Solved Examples

JEE Main/Boards

Example 1: For a common base transistor if the values of I_E and I_C are $10^3 \mu A$ and 0.96 mA respectively then the value of I_B will be-

Sol: The base current in the circuit is given by $I_B = I_E - I_C$.

$\therefore I_E = I_B + I_C \;;\; I_B = I_E - I_C$

$= 1000X10^{-6} - 0.96X10^{-3}$

$= 1mA - 0.96mA = 0.04mA$

Example 2: Mobility of electronics in Germanium of N types & their conductivity are 3900 cm^2/ V s & 5 mho/cm respectively. If effect of holes are negligible then concentration of impurity will be-

Sol: The density of the electron is given by $n_d = \frac{\sigma_n}{e\mu_d}$

$\mu_a = 3900\,cm^2$ / volt sec

$\sigma_n = 5$ mho / cm

$\sigma_n = n_d x1.6x10^{-19} x3900$

$\therefore n_d = \frac{5}{1.6x39x10^{-17}} = 8x10^{15}$

Example 3: What will be conductance of pure silicon crystal at 300 K Temp. If electron hole pairs per cm^3 is $1.072/10^{10}$ at this Temp; $\mu_n = 1350\,cm^2$ / volt sec & $\mu_h = 480 cm^2$ / volt sec

Sol: The conductivity of the sample is given by $\sigma = n_i e(\mu_e + \mu_h)$ where n_i is the concentration of the hole-electron pair.

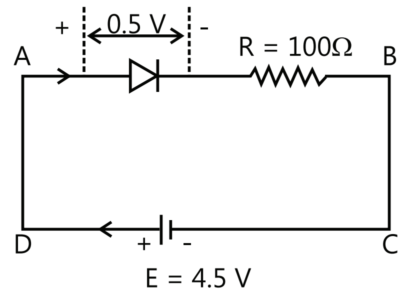
$\sigma = n_i e\mu_e + n_i e\mu_h = n_i e(\mu_e + \mu_h)$

$= 3.14x10^{-6}$ mho / cm

Example 4: Figure shows a diode connected to an external resistance and an e.m.f. assuming that the barrier potential developed in diode is 0.5V obtain the value of current in the circuit in milli-ampere.

Sol: The current in the circuit is obtained by Ohm's law, as the diode resistance is zero in forward biased condition.

Here, $E = 4.5V, R = 100\Omega$, voltage in the circuit,



V=4.5-0.5=4.0V

Current in the circuit,

$I = \frac{V}{R} = \frac{4.0}{100} = 0.04A = 0.04x1000mA = 40mA$

Example 5: Calculate the emitter current for which $I_b = 20\mu A, \beta = 100$

Sol: The emitter current in the transistor circuit is given by $I_e = I_b + I_c$ where I_b and I_c are the base and collector current respectively.

Here $\beta = 100,\ I_b = 20\mu A$

$\beta = \frac{I_c}{I_b} \;\therefore I_c = \beta I_b = 100x20 = 2000\mu A$

Using $I_e = I_b + I_c$, we get

$I_e = 20 + 2000 = 2020\mu A = 2.02x10^{-3} A = 2.02mA$

Example 6: Transistor with $\beta = 75$ is connected to common-base configuration. What will be the maximum collector current for an emitter current of 5 mA?

Sol: As value of CE gain is given we find the value of CB gain by $\beta = \frac{\alpha}{1-\alpha}$. The value of collector current is found as $I_c = \alpha I_e$.

Here $\beta = 75, I_c = 5mA$

Step-I Using $\beta = \frac{\alpha}{1-\alpha}$,

we get $75 = \frac{\alpha}{1-\alpha}$ or $75 - 75\alpha = \alpha$

or $76\alpha = 75$ or $\alpha = \frac{75}{76}$

Step – II $\alpha = \frac{I_c}{I_e} \;\therefore I_c = \alpha I_e = \frac{75}{76} \times 5 = 4.93A$

Example 7: In NPN transistor circuit, the collector current is 10 mA. If 95% of the electrons emitted reach the collector, what is the base current?

Sol: The base current in NPN transistor circuit is $I_b = I_e - I_c$ where I_e is the emitter current and I_c is the collector current.

Step-I I_c=95% I_c=0.95I_e

$$\therefore\ I_e = \frac{I_c}{0.95} = \frac{10}{0.95}\ (\because I_c = 10mA)$$

$$= 10.53mA$$

Step II Now $I_e = I_c + I_b$

$$\therefore\ I_b = I_e - I_c = 10.53 - 10 = 0.53mA$$

Example 8: In a pure silicon sample, 10^{13} atoms of phosphorus are doped per cm. If all the donor atoms produce carriers and $\mu_c = 1200\,cm^2$ / volt-sec then, calculate the resistivity of the sample.

Sol: The resistivity is obtained as $\rho = \frac{1}{\sigma} = \frac{1}{en_e\mu_e}$

Given $n_e = 10^{13}$ per $cm^3 = 10^{19}$ per m^3

$\mu_c = 0.12m^2$ / volt sec

Therefore, for doped, n-type semiconductor

$$\sigma = en_e\mu_e = 1.6x10^{-19}x10^{19}x0.12 = 0.192\ ohm\ m^{-1}$$

The resistivity is $\rho = \frac{1}{0.192} = 5.2$ ohm meter

Example 9: What will be the antenna current when modulation is 40%?

Sol: The antenna current is obtained using equation $\frac{P_T}{P_C} = \left(\frac{I_T}{I_C}\right)^2 = 1 + \frac{m_a^2}{2}$ where P_T is the power of transmitter and P_C is the power of carrier wave.

$$P_s = \frac{1}{2}m_a^2 P_c$$

$$P_T = P_c + P_s = P_c\left(1 + \frac{m_a^2}{2}\right)$$

$$\therefore\ \frac{P_T}{P_C} = 1 + \frac{m_a^2}{2}\ \text{or}\ \left(\frac{I_T}{I_C}\right)^2 = 1 + \frac{m_a^2}{2}$$

Given that $I_c = 8A; m_a = 0.4$

$$\therefore\ \left(\frac{I_T}{8}\right)^2 = 1 + \frac{(0.4)^2}{2}$$

or $(I_T / 8) = 1.08$ or $I_T = 8\sqrt{1.08} = 8.31A$

JEE Advanced/Boards

Example 1: A potential barrier of 0.5V exists across a p-n junction

(i) If the depletion region is $5x10^{-7}$m wide. What is the intensity of the electric field in this region?

(ii) An electron with speed $5x10^6$m/s approaches the p-n junction from the n-side with what speed will it enter the p-side.

Sol: The intensity of electric field is given by $E = \frac{V}{\Delta L}$.

The energy required by electron to move from N side to the P side is greater than or equal to the barrier potential.

(i) $E = \frac{V}{\Delta L} = \frac{0.5V}{5X10^{-7}}$,

Depletion layer= ΔL ; $E = 10^6\frac{V}{m}$

(ii) Work energy theorem

$$\frac{1}{2}MV_i^2 = eV + \frac{1}{2}MV_i^2$$

$$V_f = \sqrt{\frac{MV_i^2 - 2eV}{M}} = 2.7x10^5\ m/s$$

Example 2: The base current is 100 μA and collector current is 3 mA.

(a) Calculate the values of β and α

(b) A change of 20 μA in the base current produces a change of 0.5mA is the collector current. Calculate β_{ac}

Sol: The value of α and β are given as $\beta = \frac{I_c}{I_b}$ and $\beta = \frac{\alpha}{1-\alpha}$. The value of β_{ac} is found as $\beta_{ac} = \frac{\Delta I_c}{\Delta I_b}$.

Here $I_b = 100\mu A = 0.100mA$; $I_c = 3mA$

(a) Using $\beta = \frac{I_c}{I_b}$, we get $\beta = \frac{3}{0.100} = 30$

Using $\beta = \frac{\alpha}{1-\alpha}$,

we get $30 = \frac{\alpha}{1-\alpha} = 30 - 30\alpha = \alpha$

or $31\alpha = 30\ \therefore \alpha = \frac{30}{31} = 0.97$

Using $\alpha = \frac{I_c}{I_e}$, we get $I_e = \frac{I_c}{\alpha} = \frac{3x31}{30} = 3.1mA$

(b) Here $\Delta I_b = 20\mu A = 0.02mA$; $\Delta I_c = 0.50mA$

$$\therefore \beta_{ac} = \frac{\Delta I_c}{\Delta I_b} = \frac{0.5}{0.02} = 25$$

Example 3: The Concentration of hole – electron pairs in pure silicon at T=300 K is 7×10^{15} per cubic meter. Antimony is doped in silicon in proportion of 1 atom in 10^7 Si atoms. Assuming that half of the impurity atoms contribute electron. In the conduction band, calculate the factor by which the number of charge carriers increases due to doping the number of silicon atoms per cubic meter is 5×10^{28}.

Sol: The factor to increase the number of charge carriers from initial to final is given by $\frac{n_{final} - n_{initial}}{n_{initial}}$ where n_{final} and $n_{initial}$ are the charge concentration after and before doping the silicon with antimony.

In pure semiconductor electron-hole pair $= 7\times10^{15}$; $n_{initial} = n_h + n_e = 14\times10^{15}$

After doping: Donor Impurity,

$$N_D = \frac{5\times10^{28}}{10^7} = 5\times10^{21}$$

According to question $n_e = \frac{N_D}{2} = 2.5\times10^{21}$

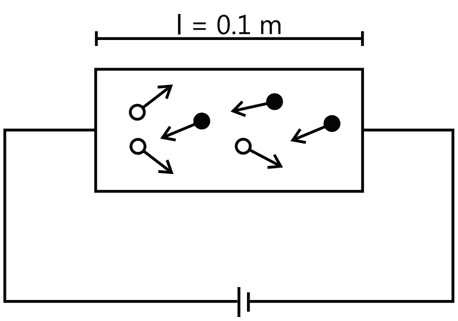
so $n_{final} = n_h + n_e$

Here $n_e >> n_h$

so $n_{final} \approx n_e \approx 2.5\times10^{21}$

$$\text{Factor} = \frac{n_{final} - n_{initial}}{n_{initial}} \approx \frac{2.5\times10^{21}}{14\times10^{15}} = 1.8\times10^5$$

Example 4: In Figure below a battery of e.m.f. 2V is used. The length of the block is 0.1 m and the area is $1\times10^{-4}m^2$. If the block is of intrinsic silicon at 300 K, find the electron and hole current. What will be the magnitude of total current if germanium is used instead of silicon? For silicon



$\mu_e = 0.135m^2 / Vs; \mu_h = 0.048m^2 / Vs$ and $n_i = 1.5\times10^{16}m^{-3}$ For germanium, $\mu_e = 0.39m^2 / Vs, \mu_h = 0.19m^2 / Vs$ and $n_i = 2.4\times10^{19}m^{-3}$.

Sol: The electron and hole current in semiconductor block is given by $I_e = n_e eA\mu_e E$ and $I_h = n_h eA\mu_h E$ where A is the area, n_e and n_h are the number densities of electron and holes and μ_e and μ_h are electron and hole mobilities, in the semiconductor block. The total current is given by $I = I_e + I_h$.

$$\text{Electric field} = \frac{\text{e.m.f.}}{l} = \frac{2}{0.1} = 20Vm^{-1}$$

Cross-sectional area, $A = 1\times10^{-4}m^2$

For silicon block

$n_e = n_h = n_i = 1.5\times10^{16}m^{-3}$

$\mu_e = 0.135m^2 / Vs; \mu_h = 0.048m^2 / Vs$

Electron Current,

$$I_e = n_e eA\nu_e = n_e eA\mu_e E \quad \left(\because \mu_e = \frac{\nu_e}{E}\right)$$

$$= (1.5\times10^{16})\times(1.6\times10^{-19})\times(1\times10^{-4})\times0.135\times20$$

$$= 0.648\times10^{-16}A = 0.648\mu A$$

Hole current,

$$I_h = n_h eA\nu_h = n_h eA\mu_h E \quad \left(\because \mu_h = \frac{\nu_h}{E}\right)$$

$$= (1.5\times10^{16})\times(1.6\times10^{-19})\times(1\times10^{-4})\times0.048\times20$$

$$= 0.23\times10^{-16}A = 0.23\mu A$$

Total current $I = I_e + I_h = 0.648 + 0.23 = 0.878\mu A$

For germanium block

$n_e = n_h = n_i = 2.4\times10^{19}m^{-3}; \mu_e = 0.39m^2 / Vs; \mu_h = 0.19m^2 / Vs$

Electron Current, $I_e = n_e eA\mu_e E$

$$= (2.4\times10^{19})\times(1.6\times10^{-19})\times(1.0\times10^{-4})\times0.39\times20$$

$$= 2.995\times10^{-3}A = 2.995mA$$

Hole current, $I_h = n_h eA\mu_h E$

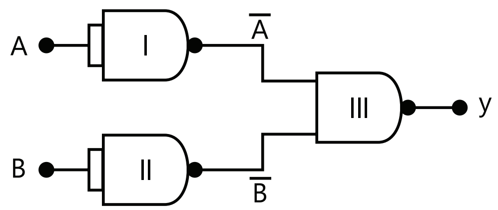
$= (2.4\times10^{19})\times(1.6\times10^{-19})\times(1.0\times10^{-4})\times0.19\times20$

$= 1.459\times10^{-3}\,A = 1.459mA$

Total current, $I = I_e + I_h = 2.995 + 1.459 = 4.454mA$

Example 5: Explain how OR gate is realized using NAND gate.

