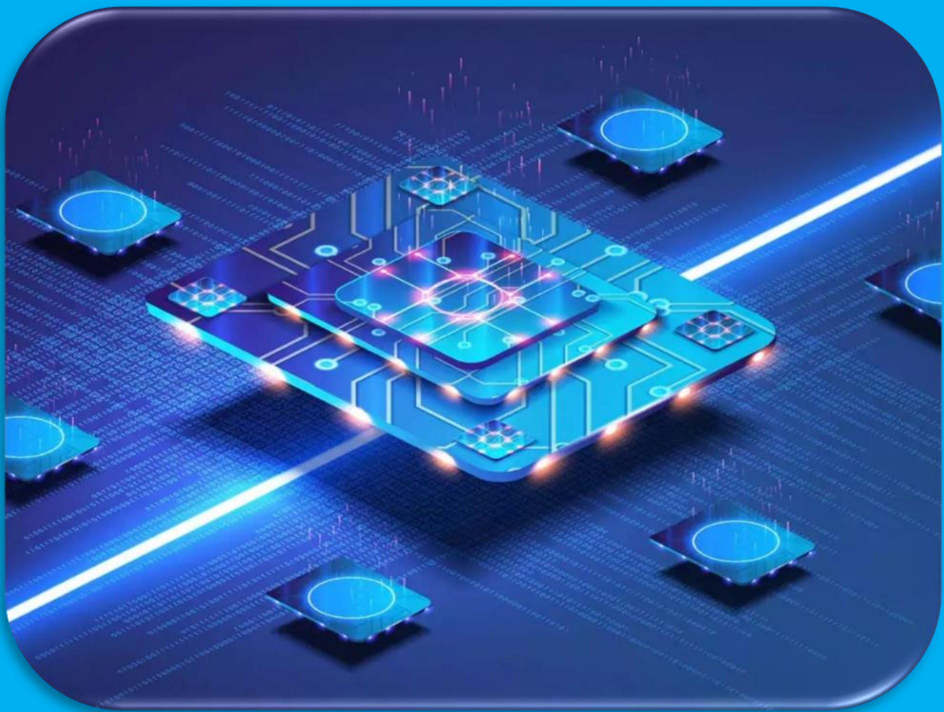
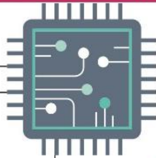
14.Semiconductor Electronics



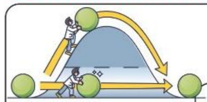
Physics Smart Booklet

Theory + NCERT MCQs + Topic Wise Practice MCQs + NEET PYQs

Semiconductor Electronics: Material Devices and Simple circuit



Classification of metals.Insulator And Semiconductor



ON THE BASIS OF CONDUCTIVITY

(1) For metals:

$S \sim 10^{-2} - 10^{-8}\,\Omega\,m$

$\sigma \sim 10^{2} - 10^{8}$ S/m

They have high conductivity.

(2) For Semiconductors:

$S \sim 10^{-5} - 10^{6}\,\Omega\,m$

$\sigma \sim 10^{5} - 10^{-6}$ S/m

They have intermediate conductivity to metals and insulators.

(3) For insulators:

$S \sim 10^{11} - 10^{19}\,\Omega\,m$

$\sigma \sim 10^{-11} - 10^{-19}$ S/m

They have low conductivity

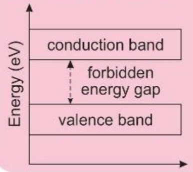
σ = electrical conductivity

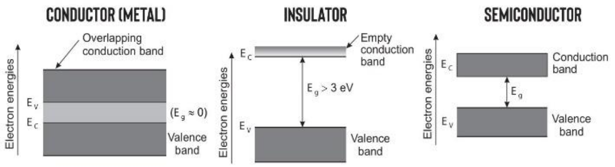
ρ = resistivity

The band which is completely filled with electrons at 0K is called valence band.

Conduction Band is completely empty at 0K.

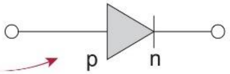
energy band gap is the difference between Valence band and Conduction band





SEMICONDUCTOR AND ITS TYPES

Semiconductors exhibit electrical conductivity between conductors and non – Conductors.



INTRINSIC SEMICONDUCTORS

(1) Pure Semiconductors are intrinsic Semiconductors.

(2) $n_i = n_e = n_h$. where, n_e = no. of free electrons. n_h = no. of holes. n_i = intrinsic carrier Concentration

(3) Examples:- Ge. Si

EXTRINSIC SEMICONDUCTORS

(1) Impure or doped Semiconductors are Said to be extrinsic Semiconductors

(2) Impurities are added to improve Conductivity

N – type Semiconductor $n_e >> n_h$

(1) Electrons are majority charge carriers.

(2) Holes are minority charge carriers.

(3) Si or Ge doped with pentavalent elements (P.AS. Sb)

P – type Semiconductor $n_h >> n_e$

(1) Si or Ge doped with trivalent (B. Al) elements

(2) Electrons are minority charge carriers.

(3) Holes are majority charge carriers

THERMAL EQUILIBRIUM

The electron and hole Concentration in a Semiconductor in thermal equilibrium is given by. $n_e n_h = n_i^2$

P – N junction diode

P – N junction diode is the Combination of P – type and N – type Semiconductor.

P – region has mobile majority holes and immobile – ve ions.

N – region has mobile majority free electrons and immobile Positively charged ions.

POTENTIAL BARRIES

Potential barrier is the potential difference developed across depletion region.

VB = 0.7 for Silicon

= 0.3 for germanium

FORWARD BIAS

In Forward Bias

(1) +ve terminal to P – Side

(2) –ve terminal to N – Side

(3) depletion layer reduced

(4) diffusion current increases

REVERSE BIAS

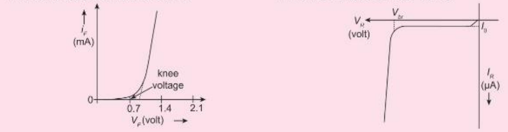
In reverse Bias

(1) –ve terminal to P – Side

(2) +ve terminal to N -Side

(3) depletion layer increases

(4) diffusion current increases



Knee or cut in voltage

Ge → 0.3 V, Si → 0.7 V

Breakdown voltage

Ge → 25 V, Si → 35 V

ZENER BREAKDOWN

This Phenomenon takes place in

(1) P – N junction having ' high doping'

(2) P – N junction having thin depletion layer

- Here. P –N junction does not damage permanently

AVALANCHE BREAKDOWN

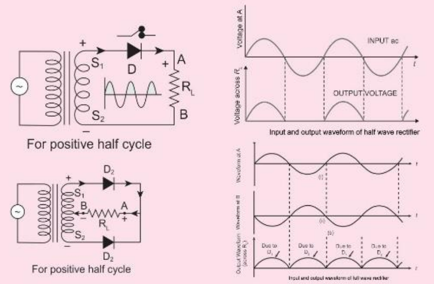
This Phenomenon takes place in.

(1) P – N junction having 'Low doping'

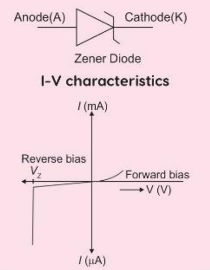
(2) P – N junction having thick depletion layer.

- Here. P – N junction damages permanently due to abruptly increment of minorities during repetitive collisions.

APPLICATIONS OF JUNCTION DIVIDE

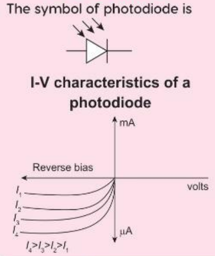


SEMICONDUCTOR ZENERDIONDE DIODES



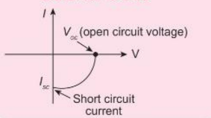
PHOTODIODE

The symbol of photodiode is



I-V CHARACTERISTICS OF A SOLAR CELL.

SOLAR CELL



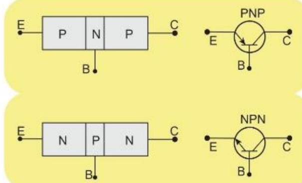
TRANSISTOR

Transistor is a three terminal device

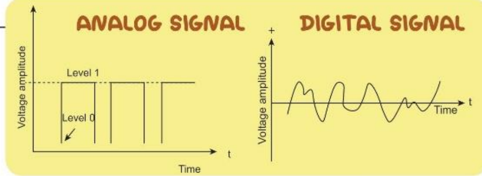
(1) Emitter (E)

(2) Base (B)

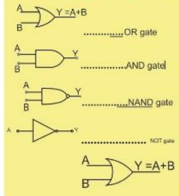
(3) Collector (C)



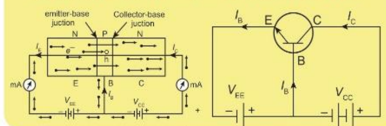
ANALOG SIGNAL   DIGITAL SIGNAL



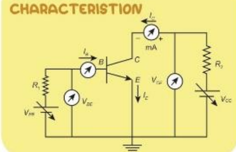
BASIC LOGIC GATES

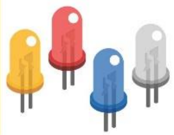


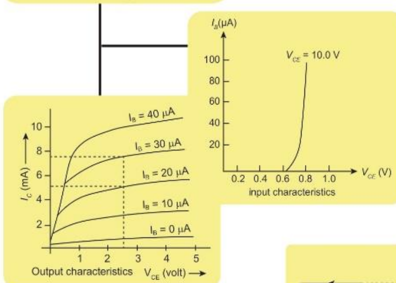
WORKING OF N – P – N TRANSISTOR



CE CONFIGURATION CHARACTERISTION

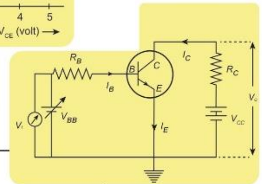




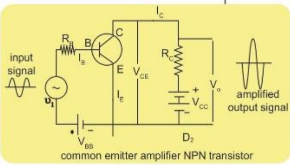


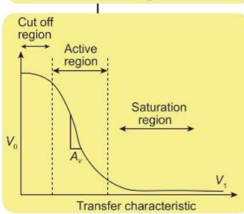
APPLICATION OF TRANSISTOR

AS A SWITCH



AS AN AMPLIFIER





Semiconductor Electronics

Materials, Devices and Simple Circuits

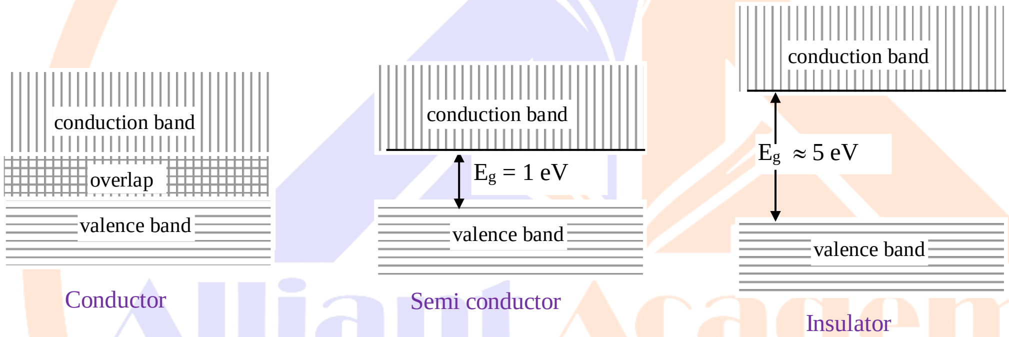
Introduction

Materials having the following electrical properties are semiconductors:

1. Considerably greater resistivity than that for metals and less than that for insulators.
2. Temperature co-efficient of resistance is negative and high.
3. Number density (number of charge carriers / unit volume) n is considerably smaller than that for metals but greater than that for insulators.

Silicon and germanium are commonly used semiconducting materials for electronic devices. Now-a-days, silicon is widely used. Both silicon and germanium are tetravalent Z = 14 for silicon and Z = 32 for germanium. Crystal structure of Ge or Si is the same as that of diamond, i.e., pure carbon. The atoms are held in the crystal lattice by covalent bonds.

Classification of solids based on the Bond theory of solids



Energy band diagram of solids

Extrinsic semiconductors

- The extra element added to an intrinsic semiconductor is called the *impurity atom*.
- The process of adding impurity into an intrinsic semiconductor is called *doping*.
- A pentavalent atom is used as a *donor impurity*. Eg. P, Sb, As
- A trivalent atom is used as an *acceptor impurity*. Eg. In, B, Al
- In addition to the equal number of electrons and holes already existing due to breaking of bonds (at a temperature)
  - (a) there are as many extra holes as the number of acceptor atoms, in a p-type semiconductor.
  - (b) there are as many extra free electrons as the number of donor atoms, in a n-type semiconductor.

Both p- and n-type semiconductors are electrically neutral.

Effect of doping

- For the same semiconductor material (whether Si or Ge etc), the pn product is constant independent of the type or density of the impurity and depends only on temperature.

$$p_n n_n = p_p n_p = p_i n_i = p_i^2 = n_i^2$$

where n_n = electron density, p_n = minority hole density in a N-type semiconductor

p_p = hole density, n_p = minority electron density in a P-type semiconductor

p_i = hole density, n_i = electron density in a intrinsic semiconductor

Differences between intrinsic and extrinsic semiconductors

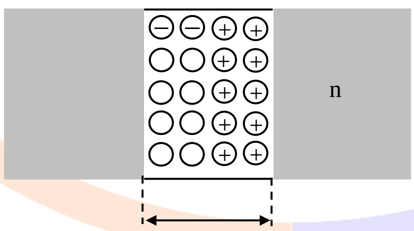
Sl. No.	Intrinsic Semiconductor	Extrinsic Semiconductor
1.	Pure Ge or Si crystal is known as intrinsic semiconductor.	The semiconductor with specific impurities in controlled quantities is known as extrinsic semiconductor.
2.	Conductivity is low.	Conductivity is high.
3.	At any given temperature, the number of electrons is always equal to the number of holes.	The number of electrons and holes are always unequal.

Differences between p-type and n-type semiconductor

Sl.	p-type	n-type
1.	A p-type semiconductor is obtained by doping a trivalent impurity like B or A*l* with intrinsic semiconductor.	An n-type semiconductor is obtained by doping a pentavalent impurity like P or As with intrinsic semiconductor.
2.	Majority charge carriers are holes and minority charge carriers are electrons.	Majority charge carriers are electrons and minority charge carriers are holes.
3.	The impurity atom accepts the electron from valence band and contribute to increased conductivity.	The impurity atom donates an electron to conduction band and contributes to increased conductivity.
4.	The acceptor impurity energy level is close to the valence band.	The donor impurity energy level is close to the conduction band.

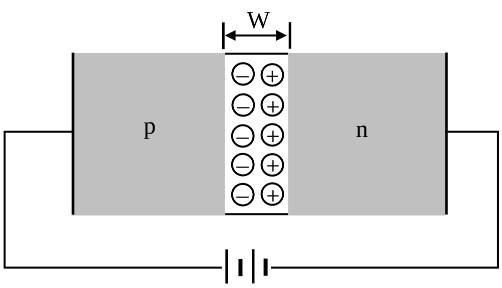
p-n junction or semiconductor diode (unbiased)

The charge depletion region has a thickness of about one-tenth of a μm and the junction voltage is about 0.3 V for a germanium diode and 0.7 V for a silicon diode at 20 °C.

