CHAPTER 1

SEMICONDUCTORS IN EQULIBRIUM

QUESTION 1.1

The process of adding impurities to a pure semiconductor is called

(A) mixing

(B) doping

(C) diffusing

(D) refining

QUESTION 1.2

In p-type semiconductor, there are

(A) no majority carriers

(B) electrons as majority carriers

(C) immobile negative ions

(D) immobile positive ions

QUESTION 1.3

An n-type semiconductor as a whole is

(A) positively charged

(B) negatively charged

(C) positively or negatively charged depending upon doping

(D) electrically neutral

QUESTION 1.4

A silicon wafer is uniformly doped p-type with acceptor impurity $N_A = 10^{15}$ per cm^3. At $T \cong 0°$K what is the equilibrium electron concentration ?

(A) $10^{15}/\text{cm}^3$

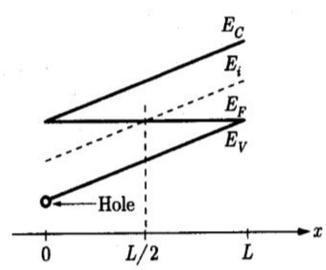
(B) $10^5/\text{cm}^3$

(C) $10^{10}/\text{cm}^3$

(D) $\cong 0$

QUESTION 1.5

Consider the following energy band diagram of silicon sample maintained at 300 K.



The semiconductor is in

(A) equilibrium

(B) non-equilibrium

(C) Equilibrium and Non-equilibrium depends on the distance 'x'

(D) equilibrium at $x = L/2$, and non-equilibrium at $x = 0, L$

QUESTION 1.6

If N_d and N_a are the donor and acceptor concentrations respectively and $N_d > N_a$, then net impurity concentration is

(A) $N_d - N_a$

(B) $N_d + N_a$

(C) $N_a - N_d$

(D) $N_d . N_a$

QUESTION 1.7

Fermi level represents the energy level with probability of its occupation of

(A) 0

(B) 50%

(C) 75%

(D) 100%

QUESTION 1.8

If Fermi energy level E_F is positioned at E_C (edge of the conduction band), then the probability of finding electrons in states at the $E_C + KT$ will be

____

QUESTION 1.9

The probability of occupancy of a state at the bottom of the conduction band in intrinsic silicon at room temperature is (assume at room temperature $KT = 0.026$ V)

6.5_____ $\times 10^{-10}$

QUESTION 1.10

The probability that an energy state is filled at $E_C + KT$, is equal to the probability that a state is empty at $E_C + KT$. Where is the Fermi level (E_F) located ?

(A) $E_F = E_C + 2KT$

(B) $E_F = E_C - 2KT$

(C) $E_F = E_C + KT$

(D) $E_F = E_C - 2KT$

QUESTION 1.11

At room temperature ($T = 300$ K), the probability that an energy state in the conduction band edge (E_C) of silicon is 10^{-4}. The type of semiconductor is

(A) n-type

(B) p-type

(C) intrinsic

(D) can't be determine

QUESTION 1.12

In an intrinsic silicon the band gap is

_______ eV

QUESTION 1.13

In an n-type semiconductor, the Fermi level E_F equals

(A) $E_c - kT\ln\left(\frac{N_c}{N_d}\right)$

(B) $E_c - kT\ln\left(\frac{N_d}{N_c}\right)$

(C) $E_v + kT\ln\left(\frac{N_c}{N_d}\right)$

(D) $E_v + kT\ln\left(\frac{N_d}{N_c}\right)$

QUESTION 1.14

For a silicon sample maintained at $T = 300$ K, the Fermi level is located 0.259 eV above the intrinsic level and intrinsic concentration $n_i = 10^{10}$ per cm^3. The hole concentration is

_______ $\times 10^5$ per cm^3.

QUESTION 1.15

Two semiconductors A and B have the same density of states effective masses. Semiconductor A has a bandgap energy of 1.0 eV and semiconductor B has a bandgap energy of 2 eV. The ratio of intrinsic concentration of semiconductor A to semiconductor B for $T = 300$ K will be

_______ $\times 10^8$.

QUESTION 1.16

If the Fermi energy in silicon is 0.22 eV above the valence band energy, what will be the values of n_0 and p_0 for silicon at $T = 300$ K ?

	n_0 (in cm^{-3})	p_0 (in cm^{-3})
(A)	2.27×10^4	2.13×10^{15}
(B)	2.13×10^{15} cm^{-3}	2.27×10^4
(C)	1.04×10^4 cm^{-3}	2.8×10^{15}
(D)	2.8×10^{15}	1.04×10^4

QUESTION 1.17

The hole concentration in silicon at $T = 300$ K is 10^{15} cm^{-3}. The concentration of electrons in the material will be

_______ $\times 10^4$ cm^{-3}.

QUESTION 1.18

Silicon at $T = 300$ K is doped with acceptor atoms at a concentration of $N_a = 7 \times 10^{15}$ cm^{-3}. The difference between Fermi energy and valence band energy, $E_F - E_v$ equals to

_______ eV

QUESTION 1.19

A piece of intrinsic silicon at room temperature is kept at thermal equilibrium. The position of some random level E_x is to be fixed at 0.9 eV above the valence band edge. The doping concentration such that the probability of capture of an energy state by an electron at E_x is 50% is

_______ $\times 10^{16}$ cm^{-3}

QUESTION 1.20

Given the effective masses of holes and electrons in silicon respectively as

$$m_p^* = 0.56 m_o, \; m_n^* = 1.08 m_o$$

What will be the position of the intrinsic Fermi energy level with respect to the center of the bandgap for the semiconductor at $T = 300$ K ?

(A) 0.0290 eV below the centre

(B) 0.0128 eV above the centre

(C) 0.0128 eV below the centre

(D) 0.0290 eV above the centre

QUESTION 1.21

The energy gap in a semiconductor

(A) does not change with temperature

(B) increases with temperatures

(C) decreases with temperature. Why ?

(D) is zero

QUESTION 1.22

An unknown semiconductor has

$$E_g = 1.1\,\text{eV}$$

and $N_c = N_v$.

It is doped with $10^{15}\,\text{cm}^{-3}$, where the donor level is 0.2 eV below E_c. Given that E_F is 0.25 eV below E_c. What is the number of electrons ?

(A) $8.733 \times 10^{14}\,\text{cm}^{-3}$

(B) 10^{15}cm^{-3}

(C) $0.1267 \times 10^{14}\,\text{cm}^{-3}$

(D) $8.142 \times 10^{9}\,\text{cm}^{-3}$

QUESTION 1.23

In previous question what is the intrinsic concentration ?

(A) $7.591 \times 10^{4}\,\text{cm}^{-3}$

(B) $1.5 \times 10^{10}\,\text{cm}^{-3}$

(C) $8.142 \times 10^{9}\,\text{cm}^{-3}$

(D) None of the above

QUESTION 1.24

In a p-type semiconductor, as the temperature T increases, the Fermi level E_F

(A) remains unaltered

(B) moves towards valence band

(C) moves towards the centre of forbidden energy gap

(D) may or may not more move depending upon the acceptor concentration

QUESTION 1.25

In intrinsic semiconductor at 300 K, the magnitude of free electron concentration in silicon is about

(A) 15×10^{4} per cm^3

(B) 5×10^{12} per cm^3

(C) 1.45×10^{10} per cm^3

(D) 1.45×10^{6} per cm^3

QUESTION 1.26

In p-type semiconductor, the minority carrier electron concentration equals

(A) N_D

(B) N_A

(C) $\frac{n_i^2}{N_A}$

(D) $\frac{n_i^2}{N_D}$

QUESTION 1.27

The electron concentration in silicon at $T = 300\,\text{K}$ is $n_0 = 5 \times 10^{4}\,\text{cm}^{-3}$. What will be the hole concentration (in cm^{-3}) in silicon ?

(A) 9×10^{15}

(B) 3×10^{9}

(C) 4.5×10^{15}

(D) 3×10^{5}

QUESTION 1.28

Two initially identical samples A and B of pure germanium are doped with donors to concentrations of 1×10^{20} and 3×10^{20} respectively. If the hole concentration in A is 9×10^{12}, then the hole concentration in B at the same temperature will be

(A) $3 \times 10^{12}\,\text{m}^{-3}$

(B) $7 \times 10^{12}\,\text{m}^{-3}$

(C) $11 \times 10^{12}\,\text{m}^{-3}$

(D) $27 \times 10^{12}\,\text{m}^{-3}$

QUESTION 1.29

A silicon semiconductor is doped with the donor and acceptor concentrations respectively as

$$N_d = 2 \times 10^{15}\ \text{cm}^{-3}$$

and $N_a = 0$.

The thermal equilibrium hole concentration in the material at $T = 300$ K will be

_______ $\times 10^5\ \text{cm}^{-3}$.

QUESTION 1.30

Two semiconductor materials have exactly the same properties except that material A has a bandgap energy of 1.0 eV and material B has a bandgap energy of 1.2 eV. The ratio of intrinsic concentration of material A to that of material B for $T = 300$ K will be

____

QUESTION 1.31

The intrinsic carrier concentration in silicon is to be no greater than $n_i = 1 \times 10^{12}\ \text{cm}^{-3}$. What will be the maximum temperature allowed for the silicon ?

_______ K

QUESTION 1.32

In a sample of GaAs at $T = 200$ K, we have experimentally determined that $n_0 = 5p_0$ and $N_a = 0$. What will be the concentration of electrons in the material ?

_______ cm^{-3}

QUESTION 1.33

The intrinsic carrier concentration, n_i at $T = 200$ K for silicon is

_______ $\times 10^4\ \text{cm}^{-3}$

QUESTION 1.34

Fermi level in the intrinsic Si or Ge is

(A) in the middle of the band gap

(B) near the valance band

(C) near the conduction band

(D) none of these

QUESTION 1.35

Acceptor impurity atom in germanium results in

(A) increased for bidden energy gap

(B) reduced for bidden energy gap

(C) new narrow energy band slightly above the valence level

(D) new discrete energy level slightly above the valence level

QUESTION 1.36

For a particular material,

$$N_C = 1.5 \times 10^{18}\ \text{cm}^{-3},$$

$$N_V = 1.3 \times 10^{19}\ \text{cm}^{-3}$$

and bandgap $E_G = 1.43$ eV

at $T = 300°$ K.

What is the position of the Fermi level with respect to the top of the valence band E_V ?

(A) 0.028 eV above the valence band edge E_V

(B) 0.743 eV below the valence band edge E_V

(C) 0.028 eV below the valence band edge E_V

(D) 0.743 eV above the valence band edge E_V

QUESTION 1.37

In previous question what is the position of the Fermi level with respect to the conduction band edge E_C ?

(A) 0.687 eV above E_C

(B) 0.687 eV below E_C

(C) 0.743 eV below E_C

(D) 0.743 eV above E_C

QUESTION 1.38

If silicon is doped with phosphorus atoms at a concentration of 10^{15} cm^{-3} then, what will be the position of the Fermi level with respect to the intrinsic Fermi level in silicon at $T = 300$ K ?

(A) 0.1855 eV below the intrinsic Fermi level

(B) 0.2877 eV above the intrinsic Fermi level

(C) 0.2877 eV below the intrinsic Fermi level

(D) 0.1855 eV above the intrinsic Fermi level

QUESTION 1.39

Gallium arsenide at $T = 300$ K contains acceptor impurity atoms at a density of 10^{15} cm^{-3}. Additional impurity atoms are to be added so that the Fermi level is 0.45 eV below the intrinsic level. The concentration and type of additional impurity atoms will be respectively

(A) $N_a = 9.368 \times 10^{14}$ cm^{-3}, acceptor

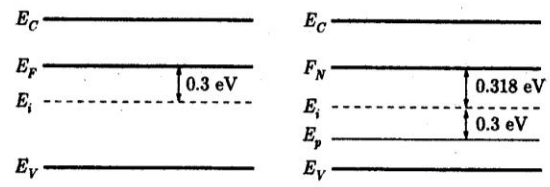
(B) $N_a = 6.32 \times 10^{13}$ cm^{-3}, acceptor

(C) $N_d = 9.368 \times 10^{14}$ cm^{-3}, donor

(D) $N_d = 6.32 \times 10^{13}$ cm^{-3}, donor

QUESTION 1.40

The equilibrium and steady state condition before and after illumination of a semiconductor are characterized by the energy band diagram shown below.



(a) Before (b) After

At $T = 300$, the intrinsic concentration

$n_i = 10^{10}$ per cm^3,

The value of the equilibrium carrier concentration n_o and p_o respectively, are

(A) 1.07×10^{15} per cm^3, 9.32×10^{4} per cm^3

(B) 1.07×10^{15} per cm^3, 2.15×10^{15} per cm^3

(C) 9.32×10^{15} per cm^3, 1.07×10^{4} per cm^3

(D) 2.15×10^{15} per cm^3, 9.32×10^{15} per cm^3

QUESTION 1.41

In previous question carrier concentration n and p under steady state conditions are

	n	p
(A)	2.15×10^{15} per cm^3	4.65×10^{19} per cm^3
(B)	9.34×10^{4} per cm^3	1.07×10^{15} per cm^3
(C)	1.07×10^{15} per cm^3	9.32×10^{4} per cm^3
(D)	2.15×10^{15} per cm^3	1.07×10^{15} per cm^3

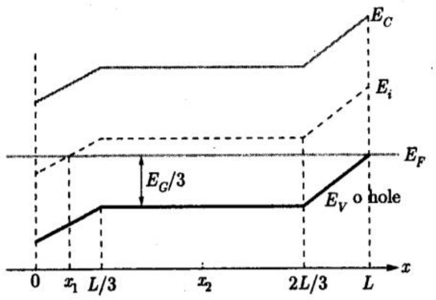
QUESTION 1.42

For a piece of GaAs (Gallium Arsenide) having a band gap $E_g = 1.43$ eV. The minimum frequency of an incident photon that can interact with a valence electron and elevate the electron to the conduction band is

_______ $\times 10^{14}$ Hz

QUESTION 1.43

A silicon device maintained at 300 K is characterized by the following energy band diagram.



The semiconductor is degenerated.

(A) Near $x = 0$

(B) For $L/3 \le x \le \frac{2L}{3}$

(C) Near $x = L$

(D) At $x = x_1$

QUESTION 1.44

If silicon is doped with boron atoms at a concentration of $10^{15}\,\text{cm}^{-3}$ then, the change in Fermi level, $E_F - E_{Fi}$ will be

_______ eV

QUESTION 1.45

A piece of intrinsic silicon at room temperature is kept at thermal equilibrium. The position of energy level, E_x is set exactly 0.6 eV above the intrinsic level and band gap of intrinsic silicon $(E_g) = 1.1\,\text{eV}$. What is the type of semiconductors if the probability of capture of an energy state by an electron at E_x is 50%.

(A) p-type, non degenerate

(B) n-type, non degenerate

(C) p-type, degenerate

(D) n-type, degenerate

QUESTION 1.46

In previous question what is the doping concentration

(A) $1.725 \times 10^{16}\,\text{cm}^{-3}$

(B) $1.725 \times 10^{20}\,\text{cm}^{-3}$

(C) $2.879 \times 10^{19}\,\text{cm}^{-3}$

(D) $2.879 \times 10^{16}\,\text{cm}^{-3}$

QUESTION 1.47

Consider germanium at $T = 300$ K with doping concentrations of $N_d = 10^{14}\,\text{cm}^{-3}$ and $N_a = 0$. What will be the position of Fermi energy level with respect to the intrinsic Fermi level for these doping concentrations ?

$n_i = ?$

(A) 0.1855 eV below the intrinsic Fermi level

(B) 0.0382 eV above the intrinsic Fermi level

(C) 0.0382 eV below the intrinsic Fermi level

(D) 0.1855 eV above the intrinsic Fermi level

QUESTION 1.48

The effective masses of electron and hole in germanium are $m_n^* = 0.55\,m$ and $m_p^* = 0.37\,m$ (where m is the electron rest mass) what will be the position of the intrinsic Fermi energy laval with respect to the centre of the bandgap for the Germanium semiconductor at $T = 300$ K ?

(A) 0.0154 eV above the centre

(B) 0.0154 eV below the centre

(C) 0.0077 eV above the centre

(D) 0.0077 eV below the centre

QUESTION 1.49

In an n-type silicon, the donor concentration is 1 atom per 2×10^8 silicon atoms. Assume that the effective mass of the electron equals the true mass and the density of atoms in the silicon is $5 \times 10^{22}\,\text{atoms/cm}^3$. At what temperature will the Fermi level coincide with the edge of the conduction band ?

_______ °K

QUESTION 1.50

In a non-degenerate germanium sample maintained under equilibrium conditions near room temperature, it is known that intrinsic concentration $n_i = 10^{13}/\text{cm}^3$, $n = 2p$ and $N_A = 0$. What are the values of n (electron concentration) and N_D (Donor concentration) ?

	n	N_D
(A)	7.07×10^{12} per cm^3	1.414×10^{13} per cm^3
(B)	1.414×10^{13} per cm^3	0.707×10^{13} per cm^3
(C)	2.828×10^{13} per cm^3	0.707×10^{13} per cm^3
(D)	1.414×10^{13} per cm^3	1.414×10^{13} per cm^3

QUESTION 1.51

A particular semiconductor material is doped at $N_d = 2 \times 10^{13}\ \text{cm}^{-3}$, $N_a = 0$, and the intrinsic carrier concentration is $n_i = 2 \times 10^{13}\ \text{cm}^{-3}$. The thermal equilibrium majority and minority carrier concentrations will be, respectively (Assume complete ionization)

(A) $p_0 = 1.23 \times 10^{13}\ \text{cm}^{-3}$, $n_0 = 0.216\ \text{cm}^{-3}$

(B) $p_0 = 0.216\ \text{cm}^{-3}$, $n_0 = 3.24 \times 10^{13}\ \text{cm}^{-3}$

(C) $p_0 = 1.23 \times 10^{13}\ \text{cm}^{-3}$, $n_0 = 3.24 \times 10^{13}\ \text{cm}^{-3}$

(D) $p_0 = 3.24 \times 10^{13}\ \text{cm}^{-3}$, $n_0 = 1.23 \times 10^{13}\ \text{cm}^{-3}$

QUESTION 1.52

A sample of silicon at $T = 450\ \text{K}$ is doped with boron at a concentration of $1.5 \times 10^{15}\ \text{cm}^{-3}$ and with arsenic at a concentration of $8 \times 10^{14}\ \text{cm}^{-3}$. The material is

(A) p-type with $p_0 = 4.23 \times 10^{11}\ \text{cm}^{-3}$,
$n_0 = 7 \times 10^{14}\ \text{cm}^{-3}$

(B) p-type with $p_0 = 7 \times 10^{14}\ \text{cm}^{-3}$,
$n_0 = 4.23 \times 10^{11}\ \text{cm}^{-3}$

(C) n-type with $p_0 = 4.23 \times 10^{11}\ \text{cm}^{-3}$,
$n_0 = 7 \times 10^{14}\ \text{cm}^{-3}$

(D) n-type with $p_0 = 7 \times 10^{14}\ \text{cm}^{-3}$,
$n_0 = 4.23 \times 10^{11}\ \text{cm}^{-3}$

QUESTION 1.53

Silicon at $T = 300\ \text{K}$ is uniformly doped with phosphorus atoms at a concentration $2 \times 10^{15}\ \text{cm}^{-3}$ and boron atoms at a concentration of $3 \times 10^{16}\ \text{cm}^{-3}$. The thermal equilibrium concentration (in cm^{-3}) of minority carriers will be

_______ $\times 10^3\ \text{cm}^{-3}$.

$N_v = 1.04 \times 10^{19}$

$N_c = 2.8 \times 10^{19}$

QUESTION 1.54

Silicon at $T = 300\ \text{K}$ contains acceptor atoms at a concentration of $N_a = 5 \times 10^{15}\ \text{cm}^{-3}$. Donor atoms are added forming an n-type compensated semiconductor such that the Fermi level is $0.215\ \text{eV}$ below the conduction band edge. The concentration of donor atoms added is

_______ $\times 10^{16}\ \text{cm}^{-3}$

QUESTION 1.55

Given the acceptor and donor concentrations in a germanium semiconductor respectively as $N_a = 10^{13}\ \text{cm}^{-3}$, $N_d = 0$. The thermal equilibrium hole concentration in the material at $T = 300\ \text{K}$ will be

