EXAM DRILL

CHAPTER
14

Semiconductor Electronics : Materials, Devices and Simple Circuits

ANSWERS

1. **(d) :** In a good conductor of electricity the type of bonding that exist is metallic.

2. **(c) :** If a small amount of antimony is added to germanium crystal there will be more free electron than holes in the semiconductor.

3. **(c) :** Region without free electrons and holes in a p-n junction is depletion layer.

4. **(b) :** Potential barrier developed in a junction diode oppose the flow of majority carrier only.

5. **(b) :** In a half wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be 50 Hz.

6. **(b) :** If in a n-type semiconductor when all donor states are filled, then the net charge density in the donor states becomes greater than 1.

7. **(a)**

8. **(b) :** The manifestation of band structure in solids is due to Paul's exclusion principle.

9. **(c) :** At absolute zero temperature, Si acts as an insulator.

10. **(b) :** A reverse bias on a *p-n* junction opposes the movement of the majority charge carriers thus stopping the diffusion current. It makes the free electrons and holes to drift cross the junction. Therefore a small current in μA flows even when the p-n junction is reverse biased. The drift current is due to the thermal excitations of the electrons and holes.

OR

(c) : A small increase in forward voltage across *p-n* junction shows large increase in forward current. Hence the resistance (= voltage / current) of *p-n* junction is low when forward biased. Also the width of depletion layer of *p-n* junction decreases in forward bias.

A large increase in reverse voltage across p-n shows small increase in reverse current. Hence the resistance of p-n junction is high when reverse biased. Also the width of the depletion layer of p-n junction increases in reverse biased.

11. **(d) :** In p-n junction, the diffusion of majority carriers takes place when junction is forward biased and drifting of minority carriers takes place across the junction, when reverse biased. The reverse bias opposes the majority carriers but makes the minority carriers to cross the p-n junction. Thus the small current in μA flows during reverse bias.

12. **(i) (c) :** Electron concentration in n-region is more as compared to that in p-region. So electrons diffuse from n-side to p-side.

(ii) (a) : When an electron and a hole recombine, the energy is released in the form of light.

(iii) (a) : In an unbiased p-n junction, potential at p is equal to that at n.

(iv) (c) : The potential of depletion layer is due to ions.

(v) (a) : In the depletion layer of unbiased p-n, junction has no charge carriers.

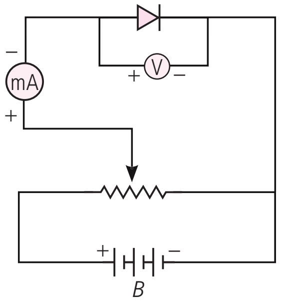
13. Hole is a vacancy of electron in valence band. The vacancy of the hole behaves as an apparent free particle with effective positive charge.

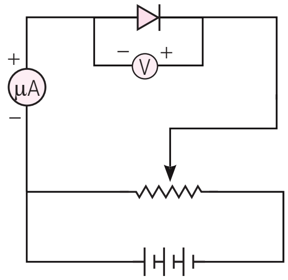
14. Dynamic resistance is the ratio of a small change in voltage ΔV to a small change in current ΔI *i.e.*, $r_d = \frac{\Delta V}{\Delta I}$.

15.

Forward bias	Reverse bias
Positive terminal of battery is connected to p-type and negative terminal to n-type semiconductor	Positive terminal of battery connected to n-type and negative terminal to p-type semiconductor.
Depletion layer is very thin P-N junction offers very low resistance.	Depletion layer is thick P-N junction offers very high resistance.

16. Circuit diagram of forward biased and reverse biased p-n junction diode shown





The width of depletion layer

(i) decreases in forward bias

(ii) increases in reverse bias.

OR

Intrinsic semiconductors : Pure semiconductors are called intrinsic semiconductors. Example, germanium and silicon. The number of electrons and holes are equal in it.

Extrinsic semiconductors : The semiconductors containing impurities of pentavalent or trivalent substance are called extrinsic semiconductors. The electrons density is not equal to hole density.

17. (i) Covalent bond consist of mutual sharing of one or more electron pair between the two atoms.

(ii) The dynamic resistance can be defined from the I-V characteristic of a diode in forward bias. It is defined as the ratio of a small current change in current.

(iii) Breakdown voltage is a parameter of a diode that defines the largest reverse voltage that can be applied without causing an exponential increase in leakage current.

(iv) The potential difference required to more the electrons through the electric field.

