NCERT Solutions for Class XII Physics

Chapter-14

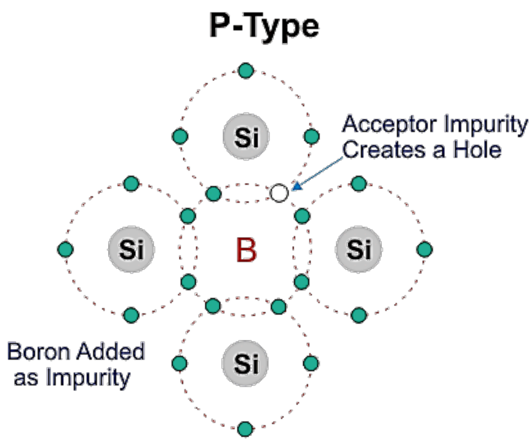
NCERT Physics Class 12

1. In an n-type silicon, which of the following statement is true:
(a) Electrons are majority carriers and trivalent atoms are the dopants.
(b) Electrons are minority carriers and pentavalent atoms are the dopants.
(c) Holes are minority carriers and pentavalent atoms are the dopants.
(d) Holes are majority carriers and trivalent atoms are the dopants.

1. The correct statement is (c).
In an n-type silicon, the electrons are the majority carriers, while the holes are the minority carriers. An n-type semiconductor is obtained when pentavalent atoms, such as phosphorus, are deped in silicon atoms.

2. Which of the statements given in Exercise 1 is true for p-type semiconductors.

2. The correct statement is (d).
In a p-type semiconductor holes are majority carriers and trivalent atoms are dopants as it is formed by doping of a trivalent atom in a tetravalent crystal.
Trivalent atoms have an electron less than a tetravalent atom, hence a number of holes are greater than the number of electrons (As Absence of electron represents hole).So, holes are the majority carriers.



3. Carbon, silicon and germanium have four valence electrons each.
These are characterised by valence and conduction bands separated by energy band gap respectively equal to $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$. Which of the following statements is true?

(a) $(E_g)_{Si} < (E_g)_{Ge} < (E_g)_C$

(b) $(E_g)_C < (E_g)_{Ge} > (E_g)_{Si}$

(c) $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$

(d) $(E_g)_C = (E_g)_{Si} = (E_g)_{Ge}$

3. The correct statement is (c).

Of the three given elements, the energy band gap of carbon is the maximum and that of germanium is the least.

The energy band gap of these elements are related as: $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$.

4. In an unbiased p-n junction, holes diffuse from the p-region to n-region because

(a) free electrons in the n-region attract them.

(b) they move across the junction by the potential difference.

(c) hole concentration in p-region is more as compared to n-region.

(d) All the above.

4. The correct statement is (c).

In an unbiased p-n junction diode, the holes diffuse from the p-region to the n-region because of the difference in their concentration in the regions. Holes concentration is more in p-region, hence to achieve equilibrium they diffuse towards less concentrated n-region.

5. When a forward bias is applied to a p-n junction, it

(a) raises the potential barrier.

(b) reduces the majority carrier current to zero.

(c) lowers the potential barrier.

(d) None of the above.

5. The correct statement is (c).

When a forward bias is applied to a p-n junction, it lowers the value of potential barrier. In the case of a forward bias, the potential barrier opposes the applied voltage. Hence, the potential barrier across the junction gets reduced.

6. For transistor action, which of the following statements are correct:

(a) Base, emitter and collector regions should have similar size and doping concentrations.

(b) The base region must be very thin and lightly doped.

(c) The emitter junction is forward biased and collector junction is reverse biased.

(d) Both the emitter junction as well as the collector junction are forward biased.

