MADE EASY PUBLICATIONS

POSTAL BOOK PACKAGE 2025

CONTENTS

ELECTRONICS ENGINEERING

Objective Practice Sets

Electronic Devices and Circuits

1 CHAPTER Semiconductor Physics

MCQ and NAT Questions

Q.1 A conductor carries a current of 4 A and if magnitude of charge of an electron e = 1.6×10^{-19} Coulomb, then the number of electrons which flow past the cross-section per second is

(a) 2.5×10^{19} (b) 1.6×10^{19}
(c) 6.4×10^{19} (d) 0.4×10^{19}

Q.2 Long wavelength threshold for Si at room temperature is

(a) 1.13 mm (b) 1.73 mm
(c) 1 mm (d) 1.21 mm

Q.3 Given that the band gap of cadmium sulphide is 2.5 eV, the maximum photon wavelength, for electron-hole pair generation will be

(a) 4968 μm (b) 496 μm
(c) 4968 Å (d) 496 Å

Q.4 Doping of semiconductors is

(a) the process of purifying semiconductor materials
(b) the process of adding certain impurities to the semiconductor material
(c) the process of converting a pure semiconductor material into some form of an active device like diode, transistor, FET etc.
(d) one of the processes used in the fabrication of ICs

Q.5 The conductivity of a semiconductor crystal due to any current carrier is NOT proportional to

(a) mobility of the carrier
(b) effective density of states in the conduction band
(c) electronic charge
(d) surface states in the semiconductor

Q.6 Consider the following statements for an *n*-type semiconductor:

1. Donor level ionization decreases with temperature
2. Donor level ionization increases with temperature.
3. Donor level ionization in independent of temperature.
4. Donor level ionization increases as E_D (donor energy) moves towards the conduction band at a given temperature.

Which of these statement(s) is/are correct?

(a) 1 only (b) 2 only
(c) 2 and 4 (d) 3 only

Q.7 Electron mobility and life-time in a semiconductor at room temperature are respectively 0.36 m^2/(V-s) and 340 μs. The diffusion length is

(a) 3.13 mm (b) 1.77 mm
(c) 3.55 mm (d) 3.13 cm

Q.8 The ratio of minority to majority diffusion coefficient D_p / D_n for germanium is approximately

(a) 2 (b) 0.5
(c) 3 (d) 0.33

Q.9 The concentration of minority carriers in an extrinsic semiconductor under equilibrium is

(a) directly proportional to the doping concentration
(b) inversely proportional to the doping concentration
(c) directly proportional to the intrinsic concentration
(d) inversely proportional to the intrinsic concentration

Q.10 The bonding forces in compound semiconductor, such as GaAs, arises from

(a) Ionic bonding
(b) Metallic bonding
(c) Covalent bonding
(d) Combination of ionic and covalent bonding

Q.11 Mobility μ varies as T^{-m} over a temperature range of 100 to 400° k. For silicon, m = ____ for holes.

(a) 2.5 (b) 2.7
(c) 1.66 (d) 2.33

Q.12 The ratio of mobility to the diffusion coefficient in a S.C. has the unit
(a) V^{-1} (b) cm – V^{-1}
(c) V – cm^{-1} (d) V - sec

Q.13 **Assertion (A):** Gallium arsenide is a direct band semiconductor having faster switching capabilities and high temperature operating capabilities.
Reason (R): A substance for which the width of the forbidden energy region is relatively small is called a semiconductor.
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

Q.14 The intrinsic carrier concentration of silicon sample at 300 K is 1.5×10^{16}/m^3. If after doping, the number of majority carriers is 5×10^{20}/m^3, the minority carrier density is
(a) 4.50×10^{11}/m^3 (b) 3.33×10^{4}/m^3
(c) 5.00×10^{20}/m^3 (d) 3.00×10^{-5}/m^3

Q.15 Consider the following statements:
Impurity diffusion is used in semiconductor to control the conductivity. The nature of the impurity profile should be such that the
1. impurity concentration decreases with diffusion depth.
2. profile results in an internal electric field.
3. impurity concentration is homogeneous with no internal electric field.

