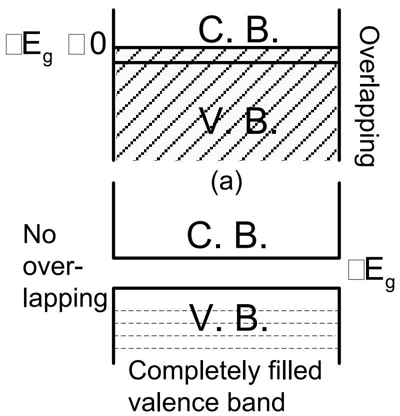
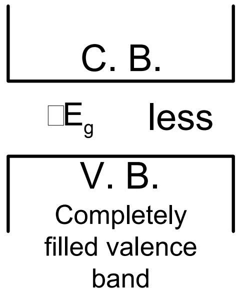
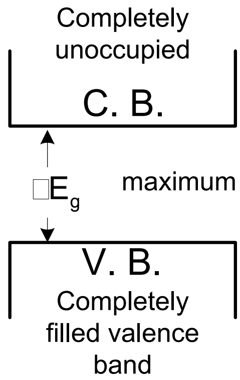
SAFALTA.COM
An Initiative by अमर उजाला

1. VARIOUS TYPES OF SOLIDS

(i) On the basis of band structure of crystals, solids are divided in three categories.
(a) Insulators (b) Semi-conductors (c) Conductors.

(ii) Difference between Conductors, Semi-conductors and Insulators

S.No.	Property	Conductors	Semi-conductors	Insulators
1.	Electrical conductivity and its value	Very high 10^{-7} mho/m	Between those of conductors and insulators i.e. 10^{-7} mho/m to 10^{-13} mho/m	Negligible 10^{-13} mho/m
2.	Resistivity and its value	Negligible Less than 10^{-5} Ω-m	Between those of conductors and insulators i.e. 10^{-5} Ω-m to 10^{5} Ω-m	Very high more than 10^{5} Ω-m
3.	Band structure			
4.	Energy gap and its value	Zero or very small	More that in conductors but less than that in insulators e.g. in Ge, ΔE_g =0.72 eV is Si, ΔE_g =1.1 eV in Ga As ΔE_g =1.3 eV	Very large e.g. in diamond ΔE_g = 7 eV
5.	Current carriers and current flow	Due to free electrons and very high	Due to free electrons and holes more than that in insulators	Due to free electrons but negligible.
6.	Number of current carriers (electrons or holes) at ordinary temperature	Very high	very low	negligible
7.	Condition of valence band	The valence and conduction bands are completely filled	Valence band in somewhat empty	Valence band is completely filled

	and conduction band at ordinary temperature	or conduction band is some what empty (e.g. in Na)	and conduction band is somewhat filled	and conduction band is completely empty.
8.	Behaviour at 0 K	Behaves like a superconductor.	Behaves like an insulator	Behaves like an insulator
9.	Temperature coefficient of resistance (α)	Positive	Negative	Negative
10.	Effects of temperature on conductivity	Conductivity decreases	Conductivity increases	Conductivity increases
11.	On increasing temperature the number of current carriers	Decreases	Increases	Increases
12.	On mixing impurities their resistance	Increases	Decreases	Remains unchanged
13.	Current flow in these takes place	Easily	Very slow	Does not take place
14.	Examples	Cu, Ag, Au, Na, Pt, Hg etc.	Ge, Si, Ga, As etc.	Wood, plastic, mica, diamond, glass etc.

(iii) **Other properties of semiconductors:**

(a) Semi conducting elements are tetravalent i.e. there are four electrons in their outermost orbit.

(b) Their lattice is face centered cubic (F.C.C.)

(c) The number of electrons or cotters is given by

$n_i = p_i = AT^{3/2}e^{-E_g/2kT}$

i.e. on increasing temperature, the number of current carriers increases.

(d) There are uncharged

(iv) **Holes or cotters:**

(a) The deficiency of electrons in covalent band formation in the valence band in defined as hole or cotter.

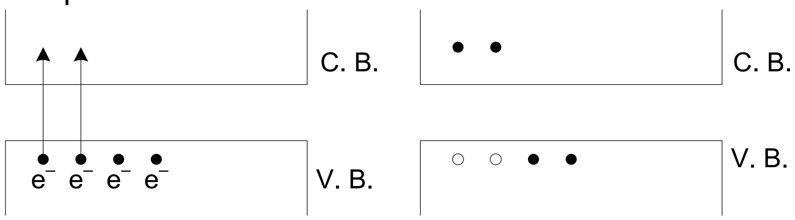
(b) These are positively charged. The value of positive charge on them is equal to the electron charge.

(c) Their effective mass is less than that of electrons.

(d) In an external electric field, holes move in a direction opposite to that of electrons i.e. they move from positive to negative terminal.

(e) They contribute to current flow.

(f) Holes are produced when covalent bonds in valence band break.



2. TYPES OF SEMICONDUCTORS AND DIFFERENCE BETWEEN THEM

(i) The semiconductors are of two types.
   (a) Intrinsic or pure semiconductors
   (b) Extrinsic or dopes semiconductors

(ii) **Difference between intrinsic and extrinsic semiconductors:**

S.No.	**Intrinsic semiconductors**	**Extrinsic semiconductors**
1.	Pure Ge or Si is known as intrinsic semiconductor	The semiconductor, resulting from mixing impurity in it, is known as extrinsic semiconductors.
2.	Their conductivity is low (because only one electron in 10^9 contribute)	Their conductivity is high
3.	The number of free electrons (n_i in conduction band is equal to the number of holes p_i in valence band.)	In these $n_i \neq p_i$
4.	These are not practically used	These are practically used
5.	In these the energy gap is very small	In these the energy gap is more than that in pure semiconductors.
6.	In these the Fermi energy level lies in the middle of valence band and conduction	In these the Fermi level shifts towards valence or conduction energy bands.

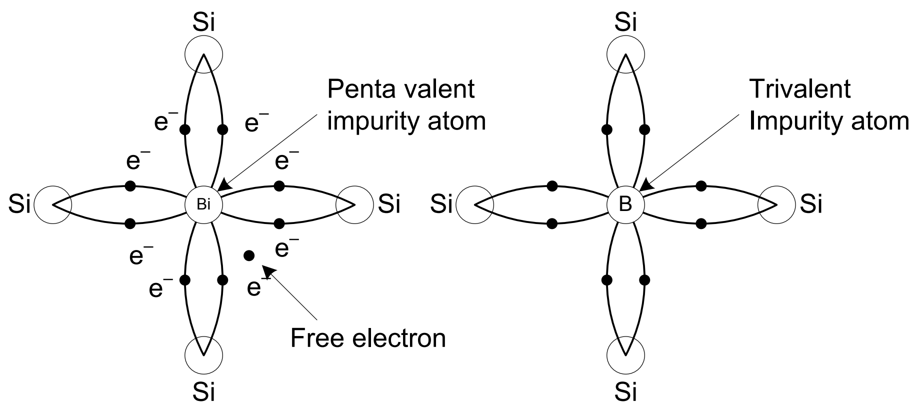
(iii) **Properties of intrinsic semiconductors:**

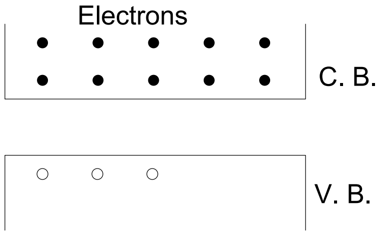
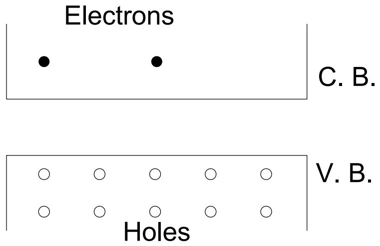
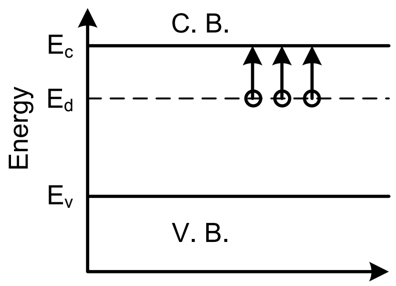
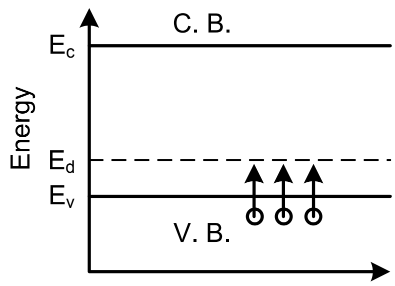
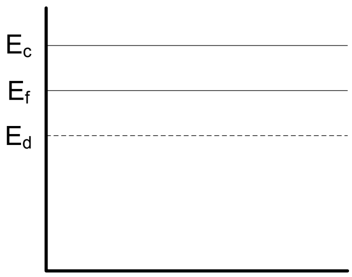
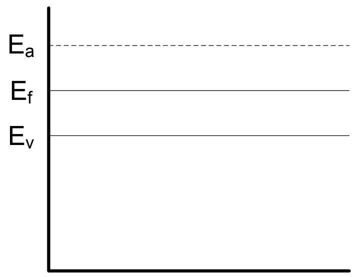
(a) At absolute zero temperature (0 K) there are no free electrons in them.
(b) At room temperature, the electron-hole pair in sufficient number are produced.
(c) Electric conduction takes place via both electrons and holes.
(d) The drift velocities of electrons and holes are different.
(e) The drift velocity of electrons (V_{dn}) is greater than that of holes (V_{dp}).
(f) The total current is $I = I_n + I_p$
(g) In connecting wires the current flows only via electrons.

(iv) **Extrinsic semiconductors:**

(a) **Doping:** The process of mixing impurities of other elements in pure semiconductors is known as doping.
(b) **Extrinsic semiconductors:** the semiconductors, in which trivalent and pentavalent elements are mixed as impurities, are known as extrinsic semiconductors.
(c) The extrinsic semiconductors are of two types
(i) N-type semiconductors (ii) P-type semiconductors.

