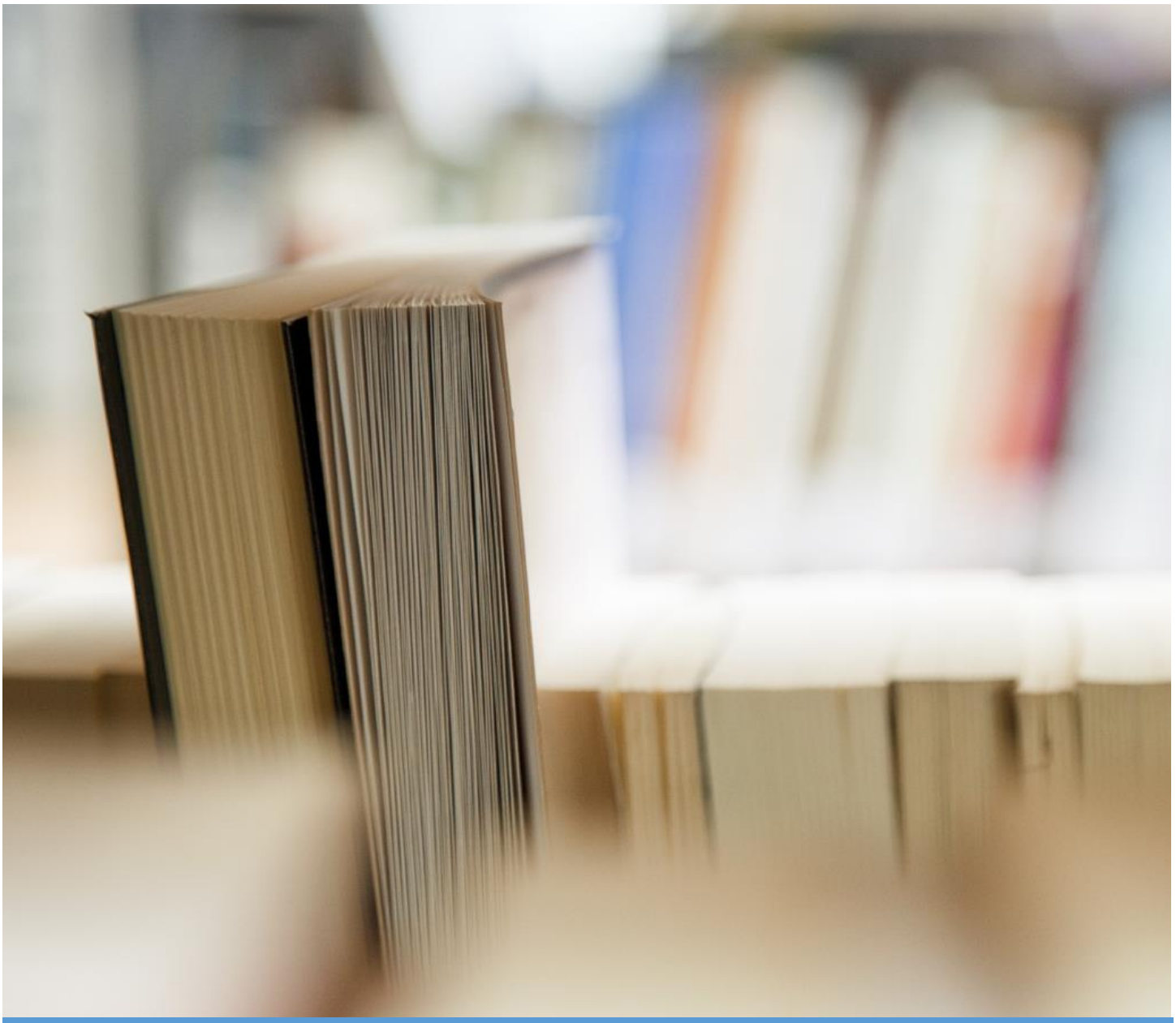


FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING

CAPTER-2 SOLUTION

PARUL UNIVERSITY

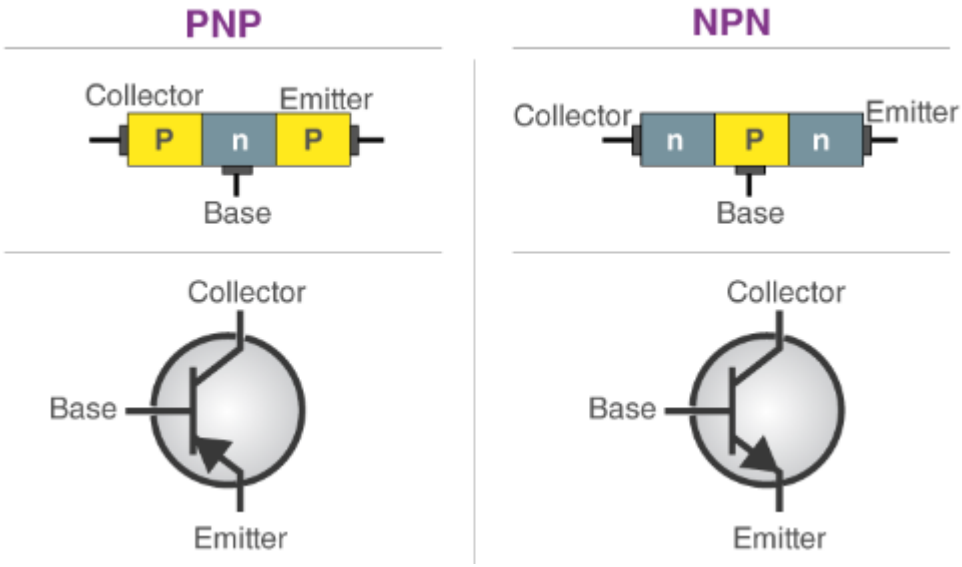
DIPLOMA STUDIES

ELECTRICAL ENGINEERING DEPATEMENT

CHAPTER-2 INTRODUCTION TO SEMICONDUCTOR COMPONENTS

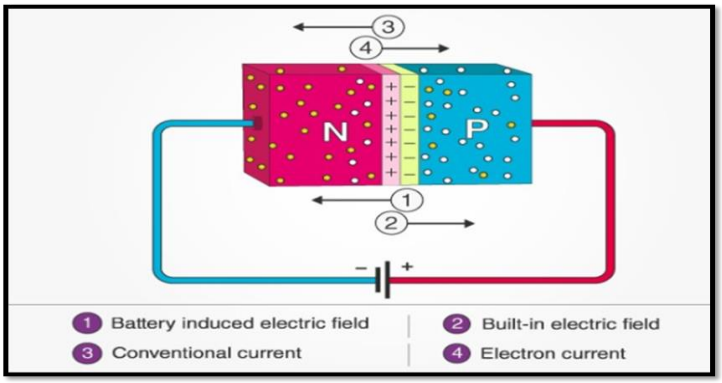
2 MARKS QUESTIONS

1. Draw the symbol of NPN and PNP transistor.



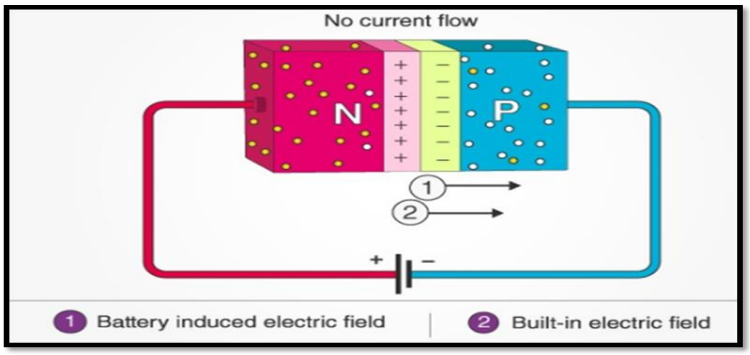
2. Define forward bias with diagram.

- When the p-type is connected to the battery's positive terminal and the n-type to the negative terminal, then the P-N junction is said to be forward-biased. When the P-N junction is forward biased, the built-in electric field at the P-N junction and the applied electric field are in opposite directions.
- When both the electric fields add up, the resultant electric field has a magnitude lesser than the built-in electric field.
- This results in a less resistive and thinner depletion region. The depletion region's resistance becomes negligible when the applied voltage is large. In silicon, at the voltage of 0.6 V, the resistance of the depletion region becomes completely negligible, and the current flows across it unimpeded.



3. Define reverse bias with diagram.

- When the p-type is connected to the battery's negative terminal and the n-type is connected to the positive side, the P-N junction is reverse biased. In this case, the built-in electric field and the applied electric field are in the same direction.
- When the two fields are added, the resultant electric field is in the same direction as the built-in electric field, creating a more resistive, thicker depletion region. The depletion region becomes more resistive and thicker if the applied voltage becomes larger.



