
7. **Temperature Coefficient of Resistance:**
    - Semiconductors exhibit a positive temperature coefficient of resistance, meaning that their resistance tends to increase with rising temperature.
    - This effect is more pronounced in semiconductors than in metals.
8. **Breakdown Voltage:**
    - The breakdown voltage of a semiconductor, which represents the voltage at which the semiconductor breaks down and conducts significantly, may be influenced by temperature.

3. Illustrate the behaviour of a pn junction under forward and reverse biasing.
4. Draw and explain the V-I characteristics of a pn junction.
5. Explain the operation and characteristics of Zener diode.
6. Describe the operation of Bipolar Junction Transistor (NPN or PNP) with a neat diagram.
7. Explain the transistor operation with its characteristics in
    a) CB Configuration
    b) CE Configuration
    c) CC Configuration
8. Explain the operation of transistor as an amplifier.