(d) **Difference between N-type and P-type semiconductors**

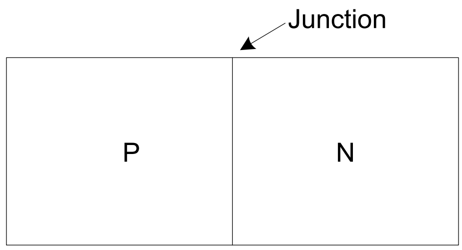
<table>
<tr><th>S.No.</th><th>N-type semiconductors</th><th>P-type semiconductors</th></tr>
<tr><td>1.</td><td>In these the impurity of some pentavalent element like P, As, Sb, Bi, etc. is mixed</td><td>In these, the impurity of some trivalent element like b, Al, In, Ga etc. is mixed</td></tr>
<tr><td>2.</td><td colspan="2">
</td></tr>
<tr><td>3.</td><td>In these the impurity atom donates one electrons, hence these are known as donor type semiconductors</td><td>In these, the impurity atom can accept one electron, hence these are known as acceptor type semiconductors.</td></tr>
<tr><td>4.</td><td>In these the electrons are majority current carriers and holes are minority current carriers. (i.e. the electron density is more than hole density $n_n >> n_p$)</td><td>In these the holes are majority current carriers and electrons are minority current carriers i.e. $n_p >> n_n$</td></tr>
</table>

5.	In these there is majority of negative particles (electrons) and hence are known as N-type semiconductors 	In these there is majority of positive particles (cotters) and hence are known as P-type semiconductors. 
6.	In these the donor energy level is close to the conduction band and far away from valence band. 	In these the acceptor energy level is close to the valence band and far away from conduction band. 
7.	Current density $J_n = nq\, V_{dn}$	$J_p = pq\, V_{dp}$
8.	Electric conductivity $\sigma_n = nq\mu_n$ $\approx n_d\, q\mu_n$ Where nd = number of donor atoms / cm^3.	$\sigma_p = nq\mu_p$ $\approx n_p\, q\mu_p$ Where np = number of acceptor atoms / cm^3.
9.	The Fermi energy level lies close to conduction band (i.e. the Fermi energy level lies in between the donor energy level and conduction band)	The Fermi energy level lies close to the valence band (i.e. the Fermi energy level lies in between the acceptor energy level and valence band)
		

3. SEMICONDUCTOR DIODE OR P-N JUNCTION, CONDUCTION IN P-N JUNCTION, DEPLETION LAYER AND BARRIER ENERGY

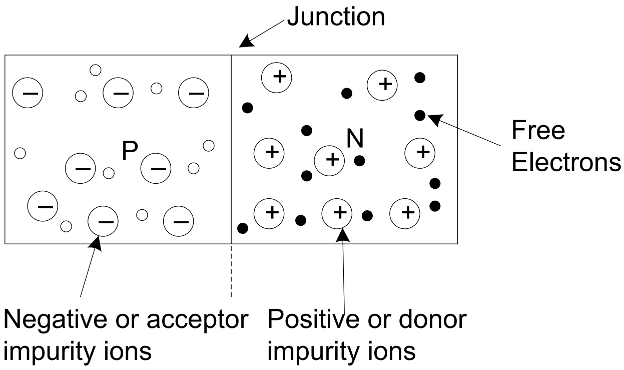
P-N Junction

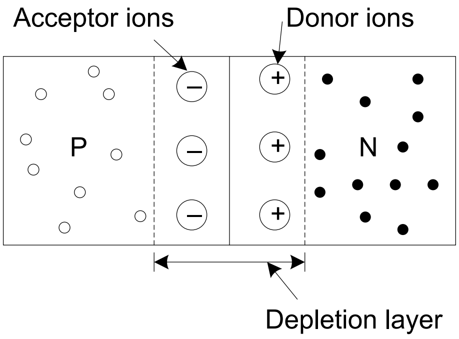
(a) The device formed by joining atomically a wafer of P-type semiconductor to the wafer of N-type semiconductor is known as P-N junction.

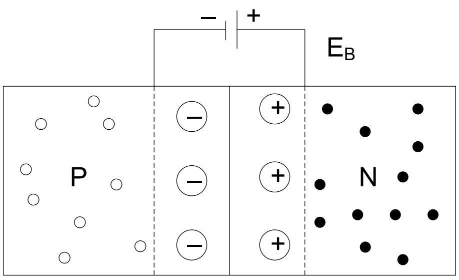


(b) There are three processes of making junctions
(i) Diffusion (ii) Alloying (iii) Growth
In majority of cases P-N junction is formed by diffusion process. The impurity concentration is maximum at surface and decreases gradually inside the semiconductor.

(c) **Conduction of current in P-N Junction:**







(i) In P-N junction the majority cotters in P-region and majority electrons in N-region start diffusing due to concentration gradient and thermal disturbance towards N-region and P-region respectively and combine respectively with electrons and cotters and become neutral.

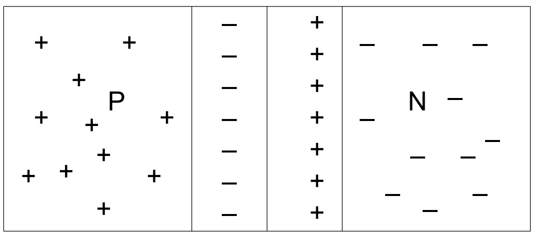
(ii) In this process of neutralization there occurs deficiency of free current carriers near the junction and layers of positive ions in N-region and negative ions in P-region are formed. These ions are immobile. Due to this an imaginary battery or internal electric field is formed at the junction which is directed from N to P.

(iii) **Depletion layer:**

(a) The region on both sides of P-N junction in which there is deficiency of free current carriers, is known as the depletion layer.

(b) Its thickness is of the order of 1μm (= 10^{-6})

(c) On two sides of it, there are ions of opposite nature. i.e. donor ion (+ve) on N-side and acceptor ions (–ve) on P-side.



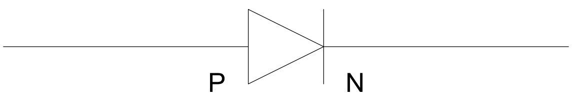
(d) This stops the free current carriers to crossover the junction and consequently a potential barrier is formed at the junction.

(e) The potential difference between the ends of this layer is defined as the contact potential or potential barrier (V_B).

(f) The value of V_B is from 0.1 to 0.7 volt which depends on the temperature of the junction. It also depends on the nature of semiconductor and the doping concentration. For germanium and silicon its values are 0.3 V and 0.7 V respectively.

(g) **P-N Junction diode or semiconductor diode:**

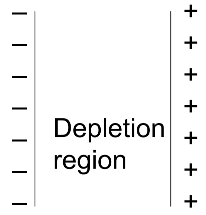
(i) **Symbolic representation of diode:**



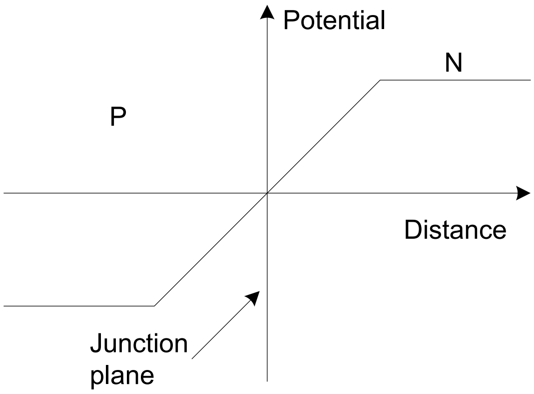
(ii) The direction of current flow is represented by the arrow head.

(iii) In equilibrium state current does not flow in the junction diode.

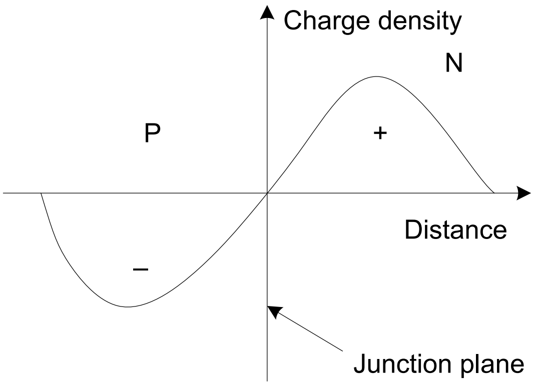
(iv) In can be presumed to be equivalent to a condenser in which the depletion layer acts as a dielectric.



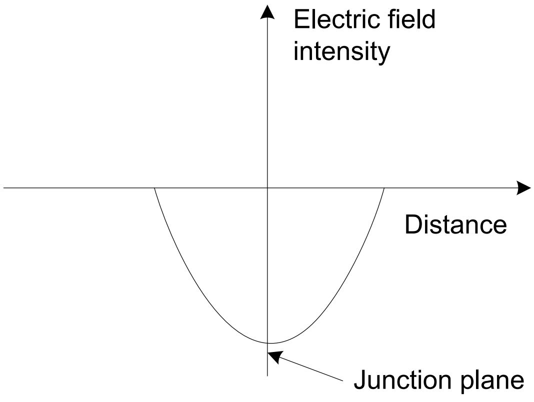
(v) **Potential distance curve at P-N Junction**