4. What is knee voltage? Give its value for Ge and Si.

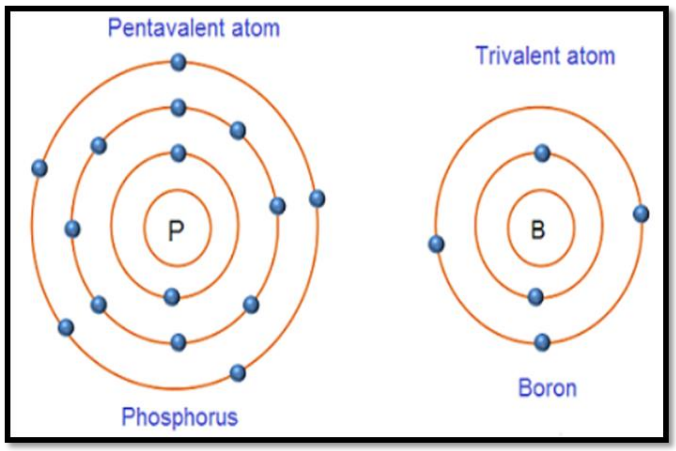
- The voltage is cross toward the barrier potential, the diode current raises quickly and diode performs greatly. This barrier voltage at which the flow of current will increase is known as knee voltage.
- The knee voltage for a silicon diode is approximately 0.7 volt and for a germanium diode 0.3 volt.

5. Give example of Trivalent Impurities.

- Trivalent impurity atoms have 3 valence electrons. The various examples of trivalent impurities include Boron (B), Gallium (G), Indium(In), Aluminum(Al).
- Boron is a substance consisting of atoms which all have the same number of protons. The atomic number of boron is 5 i.e. 5 protons. Boron atom has 5 electrons (2 electrons in first orbit and 3 electrons in the outermost orbit).

6. Give example of Pentavalent Impurities.

- Pentavalent impurity atoms have 5 valence electrons. The various examples of pentavalent impurity atoms include Phosphorus (P), Arsenic (As), Antimony (Sb), etc. The atomic structure of pentavalent atom (phosphorus) and trivalent atom (boron) is shown in below fig.



- Phosphorus is a substance consisting of atoms which all have the same number of protons. The atomic number of phosphorus is 15 i.e. 15 protons. The number of protons in the nucleus of an atom is called atomic number.
- Phosphorus atom has 15 electrons (2 electrons in first orbit, 8 electrons in second orbit and 5 electrons in the outermost orbit).

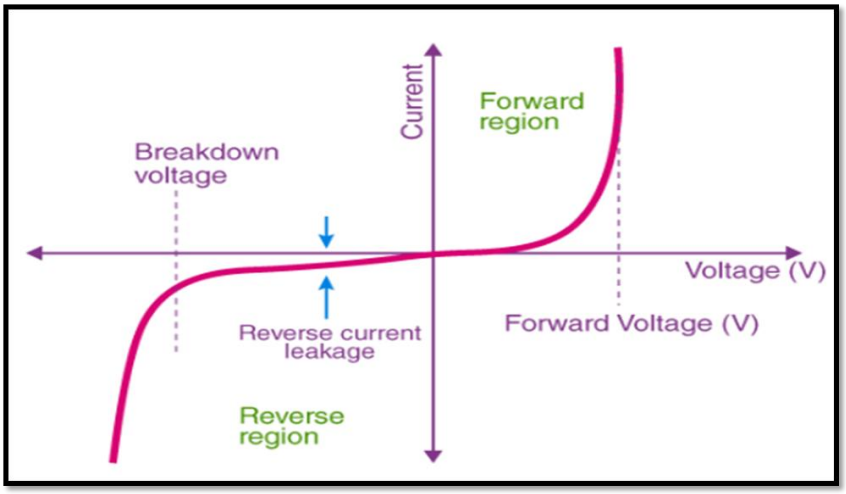
3 MARKS QUESTIONS

1. Explain V-I characteristics of PN junction diode.

- VI characteristics of P-N junction diodes is a curve between the voltage and current through the circuit. Voltage is taken along the x-axis while the current is taken along the y-axis. The above graph is the V-I characteristics curve of the P-N junction diode. With the help of

the curve, we can understand that there are three regions in which the diode works, and they are:

- **Zero bias**
- **Forward bias**
- **Reverse bias**

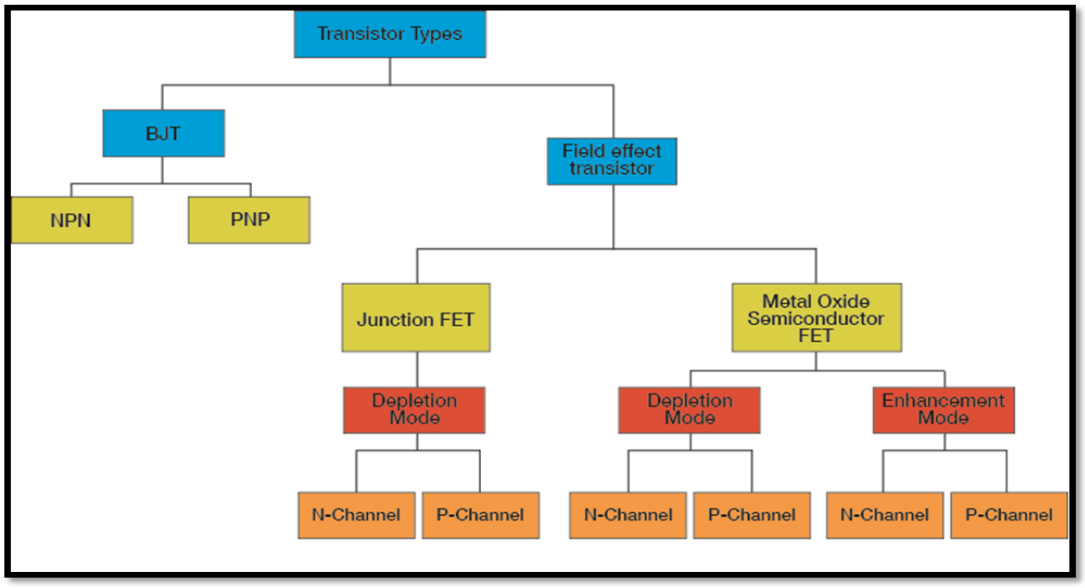


- When the P-N junction diode is in zero bias condition, there is no external voltage applied and this means that the potential barrier at the junction does not allow the flow of current.
- When the P-N junction diode is in forward bias condition, the p-type is connected to the positive terminal while the n-type is connected to the negative terminal of the external voltage. When the diode is arranged in this manner, there is a reduction in the potential barrier. For silicone diodes, when the voltage is 0.7 V and for germanium diodes, when the voltage is 0.3 V, the potential barriers decrease, and there is a flow of current.
- When the diode is in forward bias, the current increases slowly, and the curve obtained is non-linear as the voltage applied to the diode overcomes the potential barrier. Once the diode overcomes the potential barrier, the diode behaves normally, and the curve rises sharply as the external voltage increases, and the curve obtained is linear.
- When the P-N junction diode is in negative bias condition, the p-type is connected to the negative terminal while the n-type is connected to the positive terminal of the external voltage. This results in an increase in the potential barrier. Reverse saturation current flows in the beginning as minority carriers are present in the junction.

- When the applied voltage is increased, the minority charges will have increased kinetic energy which affects the majority charges. This is the stage when the diode breaks down. This may also destroy the diode.

2. State and explain classification of transistor.

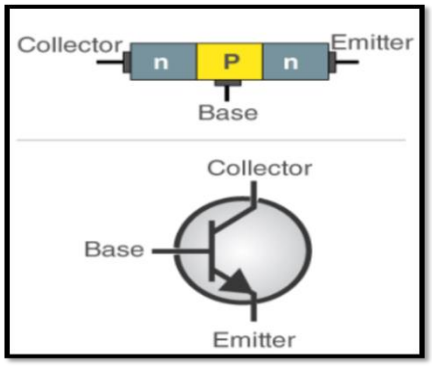
- Transistor is a semiconductor device which is used to either amplify the signals or to act as an electrically controlled switch. A Transistor is a three terminal device and a small current / voltage at one terminal (or lead) will control a large flow of current between the other two terminals (leads).
- Since a long time, the vacuum tubes are replaced with transistors because the transistors have more benefits over vacuum tubes. Transistors are small in size and it requires low energy for operation and also it has low power dissipation. The Transistor is one of the important active components (a device which can produce an output signal higher power than that in the input signal).
- Transistor is an essential component is almost every electronic circuit like: Amplifiers, Switching, Oscillators, Voltage Regulators, Power Supplies and most importantly, the Digital Logic ICs.
- From the time of invention of the first transistor to the present day, transistors are classified into different types depending either on their construction or their operation. The following tree diagram explains a Basic Classification of different Transistor types.