$n_i = ?$

_______ $\times 10^{13}\ \text{cm}^{-3}$.

QUESTION 1.56

The doping concentrations in silicon semiconductor are $N_d = N_a = 10^{15}\ \text{cm}^{-3}$. What will be the concentrations of n_0 and p_0 in the material at $T = 300\ \text{K}$?

	n_0 (in cm^{-3})	p_0 (in cm^{-3})
(A)	10^{15}	10^{15}
(B)	$2.25 \times 10^{10}\ \text{cm}^{-3}$	10^{15}
(C)	1.5×10^{10}	1.5×10^{10}
(D)	10^{15}	$2.25 \times 10^{10}\ \text{cm}^{-3}$

$n_i = 1.5 \times 10^{10}$

QUESTION 1.57

If a germanium semiconductor is doped with the donor and acceptor concentrations respectively as

$$N_d = 5 \times 10^{15}\,\text{cm}^{-3},$$

$$N_a = 0.$$

What will be the thermal equilibrium concentrations, n_0 and p_0 at $T = 300\,\text{K}$ in the material ?

	n_0 (in cm^{-3})	p_0 (in cm^{-3})
(A)	2.08×10^4	2.13×10^{15}
(B)	$1.15 \times 10^{11}\,\text{cm}^{-3}$	5.0×10^{15}
(C)	2.13×10^{15}	2.08×10^4
(D)	5.0×10^{15}	$1.15 \times 10^{11}\,\text{cm}^{-3}$

QUESTION 1.58

In silicon at $T = 300\,\text{K}$, we have experimentally found that $n_0 = 4.5 \times 10^4\,\text{cm}^{-3}$ and $N_d = 5 \times 10^{15}\,\text{cm}^{-3}$. The acceptor impurity concentration in the material will be

_______ $\times 10^{16}\,\text{cm}^{-3}$

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Answer

1.1	B
1.2	C
1.3	D
1.4	D
1.5	A
1.6	A
1.7	B
1.8	0.269
1.9	4.4
1.10	C
1.11	A
1.12	1.1eV
1.13	A
1.14	4.54
1.15	2.2
1.16	A
1.17	4.9
1.18	0.189
1.19	1.109
1.20	C
1.21	C
1.22	A
1.23	C
1.24	C
1.25	C
1.26	C
1.27	C
1.28	A
1.29	1.125
1.30	47.5
1.31	381
1.32	3.09
1.33	7.68
1.34	A
1.35	D
1.36	D
1.37	B
1.38	B
1.39	C
1.40	A

1.41	D
1.42	3.454
1.43	C
1.44	-0.2877
1.45	D
1.46	B
1.47	B
1.48	D
1.49	0.14
1.50	B
1.51	C
1.52	B
1.53	8.04
1.54	1.2
1.55	2.95
1.56	C
1.57	D
1.58	1

CHAPTER 2

SEMICONDUCTORS IN NON EQULIBRIUM

QUESTION 2.1

Current flow in a semiconductor depends on the phenomenon of

(A) drift

(B) diffusion

(C) recombination

(D) all of the above

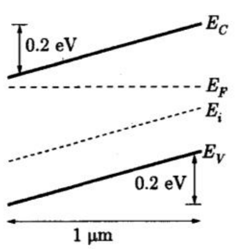
QUESTION 2.2

In pure Si sample, electric field is 100 V/cm, and electron mobility is $\mu_n = 1350\ \text{cm}^2/\text{V-sec}$. How long does it take on average to drift an electron $1\ \mu\text{m}$ in pure Si ?

_______ nsec

QUESTION 2.3

Consider the equilibrium energy band diagram shown below.



What is the value of the effective electric field for electrons ?

_______ kV/cm

QUESTION 2.4

Consider a homogeneous gallium arsenide semiconductor at $T = 300\ \text{K}$ with the following parameters:

Donor concentration: $N_d = 10^{16}\ \text{cm}^{-3}$,

Electron mobility: $\mu_n = 7500\ \text{cm}^2/\text{V-s}$

Intrinsic concentration: $n_i = 1.8 \times 10^6\ \text{cm}^{-3}$

The thermal equilibrium value of hole concentration in the material will be

(A) $10^{16}\ \text{cm}^{-3}$

(B) $3.24 \times 10^{-4}\ \text{cm}^{-3}$

(C) $3.24 \times 10^{4}\ \text{cm}^{-3}$

(D) $1.8 \times 10^{-10}\ \text{cm}^{-3}$

QUESTION 2.5

In previous question if an electric field of 10 V/cm is applied to the material then, the drift current density will be

(A) $75\ \text{A/cm}^2$

(B) $120\ \text{A/m}^2$

(C) $75\ \text{A/m}^2$

(D) $120\ \text{A/cm}^2$

QUESTION 2.6

In a perfectly compensated silicon semiconductor, donor and acceptor impurity concentrations are $N_a = N_d = 10^{14}\ \text{cm}^{-3}$ at $T = 300\ \text{K}$. For silicon the intrinsic concentration is $1.5 \times 10^{10}\ \text{cm}^{-3}$, hole mobility ($\mu_p$) is $480\ \text{cm}^2/\text{V-s}$ and electron mobility μ_n is $1350\ \text{cm}^2/\text{V-sec}$ so the conductivity of silicon at $T = 300$ is

_______ $\times 10^{-6} (\Omega\text{cm})^{-1}$.

QUESTION 2.7

At $T = 300$ K, for silicon

intrinsic concentration : $n_i = 1.5 \times 10^{10}\,\text{cm}^{-3}$

hole mobility : $\mu_p = 480\,\text{cm}^2/\text{V-s}$

electron mobility : $\mu_n = 1350\,\text{cm}^2/\text{V-sec}$

and for germanium,

intrinsic concentration: $n_i = 2.4 \times 10^{13}\,\text{cm}^{-3}$

hole mobility : $\mu_p = 1900\,\text{cm}^2/\text{V-sec}$

electron mobility : $\mu_n = 3900\,\text{cm}^2/\text{V-sec}$

At $T = 300$ K the conductivity (in $(\Omega\text{–cm})^{-1}$) of intrinsic silicon and germanium are respectively.

(A) $4.39 \times 10^{-6}, 2.23 \times 10^{-2}$

(B) $2.23 \times 10^{-2}, 4.39 \times 10^{-6}$

(C) $3.24 \times 10^{-3}, 1.49 \times 10^{-7}$

(D) $1.49 \times 10^{-7}, 3.24 \times 10^{-3}$

QUESTION 2.8

An n-type silicon sample has a resistivity of $5\,\Omega$-cm, and electron mobility is $1350\,\text{cm}^2/\text{V-s}$ at $T = 300$ K. What is the donor impurity concentration ?

(A) $1.48 \times 10^{15}\,\text{cm}^{-3}$

(B) $4.63 \times 10^{15}\,\text{cm}^{-3}$

(C) $9.26 \times 10^{14}\,\text{cm}^{-3}$

(D) $6.25 \times 10^{17}\,\text{cm}^{-3}$

QUESTION 2.9

A sample of GaAs doped with $N_A = 10^{17}\,\text{cm}^{-3}$. For GaAs, intrinsic concentration is $n_i = 2.2 \times 10^{6}\,\text{cm}^{-3}$, mobility of electron is $\mu_n = 5300\,\text{cm}^2/\text{V-sec}$, and mobility of hole is $\mu_p = 230\,\text{cm}^2/\text{V sec}$. The conductivity (in the dark) of a sample of GaAs is

_______ $(\Omega\text{-cm})^{-1}$

QUESTION 2.10

What is the expression of n_0 (electron concentration) for the minimum conductivity of a semiconductor sample ?

(A) $n_i\sqrt{\dfrac{\mu_n}{\mu_p}}$

(B) $\dfrac{1}{n_i}\sqrt{\dfrac{\mu_n}{\mu_p}}$

(C) $n_i\sqrt{\dfrac{\mu_p}{\mu_n}}$

(D) $2n_i\sqrt{\mu_p\mu_n}$

QUESTION 2.11

Consider a 1 cm long semiconductor bar connected at its ends to a 3 V battery. The average electron drift velocity in the semiconductor bar is 10^4 cm/s. The electron mobility of the material will be

_______ $\text{cm}^2/\text{V-s}$

QUESTION 2.12

What is the value of electron drift velocity for $N_D - N_A = 10^{16}\,\text{cm}^{-3}$ in a bar of Si of cross-sectional area $1.0\,\text{mm}^2$ for a current of 50 mA ?

0.3125

_______ cm/s

QUESTION 2.13

A Si bar 0.1 cm long and $100\,\mu\text{m}^2$ in cross sectional area is doped with $10^{17}\,\text{cm}^{-3}$ phosphorus and mobility of electron is $700\,\text{cm}^2/\text{V-sec}$. What is the value of current at 300 K with 10 V applied ?

1.120 A

____

QUESTION 2.14

Two GaAs wafers, one n-type and one p-type, are uniformly doped such that $N_D(\text{wafer 1}) = N_A(\text{wafer 2}) \geq n_i$. which wafer will exhibit the larger resistivity?

(A) Resistivity of wafer 2 is greater than resistivity of wafer 1

(B) Resistivity of wafer 1 is greater than resistivity of wafer 2

(C) Resistivity of wafer 1 is equal to the resistivity of wafer 2

(D) None of the above

QUESTION 2.15

A voltage of 2.5 V is applied to a sample of silicon whose cross-sectional area is $0.1\,\mu m \times 1\,\mu m$. The length of the path is $0.1\,\mu m$. If the material (in mA) is doped n-type with $N_D = 10^{18}\,cm^{-3}$, what is the current in the sample ?
(Given that $\mu_n = 230\,cm^2/sec$)

92 mA
____

Imp

QUESTION 2.16

A particular intrinsic semiconductor has a resistivity of $50\,\Omega$-cm at $T = 300\,K$ and $5\,\Omega$-cm at $T = 330\,K$. What will be the bandgap energy of the semiconductor ?
(Neglecting the change in mobility with temperature).

_______ eV

QUESTION 2.17

A silicon semiconductor resistor is doped with acceptor impurities at a concentration of $N_a = 10^{17}\,cm^{-3}$. The cross-sectional area is $85\,\mu m^2$ and hole mobility is $310\,cm^2/V\text{-}s$. The current in the resistor is to be $I = 20\,mA$ with 10 V applied. The required length of the device is

_______ µm

QUESTION 2.18

In intrinsic semiconductor, the increase in conductivity per degree increase in temperature is about

(A) 2%

(B) 6%

(C) 15%

(D) 25%

QUESTION 2.19

The diffusion current is proportional to

(A) applied electric field

(B) concentration gradient of change carrier

(C) square of the applied electric field

(D) cube of the applied electric field

QUESTION 2.20

Consider a p-type Si sample of $N_A = 10^{18}\,cm^{-3}$ and $N_D = 0$. Over a length of $1\,\mu m$, the electron concentration drops linearly from $10^{16}\,cm^{-3}$ to $10^{13}\,cm^{-3}$. What is value of the electron diffusion current density ?
(Given that electron diffusion constant $D_n = 9\,cm^2/sec$)

$-144\,A/cm^2$
_______ nA/cm^2

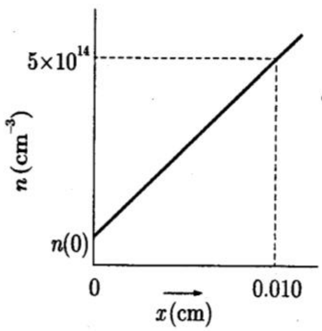
QUESTION 2.21

The electron concentration in a sample of n-type silicon varies linearly from $10^{17}\,cm^{-3}$ at $x = 0$ to $6 \times 10^{16}\,cm^{-3}$ at $x = 4\,\mu m$. There is no applied electric field. The electron current density is experimentally measured to be $-400\,A/cm^2$. What is the electron diffusion coefficient ?

_______ cm^2/s

QUESTION 2.22

Consider a sample of silicon at $T = 300$ K. Assume that the electron concentration (n) varies linearly with distance (x) as shown in Figure.



The diffusion current density is found to be $J_n = 0.19\ \mathrm{A/cm^2}$. If the electron diffusion coefficient is $D_n = 25\ \mathrm{cm^2/s}$, what is the electron concentration at $x = 0$ is

_______ $\times 10^{14}\ \mathrm{cm^{-3}}$

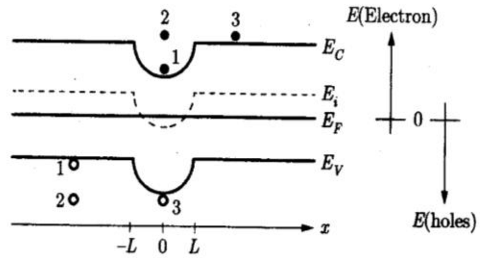
QUESTION 2.23

The electron concentration in silicon decreases linearly from $10^{16}\ \mathrm{cm^{-3}}$ to $10^{15}\ \mathrm{cm^{-3}}$ over a distance of 0.10 cm. The cross-sectional area of the sample is $0.05\ \mathrm{cm^2}$. What is the electron diffusion current in silicon ?
(Electron diffusion coefficient, $D_n = 25\ \mathrm{cm^2/s}$).

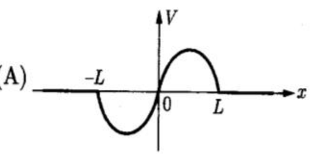
_______ mA

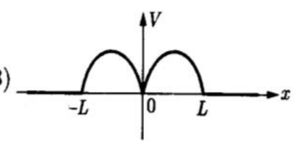
QUESTION 2.24

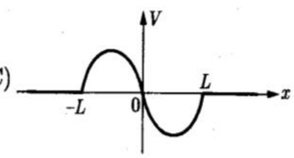
Consider the following energy band diagram. Take the semiconductor represented to be Si maintained at $T = 300^\circ$K with $E_i - E_F = E_G/4$ at $x = \pm L$ and $E_F - E_i = E_G/4$ at $x = 0$. Note the choice of E_F as the energy reference level. Given that band gap of Si is 1.12 eV, hole mobility $\mu_p = 459\ \mathrm{cm^2/V\text{-}sec}$, and intrinsic concentration $n_i = 10^{10}\ \mathrm{cm^{-3}}$

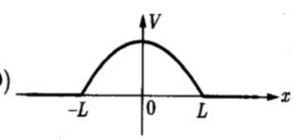


The electrostatic potential (V) inside the semiconductor as a function of x is

(A)


(B)


(C)


(D)


QUESTION 2.25

The drift plus diffusion current density of electron in amp/ $\mathrm{m^2}$ is expressed as

(A) $J_n = \{qn\mu_n E + qD_n(dn/dx)\}$

(B) $J_n = \{qn\mu_n E - qD_n(dn/dx)\}$

(C) $J_n = \{qn\mu_n E - AqD_n(dn/dx)\}$

(D) $J_n = \{qn\mu_n E + AqD_n(dn/dx)\}$

QUESTION 2.26

Consider a semiconductor in thermal equilibrium (no current). Assume that the donor concentration varies exponentially as $N_d(x) = N_{d0}\exp(-\alpha x)$ over the range $0 \le x \le 1/\alpha$; where N_{d0} is a constant. Electric field in the range $0 \le x \le 1/\alpha$ will be

(A) independent of x

(B) linearly dependent on x

(C) zero

(D) none of these

Einstein Relation

QUESTION 2.27

Assume that the mobility of a carrier at $T = 300$ K is $\mu = 925\ \text{cm}^2/\text{V-s}$. The diffusion coefficient of the carrier will be

_______ cm^2/s

QUESTION 2.28

The diffusion constant and the mobility of electron are related as

(A) $D_n/\mu_n = KT/q$

(B) $D_n/\mu_n = q/KT$

(C) $D_n/\mu_n = KTq$

(D) $D_n/\mu_n = qKT$

QUESTION 2.29

Three scattering mechanisms are present in a particular semiconductor material. If only the first scattering mechanism were present, the mobility would be $\mu_1 = 2000\ \text{cm}^2/\text{V-s}$, if only the second mechanism were present, the mobility would be $\mu_2 = 1500\ \text{cm}^2/\text{V-s}$ and if only the third mechanism were present, the mobility would be $\mu_3 = 500\ \text{cm}^2/\text{V-s}$. What is the net mobility ?

$\frac{1}{\mu_T} = \frac{1}{\mu_0} + \frac{1}{\mu_2}$

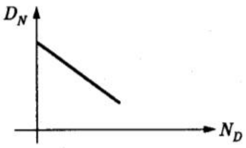
_______ $\text{cm}^2/\text{V-s}$

QUESTION 2.30

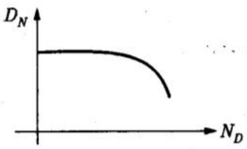
Which of the following sketches best describes the D_N versus N_D dependence of electrons in silicon at room temperature ?

(A)

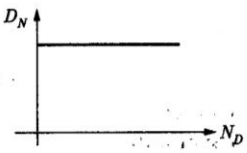
(B)



(C)



(D)



QUESTION 2.31

A sample of Ge at $T = 300$ K has a uniform donor concentration of $2 \times 10^{13}\ \text{cm}^{-3}$ and electron mobility $\mu_n = 3900\ \text{cm}^2/\text{V-sec}$, hole mobility $\mu_p = 1900\ \text{cm}^2/\text{V-sec}$ The excess carrier lifetime is found to be $\tau_{p0} = 24\ \mu\text{s}$. What is the electron lifetime in the sample of germanium ?

_______ μs

QUESTION 2.32

In previous question what is the ambipolar diffusion coefficient ?

_______ cm^2/s

QUESTION 2.33

If an intrinsic semiconductor is doped with a very small amount of boron, then in the extrinsic semiconductor so formed, the number of electrons and holes will,

(A) decrease

(B) increase and decrease respectively

(C) increase

(D) decrease and increase respectively

QUESTION 2.34

Consider a semiconductor in which $n_0 = 10^{15}\,\text{cm}^{-3}$ and $n_i = 10^{10}\,\text{cm}^{-3}$. Assume that the excess-carrier lifetime is 10^{-6} s. If the excess-hole concentration is $\delta p = 5 \times 10^{13}\,\text{cm}^{-3}$, what will be the excess electron-hole recombination rate ?

(A) $5 \times 10^{29}\,\text{cm}^{-3}\,\text{s}^{-1}$

(B) $5 \times 10^{17}\,\text{cm}^{-3}\,\text{s}^{-1}$

(C) $5 \times 10^{19}\,\text{cm}^{-3}\,\text{s}^{-1}$

(D) $5 \times 10^{7}\,\text{cm}^{-3}\,\text{s}^{-1}$

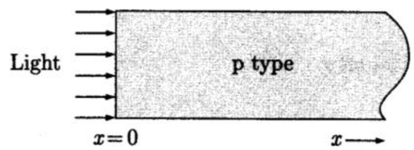
QUESTION 2.35

An n-type GaAs semiconductor is doped with $N_d = 10^{16}\,\text{cm}^{-3}$ and $N_a = 0$ at $T = 300\,\text{K}$ the electron mobility is $8500\,\text{cm}^2/\text{V-sec}$ and hole mobility is $400\,\text{cm}^2/\text{V-sec}$ for GaAs. The minority carrier lifetime is $\tau_{p0} = 2 \times 10^{-7}$ sec. If a uniform generation rate $g' = 2 \times 10^{21}\,\text{cm}^{-3}\text{sec}^{-1}$ is incident on the semiconductor, then the steady state increase in conductivity will be

_______ $(\Omega\text{-cm})^{-1}$

QUESTION 2.36

Consider a bar of p-type silicon material that is homogeneously doped to a value of $3 \times 10^{15}\,\text{cm}^{-3}$ at $T = 300\,\text{K}$. The applied electric field is zero. A light source is incident on the end of the semiconductor as shown in figure.



