MADE EASY PUBLICATIONS

POSTAL BOOK PACKAGE 2024

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 $e = 1.6 \times 10^{-19}$ 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 A semiconductor material with impurities added is

(a) an extrinsic semiconductor
(b) an intrinsic semiconductor
(c) an *N*-type semiconductor
(d) a *P*-type semiconductor

Q.6 Boron and Indium are two commonly used trivalent impurities used for doping of semiconductors. Another is

(a) Arsenic (b) Phosphorus
(c) Aluminium (d) none of these

Q.7 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.8 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.9 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.10 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.11 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.12 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.13 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.14 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.15 **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.16 In an n-type silicon, mobility is found to be a function of electric field intensity. If electric field intensity (E) applied is in the range:
R_1 : 500 V/cm – 883 V/cm and
R_2 : 500 V/cm – 8830 V/cm,
then for the above ranges R_1 and R_2, the mobility varies as
(a) constant, constant (b) $E^{-1/2}$, E^{-1}
(c) E^{-1}, $E^{-1/2}$ (d) constant, $E^{-1/2}$

Q.17 The intrinsic carrier concentration of silicon sample at 300 K is $1.5 \times 10^{16}/m^3$. If after doping, the number of majority carriers is $5 \times 10^{20}/m^3$, the minority carrier density is
(a) $4.50 \times 10^{11}/m^3$ (b) $3.33 \times 10^{4}/m^3$
(c) $5.00 \times 10^{20}/m^3$ (d) $3.00 \times 10^{-5}/m^3$

Q.18 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.19 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.20 The number of holes in an N-type silicon with intrinsic value $1.5 \times 10^{10}/cm^3$ and doping concentration of $10^{17}/cm^3$, by using mass-action law is
(a) 6.67×10^{6}/cc (b) 4.44×10^{-25}/cc
(c) 1.5×10^{-24}/cc (d) 2.25×10^{3}/cc

Q.21 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.22 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.23 **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.24 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.25 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

Q.26 Find the maximum speed with which the photoelectrons will be emitted when the radiation of wavelength 5893 A° falls upon a caesium surface with work function of 1.8 eV.

(a) 1.8×10^5 m/s (b) 3.27×10^5 m/s
(c) 1.34×10^5 m/s (d) 3.24×10^5 m/s

Q.27 An *n*-type semiconductor has a conductivity of 2 $(\Omega\text{-cm})^{-1}$. If the dielectric constant of the semiconductor is $\varepsilon_{si} = 1.03 \times 10^{-12}$ F/cm, then the value of dielectric relaxation time constant is equal to

(a) 2.06 ps (b) 1.61 ps
(c) 0.10 ps (d) 0.515 ps

Q.28 In a degenerate semiconductor, the majority carriers are controlled by

(a) Fermi-Dirac statistics
(b) Maxwell-Boltzmann statistics
(c) Bose-Einstein (B-E) statistics
(d) Pauli's exclusion principle

Q.29 Consider the following statements for an n-type semiconductor:

1. E_F lies below E_D at a room temperature (T).
2. E_F lies above E_D as $T \to 0$
3. $E_F = E_D$ at some intermediate temperature
4. E_F is invariant with temperature.

Where E_F is Fermi energy and E_D is donor level energy. Which of these statement(s) is/are correct?

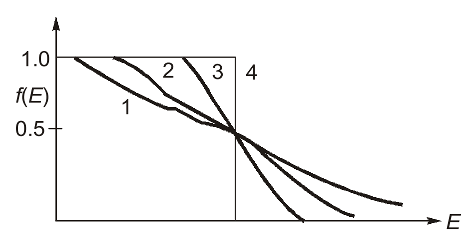
(a) 1 and 2 (b) 2 and 3
(c) 4 only (d) 1, 2 and 3

Q.30 Diffusion current of holes in S.C. is proportional to

(a) $\frac{d^2P}{dn^2}$ (b) $\frac{dP}{dn}$
(c) $\frac{dP}{dt}$ (d) $\frac{d^2P}{dx^2}$

Where, P = conc. of holes per unit volume.

Q.31 Fermi Dirac distribution function is plotted for four different temperatures (T) as curves labelled 1 to 4.



Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I		List-II	
A.	0 K	**1.**	Curve-1
B.	50 K	**2.**	Curve-2
C.	300 K	**3.**	Curve-3
D.	400 K	**4.**	Curve-4

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	3	4	2
(c)	4	3	2	1
(d)	4	1	2	3

Q.32 A long specimen of *p*-type semiconductor material

(a) is positively charged
(b) is electrically neutral
(c) has an electric field directed along its length
(d) acts as a dipole

Q.33 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.34 The position of the intrinsic Fermi level of an undoped semiconductor (E_{Fi}) is given by
(a) $\frac{E_C - E_V}{2} + \frac{kT}{2} ln \frac{N_V}{N_C}$
(b) $\frac{E_C + E_V}{2} - \frac{kT}{2} ln \frac{N_V}{N_C}$
(c) $\frac{E_C + E_V}{2} + \frac{kT}{2} ln \frac{N_V}{N_C}$
(d) $\frac{E_C - E_V}{2} - \frac{kT}{2} ln \frac{N_V}{N_C}$

Q.35 The probability that an electron in a metal occupies the fermi level at any temperature (> 0°K).
(a) 0
(b) 1
(c) 0.5
(d) 0.1

Q.36 The resistivity at room temperature of intrinsic silicon is 2.3×10^3 Ω m and that of an *n*-type extrinsic silicon sample is 8.33×10^{-2} Ωm. A bar of this extrinsic silicon sample is 3 mm long and has a rectangular cross-section 50 × 100 mm and a steady current of 1 μA exists in the bar. The voltage across the bar is found to be 50 mV. If the same bar is of intrinsic silicon, the voltage across the bar will be about
(a) 1400 V
(b) 140 V
(c) 14 V
(d) 1.4 V

Q.37 Match **List-I** (Material) with **List-II** (Energy Level) and select the correct answer using the code given below the lists:

List-I
A. *p*-type semiconductor at 0° K
B. Intrinsic semiconductor at 0° K temperature
C. *n*-type semiconductor at room temperature
D. *p*-type semiconductor at room temperature

List-II
1. Donor energy level is closed to the conduction band
2. Acceptor energy level is closed to the valence band
3. Fermi-level is very closed to valence band
4. Fermi-level is half-way between the valence band and the conduction band

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	1	2
(c)	1	4	3	2
(d)	3	2	1	4

Q.38 The free electron density in a conductor is $(1/1.6) \times 10^{22}$ cm^{-3}. The electron mobility is 10 cm^2/Vs. What is the value of its resistivity?
(a) 10^{-4} Ω m
(b) 1.6×10^{-2} Ω m
(c) 10^{-4} Ω cm
(d) 10^4 mho cm^{-1}

Q.39 **Assertion (A) :** The semiconductor devices like BJTs have a maximum temperature of operation beyond which they do not function.
Reason (R) : Extrinsic, *p*-type and *n*-type semiconductors behave as intrinsic beyond that temperature and the effect of doping is lost.
(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 a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.40 Consider the following statements:
The conductivity of a metal has negative temperature coefficient since:
1. The electron concentration increases with temperature.
2. The electron mobility decreases with temperature.
3. The electron-lattice scattering rate increases with temperature.

Which of the above statements is/are correct?
(a) 1 only
(b) 1 and 2
(c) 2 and 3
(d) 3 only

Q.41 In an *n*-type Si sample, the concentration of electrons varies linearly from (10^{18} to 7×10^{17}) cm^{-3} over a distance of 0.1 cm and diffusion coefficient of electrons is D_n = 225 cm^2/s. Then the electron diffusion current density is equal to
(a) 108 A/cm^2
(b) 110 A/cm^2
(c) 210 A/cm^2
(d) 228 A/cm^2

Which of the below statement(s) is/are correct?
(a) The electron mobility is 2000 cm^2/V-s.
(b) Drift velocity is in the linear region for given supply voltage.
(c) The current flowing through the circuit is 16 μA.
(d) The electric field across the semiconductor bar is 2×10^5 V/cm.

Q.107 A semiconductor has following parameters : $\mu_n = 7500\ cm^2/V\text{-}s$, $\mu_p = 300\ cm^2/V\text{-}s$ and $n_i = 3.6 \times 10^{12}\ cm^{-3}$. Which of the following statements is/are correct?
(a) When conductivity is minimum, the hole concentration is $1.8 \times 10^{13}\ cm^{-3}$.
(b) When conductivity is maximum, the electron concentration is $1.8 \times 10^{13}\ cm^{-3}$.
(c) The minimum conductivity of semiconductor is 1.7 mS.
(d) The semiconductor has minimum conductivity when it has a acceptor doping more than donor doping.