(vi) **Charge density curve at P-N Junction**



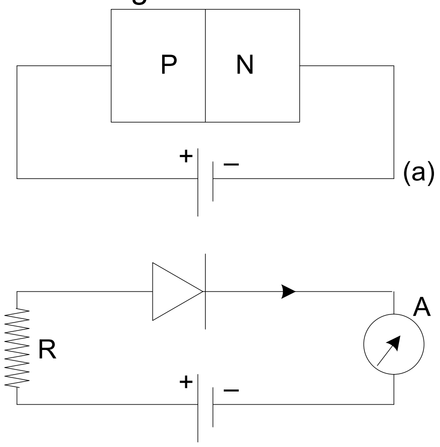
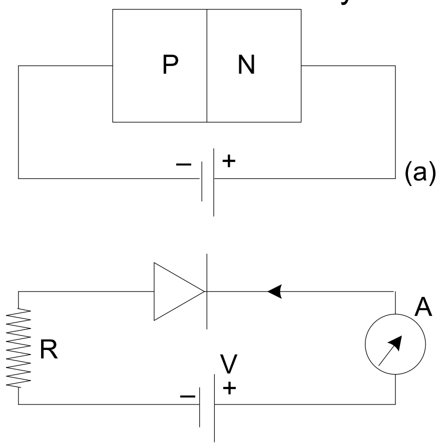
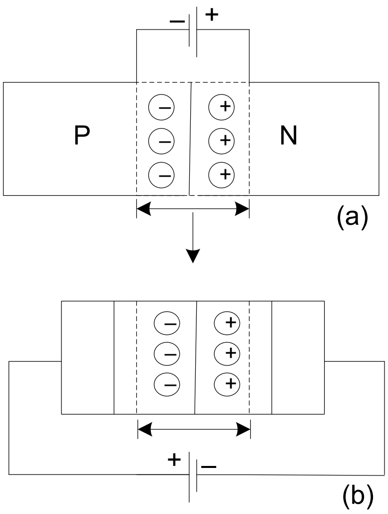
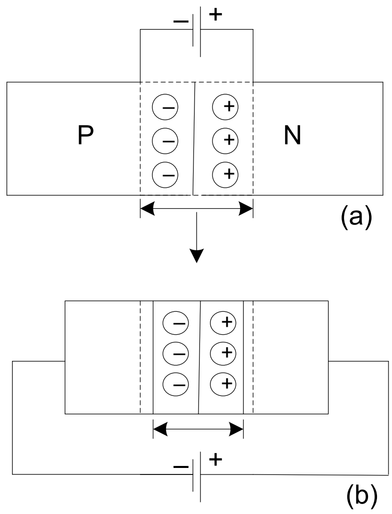
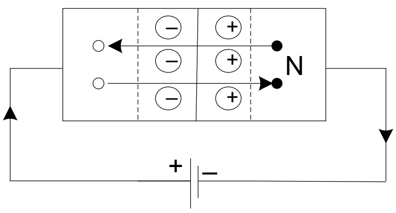
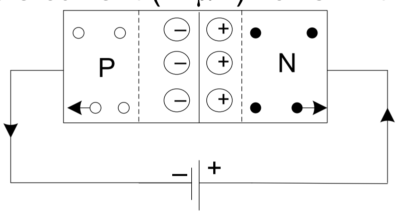
(vii) **Curve between electric field and distance near P-N junction**

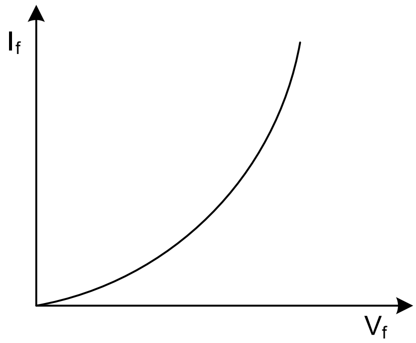
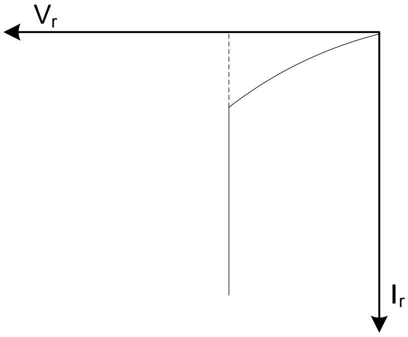


4. BIASING OF JUNCTION DIODE

(i) No current flows in the junction diode without an external battery. It is connected to a battery in two different ways. Hence two different bias are possible in junction diode.
(a) Forward bias (b) Reverse bias

(ii) **Difference between forward bias and reverse bias:**

S.No.	Forward bias	Reverse bias
1.	The P-region of junction diode is connected to positive terminal of battery and N-region is connected to negative terminal of battery. 	The P-region is connected to negative terminal and N-region is connected to positive terminal of the battery. 
2.	In this the width of depletion layer decreases 	In this the width of depletion layer increases 
3.	Current flows in it due to majority electrons and majority holes and hence high current (mA) flows in it.  The direction of current in it is from P to N.	Current flows in it due to minority electrons and minority holes and hence negligible current (in μA) flows in it.  Direction of current is from N to P
4.	The junction resistance is low	The junction resistance is high
5.	Curve between forward voltage and forward current	Curve between reverse voltage and reverse current

5. CHARACTERISTICS OF JUNCTION DIODE

(i) The characteristic curves of junction diode are of two types
  (a) Static characteristic curves
  (b) Dynamic characteristic curves

(ii) The static and the dynamic characteristics are also of two types

(A) (a) Static forward characteristics curves

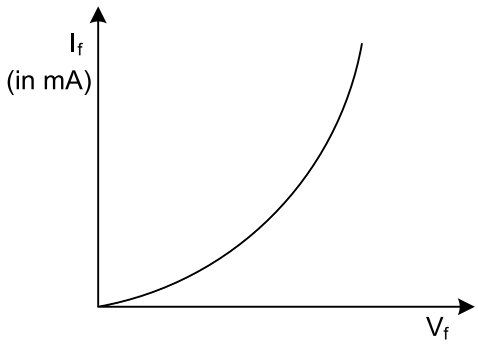
(b) Static reverse characteristic curves

(B) (a) Dynamic forward characteristic curves
(b) Dynamic reverse characteristic curves

(iii) **Static forward characteristics**

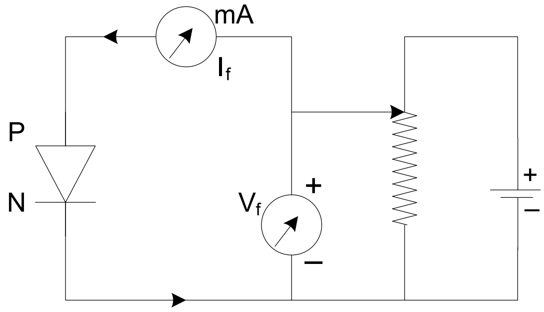
(a) In the absence of load resistance, the curves drawn between the forward voltage (V_f) and forward current (I_f) are known as the static forward characteristics of junction diode.

(b)



(c) On increasing the V_f the value of I_f increases exponentially

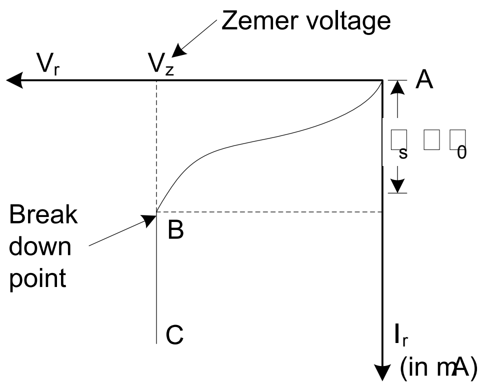
(d) **Circuit diagram:**



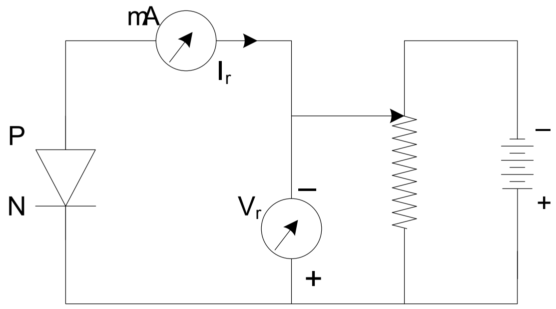
(iv) **Static reverse characteristics:**

(a) In the absence of load resistance, the curves drawn between the reverse voltage (V_r) and reverse current (I_r) are known as the static reverse characteristics of junctions diode.

(b)



(c)



(d) After the breakdown point at B, the reverse current (I_r) does not depend on the reverse voltage (V_r) in the BC portion of curve.

6. ZENER BREAKDOWN, AVALANCHE BREAKDOWN AND ZENER DIODE:

S.No.	Avalanche breakdown	Zener breakdown

1.	The doping in the formation of P-N Junction is low	The doping in the formation of P-N junction is high
2.	The covalent bonds break as a result of collision of electrons and holes with the valence electrons	In this the covalent bonds break spontaneously.
3.	Higher reverse potential is required for breakdown.	Low reverse potential is required for breakdown
4.	In this the thermally generated electrons due to electric field ionize other atoms and release electrons.	In this the covalent bonds near the junction break due to high reverse potential ~20 V and consequently electrons become free.

(ii) **Zener diode:**

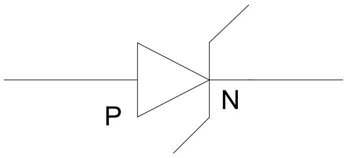
(a) The junction diode made of Si or Ge, whose reverse resistance is very high, is known as Zener diode.

(b) It works at Zener voltage (V_z) i.e. the voltage at which breakdown starts.

Zener voltage (V_z): The voltage at which breakdown starts in Zener diode and consequently the reverse current in the circuit abruptly increases, is defined as Zener voltage.

(c) It is used in power supplies as a voltage regulator.

(d) **Symbolic representation of Zener diode.**



7. SALIENT FEATURES RELATING TO JUNCTION DIODE

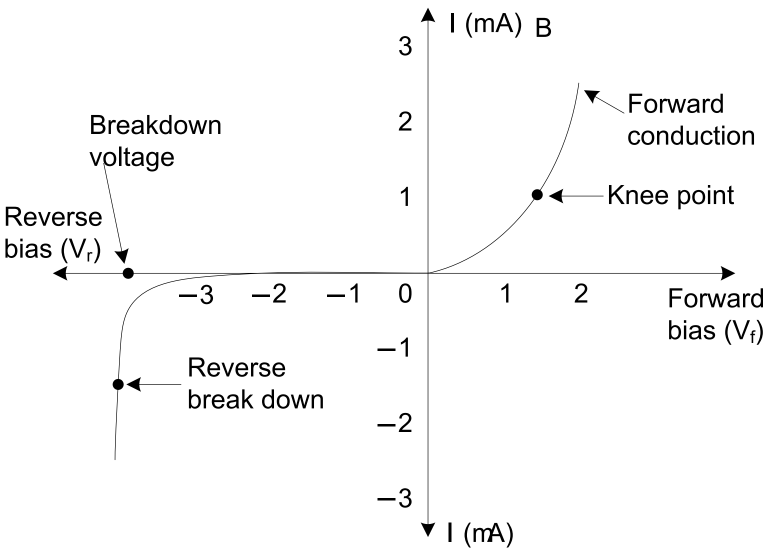
(i) In junction diode the current flow is unidirectional as in vacuum diode.

