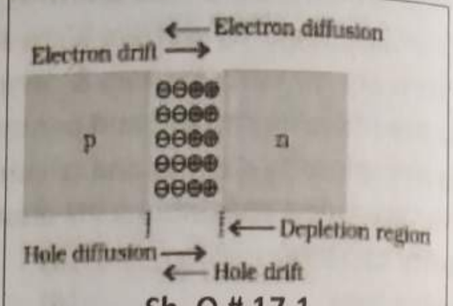
CONCEPTUAL QUESTIONS

17.1 Explain the formation of depletion region in a PN-junction.

Ans: When one half of a pure semiconductor crystal is doped with pentavalent impurity atoms, it becomes N-type. Similarly when then other half is doped with trivalent impurity atoms it becomes P-type. Since one side contains excess of electrons and the other side contains excess of holes therefore diffusion of charges takes place. Each electron when diffuses from N-side to P-side, leaves a hole behind it. When electron is received in the P-type region,

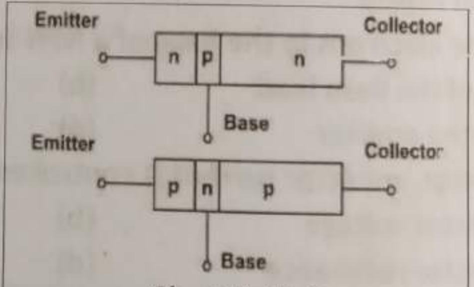


Sh. Q # 17.1

negative charge appears in P-region and vice versa. The electrons in P-region and holes in N-region stops further diffusion of electrons from N-side and holes from P-side respectively thus maintaining separation of charge carriers. This region of separation between charge carriers is free of mobile charges and it is called depletion region.

17.2 Explain why in a transistor (a) the base is thin lightly doped and (b) the collector is large in size.

Ans: (a) In a transistor operation, the electrons that are injected in emitter constitute emitter current. This emitter current reaches the collector through base. Now when electrons enter the base, some of them recombine with the holes in the base and hence they form base current which returns to the battery. They cannot reach the collector. Therefore, in order to minimize base current, the base of transistor is made thin and doped lightly. By doping lightly,



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lesser recombination will occur and hence more charges will be able to reach the collector.

(b) Collector current is the current which is supplied to the load. The key role of the collector is to receive the charges from base to constitute collector current. Transistor must be configured in such a way that almost all the emitter current is received at the collector. For this purpose collector is made larger in size so that all the charges can be received at the collector as shown in the figure.

17.3 Explain why the base current is weak as compared to collector current?

Ans: In the manufacture of the transistor, base is very thin and also it is doped lightly than collector. Reason behind it is that smaller recombination of charges occur at the base. If base is heavily doped, then a very significant amount of charges will recombine in the base to form base current and return to the battery. This will reduce the current gain of the transistor. Collector is doped higher and its size is also larger than base so that majority of the charges can be received at the collector to make the current gain of the transistor larger. Therefore, base current is weak as compared to collector current.

17.4 Why emitter base junction is forward biased & collector base junction reverse biased?

Ans: In the normal operation of transistor (active region), its emitter-base junction is forward biased so that maximum charges are injected through the emitter into the base. Minimum opposition is offered in forward biased configuration by barrier region. These charge carriers reach the base, which is quite thin and lightly doped. So, in order to make current gain larger, most of these charges must be received at the collector. This is only possible when collector-base junction is reversed biased. Hence, most of the charges that are injected in the base through forward biased configuration, are received by collector through reversed biased configuration. This is the reason that in a transistor, EB junction is forward biased and CB junction is reverse biased.

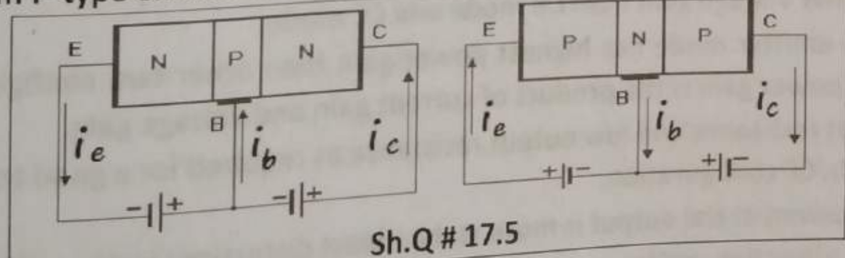
17.5 Draw diagram of NPN and PNP transistors and explain how it works.