Q.108 Which of the below statement(s) is/are correct?
(a) When GaAs is doped with Magnesium, it becomes a *p*-type semiconductor.
(b) When GaAs is doped with Si, it becomes a *n*-type semiconductor.
(c) GaAs has higher electron mobility than Si.
(d) GaAs have very narrow band gap compared to Si.

■■■■

Answers — Semiconductor Physics

1. (a)	2. (a)	3. (c)	4. (b)	5. (a)	6. (c)	7. (d)
8. (c)	9. (b)	10. (b)	11. (b)	12. (c)	13. (b)	14. (a)
15. (b)	16. (d)	17. (a)	18. (d)	19. (b)	20. (d)	21. (b)
22. (b)	23. (a)	24. (b)	25. (a)	26. (b)	27. (d)	28. (a)
29. (d)	30. (b)	31. (c)	32. (b)	33. (d)	34. (c)	35. (c)
36. (a)	37. (b)	38. (c)	39. (b)	40. (c)	41. (a)	42. (b)
43. (d)	44. (d)	45. (a)	46. (b)	47. (c)	48. (d)	49. (b)
50. (c)	51. (b)	52. (a)	53. (a)	54. (d)	55. (b)	56. (c)
57. (a)	58. (b)	59. (d)	60. (b)	61. (c)	62. (c)	63. (c)
64. (d)	65. (b)	66. (d)	67. (a)	68. (c)	69. (b)	70. (a)
71. (c)	72. (c)	73. (d)	74. (b)	75. (d)	76. (13)	77. (1.12)
78. (225.2)	79. (0.52)	80. (1.92)	81. (14)	82. (100)	83. (0.27)	84. (500)
85. (500)	86. (16.25)	87. (0.318)	88. (–0.262)	89. (134)	90. (1.048)	91. (1.627)
92. (1.198)	93. (16)	94. (1.6)	95. (0.81)	96. (3.87)	97. (b, c)	98. (a, b, d)
99. (a, c)	100. (b, d)	101. (a, c, d)	102. (b, c)	103. (a, b)	104. (a, c)	105. (b, d)
106. (b, c)	107. (a, c, d)	108. (a, c)				

Explanations **Semiconductor Physics**

1. (a)

$$I = ne$$

$$\Rightarrow \quad n = \frac{I}{e} = \frac{4}{1.6\times10^{-19}} = 2.5 \times 10^{19}/\text{sec}$$

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. (a)

Semiconductor material with impurities is known as extrinsic semiconductor and without impurities (pure) - intrinsic.

6. (c)

Trivalent/Acceptor impurities - B, Al, Ga, In
Pentavalent / donor - P, As, Sb, Bi

7. (d)

Conductivity, $\sigma = nq\mu_n$

μ_n : mobility of carrier

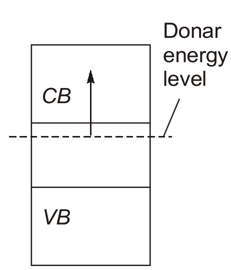
q : electron charge

n : effective density of states in conduction band

8. (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*.



Donar level ionisation

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

9. (b)

$$L_n = \sqrt{D_n\tau_n}$$

$$\frac{D_n}{\mu_n} = V_T$$

$$\therefore \quad D_n = \mu_n V_T = 0.36 \times 0.025$$

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

10. (b)

Since $\frac{D}{\mu}$ α constant

$\therefore$ D $\propto \mu$

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

11. (b)

According to mass action law

$$np = n_i^2$$

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

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

12. (c)

The bonding in GaAs is covalent bonding.

13. (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

14. (a)

Einstein equation,

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

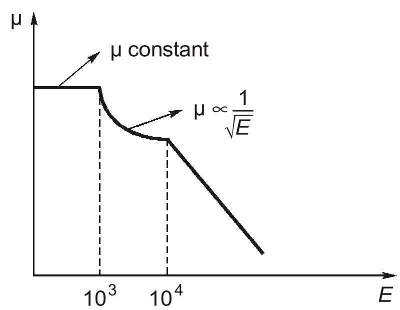
$$\Rightarrow \quad \frac{\mu}{D} = \frac{1}{V_T} = (\text{volt})^{-1}$$

15. (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.

