CHAPTER-14
Semiconductor Electronics

1. Give the classification of materials on the basis of their conductivity.

Ans: On the basis of conductivity, materials can be classified into:

(i) **Metals**: They possess very low resistivity (or high conductivity).

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

$\sigma \sim 10^{2} - 10^{8}\ Sm^{-1}$

(ii) **Semiconductors:** They have resistivity or conductivity intermediate to metals and insulators.

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

$\sigma \sim 10^{5} - 10^{-6}\ Sm^{-1}$

(iii) **Insulators**: They have high resistivity (or low conductivity).

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

$\sigma \sim 10^{-11} - 10^{-19} Sm^{-1}$

2. Define **energy band** in solids

Ans: In solids atoms are very close to each other. So the outer orbits of electrons in neighbouring atoms come very close to each other or even overlap. Inside a crystal each electron has a unique position and no two electrons have exactly the same pattern of surrounding charges. So the energy level of each electron is different. And these energy levels are very close to each other so that they can be treated as continuous. **The range of energy possessed by the electrons in a solid is called the energy band.**

3. Define valence band, conduction band and forbidden energy gap.

Ans: **Valence band is the range of energy possessed by the valence electrons.** It is the most occupied band.

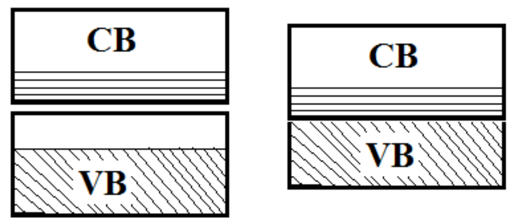
Conduction band is the range of energy possessed by the conduction electrons. It is the least occupied band.

The energy difference between the bottom of the conduction band and the top of the valence band is called the forbidden energy gap.

4. Draw the energy band diagram of (a) metals (b) semiconductors and (c) insulators

Ans:

(a) Metals



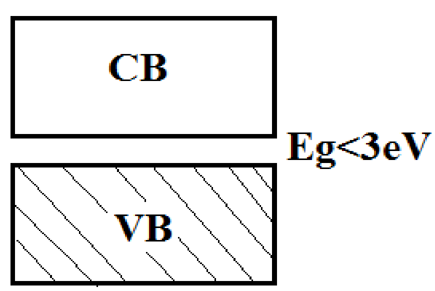
(i) **(ii)**

In metals there are two cases:

(i) In certain metals the conduction band is partially filled and the valence band is partially empty. Then the electrons in the lower levels of valence band move to its higher levels making conduction possible.

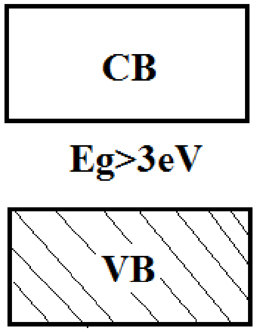
(ii) In some other metals the valence band and the conduction band overlap each other. Then the electrons in the valence band can easily move to the conduction band.

(b) Semiconductor



In semiconductors there is a small energy gap (**E_g<3eV**) between the valence band and the conduction band.

(c) Insulator



In insulators there is a large energy gap (E_g>3eV) between the valence band and the conduction band.

5. Explain the temperature dependence of metals and semiconductors based on band theory.
Ans: As the temperature increases in a **metal** the electrons in the valence band get enough energy to reach the conduction band. As the number of free electrons increases the number of collisions increases. So the resistance of a metal increases with temperature.

At absolute zero of temperature there are no electrons in the conduction band of a **semiconductor**. As the temperature increases electrons in the valence band get enough energy to reach the conduction band. So the resistance of semiconductors decreases with temperature.

6. Give examples for semiconductors.
Ans: Germanium (Ge), Silicon (Si) etc. are examples for semiconductors in pure state. Gallium arsenide (GaAs), indium phosphide (InP) etc. are examples for semiconductors in the compound state.

7. What are the two types of semiconductors?
Ans: Intrinsic semiconductors and extrinsic semiconductors.

8. What are intrinsic semiconductors?
Ans: They are the semiconductors in the pure state.

9. What are the methods to increase the conductivity of an intrinsic semiconductor?
Ans: The conductivity of a semiconductor can be increased by
(i) Heating and (ii) Doping

10. What is doping?
Ans: The process of adding impurities to an intrinsic semiconductor so as to increase its conductivity is called doping.

