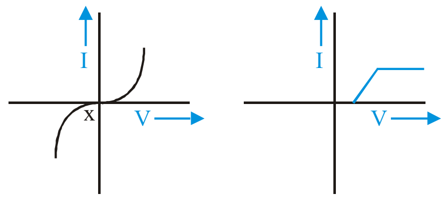
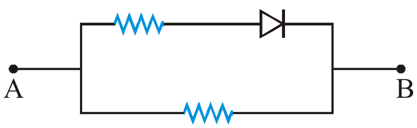


16. Let the potentials at A and B be V_A and V_B respectively.



(i) If $V_A > V_B$
Then current flows from A to B and the diode is in forward biased.
Eq. Resistance = 10/2 = 5 Ω.

(ii) If $V_A < V_B$
Then current flows from B to A and the diode is reverse biased.
Hence Eq. Resistance = 10 Ω.

EXERCISE - 4

Part # I : AIEEE/JEE-MAIN

1. (3)
2. Increase of temperature increases resistance of conductor but decreases resistance of semiconductor.
3. (3)
4. (1)
5. Cu is conductor and Ge is semiconductor.
Increase of temperature increases resistance of conductor but decreases resistance of semiconductor.
6. (2)
7. (3)
8. When NPN transistor is used as an amplifier, majority charge carrier electrons of N-type emitter move from emitter to base and than base to collector.
9. (3)
10. (3)
11. (3)
12. $I = n_e A v_d$

$$\frac{I_e}{I_h} = \frac{n_e \times (v_d)_e}{n_h \times (v_d)_h}$$

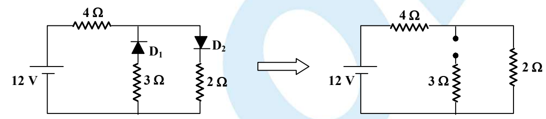
Here, $\frac{n_e}{n_h} = \frac{7}{5}, \frac{I_e}{I_h} = \frac{7}{4}$

$$\frac{7}{4} = \frac{7}{5} \times \frac{(v_d)_e}{(v_d)_h} \Rightarrow \frac{(v_d)_e}{(v_d)_h} = \frac{5}{7} \times \frac{7}{4} = \frac{5}{4}.$$

13. $\beta = \frac{I_C}{I_B}$ and $I_E = I_C + I_B$ $\quad \therefore \beta = \frac{I_C}{I_E - I_C}$

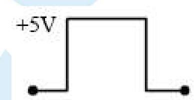
$$= \frac{5.488}{5.60 - 5.488} = 49.$$

14. If lattice constant of semiconductor is decreased, then E_C and E_v decrease but E_g increases.

15. 

$$i = \frac{12}{6} = 2 \text{ amp}$$

16. Diode is forward biased in first half cycle and amplitude of signal is 5V.



17. (4) 18. (4) 19. (3)

20. $Y = \overline{(\overline{A} + \overline{B})} = A.B$
it is AND gate.

21. From Half wave rectifier

22. $\overline{(A+B)}$ = NOR gate
When both inputs of NAND gate are connected, it behaves as NOT gate.
⇒ OR + NOT = NOR.

23. $y = \overline{\left(A\cdot\overline{A\cdot B}\right)\cdot\left(B\cdot\overline{A\cdot B}\right)} = \left(\overline{\overline{A\cdot\overline{A\cdot B}}}\right)\cdot\left(\overline{\overline{B\cdot\overline{A\cdot B}}}\right)$

$= A\cdot(\overline{A}+\overline{B}) + B\cdot(\overline{A}+\overline{B}) = A\cdot\overline{A} + A\cdot\overline{B} + B\cdot\overline{A}$

$+ B\cdot\overline{B}$ $y = 0 + A\cdot\overline{B} + B\cdot\overline{A} + 0$

24. (1)

Part # II : IIT-JEE ADVANCED

1. B 2. C 3. B 4. B

10. $\sigma = \sigma_0 e^{-\Delta E/2KT}$

$\Delta E = 0.650$ eV, $T = 300$ K

According to question, $K = 8.62 \times 10^{-5}$ eV.

$$\sigma_0 e^{-\Delta E/2KT} = 2 \times \sigma_0 e^{\frac{-\Delta E}{2 \times K \times 300}}$$

$$\Rightarrow \quad e^{\frac{-0.65}{2 \times 8.62 \times 10^{-5} \times T}} = 6.96561 \times 10^{-5}$$