Sol: The OR gate is made using the NAND gate. The equation explaining the structure is given by $Y = \overline{\left[\overline{(A\bullet A)}\bullet\overline{(B\bullet B)}\right]} = \overline{(\overline{A}\bullet\overline{B})}$ where $\overline{A}$ and $\overline{B}$ are the output of the two NAND gates used as input in third NAND gate



A	B	$\overline{A}$			$\overline{B}$	$Y = \overline{\overline{A}.\overline{B}}$
0	0	1			1	0
1	0	0			1	1
0	1	1			0	1
1	1	0			0	1

For this purpose, we use three NAND gates; the first two NAND gates (I and II) are operated as NOT gates and their outputs are fed to the third NAND gate (III). The resulting circuit is OR gate. This is proved as under:

Output of gate $I = \overline{A.A} = \overline{A} + \overline{A} = \overline{A}$ Output of gate $II = \overline{B.B} = \overline{B} + \overline{B} = \overline{B}$

Output of gate III, $Y = \overline{\overline{A}.\overline{B}} = \overline{A} + \overline{B} = A + B$

Since Y=A+B is the Boolean expression for OR gate, the circuit shown in Fig. is OR gate, its truth table is also shown.

JEE Main/Boards

Exercise 1

Semiconductor

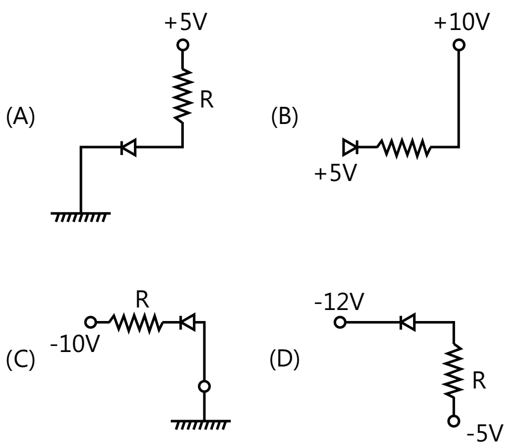
Q.1 What is meant by the term doping of an intrinsic semiconductor? How does it affect the conductivity of a semiconductor?

Q.2 If the output of a 2-input NAND gate is fed as the input to a NOT gate (i) name the new logic gate obtained and (ii) write down its truth table.

Q.3 Draw the energy band diagram of a p-type semiconductor. Deduce an expression for the conductivity of a p-type semiconductor.

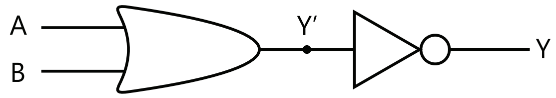
Q.4 How does the width of the depletion region of p-n junction vary, if the reverse bias applied to it?

Q.5 In the following diagrams, write which of the diodes are forwards biased and which are reverse biased.



Q.6 The output of a 2-input NAND gate is fed to a NOT gate. Write down the truth table for the output of the combination for all possible inputs of A and B.

Q.7 Name the gate obtain from the combination of gates shown in the figure. Draw its logic symbol. Write the truth table of the combination.

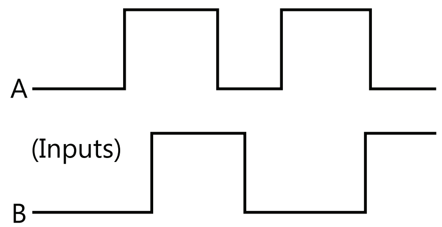


Q.8 How is a p-type semiconductor formed? Name the major charge carriers in it. Draw the energy band diagram of p-type semiconductor.

Q.9 Draw a labeled circuit diagram of a common base amplifier using a p-n-p transistor. Define the term `voltage gain' and write an expression for it.

Q.10 Draw the voltage-current characteristic of a Zener diode.

Q.11 Give the logic symbol for an OR gate. Draw the output wave from for input wave forms A and B for this gate.



Q.12 With the help of a labeled circuit diagram, explain how an n-p-n transistor can be used as an amplifier in common emitter configuration. Explain how the input and output voltages are out of phase by 180° for a common-emitter transistor amplifier. OR

For an n-p-n transistor in the common-emitter configuration, draw a labeled circuit diagram of an arrangement for measuring the collector current as a function of collector-emitter voltage for at least two different values of base current. Draw the shape of the curves obtained. Define the terms: (i) output resistance and (ii) current amplification factor.

Q.13 On the basis of the energy band diagrams distinguish between metals, insulators and semiconductors.

Q.14 (a) With the help of a circuit diagram explain the working of transistor as oscillator.

(b) Draw a circuit diagram for a two input OR gate and explain its working with the help of input, Output waveforms. OR

(c) Explain briefly with the help of a circuit diagram how V-I characteristics of p-n junction diode are obtained in (i) forward bias, and (ii) reverse bias.

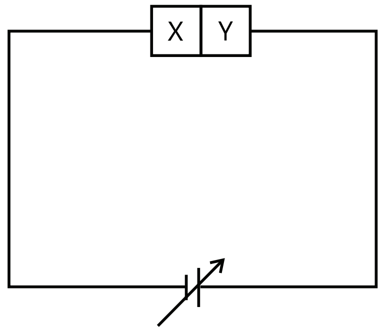
(d) A photodiode is fabricated from a semiconductor with a band gap of 2.8 eV. Can detect wavelength of 6000nm? Justify.

Q.15 Explain (i) Forward biasing, (ii) Reverse biasing of a P-N junction diode. With the help of a circuit diagram, explain the use of this device as a half-wave rectifier.

Q.16 What are energy bands? How are these formed? Distinguish between a conductor, an insulator and a semiconductor on the basis of energy band diagram. OR

Explain the function of base region of a transistor. Why this region is made thin and lightly doped? Draw a circuit diagram to study the input and output characteristics of n-p-n transistor in a common `emitter (CE) configuration. Show these characteristics graphically. Explain how current amplification factor of the transistor is calculated using output characteristics.

Q.17 Two semiconductor materials X and Y shown in the given figure, are made by doping germanium crystal with indium and arsenic respectively. The two are joined end to end and connected to a battery as shown.



(i) Will the junction be formed biased or reverse biased?

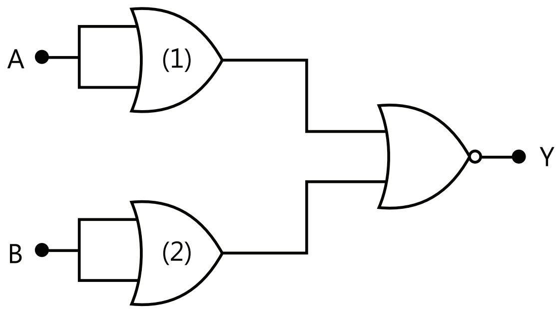
(ii) Sketch a V-I graph for this arrangement.

Q.18 Draw the circuit diagram of a common emitter amplifier using n-p-n transistor. What is the phase difference between the input signal and output voltage? State two reasons why a common emitter amplifier is preferred to a common base amplifier.

Q.19 Explain the formation of energy band in solids. Draw energy band diagram for (i) a conductor (ii) and intrinsic semiconductor.

Q.20 State the reason, why GaAs is most commonly used in making of a solar cell.

Q.21 The input A and B are inverted by using two NOT gates and their outputs are fed to the NOR gate as shown below.



Analyses the action of the gates (1) and (2) and identify the logic gate of the complete circuit so obtained. Given its symbols and the truth table.

Q.22 Draw the labeled circuit diagram of a common-emitter transistor amplifier. Explain clearly how the input and output signals are in opposite phase. Or

State briefly the underlying principle of a transistor oscillator. Draw a circuit diagram showing how the feedback is accomplished by inductive coupling. Explain the oscillator action.

Q.23 Give the logic symbol of NOR gate.

Q.24 With the help of a suitable diagram, explain the formation of depletion region in p-n junction. How does its width change when the junction is (i) forward biased, and (ii) reverse biased?

Q.25 Give a circuit diagram of a common emitter amplifier using an n-p-n transistor. Draw the input and output waveforms of the signal. Write the expression for its voltage gain.

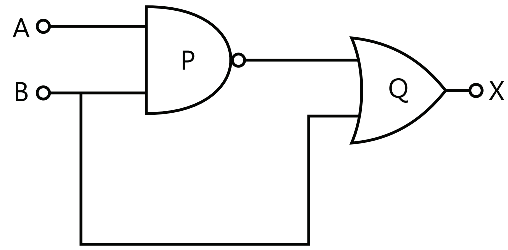
Q.26 (a) Draw the circuit diagrams of p-n junction diode in (i) forward bias, (ii) reverse bias. How are these circuits used to study to study the V-I characteristics.

(b) What is a light emitting diode (LED)? Mention two important advantages of LED's over conventional lamps. **Or**

(a) Draw the circuit arrangement for studying the input and output characteristics of an n-p-n transistor in CE configuration. With the help of these characteristics define (i) input resistance, (ii) current amplification factor.

(b) Describe briefly with the help of a circuit diagram how an n-p-n transistor is used to produce self-sustained oscillations.

Q.27 (i) Identify the logic gates marked P and Q in the given logic circuit.

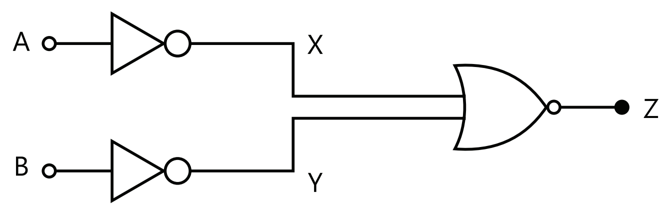


(ii) Write down the output at X for the inputs A=0, B=0 and A=1, B=1.

Q.28 What happens to the width of depletion layer of p-n junction when it is (i) forward biased, (ii) reverse biased?

Q.29 Draw a labeled diagram of a full wave rectifier circuit. State its working principle. Show the input-output waveforms.

Q.30 You are given a circuit below. Write its truth table. Hence, identify the logic operation carried out by this circuit. Draw the logic symbols of the gate it corresponds to.



Q.31 Describe briefly with the help of a circuit diagram, how the flow of current carriers in a p-n-p transistor is regulated with emitter-base junction forward biased and base-collector junction reverse biased.

Q.32 (a) Describe briefly, with the help of diagram, the role of the two important processed involved in the formation of a p-n junction.

(b) Name the device which is used as a voltage regulator. Draw the necessary circuit diagram and explain its working.

Q.33 (a) Explain briefly the principle on which a transistor-amplifier works as an oscillator. Draw the necessary circuit diagram and explain its working.

(b) Identify the equivalent gate for the following circuit and write its truth table.

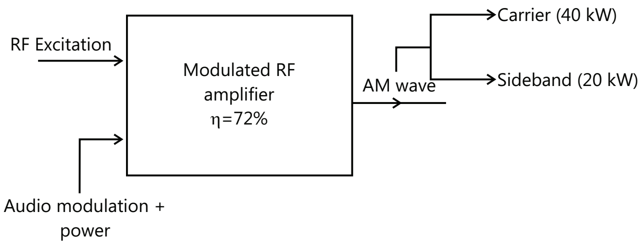
Communication System

Q.34 A 40 kW carrier is to be modulated to a level of 100%.

(i) What is the carrier power after modulation?

(ii) How Much audio power is required if the efficiency of the modulated RF amplifier is 72%?

Q.35 The load current in the transmitting antenna of an unmodulated AM transmitter is 8 A. What will be the antenna current when modulation is 40%?



Q.36 The antenna current of an AM transmitter is 8 A when only carrier is sent but it increase to 8.93 A when the carrier is sinusoidally modulated. Find the % age modulation.

Q.37 The r.m.s value of carrier voltage is 100V. After amplitude modulation by a sinusoidal a.f. (audio frequency) voltage, the r.m.s. value becomes 110 V. Calculate the modulation index.

Q.38 An AM wave consists of the following components: Carrier component =5.V peak value. Lower sideband component = 2.5 V peak value. Upper sideband component =2.5 V peak value. If the AM wave drives a $2K\Omega$ resistor, find the power delivered to the resistor by (i) carrier component (ii) Lower sideband component and (iii) upper sideband component. What is the power delivered?

Q.39 When modulation is 75% and AM transmitter produces 10kw. What would be percentage power saving if the carrier and one of sidebands were suppressed before transmission took place?

Q.40 Is it necessary for a transmitting antenna to be at the same height as that of the receiving antenna for line-of-sight communication? A TV transmitting antenna is 81 m tall. How much service area can it cover if the receiving antenna is at the ground level?