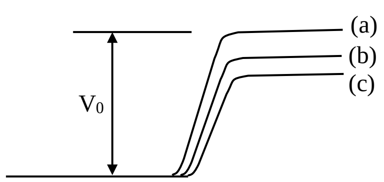


Biasing of a p-n junction or (Semiconductor) diode

Forward bias



W → width of depletion region
p-n junction diode under forward bias

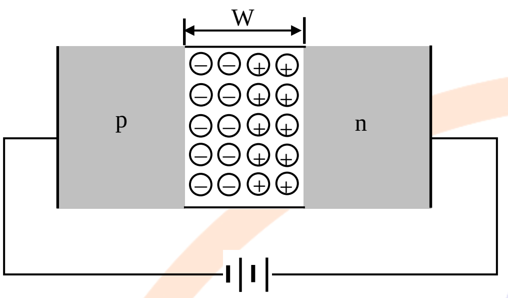


Barrier potential
(a) without battery
(b) low batter voltage
(c) high battery voltage

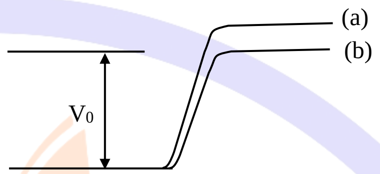
When in forward bias, a diode

- offers negligible (ideally zero) resistance
- behaves like a closed switch
- external voltage opposes the junction voltage.

Reverse bias



Diode under reverse bias



When in reverse bias, a diode

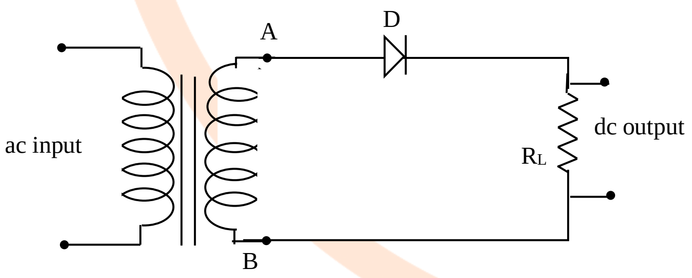
- offers very large (ideally infinite) resistance
- behaves like an open switch
- external voltage aids the junction voltage.

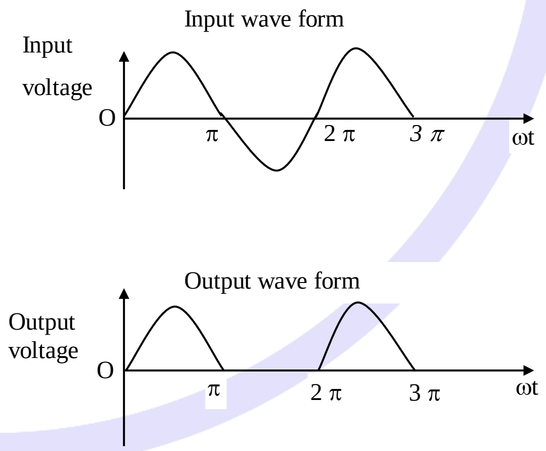
At a very large reverse voltage, reverse breakdown occurs and, hence, a large current flows through the device. This voltage is about 400 V for germanium and 1000 V for silicon.

Rectifiers

A rectifier is a circuit that converts an ac signal into a dc signal. The unidirectional property of a diode is used in the construction of a rectifier.

Half wave rectifier

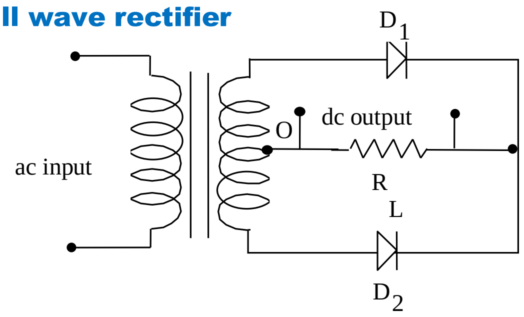


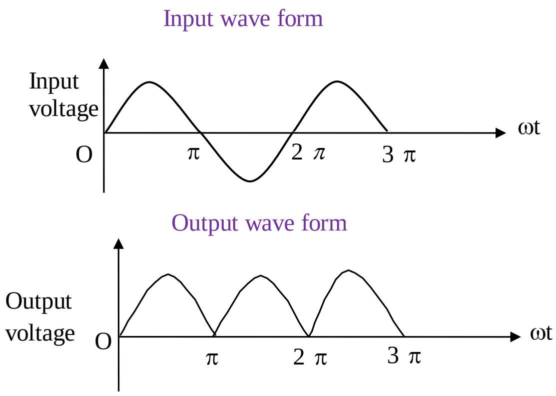


The output of a half-wave rectifier, is still pulsed, and hence it is not pure dc. (Thus a filter is required to remove the ripples)

$f_{output} = f_{input}$

Full wave rectifier





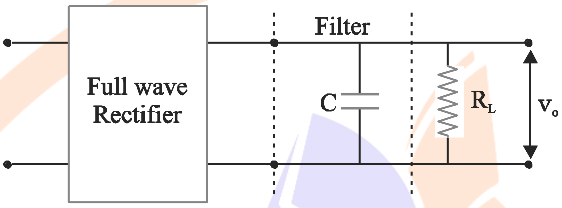
The output of a full wave rectifier is still pulsed and hence, it is not pure dc. (Thus a filter is required to remove the ripples)

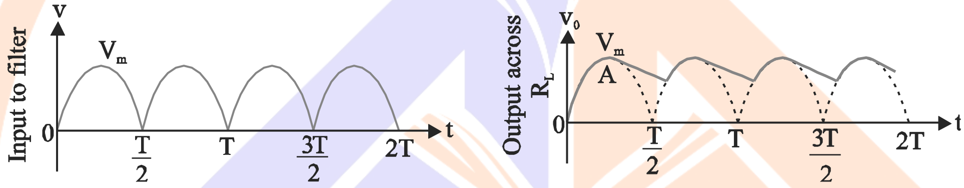
$f_{output} = 2f_{input}$

Capacitor input filter (Shunt capacitor filter)

Need for filter

Even through the output of a rectifier is unidirectional, to does not have a steady value. To get, steady output, a capacitor is connected across R_L (the output terminals) (an inductor connected in series with R_L or a suitable combination of L and C also can be used) which function as a filter.



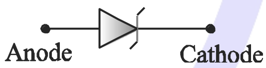


The product R_LC is called the time constant of the filter circuit. Larger the value of R_LC, better is the filtering action. Generally a capacitor of large capacitance is used.

Special purpose p-n junction diodes

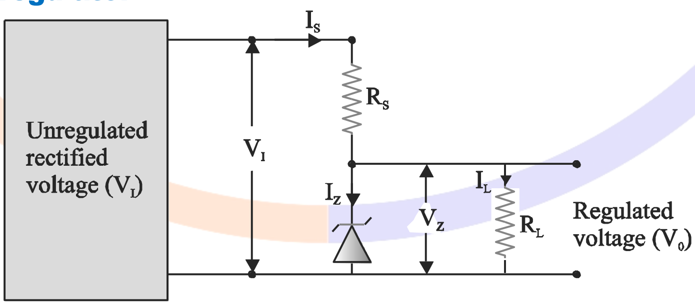
Zener diode

Zener diode is a special purpose diode designed to operate in its reverse breakdown region. The breakdown voltage is called the *zener voltage*.



Symbol of zener diode

Zener diode as a voltage regulator



Zener diode as voltage regulator

Let us assume an unregulated dc voltage V_1 be applied as the input, as shown in the figure.

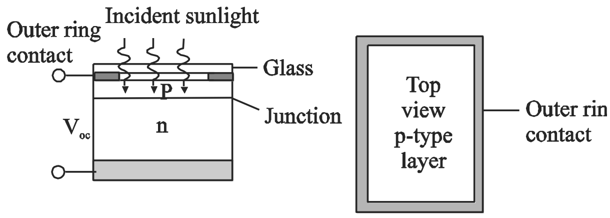
- If $V_1 < V_Z$ there, is no voltage across the zener diode
- If $V_1 > V_Z$, then voltage across the zener diode is V_Z and the remaining voltage appears across R_L. If V_1 varies, then $(V)_{R_S}$ also varies keeping V_Z constant.

Voltage across zener remains same independent of the current drawn by the device. Thus, a zener diode in reverse bias maintains constant voltage across the load independent of variation in the input voltage and in the load.

Optoelectronic junction devices

Semiconductor diodes which generate charge carriers by photons are called optoelectronic devices. This includes.

- **Light emitting diodes (LED)** which convert electric energy into light
- **Photo diodes** used for detecting optical signals
- **Photovoltaic devices (solar cells)** which convert light into electrical energy



p-n junction solar cell

Light emitting diode (LED)

LED is a heavily doped p-n junction when in forward bias emits light (in visible, ultraviolet or infrared region). When a diode is in forward bias, electrons from the n-type material recombines with the holes in the p-type material, near the junction. Due to this recombination energy is released in the form of heat and light.

In Ge and Si diodes, much of their energy is dissipated in the form of heat within the body of the diode.

This is due to *non-radiative recombination* and light emitted is insignificant. For this reason, Si and Ge are not used in the construction of a LED.

Diodes made of Gallium arsenide (Ga As) when in forward bias emit light in the infrared region during the recombination process at the p-n junction.

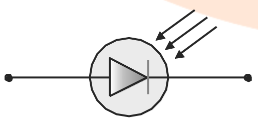
V-I characteristics of LED

V-I characteristics are similar to that of a p-n junction diode made of Si or Ge. The threshold voltages are much higher and different for each colour. The reverse breakdown voltages of most LEDs are small, about 5 V.

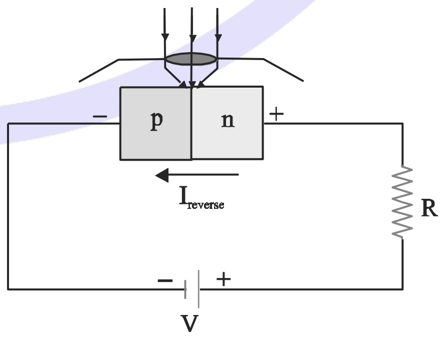
Advantages of LED over conventional incandescent lamp

1. Low operational voltage and less power consumption.
2. Fast action and no warm-up time required.
3. The bandwidth of emitted light is 100 Å to 500 Å. Light emitted is fairly monochromatic.
4. Long life and rugged.

Photodiode



Symbol of a photodiode



Basic biasing arrangement of photodiode

A photodiode is a special purpose photosensitive semiconducting diode operated in the reverse biased condition. When light is incident on the junction, the junction resistance decreases rapidly with the increase in the intensity of light.

Solar cells

A solar cell is a p-n junction which generates emf when light radiation is incident on it.

The top p-type material is made very thin so that the photons reach the junction. The contact to the p-type material is made through an outer ring deposited on it while a metallic contact is established to the bottom of the n-type material. A protective glass covering is provided for the top surface.

Reason for wide use of the materials like Si, Se and Ga As

i. Semiconductors with band gap $E_g \approx 1.5$ eV has a higher conversion efficiency, greater stability and less fatigue.

ii. They have higher absorption coefficients.

iii. These materials have excellent temperature characteristics. They can withstand extreme high or low temperatures without a significant drop-off in efficiency.

Materials with smaller band gaps are not suitable since most of the radiation will be absorbed on the top layer of solar cell and may not reach the depletion region. For effective electron-hole separation due to junction field, they must be generated in the junction region only.

Transistor

A transistor is a three terminal semiconducting device, which has a thin wafer of one type of extrinsic semiconductor between two layers of the other type.

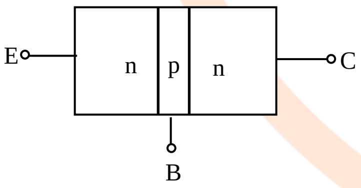
A transistor with an n-type wafer between two p-type wafers, is called a *p-n-p transistor*. Similarly a transistor which has a p-type of wafer between two n-type layers, is called *n-p-n transistor*.

The thin layer in the middle region of the transistor is called the *base*. The two layers on either side of the base are called *emitter* and *collector*.

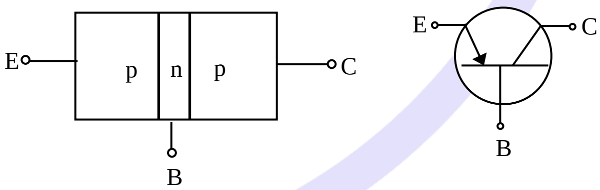
For any transistor
- The size of the base is the least and that of the collector region is the highest.
- Doping level is least in the base and highest in the emitter region.

The function of the emitter is to emit the majority charge carriers, and that of the collector is to collect the majority charge carriers. The function of the base is to modify the emitter current.

The arrows in the circuit symbol of n-p-n and p-n-p transistor indicate the direction of conventional current.



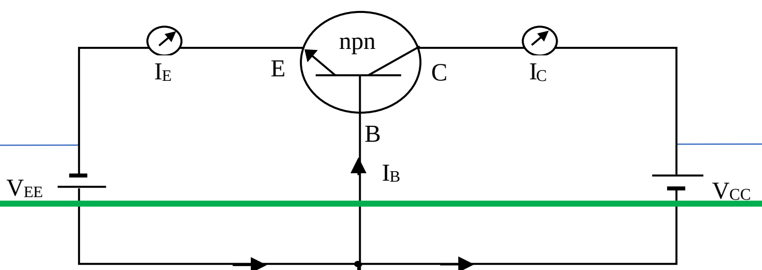
(a) npn transistor and circuit symbol



(b) pnp transistor and circuit symbol

- Though both the emitter and collector are made of same type of the extrinsic semiconducting material, they are not interchangeable because of
  (a) different doping levels
  (b) different physical sizes.
- A transistor as a whole, is a single crystal doped with suitable materials and not a combination of 3 pieces of different crystals.

Operation of a transistor



he emitter base junction should be forward biased and the collector base junction should be reverse biased.

If I_E, I_B and I_C represent the emitter current, the base current and the collector current respectively, then $I_E = I_B + I_C$.

I_B is of the order of micro ampere and I_E and I_C are of the order of milliampere. As an approximation, we can write $I_E \approx I_C$.

Consider an n-p-n transistor. The majority charge carriers namely, free electrons, are transferred from the low resistance emitter-base junction (forward bias) to the high resistance collector-base junction (reverse bias). Hence, the device is called **transfer - resistor**-abbreviated as **transistor.**

Since, nearly the same current flows from emitter to collector; and the collector base junction offers very high resistance compared to the emitter base junction; there is an amplification of power. Thus, *a transistor can be used as a power amplifier*.

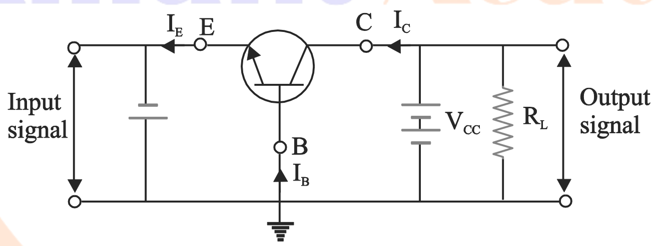
Transistor configurations (modes)

Transistor configurations

Amplifier circuits using transistors can be classified into three categories determined by the circuit arrangement and the load.

(a) Common base configuration

Input signal is provided between the emitter and the base. The output signal appears across the collector and the base.



The **current gain (α_{dc})** in CB mode of a transistor is given by $\alpha_{dc} = \frac{I_C}{I_E}$

α_{dc} is in the range of 0.95 to greater than 0.99 but less than 1.

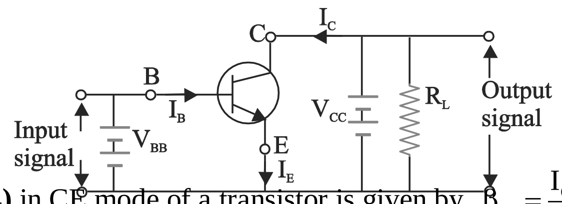
The **current amplification factor (α_{ac})** in CB mode is defined by

$$\alpha_{ac} = \left(\frac{\Delta I_C}{\Delta I_E}\right)_{V_{CB}=\text{constant}}$$

Generally, α_{ac} and α_{dc} are quite close.

