Physics

NCERT Exemplar Problems

Chapter 14

Semiconductor Electronics

Answers

14.1	(d)
14.2	(b)
14.3	(b)
14.4	(d)
14.5	(b)
14.6	(c)
14.7	(b)
14.8	(c)
14.9	(a), (c)
14.10	(a), (c)
14.11	(b), (c), (d)
14.12	(b), (c)
14.13	(a), (b), (d)

14.14 (b), (d)

14.15 (a), (c), (d)

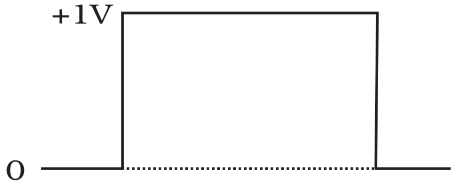
14.16 (a), (d)

14.17 The size of dopant atoms should be such as not to distort the pure semiconductor lattice structure and yet easily contribute a charge carrier on forming co-valent bonds with Si or Ge.

14.18 The energy gap for Sn is 0 eV, for C is 5.4 eV, for Si is 1.1 eV and for Ge is 0.7eV, related to their atomic size.

14.19 No, because the voltmeter must have a resistance very high compared to the junction resistance, the latter being nearly infinite.

14.20



14.21 (i) $10 \times 20 \times 30 \times 10^{-3} = 6V$

(ii) If dc supply voltage is 5V, the output peak will not exceed $V_{cc} = 5V$. Hence, $V_0 = 5V$.

14.22 No, the extra power required for amplified output is obtained from the DC source.

14.23 (i) ZENER junction diode and solar cell.

(ii) Zener breakdown voltage

(iii) Q- short circuit current

P- open circuit voltage.

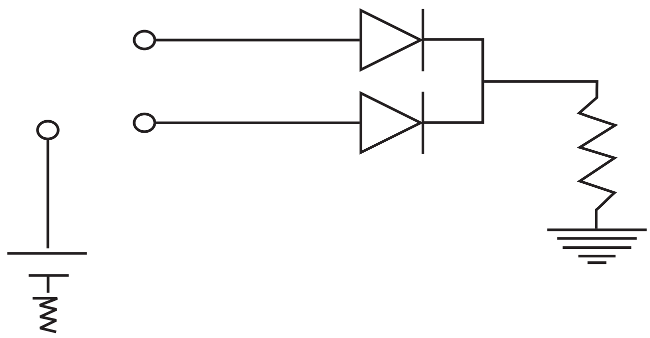
14.24 Energy of incident light photon

$$h\upsilon = \frac{6.6\times10^{-34}\times3\times10^{8}}{6\times10^{-7}\times1.6\times10^{-19}} = 2.06eV$$

For the incident radiation to be detected by the photodiode, energy of incident radiation photon should be greater than the band gap. This is true only for D2. Therefore, only D2 will detect this radiation.

14.25 $I_B = \dfrac{V_{BB} - V_{BE}}{R_1}$. If R_1 is increased, I_B will decrease. Since $I_c = \beta I_b$, it will result in decrease in I_C i.e decrease in ammeter and voltmeter readings.

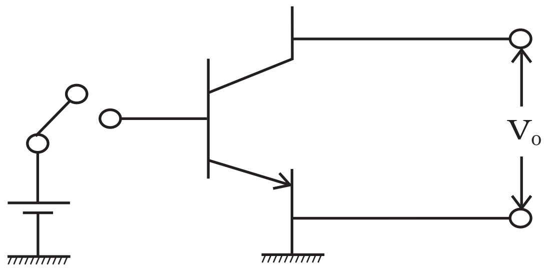
14.26



OR gate gives output according to the truth table.

A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

14.27



Input	Output
A	A
0	1
1	0

14.28 Elemental semiconductor's band-gap is such that emissions are in IR region.

14.29 Truth table

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

AND Gate

14.30 $I_{Z\max} = \frac{P}{V_Z} = 0.2\text{A} = 200\,\text{mA}$

$$R_S = \frac{V_s - V_Z}{I_{Z\max}} = \frac{2}{0.2} = 10\,\Omega.$$

14.31 I_3 is zero as the diode in that branch is reverse bised. Resistance in the branch AB and EF are each $(125 + 25)\,\Omega = 150\,\Omega$.