Exercise 2

Semiconductor

Single Correct Choice Type

Q.1 The forbidden energy gap of a germanium semiconductor is 0.75 eV. The minimum thermal energy of electrons reaching the conduction band from the valence band should be

(A) 0.5 eV (B) 0.75 eV

(C) 0.25 eV (D) 1.5 eV

Q.2 The energy of a photon of sodium light $(\lambda = 5890A)$ equal the band gap of a semiconductor. The minimum energy required to create an electron-hole pair is

(A) 0.026 eV (B) 0.75 eV

(C) 2.1 eV (D) 6.4 eV

Q.3 On increasing temperature the specific resistance of a semiconductor

(A) Decreases (B) Increases

(C) Remains constant (D) Become zero

Q.4 In a good conductor the energy gap between the conduction band and the valence band is-

(A) Infinite (B) Wide

(C) Narrow (D) Zero

Q.5 In a semiconducting material the mobilities of electrons and holes are μ_e and μ_h respectively. Which of the following is true

(A) $\mu_e > \mu_h$ (B) $\mu_e < \mu_h$

(C) $\mu_e = \mu_h$ (D) $\mu_e < 0; \mu_h > 0$

Q.6 Those materials in which number of holes in valence band is equal to number of electrons in conduction band are called

(A) Conductors

(B) Intrinsic semiconductors

(C) p-type semiconductors

(D) n-type semiconductors

Q.7 In p-type semiconductor holes move in

(A) Forbidden region (B) Conduction band

(C) Valence band (D) all the above regions

Q.8: Fermi level of energy of intrinsic semiconductor lies-

(A) In the middle of forbidden gap

(B) Below the middle of forbidden gap

(C) Above the middle of forbidden gap

(D) Outside the forbidden gap

Q.9 The electron mobility in N-type germanium is 3900 $cm^2/V.s$ and its conductivity is 6.24 mho/cm, then impurity concentration will be if the effect of cotters is negligible-

(A) $10^{15} cm^3$ (B) $10^{13}/cm^3$

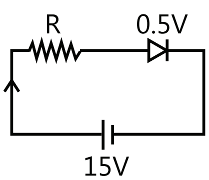
(C) $10^{12}/cm^3$ (D) $10^{16}/cm^3$

Q.10 The approximate radio of resistances in the forward and reverse bias of the PN-junction diode is-

(A) $10^2 : 1$ (B) $10^{-2} : 1$

(C) $1 : 10^{-4}$ (D) $1 : 10^4$

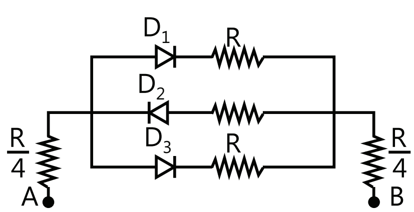
Q.11 The diode used in the circuit shown in the figure has a constant voltage drop of 0.5 V at all current and a maximum power rating of 100 milliwatts. What should be the value of the resistor R, connected in series with the diode for obtaining maximum current-?



(A) 1.5Ω (B) 5Ω

(C) 6.67Ω (D) 200Ω

Q.12: In the following circuits PN-junction diodes D_1, D_2 and D_3 are ideal for the following potential of A and B, the correct increasing order of resistance between A and B will be



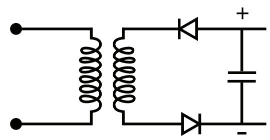
(i) -10 V, -5 V (ii) -5 V, -10 V (iii)-4 V, -12 V

(A) (i)<(ii)<(iii) (B) (iii)<(ii)<(i)

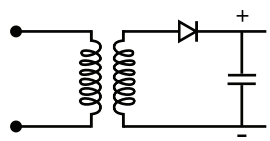
(C) (ii)=(iii)<(i) (D) (i)=(iii)<(i)

Q.13 Which is the correct diagram of a half-wave rectifier –

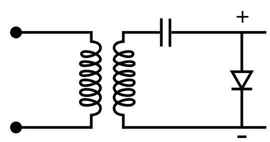
(A)



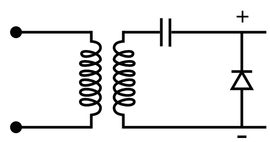
(B)



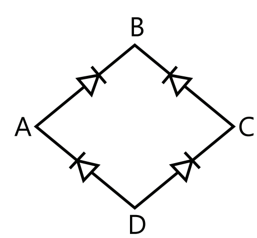
(C)



(D)



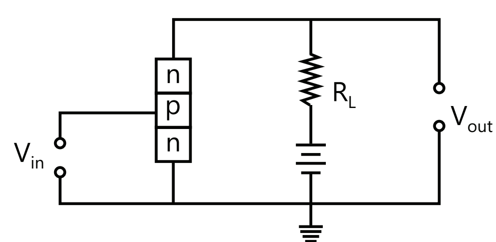
Q.14 In the diagram, the input is across the terminals A and C and the output is across the terminals B and S, then the output is



(A) Zero (B) Same as input

(C) Full wave rectifier (D) Half wave rectifier

Q.15 An n-p-n transistor circuit is arranged as shown in figure It is-



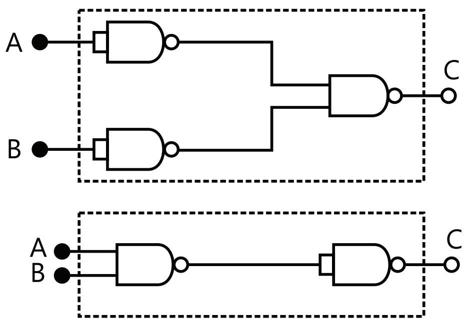
(A) A common-base amplifier circuit

(B) A common- emitter amplifier circuit

(C) A common-collector amplifier circuit

(D) None of the above

Q.16 The combination of `NAND' gates shown here under (See below figure) are equivalent to



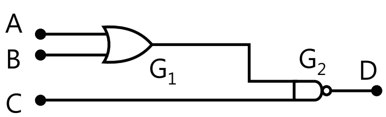
(A) An OR gate and an AND gate respectively

(B) An AND gate and a NOT gate respectively

(C) An AND gate and an OR gate respectively

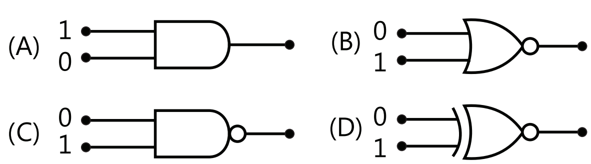
(D) An OR gate and a NOT gate respectively

Q.17 For the given combination of gates, if the logic states of inputs A,B, C are as follows A=B=C=0 and A=B=1, C=0 then the logic states of output D are-

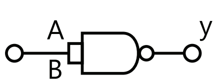


(A) 0, 0 (B) 0, 1 (C) 1, 0 (D) 1, 1

Q.18 Which of the following gates will have an output of 1-



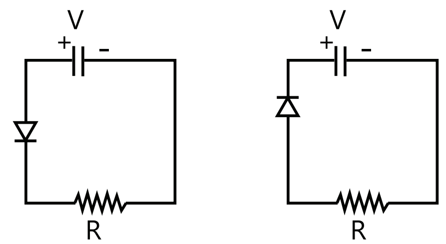
Q.19 This symbol represents-



(A) NOT gate (B) OR gate

(C) AND gate (D) NOR gate

Q.20 Two identical capacitors A and B are charged to the same potential V and are connected in two circuits at t=0 as shown in Figure The charge of the capacitors at a time t=CR are respectively.



(A) VC, VC (B) VC/e, VC

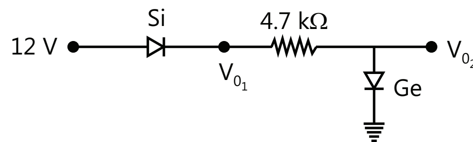
(C) VC, VC/e (D) VC/e, VC/e

Q.21 In the given circuit V_{0_1} & V_{0_2} are

(A) 11.3 V & 0.3 V (B) 0.3 V & 11.3 V

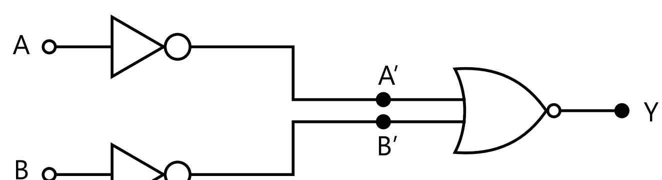
(C) 11.3 V & 11.3 V (D) 0.3 V & 0.3 V

Q.22 In Figure the current supplied by the battery is



(A) 0.1 A (B) 0.2 A (C) 0.3 A (D) 0.4 A

Q.23 Which of the following frequencies will be suitable for beyond-the horizon communication using sky waves?



(A) 10 kHZ (B) 10 MHz

(C) 1 GHz (D) 1000 GHz

Q.24 Frequencies in the UHF rage normally propagate by means of :

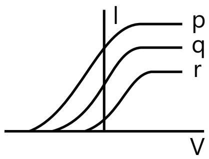
(A) Ground waves (B) Sky waves

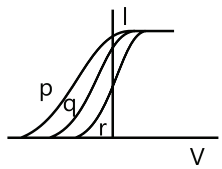
(C) Surface waves (D) Space waves

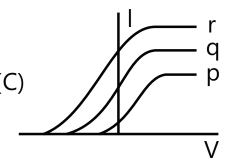
Previous Years' Questions

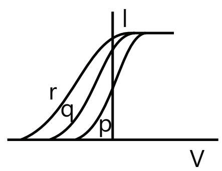
Semiconductor

Q.1 Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions $\phi_p = 2.0\,eV, \phi_q = 2.5\,eV$, and $\phi_r = 3.0\,eV$, respectively. A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct I-V graph for the experiment is (Take hc=1240 eV nm) ***(2009)***

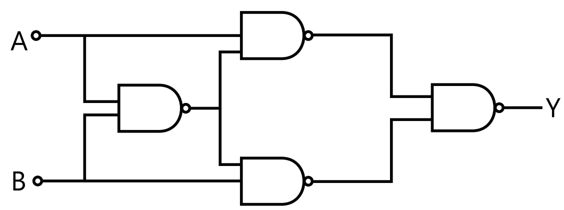
(A)


(B)


(C)


(D)


Q.2 Truth table for system of four NAND gates as shown in Figure is ***(2010)***



(A)

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

(B)

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

(C)

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

(D)

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

Q.3 A working transistor with its three legs marked P, Q and R is tested using a multi meter. No conduction is found between P and Q. By connecting the common (negative) terminal of the multi meter to R and the other (positive) terminal to P or Q, some resistance is seen on the multi meter. Which of the following is true for the transistor? ***(2008)***

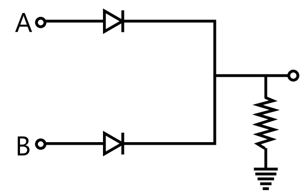
(A) It is an npn transistor with R as base

(B) It is a pnp transistor with R as collector

(C) It is a pnp transistor with R as emitter

(D) It is an npn transistor with R as collector

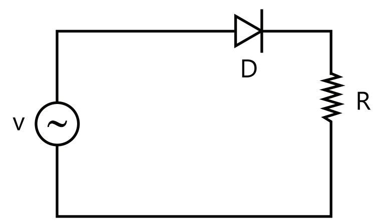
Q.4 In the circuit below, A and B represent two inputs and C represents the output. The circuit represents ***(2008)***

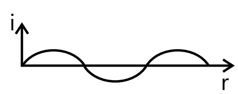


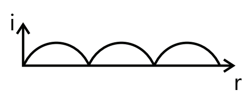
(A) NOR gate (B) AND gate

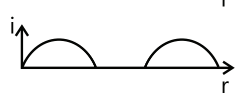
(C) NAND gate (D) OR gate

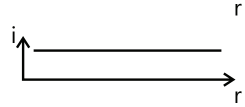
Q.5 A p-n junction (D) shown in the figure can act as a rectifier. An alternating current source (V) is connected in the circuit. ***(2009)***



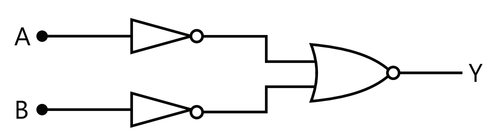
(A)


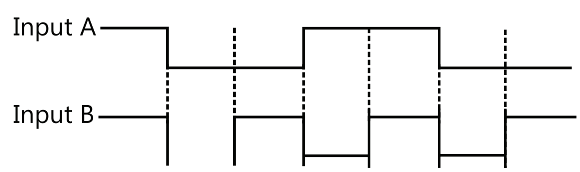
(B)


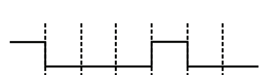
(C)


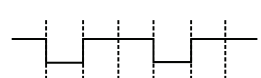
(D)


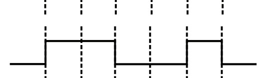
Q.6 The logic circuit shown below has the input waveforms 'A' and 'B' as shown. Pick out the correct output waveform. ***(2009)***

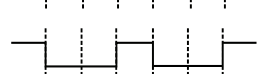




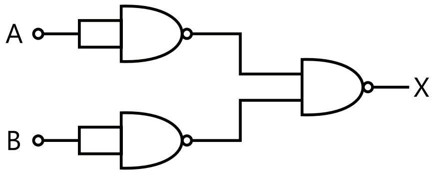
(A)


(B)


(C)


(D)


Q.7 The combination of gates shown below yields ***(2010)***



(A) OR gate (B) NOT gate

(C) XOR gate (D) NAND gate

Q.8 This question has Statement-I and Statement-II. Of the four choices given after the statements, choose the one that best describes the two statements. ***(2011)***

Statement-I: Sky wave signals are used for long distance radio communication. These signals are in general, less stable than ground wave signals.