Which of these statements are correct?
(a) 1, 2 and 3 (b) 1 and 3
(c) 2 and 3 (d) 1 and 2

Q.16 The drift velocity of electrons in silicon varies with applied electric field in which one of the ways?
(a) It monotonically increases with increasing field
(b) It first increases linearly, then sub linearly increases and finally attains saturation with increasing field
(c) It first increases, then decreases showing a negative differential region, again increases and finally saturates
(d) The drift velocity remains unchanged with increase in field

Q.17 In degenerately doped *n*-type semiconductor, the Fermi level lies in conduction band when
(a) concentration of electrons in the conduction band exceeds the density of states in the valence band.
(b) concentration of electrons in the valence band exceeds the density of states in the conduction field.
(c) concentration of electrons in the conduction band exceeds the product of the density of states in the valence band and conduction band.
(d) None of the above

Q.18 A Ge sample at room temperature has intrinsic carrier concentration $n_i = 1.5 \times 10^{13}$ cm^{-3} and is uniformly doped with acceptor of 3×10^{16} cm^{-3} and donor of 2.5×10^{15} cm^{-3}. Then, the minority charge carrier concentration is
(a) 0.918×10^{10} cm^{-3} (b) 0.818×10^{10} cm^{-3}
(c) 0.918×10^{12} cm^{-3} (d) 0.818×10^{12} cm^{-3}

Q.19 **Assertion (A):** At low temperature, the conductivity of a semiconductor increases with increase in the temperature.
Reason (R): The breaking of the covalent bonds increases with increase in the temperature, generating increasing number of electrons and holes.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.20 The electrical resistivity of sodium silicate glass is 10^5 Ωm whereas that of pure silicate glass is 10^{17} Ωm. This vast difference of 12 orders of magnitude is due to which one of the following reasons?
(a) The loosely-bound sodium ions in the silicate
(b) The impurities in silica
(c) The difference in the crystal structures
(d) The presence of free electrons in the silicate

Q.21 In an *n*-type Si sample, the drift velocity of electrons is 50 m/s. Then the time taken for the electrons to travel 20 μm distance in the Si sample is equal to
(a) 0.4 μs (b) 0.8 μs
(c) 2 μs (d) 4 μs

Answers Semiconductor Physics

1. (a)	2. (a)	3. (c)	4. (b)	5. (d)	6. (c)	7. (b)
8. (b)	9. (b)	10. (c)	11. (b)	12. (a)	13. (b)	14. (a)
15. (d)	16. (b)	17. (b)	18. (b)	19. (a)	20. (b)	21. (a)
22. (b)	23. (d)	24. (a)	25. (b)	26. (b)	27. (c)	28. (c)
29. (a)	30. (b)	31. (b)	32. (c)	33. (a)	34. (b)	35. (d)
36. (d)	37. (a)	38. (b)	39. (c)	40. (b)	41. (c)	42. (b)
43. (a)	44. (a)	45. (d)	46. (b)	47. (a)	48. (b)	49. (d)
50. (c)	51. (c)	52. (d)	53. (b)	54. (d)	55. (c)	56. (b)
57. (c)	58. (c)	59. (d)	60. (d)	61. (225.2)	62. (0.52)	63. (16.25)
64. (134)	65. (b, c)	66. (a, b, d)	67. (a, c)	68. (b, d)	69. (a, c, d)	70. (b, c)
71. (a, b)	72. (a, c)	73. (b, d)	74. (b, c)	75. (a, c, d)	76. (a, c)	

Explanations Semiconductor Physics

1. (a)

$$I = ne \text{ C/sec}$$

$$\Rightarrow \quad n = \frac{I}{e} = \frac{4}{1.6\times10^{-19}} = 2.5\times10^{19}/\text{sec}$$

2. (a)

$$E = \frac{1.24}{\lambda_g(\text{in }\mu\text{m})}\text{eV}$$

$$\therefore \quad \lambda = \frac{1.24}{E}$$

for $E = 1.1$ eV at room temperature

$$= \frac{1.24}{1.1} = 1.127\ \mu\text{m}$$

3. (c)

$$\lambda = \frac{hc}{E_g} = \frac{1.242 \text{ eV-}\mu\text{m}}{2.5 \text{ eV}} = 0.4968\ \mu\text{m} = 4968\ \text{Å}$$

4. (b)

Doping is process of adding impurities to the pure sc. It increases carrier concentration and therefore increases the conductivity.

5. (d)

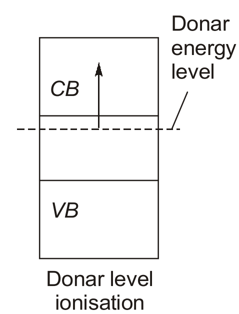
Conductivity, $\sigma = nq\mu_n$

μ_n : mobility of carrier

q : electron charge

n : effective density of states in conduction band

6. (c)



Donor energy level is a discrete energy level and is created just below the conduction band.