The excess-carrier concentration generated at $x = 0$ is $\delta p(0) = \delta n(0) = 10^{13}\,\text{cm}^{-3}$. Assume the following parameters (neglect surface effects):

$$\mu_n = 1200\,\text{cm}^2/\text{V-s} \quad \tau_{n0} = 5 \times 10^{-7}\,\text{s}$$

$$\mu_p = 400\,\text{cm}^2/\text{V-s} \quad \tau_{p0} = 1 \times 10^{-7}\,\text{s}$$

The steady-state excess electron concentration at any distance x into the semiconductor is

(A) $10^{-13}\exp\left(\frac{-L_n}{x}\right)$

(B) $10^{13}\exp\left(\frac{-L_n}{x}\right)$

(C) $10^{-13}\exp\left(\frac{-x}{L_n}\right)$

(D) $10^{13}\exp\left(\frac{-x}{L_n}\right)$

QUESTION 2.37

In previous question the electron diffusion current density (in mA/cm^2) at a distance x in the semiconductor will be

(A) $-12.6\exp\left(\frac{-x}{L_n}\right)$

(B) $-12.6\exp\left(\frac{-L_n}{x}\right)$

(C) $-3.11\exp\left(\frac{-x}{L_n}\right)$

(D) $-4.05\exp\left(\frac{-x}{L_n}\right)$

QUESTION 2.38

A direct gap semiconductor sample is illuminated at one end with light of $\lambda = 500\,\text{nm}$ (green), with an intensity of $1\,\text{mW/cm}^2$. The area of the illuminated surface is $1\,\text{cm}^2$. The number of photons striking the sample per second is

_______ $\times 10^{15}$

QUESTION 2.39

At $T = 300\,\text{K}$, an n-type silicon sample contains a donor concentration $N_d = 10^{16}\,\text{cm}^{-3}$ and intrinsic concentration $n_i = 1.5 \times 10^{10}\,\text{cm}^{-3}$ the minority carrier hole lifetime is found to be $\tau_{p0} = 20\,\mu\text{s}$. What will be the thermal-equilibrium hole recombination rate in this material ?

(A) $2.25 \times 10^{9}\,\text{cm}^{-3}\,\text{s}^{-1}$

(B) $5.0 \times 10^{20}\,\text{cm}^{-3}\,\text{s}^{-1}$

(C) $1.125 \times 10^{9}\,\text{cm}^{-3}\,\text{s}^{-1}$

(D) $8.88 \times 10^{10}\,\text{cm}^{-3}\,\text{s}^{-1}$

QUESTION 2.40

Electron-hole pairs are produced by

(A) recombination

(B) thermal energy

(C) ionization

(D) doping

QUESTION 2.41

Consider an n-type gallium arsenide semiconductor at $T = 300\,\text{K}$ doped at $N_d = 5 \times 10^{16}\,\text{cm}^{-3}$ and intrinsic concentration $n_i = 1.8 \times 10^{6}\,\text{cm}^{-3}$. The change in Fermi level, $E_F - E_{Fi}$ will be

(A) $2.405\,\text{eV}$

(B) $-0.9284\,\text{eV}$

(C) $0.6228\,\text{eV}$

(D) $-0.6228\,\text{eV}$

QUESTION 2.42

In previous question if the excess-carrier concentration is $0.1\,N_d$ then, quasi-Fermi energy level for electrons will be

(A) $0.0025\,\text{eV}$ above the Fermi level E_F

(B) $0.0025\,\text{eV}$ below the Fermi level E_F

(C) $0.6253\,\text{eV}$ above the Fermi level E_F

(D) $0.6253\,\text{eV}$ below the Fermi level E_F

QUESTION 2.43

In a silicon semiconductor material at $T = 300\,\text{K}$, the doping concentrations are $N_d = 10^{15}\,\text{cm}^{-3}$ and $N_a = 0$. The equilibrium recombination rate is $R_{p0} = 10^{11}\,\text{cm}^{-3}\text{-s}^{-1}$. A uniform generation rate produces an excess-carrier concentration of $\delta n = \delta p = 10^{14}\,\text{cm}^{-3}$. What is the excess-carrier lifetime ?

_______ $\times 10^{-7}$ s.

QUESTION 2.44

In previous question by what factor does the total recombination rate increase ?

_______ $\times 10^{9}$

QUESTION 2.45

The amount of time between the creation and disappearance of a hole in an intrinsic semiconductor material is called

(A) life cycle

(B) recombination time

(C) life time

(D) half life

QUESTION 2.46

Hall effect may be used for which of the following

(A) Determining whether a semiconductor is n-type or p-type

(B) Determining the carrier concentration

(C) Calculating the mobility

(D) All of the above

QUESTION 2.47

Hall effect is observed in a specimen when it (metal or a semiconductor) is carrying current and is placed in a magnetic field. The resultant electric field inside the specimen will be in

(A) a direction normal to both current and magnetic field

(B) the direction of current

(C) a direction antiparallel to the magnetic field

(D) an arbitary direction depending upon the conductivity of the specimen

QUESTION 2.48

The Hall coefficient of a sample of silicon having 10^{22} arsenic atoms per m^3 is

(A) $3.49 \times 10^{-3}\,m^3/C$

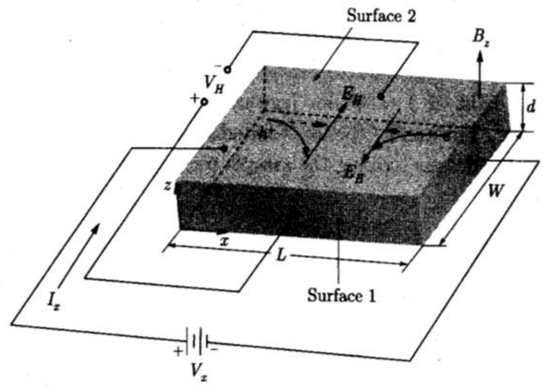
(B) $6.25 \times 10^{-4}\,m^3/C$

(C) $1.37 \times 10^{-4}\,m^3/C$

(D) $9.44 \times 10^{-5}\,m^3/C$

QUESTION 2.49

Germanium is doped with 5×10^{15} donor atoms per cm^3 at $T = 300\,K$. The dimensions of the Hall device are $d = 5 \times 10^{-3}\,cm$, $W = 2 \times 10^{-2}\,cm$, and $L = 10^{-1}\,cm$. The current is $I_x = 250\,\mu A$, the applied voltage is $V_x = 100\,mV$, and the magnetic flux density is $B_z = 500\,gauss = 5 \times 10^{-2}\,tesla$.

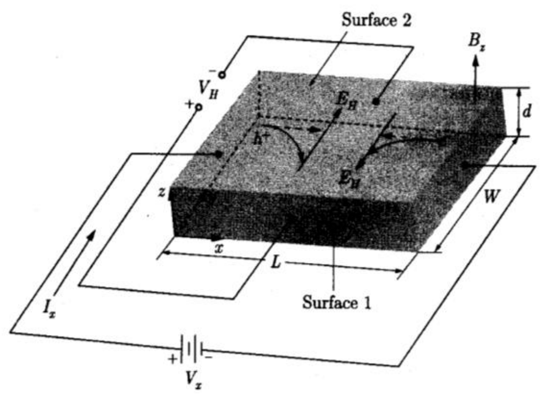


What will be Hall voltage of the device ?

________ mV

QUESTION 2.50

A silicon Hall device at $T = 300\,K$ has the following geometry: $d = 10^{-3}\,cm$, $W = 10^{-2}\,cm$ and $L = 10^{-1}\,cm$. The following parameters are measured: $I_x = 0.75\,mA$, $V_x = 15\,V$, $V_H = +5.8\,mV$ and $B_z = 1000\,gauss = 10^{-1}\,tesla$.



The silicon hall device is

(A) p-type

(B) n-type

(C) intrinsic

(D) can't be determined

****

Answer

2.1	D
2.2	0.74
2.3	2
2.4	B
2.5	D
2.6	4.39
2.7	A
2.8	C
2.9	3.68
2.10	C
2.11	3333
2.12	3100
2.13	1.12
2.14	A
2.15	9
2.16	1.312
2.17	21.1
2.18	B
2.19	B
2.20	-0.014
2.21	25
2.22	0.25
2.23	18
2.24	D
2.25	B
2.26	A
2.27	23.96
2.28	A
2.29	316
2.30	C

2.31	54
2.32	58.4
2.33	D
2.34	C
2.35	0.57
2.36	D
2.37	A
2.38	2.5
2.39	C
2.40	B
2.41	C
2.42	A
2.43	2.25
2.44	4.44
2.45	C
2.46	D
2.47	A
2.48	B
2.49	-0.3125
2.50	A

CHAPTER 3

PN JUNCTION DIODE

QUESTION 3.1

When a *pn* junction is formed, diffusion current causes

(A) mixing of current carriers

(B) forward bias

(C) reverse bias

(D) barrier potential

QUESTION 3.2

In a p-n-junction, holes diffuse from the p-region to the n-region hence

(A) they move across the junction by the potential difference

(B) free electron available in the n-region attract them

(C) the holes concentration in the p-region is greater as compared to n-region.

(D) all of the above

QUESTION 3.3

At $T = 300\,\text{K}$, silicon *pn* junction has the following doping concentrations :

$$N_d = 10^{15}\,\text{cm}^{-3},$$

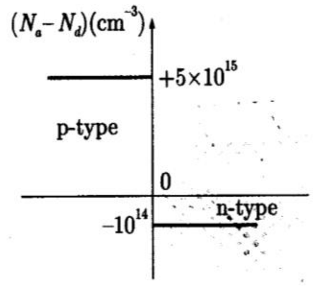
$$N_a = 10^{16}\,\text{cm}^{-3}$$

The built in potential barrier, V_{bi} in the *pn* junction will be

_______ Volt

QUESTION 3.4

A silicon *pn* junction at $T = 300\,\text{K}$ has the doping profile shown in figure



What will be the built in potential barrier in the *pn* junction ?

_______ Volt

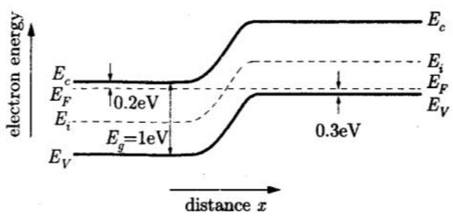
QUESTION 3.5

A silicon step junction maintained at room temperature is doped such that $E_F = E_V - 2\,kT$ on the p side and $E_F = E_C - E_G/4$ on the n side. What is the value of built in potential (V_{bi}) ?

_______ Volt

QUESTION 3.6

Consider the equilibrium energy band diagram, for the *pn* junction diode shown in Figure.



What is the value of built in potential (V_{bi}) ?

_______ Volt

QUESTION 3.7

A silicon abrupt junction in thermal equilibrium at $T = 300\text{K}$ is doped such that $E_c - E_F = 0.21\,\text{eV}$ in *n*-region and $E_F - E_v = 0.18\,\text{eV}$ in the *p* region. What will be the impurity doping concentrations N_d and N_a in *n* and *p*-regions respectively ?

	N_d in *n*-region	N_a in *p*-region
(A)	$1.024 \times 10^{14}\,\text{cm}^{-3}$	$1.186 \times 10^{14}\,\text{cm}^{-3}$
(B)	$1.186 \times 10^{14}\,\text{cm}^{-3}$	$1.024 \times 10^{14}\,\text{cm}^{-3}$
(C)	$8.43 \times 10^{15}\,\text{cm}^{-3}$	$9.97 \times 10^{15}\,\text{cm}^{-3}$
(D)	$9.97 \times 10^{15}\,\text{cm}^{-3}$	$8.43 \times 10^{15}\,\text{cm}^{-3}$

QUESTION 3.8

In previous question the built in potential barrier, V_{bi} in the *pn* junction will be

(A) 0.178 V

(B) 2.664 V

(C) 1.449 V

(D) 0.690 V

QUESTION 3.9

An abrupt silicon *pn* junction at zero bias has dopant concentrations of $N_a = 10^{17}\,\text{cm}^{-3}$ and $N_d = 5 \times 10^{15}\,\text{cm}^{-3}$ at $T = 300\,\text{K}$. What will be the differences in Fermi levels in *n* and *p*-regions ?

	$E_F - E_{Fi}$ in *n*-region	$E_{Fi} - E_F$ in *p*-region
(A)	0.3294 eV	0.4070 eV
(B)	1.571 eV	1.272 eV
(C)	1.272 eV	1.571 eV
(D)	0.4070 eV	0.3294 eV

QUESTION 3.10

We have a symmetric *p-n* silicon junction ($N_a = N_d = 10^{17}\,\text{cm}^{-3}$). If the peak electric field in the junction at break down is $5 \times 10^5\,\text{V/cm}$, what is the reverse breakdown voltage in this junction ?

_______ Volt

QUESTION 3.11

A Si step junction, maintained at room temperature under equilibrium conditions, has a *p*-side doping of $N_a = 2 \times 10^{15}/\text{cm}^3$ and an *n*-side doping of $N_d = 10^{15}/\text{cm}^3$. What is the value of electric field E at $x = 0$?

(A) $-9.56 \times 10^4\,\text{V/cm}$

(B) $-1.12 \times 10^4\,\text{V/cm}$

(C) $0.56 \times 10^4\,\text{V/cm}$

(D) $-1.68 \times 10^4\,\text{V/cm}$

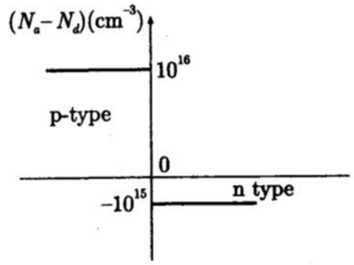
QUESTION 3.12

A *pn* junction is formed in silicon between *n*-type ($N_d = 10^{18}\,\text{cm}^{-3}$) and *p* type ($N_a = 10^{17}\,\text{cm}^{-3}$) materials for equilibrium, the maximum electric field is

_______ kV/cm.

QUESTION 3.13

Consider the impurity doping profile in a silicon *pn* junction as shown in figure. Assume that zero voltage is applied to the *pn* junction. (For Si, relative permittivity is $\varepsilon_r = 11.7$)



The built in potential barrier, V_{bi} is

_______ V

QUESTION 3.14

In previous question what will be the distances x_n and x_p that the space charge region extends into the n and p-regions respectively ?

	x_n (in μm)	x_p (in μm)
(A)	0.864	0.864
(B)	1.157	1.157
(C)	1.157	0.864
(D)	0.864	1.157

QUESTION 3.15

An abrupt Si p-n junction has $N_a = 10^{18}\,\text{cm}^{-3}$ on one side and $N_d = 5 \times 10^{15}\,\text{cm}^{-3}$ on the other and has a circular cross section with a diameter of $10\,\mu\text{m}$. What is the value of charge Q_+ in space charge region in n side?

(A) 8×10^{-4}C

(B) 1.6×10^{-1}C

(C) 3.62×10^{-12}C

(D) 2.85×10^{-14}C

QUESTION 3.16

A *pn* junction is formed in silicon between n-type ($N_D = 10^{18}\,\text{cm}^{-3}$) and p-type ($N_A = 10^{17}\,\text{cm}^{-3}$) material for equilibrium. How much of V_{bi} is dropped on the n-side and on the p-side ?

(A) 0.080, 0.80 V

(B) 0.88 V, 0.88 V

(C) 0.44 V, 0.44 V

(D) 0.16 V, 7.2 V

QUESTION 3.17

Consider a particular type of junction in an n region adjacent to an intrinsic region. This junction can be modeled as an n-type region to a lightly doped p-type region. The doping concentrations in silicon at $T = 300$ K are $N_d = 10^{16}\,\text{cm}^{-3}$ and $N_a = 10^{12}\,\text{cm}^{-3}$. Assume the junction has zero applied bias. What will be the distances x_n and x_p that the space charge region extends into the n and p-regions respectively ?

	x_n (in cm)	x_p (in cm)
(A)	2.43×10^{-3}	2.43×10^{-7}
(B)	2.43×10^{-7}	2.43×10^{-3}
(C)	1.52×10^{-7}	1.52×10^{-3}
(D)	1.52×10^{-3}	1.52×10^{-7}

QUESTION 3.18

In reverse bias, the number of minority carries crossing the junction of a diode depends primarily upon the

(A) concentration of doping impurities.

(B) rate of thermal generation of electron hole pairs

(C) magnitude of the potential barrier

(D) None of the above

QUESTION 3.19

Consider a reverse-biased gallium arsenide pn junction at $T = 300\,\text{K}$. Assume that a reverse-bias voltage, $V_R = 5\,\text{V}$ is applied. Also, consider the following parameter values for the pn junction:

$$N_a = N_d = 10^{16}\,\text{cm}^{-3},$$

$$D_p = 6\,\text{cm}^2/\text{s},$$

$$D_n = 200\,\text{cm}^2/\text{s}$$

and $\tau_{p0} = \tau_{n0} = 10^{-8}\,\text{s}$.

What will be the ideal reverse saturation current density ?

(A) $6.04 \times 10^{-18}\,\text{A/cm}^2$

(B) $1.26 \times 10^{-18}\,\text{A/cm}^2$

(C) $8.57 \times 10^{-18}\,\text{A/cm}^2$

(D) $7.30 \times 10^{-18}\,\text{A/cm}^2$

QUESTION 3.20

In previous question what will be the reverse-biased generation current density ?

(A) $1.44 \times 10^{-13}\,\text{A/cm}^2$

(B) $1.07 \times 10^{-13}\,\text{A/cm}^2$

(C) $1.93 \times 10^{-9}\,\text{A/cm}^2$

(D) $3.86 \times 10^{-9}\,\text{A/cm}^2$

QUESTION 3.21

A reverse voltage of 18 V is applied to a semiconductor diode. The voltage across the depletion layer is

(A) 0

(B) 0.7 V

(C) about 10 V

(D) 18 V

QUESTION 3.22

The leakage current of a pn diode is caused by

(A) heat energy

(B) chemical energy

(C) barrier potential

(D) majority carrier

QUESTION 3.23

An abrupt silicon pn junction has dopant concentrations of $N_a = 2 \times 10^{16}\,\text{cm}^{-3}$ and $N_d = 2 \times 10^{15}\,\text{cm}^{-3}$ at $T = 300\,\text{K}$. A reverse-bias voltage of $V_R = 8\,\text{V}$ is applied to the pn junction. (For Si, relative permittivity $\varepsilon_r = 11.7$). The total space charge width in the pn junction will be

_______ $\times 10^{-4}$ cm

QUESTION 3.24

An ideal one-sided silicon n^+p junction has uniform doping on both sides of the abrupt junction. The doping relation is $N_d = 50N_a$. The built-in potential barrier is $V_{bi} = 0.752\,\text{V}$. The maximum electric field in the junction is $E_{max} = 1.14 \times 10^5\,\text{V/cm}$ for a reverse-bias voltage of 10 V at $T = 300\,\text{K}$. What will be the impurity dopant concentrations N_d and N_a in n and p-regions respectively ?

	N_d (in cm^{-3})	N_a (in cm^{-3})
(A)	2.14×10^{17}	4.28×10^{15}
(B)	1.71×10^{15}	8.56×10^{13}
(C)	8.56×10^{13}	1.71×10^{15}
(D)	4.28×10^{15}	2.14×10^{17}

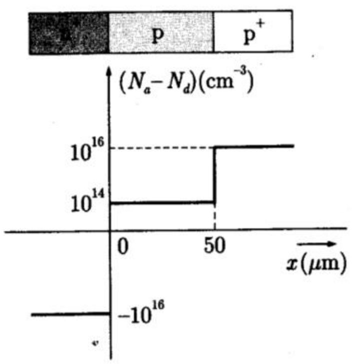
QUESTION 3.25

In previous question the distance, x_p that the space charge region extends into the p-region will be

_______ μm

QUESTION 3.26

Consider a silicon pn junction with the doping profile shown in figure at $T = 300\,\text{K}$



What is the applied reverse-bias voltage required so that the space charge region extends entirely through the p region ?

_______ V

QUESTION 3.27

Consider two p^+n silicon junctions reverse biased at 300 K. The impurity doping concentrations in junction A are $N_a = 10^{18}\,\text{cm}^{-3}$ and $N_d = 10^{15}\,\text{cm}^{-3}$, and those in junction B are $N_a = 10^{18}\,\text{cm}^{-3}$ and $N_d = 10^{16}\,\text{cm}^{-3}$. If W_A be the space charge width in junction A and W_B be the space charge width in junction B then, the ratio $\frac{W_A}{W_B}$ will be

____

QUESTION 3.28

A uniformly doped silicon p^+n junction at $T = 300\,\text{K}$ is to be designed such that at a reverse-bias voltage of $V_R = 10\,\text{V}$, the maximum electric field is limited to $E_{max} = 10^6\,\text{V/cm}$. What will be the maximum doping concentration in the n region ?