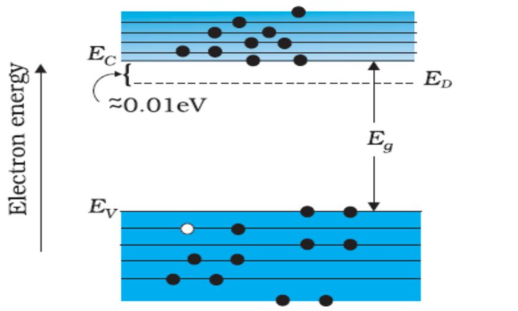
11. What are extrinsic semiconductors?
Ans: Doped semiconductors are called extrinsic semiconductors.

12. Which are the two types of extrinsic semiconductors?
Ans: Extrinsic semiconductors are of two types: (i) n-type and (ii) p-type

13. What is an **n-type** semiconductor?
Ans: When a pentavalent impurity like **As** is added to an intrinsic semiconductor **Ge** or **Si** crystal, an n-type semiconductor is formed. Corresponding to e ach impurity atom added a free electron is created in the crystal.

In an n-type semiconductor electrons are the majority charge carriers and holes are the minority charge carriers. $n_e >> n_h$

14. Draw the **donor energy level** in the energy band diagram.
Ans: It is the energy level of free electron, donated by the pentavalent impurity atoms in an n-type semiconductor.



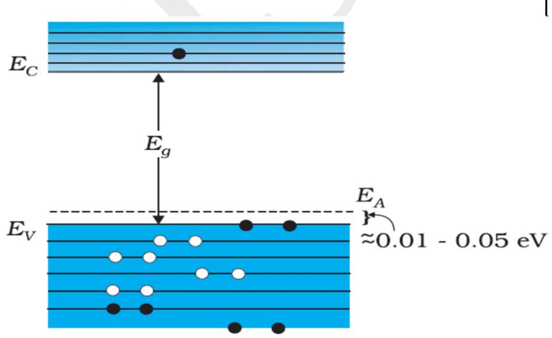
(a) $T > 0K$
one thermally generated electron-hole pair + 9 electrons from donor atoms

15. Which are the pentavalent impurities or donor impurities?
Ans: The 15[th] group elements like As, Sb, P, Bi etc. are examples of pentavalent impurities.

16. What is a **p-type** semiconductor?
Ans: When a trivalent impurity like **In** is added to an intrinsic semiconductor **Ge** or **Si** crystal, an p-type semiconductor is formed. Corresponding to each impurity atom added a free hole is created in the crystal.

In a p -type semiconductor holes are the majority charge carriers and electrons are the minority charge carriers. $n_h >> n_e$

17. Draw the **acceptor energy level** in the energy band diagram.
Ans:

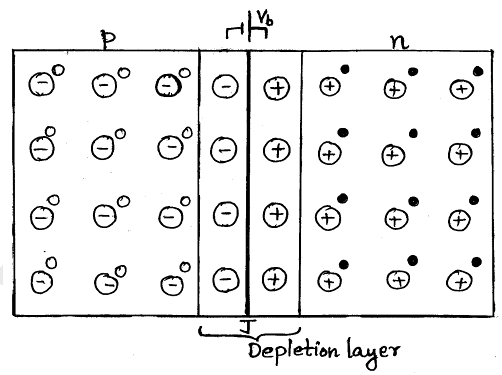


(b) $T > 0K$

18. Which are the trivalent impurities?
Ans: The **13**[th] group elements like **In**, **B**, **Al**, **Ga** etc. are examples of trivalent impurities.

19. **n-type** semiconductor is electrically neutral. Explain?
Ans: Corresponding to each free electron, there are positive impurity ions or thermally generated holes in the crystal. So the charges balanced. And the n-type semiconductor is electrically neutral.

20. Explain the formation of p-n junction diode. Give the symbol of diode
Ans:



A half of a semiconductor crystal like Ge or Si is doped with trivalent impurities and the other half is doped with pentavalent impurities.

Depletion Layer

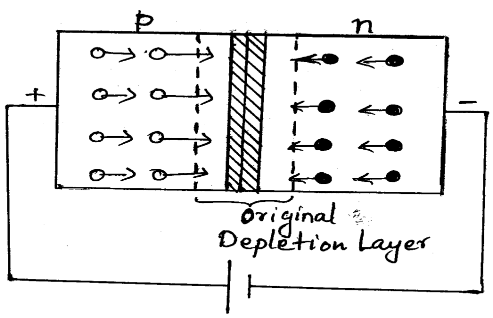
During the formation of the p-n junction, electrons from the n-side and holes from the p-side, move towards the junction and neutralize each other. Thus in a small region near the junction, there are no free electrons and holes. This region is called depletion layer.

Potential Barrier

In the depletion layer, there are a large number of negative ions on the p-side of the junction and a large number of positive ions on the n-side. This creates a negative potential on the p-side of the junction and a positive potential on the n-side. This prevents the further flow of electrons to the p-side and holes to the n-side. Therefore, the potential difference at the junction is called potential barrier.