Statement-II: The state of ionosphere varies from hour to hour, day to day and season to season.

(A) Statement-I is true, statement-II is true; statement-II is the correct explanation of statement-I.

(B) Statement-I is true, statement-II is true; statement-II is not the correct explanation of statement-I.

(C) Statement-I is false, statement-II is true.

(D) Statement-I is true, statement-II is false.

Q.9 A radar has a power of 1 Kw and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500 m. The maximum distance upto which it can detect object located on the surface of the earth (Radius of earth = 6.4×10^6 m) is ***(2012)***

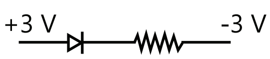
(A) 80 km (B) 16 km (C) 40 km (D) 64 km

Q.10 The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT. The peak value of electric field strength is : ***(2013)***

(A) 3V/m (B) 6V/m (C) 9V/m (D) 12 V/m

Q.11 The forward biased diode connection is ***(2014)***

(A) 

(B) 

(C) 

(D) 

Q.12 A signal of 5 kHZ frequency is amplitude modulated on a carrier wave of frequency 2 mHz. The frequencies of the resultant signal is/are : ***(2015)***

(A) 2 MHz only

(B) 2005 kHz, and 1995 kHz

(C) 2005 kHz, 2000 kHz and 1995 kHz

(D) 2000 kHz and 1995 kHz

Q.13 A red LED emits light at 0.1 watt uniformly around it. The amplitude of the electric field of the light at a distance of 1 m from the diode is : ***(2015)***

(A) 1.73 V/m (B) 2.45 V/m

(C) 5.48 V/m (D) 7.75 V/m

Q.14 The temperature dependence of resistances of Cu and undoped Si in the temperature range 300 – 400 K, is best described by : ***(2016)***

(A) Linear increase for Cu, exponential increase for Si

(B) Linear increase for Cu, exponential decrease for Si

(C) Linear decrease for Cu, linear decrease for Si

(D) Linear increase for Cu, linear increase for Si

Q.15 Choose the correct statement : ***(2016)***

(A) In amplitude modulation the frequency of high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal

(B) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

(C) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal

(D) In amplitude modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal

Q.16 Arrange the following electromagnetic radiations per quantum in the order of increasing energy: ***(2016)***

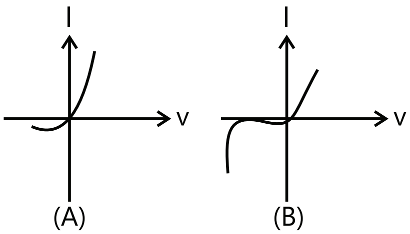
A : Blue light B : Yellow light

C : X-ray D : Radio wave

(A) A, B, D, C (B) C, A, B, D

(C) B, A, D, C (D) D, B, A, C

Q.17 Identify the semiconductor devices whose characteristics are given below, in the order (a),(b),(c),(d) ***(2016)***



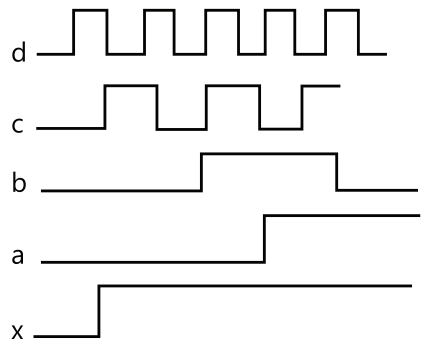
(A) Zener diode, simple diode, Light dependent resistance, Solar cell

(B) Solar cell, Light dependent resistance, Zener diode, simple diode

(C) Zener diode, Solar cell, Simple diode, Light dependent resistance

(D) Simple diode, Zener diode, Solar cell, Light dependent resistance.

Q.18 If a, b, c, d are inputs to a gate and x is its output, then, as per the following time graph, the gate is: ***(2016)***



(A) AND (B) OR

(C) NAND (D) NOT

Q.19 For a common emitter configuration, if α and β have their usual meanings, the incorrect relationship between α and β is. ***(2016)***

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

(C) $\alpha = \frac{\beta^2}{1+\beta^2}$ (D) $\frac{1}{\alpha} = \frac{1}{\beta} + 1$

JEE Advanced/Boards

Exercise 1

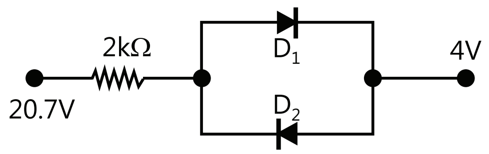
Semiconductor

Q.1 If resistivity of pure silicon is 3000 ohm-meter and the mobilities of electrons and holes are $0.12\,m^2/V-s$ and $0.025\ m^2/V-s$ respectively, find

(i) The resistivity of a specimen of the material when 10^{19} atoms phosphorous added per ms,

(ii) The resistivity of specimen if further 2×10^{19} boron atoms per m^3 are also added.

Q.2 Determine the current i in the circuit shown in Figure Assume diodes are made of silicon $(V_0 = 0.7V)$.



Q.3 For a transistor, $\beta = 45$ and voltage drop across $1k\Omega$ which is connected in the collector circuit is 1 volt. Find the base current for common emitter connection.

Q.4 A silicon transistor amplifier circuit is given below:

If the current amplification factor $\beta = 100$, determine:

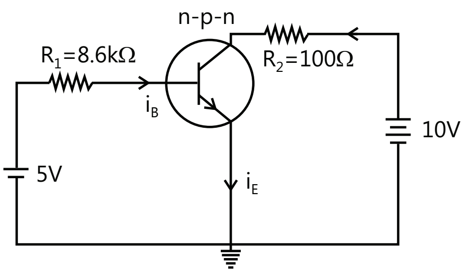
(a) Base current i_B

(b) Collector current i_O

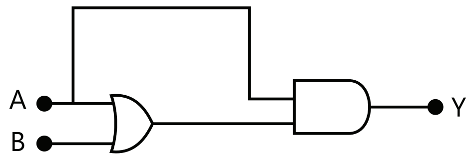
(c) Collector –emitter voltage

(d) Collector base-voltage.

Take the voltage drop between drop between base and emitter as 0.7 V.



Q.5 Construct the truth table for the function Y of A and B represented by Figure.



Q.6 If n_i is density of intrinsic charge carriers; n_h and n_e are densities of hole and electrons in extrinsic semiconductor, what is the relation among them?

Q.7 What type of impurity is added to obtain n-type semiconductor?

Q.8 Distinguish between n-type and p-type semiconductors

Q.9 Name the fundamental gates.

Q.10 What is the width of depletion layer in p-n junction diode?

Q.11 Show diagrammatically a forward biased and a reverse biased p-n junction.

Q.12 Distinguish between forward biasing and reverse biasing in p-n junction. Discuss its use.

Q.13 What is the net charge on (i) p-type semiconductor (ii) n-type semiconductor?

Q.14 Name of the type of charge carriers in p-n junction diode when forward biased?

Q.15 Which type of biasing result in very high resistance of a p-n-junction diode? Draw a diagram showing this bias.

Q.16 Draw the circuit diagram of a half wave rectifier using a junction diode.

Q.17 Name the type of charge carriers in p-n-junction when reverse biased.

Q.18 What are charge carriers in p-n-p transistor?

Q.19 Draw a labeled circuit diagram showing use of p-n junctions as full wave rectifier.

Q.20 State the function of a Zener diode in a circuit.

Q.21 What type of charge is on n-type semiconductor? On p-type semiconductor? Why?

Q.22 Write down the truth table for a NOR gate.

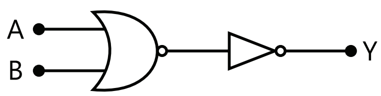
Q.23 In half-wave rectification, what is the output frequency if the input frequency is 50Hz? What is the output frequency of a full-wave rectifier for the same input frequency?

Q.24 Which logic gate is represented by Boolean expression $Y = \overline{A + B}$?

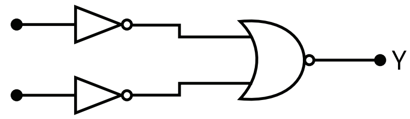
Q.25 Name the logic gate whose repetitive use can make digital circuits.

Q.26 For a CE-transistor amplifier, the audio signal voltage across the collected resistance of $2k\Omega$ is 2V. Suppose the current amplification factor of the transistor is 100, find the input signal voltage and base current, if the base resistance is $1k\Omega$.

Q.27 You are given the two circuits as shown in figure. Show that circuit (a) acts as OR gate while the circuit (b) acts as AND gate.



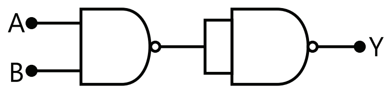
(a)



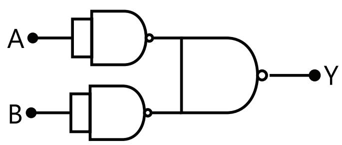
(b)

Q.28 Write the truth table for a NAND gate connected as given in figure Hence identify the exact logic operation carried out by this circuit.

Q.29 You are given two circuits as shown in figure which consist of NAND gates. Identify the logic operation carried out by the two circuits.

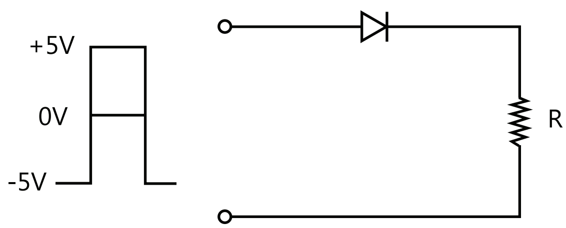


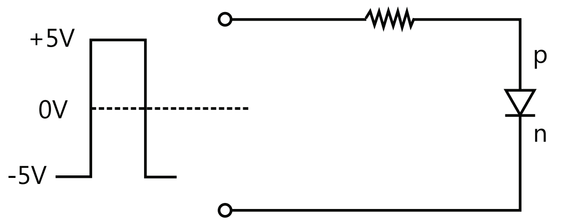
(a)



(b)

Q.30 In the following circuits shown if the input wave from is as shown in figure, What will be the output waveform (assume diode is ideal)





(i) Across R (See figure)

(ii) Across the diode (in figure)

Assume that the diode is ideal.

Exercise 2

Semiconductor

Single Correct Choice Type

Q.1 A potential barrier of 0.50 V exists across a P-N junction. If the depletion region is 5.0×10^{-7} m wide, the intensity of the electric field in this region is-

(A) 1.0×10^{6} V / m (B) 1.0×10^{5} V / m

(C) 2.0×10^{5} V / m (D) 2.0×10^{6} V / m

Q.2 The main cause of avalanche breakdown is

(A) Collision ionization

(B) High doping

(C) Recombination of electron and holes

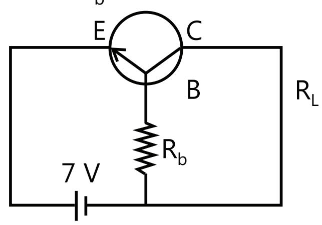
(D) None of these

Q.3 When reverse bias in a junction diode is increased, the width of depletion layer

(A) Increase (B) Decreases

(C) Does not change (D) Fluctuate

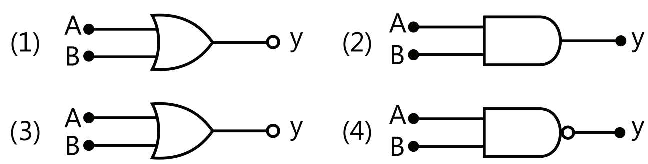
Q.4 In the given transistor circuit, the base current is 35 μA. The value of R_b is



(A) 100kΩ (B) 200kΩ

(C) 300kΩ (D) 400kΩ

Q.5 Given below are four logic gate symbol (figure). Those for OR, NOR and NAND are respectively



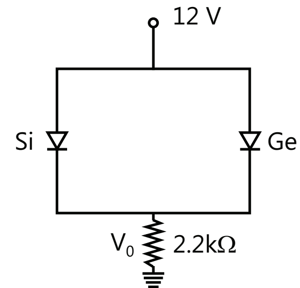
(A) 1, 4, 3 (B) 4, 1, 2 (C) 1, 3, 4 (D) 4, 2, 1

Q.6: The following truth table corresponds to the logic gate

A	0	0	1	1
B	0	1	0	1
X	0	1	1	1

(A) NAND (B) OR (C) AND (D) XOR

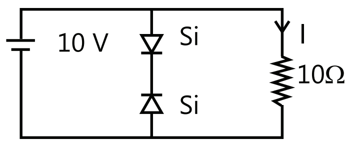
Q.7 In the circuit shown in figure, Voltage V_0 is



(A) 11.7 volt (B) 11.3 volt

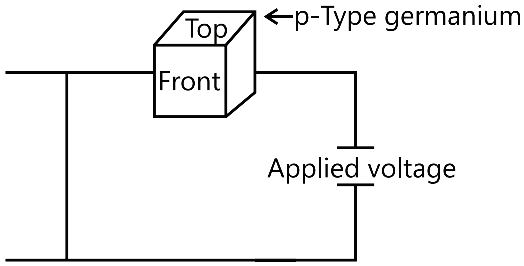
(C) 0 (D) None

Q.8 Determine current I in the configuration



(A) 1A (B) 0 A (C) Less than 1A (D) None

Q.9 A cube of germanium is placed between the poles of a magnet and a voltage is applied across opposite faces of the cube as shown in Figure. Magnetic field is directed vertical downward in the plane of the paper:



What effect will occur at the surface of the cube?