18. When p-type semiconductor is joined with n-type semiconductor by some special technique as etching or sand witching, then the junction forward is called p-n diode. It works similar to that of diode value. Hence, it is called p-n junction diode. When p-n junction diode is made, free electrons present in n-type from p-type. Thus, a thin film (less than 10^{-3} cm) at the junction becomes free from holes and electrons. This thin film is called depletion layer.

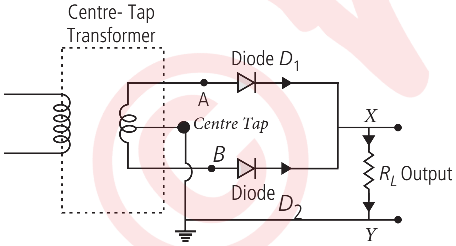
OR

(1) Uncovered charge: The positive immobile ions present on the n-region and negative immobile ions present in p-region near the junction are called uncovered charge.

(2) Depletion layer : The layer on either side of p-n junction which does not contain any charge carrier (neither positive charge carrier nor negative charge carrier) is called depletion layer.

(3) Potential barrier : The potential difference developed across the depletion layer is called the potential barrier.

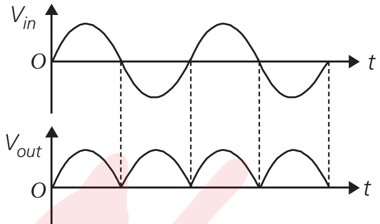
19. Two p-n junction diodes can be used to make full wave rectifier which is used to convert alternating current into direct current.



A full wave rectifier consists of two diodes connected in parallel across the ends of secondary winding of a center tapped step down transformer. The load resistance R_L is connected across secondary winding and the diodes between A and B as shown in the circuit.

During positive half cycle of input a.c., end A of the secondary winding becomes positive and end B negative. Thus diode D_1 becomes forward biased, whereas diode D_2 reverse biased. So diode D_1 allows the current to flow through it, while diode D_2 does not, and current in the circuit flows from D_1 and through load R_L from X to Y.

During negative half cycle of input a.c., end A of the secondary winding becomes negative and end B positive, thus diode D_1 becomes reverse biased, whereas diode D_2 forward biased. So diode D_1 does not allow the current to flow through it but diode D_2 does, and current in the circuit flows from D_2 and through load R_L from X to Y.



Input-Output waveforms

Since in both the half cycles of input a.c., electric current through load R_L flows in the same direction, so d.c. is obtained across R_L. Although direction of electric current through R_L remains same, but its magnitude changes with time, so it is called pulsating d.c.

OR

(a) The four valence electrons of carbon are present in second orbit while that of silicon in third orbit. So energy required to excite a electron from silicon is much smaller than carbon. Therefore, the number of free electrons for conduction in silicon is significant of carbon This makes silicon conductivity much higher than carbon this is main distinguished property.

(b) The process of introducing the impurity in a pure semiconductor is called doping. For n-type and p-type semiconductors doping is necessary to increase the conductivity of material.

20. (a) The electrical conductivity of germanium is

$$\sigma = e[n_e\mu_e + n_h\mu_h]$$

Here, $\mu_e = 0.36\ \text{m}^2\ \text{V}^{-1}\ \text{s}^{-1}$, $\mu_h = 0.17\ \text{m}^2\ \text{V}^{-1}\ \text{s}^{-1}$,

$$n_e = n_h = 2.5 \times 10^{19}\ \text{m}^{-3}$$

$$\therefore \quad \sigma = (1.6 \times 10^{-19}\ \text{C})[(2.5 \times 10^{19}\ \text{m}^{-3})(0.36\ \text{m}^2\ \text{V}^{-1}\ \text{s}^{-1}) + (2.5 \times 10^{19}\ \text{m}^{-3})\,(0.17\ \text{m}^2\ \text{V}^{-1}\ \text{s}^{-1})] = 2.12\ \text{S m}^{-1}$$

(b) Here, $\rho = 0.50\ \Omega$ m, $\mu_e = 0.39\ \text{m}^2/\text{V s}$,

$$\mu_h = 0.11\ \text{m}^2/\text{V s}$$

The resistivity of intrinsic semiconductor is

$$\rho = \frac{1}{en_i(\mu_e + \mu_h)} \Rightarrow n_i = \frac{1}{\rho e(\mu_e + \mu_h)}$$

Substituting the given values, we get

$$n_i = \frac{1}{(0.5)(1.6 \times 10^{-19})(0.39 + 0.11)} = 2.5 \times 10^{19}/\text{m}^3$$

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