(A) $3.24 \times 10^{11}\,\text{cm}^{-3}$

(B) $3.24 \times 10^{17}\,\text{cm}^{-3}$

(C) $5.18 \times 10^{-2}\,\text{cm}^{-3}$

(D) $6.48 \times 10^{17}\,\text{cm}^{-3}$

QUESTION 3.29

The peak electric field in a reverse-biased silicon pn junction is $|E_{max}| = 3 \times 10^5\,\text{V/cm}$. The doping concentrations are $N_d = 4 \times 10^{15}\,\text{cm}^{-15}$ and $N_a = 4 \times 10^{17}\,\text{cm}^{-3}$ at $T = 300\,\text{K}$. What will be the magnitude of the reverse-bias voltage ?

_______ Volt

QUESTION 3.30

An abrupt Si p-n junction ($A = 10^{-4}\,\text{cm}^2$) have $N_d = 10^{15}\,\text{cm}^{-3}$ (in n side), $N_a = 10^{17}\,\text{cm}^{-3}$ (in p-side). If the intrinsic concentration of Si is $1.5 \times 10^{10}\,\text{cm}^{-3}$, then what is the total depletion capacitance at $-4\,\text{V}$?

_______ pF

QUESTION 3.31

A silicon n^+p junction is biased at $V_R = 10\,\text{V}$. The doping in the p region increases by a factor of 2. The percent change in junction capacitance will be (neglecting the change in built in potential)

____

QUESTION 3.32

GaAs pn junction at $T = 300\,\text{K}$ has impurity doping concentrations of $N_a = 10^{16}\,\text{cm}^{-3}$ and $N_d = 5 \times 10^{16}\,\text{cm}^{-3}$. For a particular device application, the ratio of junction capacitance at two values of reverse bias voltage must be $\frac{C'(V_{R1})}{C'(V_{R2})} = 3$ where the reverse bias voltage $V_{R1} = 1\,\text{V}$. What will be the reverse bias voltage, V_{R2} ?

_______ Volt

QUESTION 3.33

In a p^+n junction, reverse biased at 10 V, the capacitance is 10 PF. If the doping of the n side is doubled and the reverse bias is changed to 80 V, what is the capacitance ?

_______ pF

QUESTION 3.34

A Si junction has $N_d = 10^{17}$ cm^{-3} and $N_a = 10^{18}$cm^{-3}. The junction area is 100 μm^2, intrinsic concentration of Si is $n_i = 1.08 \times 10^{10}$ cm^{-3}, and relative permittivity is $\varepsilon_r = 11.8$. What is the junction capacitance at applied voltage, $V_a = -5$ V ?

_______ pF

QUESTION 3.35

A silicon p^+n junction at $T = 300$ K has doping concentrations of $N_a = 10^{18}$ cm^{-3} and $N_d = 5 \times 10^{15}$ cm^{-3}. The cross-sectional area of the junction is $A = 5 \times 10^{-5}$ cm^2. What will be the junction capacitance for the applied reverse voltage, $V_R = 3$ V ?

(A) 2.605 nF

(B) 1.042 nF

(C) 0.005 pF

(D) 0.521 pF

QUESTION 3.36

A silicon p-n junction has a built in potential of 0.65 V. The acceptor concentration on the p-side is 100 times greater than the donor concentration on the n-side, and a reverse bias of 10 V is applied. What is the width of the depletion region

(A) 4.22×10^4 cm

(B) 0.576×10^{-4} cm

(C) 0.422×10^4 cm

(D 5.76×10^{-4} cm

QUESTION 3.37

In previous question what is the value of depletion capacitance per unit area?

(A) 4.22 nF/cm^2

(B) 5.22 nF/cm^2

(C) 1.797 nF/cm^2

(D) 1.797 pF/cm^2

QUESTION 3.38

An abrupt silicon junction at $T = 300$ K is uniformly doped with $N_a = 10^{18}$cm^{-3} and $N_d = 10^{15}$cm^{-3}. The pn junction area is 6×10^4 cm^2. An inductance of 2.2 millihenry is placed in parallel with the pn junction. What will be the resonant frequency of the circuit for reverse-bias voltage of $V_R = 1$ V ?

_______ MHz

QUESTION 3.39

Under he application of a bias, in a typical p-n junction structure, the hole current contribution is around 40% of the total current. As a designer, what will you do to increase this hole current contribution to 80%?

(A) Increase the p dopant concentration to double of its existing value

(B) Reduce the n dopant concentration to half of its existing value

(C) Increase the n dopant concentration to double of its existing value.

(D) (A) and (B)

QUESTION 3.40

Consider an ideal pn junction diode at $T = 300$ K operating in the forward-bias region. The change in diode voltage that will cause a factor of 10 increase in current will be

_______ mV

QUESTION 3.41

The applied reverse-bias voltage at which the ideal reverse current in a pn junction diode at $T = 300\,\text{K}$ reaches 90 percent of its reverse saturation current value is

(A) 59.6 mV

(B) 2.30 V

(C) 1.54 mV

(D) 2.73 mV

QUESTION 3.42

Consider a silicon pn junction at $T = 300\,\text{K}$ with doping concentration of $N_d = N_a = 5 \times 10^{19}\,\text{cm}^{-3}$. The space charge width at a forward-bias voltage of $V_a = 0.40\,\text{V}$ will be

(A) 8.75×10^{-15} cm

(B) 6.19×10^{-7} cm

(C) 4.37×10^{-7} cm

(D) 3.83×10^{-15} cm

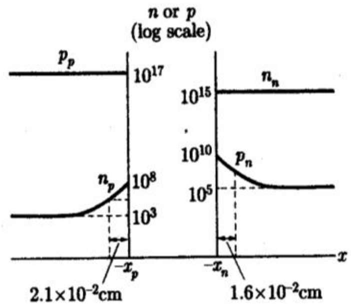
QUESTION 3.43

Consider two ideal pn junctions at $T = 300\,\text{K}$ having exactly the same electrical and physical parameters except for the bandgap energy of the semiconductor materials. The first pn junction has a bandgap energy of 0.525 eV and a forward-bias current of 10mA with $V_a = 0.255\,\text{V}$. If a forward-bias voltage of $V_a = 0.32\,\text{V}$ produces a current of $10\,\mu A$, what will be the bandgap energy of the second pn junction ?

_______ eV

QUESTION 3.44

The figure shown below is a dimensioned plot of the steady state carrier concentrations inside a pn junction diode maintained at room temperature.



What is the bias condition of the diode?

(A) Forward biased

(B) Reverse Biased

(C) Unbaised

(D) Can't say

QUESTION 3.45

In previous question what is the value of applied voltage magnitude (V_A) ?

(A) 0.70 V

(B) 1.70 V

(C) 0.3 V

(D) 1.30 V

QUESTION 3.46

A silicon diode, with $N_d = 5 \times 10^{17}\,\text{cm}^{-3}$ and $N_a = 10^{17}\,\text{cm}^{-3}$, is forward biased with $V_a = 0.5\,\text{V}$. Assume that the intrinsic concentration of silicon is $n_i = 1.08 \times 10^{10}\,\text{cm}^{-3}$. What are the minority carrier concentrations $\Delta n_p(x_n)$ and $\Delta p_n(x_n)$ at the edge of transition region ?

(A) $\Delta n_p(x_p) = 2.6 \times 10^{11}\text{cm}^{-3}$, $\Delta p_n(x_n) = 5.1 \times 10^{10}\text{cm}^{-3}$

(B) $\Delta n_p(x_p) = 5 \times 10^{17}$, $\Delta p_n(x_n) = 10^{17}\text{cm}^{-3}$

(C) $\Delta n_p(x_p) = 2.33 \times 10^{2}\text{cm}^{-3}$, $\Delta p_n(x_n) = 1.17 \times 10^{8}\text{cm}^{-3}$

(D) $\Delta n_p(x_p) = 5.97 \times 10^{7}\text{cm}^{-3}$, $\Delta p_n(x_n) = 9.7 \times 10^{6}\text{cm}^{-3}$

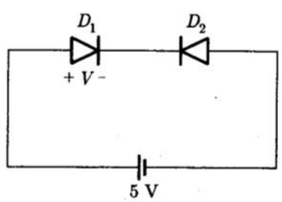
QUESTION 3.47

A silicon diode is used to measure temperature by operating the diode at a fixed forward-bias current. The forward-bias voltage is then a function of temperature. At $T = 300\,\text{K}$, the diode voltage is found to be $0.60\,\text{V}$. What will be the diode voltage at $T = 310\,\text{K}$?

_______ Volt

QUESTION 3.48

Two p-n germanium diodes are connected in series opposing, as shown in figure.



A 5 V battery is impressed upon this series arrangement. What is the value of voltage V at room temperature ?

_______ Volt

QUESTION 3.49

Consider a p^+n silicon diode at $T = 300\,\text{K}$. The slope of the diffusion capacitance versus forward-bias current is $2.5 \times 10^{-6}\,\text{F/A}$. What is the hole lifetime ?

(A) $5.02 \times 10^{-6}\,\text{s}$

(B) $6.5 \times 10^{-8}\,\text{s}$

(C) $4.83 \times 10^{-6}\,\text{s}$

(D) $1.3 \times 10^{-7}\,\text{s}$

QUESTION 3.50

In a forward biased, with $N_a >> N_d$, product to the diffusion capacitance C_D and the dynamic diode resistance r equals

(A) $1/\tau_p$

(B) τ_p

(C) τ_{p2}

(D) $\frac{1}{t_p^2}$

QUESTION 3.51

The minimum small-signal diffusion resistance of an ideal forward-biased silicon pn junction diode at $T = 300\,\text{K}$ is to be $r_D = 48\,\Omega$. The reverse saturation current is $I_s = 2 \times 10^{-11}\,\text{A}$. The maximum applied forward-bias voltage that can be applied to meet this specification is

_______ Volt

QUESTION 3.52

Consider a p^+n silicon diode at $T = 300\,\text{K}$ The diode is forward biased at a current of $1\,\text{mA}$. The hole lifetime in the region is 10^{-7}s. The diode impedance at a frequency of $10\,\text{kHz}$ will be (Neglect the depletion capacitance)?

(A) $25.64 - j8.26 \times 10^{-3}$

(B) $25.9 - j0.0814$

(C) $0.039 + j1.21 \times 10^{-4}$

(D) $25.9 + j0.0814$

QUESTION 3.53

A silicon pn junction diode at $T = 300\,\text{K}$ has a cross-sectional area of 10^{-2}cm^2. Length of the p region is $0.2\,\text{cm}$, and the length of the n region is $0.1\,\text{cm}$. The doping concentrations are $N_d = 10^{15}\,\text{cm}^{-3}$ and $N_a = 10^{16}\,\text{cm}^{-3}$. The series resistance of the diode approximately equals to

_______ Ω

QUESTION 3.54

Assume that the reverse saturation current in a diode is $I_s = 10^{-10}$ A at $T = 300$ K. The resistivity of the n region is $0.2\,\Omega$–cm, and the resistivity of the p region is $0.1\,\Omega$-cm. The length of each neutral region is 10^{-2}cm and the cross-sectional area is $2 \times 10^{-5}\,\text{cm}^2$. What is the required applied voltage to achieve the current of 1 mA ?

(A) 0.717 V

(B) 0.417 V

(C) 0.146 V

(D) 0.567 V

QUESTION 3.55

Consider a p^+n silicon diode at $T = 300$ K with doping concentrations of $N_a = 10^{18}\text{cm}^{-3}$ and $N_d = 10^{16}\text{cm}^{-3}$. The minority carrier hole diffusion coefficient is $D_p = 12\,\text{cm}^2/\text{s}$ and the minority carrier hole lifetime is $\tau_{pO} = 10^{-7}$s. The cross-sectional area is $A = 10^{-4}\text{cm}^2$. The diode current at a forward-bias voltage of 0.50 V will be

(A) 4.14×10^{-15} A

(B) 2.42×10^{-7} A

(C) 9.54×10^{-7} A

(D) 27.15×10^{-15} A

QUESTION 3.56

Consider an ideal silicon pn junction diode with the following parameters :

$$\tau_{n0} = \tau_{p0} = 0.1 \times 10^{-6}\,\text{s},$$

$$D_n = 25\,\text{cm}^2/\text{s},$$

$$D_p = 10\,\text{cm}^2/\text{s}$$

What must be the value of N_a/N_d so that 95 percent of the current in the depletion region is carried by electrons ?

QUESTION 3.57

Two ideal p^+n step junction diodes maintained at room temperature are identical except that $N_{D1} = 10^{15}/\text{cm}^3$ and $N_{D2} = 10^{16}/\text{cm}^3$. If the currents through the diodes be I_{D1} and I_{D2}, then the ratio $I_{D1}/I_{D2} =$

QUESTION 3.58

A germanium p^+n diode at $T = 300$ K has the following parameters:

$$N_a = 10^{18}\,\text{cm}^{-3},$$

$$N_d = 10^{16}\,\text{cm}^{-3},$$

$$D_p = 49\,\text{cm}^2/\text{s},$$

$$D_n = 100\,\text{cm}^2/\text{s},$$

$$\tau_{p0} = \tau_{n0} = 4\mu s$$

and $$A = 10^{-4}\,\text{cm}^2.$$

The diode current for a forward-bias voltage of 0.2 V will be

(A) 2.29 kA

(B) 2.41 μA

(C) 0.99 A

(D) 6.55 μA

QUESTION 3.59

In previous question the diode current for a reverse-bias voltage of 0.2 V will be

(A) −1.29 pA

(B) −2.91 nA

(C) −0.34 pA

(D) −2.91 μA

QUESTION 3.60

The cross-sectional area of the silicon pn junction is 10^{-3}cm^2 The temperature of the diode is $T = 300\,\text{K}$, and the doping concentrations are $N_d = 10^{16}\,\text{cm}^{-3}$ and $N_a = 8 \times 10^{15}\,\text{cm}^{-3}$. Assume minority carrier lifetimes of $\tau_{n0} = 10^{-6}\,\text{s}$ and $\tau_{p0} = 10^{-7}\,\text{s}$. A forward bias voltage of $V_a = 0.3\,\text{V}$ is applied to the silicon pn junction. The total number of excess electrons in the p region will be

(A) 6.55×10^3

(B) 1.78×10^4

(C) 3.95×10^4

(D) 1.07×10^5

QUESTION 3.61

In previous question the total number of excess holes in the n region will be

(A) 2.97×10^4

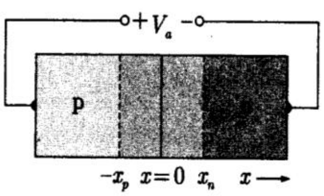
(B) 0.24×10^3

(C) 1.19×10^3

(D) 2.68×10^3

QUESTION 3.62

A silicon step junction has uniform impurity doping concentrations of $N_a = 5 \times 10^{15}\,\text{cm}^{-3}$ and $N_d = 1 \times 10^{15}\,\text{cm}^{-3}$, and a cross-sectional area of $A = 10^{-4}\text{cm}^2$. Let $\tau_{n0} = 0.4\,\mu\text{s}$ and $\tau_{p0} = 0.1\,\mu\text{s}$, hole mobility $\mu_p = 480\,\text{cm}^2/\text{V-s}$, electron mobility $\mu_n = 1350\,\text{cm}^2/\text{V-s}$. Consider the geometry shown in figure.



The ideal reverse saturation current due to holes will be

(A) $4.02 \times 10^{-14}\,\text{A}$

(B) $4.46 \times 10^{-9}\,\text{A}$

(C) $4.02 \times 10^{-10}\,\text{A}$

(D) $0.324 \times 10^{-14}\,\text{A}$

QUESTION 3.63

In previous question the ideal reverse saturation current due to electrons will be

(A) $0.19 \times 10^{-15}\,\text{A}$

(B) $2.52 \times 10^{-9}\,\text{A}$

(C) $6.74 \times 10^{-15}\,\text{A}$

(D) $6.74 \times 10^{-11}\,\text{A}$

QUESTION 3.64

In previous question if the applied voltage, $V_a = \frac{1}{2} V_{bi}$ then, the hole concentration at x_n will be

(A) $3.42 \times 10^{10}\,\text{cm}^{-3}$

(B) $1.52 \times 10^5\,\text{cm}^{-3}$

(C) $2.42 \times 10^5\,\text{cm}^{-3}$

(D) $3.42 \times 10^5\,\text{cm}^{-3}$

QUESTION 3.65

Consider a diode with a junction capacitance of 18 pF at zero bias and 4.2 pF at a reverse bias voltage of $V_R = 10\,\text{V}$. The minority carrier lifetime is 10^{-7}s. The diode is switched from a forward bias with a current of 2 mA to a reverse bias voltage of 10 V applied through a 10 kΩ resistor. The turn-off time will be

_______ $\times 10^{-7}$ sec

QUESTION 3.66

Avalanche breakdown in a semiconductor or diode occurs if

(A) forward current exceeds a certain value

(B) reverse bias exceeds a certain value.

(C) forward bias exceeds a certain value

(D) the potential barrier is reduced to zero.

QUESTION 3.67

Zener breakdown depends on

(A) electric field created across the depletion region

(B) velocity of the carries

(C) number of donor ions

(D) number. of acceptor ions

QUESTION 3.68

The critical electric field for breakdown in silicon is approximately $E_{crit} = 4 \times 10^5$ V/cm. What will be the maximum n-type doping concentration in an abrupt silicon p^+n junction such that the breakdown voltage is 30 V ?

(A) 1.47×10^{15} cm^{-3}

(B) 1.73×10^{16} cm^{-3}

(C) 2.95×10^{15} cm^{-3}

(D) 3.46×10^{16} cm^{-3}

QUESTION 3.69

A p^+n Si diode having built in potential $V_{bi} = 0.956$ has a donor doping of 10^{17}cm^{-3}, n-region width $= 1\,\mu$m, and avalanche breakdown $V_{avalanche} = 13$ V. Which of the following breakdown occurs in the diode ?

(A) avalanche breakdown

(B) punch through breakdown

(C) both breakdown occurs

(D) None of the above

QUESTION 3.70

An abrupt p^+n junction is formed in Si with a donor doping of $N_d = 10^{15}$cm^{-3}. What is the minimum thickness of the n -region to ensure avalanche breakdown rather than punch through? (Assume that breakdown voltage is $V_{br} = 300$ V)

_______ μm

QUESTION 3.71

An abrupt silicon p^+n junction has an n-region doping concentration of $N_d = 5 \times 10^{15}$ cm. What must be the minimum n-region width such that avalanche breakdown occurs before the depletion region reaches punch through ? (Assume breakdown voltage for silicon, $V_B = 100$ V)

_______ μm

QUESTION 3.72

An abrupt p^+n junction is formed in silicon with a donor doping of $N_d = 10^{15}$ cm^{-3} and acceptor doping of $N_a = 10^{19}$cm^{-3}. If the length of the n-region is $22\,\mu$m, and the junction is operated at a reverse bias of 300 V (which is also the breakdown voltage for the junction), then the device operates in

(A) avalanche breakdown

(B) zener breakdown

(C) punch through

(D) ohmic region

QUESTION 3.73

Which of the following diodes show the negative resistance region?

