Applied Physics

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MID TERM ASSIGNMENT

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Note: Attempt all Questions

Q1: (A). Discuss the significance of the knee of the characteristics curve in forward Bias?

(Ans.) The significance is the knee of the characteristics curve in forward bias is the point which the barrier potential is overcome and current will increase rapidly (The minimum voltage required for conducting the diode is known as "Kee voltage"). Also, Knee voltage is the characteristic voltage of a P-N junction. It's around 0.6–0.7 V for Silicone and 0.2–0.3 for Germanium. The shape of the forward bias side of the P-N junction characteristic curve looks like the knee, so it's named knee voltage.

The "knee" is the first quadrant of the current vs voltage characteristics curve (I vs V) of a semi-conductor diode represents an abrupt change in its conduction, at a voltage which produces the necessary electric field to cancel the intrinsic electric field in the junction.

(B). What happens to the barrier potential when the temperature increases?

(Ans.) In semiconductors, there is a layer near the p-n junction which is partially devoid of free charge carriers. This layer is known as depletion layer.

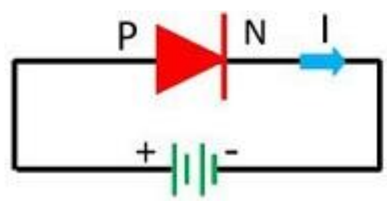
For the diffusion of charge carriers from one region to another, there is a barrier across junction known as potential barrier. This is the amount of voltage which must be applied for the flow of free charge carriers.

This barrier potential is directly proportional to the concentration of free charge carriers.

Barrier potential is inversely proportional to the temperature. Higher the temperature, greater will be the mobility of charge carriers and lower potential difference across the junction can break the potential barrier. But as the temperature lowers, kinetic energy of charge carriers decreases and higher will be the value of potential barrier.

Q2: (A). Compare the depletion regions in forward bias and reverse bias?

(Ans.)

<table>
<tr><th>Basis for Comparison</th><th>Forward Biasing</th><th>Reverse Biasing</th></tr>
<tr><td>Symbol</td><td>


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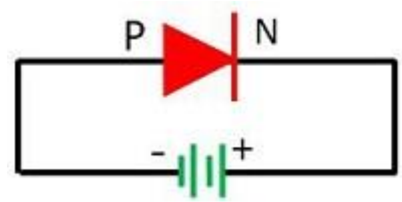

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<tr><td>Definition</td><td>The external voltage which is applied across the PN-diode for reducing the potential barrier to constitutes the easy flow of current through it is called forward bias.</td><td>The external voltage which is applied to the PN junction for strengthening the potential barrier and prevents the flow of current through it is called reverse bias.</td></tr>
</table>

Connection	The positive terminal of the battery is connected to the P-type semiconductor of the device and the negative terminal is connected to N-type semiconductor	The negative terminal of the battery is connected to the P-region and the positive terminal of the battery is connected to N-type semiconductor.
Barrier Potential	Reduces	Strengthen
Voltage	The voltage of an anode is greater than cathode.	The voltage of cathode is greater than an anode.
Forward Current	Large	Small
Depletion layer	Thin	Thick
Resistance	Low	High
Current Flow	Allows	Prevents

Magnitude of Current	**Depends on forward voltage.**	**Zero**
Operate	**Conductor**	**Insulator**

(b). When does reverse breakdown occur in a diode?

(Ans). In the reverse bias condition of a diode, when voltage is increased, the current (of the order of micro ampere), in the beginning remains almost constant. This current is called reverse saturation current and is formed by minority charge carriers.
Now, if we increase the reverse voltage, at one stage the current increases suddenly. This value of reverse voltage is known as breakdown voltage.
In the reverse bias condition, the dynamical resistance is ~ 10^6 ohm.

Explanation: The width of the depletion region is very small when impurity concentration is very high. As a result, at a low reverse bias voltage we get high intensity electric field in the depletion region. For example, if width of depletion region is 200 angstrom and reverse bias voltage is 2V, the electric field strength is 10^6 V/cm. This magnitude of electric field is sufficient to break the covalent bonds and make the electrons free. A large number of electron- hole pairs are formed which causes the sudden and rapid increase in reverse current. This explanation, in case of highly doped P and N regions was given by Zener.

Q3: (a): Find the difference between electric potential energy and electric potential?