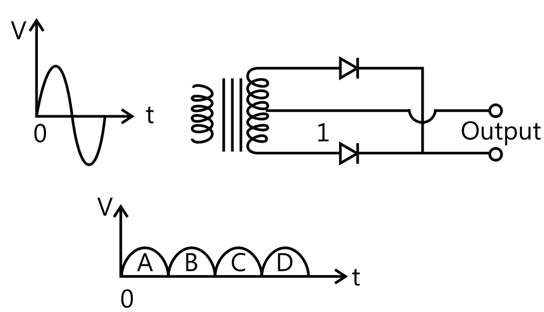
(A) The top surface of cube will become negatively charged

(B) The front surface of the cube will become positively charged

(C) The front surface of the cube will become negatively charged

(D) Both top and front surface of cube will become positively charged.

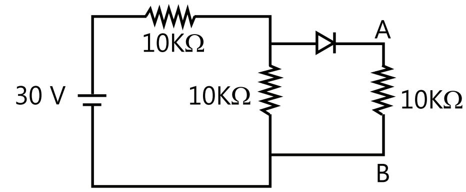
Q.10 A full wave rectifier circuit along with the output is shown in the following diagram. The contribution(s) from the diode (1) is (are):



(A) C (B) A, C

(C) B, D (D) A, B, C, D

Q.11 In the given figure potential difference between A and B is;



(A) 0 (B) 5 volt

(C) 10 volt (D) 15 volt

Multiple Correct Choice Type

Q.12 In a p-n junction-

(A) New holes and conduction electrons are produced continuously throughout the material

(B) New holes and conduction electrons are produced continuously throughout the material except in the depletion region

(C) Holes and conduction electrons recombine continuously throughout the material

(D) Holes and conduction electrons recombine continuously throughout the material except in the depletion region

Assertion Reasoning Type

(A) Statement-I is true, statement-II is true and statement-II is correct explanation for statement-I.

(B) Statement-I is true, statement-II is true and statement-II is NOT the correct explanation for statement-I.

(C) Statement-I is true, statement-II is false.

(D) Statement-I is false, statement-II is true.

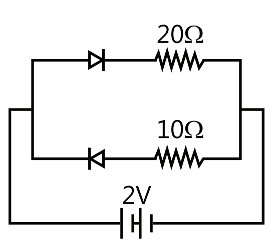
Q.13 Statement-I: Conductivity

Semiconductors decreases with increase in temperature.

Statement-II: More electrons go from valance band to conduction band, with increase in temperature.

Q.14 Statement-I: In semiconductors current is obtained due to motion of electrons and holes.

Statement-II: Breaking up of covalent bond produces holes in valence band and electrons in conduction band.

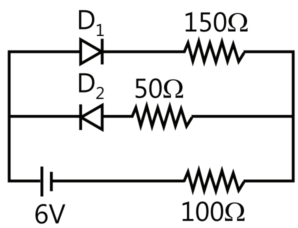


Q.15 Statement-I: Doping concentration is maximum in emitter in transistor.

Statement-II: Maximum number of electrons flows emitter to base in n-p-n transistor.

Comprehension Type

The circuit shown in diagram contains two diodes each with a forward resistance of 50 ohm and with infinite reverse resistance of 50 ohm and with infinite reverse resistance. If the battery voltage is 6V then.



Q.16 Current through 100Ω resistance is

(A) 0 (B) 0.02 amp

(C) 0.03 amp (D) None of these

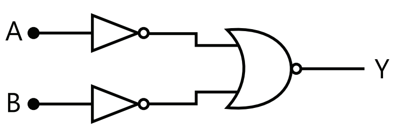
Q.17 Current through 50Ω resistance is

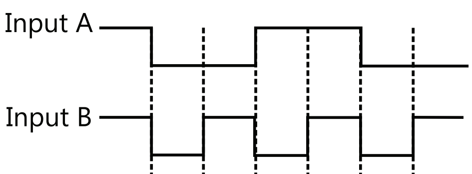
(A) 0 (B) 0.02 amp

(C) 0.03 amp (D) None of these

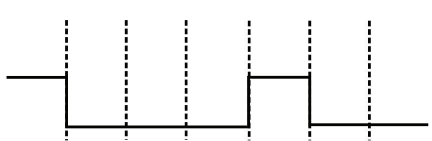
Previous Years' Questions

Q.1 The logic circuit shown below has the input waveforms 'A' and 'B' as shown. Pick out the correct output waveform. ***(2009)***

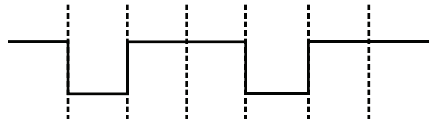




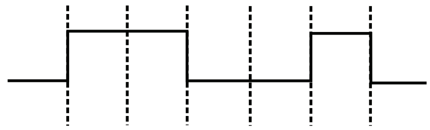
(A)



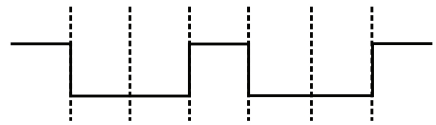
(B)



(C)

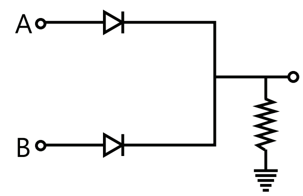


(D)



Q.2 In the circuit below, A and B represent two inputs and C represents the output.

The circuit represents ***(2008)***



(A) NOR gate (B) AND gate

(C) NAND gate (D) OR gate

Q.3 A radar has a power of 1 Kw and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500m. The maximum distance upto which it can detect object located on the surface of the earth (Radius of earth $= 6.4 \times 10^6 m$) is ***(2012)***

(A) 80 km (B) 16 km

(C) 40 km (D) 64 km

Q.4 To find the distance d over which a signal can be seen clearly in foggy conditions, a railways engineer uses dimensional analysis and assumes that the distance depends on the mass density ρ of the fog, intensity (power/area) S of the light from the signal and its frequency f. The engineer finds that d is proportional to S1/n. The value of n is ***(2014)***

(A) 4 (B) 2 (C) 3 (D) 5

MASTERJEE Essential Questions

JEE Main/Boards

Exercise 1

Q.5 Q.14 Q.16
Q.27 Q.30 Q.32

Exercise 2

Q.1 Q.5 Q.8
Q.9 Q.11 Q.12
Q.17 Q.21

Previous Years' Questions

Q.1 Q.2 Q.3

JEE Advanced/Boards

Exercise 1

Q.1 Q.2 Q.4

Q.26 Q.30Exercise 2

Q.5 Q.7 Q.8
Q.11 Q.16 Q.17

Previous Years' Questions

Q.14

JEE Main/Boards

Answer Key

Exercise 1

Semiconductor

Q.2 (i) AND gate

(ii) Truth Table of AND gate

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

Q.4 Increases.

Q.5 Diodes (a), (c) and (d) are forward biased while (b) is reverse bias.

Q.6

A	B	Output NAND gate, Y	Final output,(Y)′=Y′
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1

Q.7 NOR gate.

Truth Table of NOR gate

Input		Output
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

Communication Systems

Q.34 (i) 40 kW; (ii) 27.8 kW

Q.35 8.31 A

Q.36 70.1%

Q.37 0.648

Q.38 (i) 6.25 mW; (ii) 1.562 mW; (iii) 9.374 mW

Q.39 88.8%

Q.40 3258 km^2

Exercise 2

Semiconductor

Single Correct Choice Type

Q.1 B	**Q.2** C	**Q.3** B	**Q.4** D	**Q.5** A	**Q.6** B
Q.7 C	**Q.8** A	**Q.9** D	**Q.10** D	**Q.11** B	**Q.12** C
Q.13 B	**Q.14** C	**Q.15** B	**Q.16** A	**Q.17** D	**Q.18** C
Q.19 A	**Q.20** B	**Q.21** A	**Q.22** A	**Q.23** D	**Q.24** B

Previous Years’ Questions

Q.1 A	**Q.2** A	**Q.3** A	**Q.4** D	**Q.5** C	**Q.6** A
Q.7 A	**Q.8** A	**Q.9** A	**Q.10** B	**Q.11** A	**Q.12** C
Q.13 B	**Q.14** B	**Q.15** D	**Q.16** D	**Q.17** D	**Q.18** B
Q.19 A, C					

JEE Advanced/Boards

Exercise 1

Semiconductor

Q.1 (i) 5.2 Ω-m, (ii) 25 Ω-m

Q.2 8 mA

Q.3 0.0222 mA.

Q.4 (a) 0.5 mA, (b) 50 mA, (c) 5 V, (d) 4.3 V

Q.5

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

Q.6 $n_e n_h = n_i^2$

Q.7 Pentavalent atoms.

Q.9 OR, AND and NOT gates.

Q.10 10^{-6}m

Q.13 (i) Zero (ii) Zero.

Q.14 Majority change carriers: electrons and holes.

Q.17 Minority charge carriers: electrons and holes.

Q.23 50 Hz for half-wave, 100 Hz for full –wave

Q.26 $V_1 = 0.01V; I_B = 10\mu A$

Q.28 NOT;

A	Y
0	1
1	0

Q.29 (a) AND (b) OR

Exercise 2

Semiconductor

Single Correct Choice Type

Q.1 A **Q.2** A **Q.3** A **Q.4** B **Q.5** C **Q.6** B

Q.7 A **Q.8** A **Q.9** B **Q.10** C **Q.11** C

Multiple Correct Choice Type

Q.12 A, D

Assertion Reasoning Type

Q.13 D **Q.14** A **Q.15** C

Comprehension Type

Q.16 B **Q.17** A

Previous Years' Questions

Q.1 A **Q.2** D **Q.3** A **Q.4** C

Solutions

JEE Main/Boards

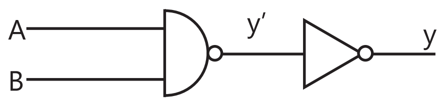
Exercise 1

Semiconductor

Sol 1: The process of deliberately adding impurities to a semiconductor is called doping.

The conductivity of extrinsic semiconductor is controlled by the amount of doping, 1 part of a donor impurity per 10^9 parts of germanium increases its conductivity by a factor of nearly 10^3

Sol 2:



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

Y represents the AND gate output.

So this logic gate is AND gate

Sol 3: Refer page-10

Sol 4: The holes in the P-region are attracted towards the negative terminal and the electrons in the N-region are attracted towards positive terminal. Thus the majority carriers more away from the junction. The depletion region increases for a reverse biased PN-junction.

Sol 5: (a) Forward biased

(b) Reverse biased

(c) Forward biased

(d) Forward biased

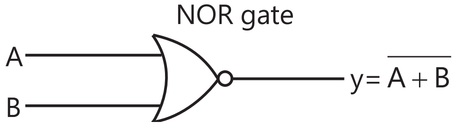
Sol 6:

A	B	Output NAND gate, Y	Final output,(Y)′=Y′
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1

Sol 7:

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

NOR gate



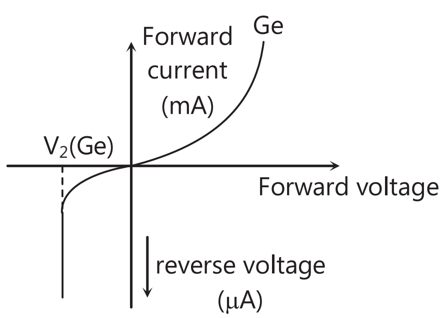
So y is an output of NOR gate.