(A) pn junction diode

(B) Zener diode

(C) Tunnel diode

(D) PIN

QUESTION 3.74

Tunnel diode is made by following semiconductors

(A) highly doped

(B) sparsely doped

(C) intrinsic

(D) none of the above

QUESTION 3.75

The main reason why electrons can tunnel through a *pn* junction is that

(A) they have high energy

(B) barrier potential is very low

(C) depletion layer is extremely thin

(D) impurity level is low

QUESTION 3.76

Mark the INCORRECT statement
A varactor diode

(A) has variable capacitance

(B) utilizes transition capacitance of a junction

(C) has always a uniform doping profile

(D) is often used as automatic frequency control device

QUESTION 3.77

Radiation emitted by LED can be seen in the

(A) ultraviolet region

(B) visible spectrum

(C) infrared region

(D) visible as well as infrared region

QUESTION 3.78

The efficiency of an LED for generating light is directly proportional to the

(A) temperature

(B) voltage applied

(C) level of doping used

(D) current injected

QUESTION 3.79

A photodiode is a type of

(A) photo-conductive cell

(B) photo-voltaic cell

(C) semiconductor p-n junction diode

(D) light dependent resistor

QUESTION 3.80

In case a reverse biased photodiode is kept in dark condition, the current flowing through the device corresponds to

(A) maximum value of current which can flow through the device

(B) value of reverse saturation current

(C) normal value of current

(D) zero

QUESTION 3.81

In a photo-transistor, light is focused to fall on

(A) emitter-to-base junction

(B) collector-to-base junction

(C) base region only

(D) all the three regions of the transistor

QUESTION 3.82

Transferred electron mechanism involved in Gunn diode consists in transfer of electrons

(A) from valence band to conduction band

(B) from valence band to satellite valley

(C) from central valley to satellite valley

(D) from satellite valley to central valley

****

Answer

3.1	D
3.2	C
3.3	0.635
3.4	0.557
3.5	0.89
3.6	0.5
3.7	C
3.8	D
3.9	A
3.10	16.32
3.11	B
3.12	15.5
3.13	0.635V
3.14	A
3.15	D
3.16	A
3.17	B
3.18	B
3.19	C
3.20	C
3.21	D
3.22	A
3.23	2.48
3.24	D
3.25	C
3.26	193V
3.27	3.13
3.28	B
3.29	73
3.30	0.4198
3.31	41.4
3.32	18.6
3.33	5
3.34	0.036
3.35	D
3.36	D
3.37	C
3.38	1.67
3.39	D
3.40	59.6
3.41	A

3.42	B
3.43	0.769
3.44	A
3.45	C
3.46	A
3.47	0.5827
3.48	0.018
3.49	D
3.50	B
3.51	0.443
3.52	B
3.53	72.3
3.54	D
3.55	C
3.56	0.083
3.57	10
3.58	D
3.59	B
3.60	B
3.61	D
3.62	A
3.63	C
3.64	A
3.65	2.21
3.66	B
3.67	A
3.68	B
3.69	A
3.70	um
3.71	5.09
3.72	A
3.73	C
3.74	A
3.75	C
3.76	C
3.77	D
3.78	D
3.79	C
3.80	B
3.81	B
3.82	C

CHAPTER 4

BJT

QUESTION 4.1

When a p-n-p transistor is properly biased to operate in active region the holes from emitter.

(A) diffuse through base into collector region

(B) recombine with electrons in base

(C) recombine with electrons in emitter

(D) none of above

QUESTION 4.2

The emitter of a transistor is generally doped the heaviest because it

(A) has to dissipate maximum power

(B) has to supply the charge carriers

(C) is the first region of the transistor

(D) must possess low resistance

QUESTION 4.3

In a *pnp* transistor operating in active region, the main stream of current is

(A) drift of holes

(B) drift of electrons

(C) diffusion of holes

(D) diffusion of electrons.

QUESTION 4.4

Pick up the most appropriate alternative
In an *npn* diffused junction transistor, the p-type base region is formed on the n-type collector region through process of

(A) change in the nature of doping during crystal growth

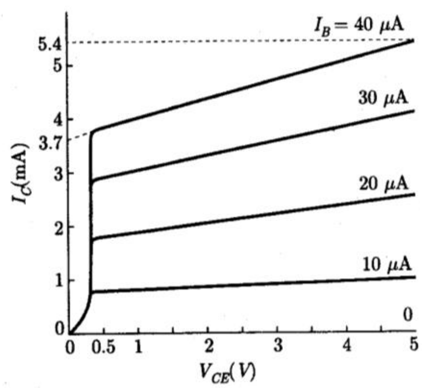
(B) epitaxially

(C) alloying

(D) diffusion of n-type impurity

QUESTION 4.5

Consider the transistor whose I_C-V_{CE} curves are shown in figure.



What is the value of early voltage (Volt)?

(A) -11 V

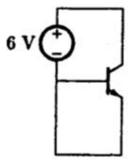
(B) 0.5 V

(C) -100 V

(D) -20 V

QUESTION 4.6

Consider the transistor shown in figure below.



What is the region of operation of the transistor ?

(A) Forward-Active

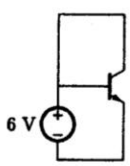
(B) Reverse-Active

(B) Saturation

(D) Cut off

QUESTION 4.7

Consider the transistor shown in figure below :



The transistor is operating in

(A) Forward-Active region

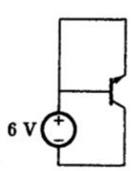
(B) Reverse-Active region

(C) Saturation region

(D) Cutoff region

QUESTION 4.8

Consider the transistor shown in figure below.



The transistor is operating in

(A) Forward-Active region

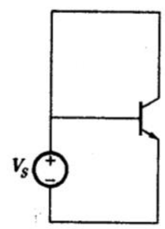
(B) Reverse-Active region

(C) Saturation region

(D) Cut off region

QUESTION 4.9

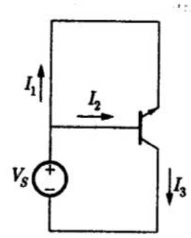
Consider the circuit shown below. For the source voltage $V_S = 0.63\,\text{V}$, the currents are $I_C = 275\,\mu\text{A}$ and $I_B = 5\,\mu\text{A}$.



The forward common emitter gain β_F is

QUESTION 4.10

Consider the circuit shown below. If $V_S = 0.63\,\text{V}$, $I_1 = 275\,\mu\text{A}$, and $I_2 = 125\,\mu\text{A}$ then the value of I_3 is



(A) $-400\,\mu\text{A}$

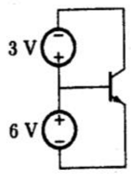
(B) $400\,\mu\text{A}$

(C) $-600\,\mu\text{A}$

(D) $600\,\mu\text{A}$

QUESTION 4.11

The transistor given below is operating in



(A) Forward-Active region

(B) Reverse-Active region

(C) Saturation region

(D) Cutoff region

QUESTION 4.12

For operation of *pnp* amplifier, the base of the amplifier must be

(A) 0 V

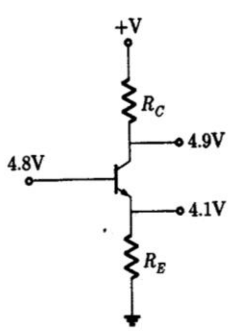
(B) positive with respect to collector

(C) negative with respect to collector

(D) greater than the collector current

QUESTION 4.13

Consider the transistor shown in figure below.



The mode of operation of the transistor is

(A) reverse active mode

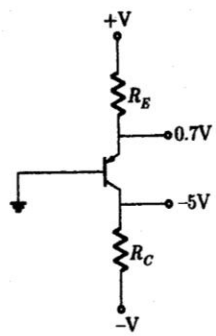
(B) cut off mode

(C) forward active mode

(D) saturation mode

QUESTION 4.14

What is mode of operation of the transistor circuit shown in figure below?



(A) reverse active mode

(B) cut off mode

(C) forward active mode

(D) saturation mode

QUESTION 4.15

The conductivity of the emitter region of a BJT is kept

(A) same as that of base region

(B) much larger than that of base region

(C) same as that of collector region

(D) much smaller than that of base region

QUESTION 4.16

The concentration of minority carriers in the base region at the collector end of a *pnp* transistor operating in the active region is

(A) zero

(B) same as at J_E

(C) thermal equilibrium value p_{n0}

(D) thermal equilibrium value n_{p0} in the collector region

QUESTION 4.17

An *npn* silicon bipolar transistor at $T = 300\,\mathrm{K}$ has uniform dopings of $N_B = 10^{17}\,\mathrm{cm}^{-3}$ and $N_C = 7\times10^{15}\,\mathrm{cm}^{-3}$. The transistor is operating in the inverse-active mode with $V_{BE} = -2\,\mathrm{V}$ and $V_{BC} = 0.565\,\mathrm{V}$. The minority carrier concentrations (in cm^{-3}) at $x = x_B$ and $x'' = 0$ will be respectively

(A) 6.7×10^{12}, 9.56×10^{13}

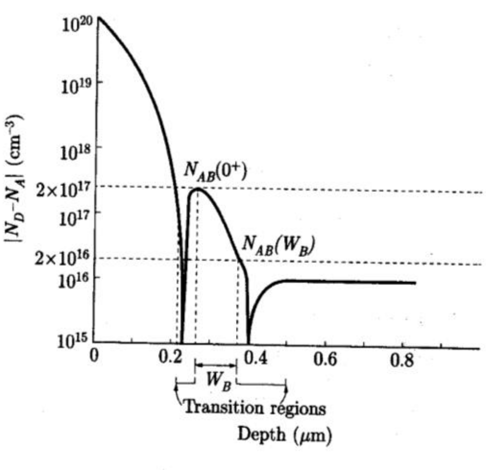
(B) 2.97×10^{12}, 9.56×10^{13}

(C) 6.7×10^{12}, 2.97×10^{9}

(D) 2.97×10^{12}, 2.97×10^{9}

QUESTION 4.18

Consider the figure shown below.



What is the value of η ?

QUESTION 4.19

In previous question what is the built in electric field (E) in the base ?

_______ kV/cm

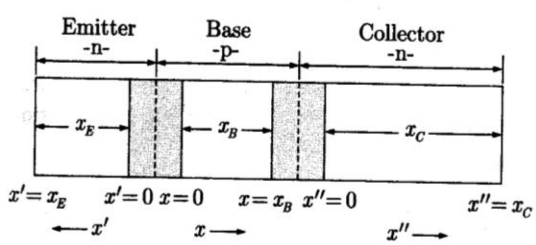
QUESTION 4.20

The parameters in the base region of an *npn* bipolar transistor are $D_n = 20\,\mathrm{cm}^2/\mathrm{s}$, $n_{B0} = 10^4\,\mathrm{cm}^{-3}$, $x_B = 1\,\mu\mathrm{m}$, and $A_{BE} = 10^{-4}\,\mathrm{cm}^2$. What will be the collector current for $V_{BE} = 0.5\,\mathrm{V}$?

_______ μA

QUESTION 4.21

A uniform doped silicon *pnp* transistor is biased in the forward-active mode. Its geometry has been shown in the figure below. The doping concentrations are $N_E = 10^{18}\,\mathrm{cm}^{-3}$, $N_B = 5\times10^{16}\,\mathrm{cm}^{-3}$ and $N_C = 10^{15}\,\mathrm{cm}^{-3}$.



What will be the thermal equilibrium minority carrier concentrations, n_{E0}, p_{B0} and n_{C0} (in cm^{-3})?

	n_{E0}	p_{B0}	n_{C0}
(A)	2.25×10^{2}	2.25×10^{5}	4.5×10^{3}
(B)	2.25×10^{2}	4.5×10^{3}	2.25×10^{5}
(C)	4.5×10^{3}	2.25×10^{2}	2.25×10^{5}
(D)	4.5×10^{3}	2.25×10^{5}	2.25×10^{2}

QUESTION 4.22

In previous question for $V_{EB} = 0.650\text{ V}$, total minority carrier hole concentration, p_B at $x = 0$ will be

(A) $4.68 \times 10^{3}\text{ cm}^{-3}$

(B) $7.93 \times 10^{13}\text{ cm}^{-3}$

(C) $5.54 \times 10^{4}\text{ cm}^{-3}$

(D) $3.57 \times 10^{14}\text{ cm}^{-3}$

QUESTION 4.23

In Q 21, for $V_{EB} = 0.650\text{ V}$, total minority carrier (electron) concentration, n_E at $x' = 0$ will be

(A) $1.78 \times 10^{13}\text{ cm}^{-3}$

(B) $7.91 \times 10^{12}\text{ cm}^{-3}$

(C) $2.34 \times 10^{2}\text{ cm}^{-3}$

(D) $4.31 \times 10^{2}\text{ cm}^{-3}$

QUESTION 4.24

A uniformly doped silicon *pnp* bipolar transistor at $T = 300\text{ K}$ with dopings of $N_E = 5 \times 10^{17}\text{ cm}^{-3}$, $N_B = 10^{16}\text{ cm}^{-3}$ and $N_C = 5 \times 10^{14}\text{ cm}^{-3}$ is biased in the inverse-active mode. What is the maximum B-C voltage so that the low-injection condition applied ?

_______ Volt

QUESTION 4.25

A silicon *npn* bipolar transistor is uniformly doped and biased in the forward-active region. The transistor doping concentrations are

$$N_E = 5 \times 10^{17}\text{ cm}^{-3},$$

$$N_B = 10^{16}\text{ cm}^{-3},$$

and $$N_C = 10^{15}\text{ cm}^{-3}.$$

What will be the values of p_{E0}, n_{B0} and p_{C0} (in cm^{-3})?

	p_{E0}	n_{B0}	p_{C0}
(A)	4.5×10^{2}	2.25×10^{4}	2.25×10^{5}
(B)	2.25×10^{4}	4.5×10^{2}	2.25×10^{5}
(C)	2.25×10^{5}	2.25×10^{4}	4.5×10^{2}
(D)	4.5×10^{2}	2.25×10^{5}	2.25×10^{4}

QUESTION 4.26

An *npn* silicon transistor is biased in the inverse active mode with $V_{BE} = -3\text{ V}$ and $V_{BC} = 0.6\text{ V}$. The doping concentrations are

$$N_E = 10^{18}\text{ cm}^{-3},$$

$$N_B = 10^{17}\text{ cm}^{-3}$$

and $$N_C = 10^{16}\text{ cm}^{-3}.$$

Other parameters are

$$x_B = 1\,\mu\text{m},$$

$$\tau_{E0} = \tau_{B0} = \tau_{C0} = 2 \times 10^{-7}\text{ s},$$

$$D_E = 10\text{ cm}^2/\text{s},$$

$$D_B = 20\text{ cm}^2/\text{s},$$

$$D_C = 15\text{ cm}^2/\text{s}$$

and $$A = 10^{-3}\text{ cm}^2.$$

The collector and emitter currents in the transistor will be respectively (Neglect geometry factors and assume that the recombination factor is unity)

(A) $1.19\text{ mA}, 0.829\text{ mA}$

(B) $0.829\text{ mA}, 1.19\text{ mA}$

(C) $0.359\text{ mA}, 0.47\text{ mA}$

(D) $0.47\text{ mA}, 0.359\text{ mA}$

QUESTION 4.27

A silicon *pnp* bipolar transistor at $T = 300\text{ K}$ has uniform dopings of $N_E = 10^{18}\text{ cm}^{-3}$, $N_B = 10^{16}\text{ cm}^{-3}$ and $N_C = 10^{15}\text{ cm}^{-3}$. The metallurgical base width is 1.2 cm. Let $D_B = 10\text{ cm}^2/\text{s}$ and $\tau_{B0} = 5 \times 10^{-7}\text{ s}$. Assume that the minority carrier hole concentration in the base can be approximated by a linear distribution. Let $V_{EB} = 0.625\text{ V}$ and $V_{BC} = 5\text{ V}$. The distances x_n that the space charge region extends into the n region (base) is _______ $\times 10^{-4}\text{ cm}$?

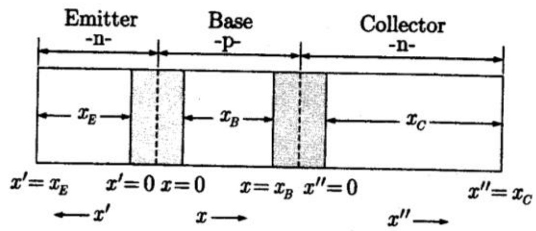
QUESTION 4.28

In previous question what will be the hole diffusion current density in the base ?

_______ (A/cm²)

QUESTION 4.29

Consider the geometry of an *npn* transistor as shown in figure below.



A uniformly doped silicon *npn* bipolar transistor is to be biased in the forward-active mode with the B-C junction reverse biased by 3 V. The metallurgical base width is 1.10 μm. The transistor dopings are $N_E = 10^{17}\,\text{cm}^{-3}$, $N_B = 10^{16}\,\text{cm}^{-3}$ and $N_C = 10^{15}\,\text{cm}^{-3}$ at $T = 300$ K. What is the required B-E voltage at which the minority carrier electron concentration at $x = 0$ is 10 percent of the majority carrier hole concentration ?

(A) 0.016 V

(B) 24.51 V

(C) 0.0408 V

(D) 0.635 V

QUESTION 4.30

Consider a Si *pnp* BJT with

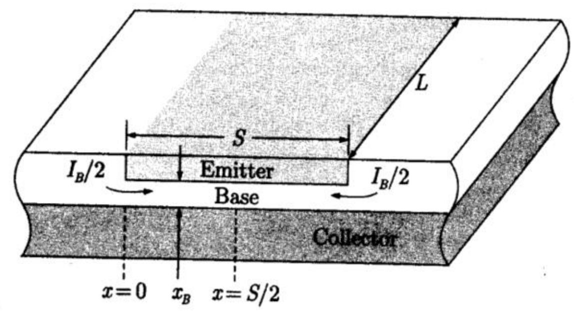
$N_{DE} = 10^{18}/\text{cm}^3$, $N_{AB} = 10^{16}/\text{cm}^3$ and $N_{DC} = 10^{15}/\text{cm}^3$

The net potential difference between the collector and emitter is

_______ Volt

QUESTION 4.31

Consider the *npn* transistor shown in figure.



Assume that one-half of the base current enters from each side of the emitter strip and flows uniformly to the centre of the emitter. Assume the following parameters for the transistor:

$$N_B = 10^{16}\,\text{cm}^{-3} \qquad x_B = 0.70\,\mu\text{m}$$

$$\mu_p = 400\,\text{cm}^2/\text{V-s} \qquad S = 8\,\mu\text{m}$$

$$\text{Emitter length} \quad L = 100\,\mu\text{m}$$

The resistance between $x = 0$ and $x = S/2$ for the flow of base current (I_B) will be

_______ Ω

QUESTION 4.32

In previous question if $I_B = 20\,\mu\text{A}$ then, the voltage drop between $x = 0$ and $x = S/2$ will be

_______ mV

QUESTION 4.33

In Q 31, if $V_{BE} = 0.6$ V at $x = 0$ then what will be the percentage of the number of electrons being injected into the base at $x = S/2$, compared to $x = 0$.

____

QUESTION 4.34

A Si *pnp* BJT with $N_{AE} = 5 \times 10^{17}/\text{cm}^3$, $N_{DB} = 10^{15}/\text{cm}^3$, $N_{AC} = 10^{14}/\text{cm}^3$ and $w_B = 3\,\mu\text{m}$ is maintained under equilibrium conditions at room temperature. What is the net potential difference between the collector and emitter ?

_______ Volt

QUESTION 4.35

In previous question if built in potential of E-B junction is 0.757 V, then the maximum magnitude of the electric field in the E-B depletion region is

_______ $\times 10^4$ V/cm

QUESTION 4.36

A uniformly doped silicon *pnp* bipolar transistor to be designed with $N_E = 10^{19}\,\text{cm}^{-3}$ and $N_C = 10^{16}\,\text{cm}^{-3}$. The metallurgical base width is $0.75\,\mu\text{m}$. What will be the minimum base doping so that the punch-through voltage is no less than $V_{pt} = 25$ V ?

(A) $1.95 \times 10^{16}\,\text{cm}^{-3}$

(B) $2.95 \times 10^{16}\,\text{cm}^{-3}$

(C) $1.67 \times 10^{26}\,\text{cm}^{-3}$

(D) $4.31 \times 10^{28}\,\text{cm}^{-3}$

QUESTION 4.37

In a BJT with $I_{c0} = 1\,\mu\text{A}$, $\alpha = 0.99$, the value of I_{CE0} is

(A) 0.01 μA

(B) 0.1 μA

(C) 1 μA

(D) 100 μA

QUESTION 4.38

An *npn* BJT is operating in the forward active region. Assuming the reverse saturation current $I_S = 10^{-16}$ A and $\beta_F = 100$. What is the value of emitter current I_E for $V_{BE} = 0.7$ V ?

_______ μA

QUESTION 4.39

Given a *pnp* BJT

where $I_{Ep} = 1$ mA,

$I_{En} = 0.01$ mA,

$I_{Cp} = 0.98$ mA,

and $I_{Cn} = 0.1\,\mu$A.

What is the value of base current I_B ?

_______ μA

QUESTION 4.40

Given an *npn* BJT

where $I_{En} = 100\,\mu$A,

$I_{Ep} = 1\,\mu$A,

$I_{Cn} = 99\,\mu$A

and $I_{Cp} = 0.1\,\mu$A

What is the value of gain, β_{dc} ?