(b) Common emitter configuration

Input signal is provided between the emitter and the base. Output signal appears across the collector and the emitter.



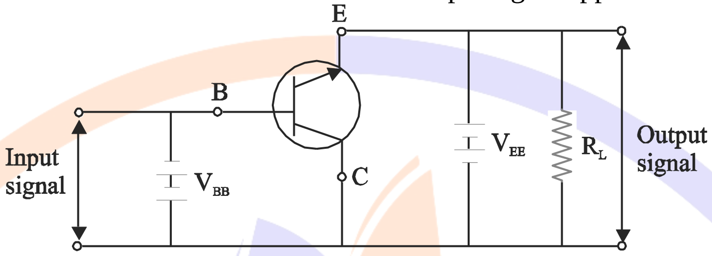
The **current gain (β_{dc})** in CE mode of a transistor is given by, $\beta_{dc} = \frac{I_C}{I_B}$

The **current amplification factor (β_{ac})** in CE mode is given by, $\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE} = \text{constant}}$

β is in the range of about 50 to 300

(c) Common collector configuration

Input signal is provided between the base and the collector. Output signal appears across the emitter and the collector.



CC configuration

- CC configuration is also called emitter follower. The common-collector configuration is used for impedance matching purposes because it has a high input impedance and low output impedance. In the case of common-base and common-emitter configurations, input impedance is low and output impedance is high. Because of this characteristic, CE and CB configurations are widely used for amplification purposes.
- A transistor is most widely used in CE configuration. npn-Si transistors are widely used. With pnp transistors, the polarities of the external power supplies must be reversed.

Relation between α_{dc} and β_{dc}

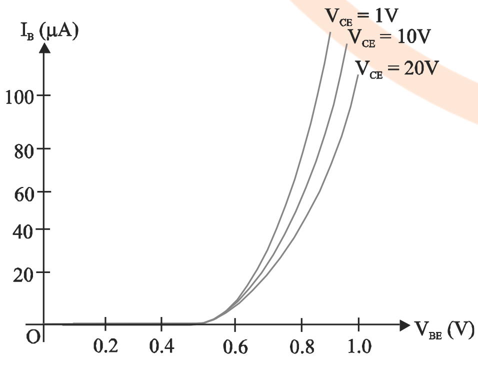
We have for a transistor $I_E = I_B + I_C$

$$\boxed{\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}}}$$

$$\boxed{\alpha_{dc} = \frac{\beta_{dc}}{1+\beta_{dc}}}$$

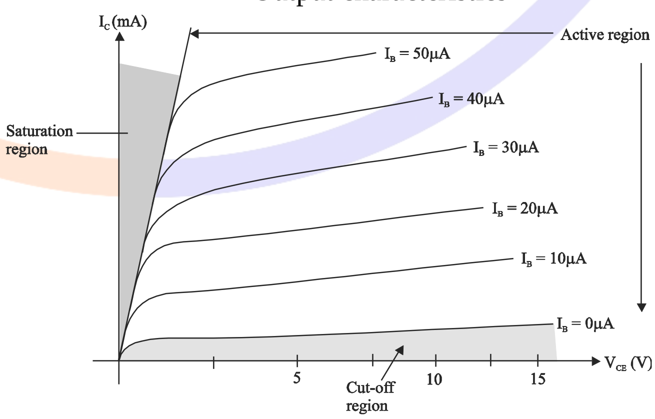
- α_{dc} and β_{dc} of a transistor are temperature dependent.

Common emitter characteristics



Input characteristics of a npn transistor in CE mode

Input resistance, $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$



Output characteristics of a npn transistor in CE mode

Output resistance = $r_o = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$

r_0 is in the range of about 20 kΩ to 50 kΩ

Features of output characteristics

i. In the active region, i_c increases slowly with V_{CE}.

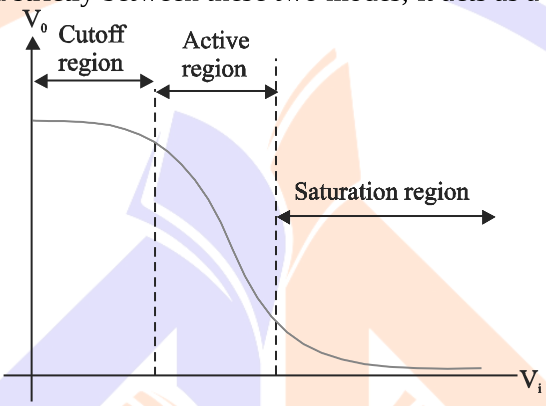
ii. In the saturation region, i_c decreases rapidly as V_{CE} decreases [$V_{CE} < 1$]. This occurs as V_{CE} drops below the value of V_{BE}. The collector-base junction is then forward biased. In this condition, both EB junction and CB junction are forward biased. This is called saturation region as I_C no longer depends upon the input current I_B.

iii. In the active region, a small input current I_B produces a large collector current I_C (output current)

iv. The collector current is not zero when I_B is zero. It has a value of I_{CEO}, the reverse leakage current.

Transistor as a switch

If a very large base current is present in a transistor in a common emitter configuration, the transistor will be driven into *saturation*. On the other hand, if the base current is reduced to zero, the transistor is placed in cut-off. When a BJT is operated strictly between these two modes, it acts as a switch.

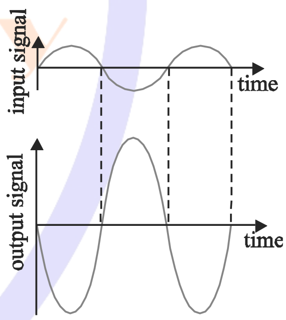


Transfer characteristics – Transistor switch

When v_i is low, the transistor is not conducting. It is said to be switched OFF. When the input is high, transistor operates at saturation, it is said to be switched ON.

Transistor as an amplifier – npn CE amplifier

Principle



A small change in the base current causes a larger change in the collector current. This is the underlying principle of the transistor amplifier. The condition necessary for the amplifier to work is that *the base emitter junction should be forward biased and collector base junction should be reverse biased.*

AC voltage gain

$$A_v = -\beta_{ac}\left(\frac{R_L}{r_i}\right)$$

The negative sign indicates that the output is inverted w.r.t. the input.

Power gain

In CE-mode, a transistor amplifier produces a current gain (β_{ac}) and also a voltage gain (A_v). Thus, power gain (A_p) is given by

$$A_p = \beta_{ac} A_v$$

Since both β_{ac} and A_v are greater than 1, there will be a power gain. However, a transistor is not a power generating device. The energy for the higher ac power at the output is provided by the battery.

Feedback amplifier

The process in which a fraction of the amplifier output is fed back to the input circuit is called feedback. It helps to control the output of the amplifier.

If the feedback voltage is such that the returning signal is in phase with the input signal, the amplitude of the input signal increases. This is called **positive feedback or regenerative feedback.** This principle is used in the construction of oscillators. Positive feedback produces excessive distortion and not suitable in amplifiers.

If the feedback voltage is such that the returning signal is in opposite phase with the input signal, the amplitude of input signal decreases. This is called **negative feedback or degenerative feedback.** The advantages of negative feedback are stable gain, less distortion and more bandwidth. Hence, it is used in amplifiers.

Illustrations

1. The density of electrons and holes in a pure germanium sample at room temperature are equal and its value is 3×10^{16} per m^3. On doping with aluminium, the hole density increases to 4.5×10^{22} per m^3. Then the electron density in doped germanium is

(A) $2 \times 10^{10}\ m^{-3}$ (B) $5 \times 10^{9}\ m^{-3}$

(C) $4.5 \times 10^{-10}\ m^{-3}$ (D) $3 \times 10^{9}\ m^{-3}$

Ans (A)

The electron and hole concentration in a semiconductor in thermal equilibrium is given by $n_e n_n = n_i^2$

$$n_e = \frac{n_i^2}{n_h} = \frac{(3\times10^{16})^2}{4.5\times10^{22}} \approx 2\times10^{10}\ m^{-3}$$

2. A block of pure silicon at 300 K has a length of 10 cm and an area of $10^{-4}\ m^2$. If a battery of emf 2 V is connected across it, the electron current is (Given: mobility of electrons is $0.14\ m^2\ V^{-1} s^{-1}$ and electron density is $1.4 \times 10^{16}\ m^{-3}$)

(A) 6.72×10^{-4} A (B) 6.72×10^{-5} A (C) 6.72 μA (D) 0.56 μA

Ans (D)

Given $\mu_e = 0.14\ m^2\ V^{-1}\ s^{-1}$, $n_e = 1.4 \times 10^{16}\ m^{-3}$,

$l = 10$ cm $= 0.1$ m, $A = 10^{-4}\ m^2$ and $V = 2$ volt.

The electric field in the block is

$$E = \frac{V}{l} = \frac{2}{0.1} = 20\ V\ m^{-1}$$

The drift speed of electrons is

$v_e = \mu_e E = 0.14 \times 20 = 2.8\ m\ s^{-1}$ $\therefore$ Electron current $I_e = n_e A e v_e$

$= (1.4 \times 10^{16}) \times (1.0 \times 10^{-4}) \times (1.4 \times 10^{-19}) \times 2.8$

$\approx 5.6\times10^{-7}\ A = 0.56\ \mu A$

3. A piece of copper and silicon are first heated to a temperature of 150°C and then gradually cooled. During the cooling

(A) the resistance of copper increases and that of silicon decreases

(B) the resistance of silicon increases and that of copper decreases

(C) the resistance of both silicon and copper increase

(D) the resistance of both copper and silicon decrease

Ans (B)

Copper is a conductor whose resistance decreases with decrease in temperature whereas silicon is a semiconductor whose resistance increases with decrease in temperature (semiconductors have negative temperature coefficient of resistance).

4. The electrical conductivity of a semiconductor specimen is found to increase when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap in (eV) for the semiconductor is

(A) 0.7 eV (B) 0.5 eV (C) 2.5 eV (D) 1.2 eV

Ans (B)

$$E_g = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{2480\times10^{-9}\times(1.6\times10^{-19})} = 0.5\ eV$$

Quick calculation

$$E\ (\text{in eV}) = \frac{1240}{\lambda(\text{nm})} = \frac{1240}{2480\ (\text{nm})} = 0.5\ eV$$

5. In a p-type semiconductor the acceptor level is situated 60 meV above the valence band. The maximum wavelength of light required to produce a hole in the valence band is

(A) 0.207×10^{-5} m (B) 2.07×10^{-5} m (C) 20.7×10^{-5} m (D) 2075×10^{-5} m

Ans (B)

$$E = h\nu \ ; E = \frac{hc}{\lambda}$$

$$\therefore \ \lambda = \frac{hc}{E} = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{60 \times 10^{-3} \times 1.6 \times 10^{-19}} = 2.07 \times 10^{-5} \text{ m}$$

Quick calculation

$$E \approx \frac{12400}{\lambda(\text{in Å})} \approx \frac{1240}{\lambda(\text{in nm})} \text{ eV}$$

$$\lambda \approx \frac{1240}{60 \times 10^{-3}} = 20.7 \times 10^{3} \text{ nm} = 2.07 \times 10^{-5} \text{ m}$$

6. A sample of silicon is doped with 1.5×10^5 arsenic atoms/cm^3. If the intrinsic carrier density in silicon at 300 K is 1.5×10^{10} / cm^3, the electron density and hole density in each sample at 300 K respectively (number density is in cm^{-3})

(A) are 1.5×10^{10}, 1.5×10^{10} and the sample behaves as an intrinsic semiconductor

(B) are 1.5×10^{10}, 1.5×10^{10} and the sample behaves as an extrinsic semiconductor

(C) are 1.5×10^{15}, 1.5×10^{10} and the sample behaves as an extrinsic semiconductor

(D) cannot be calculated with the given data

Ans (A)

As arsenic is a donor to a silicon crystal, the samples would tend to become n-type. As practically all the donors will be ionized at room temperature of 300 K, the extra electron density introduced will be equal to 1.5×10^5 / cm^3. As this is 5 order of magnitude lesser than the electron and hole densities in the pure sample ($n_i = p_i = 1.5 \times 10^{10}$ / cm^3), the impurity density will produce negligible changes in the original carrier densities existing in the silicon crystal due to thermal breaking of the covalent bonds. Hence, though the sample is not strictly pure, it will still show intrinsic behaviour only, and

$n_e = n_h = 1.5 \times 10^{10}$ / cm^3 = n_i.

Aliter

The impurity being arsenic, one may wrongly jump to the conclusion that the doped sample is extrinsic. The impurity concentration is $\frac{1.5 \times 10^5}{1.5 \times 10^{10}}$ = 1 atom of arsenic for every 10^5 atoms of the host element and it is insignificant. Hence the sample shows intrinsic behaviour.

7. n-type and p-type silicon semiconductors can be obtained by doping pure silicon with

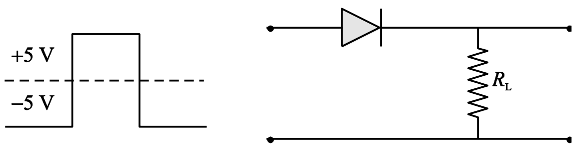
(A) sodium and magnesium respectively (B) phosphorus and boron respectively

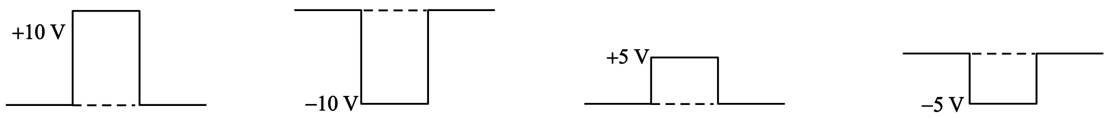
(C) boron and phosphorus respectively (D) indium and sodium respectively

Ans (B)

Phosphorous is pentavalent and boron is trivalent material.

8. If in a p-n junction diode, a square input signal of 10 V is applied, then the value of output signal across R_L will be



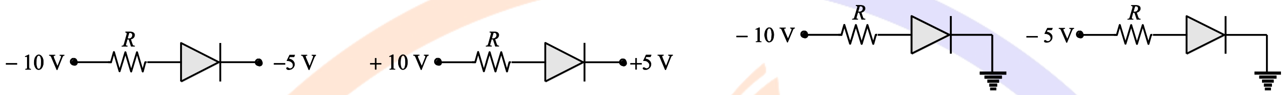


(A) (B) (C) (D)

Ans (C)

The junction diode will conduct when it is forward biased. Therefore, the output voltage will be obtained during positive half cycle.

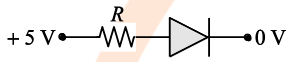
9. Which of the junction diodes shown in the following circuits is forward biased?



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

Ans (B)

Circuit (B)



10. Zener diode is fabricated by

(A) heavily doping both p and n sides of the junction

(B) heavily doping the p side and lightly doping the n-side

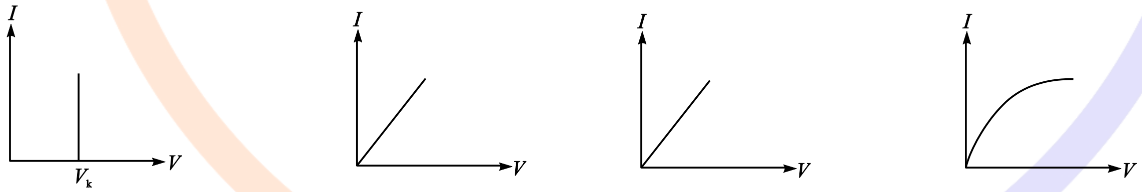
(C) lightly doping the p side and heavily doping the n-side

(D) lightly doping both p and n sides of the junction

Ans (A)

When both p and n sides of the junction are heavily doped, the depletion region formed is very thin (less than 10^{-6} m). Even for a small reverse bias, (a few volts) the electric field is very high (~ 5×10^{6} V m^{-1}) which results in a breakdown.