As AB and EF are identical parallel branches, their effective resistance is $\frac{150}{2} = 75\Omega$

$\therefore$ Net resistance in the circuit = $(75 + 25)\ \Omega = 100\,\Omega$.

$\therefore$ Current $I_1 = \frac{5}{100} = 0.05\text{A}$.

As resistances of AB and EF are equal, and $I_1 = I_2 + I_3 + I_4$, $I_3 = 0$

$$\therefore I_2 = I_4 = \frac{0.05}{2} = 0.025\text{A}$$

14.32 As $V_{be} = 0$, potential drop across R_b is 10V.

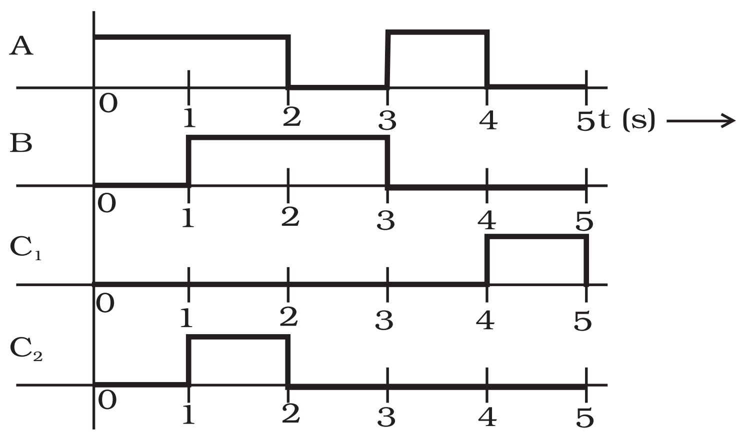
$$\therefore I_b = \frac{10}{400 \times 10^3} = 25\mu A$$

Since $V_{ce} = 0$, potential drop across R_c, i.e. $I_c R_c$ is 10V.

$$\therefore I_c = \frac{10}{3 \times 10^3} = 3.33 \times 10^{-3} = 3.33\text{m}A\ .$$

$$\therefore \beta = \frac{I_c}{I_b} = \frac{3.33 \times 10^{-3}}{25 \times 10^{-6}} = 1.33 \times 10^2 = 133.$$

14.33



14.34 From the output characteristics at point Q, V_{CE} = 8V & I_C = 4mA

$V_{CC} = I_C RC + V_{CE}$

$$R_c = \frac{V_{CC} - V_{CE}}{I_C}$$

$$R_c = \frac{16-8}{4\times10^{-3}} = 2\text{K}\Omega$$

Since,

$V_{BB} = I_B R_B + V_{BE}$

$$R_B = \frac{16-0.7}{30\times10^{-6}} = 510\text{K}\Omega$$

Now, $\beta = \frac{I_C}{I_B} = \frac{4\times10^{-3}}{30\times10^{-6}} = 133$

Voltage gain $= A_V = -\beta\frac{R_C}{R_B}$

$$= -133\times\frac{2\times10^3}{510\times10^3}$$

$= 0.52$

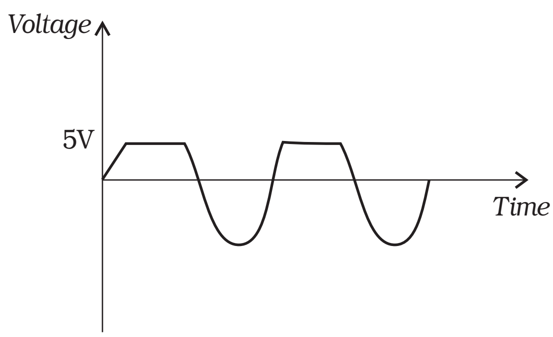
Power Gain $= A_p = \beta\times A_V$

$$= -\beta^2\frac{R_C}{R_B}$$

$$= (133)^2\times\frac{2\times10^3}{510\times10^3} = 69$$

14.35 When input voltage is greater than 5V, diode is conducting

When input is less than 5V, diode is open circuit



14.36 (i) In 'n' region; number of e^- is due to As:

$n_e = N_D = 1\times10^{-6}\times5\times10^{28}$ atoms/m^3

$n_e = 5\times10^{22}$/m^3

The minority carriers (hole) is

$$n_h = \frac{n_i^2}{n_e} = \frac{(1.5\times10^{16})^2}{5\times10^{22}} = \frac{2.25\times10^{32}}{5\times10^{22}}$$

$n_h = 0.45 \times 10/\text{m}^3$

Similarly, when Boron is implanted a 'p' type is created with holes

$n_h = N_A = 200 \times 10^{-6} \times 5 \times 10^{28}$

$= 1 \times 10^{25}/\text{m}^3$

This is far greater than e^- that existed in 'n' type wafer on which Boron was diffused.

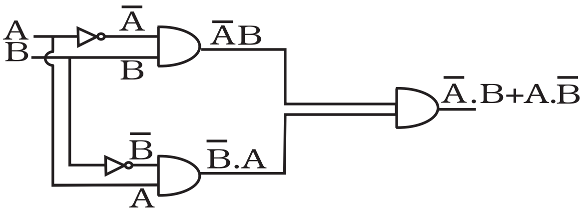
Therefore, minority carriers in created 'p' region

$$n_e = \frac{n_i^2}{n_h} = \frac{2.25\times10^{32}}{1\times10^{25}}$$

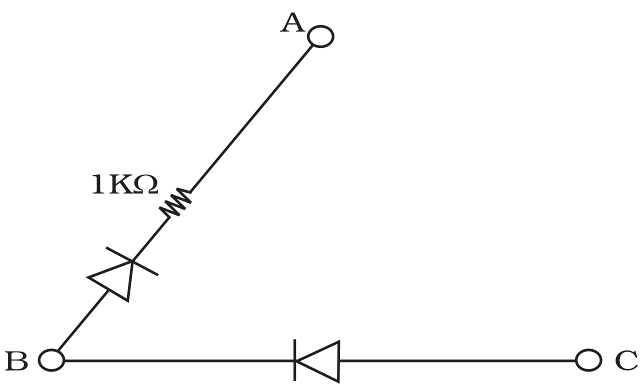
$= 2.25 \times 10^7/\text{m}^3$

(ii) Thus, when reverse biased $0.45 \times 10^{10}/\text{m}^3$, holes of '$n$' region would contribute more to the reverse saturation current than $2.25 \times 10^7/\text{m}^3$ minority e^- of p type region.

14.37



14.38



14.39 $I_C \approx I_E \quad \therefore \; I_C (R_C + R_E) + V_{CE} = 12\ \text{V}$

$R_E = 9 - R_C = 1.2\ \text{K}\Omega$

$\therefore\ V_E = 1.2\ \text{V}$

$V_B = V_E + V_{BE} = 1.7\ \text{V}$

$$I = \frac{V_B}{20\text{K}} = 0.085\,\text{mA}$$

$$R_B = \frac{12-1.7}{I_C/\beta + 0.085} = \frac{10.3}{0.01+1.085} = 108\,\text{K}\Omega$$

14.40 $I_E = I_C + I_B$ $\qquad$ $I_C = \beta\, I_B$ $\qquad$ (1)

$I_C R_C + V_{CE} + I_E R_E = V_{CC}$ $\qquad$ (2)

$R I_B + V_{BE} + I_E R_E = V_{CC}$ $\qquad$ (3)

From (3) $I_e \approx I_C = \beta\, I_B$

$$(R + \beta\, R_E) = V_{CC} - V_{BE}, \quad I_B = \frac{V_{CC} - V_{BE}}{R + \beta R_E} = \frac{11.5}{200}\,\text{mA}$$

From (2)

$$R_C + R_E = \frac{V_{CC} - V_{CE}}{I_C} = \frac{V_{CC} - V_{CE}}{\beta I_B} = \frac{2}{11.5}(12-3)\text{K}\Omega = 1.56\text{K}\Omega$$

$$R_C = 1.56 - 1 = 0.56\text{K}\Omega$$