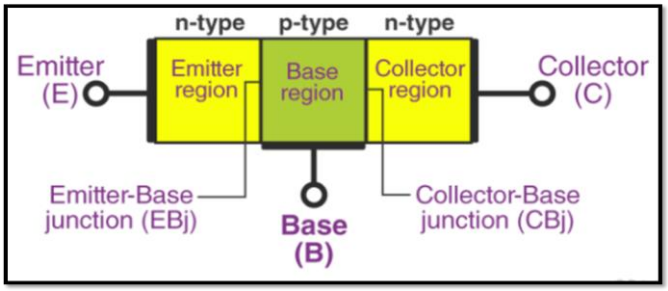
- The classification of transistors can be easily understood by observing the above tree diagram. Transistors are basically classified into two types. They are: Bipolar Junction Transistors (BJT) and Field Effect Transistors (FET). The BJTs are again classified into NPN and PNP transistors. The FET transistors are classified into JFET and MOSFET.
- Junction FET transistors are further classified into N–Channel JFET and P–Channel JFET depending on their construction. MOSFETs are classified into Depletion Mode and Enhancement Mode. Again, depletion and enhancement mode transistors are further classified into respective N–Channel and P–Channel.

3. Explain the construction of NPN transistor.

- The NPN transistor consists of two n-type semiconductors that sandwich a p-type semiconductor. Here, electrons are the majority charge carriers, while holes are the minority charge carriers. The NPN transistor is represented, as shown below.

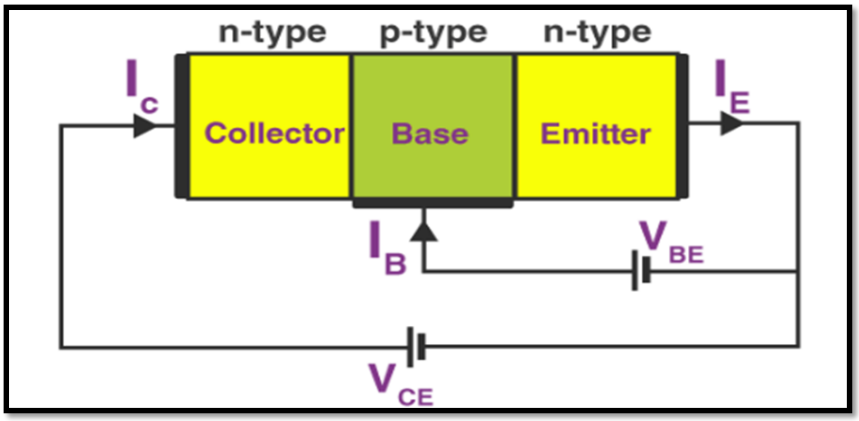


- In the above figure, we can see an arrow pointing outwards from the emitter terminal. This indicates the direction of the flow of current through the device.
- **Construction of NPN Transistor**



- The NPN transistor is made of semiconductor materials like silicon or germanium. When a p-type semiconductor material is fused between two n-type semiconductor materials, an NPN transistor is formed.
- The NPN transistor features three terminals: emitter, base and collector.
- This transistor features two diodes that are connected back to back. The diode seen between the emitter-base terminal is referred to as the emitter-base diode. The diode between collector and base terminal is known as collector-base diodes. The emitter is moderately doped, the base is lightly doped, and the collector is comparatively more doped.