6. The correct statement is (b), (c).

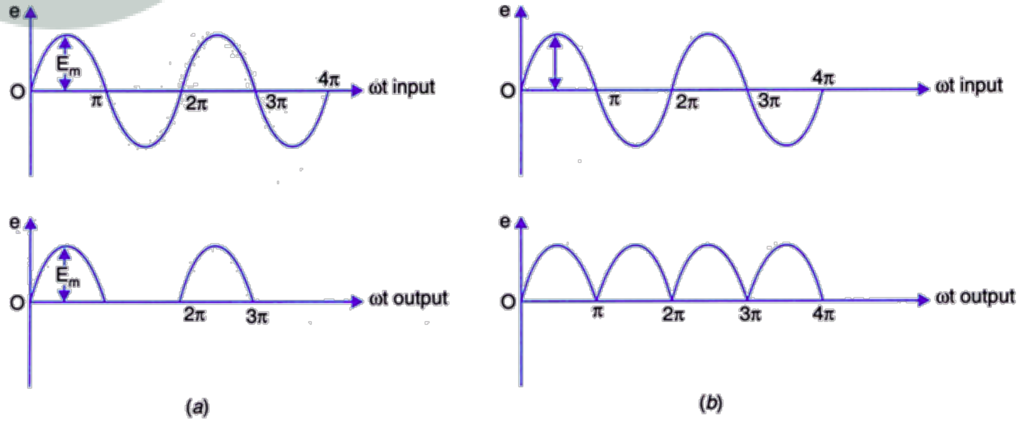
The base region is made very thin and lightly doped, as it's the main function is to control the flow of electron through the transistor. It's lightly doped hence less number of majority carriers will be there resulting in a lesser percentage of emitter current flow through the base than the collector. That's why base current is negligibly small.
Also, emitter junction is always forward biased and collector junction is reverse biased. This setup results in the transistor being in the active region. Otherwise, no current flows through the transistor.(Cut-off or saturation region)
Hence, both (b) and (c) are correct.

7. For a transistor amplifier, the voltage gain
(a) remains constant for all frequencies.
(b) is high at high and low frequencies and constant in the middle frequency range.
(c) is low at high and low frequencies and constant at mid frequencies.
(d) None of the above.

7. The correct statement is (c).
The voltage gain of a transistor amplifier is constant at mid frequency range only. It is low at high and low frequencies.

8. 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.

8. During a cycle, half wave rectifier conducts once and full wave rectifier conducts twice, hence the output frequency for the half-wave rectifier will be same i.e., 50 Hz, whereas the output frequency for the full wave rectifier will be double, i.e., 100 Hz.
Output frequency for full wave rectifier = 100 Hz, for half-wave rectifier it's 50 Hz.



(Actually, this is application of p-n junction diode).

9. For a CE-transistor amplifier, the audio signal voltage across the collected resistance of 2k is 2 V. Suppose the current the amplification factor of the transistor is 100, find the input signal voltage and base current, if the base resistance is 1k.

9. Collector resistance, R_C = 2 kΩ = 2000 Ω

Audio signal voltage across the collector resistance, V = 2 V

Current amplification factor of the transistor, β = 100

Base resistance, R_B = 1 kΩ = 1000 Ω

Input signal voltage = V_i

Base current = I_B

We have the amplification relation as: $= \frac{V}{V_l} = \beta \frac{R_C}{R_B}$

Voltage amplification

$$V_i = \frac{V}{\beta}\frac{R_B}{R_C} = \frac{2 \times 1000}{100 \times 2000} = 0.01\,\text{V}$$

Therefore, the input signal voltage of the amplifier is 0.01 V.

Base resistance is given by the relation:

$$R_B = \frac{v_i}{I_B} = \frac{0.01}{1000} = 10 \times 10^{-6}\,\mu\text{A}$$

Therefore, the base current of the amplifier is 10 μA.

10. Two amplifiers are connected one after the other in series(cascaded). The first amplifier has a voltage gain of 10 and the second has a voltage gain of 20. If the input signal is 0.01 volt, calculate the output ac signal.

10. Let A_1 = 10 (Voltage gain of the first amplifier)

and A_2 = 20 (Voltage gain of the second amplifier)

V_i = 0.01 V (Input signal voltage)

Let, Output AC signal voltage = V_o

We have the relation:

$V_o = A \times V_i$

Output after the first stage $V_{O1} = A_1 \times V_i$

Then, output after the 2nd stage $V_{O2} = V_{O1} \times A_2 = V_i \times A_1 \times A_2$

Hence, the final output = V_O = 20 × 10 × 0.01 = 2 Volts

Therefore, the output AC signal of the given amplifier is 2 V.

11. A p-n photodiode is fabricated from a semiconductor with the band gap of 2.8 eV. Can it detect wavelength of 6000 nm?

11. Energy band gap of the given photodiode, E_g = 2.8 eV

Wavelength, λ = 6000 nm = 6000×10^{-9} m

The energy of a signal is given by the relation:

$$E = \frac{hc}{\lambda}$$

Where,

h = Planck's constant = 6.626×10^{-34} Js

c = Speed of light = 3×10^{8} m/s

$$E = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{6000 \times 10^{-9}} = 3.313 \times 10^{-20}\,J$$

But 1.6×10^{-19} J = 1 eV

$\therefore$ E = 3.313×10^{-20} J

$$= \frac{3.313 \times 10^{-20}}{1.6 \times 10^{-19}} = 0.207\,eV$$

The energy of a signal of wavelength 6000 nm is 0.207 eV, which is less than 2.8 eV – the energy band gap of a photodiode. Hence, the photodiode cannot detect the signal.