(ii) Current flows in the semiconductor diode when it is forward biased.

(3) The velocity gained by the charge carriers in an electric field of unit intensity, is defined as their mobility

$$m = \frac{V_d}{E} = \frac{\text{Drift Velocity}}{\text{Intensity of electricity field}}$$

(4) **Forward and reverse characteristic curves of Si and Ge diodes:**



Knee Point: That point on the forward characteristics of junction diode after which the curve becomes linear, is known as the knee point. In the diagram it is represented by the point A.

Knee voltage: The potential at knee point A is known as the knee potential or forward potential at which the forward current abruptly increases is known as the knee potential.

(a) This potential does not depend on the current.
(b) For Si its value is 0.7 V.

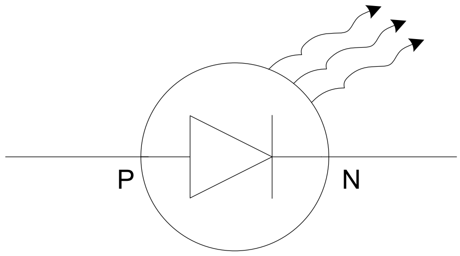
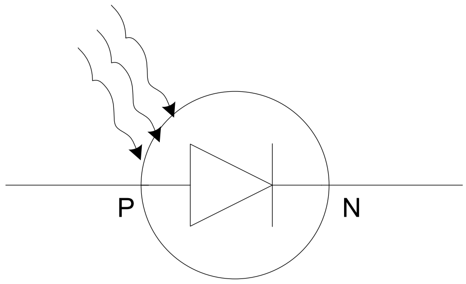
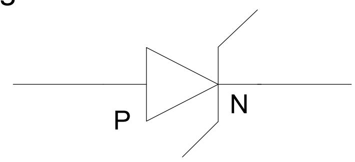
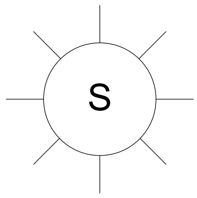
(vii) **Greater the value of ΔE_g**, stronger will be the binding of valence electrons to the nucleus.

8. USES OF JUNCTION DIODE

(i) Rectifier
(ii) Off switch
(iii) Condenser

9. VARIOUS TYPES OF P-N JUNCTIONS

S.No.	P-N Device	Biasing	Principle	Uses	Explanation
1.	Light Emitting Diode (LED)	Forward	Production of light from electric current	Burglar alarms, calculators, pilot lamps, telephone, digital watch and in switch boards	In Ga, As, Electromagnetic radiations are emitted on account of transitions of electron from conduction band to valance band.

					
2.	Photodiode	Reverse	Electric conduction from light	In sound films, computers, tape, in reading computer cards and in light driven switches.	The covalent bonds in semiconductors break due to electromagnetic radiations and more electrons become free and conductivity increases. 
3.	Zener diode	Reverse	Current is controlled	In voltage regulation	Voltage across it remains constant 
4.	Solar cell	No biasing	Production of potential difference by sun light	For generating electrical energy in cooking food etc.	Due to nuclear fusion process sun is constantly emitting light and heat energy. The upper surface of P-N junction is thin in this diode. 

Other salient features

(a) The value of electric field across the P-N junction is 10^5 V/m

(b) $E = \frac{V_B}{d} = \frac{0.5}{10^{-6}} = 5 \times 10^5$

(c) The values of contact potential for Si and Ge are 0.7 V and 0.3 V respectively.

10. SEMICONDUCTOR DIODE AS RECTIFIER

(i) **Rectification:** The process in which an alternating current is converted into direct current, is defined as rectification.

(ii) **Rectifier:** The device employing diode, used to convert an alternating current into direct current, is known as rectifier.

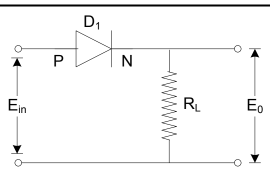
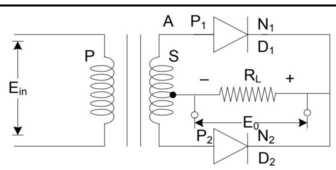
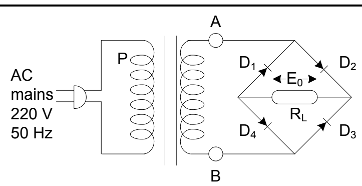
(iii) The rectifiers are of two types:

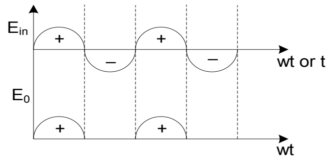
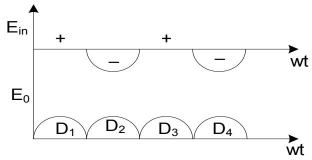
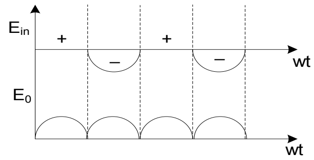
(a) Half wave rectifier (b) Full wave rectifier

Half wave rectifier: The rectifier, in which only alternate half cycles of applied alternating signal are converted into direct current, is known as half wave rectifier.

Full wave rectifier: The rectifier is which the whole cycle of applied alternating signal is converted into direct current, is known as full wave rectifier.

(iv) Difference between half wave rectifier and full wave rectifier

No.	Half-Wave Rectifier	Full Wave Rectifier centre taped	Full wave Bridge Rectifier
1.			
2.	In this, one diode or one semiconductor diode is	In this, two diodes or one double diode or two	In this four junction diodes from the bridge circuit.

	used	junction diodes are used	
3.	Ordinary transformer is used	Centre tap transformer is used	Transformer is not required
4.	It converts half cycle of applied A.C. signal into D.C. signal	It converts the whole cycle of applied A.C. signal into D.C. signal	It converts the whole cycle of applied A.C. signal into D.C. signal
5.	Input and output curves 	Input and output curves 	Input and output curves 
6.	The value of $I_{rms} = \frac{I_0}{2}$	$I_{rms} = \frac{I_0}{\sqrt{2}}$	$I_{rms} = \frac{I_0}{\sqrt{2}}$
7.	$I_{dc} = \frac{I_0}{p}$	$I_{dc} = \frac{2I_0}{p}$	$I_{dc} = \frac{2I_0}{p}$

(iv) **Working of NPN transistor**

(a) The emitter-base junction is forward biased whereas the collector-base junction is reverse biased.

(b) The majority electrons in the emitter are pushed into the base.

(c) The base is thin and is lightly doped. Therefore a very small fraction (say 1%) of incoming electrons combine with the holes. Hence base current is very small.

(d) The majority of electrons are rushing towards the collector under the electrostatic influence of C-B battery.

(e) The electrons collected by the collector move towards the positive terminal of C-B battery.

(f) The deficiency of these electron is compensated by the electrons released from the negative terminal of E-B battery.

(g) Thus in NPN transistors current is carried by electron both in the external circuit as well as inside the transistor.

(h) The relation between these current is given by

$I_E = I_C + I_B$

$I_E >> I_B, I_C < I_E$ and $I_B << I_C$

(i) The input impedance is low and output impedance is high. The output voltage required to be applied is more than the input voltage.

Illustration 8: For a common emitter connection the values of constant collector and base current are 5mA and 50 μA respectively. The current gain will be:

(A) 10 (B) 20 (C) 40 (D) 100

Sol. **(D)** $\beta = \left(\frac{\delta I_C}{\delta I_B}\right)_{V_e} = \frac{5\times10^{-3}}{50\times10^{-6}} = 100$

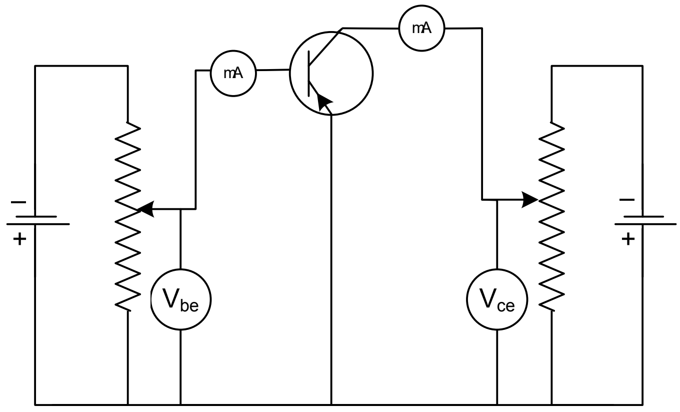
11. CHARACTERISTICS OF TRANSISTOR

The study of variation in current with respect to voltage in a transistor is called its characteristic. For each configuration of transistor, there are two types of characteristics:

(i) Input characteristics (ii) Output characteristics

(a) **Common emitter configuration:** In this configuration emitter is common to input and output circuits.

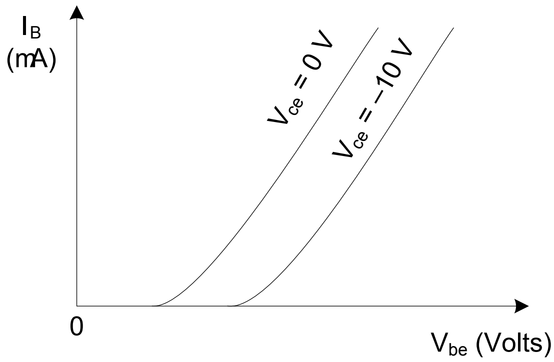
(i) **Circuit diagram**



Common base PNP transistor

(ii) **Input characteristics**

(a) Input characteristics are obtained by plotting the base current (I_B) versus base emitter voltage (V_{BE}) for constant collector-emitter voltage (V_{CE}).