Ans: Circuit diagrams for both NPN and PNP transistor are shown.

In NPN transistor, the emitter-base forward biased configuration injects a large number of electrons from N-type emitter to the P-type lightly doped base region and thus forms emitter current. At the base region, small recombination of electrons and holes occurs to form base current while most of electrons are received through reverse biased collector-base configuration to form collector current. Hence total emitter current is distributed into two parts namely base current and collector current. Mathematically

$$i_e = i_b + i_c \text{ ----------------- } (1)$$

In PNP transistor, the emitter-base forward biased configuration injects a large number of holes from P-type emitter to the N-type thin base region and thus forms emitter current. In the base, small recombination of electrons and holes occurs to form base current while most of the holes are received through reverse biased, collector-base configuration at the collector to form collector current. Hence total emitter current is distributed into two parts namely base current and collector current. Mathematical equation for current representation in PNP is same as eq (1) for NPN transistor. It may be noted



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that in P-type conductivity, the valence electrons move from one covalent bond to another unlike the N-type where current conduction is by free electrons.

17.6 Distinguish between N-type semiconductors & P-type semiconductors.

Ans. Difference between N-type and P-type semiconductors are as follows.

N-Type Semiconductors	P-Type Semiconductors
1. N-type semiconductors have electrons as majority carriers.	1. P-type semiconductors have holes in majority.
2. In N-type semiconductors, holes are in minority.	2. in P-type semiconductors, electrons are minority carriers.
3. In N-type semiconductors, pentavalent impurity is dopant.	3. In P-type semiconductors, trivalent atoms are dopant.
4. In N-type semiconductors, conduction occurs through electrons	4. In P-type semiconductors, the holes are responsible for conduction.

17.7 A P-type semiconductor has a large number of holes but still it is electrically neutral. Why?

Ans: P-type semiconductor, although having large number of holes, is neutral because number of positive charge carriers (holes) in the valence band is exactly equal to the negative charge carriers in the conduction band of acceptor atom. Acceptor impurity atoms produce holes without further generation of electrons in the conduction band.

17.8 Explain why CE configuration is widely used in amplifier circuits?

A transistor in common-emitter configuration (mode) is preferred because of following advantages:

- Common-emitter configuration (mode) has higher current gain (current amplification factor) than common-base (CB) and common-collector (CC) mode.
- It has higher voltage gain than CB mode and CC mode.
- Common emitter mode has highest power gain than other two configurations whereas power gain is the product of current gain and voltage gain.
- High input resistance and low output resistance as required for a good transistor is found in CE configuration.
- Signal received at the output is more stable (least distortion) in CE configuration than the other two modes.

17.9 Why transistor is called current amplification device?

Ans: When a transistor is properly biased, it can amplify a given weak signal up to several hundred times (up to 400 times). Reason is that it has low output resistance and thus higher current gain is achieved. Current amplification factor for a transistor,

$V_{out} = V_{in} \left[\beta \times \frac{R_C}{R_B} \right]$

which shows by how much times a current given at the input is increased at the output, clearly indicates that transistor is a current amplification device. Thus it can be used to enhance the strength of a given weak signal. The energy required for amplification is taken from power supply.

17.10. A doped semiconductor has 10^{10} silicon atoms and 10 trivalent atoms. If the temperature is 25 °C, how many free electrons and holes are there inside the semiconductor?

Ans: When 10 trivalent atoms are doped in 10^{10} silicon atoms, there will be 10 holes generated by this doping while no further electrons will be generated and the material will remain neutral. However at 25°C, due to thermal effects some electrons will break away from their covalent bond and can reach the conduction band to become a free carrier, leaving a hole in the valence band.