11. The graph that better represents the I−V characteristics of an ideal diode under forward bias is



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

Ans (A)

In an ideal diode, the current I is independent of the forward bias voltage above the junction potential. The potential difference across the diode remains constant above the junction potential.

12. In a photodiode, the value of the emf produced by monochromatic light is proportional to

(A) the barrier voltage at p-n junction
(B) the intensity of light falling on the photodiode
(C) the frequency of light falling on the photodiode
(D) the voltage applied at the p-n junction

Ans (B)

In a photodiode, the emf is produced by photovoltaic action is proportional to the intensity of incident light.

13. Efficiency of a half wave rectifier is nearly

(A) 80% (B) 60% (C) 40% (D) 20%

Ans (C)

Only around 40% of the AC input power is converted to DC in a half wave rectifier.

14. In a transistor, the least doped region is

(A) emitter (B) base (C) collector (D) both emitter and collector.

Ans (B)

The base of a transistor is made thin (about 1/150 of the total) and is least doped (about 1/10 of the doping level of collector) in order to transfer most of the charge carriers injected into the base circuit from the emitter to the collector circuit.

15. In a full wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be

(A) 70.7 Hz (B) 100 Hz (C) 25 Hz (D) 50 Hz

Ans (B)

Input → sin ωt

Output → $\sin^2 \omega t$ → which involves cos 2ωt

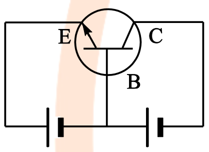
16. In the output characteristics of a transistor in CE –mode, initially even for very small change in V_{CE}, I_C increases almost linearly. This shows that the transistor is in

(A) active state (B) saturation state (C) conducting state (D) cut-off state

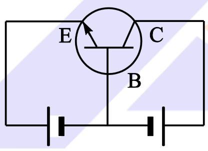
Ans (B)

In the saturation state the current is controlled by the supply voltage V_{CC} (= V_{CE}) in this part of the characteristic.

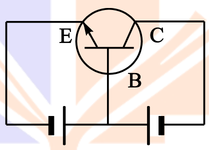
17. From the following circuits, choose the circuit that correctly represents the biasing circuit of a transistor.



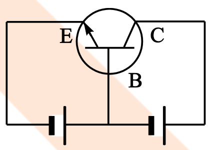
(A)



(B)



(C)



(D)

Ans (D)

In a transistor circuit for normal operation the emitter base junction is always forward biased and the collector base junction is reverse biased. Therefore, circuit (D) correctly represents the biasing circuit of a given n-p-n transistor.

18. The current gain for a transistor is less than unity for

(A) common base mode (B) common collector mode

(C) common emitter mode (D) both (A) and (B).

Ans (A)

The current gain for a transistor in common base mode is given by $\alpha = \left(\frac{\Delta I_C}{\Delta I_E}\right)_{V_{CB}}$. But $\Delta I_C < \Delta I_E$. Therefore, α is less than 1. (The value of α varies from 0.9 to 0.99).

19. The current gain of a transistor in common base mode is 0.99. If the change in emitter current is 5 mA then the change in collector current is

(A) 4.95 mA (B) 5.4 mA (C) 5.99 mA (D) 0.198 mA.

Ans (A)

Current gain $\alpha = \left(\frac{\Delta I_C}{\Delta I_E}\right)_{V_{CB}}$; Change in collector current $\Delta I_C = 0.99 \times 5 \text{ mA} = 4.95 \text{ mA}$

20. The current gain of a transistor in common base mode is 0.98. If the change in emitter current is 2 mA, the corresponding change in base current is

(A) 2 mA (B) 980 mA (C) 0.04 mA (D) 1 mA.

Ans (C)

$$\alpha = \left(\frac{\Delta I_C}{\Delta I_E}\right)_{V_{CB}} = 0.98$$

$$\Delta I_C = 0.98 \times 2 \text{ mA} = 1.96 \text{ mA}$$

$$\Delta I_B = \Delta I_E - \Delta I_C = (2 - 1.96) \text{ mA} = 0.04 \text{ mA}$$

21. In a CE-amplifier the audio signal voltage across the collector resistance of 2 kΩ is 2V. The current amplification factor of the transistor is 100. The signal current through the base is

(A) 0.01 mA (B) 0.1 mA (C) 0.001 mA (D) 0.05 mA

Ans (A)

Output ac voltage = 2V, Collector resistance = 2 kΩ

ac collector current, $i_c = \frac{2}{2 \times 10^3} = 1 \text{ mA}$

Signal current, through the base, $i_b = \frac{i_c}{\beta} = \frac{1 \times 10^{-3}}{100} = 0.01 \text{ mA}$

22. A transistor oscillator unit consists of a tuned circuit containing an inductance of 5 mH and a capacitance of 5 pF. The frequency of the oscillator is

(A) 100 kHz (B) 1 GHz (C) 10 MHz (D) 1 MHz

Ans (D)

$L = 5 \times 10^{-3}$ H, $C = 5 \times 10^{-12}$ F

$$f = \frac{1}{2\pi\sqrt{LC}}; \quad f^2 = \frac{1}{4\pi^2 LC} \approx \frac{1}{40 \times 5 \times 10^{-3} \times 5 \times 10^{-12}} = \frac{1}{10^3 \times 10^{-3} \times 10^{-12}} = 10^{12}$$

$$\therefore f = \sqrt{10^{12}} = 10^6 \text{ Hz} = 1 \text{ MHz}$$

Digital Electronics

Introduction

Circuits which process continuously varying signals such as voltage or current are called *analog circuits*, while, circuits which process digital signals (pulses) are called *digital circuits*. In general, the term digital denotes variation in discrete steps. Counting by numbers (Eg, integers) is one such process. The basic device used in digital electronics is a switching element such as a diode or a transistor.

A diode in the conducting state is like a closed switch (ON-state) and in the non-conducting state is like an open switch (OFF state). In digital circuits the actual voltages are not important as long as they can drive the device to one of the two states. Since in digital circuits, there are only two states, ON and OFF, they can be conveniently represented by digits 0 and 1. These two binary digits are called *bits*. A bit can assume a value of either 0 or 1.

Positive logic

The logic in which 1 represents the high state (ON) and 0 represents the low state (OFF).

Negative logic

The logic in which 0 represents the high state (ON) and 1 represents the low state (OFF).

Logic gate

Information (data) to be processed by digital circuits are contained in a string of digital signals (pulses). Circuits which process this for required operations are called *logic circuits* or *logic gates.*

A logic gate has one or more inputs and an output.

Truth table of a logic gate is a list of its output for different possible input combinations.

Boolean algebra

George Boole evolved a process to express logical statements in terms of mathematical expressions. This theory was based on the concept of "true" or "false".

The binary digits 0 and 1 could be used to represent the "false" and "true" state respectively. The branch of algebra based on this concept is called *boolean algebra.*

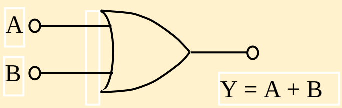
There are three basic operations namely AND, OR, NOT in boolean algebra. The corresponding gates are AND gate, OR gate and NOT gate.

However, another important logic gate is the NAND gate. Using a combination of NAND gates, all other gates can be derived. Thus a NAND gate is called a *universal gate*. Similarly NOR gate can be used as a *universal gate*.

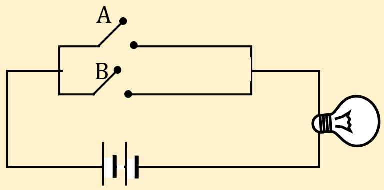
OR Gate

It performs a type of addition called OR addition. This operator is represented by "+" sign. If **A** and **B** are two variables on which OR operation is to be performed, the result Y is Logic 1 if atleast one of the variables (either A or B or both) is Logic 1. The boolean equation for OR addition is given by Y = A + B. When the variables are more than two, then the boolean equation for the OR operation is written as Y = A + B + C +----. For the four possible combinations of variables A and B, the results of OR addition are given in the truth table.

Symbol



Equivalent electric circuit

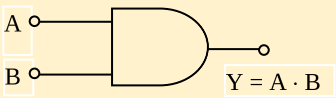


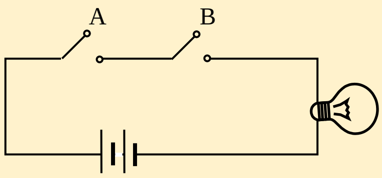
Truth Table

A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

AND Gate

It performs a type of multiplication called AND multiplication. This operator is represented by • sign. If **A** and **B** are two variables on which AND operation is to be performed, the result Y is Logic 1 if **ALL** the variables (A and B) are Logic 1. The boolean equation for AND multiplication is given by Y = A • B.



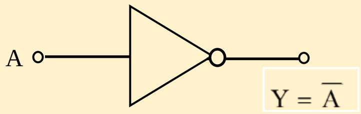


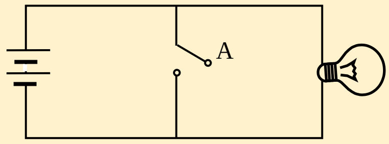
A	B	Y = A · B
0	0	0
0	1	0
1	0	0
1	1	1

NOT Gate

This operator can be performed on a single variable unlike AND and OR operators which require at least two variables to perform the operation.

NOT operation is nothing but inversion. The result is complement of the logic level of variable. The NOT operator is represented by writing a bar over the variable. If A is the variable, the result Y of NOT operation is written as $Y = \overline{A}$. *It is to be read as Y is NOT A*. For the two possible combinations, results of the NOT operation are shown in the table.



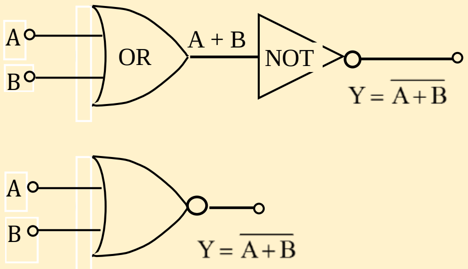


A	$Y=\overline{A}$
0	1
1	0

Some derived gates

NOR gate: (NOT OR)

Symbol

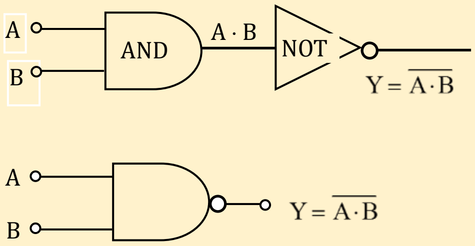


Truth Table

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

NAND gate: (NOT AND)

Symbol

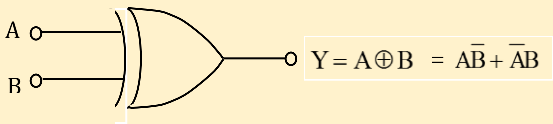


Truth Table

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

Exclusive - OR Gate (Ex - OR)

Symbol

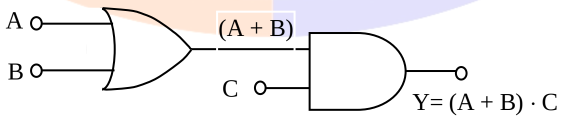


Truth Table

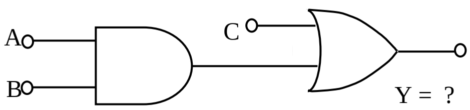
A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

Applications of logic gates

1. Boolean algebra can be translated into logic hardware using logic gates.
   Eg, Given Boolean expression Y + (A + B)· C, the logic circuit is



2. Similarly, the output of a logic hardware circuit can be obtained using boolean algebra.
   Logic circuit
   Eg,

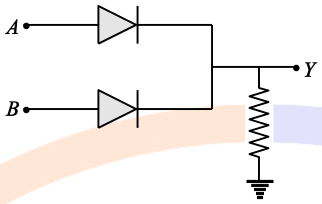


Its boolean expression is Y = A . B + C

3. If an expression contains both AND and OR operations, always AND operation is performed first, unless there are parentheses in the given expression. (Refer the examples given above).

Illustrations

23. The given circuit works as

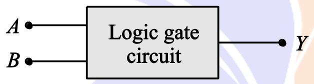


(A) an OR gate
(B) a NOR gate
(C) a AND gate
(D) a NAND gate

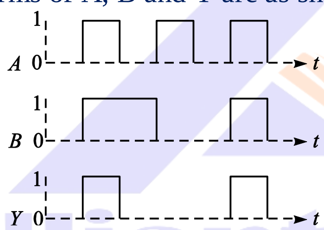
Ans (A)

The circuit represents OR gate, as the output Y is 1, when either A or B or both A and B have input at level 1. But output Y is zero, when both A and B are at zero level. [For OR gate, the Boolean expression is $Y = (A + B)$].

24. The following figure shows a logic gate circuit with two inputs A and B and the output Y.



The voltage waveforms of A, B and Y are as shown.



(A) AND gate (B) NAND gate (C) NOR gate (D) OR gate

Ans (A)

The Boolean expression which satisfies the output of this logic gate is $Y = A \cdot B$, which is for AND gate.

25. An automobile's safety system requires that an audible signal is produced so that driver can start driving when the ignition switch is on and the door is properly shut. The logic gate which can be used to activate the audio signal is

(A) OR (B) NOT (C) AND (D) NAND

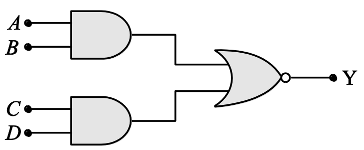
Ans (C)

Let A = ignition switch on; B = door is properly shut

Y = production of audible signal

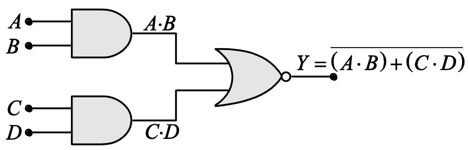
When A = B = 1, Y = 1 ⇒ Y = A·B

26. The output in the given circuit is



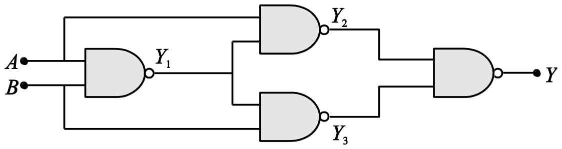
(A) $Y = \overline{AB + CD}$
(B) $Y = \overline{AB} + CD$
(C) $Y = \overline{\overline{AB} + \overline{CD}}$
(D) $Y = \overline{AB} + \overline{CD}$

Ans (A)



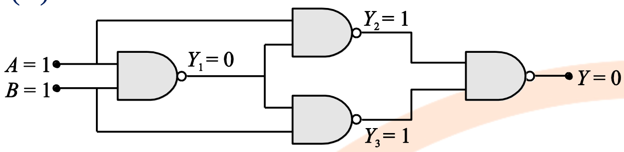
Hence identify the exact logic operation carried out by this circuit.

