PES UNIVERSITY

2022

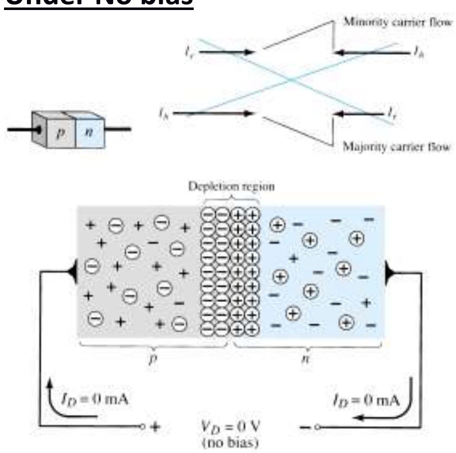
UE22EC141A: Electronic Principles and Devices

Assignment questions with Answers

UNIT I: Introduction to Electronics and Semiconductor Diodes

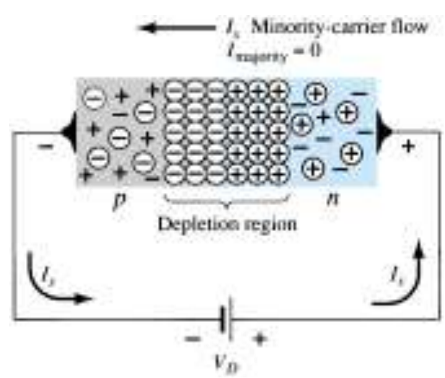
1. **With a neat diagram explain the working of a PN-junction diode under No bias, Reverse bias and forward bias**.

Under No bias



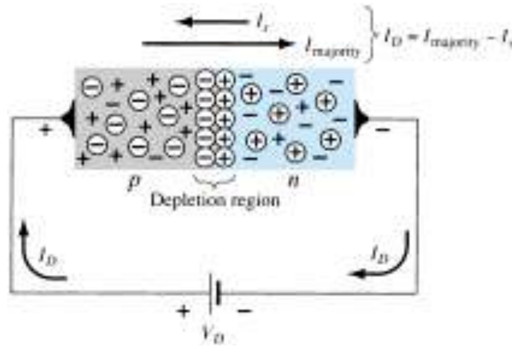
Under no-bias (no applied voltage) conditions, any minority carriers (holes) in the *n*-type material that find themselves within the depletion region will pass directly into the *p*-type material. The closer the minority carrier is to the junction, the greater the attraction for the layer of negative ions and the less the opposition of the positive ions in the depletion region of the *n*-type material.

Reverse-Bias Condition (*VD*< 0 V)



If an external potential of *V* volts is applied across the *p*-*n* junction such that the positive terminal is connected to the *n*-type material and the negative terminal is connected to the *p*-type material as shown in Fig., the number of uncovered positive ions in the depletion region of the *n*-type material will increase due to the large number of "free" electrons drawn to the positive potential of the applied voltage. For similar reasons, the number of uncovered negative ions will increase in the *p*-type.

Forward-Bias Condition (*VD*> 0 V)



The application of a forward-bias potential *VD* will "pressure" electrons in the *n*-type material and holes in the *p*-type material to recombine with the ions near the boundary and reduce the width of the depletion region as shown in Fig . The resulting minority-carrier flow of electrons from the *p*-type material to the *n*-type material (and of holes from the *n*-type material to the *p*-type material) has not changed in magnitude (since the conduction level is controlled primarily by the limited number of impurities in the material), but the reduction in the width of the depletion region has resulted in a heavy majority flow across the junction material.

2. **Explain the V-I characteristics of the diode using Shockley's equation.**

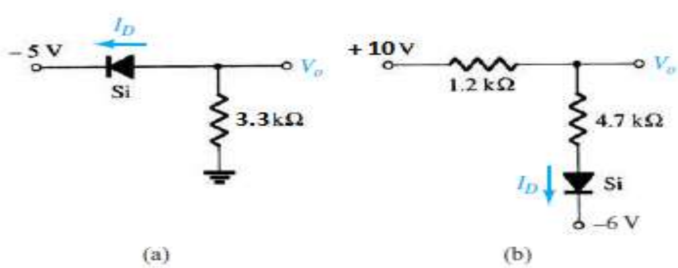
With the use of solid-state physics that the general characteristics of a semiconductor diode can be defined by the following equation for the forward- and reverse-bias regions:

$$\boxed{I_D = I_S(e^{kV_D/T_K} - 1)}$$

Is = reverse saturation current
k = 11,600/ n
For positive values of V_D the first term of the equation above will grow very quickly and overpower the effect of the second term. The result is that for positive values of V_D, I_D will be positive and grow as the function $I_D = Is\ e^{kVd/TK}$ appearing in. At V_D = 0 V becomes $ID = Is\ (e^0-1)=0mA$

For negative values of V_D the first term will quickly drop off below *Is*, resulting in $I_D = -Is$, which is simply the horizontal line.

3. **Determine Vo and I_D for the series diode networks configurations networks shown below.**



Solution:

(a) Diode forward-biased,
Kirchhoff's voltage law (CW): 5 V + 0.7 V - Vo = 0
Vo = -4.3 V
IR = ID = Vo/R = 4.3 V /3.3 K ohm= 1.3 mA
(b) Diode forward-biased
I_D = (10 V + 6 V 0.7 V)/ (1.2 kohm + 4.7 kohm) = 2.59 mA
V_0 = 10 V - (2.25 mA)(1.2 kohm) = 6.89 V

4. **Determine the thermal voltage for a diode at a temperature of 20°C and also find the diode current if reverse saturation current Is = 30 nA, n= 2, and the applied voltage is 0.5 V.**
Solution:

	$V_T = kT/q = (1.38 \times 10^{-23}$ J/K) (20 + 273) / 1.6 x 10^-19 C = 25.27 mV $I_D = I_s(e^{V_D/nV_T} - 1)$ VD = 0.5 V, Is = 50 nA, n = 2, VT = 25.27 mV. I_D = 0.591 mA