Ans). Electric potential is the amount of electrical potential energy that a unitary point electric charge would have if located at any point in space,

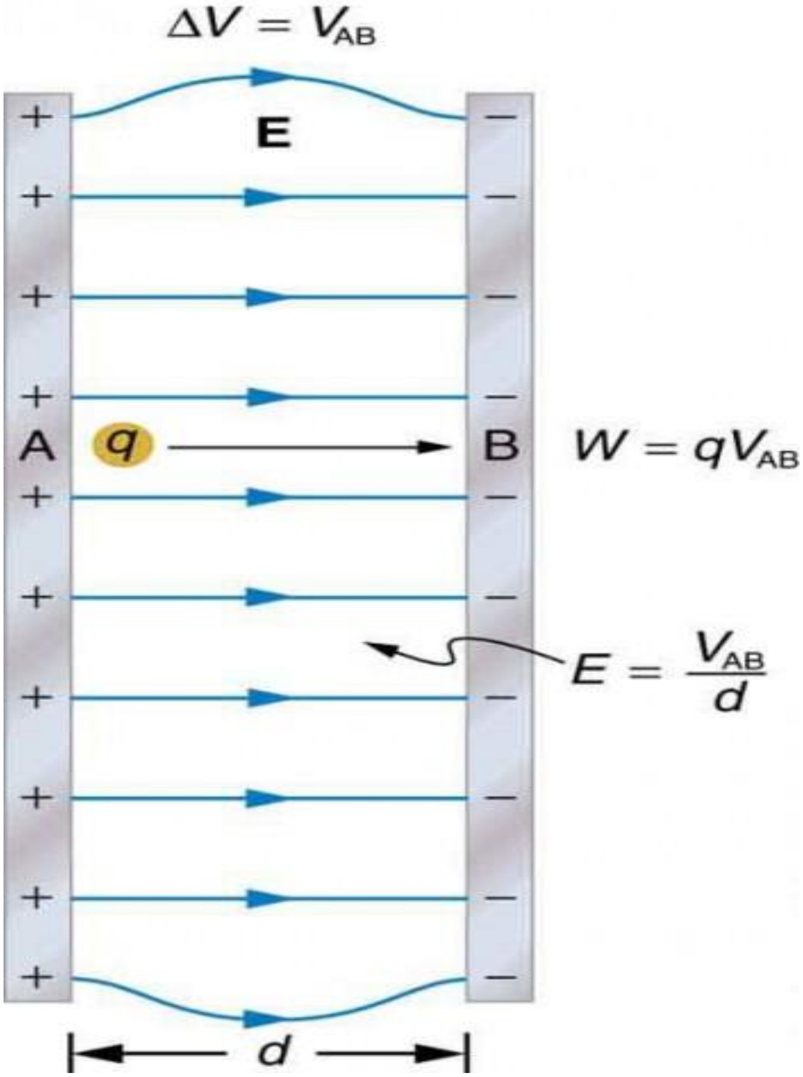
and is equal to Work done by an electric field in carrying a unit positive charge from infinity to that point.

Whereas electric potential;

It is a potential energy that results from conservative Coulomb force and is associated with the configuration of a particular set of point charges within a defined system. An object may have electric potential energy by virtue of two key elements: its own electric charge and its relative position to other electrically charged objects.

(b). How to find the potential difference between any two points in the electric field lines?

Ans). In a uniform electric field, the equation to calculate the electric potential difference is super easy: $V = Ed$. In this equation, V is the potential difference in volts, E is the electric field strength (in newton's per coulomb), and d is the distance between the two points (in meters).



The work done by the electric field in Figure 1 to move a positive charge q from A, the positive plate, higher potential, to B, the negative plate, lower potential, is

$W = -\Delta PE = -q\Delta V$.

The potential difference between points A and B is

$-\Delta V = -(V_B - V_A) = V_A - V_B = V_{AB}$.

Entering this into the expression for work yields $W = qV_{AB}$.

Work is $W = Fd \cos \theta$;

Here $\cos \theta = 1$,

Since the path is parallel to the field, and so $W = Fd$.

Since $F = qE$, we see that $W = qEd$

Substituting this expression for work into the previous equation gives;

$qEd = qV_{AB}$.

The charge cancels, and so the voltage between points A and B is seen to be
{VAB = EdE = VABd{VAB=EdE=VABd
(Uniform E − field only)

where d is the distance from A to B, or the distance between the plates in Figure 1. Note that the above equation implies the units for electric field are volts per meter. We already know the units for electric field are newtons per coulomb; thus, the following relation among units is valid: 1 N/C = 1 V/m.