27. In the logic circuit, if A = 1 and B = 1, the outputs Y_3 and Y are respectively.



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

Ans (C)



NCERT LINE BY LINE QUESTIONS

1. Which of the following is correct range of resistivity for the semiconductor material? [NCERT Pg. 468]

(1) $(10^{-2}$ to $10^{-8})\Omega$ m (2) $(10^{-5}$ to $10^{6})\Omega$ m (3) $(10^{11}$ to $10^{19})\Omega$ m (4) $(10^{5}$ to $10^{16})\Omega$ m

2. A material has band gap energy (E_g) greater than 2 eV. The material [NCERT Pg. 471]

(1) Must be conductor (2) Must be semiconductor

(3) Must be insulator (4) May be semiconductor

3. A sample of semiconductor material having hole as minority carrier is of [NCERT Pg. 476]

(1) p-type (2) n-type (3) Intrinsic (4) Data is insufficient

4. An intrinsic semiconductor sample is doped with both pentavalent and trivglent dopants. If N_a is number of acceptor atoms per unit volume, N_d is number of donor atoms per unit volume and n and h are electron and hole concentrations, then [NCERT Pg. 510]

(1) $N_a + N_d = n + h$ (2) $N_a + n = N_d + h$

(3) $N_d + n = N_a + h$ (4) $N_a^2 + N_d^2 = n^2 + h^2$

5. A pure Si crystal has 5×10^{28} atoms/m³. It is doped by 1 ppm concentration of As atom. The number of holes per unit volume is (consider n_i = 1.5 x 10^{16} m^{-3}) [NCERT Pg. 477]

1) $4.5\times10^9\ m^{-3}$ 2) $4\times10^9\ m^{-3}$ 3) $2\times10^9\ m^{-3}$ 4) $2.25\times10^{10}\ m^{-3}$

6. Consider the following statements [NCERT Pg. 485]

(a) Zener diode is fabricated by lightly doped p-n junction

(b) After breakdown of Zener diode the current in the circuit is limited by external resistance

Choose the correct statement(s)

(1) (a) only (2) (b)only (3) Both (a) and (b) (4) Neither (a) nor(b)

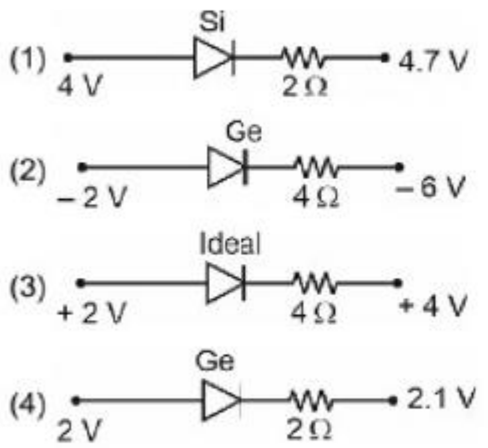
7. The semiconductor used for fabrication of visible LEDs must at least have a band gap [NCERT Pg. 488]

(1) 1.1 eV (2) 1.21 eV (3) 1.8 eV (4) 2.4 eV

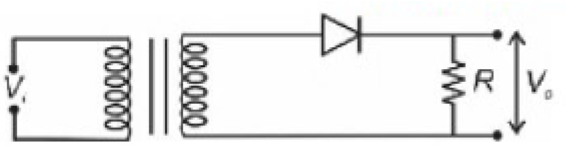
8. The V-I characteristics of photodiode lies in [NCERT Pg. 487]

(1) I quadrant (2) II quadrant (3) III quadrant (4) IV quadrant

9. Which of the following diode is in forward bias condition? (When current is flowing) [NCERT Pg.480]



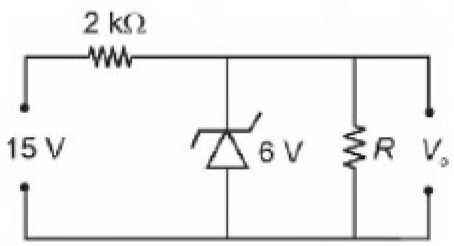
10. The output across the load ***R*** is [NCERT Pg. 483]



(1) Half wave rectified (2) Full wave (centre tap) rectified

(3) Quarter wave rectified (4) AC

11. The value of output voltage Vb in the circuit as shown in the figure is



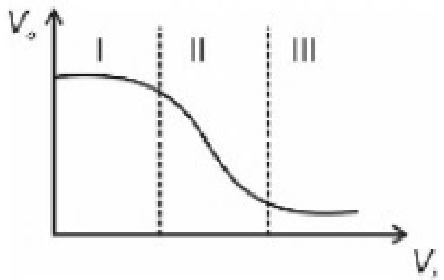
[NCERT Pg.486]

1) 9V 2) 4.5 V 3) 12V 4) 6V

12. An n-p-n transistor is configured in CE configuration. The input resistance is $2\,k\Omega$ and load is $10\,k\Omega$. If $\alpha = 0.99$, then voltage gain will be [NCERT Pg.497]

1) 495 2) 990 3) 1000 4) 500

13. The transfer characteristics of a CE amplifier is shown in the figure. The transistor works as an amplifier in region [NCERT Pg.496]



1) I 2) II 3) III 4) In both (I) an d(III)

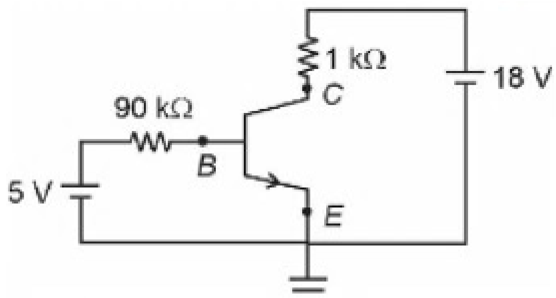
14. The input signal given to a CE amplifier having voltage gain 100 is $V_i = (20mV)\cos\left(10t + \frac{\pi}{6}\right)$.

The correspond-ing output signal will be [NCERT Pg.449]

1) $(2V)\cos\left(10t + \frac{\pi}{6}\right)$ 2) $(2V)\cos\left(10t - \frac{\pi}{6}\right)$

3) $(2V)\cos\left(10t + \frac{7\pi}{6}\right)$ 4) $(2000V)\cos\left(10t + \frac{2\pi}{3}\right)$

15. A common emitter amplifier is shown in the figure. If $\beta = 200$ and V_{BE} = 0.5 V, then value of I_C and V_{CE} respectively will be [NCERT Pg. 499]



(1) (10 mA, 10 V) (2) (10mA,8V)
(3) (5mA.8V) (4) (10 mA, 18 V)

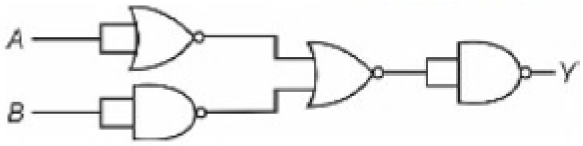
16. Which of the following relations is/are correct? (Symbols have their usual meaning) [NCERT Pg. 499]

1) $A_v = \beta\frac{R_{out}}{R_{in}}$ 2) $A_p = \beta^2\frac{R_{out}}{R_{in}}$ 3) $\beta = \frac{\alpha}{1-\alpha}$ 4) All of these

17. A transistor with CE configuration can be realized as [NCERT Pg. 502]
(1) NOT gate (2) AND gate (3) OR gate (4) NOR gate

18. A p-n photodiode is fabricated from a semiconductor with band gap of 2.0 eV. The maximum wavelength of a incident radiation that can be detected is [NCERT Pg. 487]
(1) 7200 A (2) 6200 A (3) 6200 nm (4) 7200 nm

19. The name of logic gate represented by the following symbol is [NCERT Pg. 511]



1) NOR 2) OR 3) AND 4) NAND

20. If A and B are inputs to a NAND gate and Y is output, then choose the correct option. [NCERT Pg. 504]

NCERT BASED PRACTICE QUESTIONS

1. When a semiconductor is doped its electrical conductivity:
(1) Increases
(2) Decreases in the direct ratio of the doped material
(3) Decreases in the inverse ratio of the doped material
(4) Remains unaltered

2. Which of the following semiconductor is electrically positive?
(1) Intrinsic semiconductor (2) P-type semiconductor
(3) N-type semiconductor (4) None of these

3. The depletion layer of a p-n junction :
(1) is of constant width irrespective of the bias
(2) acts like an insulating zone under reverse bias
(3) has a width that increases with an increases in forward
(4) is depleted of ions

4. Let np and ne be the numbers of holes and conduction electrons in an extrinsic semiconductor :-
(1) $n_p > n_e$ (2) $n_p = n_e$
(3) $n_p < n_e$ (4) np $\neq$ ne

5. Which of the following statements is **INCORRECT**:-
(1) The resistance of intrinsic semiconductor decrease with increase of temperature
(2) Doping pure Si with trivalent impurities gives P-type semiconductors
(3) The majority carriers in N-type semiconductors are holes

(4) A PN-junction can act as a semiconductor diode

6. The conductivity of a semiconductor increases with increase in temperature because

(1) number density of free current carriers increases.

(2) relaxation time increases.

(3) both number density of carriers and relaxation time increase.

(4) number density of current carriers increases, relaxation time decreases but effect of decrease in relaxation time is much less than increase in number density.

7. **Statement-1 :** The number of electrons in ntype semiconductor is higher than the number of electrons in a pure silicon semiconductor.

Statement-2 : The law of mass action is applicable to n-type semiconductors.

(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statament-2 is True; Statement-2 is NOT a correct explanation for Statement-I.

(3) Statement-1 is True, Statement-2 is False.

(4) Statement-1 False, Statement-2 is True.

8. In a p-n junction,

(1) new holes and conduction electrons are produced continuously throughout the material

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

(3) holes and conduction electrons recombine continuously throughout the material.

(4) holes and conduction electrons recombine continuously throughout the depletion region.

9. A Si and a Ge diode has identical physical dimensions. The band gap in Si is larger than that in Ge. An identical reverse bias is applied across the diodes

(1) The reverse current in Ge is larger than that in Si

(2) The reverse current in Si is larger than that in Ge

(3) The reverse current is identical in the two diodes

(4) The relative magnitude of the reverse currents cannot be determined from the given data only

10. Diffusion current in a p-n junction is greater than the drift current in magnitude :-

(1) If the junction is forward-biased

(2) If the junction is reverse-biased

(3) If the junction is unbiased

(4) In no case.

11. **Statement-1 :** Transistor can act as a switch.

Statement-2 : When the transistor is not conducting it is said to be switched off and when it is driven into saturation it is said to be switched on.

(1) Statement-I is true, Statement-II is true, Statement-II is the **correct** explanation of Statement-I

(2) Statement-I is true, Statement-II is true, Statement-II is **not** the correct explanation of Statement-I.

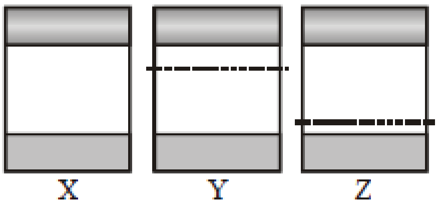
(3) Statement-I is **true,** Statement-II is false.

(4) Statement-I is **false,** Statement-II is true.

12. In P-type semiconductor, drift velocity of electrons compared to holes is :

(1) More (2) Less (3) Equal (4) None of these

13. The energy band diagrams for three semiconductor samples of silicon are as shown. We can then assert that :-



(1) Sample X is undoped while samples Y and Z have been doped with a trivalent and a pentavalent impurity respectively

(2) Sample X is undoped while both samples Y and Z have been doped with a pentavalent impurity

(3) Sample X has been doped with equal amounts of trivalent and pentavalent impurities while samples Y and Z are undoped

(4) Sample X is undoped while samples Y and Z have been doped with a pentavalent and a trivalent impurity respectively

14. In a transistor symbol, the arrow is drawn on ____(a)____ and it represents direction of ______(b)______, then (a) and (b) are respectively.

(1) Emitter ; hole movement

(2) Emitter ; electron movement

(3) Collector ; hole movement

(4) Base ; hole movement

15. One end of a device is connected to positive terminal and the other end to the negative terminal and the current is flowing. If the terminals of supply are interchanged, then there is approximately zero current. The device can be :-

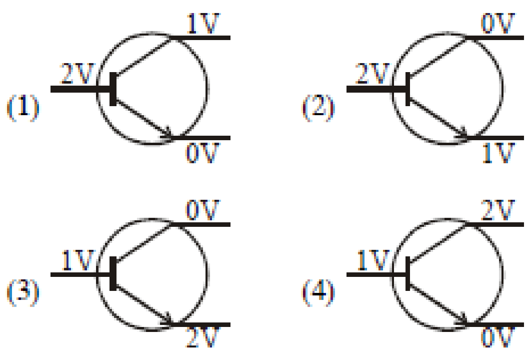
(1) p-n junction (2) transistor

(3) capacitor (4) inductor

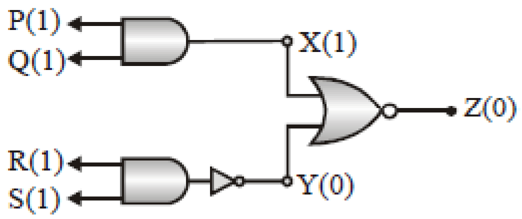
16. In a half wave rectifier if input frequency is 50 Hz then output ripple frequency will be :–

(1) 25 Hz (2) 50 Hz (3) 100 Hz (4) 200 Hz

17. In which of the following cases, the transistor is operating in the active region ?



18. The circuit diagram shows a logic combination with the states of output X, Y and Z given for inputs P, Q, R and S all at state 1. When inputs P and R change to state 0 with inputs Q and S still at 1, the states of outputs X, Y and Z change



(1) 1, 0, 0 (2) 1, 1, 1 (3) 0, 1, 0 (4) 0, 0, 1

19. Energy band gap of silicon is 1.14 eV. Maximum wavelength at which silicon will start showing conductivity is?

(1) 10888 nm (2) 1088.8 nm (3) 108.88 nm (4) 10.888 nm

20. Mobility of electrons is more than holes, because electrons

(1) are lighter

(2) are negatively charged

(3) undergo small number of collisions

(4) require less energy to move through lattice

21. **Assertion :** A pure semiconductor has negative temperature coefficient of resistance.

Reason : In a semiconductor on raising the temperature, more charge carriers are released, conductance increases and resistance decreases.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

TOPIC WISE PRACTICE QUESTIONS

Topic 1: Semiconductor and P-N Junction Diode

1. What is the resistivity of a pure semiconductor at absolute zero?

(1) Zero (2) Infinity

(3) Same as that of conductors at room temperature

(4) Same as that of insulators at room temperature

2. In a semiconductor diode, the barrier potential offers opposition to

(1) holes in P-region only

(2) free electrons in N-region only

(3) majority carriers in both regions

(4) majority as well as minority carriers in both regions

3. When an impurity is doped into an intrinsic semiconductor, the conductivity of the semiconductor

(1) increases

(2) decreases

(3) remains the same

(4) becomes zero

4. A solid which is not transparent to visible light and whose electrical conductivity decreases with increase in temperature is formed by

(1) ionic bonding

(2) metallic bonding

(3) covalent bonding

(4) vander Wall bonding

5. The electrical conductivity of pure germanium can be increased by

(1) increasing the temperature

(2) doping acceptor impurities

(3) doping donor impurities

(4) all of the above

6. The mobility of free electrons is greater than that of free holes because

(1) they are light

(2) they carry negative charge

(3) they mutually collide less

(4) they require low energy to continue their motion

7. If the two ends of a p-n junction are joined by a wire

(1) there will not be a steady current in the circuit

(2) there will be a steady current from the n-side to the p-side

(3) there will be a steady current from the p-side to the n-side

(4) there may or may not be a current depending upon the resistance of the connecting wire

8. The diffusion current in a p-n junction is

(1) from the n-side to the p-side

(2) from the p-side to the n-side

(3) from the n-side to the p-side if the junction is forward biased and in the opposite direction if it is reverse-biased

(4) from the p-side to the n-side if the junction is forward biased and in the opposite direction if it is reverse-biased

9. Let n_p and n_e be the number of holes and conduction electrons in an extrinsic semiconductor. Then

(1) $n_p > n_e$ (2) $n_p = n_e$ (3) $n_p < n_e$ (4) $n_p \neq n_e$

10. In the half wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be

(1) 25 Hz (2) 50 Hz (3) 70.7 Hz (4) 100 Hz

11. In a half wave rectifier, the r.m.s. value of the a.c. component of the wave is

(1) equal to d.c. value

(2) more than d.c. value

(3) less than d.c. value

(4) zero

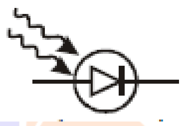
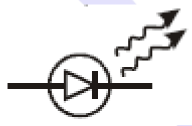
12. The average value of output direct current in a full wave rectifier is

(1) I_0/π (2) $I_0/2$ (3) $\pi I_0/2$ (4) $2\ I_0/p$

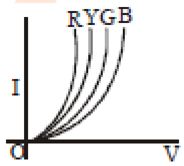
13. Carbon, Silicon and Germanium atoms have four valence electrons each. Their valence and conduction bands are separated by energy band gaps represented by $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$ respectively. Which one of the following relationship is true in their case?