16. (d)

μ vs *E* graph:



17. (a)

$$np = n_i^2$$

$$\therefore \quad p = \frac{n_i^2}{n} = \frac{(1.5\times10^{16})^2}{5\times10^{20}}$$

$$= 4.5 \times 10^{11}/\text{m}^3$$

18. (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.

19. (b)

$$v_d = \mu E$$

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

μ = constant if $E < 10^3$ V/cm

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

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

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

20. (d)

$$n_i = 1.5 \times 10^{10}\ /\ \text{cc}$$

$$N_D = 10^{17}\ /\text{cc}$$

By mass action law,

$$p = \frac{n_i^2}{N_D} = \frac{2.25\times10^{20}}{10^{17}}$$

$$= 2.25 \times 10^3/\text{cc}$$

21. (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

22. (b)

P type compensated semiconductor
Minority carrier concentration

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

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

23. (a)

Reason is correct explanation of assertion.

24. (b)

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

25. (a)

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

L = 20 μm

Time taken to travel 20 μm distance,

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

26. (b)

$$E = \phi + \frac{1}{2}mv^2, \quad \phi = 1.8\ \text{eV}$$

$$E = \frac{1.24}{0.5893} = 2.1\ \text{eV}$$

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

$$v = \sqrt{\frac{0.3\times 2\times 1.6\times 10^{-19}}{9.1\times 10^{-31}}}$$

$$= 3.27 \times 10^5 \text{ m/sec}$$

27. (d)

$$\tau_d = \frac{\varepsilon_{si}}{\sigma} = \frac{1.03\times 10^{-12}}{2} = 0.515\times 10^{-12} = 0.515\text{ ps}$$

28. (a)

In a doped semiconductor the majority carriers are controlled by Fermi-Dirac distribution function.

29. (d)

E_F is variant with temperature. For an n-type semiconductor, the concentration of electrons in conduction band is

$$n = N_C\, e^{-(E_C - E_F)/kT}$$

where, N_C = effective density of states

or $\quad \frac{E_C - E_F}{kT} = -ln\,(n/N_C)$

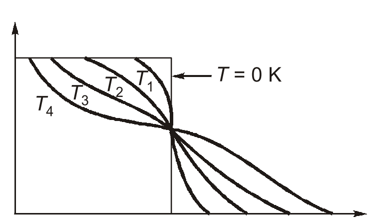
or $\quad E_F = E_C + kT\,ln\,(n/N_C)$

30. (b)

$$I_P = -qD_P\frac{DP}{dx}$$

31. (c)

$$f(E) = \frac{1}{1+e^{(E-E_F)/kT}}$$



$T_1 < T_2 < T_3 < T_4$

32. (b)

Overall any semiconductor is electrically neutral.

33. (d)

Conductivity

$$\sigma = nq\,\mu_n$$

μ_n : mobility of carrier

q : electron charge

n : effective density of states in conduction band

34. (c)

$$E_{FI} = \frac{E_C + E_V}{2} - \frac{kT}{2}ln\frac{N_C}{N_V}$$

or $$= \frac{E_C + E_V}{2} + \frac{kT}{2}ln\frac{N_V}{N_C}$$

35. (c)

$$f(E) = \frac{1}{1+e^{\frac{E-E_F}{K_T}}}$$

At $E = E_F$

$$f(E) = \frac{1}{1+1} = \frac{1}{2}$$

36. (a)

$$V = IR = I\frac{\rho L}{A}$$

$\therefore V \propto \rho \qquad (\rho$ = resistivity)

$$\therefore \quad \frac{V_2}{V_1} = \frac{\rho_2}{\rho_1}$$

$$\Rightarrow \quad V_2 = \left(\frac{\rho_2}{\rho_1}\right)V_1$$

$$= \left(\frac{2.3\times 10^3}{8.33\times 10^{-2}}\right)\times 50\times 10^{-3}$$

$$V_2 = 1385\text{ V}$$

37. (b)

At 0K: Fermi level is very closed to valance band for p-type SC.

0K: Fermi level is half way between VB and CB for intrinsic SC.

38. (c)

$$\rho = \frac{1.6}{1.6\times 10^{-19}\times 1\times 10^{22}\times 10}$$

$$= 10^{-4}\ \Omega\text{-cm}$$

39. (b)

For semiconductor