21. Give the values of barrier voltage for a **Ge** and **Si** diode.
Ans: The barrier voltage of a **Ge** diode is **0.2V** and that of a **Si** diode is **0.7V**.

22. Explain the **forward biasing** of a diode.
Ans:

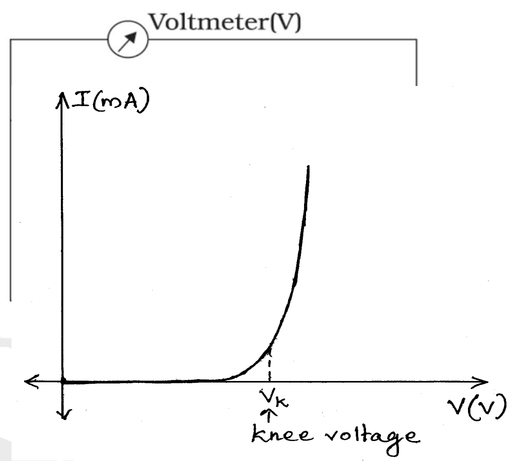


In the forward biasing, the positive terminal of the cell is connected to the p-region and the negative terminal is connected to the n-region.

The effective voltage during forward bias is (V_b-V). When forward biased voltage is greater than the barrier voltage (built in potential), due to the repulsion from the forward biasing, holes from the p-side cross the depletion layer and reach n-side and electrons from the n-side cross the depletion layer and reach the p-side. This is called **minority carrier injection**. Now because of the concentration gradient, the holes diffuse from the junction edge of n-side to the other edge. Similarly, the electrons diffuse from the junction edge of the p-side to the other edge. This motion of charge carriers on either side gives rise to a current. The total diode forward current is the sum of **hole diffusion current** and **conventional current due to the electron diffusion**.

23. What happens to the width of the depletion layer in the forward biasing?
Ans: Width of the depletion layer decreases.

24. Draw the **forward characteristics** of a diode.
Ans: The circuit diagram to draw the forward characteristics of diode is given below:

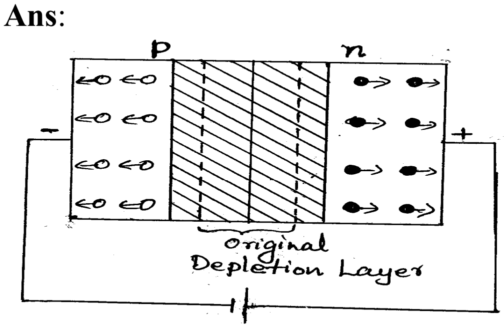


The forward characteristic is given below:

25. Define **knee voltage**.
Ans: The forward voltage after which the current through a diode increases linearly with voltage is called knee voltage.

26. Does diode obey Ohm's law?
Ans: No. The V-I graph of a diode is non-linear.

27. Explain the **reverse biasing** of a diode.
Ans:



In the reverse biasing of a diode, the positive terminal of the cell is connected to the n-region and the negative terminal is connected to the p-region.

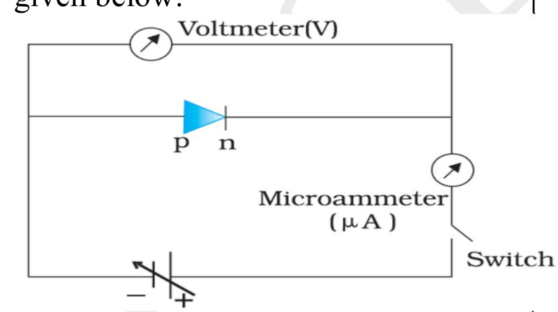
The effective voltage during reverse bias is (V_b+V). When a diode is reverse biased, due to the attraction from the reverse biasing, holes and electrons move away from the junction. The width of the depletion layer increases. No current flows through the junction. But if we increase the reverse voltage to a very high value (called breakdown voltage) then the current increases very sharply. But the diode gets damaged due to overheating.

28. What happens to the width of the depletion layer in reverse biasing of a diode?

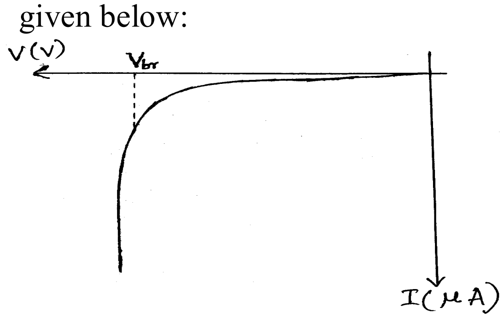
Ans: Width of the depletion layer increases.

