Blue Print (As per PU Board)

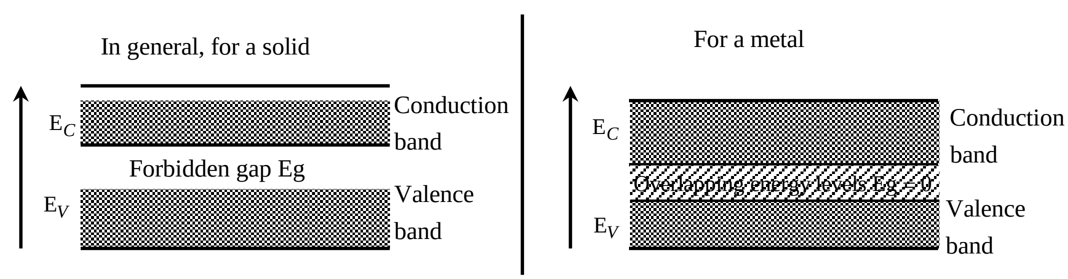
Topic	1 mark questions	2 marks questions	3 marks questions	5 marks questions	Total Marks
Semiconductor Electronics	–	1	1	–	5

One mark questions

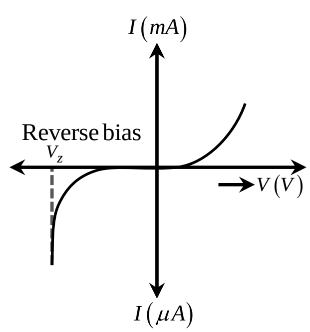
1. **How is a p-type semiconductor obtained?**
Answer: When a pure semiconductor is doped with a trivalent impurity, the resulting semiconductor is called a p-type semiconductor.
2. **Why is a trivalent dopant called acceptor type of impurity?**
Answer: Trivalent dopant is called acceptor type of impurity because it accepts an electron for the completion of the crystalline structure.
3. **What is a p-type semiconductor?**
Answer: A semiconductor is which the number of holes is greater than the number of electrons $(n_h > n_e)$.

Two marks questions

4. **Draw energy band diagram of a metal.**
Answer: Explanation (1 mark) fig. (1 mark)



5. **Draw VI characteristics of a Zener diode in forward & reverse bias condition.**
Answer:



Explanation (1 mark)

Fig. (1 mark)

6. **Mention any two applications of a light emitting diode.**
Answer: (1 mark- each any two)
1. It is used in remote control systems.
2. It is used in burglar alarms.
3. It is used in optical communication.
4. It is used in display devices.

Three marks questions

7. Give any three differences between intrinsic semiconductors and extrinsic semiconductors.

Answer: (One mark each, any three)

Intrinsic semiconductors

1. A semiconductor in its purest form is called intrinsic semiconductor.
2. Number of holes is equal to number of electrons i.e. $n_e = n_h$
3. Electrical conductivity is due to both holes and electrons.
4. Intrinsic semiconductors are not doped with any impurity.
5. Electrical conductivity is very less.

Extrinsic semiconductors

1. A semiconductor in its impure form is called extrinsic semiconductor.
2. Number of holes not equal to number of electrons i.e. $n_e \neq n_h$
3. Electrical conductivity is due to holes or electrons.
4. Extrinsic semiconductors are doped with either pentavalent or trivalent impurity.
5. Electrical conductivity is more than that of an intrinsic semiconductor.

8. Mention any three differences between p-type and n-type semiconductors.

Answer: (One mark each, any three)

p-type:

1. p-type semiconductors are obtained by doping a trivalent impurity to a pure semiconductor.
2. Number of holes is greater than number of electrons i.e $n_h > n_e$
3. Holes are the majority carriers in a p-type semiconductor.
4. Electrons are the minority carriers in a p-type semiconductor.
5. When a trivalent element is added as an impurity to an intrinsic semiconductor, holes are formed.
6. The impurity added is called acceptor impurity.