Donor energy level represents the energy level of all pentavalent atoms added to the pure *sc*.

Donor level ionisation increases with temperature. It also increases if donar energy increases.

Generally, $E_D = 0.01$ eV for Ge

$= 0.05$ eV for si

7. (b)

$$L_n = \sqrt{D_n\tau_n} \quad ; \quad \frac{D_n}{\mu_n} = V_T$$

$$\therefore \quad D_n = \mu_n V_T = 0.36\times0.025$$

$$L_n = \sqrt{0.36\times0.025\times340\times10^{-6}} = 1.77 \text{ mm}$$

8. (b)

Since $\frac{D}{\mu}$ α constant

$\therefore D \propto \mu$

For Ge $\frac{D_p}{D_n} \propto \frac{\mu_p}{\mu_n} = \frac{1800}{3800} \simeq 0.5$

9. (b)

According to mass action law

$$np = n_i^2$$

$\therefore$ minority carrier conc. $= \dfrac{n_i^2}{\text{Majority carrier conc.}}$

$$\propto \frac{1}{\text{Majority carrier conc.}}$$

10. (c)

The bonding in GaAs is covalent bonding.

11. (b)

For Ge: $m = 1.66$ for e^- $\quad m = 2.33$ for holes

For Si: $m = 2.5$ for e^- $\quad m = 2.7$ for holes

12. (a)

Einstein equation,

$$\frac{D}{\mu} = V_T$$

$$\Rightarrow \quad \frac{\mu}{D} = \frac{1}{V_T} = (\text{volt})^{-1}$$

13. (b)

- Both assertion and reason are correct statements. However, the reason for *GaAs* to have faster switching capability is due to its higher electron mobility (μ_n). The operating temperature of *GaAs* is higher (> 200°C) compared to *Ge* and *Si*.
- A semiconductor has the small width of the forbidden energy region i.e. around 1 eV.

14. (a)

$$np = n_i^2$$

$$\therefore \quad p = \frac{n_i^2}{n} = \frac{(1.5\times10^{16})^2}{5\times10^{20}} = 4.5\times10^{11}/\text{m}^3$$

15. (d)

The impurity concentration is non-homogeneous in diffusion. The diffusion hole-current density J_p is proportional to the concentration gradient, and is given by

$$J_p = -qD_p\frac{dp}{dx}$$

where D_p is called the diffusion constant for holes. A similar equation exists for diffusion electron-current density.

16. (b)

$$v_d = \mu E$$

The mobility is a function of electric field intensity as given below:

μ = constant $\quad$ if $E < 10^3$ V/cm

$\mu \propto E^{-1/2}$ $\quad$ if $10^3 < E < 10^4$ V/cm

$\mu \propto E^{-1}$ $\quad$ if $E > 10^4$ V/cm

For higher fields, the carrier speed approaches the constant value of 10^7 cm/s.

17. (b)

For a degenerated n type semiconductor

$$E_C - E_F = kT\,ln\left(\frac{N_C}{N_D}\right)$$

for degenerated semiconductor

$$\frac{N_C}{N_D} << 1$$

where, N_C = density of states in conduction band

N_D = Concentration of electrons in valance band

18. (b)

P type compensated semiconductor

Minority carrier concentration

$$= \frac{n_i^2}{N_A - N_D} = \frac{(1.5\times10^{13})^2}{(3\times10^{16} - 2.5\times10^{15})}$$

$$= \frac{(1.5\times10^{13})^2}{2.75\times10^{16}} = 0.81818\times10^{10}/\text{cm}^3$$

19. (a)

Reason is correct explanation of assertion.

20. (b)

On doping impurities in the pure semiconductor, the resistivity decreases very rapidly.

21. (a)

Given: Drift velocity, v_d = 50 m/sec and Length, L = 20 μm

Time taken to travel 20 μm distance,

$$t = \frac{L}{v_d} = \frac{20}{50} = 0.4\ \mu\text{s}$$

22. (b)

$$E = \phi + \frac{1}{2}mv^2 = \frac{1.24}{0.5893} = 2.1\text{ eV} \qquad (\phi = 1.8\text{ eV})$$

$$\therefore \quad \frac{1}{2}mv^2 = 0.3\text{ eV}$$

$$v = \sqrt{\frac{0.3\times2\times1.6\times10^{-19}}{9.1\times10^{-31}}} = 3.25\times10^5\text{ m/sec}$$