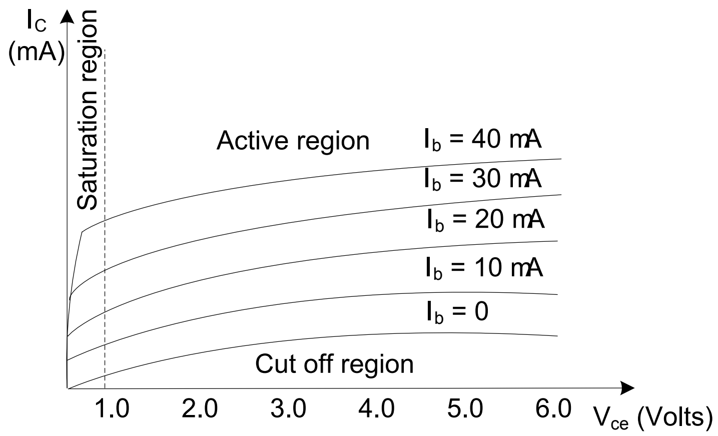


(b) I_B increases with increase in V_{BE}, but less rapidly as compared to common base configuration, indicating that input resistance of common emitter configuration is greater than that of common base configuration.

(c) These characteristics resemble with those of a forward biased junction diode indicating that the base-emitter section of a transistor is essentially a junction diode.

(iii) **Output characteristics:**

(a) The output characteristics are obtained by plotting collector current I_C versus collector-emitter voltage (V_{CE}) at constant value of base current (I_B).



(b) I_C increases with increase of V_{CE} upto 1 volt and beyond 1 volt it becomes almost constant.

(c) The value of V_{CE} upto which I_C increases is called the knee voltage. The transistor always operates above knee voltage.

(d) Above knee voltage, I_C is almost constant.

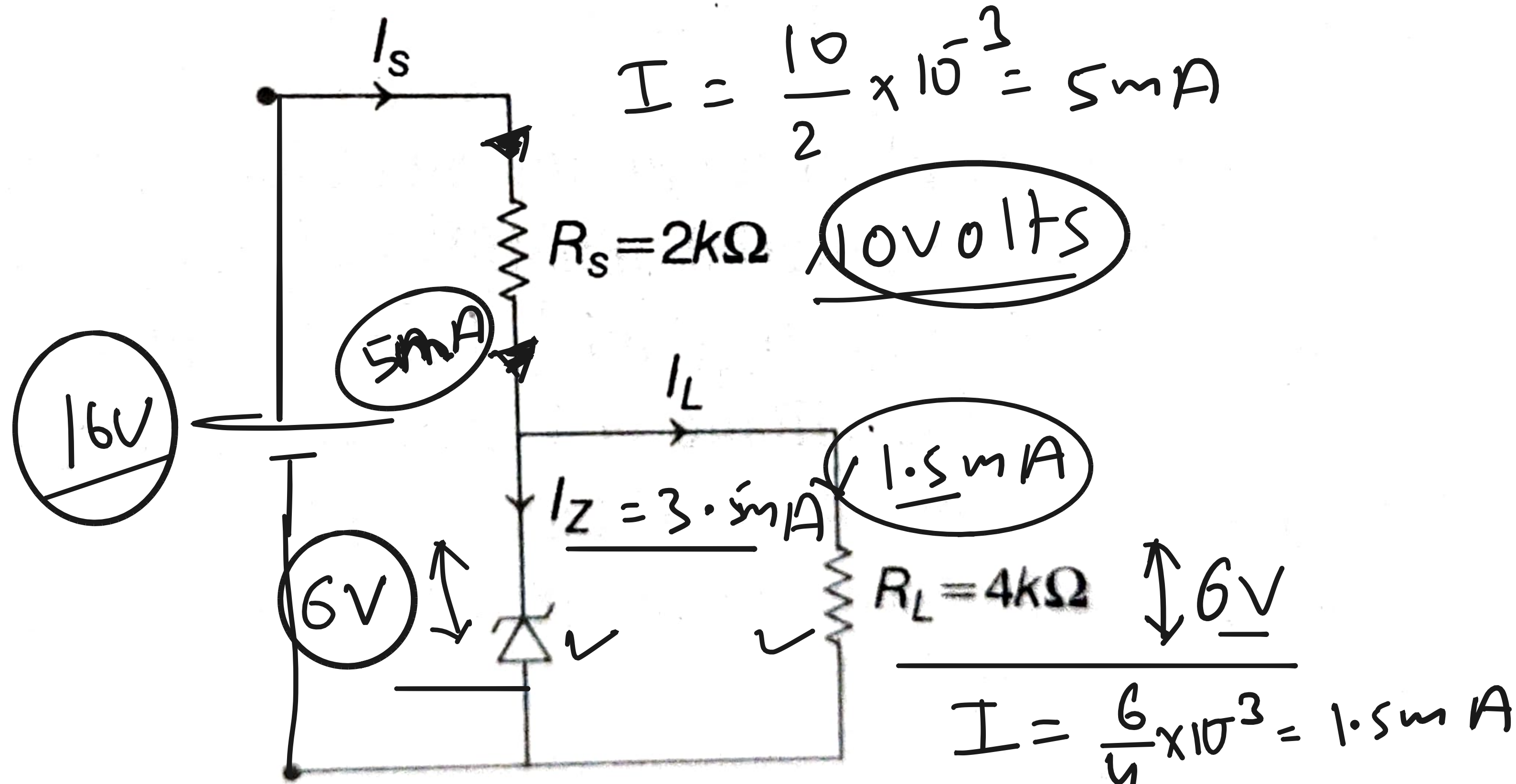
(e) The region for V_{CE} < 1 volt is called saturation region as both emitter and collector are forward biased.

(f) In the region $I_B \leq 0$, both emitter and collector are reverse biased and it is called the cut-ff region.

(g) The central region, where the curves are uniformly spaced and sloped, is called the active region. In this region the emitter is forward biased and the collector is reverse biased.

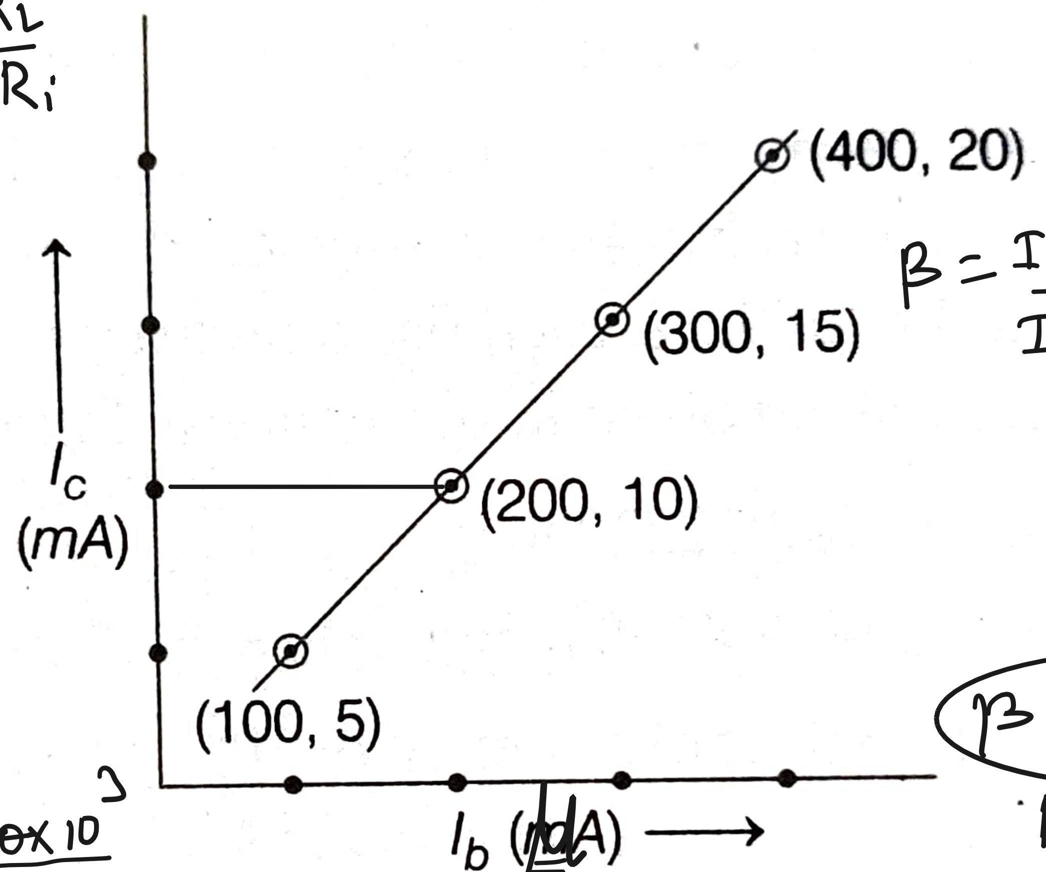
SAFALTA.COM
An Initiative by अमर उजाला

1. Figure shows a DC voltage regulator circuit, with a Zener diode of breakdown voltage = 6 V. If the unregulated input voltage varies between 10 V to 16 V, then what is the maximum Zener current? **(Main 2019, 12 April II)**



(a) 2.5 mA (b) 1.5 mA (c) 7.5 mA (d) 3.5 mA

2. The transfer characteristic curve of a transistor, having input and output resistance 100Ω and $100\ k\Omega$ respectively, is shown in the figure. The voltage and power gain, are respectively, **(Main 2019, 12 April I)**