Taking in on both sides,

$$\text{We get, } \frac{-0.65}{2 \times 8.62 \times 10^{-5} \times T'} = -11.874525$$

$$\Rightarrow \quad \frac{1}{T'} = \frac{11.574525 \times 2 \times 8.62 \times 10^{-5}}{0.65}$$

$$\Rightarrow \quad T' = 317.51178 = 318 \text{ K.}$$

11. Given band gap = 1 eV

Net band gap after doping = $(1 - 10^{-3})$ eV = 0.999 eV

According to the question, $KT_1 = 0.999/50$

$\Rightarrow \quad T_1 = 231.78 = 231.8$

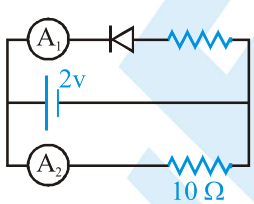
For the maximum limit $KT_2 = 2 \times 0.999$

$$\Rightarrow \quad T_2 = \frac{2 \times 1 \times 10^{-3}}{8.62 \times 10^{-5}} = \frac{2}{8.62} \times 10^2 = 23.2$$

Temperature range is (23.2 – 231.8)

12. The diode is reverse biased. Hence the resistance is infinite. So, current through A_1 is zero.

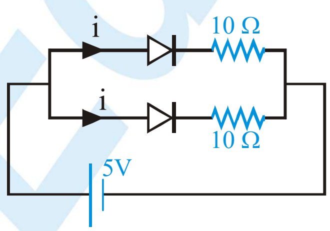
For A_2, current $= \dfrac{2}{10} = 0.2$ Amp.



13. Both diodes are forward biased. Thus the net diode resistance is 0.

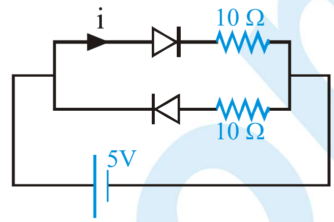
$$i = \frac{5}{(10+10)/10.10} = \frac{5}{5} = 1 \text{A.}$$

One diode is forward biased and other is reverse biased.



Current passes through the forward biased diode only.

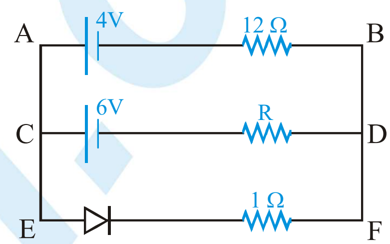
$$i = \frac{V}{R_{net}} = \frac{5}{10+0} = 1/2 = 0.5 \text{ A.}$$



14. **(a)** When R = 12 Ω

The wire EF becomes ineffective due to the net (–)ve voltage.

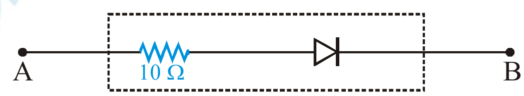
Hence, current through R = 10/24 = 0.4166 = 0.42 A.

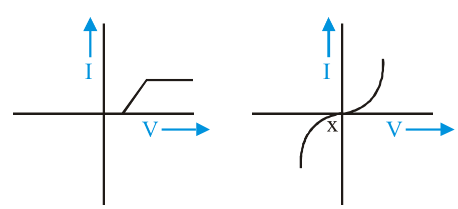


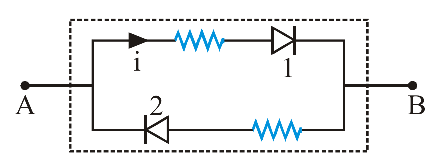
(b) Similarly for R = 48 Ω.

$$i = \frac{10}{(48+12)} = 10/60 = 0.16 \text{ A.}$$

15.







Since the diode 2 is reverse biased no current will pass through it.

9. Intrinsic semiconduct (Neutral) + Pentalvalen impurity (Neutral) $\Rightarrow$ N-type (Neutral)

10. At a particular temperature all the bonds of crystalline solids breaks and show sharp melting point.

EXERCISE - 3

Subjective Type

1. $f = 1013\ kg/m^3, V = 1\ m^3$

$m = fV = 1013 \times 1 = 1013$ kg

No. of atoms $= \dfrac{1013\times10^3\times6\times10^{23}}{23} = 264.26 \times 10^{26}$.

(a) Total no. of states $= 2N = 2 \times 264.26 \times 10^{26}$

$= 528.52 = 5.3 \times 10^{28} \times 10^{26}$

(b) Total no. of unoccupied states $= 2.65 \times 10^{26}$.