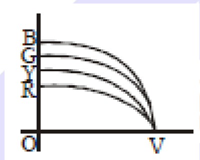
(1) $(E_g)_C > (E_g)_{Si}$ (2) $(E_g)_C < (E_g)_{Si}$ (3) $(E_g)_C = (E_g)_{Si}$ (4) $(E_g)_C < (E_g)_{Ge}$

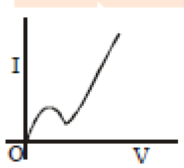
14. A light emitting diode is shown as

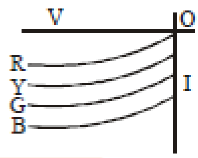
(1)  (2)  (3)  (4) 

15. The I-V characteristic of an LED is

(1) 

(2) 

(3) 

(4) 

16. In a p-type semiconductor the acceptor level is situated 60 meV above the valence band. The maximum wavelength of light required to produce a hole will be

(1) 0.207×10^{-5} m (2) 2.07×10^{-5} m (3) 20.7×10^{-5} m (4) 2075×10^{-5} m

17. For bidden gap for insulators is

(1) ≥ 6eV (2) ≤ 1 eV (3) ≤ 3 eV (4) $\cong 0$ eV

18. Copper, a monovalent, has molar mass 63.54 g/mol and density 8.96 g/cm^3. What is the number density n of conduction electron in copper?

(1) 1.1×10^{26} m^{-1} (2) 2.8×10^{25} m^{-1} (3) 8.49×10^{28} m^{-1} (4) None of these

19. An LED is constructed from a p-n junction based on a certain Ga-As -P semiconducting material whose energy gap is 1.9 eV. What is the wavelength of the emitted light?

(1) 150 nm (2) 350 nm (3) 500 nm (4) 650 nm

20. In a photodiode, the conductivity increases when the material is exposed to light. It is found that the conductivity changes only if the wavelength is less than 620 nm. What is the band gap?

(1) 1.0 eV (2) 3.2 eV (3) 6 eV (4) 2.0 eV

21. The energy gap of silicon is 1.14 eV. The maximum wavelength at which silicon starts energy absorption, will be ($h = 6.62 \times 10^{-34}$ Js ; $c = 3 \times 10^8$ m/s)

(1) 10.888 Å (2) 108.88 Å (3) 1088.8 Å (4) 10888 Å

22. On doping germanium with donor atoms of density 10^{17} cm^{-3} its conductivity in mho/cm will be [Given : $\mu_e = 3800$ cm^2/V–s and $n_i = 2.5 \times 10^{13}$ cm^{-13}]

(1) 30.4 (2) 60.8 (3) 91.2 (4) 121.6

23. The ratio of electron and hole currents in a semiconductor is 7/4 and the ratio of drift velocities of electrons and holes is 5/4, then the ratio of concentrations of electrons and holes will be

(1) 5/7 (2) 7/5 (3) 25/49 (4) 49/25

24. What is the conductivity of a semiconductor if electron density = $5 \times 10^{12}/cm^3$ and hole density = $8 \times 10^{13}/cm^3$ ($\mu_e = 2.3\ m^2\ V^{-1}\ s^{-1}$, $\mu_h = 0.01\ m2V^{-1}\ s^{-1}$)

(1) 5.634 (2) 1.968 (3) 3.421 (4) 8.964.

25. If the ratio of the concentration of electrons to that of holes in a semiconductor is $\frac{7}{5}$ and the ratio of currents is $\frac{7}{4}$, then what is the ratio of their drift velocities?

(1) $\frac{5}{8}$ (2) $\frac{4}{5}$ (3) $\frac{5}{4}$ (4) $\frac{4}{7}$

26. In germanium the energy gap is about 0.75 eV. The wavelength of light which germanium starts absorbing is

(1) 5000 Å (2) 1650 Å (3) 16500 Å (4) 165000 Å

27. A potential barrier of 0.3 V exists across a p-n junction. An electron with speed 5 × 105 m/s approaches this p-n junction from n-side, what will be its speed on entering the p-side?

(1) 3×10^5 m/s (2) 3.8×10^5 m/s (3) 5×10^5 m/s (4) 2.6×10^3 m/s

28. For a junction diode the ratio of forward current (I_f) and reverse current (I_r) is

[e = electronic charge,

V = voltage applied across junction,

k = Boltzmann constant,

T = temperature in kelvin]

(1) $e^{-V/kT}$ (2) $e^{V/kT}$ (3) $(e^{-eV/kT} + 1)$ (4) $(e^{eV/kT} - 1)$

Topic 2: Junction Transistor

29. Transistor working as an amplifier operates in its active region only when

(1) the emitter junction is forward biased and the collector junction is reverse biased

(2) the emitter junction is reverse biased

(3) the collector junction is forward biased

(4) the emitter junction is reverse biased and the collector junction is forward biased

30. Current gain of a transistor in common base mode is 0.95. Its value in common emitter mode is

(1) 0.95 (2) 1.5 (3) 19 (4) $(19)^{-1}$

31. A transistor has $\beta = 40$. A change in base current of 100 mA, produces change in collector current

(1) 40 × 100 microampere

(2) (100 – 40) microampere

(3) (100 + 40) microampere

(4) 100/40 microampere

32. In a common base amplifier the phase difference between the input signal voltage and the output voltage is

(1) 0 (2) $\pi/4$ (3) $\pi/2$ (4) π

33. The current gain b may be defined as

(1) the ratio of change in collector current to the change in emitter current for a constant collector voltage in a common base arrangement.

(2) the ratio of change in collector current to the change in the base current at constant collector voltage in a common emitter circuit

(3) the ratio of change in emitter current to the change in base current for constant emitter voltage in common emitter circuit.

(4) the ratio of change in base current to the change in collector current at constant collector voltage in common emitter circuit.

34. When n-P-n transistor is used as an amplifier, then

(1) electrons move from collector to emitter

(2) electrons move from emitter to collector

(3) electrons move from collector to base

(4) holes move from emitter to collector

35. In a transistor

(1) both emitter and collector have same length

(2) length of emitter is greater than that of collector

(3) length of collector is greater than that of emitter

(4) any one of emitter and collector can have greater length

36. If the given transistor is used as an amplifier then for input resistance of 80Ω and load resistance of 16kΩ, the output voltage corresponding to the input voltage of 12mV will be

(1) 37.5 mV (2) 37500 V (3) 300 V (4) 300 mV

37. When the base current in a transistor is changed from 30 μA to 80 μA, the collector current is changed from 1.0 mA to 3.5 mA. Find the current gain β.

(1) 30 (2) 40 (3) 45 (4) 50

38. A transistor is connected in common -emitter configuration. The collector supply is 8V and the voltage drop across a resistor of 800 W in the collector is 0.5 V. If the current gain factor α is 0.96. Find the base current.

(1) 5 μA (2) 6 μA (3) 20 μA (4) 26 μA

39. A pnp transistor is used in common-emitter mode in an amplifier circuit. A change of 40 μA in the base current brings a change of 2 mA in collector current and 0.04 V in base emitter voltage. If a load of 6kΩ is used, then also find the voltage gain of the amplifier.

(1) 1 (2) 50 (3) 300 (4) 900

40. In a npn transistor 10^{10} electrons enter the emitter in 10^{-6} s. 4% of the electrons are lost in the base. The current transfer ratio will be

(1) 0.98 (2) 0.97 (3) 0.96 (4) 0.94

41. The current gain of a transistor in common base mode is 0.995. The current gain of the same transistor in common emitter mode is

(1) 197 (2) 201 (3) 198 (4) 199

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

(1) It is an npn transistor with *R* as base

(2) It is a pnp transistor with *R* as collector

(3) It is a pnp transistor with *R* as emitter

(4) It is a pnp transistor with *R* as base

43. A transistor has three impurity regions. All the three regions have different doping levels. In order of increasing doping level, the regions are

(1) emitter, base and collector (2) collector, base and emitter

(3) base, emitter and collector (4) base, collector and emitter

44. A transistor has a base current of 1 mA and emitter current 90 mA. The collector current will be

(1) 90 mA (2) 1 mA (3) 89 mA (4) 91 mA

45. In a common emitter transistor amplifier $\beta = 60$, $R_o = 5000\,\Omega$ and internal resistance of a transistor is 500 Ω. The voltage amplification of amplifier will be

(1) 500 (2) 460 (3) 600 (4) 560

46. Operating point of a transistor is

(1) zero signal value of V_{CC} and I_b (2) zero signal value of I_c

(3) zero signal value of V_{cc} (4) zero signal value of I_c and V_{CE}

47. The main difference between voltage and power amplifiers is that

(1) power amplifier handles current (2) power amplifier handles large voltage

(3) power amplifier handles large power (4) None of these

Topic 3: Digital Electronics and Logic Gates

48. The device that can act as a complete electronic circuit is

(1) junction diode (2) integrated circuit (3) junction transistor (4) zener diode

49. What is the value of A.C + A.B.C where A, B and C are inputs?

(1) A.C (2) A.B (3) A (4) B

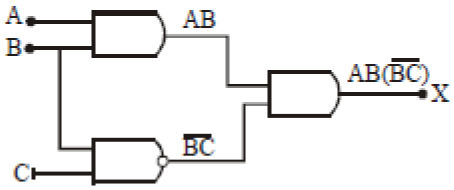
50. The output of an OR gate is connected to both the inputs of a NAND gate. The combination will serve as a:

(1) NOT gate (2) NOR gate (3) AND gate (4) OR gate

51. When the two inputs of a NAND gate are shorted, the resulting gate is

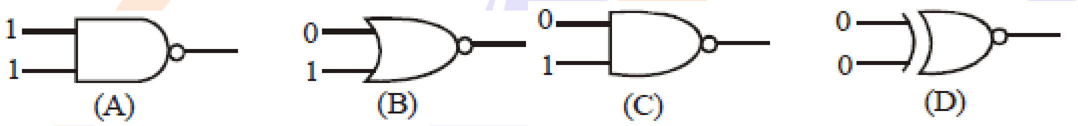
(1) NOR (2) OR (3) NOT (4) AND

52. The correct option for getting X = 1 from the given circuit is:



(1) A = B = C = 1 (2) A = B = 1 & C = 0 (3) A = C = 1 & B = 0 (4) A = 0 & B = C = 1

53. Which of the following gates will have an output of 1?



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

54. NAND and NOR gates are called universal gates primarily because they

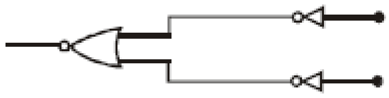
(1) are available universally

(2) can be combined to produce OR, AND and NOT gates

(3) are widely used in Integrated circuit packages

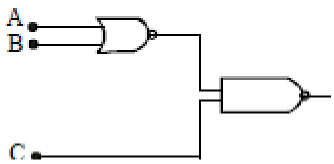
(4) are easiest to manufacture

55. Figure consists of two NOT gates followed by a NOR gate. This combination is equivalent to a single



(1) NAND gate (2) AND gate (3) OR gate (4) XOR gate

56. To get an output 1 from the circuit shown in the figure, the input must not be



(1) A = 0, B = 0, C = 1 (2) A = 1, B = 0, C = 0

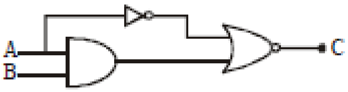
(3) A = 1, B = 0, C = 1 (4) A = 1, B = 1, C = 0

57. Digital circuit can be made by repetitive use of

(1) AND gate (2) OR gate (3) NOT gate (4) NAND gate

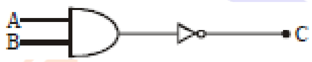
58. Which of the following circuits correctly represents the following truth table?

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

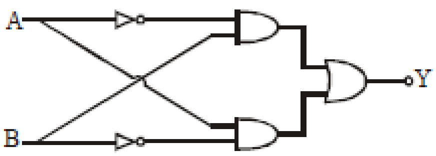
(1) 

(2) 

(3) 

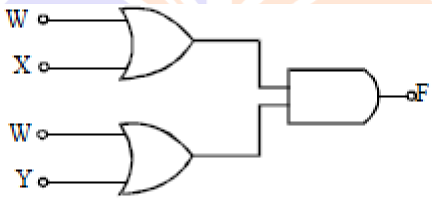
(4) 

59. The following circuit gives out put Y as:



(1) $\overline{A}+\overline{B}$ (2) $A.\overline{B}+B.\overline{A}$ (3) $\overline{A}.\overline{B}$ (4) $\overline{A+B}$

60. The diagram of a logic circuit is given below. The output F of the circuit is represented by



(1) W . (X + Y) (2) W . (X . Y) (3) W + (X . Y) (4) W + (X + Y)

NEET PREVIOUS YEARS QUESTIONS

1. In a p-n junction diode, change in temperature due to heating **[2018]**

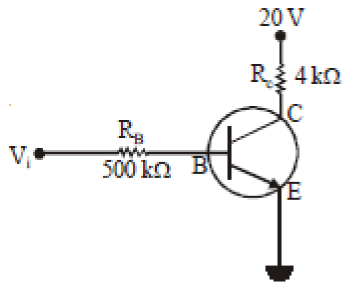
(1) Affects only reverse resistance

(2) Affects only forward resistance

(3) Affects the overall V-I characteristics of p-n junction

(4) Does not affect resistance of p-n junction

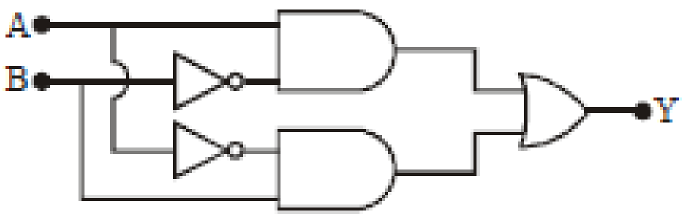
2. In the circuit shown in the figure, the input voltage V_i is 20 V, V_{BE} = 0 and V_{CE} = 0. The values of I_B, I_C and β are given by **[2018]**



(1) $I_B = 40\,\mu A$, $I_C = 10$ mA, $\beta = 250$ (2) $I_B = 25\,\mu A$, $I_C = 5$ mA, $\beta = 200$

(3) $I_B = 40\,\mu A$, $I_C = 5$ mA, $\beta = 125$ (4) $I_B = 20\,\mu A$, $I_C = 5$ mA, $\beta = 250$

3. In the combination of the following gates the output Y can be written in terms of inputs A and B as **[2018]**



(1) $\overline{A.B}$ (2) $A.\overline{B}+\overline{A}.B$ (3) $\overline{A+B}$ (4) $\overline{A.B}+A.B$

4. Which one of the following represents forward bias diode? **[2017]**

(1) 

(2) 

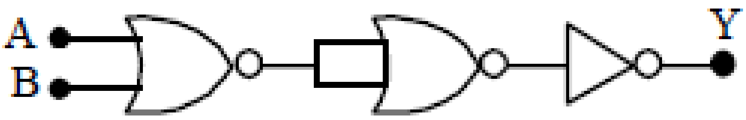
(3) 

(4) 

5. In a common emitter transistor amplifier the audio signal voltage across the collector is 3V. The resistance of collector is 3 kΩ. If current gain is 100 and the base resistance is 2 kΩ, the voltage and power gain of the amplifier is **[2017]**

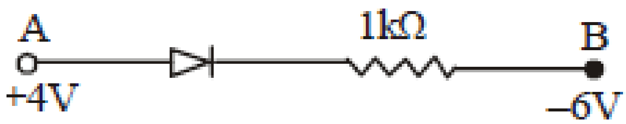
(1) 15 and 200 (2) 150 and 15000 (3) 20 and 2000 (4) 200 and 1000