$A_v = \frac{I_C R_L}{I_B R_i} = \beta \times \frac{R_L}{R_i}$

$A_v = \frac{50 \times 100 \times 10^3}{100}$

$A_v = 5 \times 10^4$

Power gain

$= \frac{i_c^2 R_L}{i_B^2 R_i}$

$= \beta^2 \times \frac{R_L}{R_i} = \frac{50^2 \times 100 \times 10^3}{100}$

$\beta = \frac{I_C}{I_B} = \frac{10 \times 10^{-3}}{200 \times 10^{-6}}$

$= \frac{10^6}{20} \times 10^{-3}$

$= 0.5 \times 10^5 \times 10^{-3}$

$\beta = 5 \times 10^4 \times 10^{-3}$

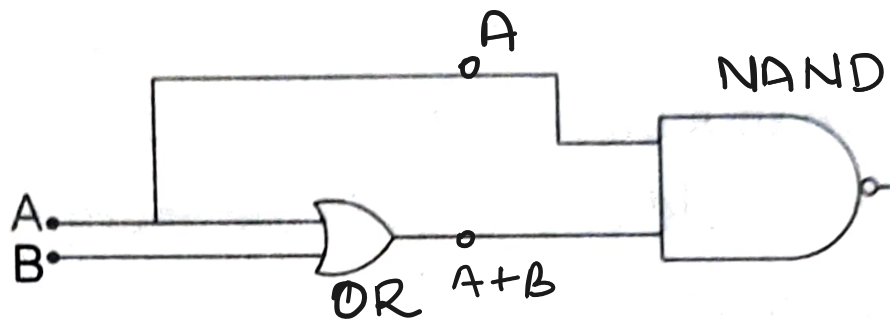
$\beta = 50$

(a) $2.5 \times 10^4, 2.5 \times 10^6$
(b) $5 \times 10^4, 5 \times 10^6$
(c) $5 \times 10^4, 5 \times 10^5$
(d) $5 \times 10^4, 2.5 \times 10^6$

Power gain $= 2500 \times 10^3 = 2.5 \times 10^6$

3. The truth table for the circuit given in the figure is

(Main 2019, 12 April I)



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

$y = \overline{AA+AB}$

$y = \overline{A+AB}$

$y = \overline{0+0} = \bar{0} = 1$

$y = \overline{0+0\times1}$

$y = \bar{0} = 1$

$y = \overline{1+1\times0}$

$= \bar{1} = 0$

(a)

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

(b)

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

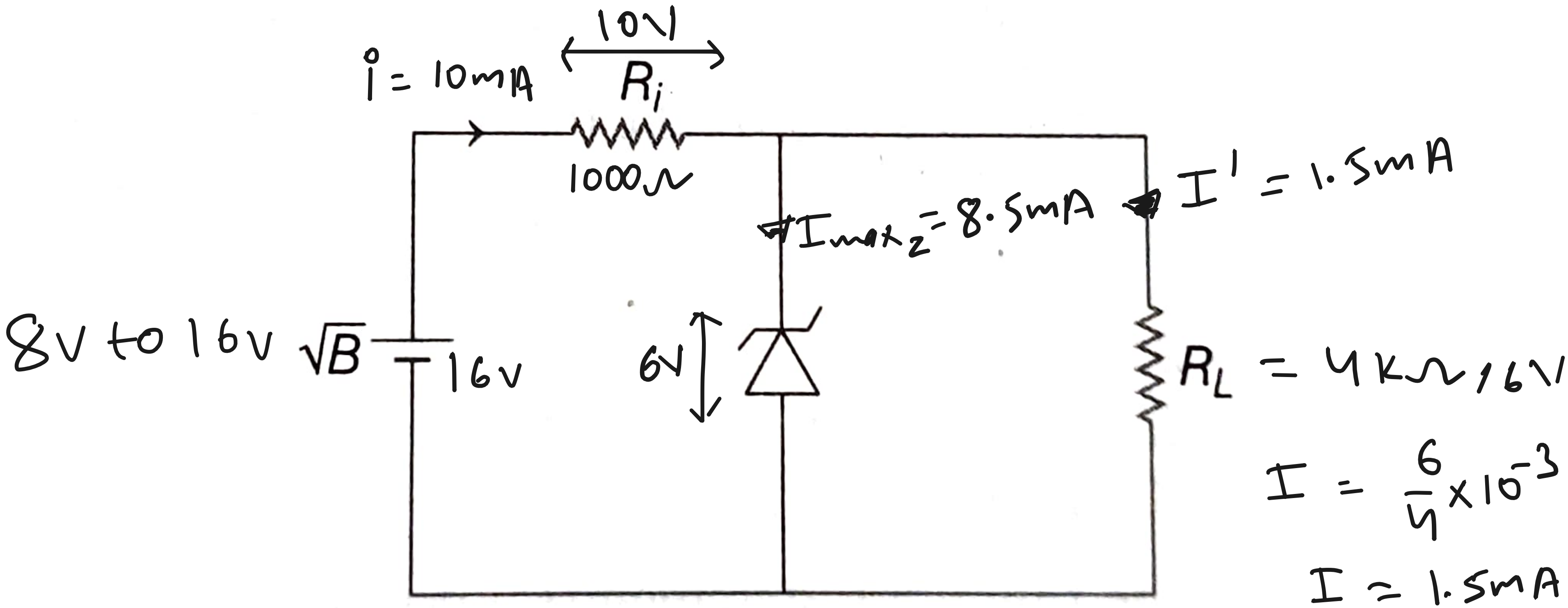
(c)

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

(d)

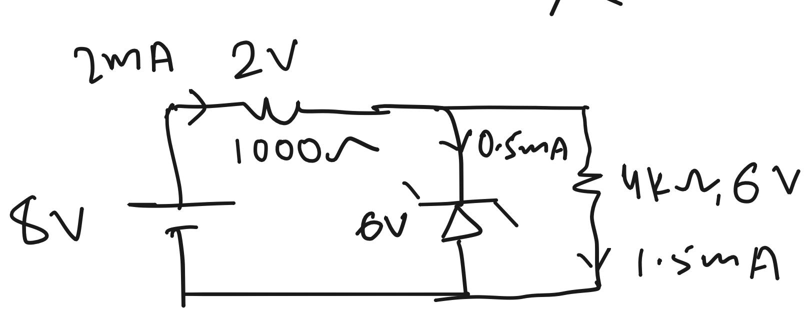
A	B	Y
0	0	0
0	1	0
1	0	1
1	1	1

4. The figure represents a voltage regulator circuit using a Zener diode. The breakdown voltage of the Zener diode is 6 V and the load resistance is $R_L = 4\ k\Omega$. The series resistance of the circuit is $R_i = 1\ k\Omega$. If the battery voltage V_B varies from 8V to 16V, what are the minimum and maximum values of the current through Zener diode? **(Main 2019, 10 April II)**



(a) 1.5 mA, 8.5 mA (b) 1 mA, 8.5 mA

(c) 0.5 mA, 8.5 mA (d) 0.5 mA, 6 mA



2mA
2V
1000Ω
0.5mA
4kΩ, 6V
8V
6V
1.5mA

5. An *n-p-n* transistor operates as a common emitter amplifier, with a power gain of 60 dB. The input circuit resistance is 100 Ω and the output load resistance is 10 kΩ. The common emitter current gain β is **(Main 2019, 10 April I)**

(a) 10^2 (b) 6×10^2 (c) 10^4 (d) 60

Power gain in decible.

$$\beta = \frac{I_C}{I_B} = ?$$

Power gain $\rightarrow A_p = 10\log_{10}\left(\frac{\text{out put power}}{\text{Input power}}\right)$

$$60 = 10\log_{10}\frac{P_{out}}{P_{in}}$$

$$10^6 = \frac{P_{out}}{P_{in}}$$

$R_{in} = 100\Omega$, $R_{out} = 10k\Omega$

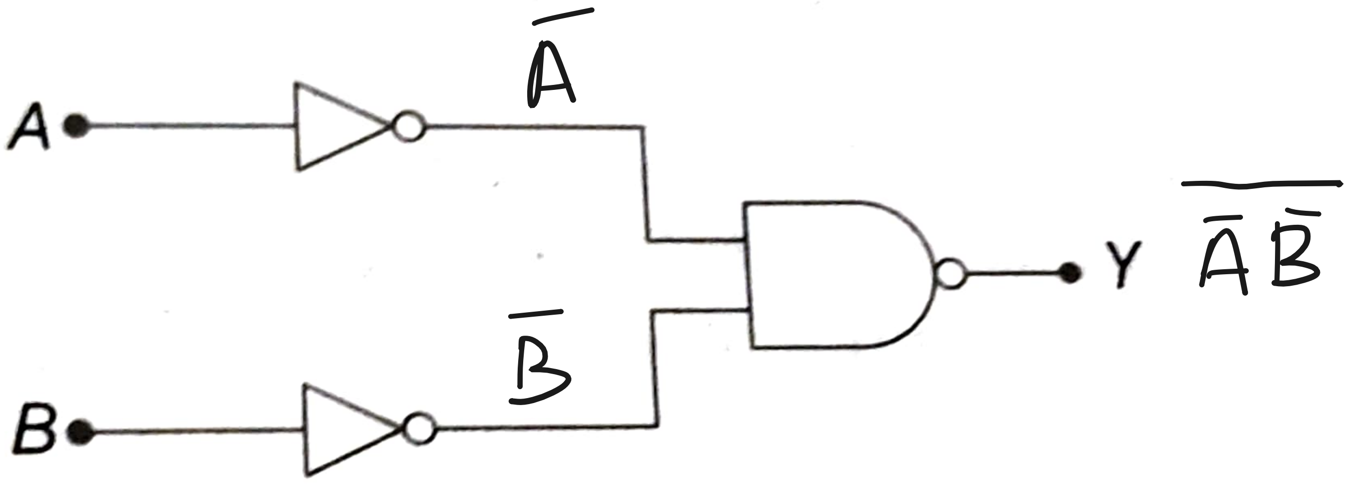
$$A_p = \beta^2 \frac{R_L}{R_{in}}$$

$$10^4\ 10^6 = \beta^2 \times \frac{10\times10^{32}}{100}$$

, $\beta = 10^2$

6. The logic gate equivalent to the given logic circuit is

(Main 2019, 9 April II)