Sol 8: Refer theory

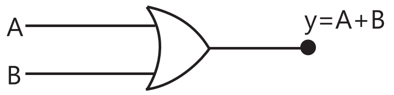
Sol 9: Voltage gain: It is defined as the ratio of the changes in the output voltage to the change in the input voltage, and is denoted by A_V

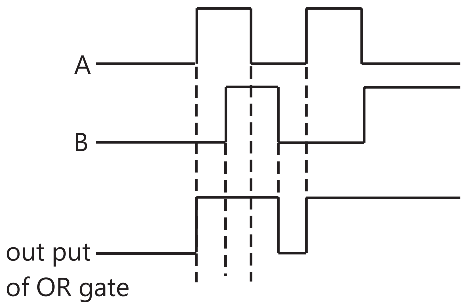
$$A_V = \frac{\Delta i_C}{\Delta i_E} \times \frac{R_{out}}{R_{in}}$$

Sol 10:



Sol 11:





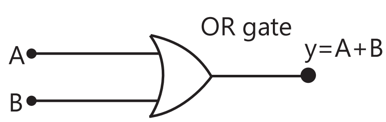
Sol 12: Phase shift can be explained as follows

- the input voltage and currents are in phase.
- the input and output currents are in phase. Therefore, output currents is in phase with the input voltage.
- An increase in output current results in a decrease in output voltage; and vice versa (as given $V_{out} = V_C = V_{CC} - I_C R_C$)

Sol 13: Refer theory

Sol 14: (a) Refer theory

(b)



for input output waveform refer Q–11 Exercise-I in sheet

(c) Refer theory

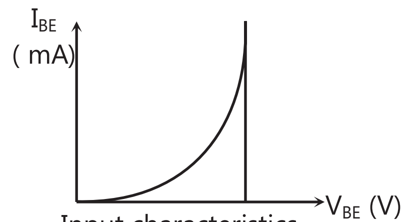
(d) Photodiode can detect light of energy greater than 2.8 eV

Energy of incident light = $\dfrac{12400}{60000}$ = 0. 2 eV

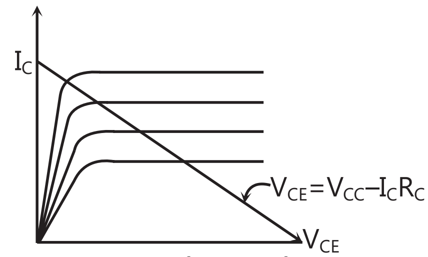
Photodiode will not detect light as energy of incident light is less than band gap.

Sol 15: Refer theory

Sol 16: The base activates the transistor Base region is made very thin and lightly doped to make the transistor more efficient. This reduces the opportunity for an electrons to recombine with a hole and be lost for the circuit refer page 29 section 16.5



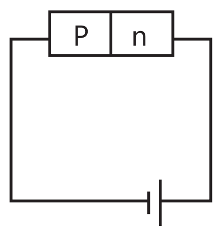
Input characteristics



Current amplification factor

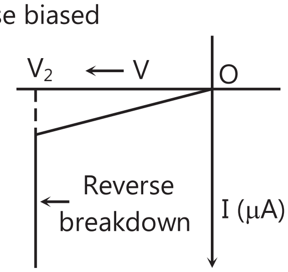
can be found by B = $\dfrac{\Delta I_C}{\Delta I_B}$

Sol 17: (i) Indium is a group 13 element and arsenic is a group is element



It's reverse biased

(ii)

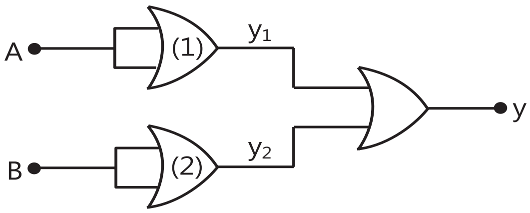


Sol 18: A common emitter amplifier is preferred over common base amplifier because of higher gain and high impedance in common emitter amplifier.

Sol 19: Refer theory

Sol 20: It's because GaAs naturally performs better at converting the sun's energy into electricity than other materials. Further, GaAs solar calls deliver more energy in high heat or low light GaAs solar cells are highly efficient than any other solar cells.

Sol 21:

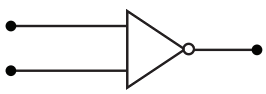


A	B	y_1	y_2	y
0	0	0	0	1
1	1	1	1	0
1	0	1	0	0
0	1	0	1	0

so this is a NAND gate

Gates (1) and (2) have the same output as the input.

Symbol

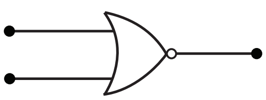


truth table

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

Sol 22: Refer theory

Sol 23:

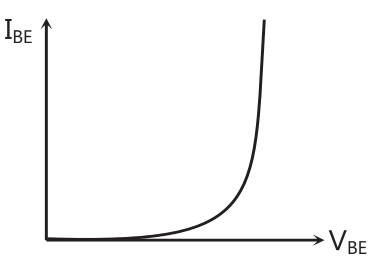


NOR gate

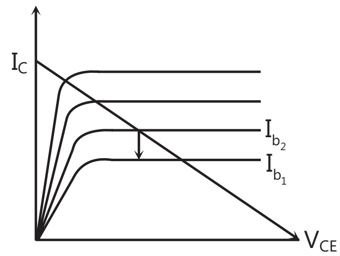
Sol 24: Refer theory

Sol 25: Voltage gain $A_V = \frac{\Delta i_C}{\Delta i_B} \times \frac{R_{out}}{R_{in}}$

Sol 26:



Input resistance is the reciprocal of the slope of this curve



current amplification factor

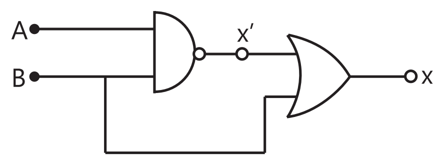
$= \frac{\Delta I_C}{\Delta I_B}$ in this curve

Sol 27: (i) P is NAND gate

Q is OR gate

(ii)

A	B	X'	x
0	0	1	1
1	1	0	1



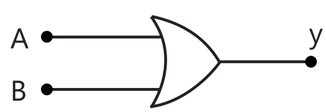
Sol 28: Refer theory

Sol 29: Refer theory

Sol 30:

A	B	X	Y	Z
0	0	1	1	0
0	1	1	0	0
1	0	0	1	0
1	1	0	0	1

Function of this logic circuit is same as that of AND gate



AND gate

Sol 31: Refer theory

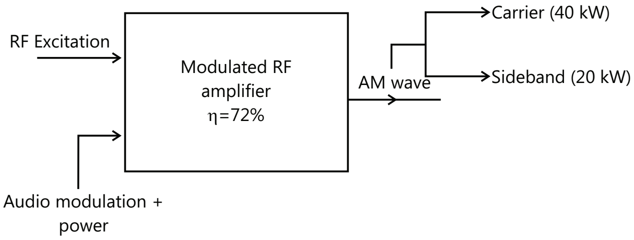
Sol 32: Refer theory

Sol 33: Refer theory

Communication System

Sol 34: (i) Since the carrier itself is unaffected by the modulating signal, there is no change in the carrier power level.

$\therefore P_C = 40kW$



(ii) $P_S = \frac{1}{2}m_a^2 P_C = \frac{1}{2}(1)^2 \times 40 = 20kW$

$\therefore P_{audio} = \frac{P_S}{0.72} = \frac{20}{0.72} = 27.8\ kW$

Sol 35: $P_S = \frac{1}{2}m_a^2 P_C$

$$P_T = P_C + P_S = P_C\left(1 + \frac{m_a^2}{2}\right)$$

$$\therefore \frac{P_T}{P_C} = 1 + \frac{m_a^2}{2} \text{ or } \left(\frac{I_T}{I_C}\right) = 1 + \frac{m_a^2}{2}$$

Given that $I_C = 8A;\ m_a = 0.4$

$$\therefore \left(\frac{I_T}{8}\right)^2 = 1 + \frac{(0.4)^2}{2}$$

$$\text{or} \left(I_T / 8\right)^2 = 1.08 \text{ or } I_T = 8\sqrt{1.08} = 8.31A$$

Sol 36: $\left(\frac{I_T}{I_C}\right)^2 = 1 + \frac{m_a^2}{2}$

Given that $I_T = 8.93A; I_C = 8A; m_a = ?$

$$\left(\frac{8.93}{8}\right)^2 = 1 + \frac{m_a^2}{2} \text{ or } 1.246 = 1 + m_a^2/2$$

$$m_a^2/2 = 0.246 \text{ or } m_a = \sqrt{2 \times 0.246} = 0.701 = 70.1\%$$

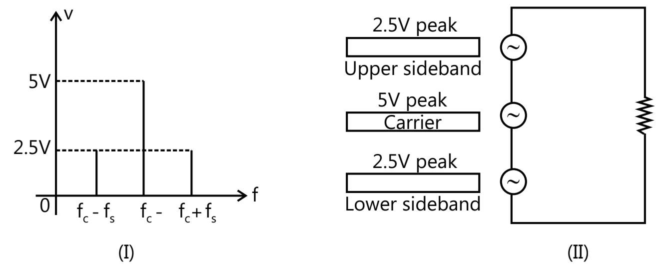
Sol 37: $\frac{P_T}{P_C} = 1 + \frac{m_a^2}{2} \text{ or } \left(\frac{V_T}{V_C}\right)^2 = 1 + \frac{m_a^2}{2}$

Given that $V_T = 110V; V_C = 100V; m_a = ?$

$$\therefore \left(\frac{110}{100}\right)^2 = 1 + \frac{m_a^2}{2} \text{ or } 1.21 = 1 + m_a^2/2$$

$$\text{or } m_a^2/2 = 0.21 \text{ or } m_a = \sqrt{0.21 \times 2} = 0.648$$

Sol 38: Figure (i) shows the spectrum of AM wave whereas figure (ii) shows the equivalent circuit.



$$\text{Power} = \frac{(\text{r.m.s.voltage})^2}{R} = \frac{(0.707 \times \text{peak value})^2}{R}$$

(i) Power delivered by the carrier,

$$P_C = \frac{(0.707 \times 5)^2}{2000} = 6.25 \times 10^{-3} W = 6.25mW$$

(ii)Power delivered by lower sideband component,

$$P_{lower} = \frac{(0.707 \times 2.5)^2}{2000} = 1.562 \times 10^{-3} W = 1.562mW$$

(iii) Power delivered by upper sideband component,

$$P_{upper} = \frac{(0.707 \times 2.5)^2}{2000} = 1.562 \times 10^{-3} W$$

$= 1.562mW$

Total power delivered by the AM wave

=6.25+1.562+1.562=9.374 mW

Sol 39: Modulation factor, m_a

=75%=75/100=0.75

Total power in AM wave, P_T =10kW

Total power in sidebands,

$$P_S = P_T\left[\frac{m_a^2}{2 + m_a^2}\right] = 10 \times \left[\frac{(0.75)^2}{2 + (0.75)^2}\right] = 2.19kW$$

Power in sideband,

$$P'_S = P_S / 2 = 2.19 / 2 = 1.095kW$$

Power in carrier, $P_C = \frac{2P_S}{m_a^2} = \frac{2 \times 2.19}{(0.75)^2} = 7.786kW$

Power saved due to suppression of carrier and one sideband

$= P_C + P'_S = 7.786 + 1.095 = 8.88kW$

$$\therefore \%\text{power saving} = \frac{8.88}{10} \times 100 = 88.8\%$$

Sol 40: However, for line-of-sight (LOS) communication, the receiving antenna must be able to directly intercept the signals radiated by the transmitting antenna.

Here, h=81m; Radius of earth, R=6.4X10^6 m

∴Radius (d) of the area covered by TV transmitting antenna is

$$d = \sqrt{2Rh} = \sqrt{2\times 6.4\times 10^6\times 81} = 3.2\times 10^4 m$$

∴ Service area covered by TV transmitting antenna is

$$A = \pi^2 = \pi\times\left(3.2\times 10^4\right)^2 = 3258\times 10^6 m^2 = 3258\ km^2$$

Exercise 2

Semiconductor

Single Correct Choice Type

Sol 1: (B) E_g = 0. 75 eV

Sol 2: (C) Minimum energy required to create e–h pair

$$= \frac{12400}{5890} = 2.1\ eV$$

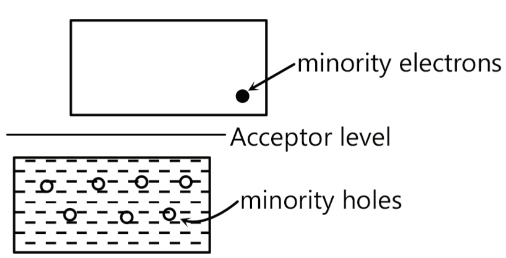
Sol 3: (B) On increasing temperature, energy of electron increases so they can easily jump in conductor band so resistance increase.

Sol 4: (D) In a good conductor, energy band gap is zero as conduction and valence band overlap.

Sol 5: (A) Movement of holes involve breaking and joining of bonds so mobility of holes is less than that of electrons.

Sol 6: (B) No of electron and hole pairs are equal in intrinsic semiconductors.

Sol 7: (C)



Holes move in valence band in p-type semiconductors.

Sol 8: (A) For intrinsic semiconductors fermi level of energy lies in the middle of forbidden gap.