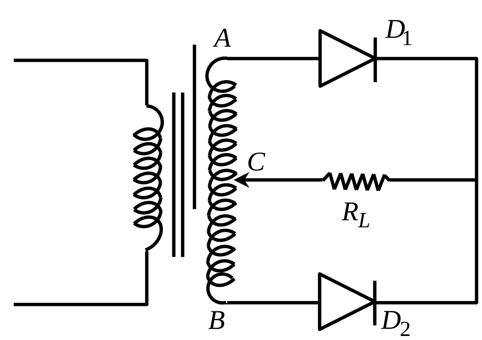
n-type:

1. n-type semiconductors are obtained by doping a pentavalent impurity to a pure semiconductor.
2. Number of holes is less than number of electrons i.e $n_h < n_e$
3. Holes are the minority carriers in a n-type semiconductor.
4. Electrons are the majority carriers in a n-type semiconductor.
5. When a pentavalent element is added as an impurity to an intrinsic semiconductor, free electrons are generated.
6. The impurity added is called donor impurity.

Five marks questions

9. With a neat diagram, explain the working of a diode as a full wave rectifier. Indicate the input and output wave forms.

Answer: For full wave rectification a minimum of two diodes is required. The p-types of these diodes are connected to the terminals of the secondary winding of step down transformer which is provided with a centre tap C. The load resistance R_L is connected through the centre tap. (1 mark)



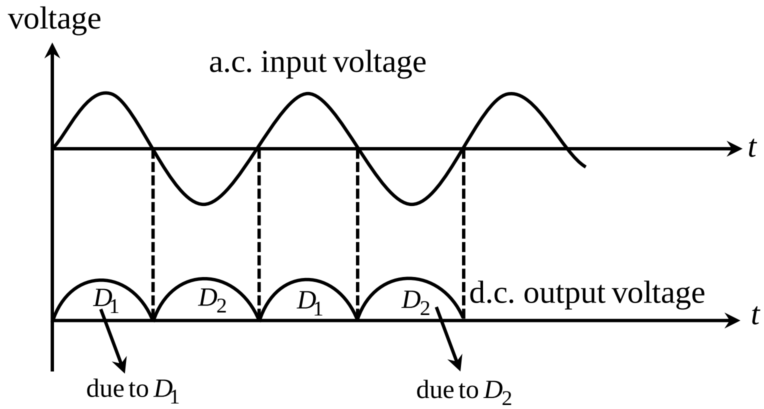


fig. (1 mark)

(1 mark)

In the first half of the applied A.C. input cycle A is positive and B is negative. A positive potential is applied on the p-type of the diode D_1 and simultaneously a negative potential is applied on the p-type of the diode D_2. This makes the p-type of the diode D_1 forward biased. So we get the output voltage due to the action of the diode D_1 only. Simultaneously the diode D_2 is reverse biased and no output voltage is obtained due to the diode D_2. In the second half of the applied A.C. input cycle A is negative and B is positive. This makes the diode D_2 forward biased and the diode D_1 reverse biased. So no output voltage is produced by D_1. The diode D_2 produces the output voltage in this case. (2 marks)
Hence the output voltage is produced in both halves of the input cycle. So this process is called full wave rectification.

10. Explain the working of a light emitting diode. Mention its use.

Answer: It is a heavily doped $p-n$ junction which under forward bias emits spontaneous radiation. The diode is encapsulated with a transparent cover so that emitted light can come out.
When the diode is forward biased, electrons are sent from $n \rightarrow p$ (where they are minority carries) and holes are sent from $p-n$ (where they are minority carries). At the junction boundary the concentration of minority carriers increases compared to the equilibrium concentration(i.e., when there is no bias) Thus at the junction boundary on either side of the junction , excess minority carries are there which recombine with majority carries near the junction . On recombination, the energy is released in the form of photons. Photons with energy equal to or slightly less than the band gap are emitted. When the forward current of the diode is small the intensity of light increases and reaches a maximum. Further increase in the forward current results in decrease of light intensity. LEDs are biased such that the light emitting efficiency is maximum. (2 marks)
The $V-I$ characteristics of a LED are similar to that of a Si junction diode. But the threshold voltage are much higher and slightly different for each colour. The reverse breakdown voltage of LEDs are very low typically around 5V. So care should be taken that high reverse voltages do not appear across them. (1 mark)
LEDs that can emit red, yellow, orange and blue light are commercially available. The semiconductor used for fabrication of visible LED.s must at least have a band gap of 1.8 eV (spectral range of visible light is from about $0.4\,\mu m$ to $0.7\,\mu m$ i.e., from about $3\,eV$ to $1.8\,eV$). The compound semiconductor Gallium arsenide –phosphide ($GaAs_{1-x}P_x$) is used for making LEDs of different colours. $GaAs_{0.6}P_{0.4}$ $\left(E_g \approx 1.9\,eV\right)$ is used for red LED. $GaAs\left(E_g \approx 1.4 eV\right)$ is used for making infrared LED. These LEDs find extensive use in remote controls, burglar alarm systems optical communication etc. Extensive research is being done for developing white LEDs which can replace incandescent lamp. (1 mark)
LEDs have the following advantages over conventional incandescent low power lamps:

(i) Low operational voltage and less power
(ii) fast action and no warm-up time required

(iii) the bandwidth of emitted light is $100\,\text{Å}$ to $500\,\text{Å}$ or in other words it is nearly (but not exactly) monochromatic.
(iv) long life and ruggedness
(iv) fast on-off switching capability (1 mark)

11. With a diagram, explain the action of a n-p-n transistor.

Answer: Consider n-p-n transistor. In the normal operation a transistor, the emitter-base junction is forward biased and the base-collector junction is reverse biased. Since the emitter-base junction is heavily doped, there is a very large number of free electrons. These free electrons move into the base region. But the base contains a very few holes only. All these holes recombine with some of the incoming electrons. Motion of electrons from the emitter to the base results in a current flowing from base to the emitter.

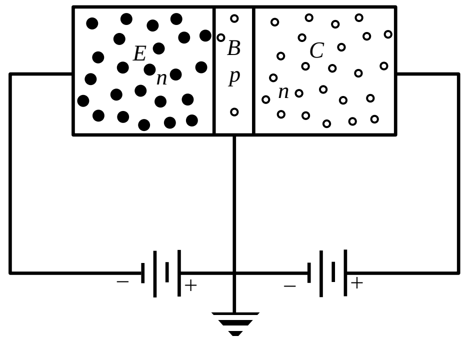
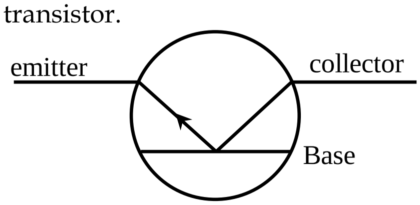


Fig. (1 mark)

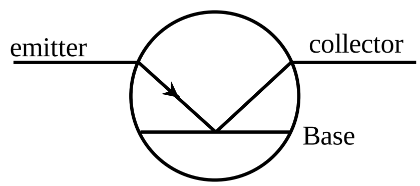
This is called **base current** I_B. There is a large number of free electrons left over in the base. These free electrons move into the collector region easily, because of the reverse bias. Hence motion of electrons from the base to the collector results in a current flowing from collector to the base. This is called **collector current** (I_C). But the electrons present in the $n-$type cannot move towards the base because of the reverse bias. Hence electrons have to move from the emitter to the base and then to the collector. So the current finally flows from the collector towards the emitter. This current is called emitter current (I_E). The total current produced by the transistor is the sum of the base current (I_B) and the collector current (I_C).

$\therefore\ I_E = I_B + I_C$ (2 marks)

The direction of the arrow mark gives the direction of the conventional current in the circuit symbol of a transistor.



npn transistor

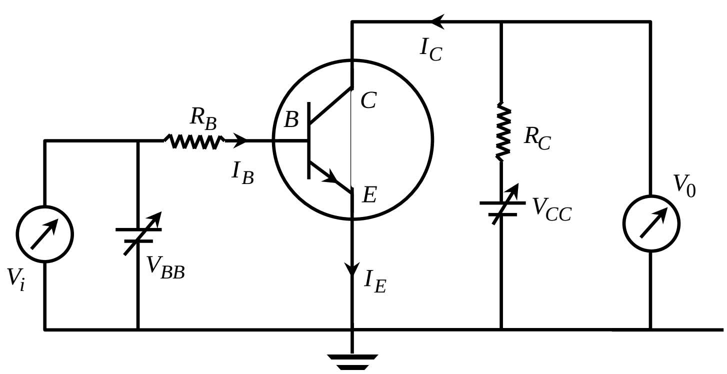


pnp transistor

In the npn transistor, the current flows from base to the emitter. In the *p-n-p* transistor, the current flows from the emitter to the base. (1+1 marks)