2. In a pure semiconductor, the no. of conduction electrons = no. of holes

Given volume = 1 cm × 1 cm × 1 mm

$= 1 \times 10^{-2} \times 1 \times 10^{-2} \times 1 \times 10^{-3} = 10^{-7}\ m^3$

No. of electrons $= 6 \times 10^{19} \times 10^{-7} = 6 \times 10^{12}$.

Hence no. of holes $= 6 \times 10^{12}$.

3. $E = 0.23$ eV, $K = 1.38 \times 10^{-23}$

$KT = E$

$\Rightarrow 1.38 \times 10^{-23} \times T = 0.23 \times 1.6 \times 10^{-19}$

$\Rightarrow T = \dfrac{0.23\times1.6\times10^{-19}}{1.38\times10^{-23}} = \dfrac{0.23\times1.6\times10^{4}}{1.38}$

$= 0.2676 \times 10^4 = 2670$.

4. Bandgap = 1.1 eV, T = 300K

(a) Ratio $= \dfrac{1.1}{KT} = \dfrac{1.1}{8.62\times10^{-5}\times3\times10^{2}} = 42.53 = 43$

(b) $4.253' = \dfrac{1.1}{8.62\times10^{-5}\times T}$ or $T = \dfrac{1.1\times10^{5}}{4.253\times8.62}$

$= 3000.47$ K.

5. 2KT = Energy gap between acceptor band and valency band

$\Rightarrow 2 \times 1.38 \times 10^{-23} \times 300$

$\Rightarrow E = (2 \times 1.38 \times 3) \times 10^{-21}$ J

$= \dfrac{6\times1.38}{1.6}\times\dfrac{10^{-21}}{10^{-19}}\,eV = \left(\dfrac{6\times1.38}{1.6}\right)\times10^{-2}\ eV$

$= 5.175 \times 10^{-2}$ eV = 51.75 meV = 50 meV.

6. Given $n = e^{-\Delta E/2KT}$, ΔE = Diamon $\to$ 6 eV ; ΔE Si $\to$ 1.1 eV

Now, $n_1 = e^{-\Delta E_1/2KT} = e^{\frac{-6}{2\times300\times8.62\times10^{-5}}}$

$n_2 = e^{-\Delta E_2/2KT} = e^{\frac{-1.1}{2\times300\times8.62\times10^{-5}}}$

$\dfrac{n_1}{n_2} = \dfrac{4.14772\times10^{-51}}{5.7978\times10^{-10}} = 7.15 \times 10^{-42}$.

Due to more ΔE, the conduction electrons per cubic metre in diamond is almost zero.

7. $\sigma = T^{3/2}\, e^{-\Delta E/2KT}$ at 4°K

$\sigma = 4^{3/2} = e^{\frac{-0.74}{2\times8.62\times10^{-5}\times4}} = 8\times e^{-1073.08}$

At 300 K,

$\sigma = 300^{3/2}\ e^{\frac{-0.67}{2\times8.62\times10^{-5}\times300}} = \dfrac{3\times1730}{8}e^{-12.95}$.

Ratio $= \dfrac{8\times e^{-1073.08}}{[(3\times1730)/8]\times e^{-12.95}} = \dfrac{64}{3\times1730}e^{-1060.13}$

8. Total no. of charge carriers initially $= 2 \times 7 \times 10^{15}$

$= 14 \times 10^{15}$/Cubic meter

Finally the total no. of charge carriers $= 14 \times 10^{17}\ /m^3$

We know :

The product of the concentrations of holes and conduction electrons remains, almost the same.

Let x be the no. of holes.

So, $(7 \times 10^{15}) \times (7 \times 10^{15}) = x \times (14 \times 10^{17} - x)$

$\Rightarrow 14x \times 10^{17} - x^2 = 79 \times 10^{30}$

$\Rightarrow x^2 - 14x \times 10^{17} - 49 \times 10^{30} = 0$

$x = \dfrac{14\times10^{17} \pm 14^2\times\sqrt{10^{34}+4\times49\times10^{30}}}{2}$

$= 14.00035 \times 10^{17}$.

= Increased in no. of holes or the no. of atoms of Boron added.

$\Rightarrow$ 1 atom of Boron is added per $\dfrac{5\times10^{28}}{1386.035\times10^{15}}$

$= 3.607 \times 10^{-3} \times 10^{13} = 3.607 \times 10^{10}$.