____

QUESTION 4.41

For a BJT, $I_C = 5.2$ mA,

$I_B = 50\,\mu$A,

and $I_{CBO} = 0.5\,\mu$A.

What is the value of β ?

QUESTION 4.42

In previous question, the value of I_E is

------- mA

QUESTION 4.43

The leakage current of a transistor are $I_{CBO} = 5\,\mu A$ and $I_{CEO} = 0.4\,mA$ and $I_B = 30\,\mu A$. The value of β is

(A) 79

(B) 81

(C) 80

(D) None of the above

QUESTION 4.44

In a bipolar transistor biased in the forward-active region, the base current is $i_B = 6.0\,\mu A$ and the collector current is $i_C = 510\,\mu A$. What will be the values of α, β and i_E ?

	α	β	i_E
(A)	0.9884	85	516 μA
(B)	0.0117	13.25	504 μA
(C)	0.8673	8.5	516 μA
(D)	0.9884	85	504 μA

QUESTION 4.45

If the value of forward β is on the order of 100, while reverse β is on the order of 0.1, then what will be the value of α_F and α_R ?

	α_F	α_R
(A)	0.49	0.049
(B)	0.99	0.09
(C)	0.09	0.99
(D)	0.049	0.49

QUESTION 4.46

Consider the equation $\alpha = \gamma\alpha_T M$, where M is the carrier multiplication factor in the base collector junction. For small base collector voltage, $M = 1$ and $\alpha = \gamma\alpha_T$ and $\beta = \frac{\alpha}{1-\alpha}$, then for avalanche breakdown the value of M is

(A) $1 + \frac{1}{\alpha}$

(B) $1 + \frac{1}{\alpha\beta}$

(C) $1 - \frac{1}{\alpha\beta}$

(D) $1 + \frac{1}{\beta}$

QUESTION 4.47

The emitter efficiency of a junction transistor decreases with

(A) decrease of emitter doping

(B) increase of emitter doping

(C) decrease of base width

(D) decrease of base doping

QUESTION 4.48

For a *npn* transistor, we have $x_B/L_B = 0.01$. The base transport factor, α_T will be

----

QUESTION 4.49

In previous question, if γ and δ are unity, then β will be

QUESTION 4.50

If a *pnp* transistor is made with the same dimension and doping concentration as an *npn*. then which of the following statement is true ?

(A) the value of β in *npn* is greater with respect to *pnp* transistor

(B) the value of β in *pnp* is greater with respect to *npn* transistor

(C) the value of β is same in *npn* and *pnp* transistor

(D) None of the above

QUESTION 4.51

A silicon *pnp* bipolar transistor at $T = 300$ K is to be designed so that the emitter injection efficiency is $\gamma = 0.996$. Assume that $x_E = x_B$, $L_E = L_B$, $D_E = D_B$ and let $N_E = 10^{19}\ \text{cm}^{-3}$. The maximum base doping (taking into account bandgap narrowing) will be

(A) $4.57 \times 10^{17}\ \text{cm}^{-3}$

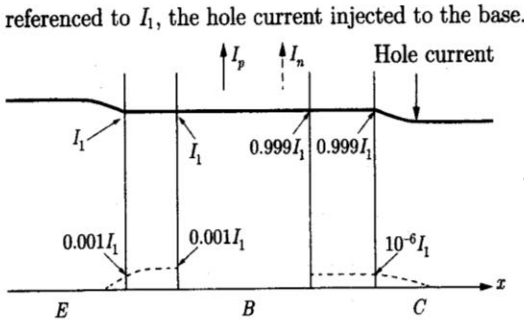
(B) $1.83 \times 10^{15}\ \text{cm}^{-3}$

(C) $9.55 \times 10^{14}\ \text{cm}^{-3}$

(D) $1.82 \times 10^{-4}\ \text{cm}^{-3}$

QUESTION 4.52

The electron and hole currents inside a *pnp* BJT biased in the active mode are plotted in figure. All the currents are referenced to I_1, the hole current injected to the base.



What is the value of common emitter dc current gain (β_{dc}) ?

QUESTION 4.53

In previous question what is the base current (I_B) ?

(A) $.999I_1$ mA

(B) $0.999\,I_1$ Amp

(C) $1.999I_1$ mA

(D) $1.999I_1$ Amp

QUESTION 4.54

Two *npn* bipolar transistor P and Q have identical parameters except for the base doping concentrations and neutral base widths. The parameters for devices are as follows.

Device	Base doping	Base width
P	$N_B = N_{B0}$	$x_B = x_{B0}$
Q	$N_B = 2N_{B0}$	$x_B = x_{B0}$

The ratio of the emitter injection efficiency of device Q to device P will be (approximately)

(A) $1 - \frac{N_{B0}}{N_E}\frac{D_E}{D_B}\frac{x_B}{x_E}$

(B) $1 - \frac{N_{B0}}{N_E}\frac{D_B}{D_E}\frac{x_B}{x_E}$

(C) $1 - \frac{N_E}{N_{B0}}\frac{D_B}{D_E}\frac{x_B}{x_E}$

(D) $1 - \frac{N_{B0}}{N_E}\frac{D_E}{D_B}\frac{x_E}{x_B}$

QUESTION 4.55

As the magnitude of the collector junction reverse biased increase, the effective base width

(A) increases

(B) decreases

(C) remain unaltered

(D) first increases and then becomes constant

QUESTION 4.56

The collector current of bipolar is $i_C = 2\,\text{mA}$ if the output resistance is greater than $10\,\text{k}\Omega$. What is the value of early voltage V_A for the transistor ?

(A) $V_A < 20\,\text{V}$

(B) $V_A < 10\,\text{V}$

(C) $V_A > 10\,\text{V}$

(D) $V_A > 20\,\text{V}$

QUESTION 4.57

What is base transit time for electron in the *npn* prototype transistor base doping level of $10^{17}\,\text{cm}^{-3}$ and base width of $w_B = 0.1\,\mu\text{m}$ and electron diffusion constant $D_n = 20\,\text{cm}^2/\text{sec}$?

_______ psec

QUESTION 4.58

The frequency f_β at which the short circuit current gain of a *CE* amplifier falls to $1/\sqrt{2}$ of its low frequency value is

(A) $\dfrac{g_{b'e}}{2\pi(C_c + C_e)}$

(B) $\dfrac{g_{b'e}}{(C_c + C_e)}$

(C) $\dfrac{g_m}{h_{fe}} \cdot \dfrac{1}{(C_c + C_e)}$

(D) $\dfrac{(C_c + C_e)}{g_{b'e}}$

QUESTION 4.59

For an Si *pnp* transistor biased in the active region with $\gamma = 1$, width of the base region $= 0.5\,\mu\text{m}$, hole diffusion coefficient $D_p = 15\,\text{cm}^2/\text{sec}$. If the frequency response is dominated by transit time delay, what is the approximate upper frequency limit ?

_______ GHz

QUESTION 4.60

In a particular bipolar transistor, the base transit time is 20 percent of the total delay time. The base width is $0.5\,\mu\text{m}$ and the base diffusion coefficient is $D_B = 20\,\text{cm}^2/\text{s}$. The cutoff frequency, f_T will be

(A) 509 MHz

(B) 124 MHz

(C) 367 MHz

(D) 890 MHz

QUESTION 4.61

To increase the upper frequency limit of *pnp* transistor.

(1) Physical size of the device should be kept small

(2) Base width should be kept small to reduce transit time

(3) Base, emitter and collector areas should be kept small to reduce junction capacitance

Which of the above statements are correct?

(A) (1), (2)

(B) (2), (3)

(C) (1), (3)

(D) (1), (2), (3)

QUESTION 4.62

Assume the base transit-time of a BJT is 100 ps and carriers cross the $1.2\,\mu\text{m}$ B-C space charge region at a speed of $10^7\,\text{cm/s}$. The emitter-base junction charging time is 25 ps and the collector capacitance and resistance are 0.10 pF and $10\,\Omega$, respectively. The cutoff frequency f_T will be

(A) 2.3 GHz

(B) 1.15 GHz

(C) 0.575 GHz

(D) 7.24 GHz

QUESTION 4.63

Consider a silicon *npn* transistor at $T = 300\,\text{K}$. Assume the following parameters.

$$I_E = 0.5\,\text{mA},\ C_{je} = 0.8\,\text{pF}$$

$$x_B = 0.7\,\mu\text{m},\ D_n = 25\,\text{cm}^2/\text{sec}$$

$$x_{dc} = 2.0\,\mu\text{m},\ r_C = 30\,\Omega$$

$$C_S = C_\mu = 0.08\,\mu\text{F},\ \beta = 50$$

What is the transit time factors τ_C and τ_D ?

	τ_C (in ps)	τ_D (in ps)
(A)	4.8	20
(B)	20	4.8
(C)	2.4	10
(D)	10	2.4

QUESTION 4.64

The $V_{CE}(\text{sat})$ voltage of an *npn* transistor in saturation continues to decrease slowly as the base current increases. In the Ebers-Moll model, assume $\alpha_F = 0.99$, $\alpha_R = 0.20$ and $I_C = 1\,\text{mA}$. For $T = 300\,\text{K}$, what will be the base current, I_B (in mA) that gives $V_{CE}(\text{sat}) = 0.30\,\text{V}$?

QUESTION 4.65

A phototransistor is connected in a circuit generally in

(A) common emitter configuration

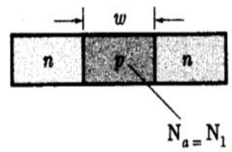
(B) common collector configuration

(C) common base configuration

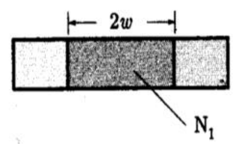
(D) any of the above

QUESTION 4.66

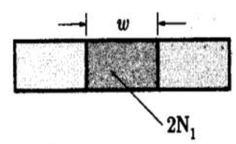
Three *npn* transistors are identical except that transistor (2) has a base region twice as long as transistor (1), and transistor (3), has a base region doped twice as heavily as transistor (1). All other dopings and lengths are identical for the three transistors.



(1)



(2)



(3)

Which transistors have the largest value of punch through voltage ?

(A) 2 and 3

(B) 2

(C) 1, 2, 3 are same

(D) 3

****

Answer

4.1	A
4.2	B
4.3	C
4.4	D
4.5	A
4.6	D
4.7	A
4.8	B
4.9	55
4.10	B
4.11	C
4.12	B
4.13	C
4.14	C
4.15	B
4.16	A
4.17	A
4.18	2.3
4.19	6
4.20	7.75
4.21	B
4.22	D
4.23	A
4.24	0.48
4.25	A
4.26	A
4.27	0.258
4.28	11.6
4.29	D
4.30	-0.179
4.31	893
4.32	8.93
4.33	70.8

4.34	0.221
4.35	1.52
4.36	A
4.37	D
4.38	49.49
4.39	29.9
4.40	49.5
4.41	103
4.42	5.25 mA
4.43	A
4.44	A
4.45	B
4.46	D
4.47	A
4.48	0.99995
4.49	19999
4.50	A
4.51	B
4.52	499
4.53	C
4.54	A
4.55	B
4.56	D
4.57	2.5
4.58	A
4.59	1.91 GHz
4.60	A
4.61	D
4.62	B
4.63	A
4.64	0.01014
4.65	A
4.66	B

CHAPTER 5

MOSFET

QUESTION 5.1

A channel is induced in a E-MOSFET by the application of a gate to source voltage V_{GS} such that (V_T is the threshold voltage, and V_P is pinch off voltage)

(A) $V_{GS} < V_T$

(B) $V_{GS} > V_P$

(C) $V_{GS} > V_T$

(D) $V_{DS} > V_P$

QUESTION 5.2

An enhancement mode MOSFET is OFF when the gate voltage is

(A) zero

(B) negative

(C) less than threshold value

(D) none of above

QUESTION 5.3

A FET cannot operate as $V_{GS} = 0$ V. The FET is

(A) JFET

(B) D-MOSFET

(C) E-MOSFET

(D) both (a) and (b)

QUESTION 5.4

A MOSFET has the following parameters : n^+ poly gate,

$$t_{ox} = 80\ \text{Å},$$

$$N_d = 10^{17}\ \text{cm}^{-3},$$

$$Q'_{ss} = 5 \times 10^{10}\ \text{cm}^{-2}$$

and $\phi_{ms} = -0.32$ V.

The device is

(A) enhancement PMOS

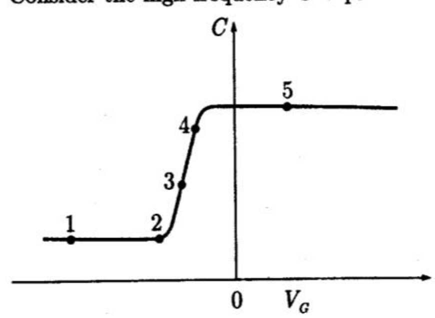
(B) depletion PMOS

(C) enhancement NMOS

(D) depletion NMOS

QUESTION 5.5

Consider the high-frequency C-V plot shown in figure.



Point 3 indicates

(A) inversion mode

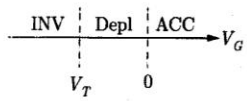
(B) Accumulation mode

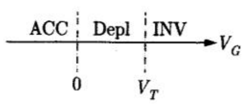
(C) flat-band mode

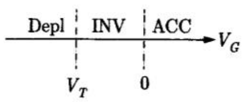
(D) depletion mode

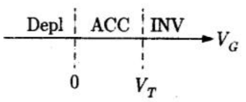
QUESTION 5.6

Which of the following plot identify the voltage ranges corresponding to accumulation (ACC), depletion (Depl), and inversion (INV) in ideal n-type devices ?

(A) 

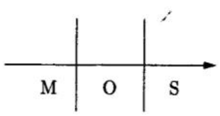
(B) 

(C) 

(D) 

QUESTION 5.7

Consider the dc charge distribution of an ideal MOS capacitor shown in figure below.



What is the type of semiconductor and condition of biasing ?

(A) p-type, Accumulation

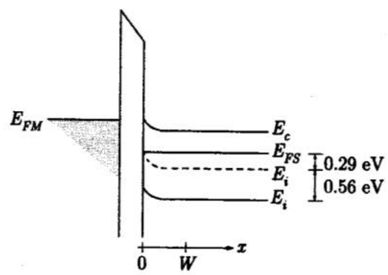
(B) n-type, Accumulation

(C) n-type, Flat band

(D) p-type inversion band

QUESTION 5.8

The energy band diagram for an ideal MOS-C operated at $T = 300$ K is sketched in figure below. Note that the applied gate voltage causes band bending in the semiconductor such that $E_F = E_i$ at the Si – SiO_2 interface and $n_i = 10^{10}/cm^3$.



What is the value of ϕ_s (surface potential) ?

(A) 0.29 V

(B) −0.29 V

(C) 0.59 V

(D) −0.59 V

QUESTION 5.9

In previous question what is the value of N_D ?

(A) $2.45 \times 10^{19}/cm^3$

(B) $2.45 \times 10^{9}/cm^3$

(C) $7.29 \times 10^{14}/cm^3$

(D) $7.29 \times 10^{4}/cm^3$

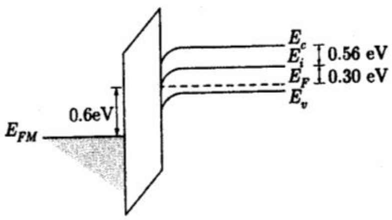
QUESTION 5.10

Consider an MOS structure with p-type silicon and $N_a = 6 \times 10^{15}\ cm^{-3}$. For an aluminium-silicon dioxide junction, $\phi'_m = 3.20$ V and for a silicon-silicondioxide junction, $\chi' = 3.25$ V and $E_g = 1.11$ eV. If the gate is aluminium then the metal-semiconductor work function difference, ϕ_{ms} of the MOS structure will be

_______ V

QUESTION 5.11

Figure shows the dimensional energy band diagram for an ideal MOS-C operated at $T = 300$ K with $V_G \neq 0$. Note that $E_F = E_i$ at the Si-SiO$_2$ interface.



For the value of $n_i = 10^{10}$, the value of N_A is

(A) $9.7 \times 10^{14}/\text{cm}^3$

(B) $1.073 \times 10^{15}/\text{cm}^3$

(C) $1.073 \times 10^{19}/\text{cm}^3$

(D) $9.7 \times 10^{21}/\text{cm}^3$

QUESTION 5.12

Consider a p-type silicon semiconductor of an MOS structure.

Let $\quad T = 300$ K

and assume $\quad N_a = 10^{16}\ \text{cm}^{-3}$.

The maximum space charge width, x_{dT} is

(A) $0.30\ \mu\text{m}$

(B) 3×10^{-12} cm

(C) $0.18\ \mu\text{m}$

(D) 1.88×10^{-12} cm

QUESTION 5.13

An NMOS-C is maintained at

$T = 300$ k,

$x_0 = 0.1\ \mu\text{m}$

and the silicon doping is

$N_A = 10^{15}/\text{cm}^3$

and $\quad n_i = 10^{10}/\text{cm}^3$.

If $\phi_s = \phi_F$, then the depletion width (w) will be

_______ μm

QUESTION 5.14

Consider an MOS structure with n-type silicon. A metal-semiconductor work function difference of $\phi_{ms} = -0.35$ V is required. For an aluminium-silicon dioxide junction, $\phi'_m = 3.20$ V and for a silicon-silicon dioxide junction $\chi' = 3.25$ V and $E_g = 1.11$ eV. If the gate is aluminium, then the silicon doping required to meet the specification is

(A) $3.43 \times 10^{14}\ \text{cm}^{-3}$

(B) $2.28 \times 10^{14}\ \text{cm}^{-3}$

(C) $2.28 \times 10^{4}\ \text{cm}^{-3}$

(D) $3.43 \times 10^{4}\ \text{cm}^{-3}$

QUESTION 5.15

One radiated (Si)^l produces on the average 8×10^{12} electron-hole pairs/cm^3 silicon dioxide. Assume that a pulse of ionizing radiation with a total dose of 10^5 rads (Si) is incident on an MOS device with a 750 Å oxide. Assume that there is no electron-hole recombination and that the electrons are swept out through the gate terminal. If 10 percent of the generated holes are trapped at the oxide-semiconductor interface, what is the threshold voltage shift ?

_______ Volt

QUESTION 5.16

Consider an n^+ polysilicon-silicon dioxide n-type silicon MOS capacitor.

Let $\quad N_d = 10^{15}\ \text{cm}^{-3}$,

$t_{ox} = 500$ Å

and $\quad Q'_{ss} = 10^{10}\ \text{cm}^{-2}$.

What will be the flat-band voltage ?

_______ Volt

QUESTION 5.17

Consider an aluminium gate-silicon dioxide p-type silicon MOS structure with $t_{ox} = 450\,\text{Å}$. For an aluminium-silicon dioxide junction, $\phi'_m = 3.20\,\text{V}$ and $\chi' = 3.25\,\text{V}$, $E_g = 1.11\,\text{eV}$. The silicon doping is $N_a = 2 \times 10^{16}\,\text{cm}^{-3}$ and the flat-band voltage is $V_{FB} = -1.0\,\text{V}$. The fixed oxide charge, Q'_{ss} (number of electronic charges per unit area) will be

_______ $\times 10^{10}\,\text{cm}^{-2}$

QUESTION 5.18

Consider a p-channel MOSFET with $t_{ox} = 600\,\text{Å}$ and $N_d = 5 \times 10^{15}\,\text{cm}^{-3}$. What will be the body-to-source voltage, V_{BS} such that the shift in threshold voltage, ΔV_T, from the $V_{BS} = 0$ curve is $\Delta V_T = -1.5\,\text{V}$?

_______ Volt

QUESTION 5.19

Consider a p-type GaAs semiconductor of an MOS structure with the doping concentration, $N_a = 10^{16}\,\text{cm}^{-3}$ at $T = 200\,\text{K}$. The maximum space charge density $|Q'_{SD}(\max)|$ is

(A) $6.85 \times 10^{-8}\,\text{C/cm}^2$

(B) $6.85 \times 10^{-24}\,\text{C/cm}^2$

(C) $1.60 \times 10^{-23}\,\text{C/cm}^2$

(D) $1.60 \times 10^{-7}\,\text{C/cm}^2$

QUESTION 5.20

Consider n-type silicon in an MOS structure at $T = 300\,\text{K}$. What will be the semiconductor doping so that maximum space charge density, $|Q'_{SD}(\max)| = 7.5 \times 10^{-9}\,\text{C/cm}^2$.