12. With a circuit diagram, explain the operation of a transistor as a switch.

Answer:



(1 mark)

Consider an npn transistor in the common emitter mode. The emitter-base junction is forward biased using the battery V_{BB}. The input voltage V_i is noted using the voltmeter connected in the input circuit.

Applying Kirchhoff's voltage rule to the input circuit, [Base-emitter circuit]

$V_{BB} = I_B R_B + V_{BE} \rightarrow (1)$

where V_{BE} is the voltage between base to emitter.

Applying Kirchhoff's voltage rule to the output circuit

$V_{CC} = I_C R_C + V_{CE}$

$\therefore V_{CE} = V_{CC} - I_C R_C \rightarrow (2)$ (1 mark)

V_{BB} is the input voltage (V_i) and V_{CE} is the output voltage (V_0)

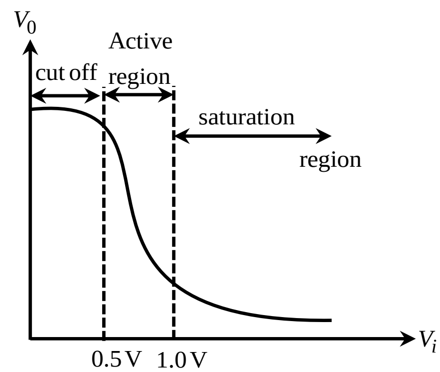
Substituting these in (1) and (2)

$V_i = I_B R_B + V_{BE} \rightarrow (3)$

$V_0 = V_{CC} - I_C R_C \rightarrow (4)$

To study the variation of V_0 w.r.t changes in V_i, we define three regions :

1. **Cut off region:** When the input voltage is less than $0.6\,\text{V}$ the transistor is said to be in cut off state. The output current I_C will be zero in this region.
   Put $I_C = 0$ in equation (2)
   $[V_{CE}]_{\text{cut off}} = V_{CC}$
   This is represented by V_0
   $\therefore V_0 = V_{CC}$ (1 mark)



2. **Active region**: When the input voltage exceeds the cut off voltage V_{CC}, there will be some output current. As the output I_C increases, V_0 starts decreasing
   From (2) $V_{CE} = V_{CC} - I_C R_C$
   In the active region, $I_C \neq 0$. V_{CC} becomes V_0
   $\therefore V_{CE} = V_0 - I_C R_C$
   As I_C increases, V_{CE} starts decreasing. With increases of V_i, I_C almost increases linearly and so V_0 goes on decreasing till its value becomes less than 1.0V
   (1 mark)
3. **Saturation state:** Beyond 1.0 V, the variation of V_0 with V_i becomes nonlinear. The transistor is now said to be in saturation state. With further increase of V_i, V_0 further moves towards zero, but it never becomes zero.

If we draw a graph of V_0 against V_i we get a curve as shown in the figure. This graph is also called base biased transfer characteristics of a transistor. Now we will try to explain the action of transistor as a switch.

1. As long as V_i is low, it is unable to forward bias the transistor. Now V_0 is high with $V_{CC} = V_0$. Now the transistor is said to be switched OFF.
2. If V_i is high enough to drive the transistor into saturation then V_0 is low and it is very nearly zero. Now the transistor is in the saturation state. It is said to be switched ON.

Let us define low voltage level and high voltage level corresponding to cut off and saturation of the transistor. In this case we say that a low input voltage switches OFF a transistor. A high input voltage switches ON a transistor. In other words a low input gives a high output and a high input gives a low output in a transistor. The switching circuits are designed in such a way that a transistor is either in the cut off region or saturation region. The transistor does not remain in the active state when it is used as a switch. (1 mark)