Sol 9: (D) $\sigma = \rho(\mu_e n_e + \mu_h n_h)$

$n_e >> n_h$

So, $\sigma = e\mu_e n_e \Rightarrow n_e = \dfrac{\sigma}{\rho\mu_e} = \dfrac{6.24}{3900\times 1.6\times 10^{-19}}$

$= 10^{16}/cm^3$

Sol 10: (D) Resistance in forward bias is much less than resistance in the reverse bias and the ratio of resistances is approximately 1 : 10^4 (Theoretical fact)

Sol 11: (B) Given:

- Diode's Voltage Drop, V_d = 0.5V
- Maximum Power Rating, P = 100mW = 0.1 Watts
- Battery EMF, E = 1.5V
- Resistance = R

1) Finding Current in the Circuit:

So it's given E = 1.5V and Vd = 0.5V

Formula: P = I*Vd => I = (P/Vd)

I = (0.1/0.5) = 0.2A

2) Finding Potential Drop Across R

V = E – Vd = 1.5 - 0.5 = 1V

3) Finding Value of R

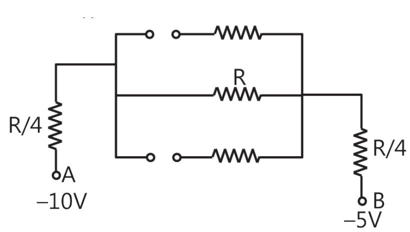
From above,

V = 1V and I = 0.2 A

V = IR R = V / I = 1 / 0.2 = 5 ohms

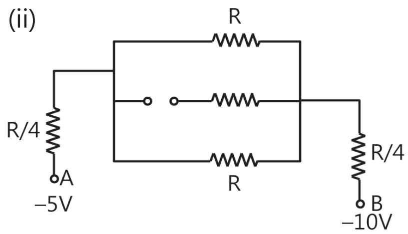
Hence the answer is B.

Sol 12: (C) (i)



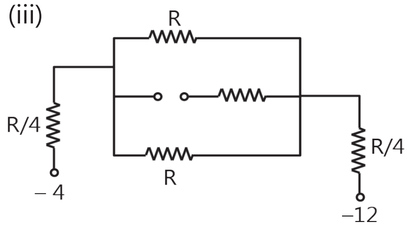
Resistance = $\dfrac{3R}{2}$

(ii)



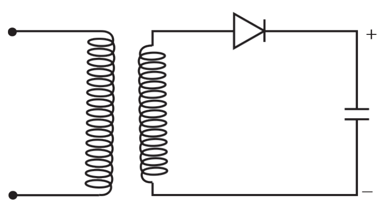
Resistance = R

(iii)

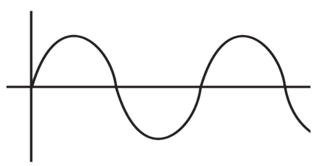


Resistance = R

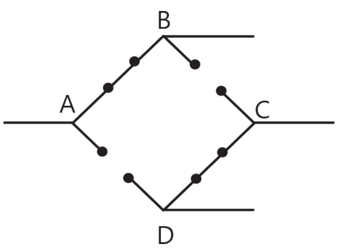
Sol 13: (B)



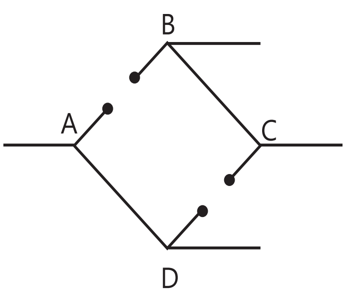
Sol 14: (C)



For the upper half wave



Circuit is as shown in figure

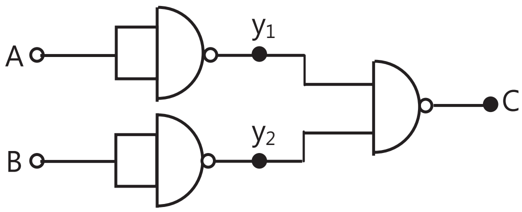


For lower half wave circuit is shown in figure.

So it is a full wave rectifier

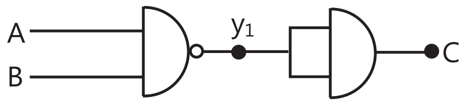
Sol 15: (B) It is a common-emitter amplifier circuit as emitter is connected to both base and collector

Sol 16: (A)



A	B	y_1	y_2	C
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

OR gate



A	B	Y_1	C
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1

AND gate

Sol 17: (D) A = B = C = 0

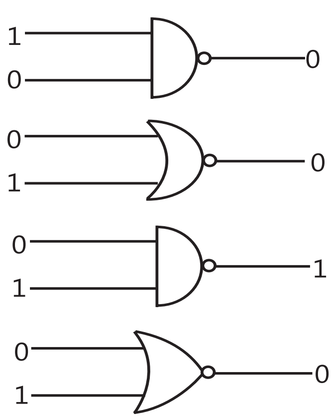
G_1 = 0, C = 0, D = 1

A = B = 1, C = 0

G_1 = 1, C = 0

D = 1

Sol 18: (C)

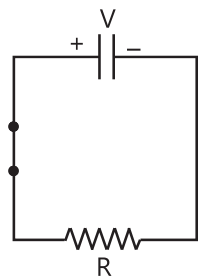


Sol 19: (A)

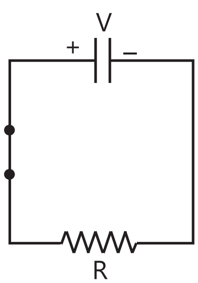
A	Y
0	1
1	0

So NOT gate

Sol 20: (B)

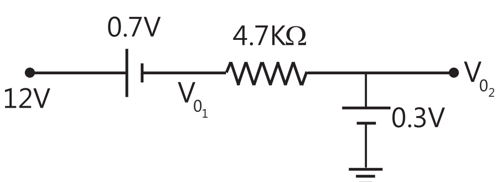


$Q(t = CR) = Q_0 e^{\frac{1}{\tau}} = VCe^1 = \frac{VC}{e}$



No current will flow so charge of the capacitor will not change.

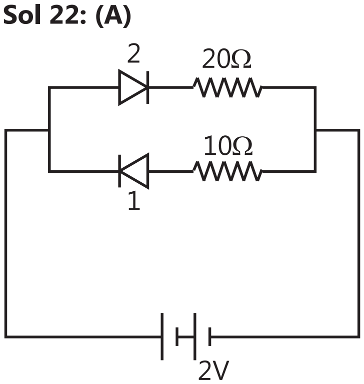
Sol 21: (A)



$V_{0_1} = 11.3V$

$V_{0_2} = 0.3\ V$

Sol 22: (A)



Diode 1 is reverse biased and diode 2 is forward bias

$i = \frac{2}{20} = 0.1\ A$

Sol 21: (B) Frequency of 10 kHz cannot be used because it will require very large transmitting antenna. Also frequencies of 1 GHz and 1000 GHz cannot be used because these will penetrate through the ionosphere; the ionosphere cannot reflect these high frequencies.

Sol 24: (D) Frequencies in UHF range (0.3 GHz to 3 GHz) normally propagate by means of space waves. Therefore, choice (d) is correct.

Previous Years' Questions

Sol 1: (A) $V_B = (1/e)[(hc/\lambda) - \phi]$

$V_P = (1/e)[(1240/550) - 2]eV = 0.2545\ V$

$V_q = (1/e)[1240/450 - 2.5]eV = 0.255\ V$

$V_r = (1/e)[(1240/350) - 3]\ eV = 0.5428\ V$

If n is the number of photons in unit time per unit area then $nhc/\lambda = I$, (Intensity)

$\Rightarrow i_p : i_q : i_r = n_p : n_q : n_r = \lambda_p : \lambda_q : \lambda_r$

Sol 2: (A)

A	B	y	y_1	y_2	y
0	0	1	1	1	0
0	1	1	1	0	1
1	0	1	0	1	1
1	1	0	1	1	0

Sol 3: (B) When the multimeter is connected across P and Q, there is no conduction. Hence both P and Q are n-type of p-type semiconductors. It is therefore, clear that R is base. When common end in connected to R and the other end connected to P or Q, conduction is obtained. Hence it is clear that transistor is n-p-n and R is base.

Sol 4: (D)

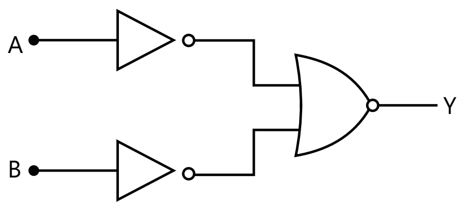
A	B	C
0	0	0

0	1	1
1	0	1
1	1	1

Sol 5: (C) Given figure is half wave rectifier

Sol 6: (A)

Truth Table		
A	B	Y
1	1	1
1	0	0
0	1	0
0	0	0



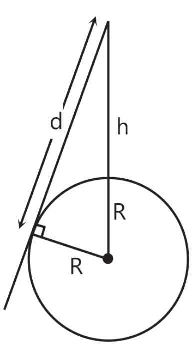
Sol 7: (A) Truth table for given combination is

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

This comes out to be truth table of OR gate

Sol 8: (A) Since ionospheric properties change with time, these signals are in general less stable than ground wave signals.

Sol 9: (A) Maximum distance on earth where object can be detected is d, then



$(h + R)^2 = d^2 + R^{2+}$

$\Rightarrow d^2 = h^2 + 2Rh$

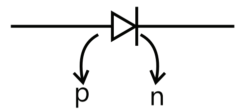
Since $h << R_1 \Rightarrow d^2 = 2\ hR$

$\Rightarrow\ d = \sqrt{2(500)(6.4\times10^6)} = 80 = km$

Sol 10: (B) $\vec{E} = \vec{B}\times\vec{C}$

$|\vec{E}| = |\vec{B}|\times|\vec{C}| = 20 \times 10^{-9} \times 3 \times 10^8 = 6$ V/m.

Sol 11: (A)



For forward Bias, p-side must be at higher potential than n-side.

Sol 12: (C)

f_c = 2MHz = 2000 KHz

f_m = 5KHz

Resultant frequencies are

$= f_C + f_m, f_c, f_c - f_m$

= 2005 KHz, 2000, 1995 KHz

Sol 13: (B) Intensity I = $\dfrac{P}{4\pi r^2}$

$I = \dfrac{1}{2}\in_0 E_0^2 \times C$

So $\dfrac{P}{4\pi r^2} = \dfrac{1}{2}\in_0 E_0^2 \times C$

$E_0^2 = \dfrac{2P}{4\pi\in_0 r^2 C} = \dfrac{2\times0.1\times9\times10^9}{1\times3\times10^8}$

$E_0 = \sqrt{6} = 2.45\ V/m$

Sol 14: (B) For conductor (Cu) resistance increases linearly and for semiconductor resistance decreases Exponentially in given temperature range.

Sol 15: (D) In amplitude modulation amplitude of carrier wave (high frequency) is varied in proportion to the amplitude of signal.

In frequency modulation frequency of carrier wave (high frequency) is varied in proportion to amplitude of signal.

Sol 16: (D)

Y X U V I M R

→ λ increasing

Hence energy of radio wave will be minimum and maximum for X ray.

Sol 17: (D) From standard data

Sol 18: (B) whenever we have 1 at input, output is 1. So the gate is or

Sol 19: (A, C) $\frac{1}{\alpha} = \frac{1}{\beta} + 1$

$\alpha = \frac{\beta}{\beta + 1}$

JEE Advanvced/Boards

Exercise 1

Sol 1: μ_e = 0. 12 m^2/V–s

μ_h = 0. 025 m^2/V–s

(i) When phosphorus is added

$n_e = 10^{19}/m^2$

$n_e. n_h = n_i^2$

$n_i = 10^{10}$

$n_h = \frac{10^{20}}{10^{19}} = 10$

$\frac{1}{\rho} = e(\mu_e n_e + \mu_h. n_h)$

$= e(0.12 \times 10^{19} + 0.025 \times 10)$

$= 1.6 \times 10^{-19} \times 0.12 \times 10^{19}$

$\frac{1}{\rho} = 1.6 \times 0.12$

$\rho = \frac{1}{1.6 \times 0.12} = 5.2\ \Omega$ m

(ii) When further 2 × 10^{19} boron atoms are added the some holes and electrons with recombine. So finally

$n_h = 10^{19}/m^2$

$n_e n_h = 10^{20}$

$n_e = 10/m^2$

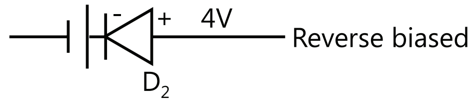
$\frac{1}{\rho} = e(\mu_e n_e + \mu_h n_h)$

$\frac{1}{\rho} = e(10 \times 0.12 + 10^{19} \times 0.025)$

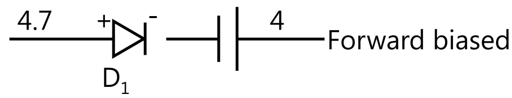
$\frac{1}{\rho} = e \times 10^{19} \times 0.025$

$\rho = 25\ \Omega$m

Sol 2:

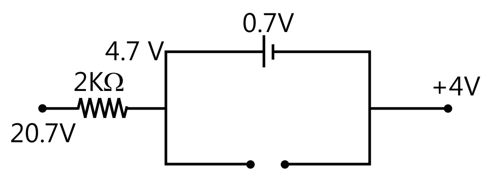


Across D_2 voltage at cathode in greater than voltage at anode so it will not conduct.



Since, across D_1 voltage at anode is greater than cathode, so it will conduct.