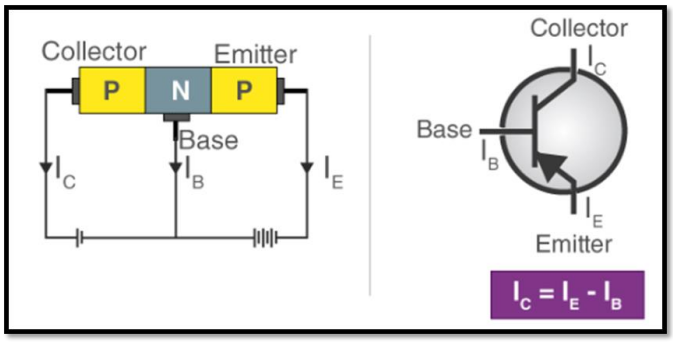
- **Working NPN Transistor**



- When the emitter-base junction is forward biased, a small voltage VBE is seen. Reverse bias voltage VCE. Due to the forward bias, the majority charge carriers in the emitter are repelled towards the base. The electron-hole recombination is very small in the base region since the base is lightly doped. Most of the electrons cross into the collector region.
- When the emitter is forward biased, electrons move towards the base and create the emitter current IE. Here, the majority charge carriers in the P-type material combine with the holes.
- Since the base of the NPN transistor is lightly doped, it lets only a few electrons to combine and the remaining current is known as the base current IB. When the collector region is reverse biased, it applies a greater force on the electrons reaching the collector junction and hence attracts the electrons at the collector.

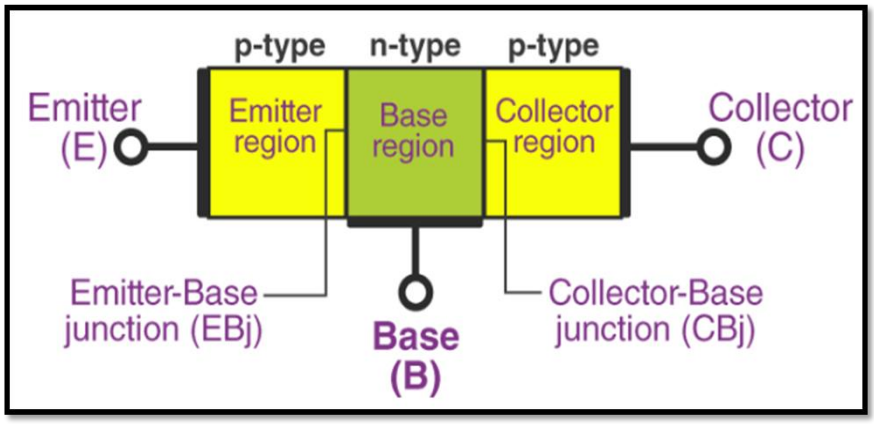
4. Explain the construction of PNP transistor.

- PNP transistors representation is as shown in the figure below.



- This bipolar PNP junction transistor is formed with three layers of semiconductor material, with two P-type regions and one N-type region. It includes three terminals:
- Emitter
- Collector
- Base
- **Emitter –** emitter part in a transistor lets it supply majority charge carriers. The emitter is always forward biased with respect to the base. Hence the majority of charge carriers are supplied to the base. The emitter of a transistor is heavily doped and moderate in size.
- **Collector –** the majority of the charge carrier supplied by the emitter is collected by the collector. The collector-base junction is always reverse biased. The collector area is moderately doped and has the capacity to collect the charge carrier supplied by the emitter.
- **Base –** The center section of the transistor is known as the base. The base forms two circuits, the input circuit with the emitter and the output circuit with the collector. The emitter-base is forward biased and offers low resistance to the circuit. The collector-base junction is in reverse bias and offers higher resistance to the circuit. The base of a transistor is lightly doped and very thin, due to which it offers the majority charge carrier to the base.
- **Construction of PNP Transistor**
- P-type semiconductors, which represent the emitter and collector, are doped heavily than N-type semiconductors, which represent the base. Hence, the depletion region at both junctions penetrates towards the N-type layer.

- In PNP transistors, in this type of transistor, majority charge carriers are holes, and minority charge carriers are electrons. The emitter emits holes and is collected at the collector.
- In a PNP transistor, the base current which enters into the collector is amplified. The flow of current is typically controlled by the base. Current flows in the opposite direction in the base. In a PNP transistor, the emitter emits "holes", and these holes are collected by the collector.
- The base region features a large number of free electrons. But, the width of the middle layer is very small and is lightly doped. So significantly less free electrons are present in the base region.
- **Construction of NPN Transistor**



- **Working of NPN Transistor**
- Emitter current is created when the emitter-base junction is forward biased, the emitter pushes the holes towards the base region. When electrons move into the N-type semiconductor or base, they combine with the holes. The base is lightly doped and is comparatively thin.
- Hence only a few holes are combined with the electrons and the remaining are moved towards the collector space charge layer. This phenomenon generates the base current. The current is carried by holes in p-n-p transistors.