(A) $6.54 \times 10^{16}\,\text{cm}^{-3}$

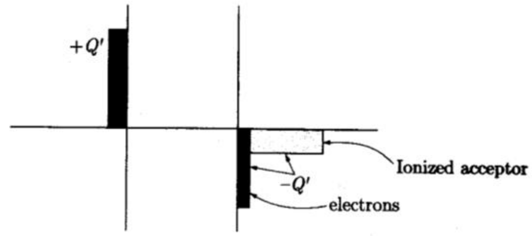
(B) $6.54 \times 10^{14}\,\text{cm}^{-3}$

(C) $3.27 \times 10^{14}\,\text{cm}^{-3}$

(D) $1.64 \times 10^{14}\,\text{cm}^{-3}$

QUESTION 5.21

Consider the dc charge distribution of an ideal MOS capacitor shown in figure below.



What is the type of semiconductor and mode of biasing ?

(A) n-type, depletion

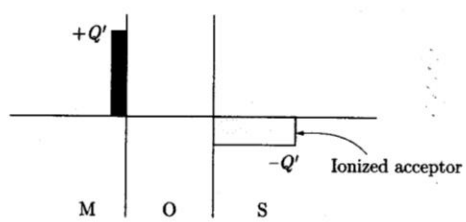
(B) n-type, inversion

(C) p-type, depletion

(D) p-type, inversion

QUESTION 5.22

Consider the dc charge distribution of an ideal MOS capacitor shown in figure below.



What is the type of semiconductor and mode of biasing ?

(A) n-type, depletion

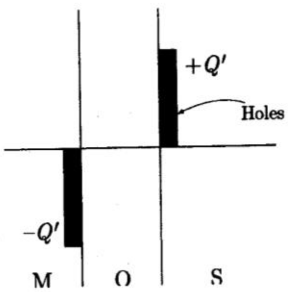
(B) n-type, inversion

(C) p-type, depletion

(D) p-type, inversion

QUESTION 5.23

Consider the dc charge distribution of an ideal MOS capacitor shown in figure below.



What is the type of semiconductor and mode of biasing ?

(A) n-type, depletion

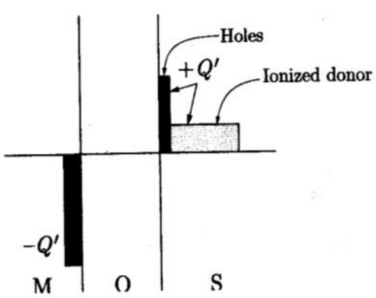
(B) n-type, accumulation

(C) p-type, depletion

(D) p-type, accumulation

QUESTION 5.24

Consider the dc charge distribution of an ideal MOS capacitor shown in figure below.



What is the type of semiconductor and mode of biasing ?

(A) n-type, depletion

(B) n-type, inversion

(C) p-type, depletion

(D) p-type, inversion

QUESTION 5.25

In an insulated gate FET, the polarity of inversion layer is the same as that of

(A) minority carriers in source

(B) majority carriers in source

(C) charge on gate electrode

(D) minority carriers in drain

QUESTION 5.26

In the MOS process, structure like the gate of a transistor are used to make capacitors as well. If the oxide thickness is 4 nm, what area is needed to achieve a capacitance of 1 pF ? (the permittivity of silicon dioxide is $3.9\,\varepsilon_o$)

(A) $1.16 \times 10^{-6}\,cm^2$

(B) $3.82 \times 10^{-5}\,cm^2$

(C) $4.51 \times 10^{-6}\,cm^2$

(D) None of the above

QUESTION 5.27

In a power MOS device, a maximum gate voltage of 20 volts is to be applied. If a safety factor of three is specified, the minimum thickness necessary for the silicon dioxide gate insulator is

_______ Å

QUESTION 5.28

An ideal MOS capacitor with an aluminium gate has a silicon dioxide thickness of $t_{ox} = 400$ Å on a p-type silicon substrate. The oxide capacitance, C_{ox} will be

(A) $8.63 \times 10^{-8}\,F/cm^2$

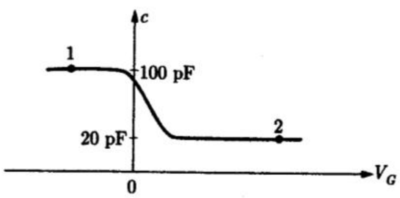
(B) $5.67 \times 10^{-9}\,F/cm^2$

(C) $3.45 \times 10^{-5}\,F/cm^2$

(D) $2.21 \times 10^{-8}\,F/cm^2$

QUESTION 5.29

The C-V characteristic exhibited by an MOS-C (assumed to be ideal) is shown in figure.



The semiconductor component of the MOS-C is doped with

(A) p-type

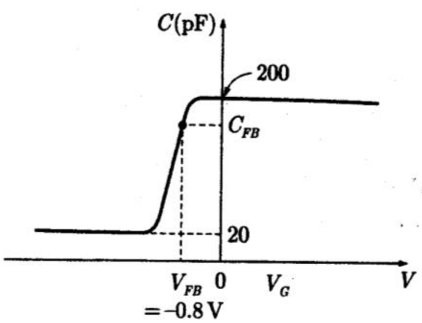
(B) n-type

(C) intrinsic

(D) Can't be say

QUESTION 5.30

The high-frequency C-V characteristic curve of an MOS capacitor is shown in figure.



The area of the device is 2×10^{-3} cm^2. The metal-semiconductor work function difference is $\phi_{ms} = -0.50$ V, the oxide is SiO_2, the semiconductor is silicon, and the semiconductor doping concentration is 2×10^{16} cm^{-3}. The semiconductor is

(A) n-type

(B) p-type

(C) intrinsic

(D) can't be determined

QUESTION 5.31

In previous question what is the oxide thickness ?

(A) 22.7 Å

(B) 345 Å

(C) 1345.5 Å

(D) 88.5 Å

QUESTION 5.32

In previous question what is the equivalent trapped oxide charge density (electronic charge per cm^2) ?

(A) 1.875×10^{11} cm^{-2}

(B) 3×10^{-8} cm^{-2}

(C) 5×10^{11} cm^{-2}

(D) 4.8×10^{-27} cm^{-2}

QUESTION 5.33

In previous question the flat-band capacitance is

(A) 7.82×10^{-8} F/cm^2

(B) 78 pF

(C) 3.91×10^{-5} F/cm^2

(D) 156 pF

QUESTION 5.34

The field effect transistor are

(A) voltage controlled device

(B) current controlled device

(C) neither current nor voltage controlled device

(D) all of these

QUESTION 5.35

For values of drain voltage smaller than gate voltage, a MOSFET acts as a voltage controlled

(A) current source

(B) resistor

(C) voltage source

(D) capacitor

QUESTION 5.36

The input impedance of the field effect transistor is

(A) very low with respect to BJT

(B) very high with respect to BJT

(C) medium with respect to BJT

(D) none of these

QUESTION 5.37

One curve of an n-channel MOSFET is characterized by the following parameters:

$$I_D(sat) = 2 \times 10^{-4}\,\text{A},$$

$$V_{DS}(sat) = 4\,\text{V}$$

and $$V_T = 0.8\,\text{V}.$$

What is the value of the conduction parameter ?

_______ μA/V²

QUESTION 5.38

Consider a p-channel enhancement mode MOSFET with parameter $k_p = 2\,\text{mA/V}^2$ and $V_{TP} = -0.5\,\text{V}$. The gate is at ground potential, the source and substrate terminals are at $+5\text{V}$. If $V_D = 0$, then I_D is

_______ mA

QUESTION 5.39

The parameters of n-channel depletion mode MOSFET are $V_{TN} = -2\text{V}$ and $k_n' = 80\,\mu\text{A/V}^2$ the drain current is $I_D = 1.5\,\text{mA}$ at $V_{GS} = 0$ and $V_{DS} = 3\,\text{V}$. The ratio w/L is

(A) 7.78 m

(B) 15.56 m

(C) 9.375 m

(D) 4.69 m

QUESTION 5.40

Consider a p-channel enhancement mode MOSFET with $k_p' = 40\,\mu\text{A/V}^2$. The device has following observation.

$$I_D = 0.225\,\text{mA at } V_{SG} = V_{SD} = 3\,\text{V}$$

$$I_D = 1.4\,\text{mA at } V_{SG} = V_{SD} = 4\,\text{V}$$

The value of threshold voltage V_{TP} is

(A) 2.33 V

(B) -2.33 V

(C) 3.29 V

(D) -3.29 V

QUESTION 5.41

For a particular NMOS device, the parameters are

$$V_{TN} = 1\,\text{V},$$

$$L = 2.4\,\mu\text{m},$$

$$\mu_n = 600\,\text{cm}^2/\text{V-sec},$$

and $$t_{ox} = 400\,\text{Å}.$$

When device is biased in the saturation region at $V_{GS} = 5\,\text{V}$, the drain current is $I_D = 1.2\,\text{mA}$. The channel width of device is

(A) 7.21 μm

(B) 10.46 μm

(C) 5.23 μm

(D) 20.92 μm

QUESTION 5.42

An ideal n-channel MOSFET maintained at $T = 300\,\text{k}$ is characterized by the following parameters

$$w = 50\,\mu\text{m},$$
$$L = 5\,\mu\text{m},$$
$$n_i = 10^{10}\,\text{cm}^{-3},$$
$$x_0 = 0.05\,\mu\text{m},$$
$$N_a = 10^5/\text{cm}^3$$

and $\mu_n = 800\,\text{cm}^2/\text{V sec}$

(assumed independent of V_G).
What is the value of threshold Voltage (V_T) ?

_______ Volt

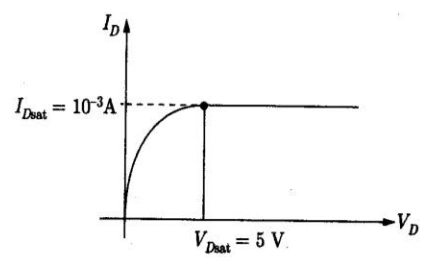
QUESTION 5.43

What is the value of saturation current in MOSFET if $V_{GS} = 2\,\text{V}$?

_______ mA

QUESTION 5.44

An I_D-V_D characteristic derived from and ideal MOSFET is shown below.



Suppose that the gate voltage is readjusted so that $V_G - V_T = 3\,\text{V}$. For the new condition, what is the value of current I_D if $V_D = 4\,\text{V}$?

_______ mA

QUESTION 5.45

Using the simple long-channel model assume constant mobility for an N-MOSFET with $\frac{w}{L} = 5$ and $t_{ox} = 4\,\text{nm}$. Take the constant mobility for electrons in the channel to be $500\,\text{cm}^2/\text{V-sec}$. For $V_{GS} - V_T = 2\,\text{V}$ and $V_{DS} = 1\text{V}$ the value of drain current I_D is

_______ mA

QUESTION 5.46

An N-MOSFET is made with

$$t_{ox} = 4\,\text{nm},$$
$$L = 1\,\mu\text{m},$$
$$w = 2\,\mu\text{m},$$
$$V_T = 1\text{V}$$

and $\mu_n = 500\,\text{cm}^2/\text{V-sec}$.

Let the low field mobility for holes be $200\,\text{cm}^2/\text{V-sec}$. If the simple model is used, what should be the width of the p-type FET to get the same characteristics (apart from polarity)?

_______ μm

QUESTION 5.47

A complementary pair of ideal n-channel and p-channel MOSFET are to be designed so that the devices exhibit the same g_m and f_{max} when equivalently biased and operated at $T = 300\,\text{k}$ the structural parameters of n-channel devices are $w = 50\,\mu\text{m}$, $L = 5\,\mu\text{m}$. The p-channel device has the same oxide thickness but differential gate dimension. Given that $\bar{\mu}_n = 673\,\text{cm}^2/\text{V sec}$, $\bar{\mu}_p = 229\,\text{cm}^2/\text{V-sec}$. What is the value of w for the p-channel device ?

_______ μm

QUESTION 5.48

An ideal p-channel MOSFET has the parameters

$$w = 15\,\mu\text{m}, \qquad \mu_p = 300\text{ cm}^2/\text{V-sec},$$

$$t_{ox} = 350\text{ A}^\circ \quad \text{and } V_{TP} = -0.80\text{ V}.$$

If transistor is operating in non-saturation region at $V_{SD} = 0.5\text{ V}$, then the value of g_m (trans conductance) is

_______ µS

QUESTION 5.49

An ideal n-channel MOSFET has an inversion carrier mobility $\mu_n = 525\text{ cm}^2/\text{V-s}$, a threshold voltage $V_T = +0.75\text{ V}$, and an oxide thickness $t_{ox} = 400\text{ Å}$. When biased in the saturation region, the required rated current is $I_D(sat) = 6\text{ mA}$ when $V_{GS} = 5\text{ V}$. The required W/L ratio is

____

QUESTION 5.50

An ideal p-channel MOSFET has an inversion carrier mobility $\mu_p = 300\text{ cm}^2/\text{V-s}$, a threshold voltage $V_T = -0.75\text{ V}$, and an oxide thickness $t_{ox} = 400\text{ Å}$. When biased in the saturation region, the required rated current is $I_D(sat) = 6\text{ mA}$ when $V_{GS} = 5\text{ V}$. The required width to length ratio (W/L) is

____

QUESTION 5.51

The ideal current-voltage relations of an MOSFET is scaled by a constant k such that $W, L, V_{GS}, V_{DS}, C_{ox}$ change to $kW, kL, kV_{GS}, kV_{DS}, \frac{C_{ox}}{k}$, respectively. The drain current I_D changes to (approximately)

(A) $k^2 I_D$

(B) kI_D

(C) $\frac{I_D}{k^2}$

(D) $\frac{I_D}{k}$

QUESTION 5.52

Consider an NMOS transistor with parameters $K_n = 0.1\text{ mA/V}^2$ and $V_{TN} = 0.8\text{ V}$. Assume operating voltages of $V_{GS} = 5\text{ V}$. Assume a constant-field scaling factor of $k = 0.6$ is applied but assume that V_{TN} remains constant. What will be the maximum drain current (I_D) and maximum power (P) in the scaled device ?

	I_D (in mA)	P (in mW)
(A)	0.807	2.42
(B)	2.42	0.807
(C)	4.842	0.484
(D)	0.484	4.842

QUESTION 5.53

An ideal n-channel MOSFET has the parameters $w = 30\,\mu\text{m}$, $\mu_n = 450\text{ cm}^2/\text{V-sec}$, $L = 2\mu\text{m}$, $t_{ox} = 350\text{ A}^\circ$, $V_{TN} = 0.8\text{ V}$. If transistor is operating in saturation at $V_{GS} = 4\text{ V}$, then the value of g_m is

_______ ms

QUESTION 5.54

Assume that the subthreshold current of a MOSFET is given by

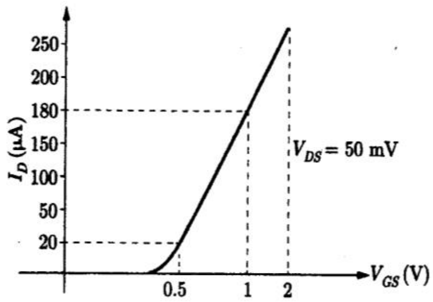
$$I_D = 10^{-15}\exp\left(\frac{V_{GS}}{(2.1)\,V_t}\right)$$

over the range $0 \le V_{GS} \le 1$ volt and where the factor 2.1 takes into account the effect of interface states. Assume that 10^6 identical transistors on a chip are all biased at the same $V_{GS} = 0.5\text{ V}$ and at $V_{DD} = 5$ volts. The total current that must be supplied to the chip is

_______ µA

QUESTION 5.55

Figure shows the characteristics for an NMOS with $V_{DS} = 50\,\text{mV}$. It is known for this device that $w = 10\,\mu\text{m}$, $L = 0.5\,\mu\text{m}$ and $t_{ox} = 5\,\text{nm}$

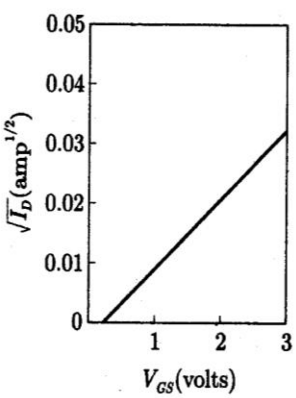


What is the value of μ_o, the electron channel mobility at threshold ?

_______ $\text{cm}^2/\text{V-sec}$

QUESTION 5.56

The experimental characteristic of an ideal n-channel MOSFET biased in the saturation region is shown in figure below.



If $W/L = 10$ and $t_{ox} = 425\,\text{Å}$, then the inversion carrier mobility, μ_n will be

_______ $\text{cm}^2/\text{V-s}$

QUESTION 5.57

Assuming that the load Capacitance is 0.1 pF. What is the dynamic power dissipation for a CMOS invertor operating with $V_{DD} = 2.5\,\text{V}$ at 100 MHz frequency ?

_______ μ watt

QUESTION 5.58

A CMOS inverter drives a load that consists of the gate of another FET. The gate area is $0.2 \times 5\,\mu\text{m}$. If the clock frequency is 350 MHz, the supply voltage is $V_{DD} = 2.5\,\text{V}$ and the oxide thickness is 5 nm. If a medium scale integration (MSI) circuit has 1000 transistors, what is the power consumption due to just to switching ?

_______ mW

QUESTION 5.59

For a CMOS inverter assume that

$$I_{Dsatn} = I_{D\,sat\,p} = 1\,\text{mA}$$

$$C = 0.1\,\text{pF and } V_{DD} = 2.5\,\text{V}$$

What is the propagation delay time for the CMOS invertor ?

_______ psec

QUESTION 5.60

Which of the following is used for generating time-varying waveforms

(A) MOSFET

(B) PIN diode

(C) tunnel diode

(D) UJT

****

Answer

5.1	C
5.2	C
5.3	C
5.4	A
5.5	D
5.6	A
5.7	C
5.8	B
5.9	C
5.10	-0.944
5.11	B
5.12	A
5.13	0.624
5.14	A
5.15	-2.09
5.16	-0.295
5.17	1.2
5.18	7.92
5.19	A
5.20	C
5.21	D
5.22	C
5.23	D
5.24	B
5.25	B
5.26	A
5.27	1000
5.28	A
5.29	A
5.30	A

5.31	B
5.32	A
5.33	D
5.34	A
5.35	B
5.36	B
5.37	12.5
5.38	40.5 mA
5.39	C
5.40	B
5.41	A
5.42	0.8
5.43	0.397
5.44	0.36
5.45	3.23
5.46	5
5.47	85.7
5.48	148 us
5.49	14.7
5.50	25.7
5.51	B
5.52	A
5.53	2.13
5.54	9.83
5.55	460
5.56	342
5.57	62.5
5.58	15
5.59	125
5.60	D

CHAPTER 6

JFET

QUESTION 6.1

In a JFET the width of channel is controlled by

(A) gate voltage

(B) drain current

(C) source current

(D) all the above

QUESTION 6.2

In a JFET, the primary control on drain current is exerted by

(A) channel resistance

(B) size of depletion regions

(C) voltage drop across channel

(D) gate reverse bias

QUESTION 6.3

The JFET is a

(A) bipolar device

(B) unipolar device

(C) voltage controlled device

(D) Both (B) and (C)

QUESTION 6.4

In an n-Channel JFET

(A) the current carriers are holes

(B) the current carriers are electrons

(C) V_{GS} is negative

(D) the input resistance is very low

QUESTION 6.5

The JFET can operate in

(A) depletion mode only

(B) enhancement mode only

(C) either depletion or enhancement mode at a time

(D) both depletion and enhancement modes simultaneously

QUESTION 6.6

In a FET

(A) One junction is reverse biased and the other forward biased

(B) both the junctions are reverse biased

(C) one junction has reverse biased on both sides of the junction

(D) one junction has reverse biased on one side and forward biased on the other side.