Equivalent circuit is



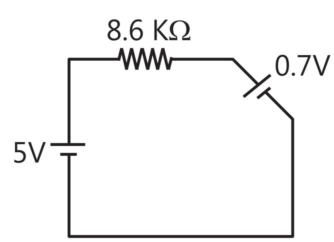
Current $i = \frac{20.7 - 4.7}{2000} = \frac{16}{2000} = 8 \times 10^{-3}$ A

Sol 3: Collector current = $\frac{1}{1000}$ = 1 mA

base current = $\frac{1\,\text{mA}}{45}$ = 0. 0222 mA

Sol 4: Equivalent base circuit is

(a)



$i = \frac{5 - 0.7}{8.6}$ = 0.5 mA

(b) $i_C = \beta i_B$ = 100 × 0.5 mA = 50 mA

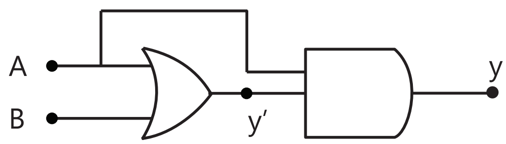
(c) $V_{CE} = 10 - i_C R_C = 10 - \frac{50}{1000} \times 100$ = 5 V

(d) $V_{CB} = V_C - V_B$

$V_{CB} = 5 - 0.7 = 4.3$ V

Sol 5:

A	B	y'	y
0	0	0	0
0	1	1	0
1	0	1	1
1	1	1	1



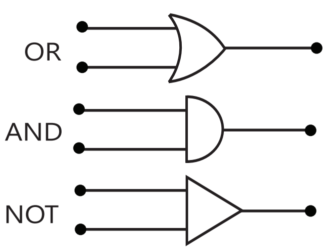
Sol 6: $n_e \cdot n_h = n_i^2$

Sol 7: Pentavalent atoms are added to obtain n-type semiconductor

Sol 8: n-type extrinsic semiconductors with large electron concentration than the hole concentration are known as n-type semiconductors, electrons are the majority carriers and holes are the minority carriers

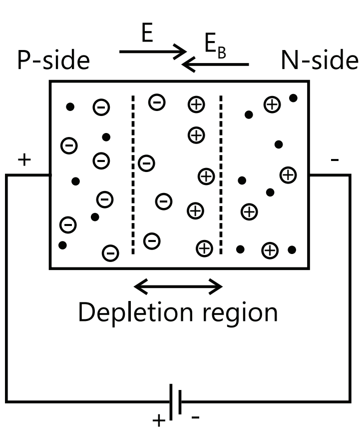
P-type semiconductors: As opposed to n-type semiconductors, P-type semiconductors have a large hole concentration than the electron concentration. Holes are majority carriers and electrons are minority carriers.

Sol 9:



Sol 10: Width of depletion region is around 1 μm.

Sol 11:



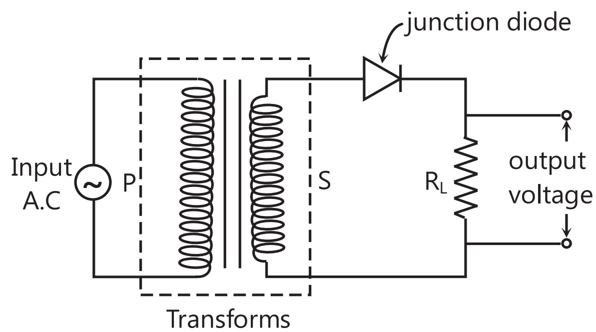
Sol 12: Refer theory

Sol 13: Net charge is zero in both the cases but number of electron and hole pairs are different in both.

Sol 14: Holes and electrons are majority change carriers in P-type and N-type respectively.

Sol 15: Reverse biasing results in very high resistance for diagram refer Q. – 11.

Sol 16:



Sol 17: Electrons and holes are minority change carriers in the P & N regions respectively.

Sol 18: Holes are the charge-carriers within the P–n–P transistor.

Sol 19: Refer page 25.17.

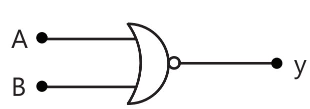
Sol 20: Refer page 25.20.

Sol 21: In n-type semiconductor the impurity atoms on donating electrons becomes positive ions. However the overall charge on the semiconductor is zero.

In p-type semiconductor, the overall charge is zero. The positive charge of majority hole pairs is balanced by the negatively charged semiconductors.

Sol 22:

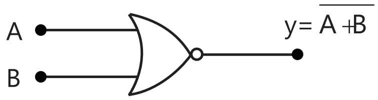
A	B	y
0	0	1
0	1	0
1	0	0
1	1	0



Sol 23: In half wave rectifier frequency does not change so frequency = 50 Hz

In full wave rectifier frequency becomes double so frequency = 100 Hz

Sol 24:



Sol 25: Any digital system can be achieved entirely from NAND or NOR gates.

Sol 26: R_C = 2 kW

$i_c = \frac{2}{2k\Omega} = 1$ mA

$\beta = 100$

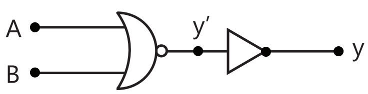
$i_B = \frac{i_C}{\beta} = 10\mu A$

voltage = $i_B R_B$

= 10 μA × 10^3

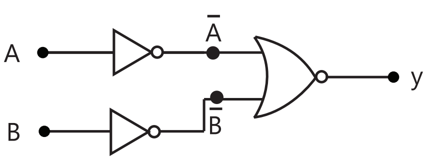
= 10 mV

Sol 27:



A	B	y'	y
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

y corresponds to the output of OR gate



A	B	$\bar{A}$	$\bar{B}$	y
0	0	1	1	0
0	1	1	0	0
1	0	0	1	0
1	1	0	0	1

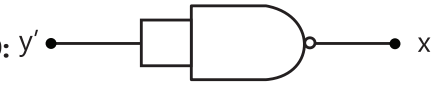
Output y is same of the output of AND gate

Sol 28:

A	y
0	1
1	0

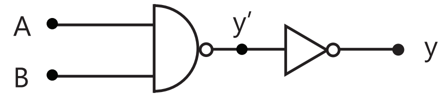
It will function as NOT gate

Sol 29:



This circuit act as NOT gate

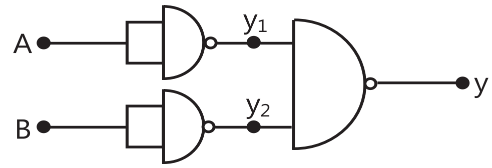
(a)



A	B	y'	y
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1

So this acts like AND gate

(b)

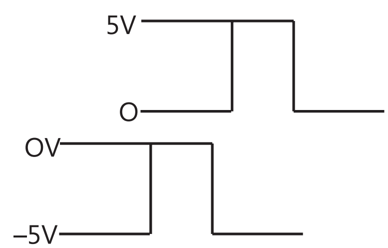


A	B	y_1	y_2	y
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

It acts as OR gate

Sol 30: (i) Diode will allow only positive voltage to pass

(ii)



Exercise 2

Single Correct Choice Type

Sol 1: (A) Intensity of electric field $E = \frac{V}{d}$

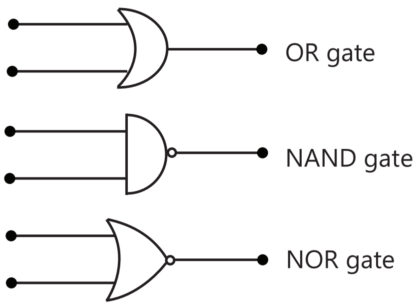
$= \frac{0.5}{5\times10^{-7}} = 10^6$ V/m

Sol 2: (A) In Avalanche breakdown the covalent bonds where the junction break down liberating a large number of electron hole pairs. So the main cause is collision ionisation.

Sol 3: (A) The holes in the p-region are attracted towards the negative terminal and the electrons in the N-region are attracted towards the positive terminal. Thus the majority carriers move away from the junction. The depletion region increases for a reverse biased PN-junction.

Sol 4: (B) $R_b = \frac{V}{i_b} = \frac{7}{35\times10^{-6}} = \frac{1}{5}\times10^{6} = 200\ K\Omega$

Sol 5: (C)



Sol 6: (B)

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

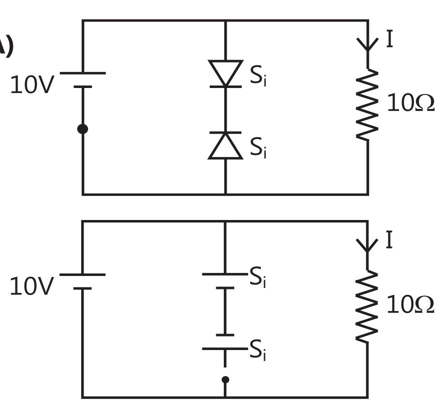
It corresponds to OR gate

Sol 7: (A) Case-I both diodes conducts but it is not possible as voltage at V can't be 11.3 and 11.7 simultaneously.

Case-II Only Si diode conduct. Then V_0 = 11.3 Volt and Ge diode should conduct so, it is not possible

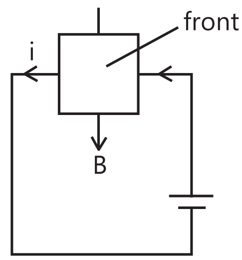
Case-III Only Ge diode conducts, Then V_0 = 11.7 Volt and Si diode is off in this condition. So this case is possible. So V_0 = 11.7 Volt.

Sol 8: (A)



$$I = \frac{10}{10\Omega} = 1\ \text{amp}$$

Sol 9: (B) $f = q\vec{V}\times\vec{B}$ so positive charge will accumulate on the front surface and negative charge on the back surface.



Sol 10: (C) During negative half cycle diode 1 is forward biased and diode 2 is reverse biased so output will be due to diode 1 so it corresponds to B and D

Sol 11: (C) Diode is forward bias so it will conduct

Equivalent resistance of circuit

$$R_{eq} = 10 + \frac{10\times10}{10+10} = 15K\Omega$$

$$i = \frac{30}{15K\Omega} = 2\ mA$$

So, voltage difference between A and B is

V_{AB} = 1 mA × 10 KΩ = 10 Volt

Multiple Correct Choice Type

Sol 12: (A, D) New holes and conduction electrons are produced continuously throughout the material.

Holes and conduction electrons recombine continuously throughout the material except in the depletion region because due to the electric field holes and electrons become immobile in depletion region.

Assertion Reasoning Type

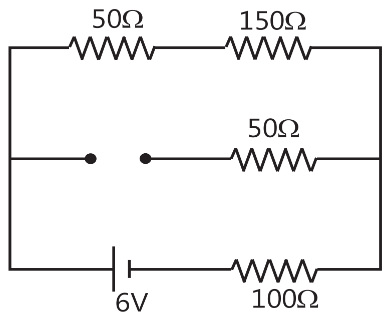
Sol 13: (D) Conductivity of semiconductors increases as more electron goes from valence band to conduction bond with increase in temperature.

Sol 14: (A) Holes move in the direction of electric field and electrons move in the opposite direction. So holes and electrons both contribute for the current in semiconductors. Covalent bond breaks up and produces holes in valence band and electrons in conduction band.

Sol 15: (C) In transistors, maximum no of electrons flows from emitter to collector in n-p-n transistors. Only a small fraction of electrons flow from emitter to base.

Comprehension Type

Sol 16: (B) Diode D_1 is forward biased and D_2 is reverse based so



current = $\frac{6}{300}$ = 0. 02 A

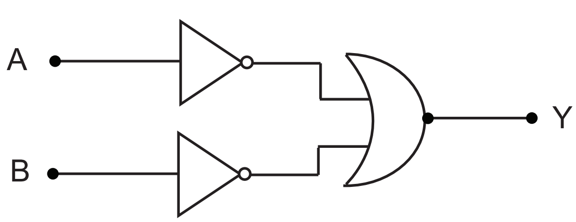
Sol 17: (A) Current is zero across 50 Ω resistor.

Previous Years' Questions

Sol 1: (A)

Truth table

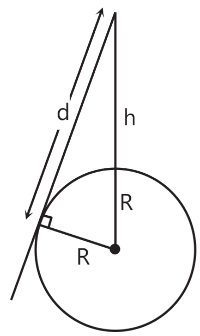
A	B	C
1	1	1
1	0	0
0	1	0
0	0	0



Sol 2: (D)

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

Sol 3: (A)



Maximum distance on earth where object can be detected is d, then

$(h + R)^2 = d^2 + R^2$

$\Rightarrow d^2 = h^2 + 2Rh$

since h << R, $\Rightarrow d^2 = 2hR$

$\Rightarrow d = \sqrt{2(500)(6.4\times10^6)} = 80$ km

Sol 4: (C) $d \propto \rho^x S^y F^z$

$\Rightarrow [L] = [ML^{-3}]^x [MT^{-3}]^y [T^{-1}]^z$

$\Rightarrow x + y = 0, -3x = 1, -3y - z = 0$

$\Rightarrow x = \frac{-1}{3}, y = \frac{1}{3}, z = -1$

$\Rightarrow y = \frac{1}{3}$

$\Rightarrow n = 3$