6. The given electrical network is equivalent to : **[2017]**



(1) OR gate (2) NOR gate (3) NOT gate (4) AND gate

7. Consider the junction diode as ideal. The value of current flowing through AB is : **[2016]**

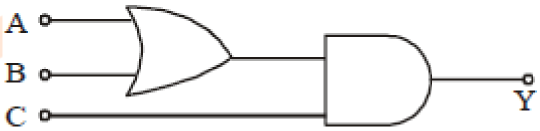


(1) 0 A (2) 10^{-2} A (3) 10^{-1} A (4) 10^{-3} A

8. A npn transistor is connected in common emitter configuration in a given amplifier. A load resistance of $800\,\Omega$ is connected in the collector circuit and the voltage drop across it is 0.8 V. If the current amplification factor is 0.96 and the input resistance of the circuit is $192\,\Omega$, the voltage gain and the power gain of the amplifier will respectively be : **[2016]**

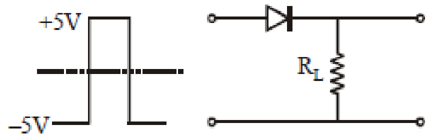
(1) 4, 3.84 (2) 3.69, 3.84 (3) 4, 4 (4) 4, 3.69

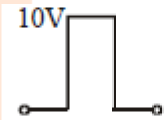
9. To get output 1 for the following circuit, the correct choice for the input is **[2016]**

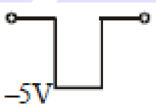


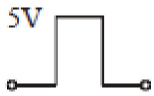
(1) A = 0, B = 1, C = 0 (2) A = 1, B = 0, C = 0 (3) A = 1, B = 1, C = 0 (4) A = 1, B = 0, C = 1

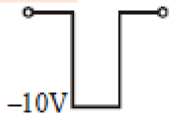
10. If in a p-n junction, a square input signal of 10 V is applied as shown, then the output across R_L will be **[2015]**



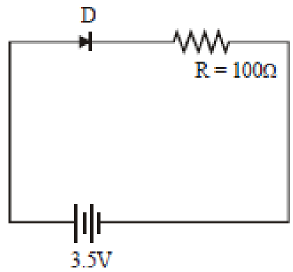
(1) 

(2) 

(3) 

(4) 

11. In the given figure, a diode D is connected to an external resistance $R = 100\,\Omega$ and an e.m.f. of 3.5 V. If the barrier potential developed across the diode is 0.5 V, the current in the circuit will be: **[2015]**

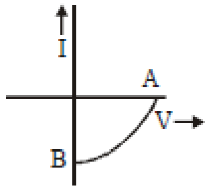


(1) 40 mA (2) 20 mA (3) 35 mA (4) 30 mA

12. The input signal given to a CE amplifier having a voltage gain of 150 is $V_i = \left(15t + \frac{\pi}{3}\right)$. The corresponding output signal will be : **[2015]**

(1) $75\cos\left(15t + \frac{2\pi}{3}\right)$ (2) $2\cos\left(15t + \frac{5\pi}{6}\right)$ (3) $300\cos\left(15t + \frac{4\pi}{3}\right)$ (4) $300\cos\left(15t + \frac{\pi}{3}\right)$

13. The given graph represents V - I characteristic for a semiconductor device.



Which of the following statement is correct ? **[2014]**

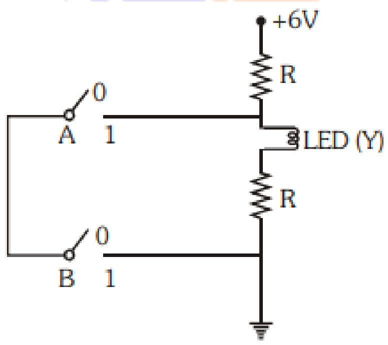
(1) It is V - I characteristic for solar cell where, point A represents open circuit voltage and point B short circuit current.

(2) It is a for a solar cell and point A and B represent open circuit voltage and current, respectively.

(3) It is for a photodiode and points A and B represent open circuit voltage and current, respectively.

(4) It is for a LED and points A and B represent open circuit voltage and short circuit current, respectively.

14.



The correct Boolean operation represented by the circuit diagram drawn is : **[NEET – 2019]**

(1) AND (2) OR (3) NAND (4) NOR

15. For a p-type semiconductor which of the following statements is true? **[NEET – 2019]**

(1) Electrons are the majority carriers and trivalent atoms are the dopants.

(2) Holes are the majority carriers and trivalent atoms are the dopants.

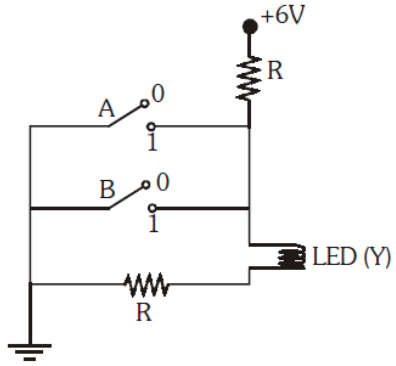
(3) Holes are the majority carriers and pentavalent atoms are the dopants.

(4) Electrons are the majority carriers and pentavalent atoms are the dopants.

16. An LED is constructed from a p-n junction diode using GaAsP. The energy gap is 1.9 eV. The wavelength of the light emitted will be equal to :- **[NEET – 2019 (ODISSA)]**

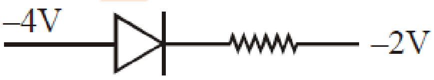
(1) 10.4×10^{-26} m (2) 654 nm (3) 654 Å (4) 654×10^{-11} m

17. The circuit diagram shown here corresponds to the logic gate, **[NEET – 2019 (ODISSA)]**

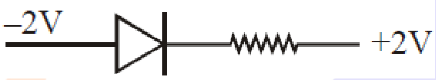


(1) NOR (2) AND (3) OR (4) NAND

18. Out of the following which one is a forward biased diode? **[NEET – 2020 (Covid-19)]**

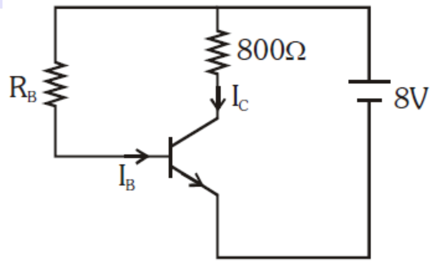
(1) 

(2) 

(3) 

(4) 

19. A n-p-n transistor is connected in common emitter configuration (see figure) in which collector voltage drop across load resistance ($800\,\Omega$) connected to the collector circuit is 0.8 V. The collector current is : **[NEET – 2020 (Covid-19)]**



(1) 2 mA (2) 0.1 mA (3) 1 mA (4) 0.2 mA

20. Which of the following gate is called universal gate? **[NEET – 2020 (Covid-19)]**

(1) OR gate (2) AND gate (3) NAND gate (4) NOT gate

21. An intrinsic semiconductor is converted into n-type extrinsic semiconductor by doping it with :- **[NEET – 2020 (Covid-19)]**

(1) Phosphorous (2) Aluminium (3) Silver (4) Germanium

22. The increase in the width of the depletion region in a p-n junction diode is due to: **[NEET – 2020]**

1) increase in forward current
2) forward bias only
3) reverse bias only
4) both forward bias and reverse bias

23. For transistor action which of the following statements is **correct**? **[NEET – 2020]**

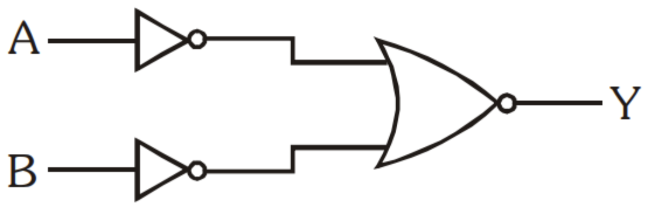
1) The base region must be very thin and lightly doped.

2) Base, emitter and collector regions should have same doping concentration

3) Base, emitter and collector regions should have same size

4) Both emitter junction as well as the collector junction are forward biased

24. For the logic circuit shown the truth table is **[NEET – 2020]**



1)

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

2)

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

3)

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

3)

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

25. The electron concentration in an n-type semiconductor is the same as hole concentration in a p-type semiconductor. An external field (electric) is applied across each of them. Compare the currents in them **[NEET-2021]**

1) current in p-type > current in n-type 2) current in n-type > current in p-type

3) No current will flow in p-type, current will only flow in n-type

4) current in n-type = current in p-type

26. Consider the following Statements (1) and (2) and identify the correct answer. **[NEET-2021]**

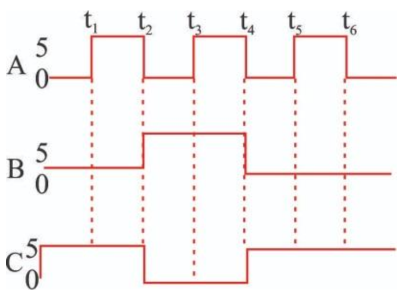
(1) A zener diode is connected in reverse bias, when used as a voltage regulator.

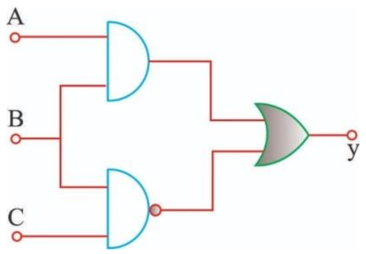
(2) The potential barrier of p-n junction lies between 0.1 V to 0.3 V

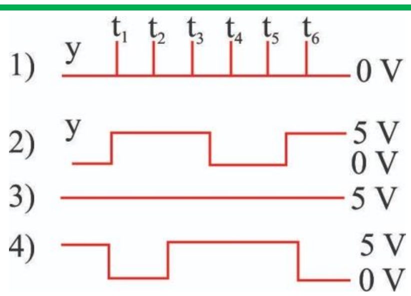
1) (1) and (2) both are incorrect 2) (1) is correct and (2) is incorrect

3) (1) is incorrect but (2) is correct 4) (1) and (2) both are correct

27. For the given circuit, the input digital signals are applied at the terminals A, B and C . What would be the output at the terminal y? **[NEET-2021]**

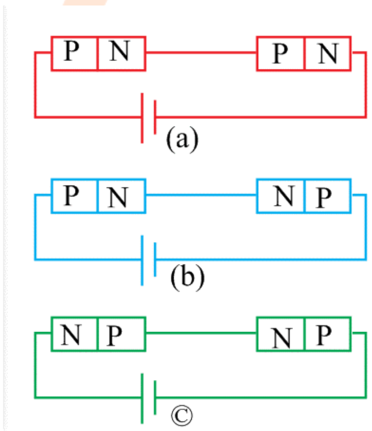






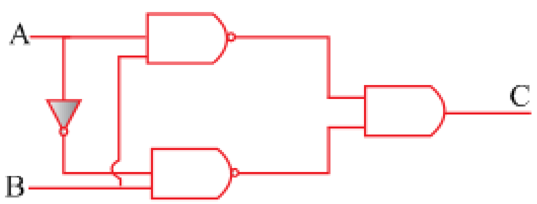
28. As the temperature increases, the electrical resistance **[NEET-2022]**
(1) increases for both conductors and semiconductors
(2) decreases for both conductors and semiconductors
(3) increases for conductors but decreases for semiconductors
(4) decreases for conductors but increases for semiconductors

29. In half wave rectification, if the input frequency is 60 Hz, then the output frequency would be **[NEET-2022]**
1) Zero 2) 30 Hz 3) 60 Hz 4) 120 Hz

30.


[NEET-2022]

In the given circuits (a), (b) and (c), the potential drop across the two p-n junctions are equal in:
(1) Circuit (a) only (2) Circuit (b) only
(3) Circuit (c) only (4) Both circuits (a) and (c)

31.


[NEET-2022]

The truth table for the given logic circuit is:

1)

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

2)

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

3)

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

4)

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

NCERT LINE BY LINE QUESTIONS – ANSWERS

1) b 2) d 3) b 4) b 5) a 6) b 7) c 8) c 9) b 10) a
11) d 12) a 13) b 14) c 15) b 16) d 17) a 18) b 19) d 20) c

NCERT BASED PRACTICE QUESTIONS - ANSWERS

1) 1 2) 4 3) 2 4) 4 5) 3 6) 4 7) 2 8) 1 9) 1 10) 1
11) 1 12) 1 13) 4 14) 1 15) 1 16) 2 17) 4 18) 3 19) 2 20) 4 21) 1

TOPIC WISE PRACTICE QUESTIONS - ANSWERS

1)	2	2)	3	3)	3	4)	2	5)	4	6)	1	7)	1	8)	2	9)	4	10)	2
11)	2	12)	4	13)	1	14)	4	15)	1	16)	2	17)	1	18)	3	19)	4	20)	4
21)	1	22)	2	23)	2	24)	2	25)	3	26)	3	27)	2	28)	4	29)	1	30)	3
31)	1	32)	1	33)	2	34)	2	35)	3	36)	3	37)	4	38)	4	39)	3	40)	3
41)	4	42)	4	43)	4	44)	3	45)	3	46)	4	47)	2	48)	2	49)	1	50)	2
51)	3	52)	2	53)	4	54)	2	55)	2	56)	1	57)	4	58)	1	59)	2	60)	3

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

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

TOPIC WISE PRACTICE QUESTIONS - SOLUTIONS

1. **(2)** The electrical conductivity of a semiconductor at 0 K is zero. Hence resistivity (= 1/electrical conductivity) is infinity.

2. **(3)** majority carriers in both regions

3. **(3)** By doping, the band gap reduce from 1eV to 0.3 to 0.7 eV & electron can achieve this energy (0.3eV to 0.7eV) at room temperature & reach in C.B (conduction band).

4. **(2)** A solid is not transparent to visible light if the value of wavelength of light is greater than the bond length between the atoms/molecules/ions of material. Conductivity depends upon the no. of free charge carriers present in the substance at a given temperature or resistance of that material at that temperature.

5. (4) As the temperature increases, the thermal motion of electrons also increases which results in increasing of the conductivity of the Ge crystal.
Also as the conductivity of extrinsic semiconductor is more than that of intrinsic semiconductor, thus the conductivity of pure germanium increases by doping Ge crystal either with acceptor impurities or the donor impurities.

6. **(1)** The mobility of free electrons is greater than that of free holes because there are light

7. **(1)** If the two ends of a p-n junction are joined by a wire then there will not be a steady current in the circuit.

8. **(2)** The diffusion current in a p-n junction is from the p-side to n-side.

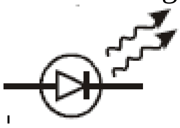
9. **(4)** In extrinsic semi conductor the number of holes are not equal to number of electrons i.e.,
$n_p \neq n_e$
In p - type $n_p > n_e$
In n - type $n_e > n_p$
But over all both p & n - type semi-conductor are uncharged.

10. **(2)** In half wave rectifier, we get the output only in one half cycle of input a.c. therefore, the frequency of the ripple of the output is same as that of input a.c. i.e. 50 Hz

11. **(2)** The r.m.s. value of a.c. component of wave is more than d.c. value due to barrier voltage of p-n junction used as rectifier.

12. **(4)** The average value of output direct current in a full wave rectifier = average value of current over a cycle $= 2\ I_0/\pi$

13. **(1)** Due to strong electronegativity of carbon.

14. **(4)**  light emitting diode

15. (1) For LED, in forward bias, intensity increases with voltage.