(a) NOR (b) NAND (c) OR (d) AND

$$\bar{A}\bar{B} = \overline{A+B}$$

$$\overline{\bar{A}\bar{B}} = \overline{\overline{A+B}} = A+B$$

7. An *n-p-n* transistor is used in common emitter configuration as an amplifier with 1 kΩ load resistance. Signal voltage of 10 mV is applied across the base-emitter. This produces a 3 mA change in the collector current and 15 μA change in the base current of the amplifier. The input resistance and voltage gain are **(Main 2019, 9 April I)**

(a) 0.67 kΩ, 200
(b) 0.33 kΩ, 1.5
(c) 0.67 kΩ, 300
(d) 0.33 kΩ, 300

$\Delta I_C = 3mA$, $\Delta I_B = 15\mu A$

$A_v = \frac{V_0}{V_i}$, $V_{out} = I_C R_L = \frac{3\cancel{m}A \times \cancel{10^3}}{10 \times 10^{-3}}$

$A_v = \frac{300\cancel{0}}{1\cancel{0}} = 300$

$V_i = I_B R_i$

$10 \times \cancel{10^{-3}} = 15 \times \cancel{10^{-6}}\ R_i$ (with 10^{-3} written above)

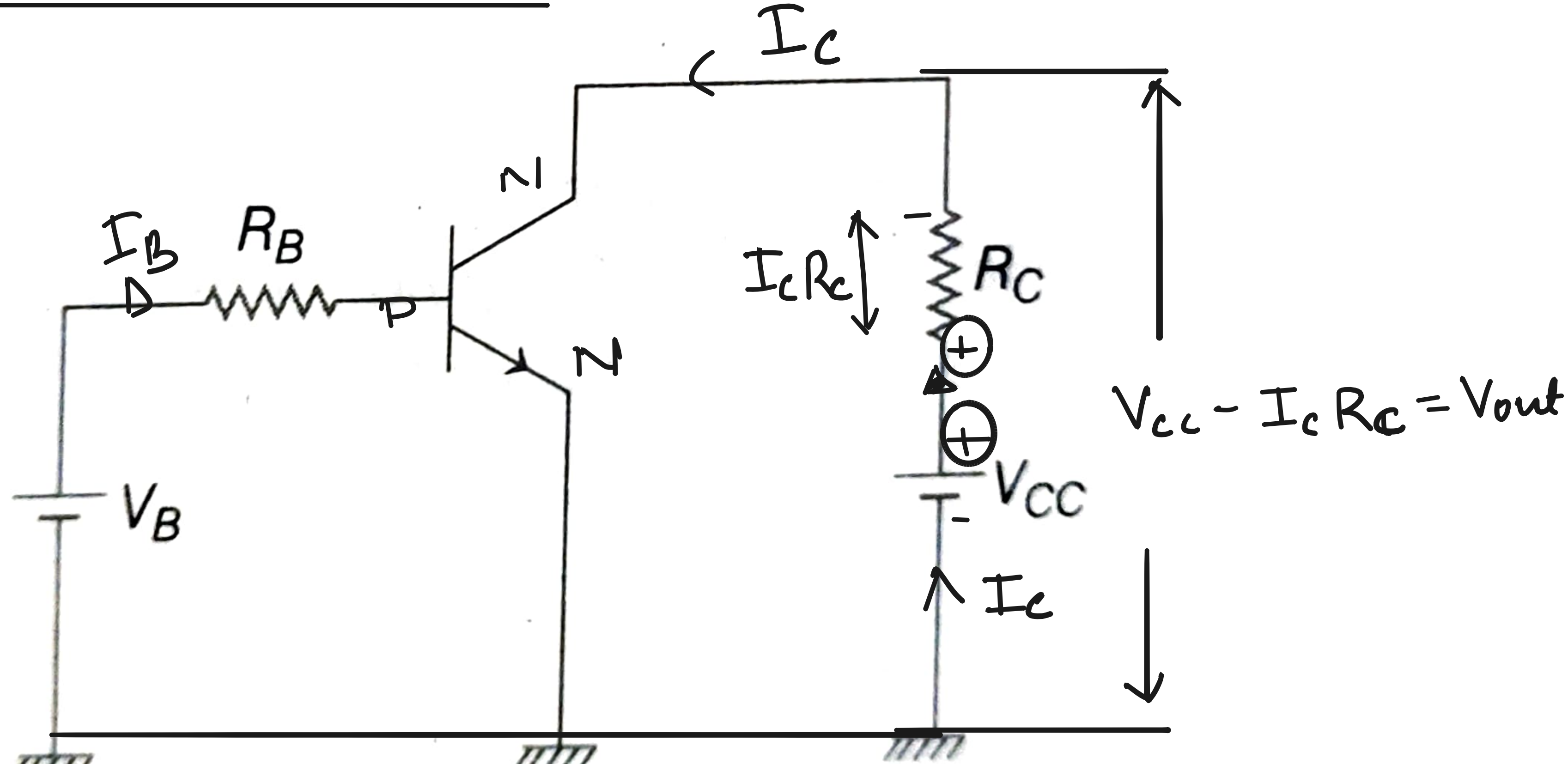
$\frac{10}{15} \times 1000 = R_i = 667$

8. A common emitter amplifier circuit, built using an *n-p-n* transistor, is shown in the figure. Its DC current gain is 250, $R_C = 1\,\text{k}\Omega$ and $V_{CC} = 10\,\text{V}$. What is the minimum base current for V_{CE} to reach saturation? **(Main 2019, 8 April II)**

$\frac{I_C}{I_B} = 250 = \beta$

$R_C = 10^3\,\Omega$

$V_{CC} = 10$ volts.