9. (No. of holes) (No. of conduction electrons) = constant.

At first :

No. of conduction electrons $= 6 \times 10^{19}$

No. of holes $= 6 \times 10^{19}$

After doping

No. of conduction electrons $= 2 \times 10^{23}$

No. of holes = x.

$(6 \times 10^{19})(6 \times 10^{19}) = (2 \times 10^{23})x$

$\Rightarrow \dfrac{6\times6\times10^{19+19}}{2\times10^{23}} = x$

$\Rightarrow x = 18 \times 10^{15} = 1.8 \times 10^{16}$.

HINTS & SOLUTIONS

EXERCISE - 1

Single Choice

1. C
2. In insulators, the forbidden energy gap is very large, in case of semiconductor it is moderate and in conductors.

3. A 4. A 5. D 6. B 7. C 8. D
9. D 10. D 11. B
12. N-type semiconductors are neutral because neutral atoms are added during doping.

13. B 14. C 15. D 16. B 17. B 18. B
19. A 20. C 21. A 22. A 23. A 24. B
25. A 26. A 27. C 28. C 29. B 30. D
31. C 32. B 33. A 34. B 35. A 36. D
37. A 38. B 39. A 40. A 41. D 42. C
43. B 44. D 45. A 46. C 47. B 48. A
49. B 50. A 51. C 52. D 53. C 54. A
55. D 56. A 57. B 58. A 59. D 60. D

EXERCISE - 2

Part # I : Multiple Choice

1. B,C 2. A, B, C, D 3. A,D 4. A, D
5. B 6. C 7. A 8. A 9. A
10. D 11. D 12. B 13. A 14. A
15. A 16. B 17. B 18. B 19. D
20. B 21. D 22. C 23. B 24. C
25. C 26. C 27. A 28. B 29. A
30. A 31. C

32. The output D for the given combination

$$D = \overline{(A+B).C} = \overline{(A+B)} + \overline{C}$$

If $A = B = C = 0$ then $D = \overline{(0+0)} + \overline{0} = \overline{0} + \overline{0} = 1 + 1 = 1$

If $A = B = 1, C = 0$ then $D = \overline{(1+1)} + \overline{0} = \overline{1} + \overline{0} = 0 + 1 = 1$

33. A 34. C 35. A 36. B 37. C 38. D
39. C

40. By using $E = \frac{V}{d} = \frac{0.6}{10^{-6}} = 6 \times 10^5$ V/m 41. A

42. Current flow is possible and $i = \frac{V}{R} = \frac{(4-1)}{300} = 10^{-2}$ A

43. For full wave rectifier $\eta = \frac{81.2}{1 + \frac{r_f}{R_L}}$

$\Rightarrow$ $n_{max} = 81.2\%$ $(r_f << R_L)$

44. The diode is in reverse bias so current through it is zero.

45. D 46. C

47. α is the ratio of collector current and emitter current while β is the ratio of collector current and base current.

48. D 49. C 50. C 51. C

52. $\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49$

53. A 54. D 55 B 56. D

Part # II : Assertion & Reason

1. In diode the output is in same phase with the input therefore it cannot be used to built NOT gate.

2. According to law of mass action, $n_i^2 = n_e n_h$. In intrinsic semiconductors $n_i = n_e = n_h$ and for P-type semiconductor n_e would be less than n_i, since n_h is necessarily more than n_i.

3. In common emitter transistor amplifier current gain $\beta > 1$, so output current > Input current, hence assertion is correct. Also, input circuit has low resistance due to forward biasing to emitter base junction, hence reason is false.

4. Input impedance of common emitter configuration = $\left|\frac{V_{BE}}{i_B}\right|_{V_{CE} = \text{constant}}$ where ΔV_{BE} = voltage across base and emitter (base emitter region is forward biased) Δi_B = base current which is order of few microampere. Thus input impedance of common emitter is low.

5. Resistivity of semiconductor decreases with temperature. The atoms of a semiconductor vibrate with larger amplitudes at higher temperatures there by increasing it's conductivity not resistivity.

6. In semiconductors the energy gap between conductin band and valence band is small (>> 1 eV). Due to temperature rise, electron in the valence band gained thermal energy and may jump across the small energy gap, goes in to the conduction badn. Thus conductivity increases and hence resistance decreases.

7. B

8. The ratio of the velocity to the applied field is called the mobility. Since electron is lighter than holes, they move faster in applied field than holes.