SELF ASSESSMENT PAPER – 9

SOLUTIONS

I. Multiple Choice Questions **[1 × 4 = 4]**

1. Option (C) is correct.

Explanation: In an *n*-type silicon the holes are the minority carriers. An *n*-type semiconductor is obtained when pentavalent atoms, such as phosphorus, are doped in silicon atoms.

2. Option (D) is correct.

Explanation: In semiconductor, the density of charge carriers (electron, holes) are very small, so its resistance is high. When temperature increases, the charge carriers density increases which increases the conductivity. As temperature of semiconductor increases, the speed of free electrons increases which decreases the relaxation time. As the density of charge carrier is small, so there is small effect on decrease of relaxation time.

3. Option (C) is correct.

Explanation: The diffusion of charge carriers across a junction takes place from the regions of higher concentration to lower concentration. In this case, the *p*-region has greater concentration of holes than the *n*-region. Hence, in an unbiased *p*-*n* junction, holes diffuse from the *p*-region to the *n*-region.

4. Option (C) is correct.

Explanation: 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.

II. Assertion and Reason **[1 × 2 = 2]**

1. Option (C) is correct.

Explanation: Resistivity of semiconductors decreases with temperature. So, assertion is true. Electrons from valence band jumps to conduction band with rise of temperature and hence the resistivity decreases. Hence, the reason is false.

2. Option (A) is correct.

Explanation: When a diode is used as a rectifier, it has to face both positive and negative halves of the alternating voltage. Care is taken so that the amplitude of the negative half cycle of the alternating voltage should not be more than the specified reverse breakdown voltage of the diode. So the assertion is true. If reverse voltage exceeds this specified break down voltage, then the diode gets permanently damaged. So, the reason is also true and explains the assertion.

III. Competency Based Questions **[1 × 4 = 4]**

(i) Option (A) is correct.

Explanation: The donor concentration is high at *n* side and acceptor concentration is high at *p*-side. There is no acceptor concentration at *n*-side and no donor concentration at *p*-side.

(ii) Option (B) is correct

Explanation: The donor concentration is high at *n* side and acceptor concentration is high at *p*-side. There is no acceptor concentration at *n*-side and no donor concentration at *p*-side.

(iii) Option (A) is correct.

Explanation: In *p*-side there are only holes. There is no electron concentration. In n-side there are only electrons. There is no hole concentration. At depletion region, there is no charge carrier.

(iv) Option (A) is correct.

Explanation: After recombination of free electrons and holes, around the depletion region, there will be positively charged ions in the *n*-side and negatively charged ions in p-side.

(v) Option (D) is correct.

Explanation: In forward bias, applied voltage does not support potential barrier. As a result, the depletion layer width decreases In reverse bias, applied voltage supports potential barrier. As a result, depletion layer widens.

IV. Very Short Answer Type Question **[1 × 3 = 3]**

1. The main cause for the conduction of any semiconductor is the number of free electrons in it. The free electrons has the kinetic energy which depends upon the temperature. As the temperature is 0 K, the kinetic energy will be zero and the free electrons are not available for conduction.

2. In case of semiconductors, Ohm's law is obeyed for low electric fields i.e., E is less than $10^6 \frac{V}{m}$. If the field is increased above this value, the current becomes independent of the voltage applied.

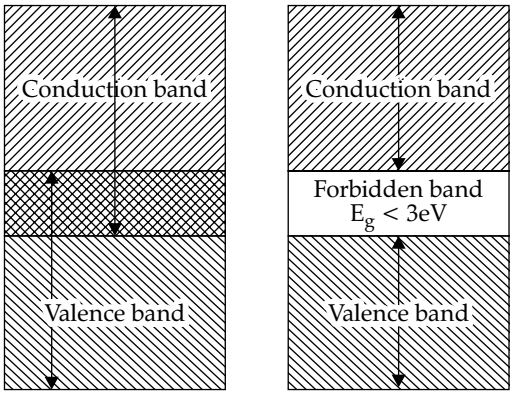
3. No, a *p*-type semi-conductor slab cannot be physically joined with a *n*-type semi-conductor slab to produce a *p*-*n* junction. If we physically join the two semi-conductor blocks, there will always be little microscopic gap between the slabs due to roughness of the surfaces.

V. Short Answer Type Question-I **[2 × 3 = 6]**

1. (a) Formation of energy bands in solid: An isolated atom possesses discrete energies of different electrons. When two isolated atoms are brought very close to each other, the electrons in the orbits of two atoms interact with each other and the energies of electrons do not remain in same level but changes from its original value. So, at the place of each energy level, a closely spaced two energy levels are created.

When large number of atoms are brought together to form a solid by interaction of electrons, a large number of closely spaced energy levels is created. These are known as bands of allowed energies. Between the bands of allowed energies, there are empty energy regions also, known as forbidden band of energies.