QUESTION 6.7

The polarity of the gate with respect to the source in n -channel JFET is

(A) positive

(B) negative

(C) neutral

(D) all of these

QUESTION 6.8

n-channel FETs are superior to p-channel FETs because

(A) they have higher input impedance

(B) they have high switching time

(C) they consume less power

(D) mobility of electrons is greater than that of holes

QUESTION 6.9

In MOSFET devices the n-channel type is better than the p -channel type in the following respects

(A) it has better noise immunity

(B) it is faster

(C) it has better drive capability

(D) it is TTL compatible

QUESTION 6.10

Which of the following statement is not true in case of FET ?

(A) it has high input impedance

(B) it is less noisier than bipolar transistor

(C) it has large gain-bandwidth product

(D) all the above

QUESTION 6.11

Consider an n-channel silicon JFET with the following parameters:

$$N_a = 3 \times 10^{18} \text{cm}^{-3},$$

$$N_d = 8 \times 10^{16} \text{cm}^{-3},$$

and $a = 0.5\,\mu m.$

The internal pinchoff voltage is

(A) 7.75 V

(B) 31 V

(C) 181.4 V

(D) 15.5 V

QUESTION 6.12

A p-channel silicon JFET at $T = 300\,\text{K}$ has doping concentrations of

$$N_d = 5 \times 10^{18}\,\text{cm}^{-3}$$

and $N_a = 3 \times 10^{16}\,\text{cm}^{-3}.$

The channel thickness dimension is $a = 0.5\,\mu\text{m}$.
What is the internal pinch off voltage V_{p0} of the device ?

_______ Volt

QUESTION 6.13

In previous question the gate to source voltage, V_p that must be applied to achieve pinch off is

_______ Volt

QUESTION 6.14

The Schottky barrier height, ϕ_{Bn}, of a metal n-GaAS MESFET is 0.90 volt. The channel doping is $N_d = 1.5 \times 10^{16} \text{cm}^{-3}$, and the channel thickness is $a = 0.5\,\mu m$ at $T = 300\,\text{K}$.
The internal pinchoff voltage, V_{p0} of the device is

_______ V

QUESTION 6.15

In previous question the threshold voltage V_T is

(A) 0.0892 V

(B) -1.78 V

(C) -2.59 V

(D) 0.811 V

QUESTION 6.16

In previous question the MESFET is

(A) enhancement type

(B) depletion type

(C) both enhancement and depletion type

(D) none of these

QUESTION 6.17

Consider a p-channel GaAs JFET with parameters.

$N_d = 5 \times 10^{18}\ \text{cm}^{-3}$,

$N_a = 3 \times 10^{16}\ \text{cm}^{-3}$,

and $a = 0.30\ \mu m$.

The pinchoff voltage is

(A) 0.511 V

(B) 1.863 V

(C) -0.841 V

(D) -1.352 V

QUESTION 6.18

In previous question if $V_{GS} = V_{DS} = 0$, what will be the width of the undepleted channel?

(A) 2.95×10^{-4} cm

(B) 4.45×10^{-6} cm

(C) 0.3×10^{-4} cm

(D) 4.15×10^{-6} cm

QUESTION 6.19

The Schottky barrier height, ϕ_{Bn}, of a metal n-silicon MESFET is 0.80 V. The channel thickness dimension is $a = 0.40\ \mu\text{m}$ and the channel doping is $N_d = 2 \times 10^{16}\ \text{cm}^{-3}$ at $T = 300$ K. What concentration of donor atoms must be added to the channel so that $V_{p0} = 4.5$ volts ?

(A) $2 \times 10^{16}\ \text{cm}^{-3}$

(B) $1.64 \times 10^{16}\ \text{cm}^{-3}$

(C) $5.64 \times 10^{16}\ \text{cm}^{-3}$

(D) $3.64 \times 10^{16}\ \text{cm}^{-3}$

QUESTION 6.20

In previous question the threshold voltage, V_T for the new channel doping will be

(A) -4.5 V

(B) 0.628 V

(C) 5.128 V

(D) -3.87 V

QUESTION 6.21

An n-channel silicon MESFET is fabricated using a gold contact. The n-channel doping is $N_d = 10^{16}\ \text{cm}^{-3}$ and the temperature is $T = 300$ K. When a gate voltage of $V_{GS} = 0.35$ volt is applied with $V_{DS} = 0$, the undepleted channel thickness is 0.075 μm. What is the channel thickness dimension a ?

_______ μm

QUESTION 6.22

In previous question what is the threshold voltage, V_T ?

_______ Volt

QUESTION 6.23

In previous question if $V_{GS} = 0.35$ volt, the value of $V_{DS(sat)}$ will be

_______ Volt

QUESTION 6.24

Consider an n-channel GaAs JFET at $T = 300$ K with the following parameters:

$N_a = 5 \times 10^{18}\,\text{cm}^{-3}$ $\quad N_d = 2 \times 10^{16}\,\text{cm}^{-3}$

$a = 0.35\,\mu m$ $\quad L = 10\,\mu m$

$W = 30\,\mu m$ $\quad \mu_n = 8000\,\text{cm}^2/\text{V-s}$

If $V_{GS} = 0$, what will be the drain to source saturation voltage, $V_{DS(sat)}$?

_______ Volt

QUESTION 6.25

The barrier heights of two n-channel GaAs MESFETs are $\phi_{Bn} = 0.89$ volts. The channel doping in device 1 is $N_d = 3 \times 10^{16}\text{cm}^{-3}$, and that in device 2 is $N_d = 3 \times 10^{17}\text{cm}^{-3}$. What will be the channel thickness required in each device such that the threshold voltage is zero for each device ?

	Device 1	Device 2
(A)	0.199 μm	0.0651 μm
(B)	0.0651 μm	0.199 μm
(C)	0.0179 μm	0.0549 μm
(D)	0.0549 μm	0.0179 μm

QUESTION 6.26

For low values of V_{DS}, the JFET behaves like a

(A) resistance

(B) constant voltage device

(C) constant current device

(D) negative resistor

QUESTION 6.27

An n-channel silicon JFET at $T = 300$ K has the following parameters:

$N_a = 10^{19}\,\text{cm}^{-3}$ $\quad N_d = 10^{16}\,\text{cm}^{-3}$

$a = 0.50\,\mu m$ $\quad L = 210\,\mu m$

$W = 400\,\mu m$ $\quad \mu_n = 1000\,\text{cm}^2/\text{V-s}$

(Ignore velocity saturation effects)

What will be the pinch off current, I_p ?

(A) 0.09 mA

(B) 0.17 mA

(C) 12.05 mA

(D) 1.03 mA

QUESTION 6.28

The V_{po} of an n-channel JFET

with $N_D = 10^{16}/\text{cm}^3$,

$\varepsilon_r = 16$,

$\varepsilon_o = 8.854 \times 10^{-14}\text{F/cm}$,

$a = 0.5\mu m$ is

(A) 1.5 V

(B) 1.4 V

(C) 5 V

(D) 0

QUESTION 6.29

Pinch off voltage V_p for an FET is the drain voltage at which

(A) significant drain current

(B) drain current becomes zero

(C) all free charges get removed from the channel

(D) avalanche breakdown takes place

...STION 6...

When V_{DS} reaches the pinch off voltage V_P, the drain current becomes

(A) low

(B) zero

(C) constant (saturated)

(D) reversed

In previous question if $V_{[illegible]} = 2\,V_{[illegible]}$, what will be the drain current $I_{D1(sat)}$ in saturation?

(A) 36.1 mA

(B) 5.73 μA

(C) 36.1 μA

(D) 300.83 μA

QUESTION 6.31

The saturation drain current I_{DS} in an FET equals

(A) $I_{DSS}\left(1-\frac{V_{GS}}{V_P}\right)$

(B) $I_{DSS}\left(1-\frac{V_{GS}}{V_P}\right)^2$

(C) $I_{DSS}\sqrt{1-V_{GS}/V_p}$

(D) $I_{DSS}\left(1-\frac{V_{GS}}{V_P}\right)$

QUESTION 6.32

A GaAs n-channel MESFET at $T = 300$ K has a threshold voltage of

$$V_T = 0.12 \text{ volt.}$$

Let $\mu_n = 7800 \text{ cm}^2/\text{V-s}$,

$W = 20\,\mu\text{m}$,

$L = 1.2\,\mu\text{m}$

and $a = 0.30\,\mu\text{m}$.

What will be the conduction parameter K_n ?

(A) 2.51 mA/V²

(B) 5.02 mA/V²

(C) [illegible]44 mA/V²

(D) [illegible] mA/V²

Consider a GaAs n-channel MESFET at

$$T = 300 \text{ K}$$

with $V_T = 0.25$ volt.

Let $\mu_n = 8000 \text{ cm}^2/\text{V-s}$,

$L = 1.0\,\mu\text{m}$,

and $a = 0.35\,\mu\text{m}$.

If the transconductance in the saturation region is to be

$$g_m = 1.75 \text{ mA/V}$$

at $V_{GS} = 0.50$ volt,

the channel width W will be

(A) 52.8 μm

(B) 26.4 μm

(C) 13.2 μm

(D) 345.8 μm

The transconductance g_m of an FET in the saturation region equals

(A) $-\frac{2I_{DSS}}{V_p}\left(1-\frac{V_{GS}}{V_p}\right)$

(B) $-\frac{2I_{DSS}}{V_p}\left(1-\frac{V_{GS}}{V_p}\right)^2$

(C) $2I_{DSS}\left(1-\frac{V_{GS}}{V_p}\right)$

(D) $\frac{1}{V_p}\left(I_{DSS}-{}_{DS}\right)^{1/2}$

The transconductance g_m of a diffused junction FET is of the order of

(A) 1 mS

(B) 1 S

(C) 100 S

(D) 1000 S

The source series resistance of a MESFET will reduce the value of transconductance, g_{ms}. Assume the doping in the source region of a GaAs MESFET is

$N_d = 7 \times 10^{16}\text{cm}^{-3}$ and the dimensions are

$a = 0.3\,\mu\text{m},$

$L = 1.5\,\mu\text{m},$

and $W = 5.0\,\mu\text{m}.$

Let $\mu_n = 4500\ \text{cm}^2/\text{V-s}$

and $\phi_{Bn} = 0.89$ volt.

If $V_{GS} = 0$, the ideal value of g_{ms} will be

(A) 5.04 mS

(B) 2.21 mS

(C) 0.55 mS

(D) 2.82 mS

****

Answer

6.1	A
6.2	D
6.3	D
6.4	B
6.5	A
6.6	C
6.7	A
6.8	D
6.9	B
6.10	C
6.11	D
6.12	5.79
6.13	4.91
6.14	2.59
6.15	B
6.16	B
6.17	A
6.18	B
6.19	B
6.20	D
6.21	0.26
6.22	0.092
6.23	0.258
6.24	0.35
6.25	A
6.26	A
6.27	D
6.28	B
6.29	C
6.30	C
6.31	B
6.32	A
6.33	C
6.34	B
6.35	A
6.36	A
6.37	D

CHAPTER 7

INTEGRATED CIRCUIT

QUESTION 7.1

Why is the term 'planer technology' for fabrication of devices in ICs used?

(A) The variety of manufacturing processes by which devices are fabricated, takes place through a single plane

(B) The aluminium contacts to the collector, base and emitter regions of the transistors in the ICs are laid in the same plane

(C) The collector, base and emitter regions of the transistors in ICs are laid in the same plane

(D) The device looks like a thin plane wafer

QUESTION 7.2

In integrated circuits, the design of electronic circuits is based on the approach of use of

(A) maximum number of resistors in the circuit

(B) large sized capacitor

(C) minimum chip area irrespective of the type of components in the design

(D) use of only bipolar transistors

QUESTION 7.3

As compared to monolithic ICs, film ICs have the advantage of

(A) better high-frequency response

(B) much reduced cost

(C) much reduced cost

(D) smaller size

QUESTION 7.4

In a monolithic-type IC

(A) each transistor is diffused into a separate isolation region

(B) all components are fabricated into a single crystal of silicon

(C) resistors and capacitors of any value may be made

(D) all isolation problems are eliminated

QUESTION 7.5

Epitaxial growth in IC chip

(A) may be n-type only

(B) may be p-type only

(C) involves growth from liquid phase

(D) involves growth form gas phase

QUESTION 7.6

Epitaxial growth is used in integrated circuit

(A) because it produces low parasitic capacitance

(B) because it yields back-to-back isolating junctions

(C) to grow single crystal n-doped silicon on a single-crystal p-type substrate

(D) to grow selectively single-crystal p-doped silicon of one resistivity on p-type substrate of a different resistivity.

QUESTION 7.7

In fabricating silicon BJT in ICs by the epitaxial process, the number of diffusions used is usually

____

QUESTION 7.8

The chemical reaction involved in epitaxial growth in IC chips takes place at a temperature of about

_______ °C

QUESTION 7.9

Which one of the following statements concerning IC fabrication is not correct?

(A) A typical wafer of doped Si may be 400 μm thick, of diameter 5-15 cm. The purity of the wafer does not matter and can be even poly crystalline in nature.

(B) Resistors are obtained by utilizing the bulk resistivity of one of the regions; for example, the DS channel of a MOSFET can serve as a resistor.

(C) Semiconductors lack magnetic properties, so they cannot exhibit inductance. However, the inductors can be realized by combination of active and passive components.

(D) In a reverse biased p-n junction, the positive and negative ions exist on opposite sides of the p-n junction; because of the p-n junction behaves like a parallel plate capacitor.

QUESTION 7.10

The process of extension of a single crystal surface by growing a film in such a way that the added atoms form a continuation of the single-crystal structure is called

(A) Ion implantation

(B) Chemical vapour deposition

(C) Electroplating

(D) Epitaxy

QUESTION 7.11

Capacitors for integrated circuits

(A) can be made using silicon oxide as the dielectric

(B) silicon oxide cannot be used as dielectric

(C) are not possible

(D) cannot be made using diffusion techniques

QUESTION 7.12

In an integrated circuit, the SiO_2 layer provides

(A) electrical connection to external circuit

(B) physical strength

(C) isolation

(D) conducting path

QUESTION 7.13

Assertion (A) : Si is mainly used for making ICs and not Ge.
Reason (R) : In Si, SiO_2 layer which act as an insulator can be formed for isolation purposes. Corresponding oxide layer cannot be formed in Ge.

(A) both (A) and (R) are individually true and (R) is the correct explanation of (A)

(B) Both (A) and (R) are individually 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.

QUESTION 7.14

The p-type substrate in a conventional p-n junction isolated integrated circuit should be connected to

(A) nowhere, i.e. left floating

(B) a DC ground potential

(C) the most positive potential available in the circuit

(D) the most negative potential available in the circuit

QUESTION 7.15

Isolation diffusion in a monolithic IC creates concentration of acceptor atoms in the region between the isolation islands of the order of

(A) $10^{15}\ cm^{-3}$

(B) $10^{20}\ cm^{-3}$

(C) $10^{25}\ cm^{-3}$

(D) $10^{35}\ cm^{-3}$

QUESTION 7.16

The *p*-type substrate in a monolithic circuit should be connected to

(A) any dc ground point

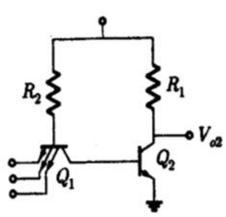
(B) the most negative voltage available in the circuit

(C) the most positive voltage available in the circuit

(D) now where, i.e. be floating

QUESTION 7.17

For the circuit shown in figure, the minimum number and the maximum number of isolation regions are respectively



(A) 2,6

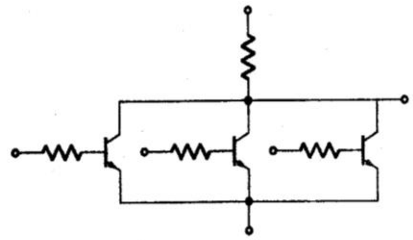
(B) 3,6

(C) 2,4

(D) 3,4

QUESTION 7.18

For the circuit shown in figure the minimum number of isolation regions is



QUESTION 7.19

The photo etching process consists in

(A) remove of photoresist

(B) curbing lines on the wafer before dicing

(C) diffusing impurities

(D) removed of layer from selected portion

QUESTION 7.20

Which of the following capacitors are made use of widely for a capacitance application in monolithic ICs.

1. MOS capacitor
2. Collector Substrate capacitor
3. Collector-Base capacitor
4. Base-Emitter capacitor

Select the correct answer using the code given below:

(A) 1 and 2 only

(B) 2 and 3 only

(C) 3 and 4 only

(D) 1 and 4 only

QUESTION 7.21

Silicon dioxide layer is used in IC chips for

(A) providing mechanical strength to the chip

(B) diffusing elements

(C) providing contacts

(D) providing mask against diffusion

QUESTION 7.22

Photo masking

(A) controls the depths of diffusion

(B) is used in process to remove selected regions of silicon oxide

(C) reduces the size of circuit elements

(D) increases the size of circuit elements

QUESTION 7.23

Almost all resistor are made in a monolithic IC

(A) during the base diffusion

(B) during the collector diffusion

(C) during the emitter diffusion

(D) while growing the epitaxial layer

QUESTION 7.24

The equation governing the diffusion of neutral atom is

(A) $\frac{\partial N}{\partial t} = D\frac{\partial^2 N}{\partial x^2}$

(B) $\frac{\partial N}{\partial x} = D\frac{\partial^2 N}{\partial t^2}$

(C) $\frac{\partial^2 N}{\partial t^2} = D\frac{\partial N}{\partial x}$

(D) $\frac{\partial^2 N}{\partial x^2} = D\frac{\partial N}{\partial t}$

QUESTION 7.25

In monolithic ICs all components are fabricated by

(A) evaporation process

(B) sputtering process

(C) diffusion process

(D) oxidisation process

QUESTION 7.26

Processing of MOS ICs is less expensive than bipolar ICs primarily because they

(A) use cheaper components

(B) need no component isolation

(C) require much less diffusion steps

(D) have very high packing density

QUESTION 7.27

In an *npn* diffused junction transistor, the *p*-type base region is formed on the *n*-type collector region through process of

(A) alloying

(B) diffusion of *p*-type impurity

(C) epitaxial

(D) none of these

QUESTION 7.28

Diffusion coefficient D of phosphorus impurity in silicon

(A) remains temperature invariant

(B) continuously increases with increase of temperature

(C) continuously decreases with increase of temperature

(D) first increases with temperature, reaches a maximum and then decreases with further increase in temperature.

QUESTION 7.29

Which one of the following statements is correct ?
In the context of IC fabrication, metallisation means

(A) connecting metallic wires

(B) formation of interconnecting conduction pattern and bonding pads

(C) doping SiO_2 layer

(D) covering with a metallic cap

QUESTION 7.30

The material popularly used for contacts and interconnections in IC's is

(A) copper

(B) aluminium

(C) silver

(D) zinc

QUESTION 7.31

The main purpose of the metalization process is

(A) to act as a heat sink

(B) to interconnect the various circuit elements

(C) to protect the chip from oxidation

(D) to supply a bonding surface for mounting the chip

QUESTION 7.32

In the fabrication of n-p-n transistor in an IC, the buried layer on the p-type substrate is

(A) p^+-doped

(B) n^+-doped

(C) Used to reduce the parasitic capacitance

(D) Located in the emitter region

QUESTION 7.33

The basic function buried n^+ layer in an n-p-n transistor in IC is to

(A) Reduce the magnitude of the base spreading resistance

(B) Reduce the collector series resistance

(C) Reduce the base width of the transistor

(D) Increase the gain of the transistor

QUESTION 7.34

Transistor of monolithic integrated circuit

(A) use the isolation junction as the collector junction

(B) are made as separate wafer

(C) are similar to discrete planar transistors, but have the collector contact on the top surface

(D) none of the above

QUESTION 7.35

The buried layer is an *npn* monolithic transistor causes the series resistance to

(A) increase

(B) decrease

(C) remain unaltered

(D) become zero

****

Answer

7.1	A
7.2	C
7.3	A
7.4	B
7.5	D
7.6	C
7.7	3
7.8	1200
7.9	A
7.10	D
7.11	A
7.12	C
7.13	A
7.14	D
7.15	B
7.16	B
7.17	D
7.18	2
7.19	D
7.20	A
7.21	D
7.22	B
7.23	A
7.24	A
7.25	C
7.26	C
7.27	B
7.28	C
7.29	B
7.30	B
7.31	B
7.32	B
7.33	B
7.34	C
7.35	B