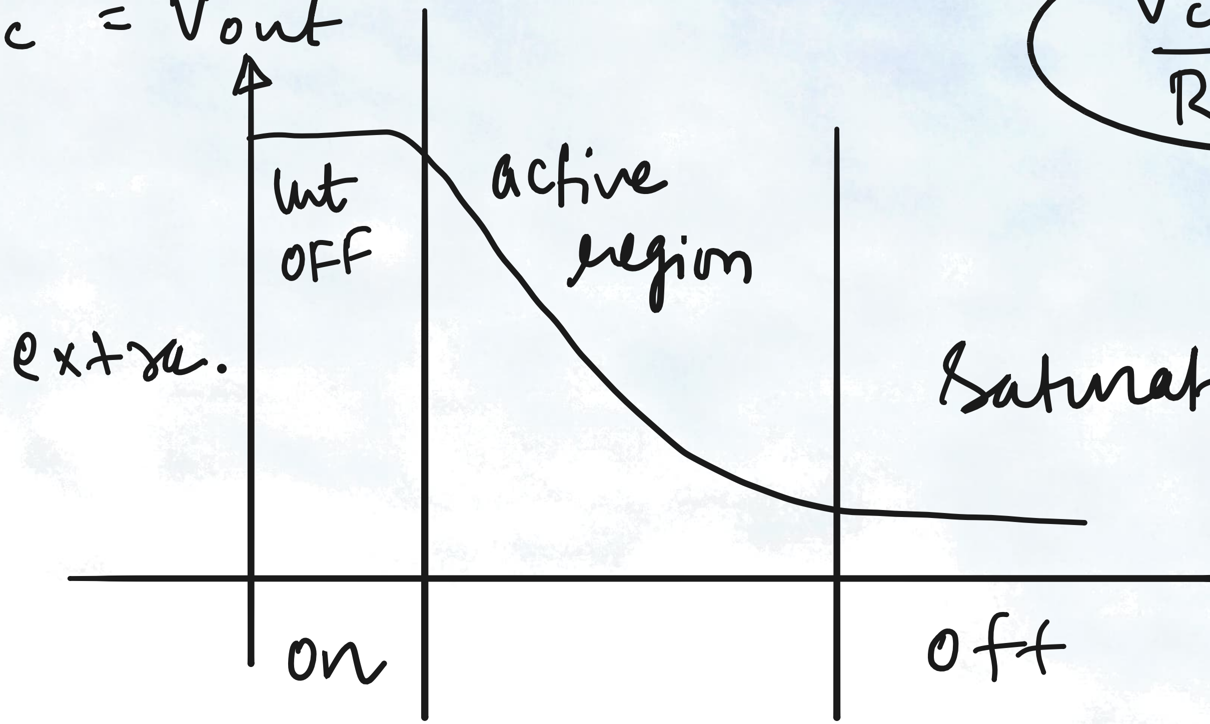
(a) 40 μA (b) 10 μA (c) 100 μA (d) 7 μA

Saturation means $V_{cc} - I_c R_c = 0$

$V_{cc} - I_c R_c = V_{out}$

$$\frac{V_{cc}}{R_c} = I_c$$

$$\frac{10}{10^3} = I_c = 10\,mA$$

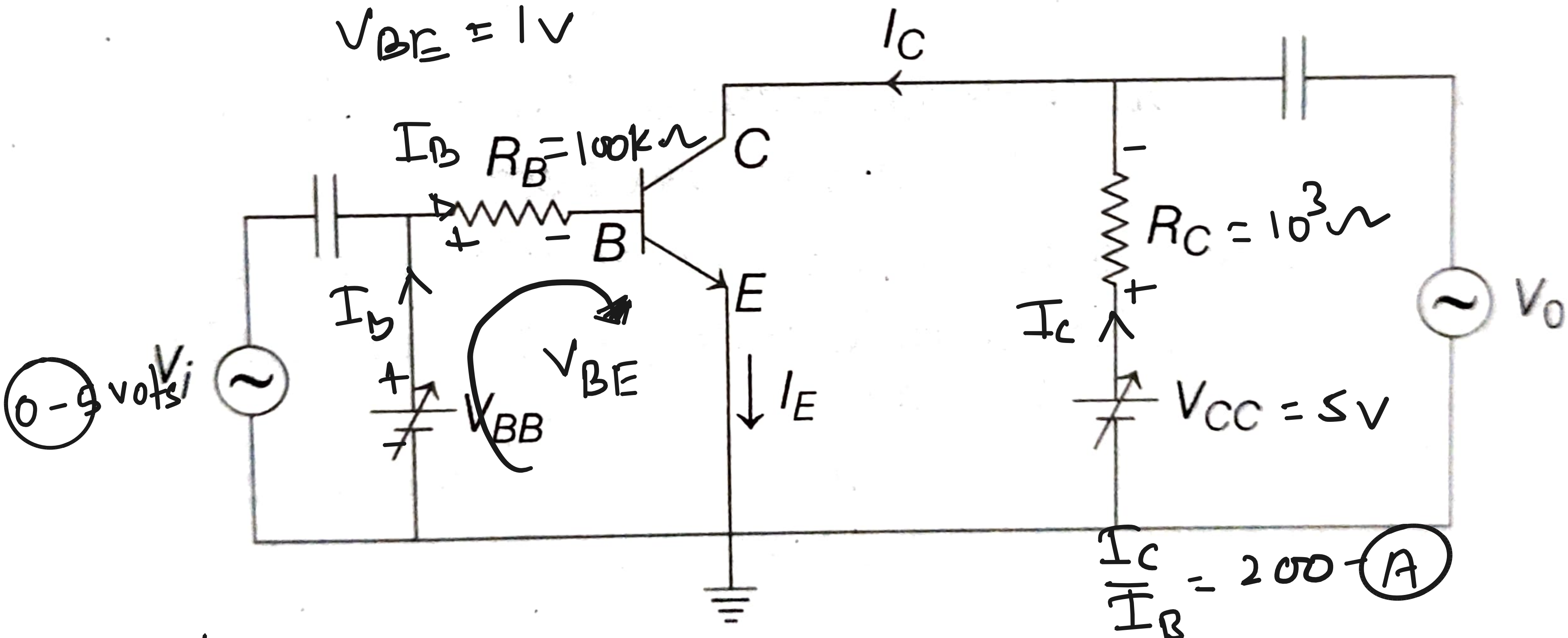


Saturation region

$$\frac{I_c}{I_B} = \beta = 250$$

$$\frac{10 \times 10^{-3}}{I_B} = 250, \quad I_B = \frac{10 \times 10^{-3}}{250} = 40\,\mu A$$

9. In the figure, given that V_{BB} supply can vary from 0 to 5.0 V, $V_{CC} = 5$ V, $\beta_{DC} = 200$, $R_B = 100$ k Ω, $R_C = 1$ k Ω and $V_{BE} = 1.0$ V. The minimum base current and the input voltage at which the transistor will go to saturation, will be, respectively **(Main 2019, 12 Jan II)**



(a) 25 μA and 2.8 V
(b) 25 μA and 3.5 V
(c) 20 μA and 3.5 V
(d) 20 μA and 2.8 V

$$V_{CC} - I_C R_C = 0 \quad \text{at saturation.}$$

$$5 - 10^3 I_C = 0$$

$$I_C = 5\,mA.$$

$$\beta = 200 = \frac{I_C}{I_B}$$

$$I_B = \frac{I_C}{200} = \frac{5\,mA}{200} = 25\,\mu A$$

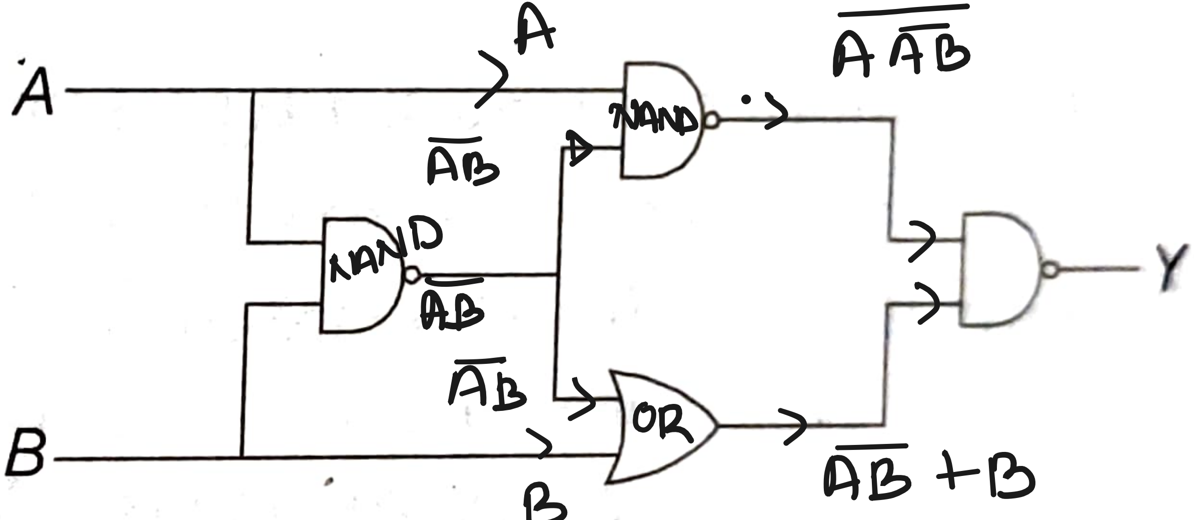
$$V_{BE} = V_{BB} - I_B R_B$$

$$10^{-1}$$

$$1 = V_{BB} - 25 \times 10^{-6} \times ~~100~~ \times 10^3$$

$$V_{BB} = 1 + 2.5 = 3.5\,V$$

10. The output of the given logic circuit is (Main 2019, 12 Jan I)



(a) $A\overline{B}$ (b) $\overline{A}B$ (c) $AB + \overline{AB}$ (d) $A\overline{B} + \overline{A}B$

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

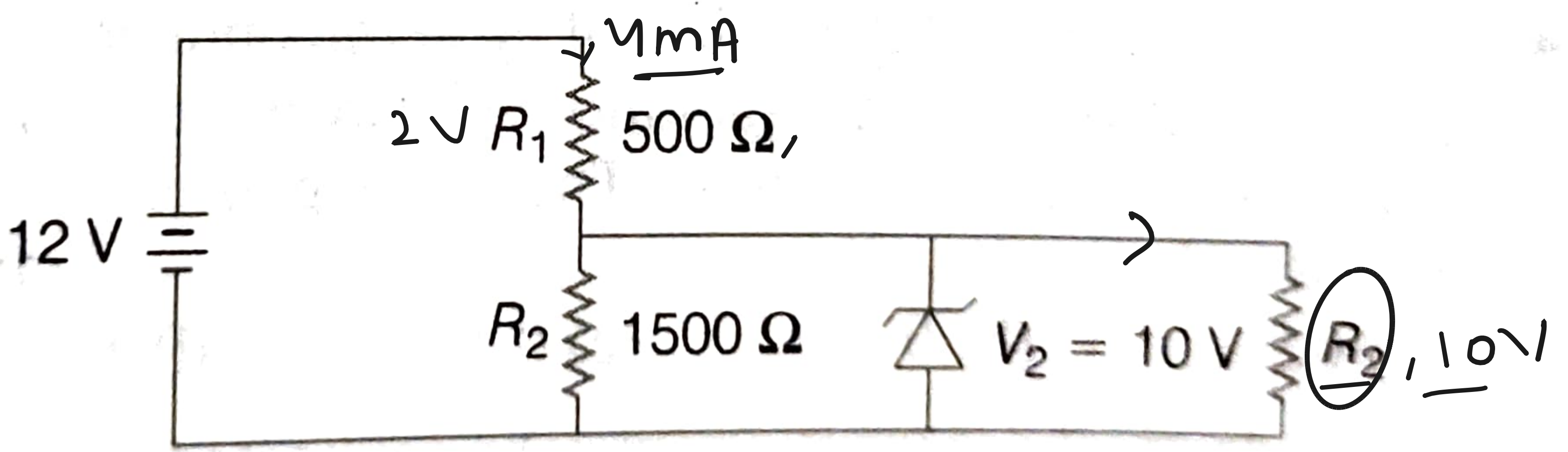
A	B	Y	$A\overline{B}$	$\overline{A}B$	$AB+\overline{AB}$	$A\overline{B}+\overline{A}B$
0	0	0	0	0	1	0
0	1	0	0	1	1	1
1	0					
1	1					

$$y = \overline{\overline{0\times 1}\,(1+0)}$$

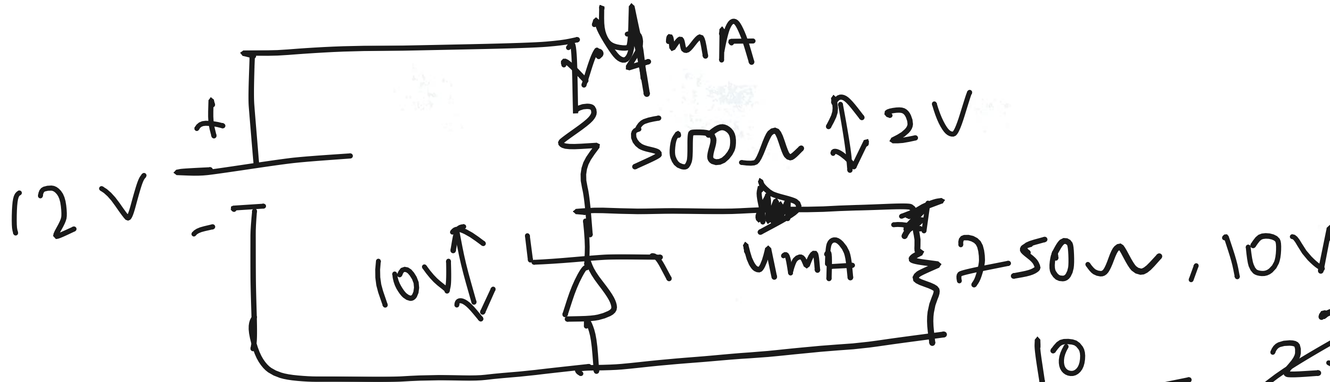
$$= \overline{1\times 1} =$$

$$y = \overline{\overline{0\times 1}\,(1)} = \overline{1\times 1} = 0$$

12. In the given circuit, the current through zener diode is closed to **(Main 2019, 11 Jan I)**



(a) 6.0 mA (b) 6.7 mA (c) 0 (d) 4.0 mA



$$\frac{10}{750} = \frac{2}{150} = 13.33\,mA$$

Not possible.