16. **(2)** $\lambda = \frac{hc}{E} = \frac{6.62\times10^{-34}\times3\times10^{8}}{\left(60\times10^{-3}\times1.6\times10^{-19}\right)} = 2.07\times10^{-5}\text{m}$

17. (1) In an insulator the forbidden band gap is of the order of $\geq 6eV$

18. **(3)** $8.49\times10^{28}\text{m}^{-1}$

19. **(4)** If λ is the wavelength of emitted light, then

$$E_g = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E_g}$$

$$= \frac{\left(6.63\times10^{-34}\right)\times\left(3\times10^{8}\right)}{(1.9)\times\left(1.60\times10^{-19}\right)} = 6.5\times10^{-7}\text{ m} = 650\text{ nm}$$

20. **(4)** The band gap E_g

$$= \frac{\left(6.63\times10^{-34}\right)\times\left(3\times10^{8}\right)}{620\times10^{-9}} = 3.2\times10^{-19}\text{ J} = 2.0\text{ eV}.$$

21. **(1)** $\lambda = \frac{hc}{E} = \frac{6.62\times10^{-34}\times3\times10^{8}}{\left(1.14\times1.60\times10^{-19}\right)} = 10.888\overset{0}{A}$

22. **(2)** Conductivity $\sigma = n_i e\mu_e = 10^{17}\times\left(1.6\times10^{-19}\right)\times3800 = 60.8$ mho/cm

23. **(2)** $I = nAev_d$ or $I \propto nv_d$

$$\therefore \frac{I_e}{I_h} = \frac{n_e v_e}{n_h v_h} \text{ or } \frac{n_e}{n_h} = \frac{I_e}{I_h}\times\frac{v_h}{v_e} = \frac{7}{4}\times\frac{4}{5} = \frac{7}{5}$$

24. **(2)** Given : $\mu_e = 2.3\ m^2\ V^{-1}\ s^{-1}$
$\mu_h = 0.01\ m^2\ V^{-1}\ s^{-1}$, $n_e = 5\times10^{12}\ /\ cm^3$
$= 5\times10^{18}/m^3$ $n_h = 8\times10^{13}/cm^3 = 8\times10^{19}/m^3$.
Conductivity $s = e[n_e\mu_e + n_h\mu_h]$
$= 1.6\times10^{-19}\ [5\times10^{18}\times2.3 + 8\times10^{19}\times0.01]$
$= 1.6\times10^{-1}\ [11.5 + 0.8]$
$= 1.6\times10^{-1}\times12.3 = 1.968\ W^{-1}\ m^{-1}$.

25. **(3)** $\frac{I_e}{I_h} = \frac{n_e eAv_e}{n_h eAv_h} \Rightarrow \frac{7}{4} = \frac{7}{5}\times\frac{v_e}{v_h} \Rightarrow \frac{v_e}{v_h} = \frac{5}{4}$

26. **(3)** $\lambda = \frac{hc}{E} = \frac{6.63\times10^{-34}\times3\times10^{8}}{0.75\times1.6\times10^{-19}} = 16500\overset{0}{A}$

27. (2) The intensity of electric field E=V$_d$=0.31×10−6=3×105V/m
The electric field retarded the electron. The retardation a=E$_{em}$ The speed of the electron on entering p-side v^2=u^2−2as=u^2−2eEm.d =(5×10^5)2−2×1.6×10^{-19}×3×1059.1×10^{-31}×(1×10^{-6}) =3.8×10^5m/s

28. **(4)** Current in junction diode, $I = I_0\left(e^{eV/kT} - 1\right)$

In forward biasing, V is positive ; In reverse bias V is negative. Then $I_r = I_0$

$$\frac{I_F}{I_r} = \frac{I_0\left(e^{eV/kT} - 1\right)}{I_0} = \left(e^{eV/kT} - 1\right)$$

29. **(1)** For transistor as an amplifier, emitter-base has to be in forward bias and collector base has to be in reverse bias.

30. **(3)** $\beta = \frac{\alpha}{1-\alpha} = \frac{0.95}{1-0.95} = \frac{0.95}{0.05} = 19$

31. **(1)** $\beta = \frac{\Delta I_C}{\Delta I_B}$ **or** $\Delta I_C = \beta \Delta I_B = 40 \times 100 \mu A$

32. **(1)** The phase difference between output voltage and input signal voltage in common base transistor circuit is zero

33. **(2)** the ratio of change in collector current to the change in the base current at constant collector voltage in a common emitter circuit

34. **(2)** electrons move from emitter to collector

35. **(3)** length of collector is greater than that of emitter

36. **(3)** Current gain $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{(15-10)\,mA}{(80-40)\,\mu A}$

$$= \frac{5\times10^{-3}}{40\times10^{-6}} = \frac{5000}{40} = 125$$

$$A_v = \beta\frac{R_L}{R_m};\ \frac{V_{out}}{V_{in}} = 125\left(\frac{16\times10^3}{80}\right)$$

$$V_{out} = 125\times\frac{16000}{80}\times12\times10^{-3} = 300V$$

37. **(4)** We know that $\beta = \frac{\Delta i_C}{\Delta i_B} = \frac{(3.5-1.0)\times10^{-3}}{(80-30)\times10^{-6}} = 50$

38. **(4)** We know that $\beta = \frac{\alpha}{1-\alpha} = \frac{0.96}{1-0.96} = 24$

The collector current is $i_C = \frac{V_C}{R} = \frac{0.5}{800} = 0.625\times10^{-3} A$

Base current $i_B = \frac{i_C}{\beta} = \frac{0.625\times10^{-3}}{24} = 26\times10^{-6} A = 26\mu A$

39. **(3)** Voltage gain in common-emitter configuration is given by

$$A_v = \beta\frac{R_L}{R_{in}} = 50\times\frac{6\times10^3}{1\times10^3} = 300$$

40. **(3)** No. of electrons reaching the collector

$$n_C = \frac{96}{100}\times10^{10} = 0.96\times10^{10}$$

Emitter current, $I_E = \frac{n_E \times e}{t}$

Collector current, $I_C = \frac{n_C \times e}{t}$

$\therefore$ Current transfer ratio,

$$\alpha = \frac{I_C}{I_E} = \frac{n_C}{n_E}$$

$$= \frac{0.96\times10^{10}}{10^{10}} = 0.96$$

41. **(4)** Current gain in common emitter mode

$$= \frac{\alpha}{1-\alpha} = \frac{0.995}{1-0.995} = \frac{0.995}{0.005} = 199$$

42. **(4)** It is a *p-n-p* transistor with *R* as base. None of the option is correct.

43. **(4)** base, collector and emitter

44. **(3)** $I_C = I_E - I_B = 90 - 1 = 89mA$

45. **(3)** Voltage amplification $A_v = \beta \frac{R_o}{R_i} = 60 \times \frac{5000}{500} = 600$

46. **(4)** Operating point of a transistor is zero signal value of I_c and V_{CE}.

47. **(2)** The power amplifier handles large power

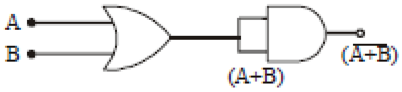
48. **(2)** Integrated circuit can act as a complete electronic circuit.

49. **(1)** The values of A.C + A.B.C is A.C

50. **(2)** $\left(\overline{A+B}\right)$ = NOR gate

When both inputs of NAND gate are connected, it behaves as NOT gate

OR + NOT = NOR



51. **(3)** When the two inputs of a NAND gate are shorted, the resulting gate is NOT

52. **(2)** X = 1 = A×B×$\left(\overline{BC}\right)$

Therefore, A = 1, B = 1, C = 0

53. (4) The logic gate (3) is a NAND gate for which the Boolean expression is X=$\overline{0.1}$

We have X=$\overline{0}$=1.

54. **(2)** Combination of NAND & NOR gates can produce OR, AND & NOT gates

55. **(2)** Truth table is as shown:

A	B	$\overline{A}$	$\overline{B}$	$\overline{A}+\overline{B}$	$\overline{\overline{A}+\overline{B}}$
0	0	1	1	1	0
0	1	1	0	1	0
1	0	0	1	1	0
1	1	0	0	0	1

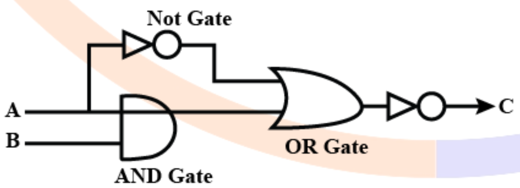
Thus the combination of two NOT gates and one NOR gate is equivalent to a AND gate

56. **(1)** A and B are the inputs of an OR gate. If A = 1, and B = 0, the output of OR gate will be 1. Now the output of OR gate along with C make the inputs of an AND gate.

57. **(4)** NAND and NOR gates are called universal gates.

58. **(1)**

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



59. **(2)** Output of upper AND gate = $\overline{A}B$

Output of lower AND gate = $A\overline{B}$

$\therefore$ Output of OR gate, $Y = A\overline{B} + B\overline{A}$

60. **(3)** (W + X) . (W + Y) = W + (X .Y)

NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

1. **(3)** On heating, number of electron-hole pairs increases, so overall resistance of diode will change. Hence forward biasing and reversed biasing both are changed.

2. **(3)** The values of I_B, I_C and β are given by

$I_B = 40\mu A, I_C = 5ma, \beta = 125$

$V_i = I_B R_B + V_{BE}$

$20 = I_B \times (500 \times 10^3) + 0$

$$I_B = \frac{20}{500 \times 10^3} = 40\,\mu A$$

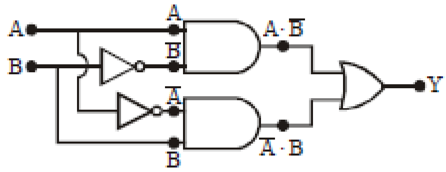
$V_{CC} = I_C R_C + V_{CE}$

$20 = I_C \times (4 \times 10^3) + 0$

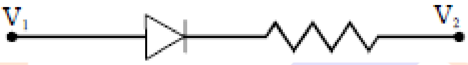
$I_C = 5 \times 10^{-3} = 5\text{ mA}$

$$\beta = \frac{I_C}{I_B} = \frac{5 \times 10^{-3}}{40 \times 10^{-6}} = 125$$

3. **(2)**



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



4. **(4)**

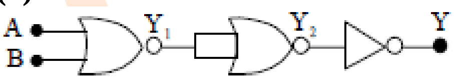
In forward bias, $V_1 > V_2$ i.e., in figure (4) p-type semiconductor is at higher potential w.r.t. n-type semiconductor.

5. **(2)** Given, current gain $\beta = 100$, $R_c = 3k\Omega$, $R_b = 2k\Omega$

Voltage gain $(A_v) = \beta \dfrac{R_c}{R_b} = 100\left(\dfrac{3}{2}\right) = 150$

Power gain $= A_v\beta = 150\ (100) = 15000$

6. **(2)**



$y_1 = \overline{A+B}$

$$y_2 = \overline{y + y_1} = \overline{y_1} = A + B$$

$y = \overline{y_2} = \overline{A+B}$ i.e., NOR gate

7. **(2)** Since diode is in forward bias, so the value of current flowing through AB

8. (1) Transistor is working in common emitter configuration. Hence, input terminal is at base and output terminal is at collector.

Given:

R_c=800Ω, V_L=0.8V, R_B=192Ω

Current amplification factor =0.96

Hence, $\frac{I_C}{I_B} = 0.96$

Assumption:

Transistor is ideal and working in forward active region (Junction BE is forward biased and Junction BC is reverse biased).

$\Rightarrow V_{BE}=0$; $V_E=0 \Rightarrow V_B=0$

Collector current is given by $I_C=V_L/R_c=0.8/800=10^{-3}$A

Base current is given by, $I_B=I_C/\beta=0.9610^{-3}$A

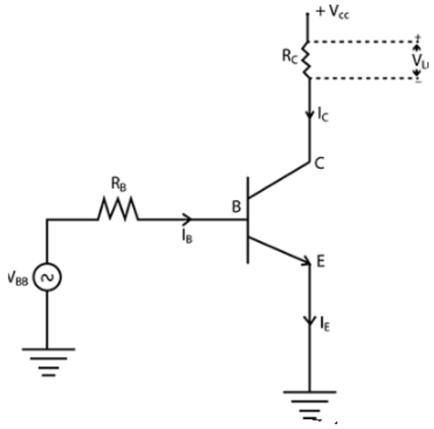
Applying KVL on Base circuit, input voltage $V_{BB}=I_BR_B$

$$V_{BB} = \frac{10^{-3}}{0.96}\times 192 = 0.2V$$

$$\text{Voltage Gain, } A_v = \frac{V_{out}}{V_{in}} = \frac{V_L}{V_{BB}} = \frac{0.8}{0.2} = 4$$

$$\text{Current Gain, } A_I = \frac{I_{out}}{I_{in}} = \frac{I_C}{I_B} = \beta = 0.96$$

$$\text{Power Gain, } A_P = A_V A_I = 4 \times 0.96 = 3.84$$

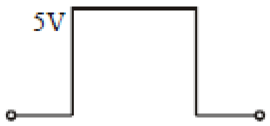


9. (4) From left side the first gate is OR gate and next one is AND gate. So the out put of OR gate is A+B and the output of AND gate Y=(A+B).C

We know that for AND gate the put will be 1 if both inputs are 1. So, A+B=1and C=1

In logic gate , 1+0=1 so A=1,B=0,C=1 will be the correct choice for output 1.

10. **(3)** Here P-N junction diode rectifies half of the ac wave i.e., acts as half wave rectifier. During + ve half cycle



Diode → forward biased output across will be

During –ve half cycle Diode → reverse biased output will not obtained.

11. **(4)** Current $I = \frac{V}{R} = \frac{(3.5-0.5)}{100}A$

[∵ Barrier potential V_B = 0.5V]

12. **(3) Given :** Voltage gain AV = 150

$V_i = 2\cos\left(15t + \frac{\pi}{3}\right); V_0 = ?$

For CE transistor phase difference between input and output signal is $\pi = 180°$

Using formula

$$A_V = \frac{V_0}{V_i} \Rightarrow V_0 = A_V \times V_i$$

$$= 150 \times 2\cos\left(15t + \frac{\pi}{3}\right) \text{ or } V_0 = 300\cos\left(15t + \frac{\pi}{3} + \pi\right)$$

$$V_0 = 300\cos\left(15t + \frac{4}{3}\pi\right)$$

13. **(1)** The given graph represents V-I characteristics of solar cell.

14.

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

It is a NAND Gate

15. For P type

Holes are majority & trivalent atoms are the dopants

16. $\lambda = \frac{1240nm}{1.9} = 652.6nm \approx 654nm$

17.

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

18. In forward bias $V_P > V_N$

19. Voltage drop across load resistance = 0.8 V

$$I_C = \frac{V_C}{R_C} = \frac{0.8}{80} = 10^{-3}A = 1mA$$

20. NAND gate and NOR gate are universal logic gates.

21. For N type semi-conductor intrinsic semi conductor doped by pentavalent impurity.

22. Height of potential barrier increases in reverse bias only

23. For a transistor base junction must be very thin and lightly doped

24. $Y = \overline{\overline{A} + \overline{B}} = \overline{\overline{A}}.\overline{\overline{B}} = A.B$

So the give logic gate acts as AND gate

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

25. Mobility of electrons > mobility of holes

26. Potential barrier of p-n junction can be up to 0.7 v

27.

A	B	C	A.B	$\overline{B.C}$	output
0	0	1	0	1	1
1	0	1	0	1	1
0	1	0	0	1	1
1	1	0	1	1	1

28 For conductors with increase in temperature, resistance increases and for semiconductors resistance decreases.

29. For half wave rectifier

Input frequency = output frequency

$\therefore n = 60Hz$

30 a and c are forward biased

31. $C = \left(\overline{A.B}\right).\left(\overline{\overline{A}.B}\right)$

$= \left(\overline{A} + \overline{B}\right).\left(A + \overline{B}\right) = \left(\overline{A}.A + \overline{A}.\overline{B} + \overline{B}A + \overline{B}.B\right) \qquad = O + \overline{B}\left(\overline{A} + A + 1\right) = \overline{B}$