(i)

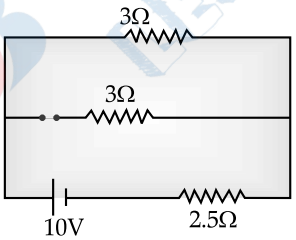


(Metal) (Semiconductor)

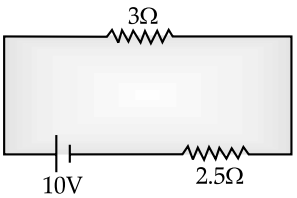
2.

Intrinsic	Extrinsic
(i) Pure semiconductor.	(i) Doped or impure.
(ii) $n_e = n_h$.	(ii) $n_e \neq n_h$.
(iii) Low conductivity at room temperature.	(iii) Higher conductivity at room temperature.
(iv) Conductivity depends on temperature.	(iv) Conductivity does not depend significantly on temperature.

3. In the circuit, if D_1 is open and D_2 is short, then equivalent circuit will result as:



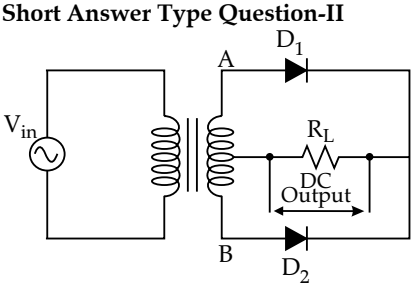
The final equivalent circuit becomes



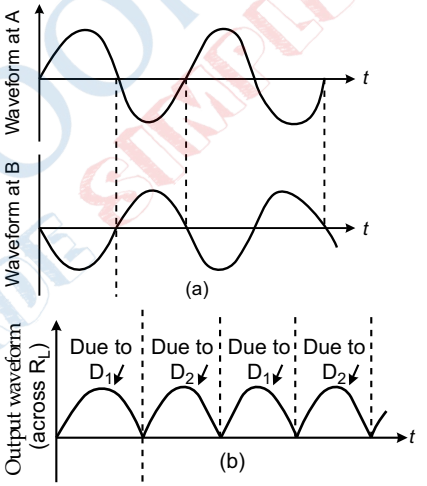
So, $$I = \frac{10}{3+2.5} = \frac{10}{5.5} = 1.8A$$

VI. Short Answer Type Question-II [3 × 2 = 6]

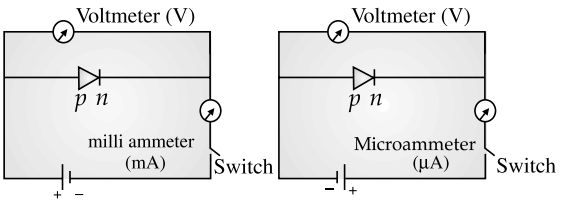
1.



Working: The diode D_1 is forward biased during positive half cycle and current flows through the resistor, but diode D_2 is reverse biased and hence no current flows through it. During the negative half cycle, D_1 gets reverse biased and no current passes through it, D_2 gets forward biased and current flows through it. In both half cycles current through the resistor, flows in the same direction.



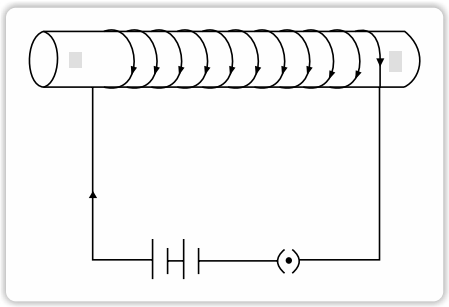
2.



In forward bias, applied voltage does not support potential barrier. As a result, the depletion layer shrinks and barrier height is reduced. Due to the applied voltage, electrons from *n* side cross the depletion region and reach *p* side. Similarly holes from *p* side cross the junction and reach the *n* side. The motion of charge carriers, on either side, give rise to current.

In reverse bias, applied voltage supports potential barrier. As a result, barrier height is increased, depletion layer widens. This suppresses the flow of electrons from n → *p* and holes from *p* → *n*, thereby decreases the diffusion current. The electric field direction of the junction is such that if electrons on *p* side or holes on *n* side in their random motion comes close to the junction, they swept to its majority zone. This drift of carriers give rise to the current called reverse current.

V–I Characteristics:



VII. Long Answer Type Question **[1 × 5 = 5]**

1. (a) Bulb B_1 glows since diode D_1 is forward biased.
(b) R would be increased.

Resistance of S (a semiconductor) decreases on heating.

(c) The two processes involved are:

Diffusion: It is the process of movement of majority charge carriers from their majority zone (*i.e.*, electrons from $n \rightarrow p$ and holes from $p \rightarrow n$) due to the electric field developed at the junction.

Drift: Process of movement of minority charge carriers (*i.e.*, holes from $n \rightarrow p$ and electrons from $p \rightarrow n$) due to the electric field developed at the junction.

Barrier potential: The loss of electrons from the *n*-region and gain of electrons by *p*-region causes a difference of potential across the junction, whose polarity is such as to oppose and then stop the further flow of charge carriers. This (stopping) potential is called Barrier potential.

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