29. Draw the **reverse characteristics** of a diode.

Ans: The circuit diagram to draw the reverse characteristics of diode is given below:



The reverse characteristic is given below:



30. Define **reverse breakdown voltage**.

Ans: The reverse voltage at which the current increases sharply is called reverse breakdown voltage.

31. What is meant by **Leakage current** (reverse saturation current)?

Ans: In the reverse bias of a diode if a voltage less than the breakdown voltage is applied very small current flows through the diode due to the minority charge carriers. This current is called leakage current.

Rectifier

32. What is meant by the unidirectional property of a diode?

Ans: Diode conducts only when it is forward biased. This is called the unidirectional property of the diode.

Because of this unidirectional property, diode is used as a rectifier.

33. What is a **rectifier**?

Ans: Rectifier is a device which converts AC to DC.

34. What is meant by rectification?

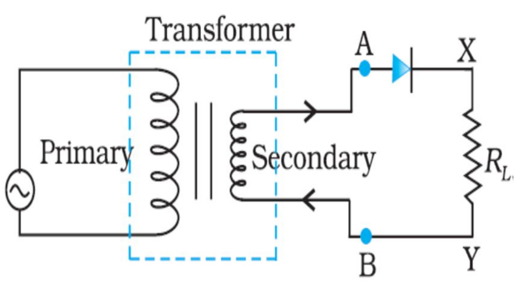
Ans: Rectification is the process of converting AC to DC.

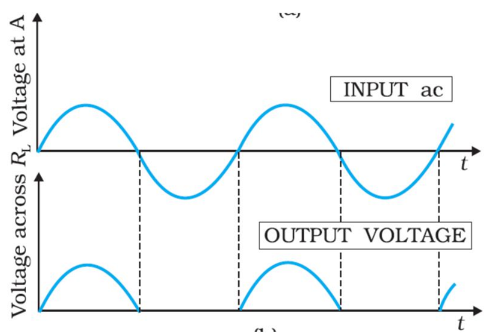
35. (i) Draw the circuit diagram of a **half wave rectifier**. Draw the input and output wave forms.

(ii) Explain the working of a half wave rectifier.

(iii) What is the efficiency of a half wave rectifier?

Ans: (i)





(ii) At the positive half cycles of the input at A, the diode is forward biased and a current flows through the diode. Thus an output voltage is produced across load resistor R_L.

At the negative half cycles of input at A, the diode becomes reverse biased and no current flows through the diode. Thus no output is produced across R_L.

Thus there is output only for the positive half cycles of the input AC. So the rectifier is called a half wave rectifier.

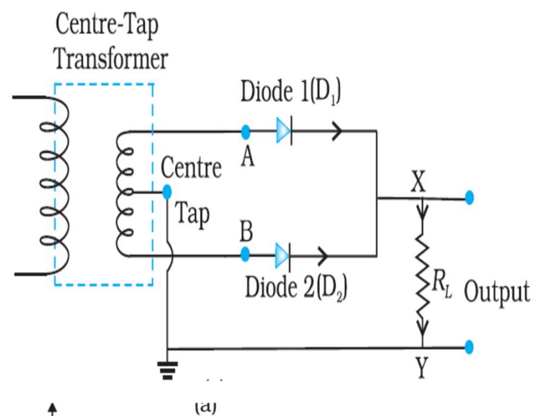
(iii) The efficiency of a half wave rectifier is about 40.6%.

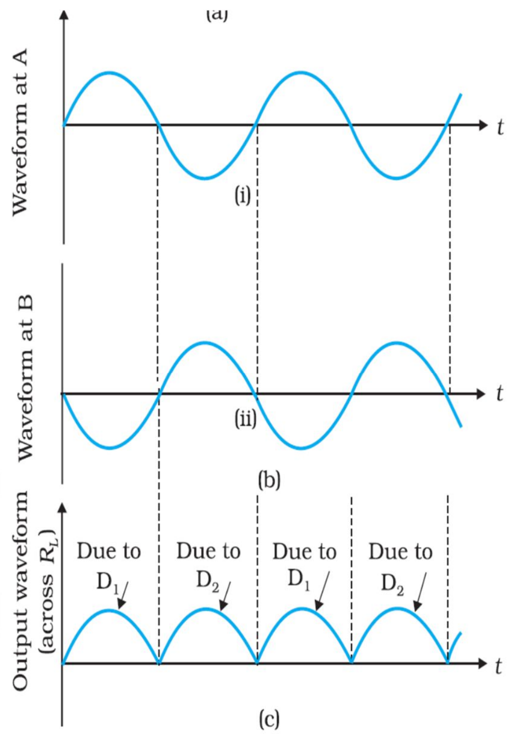
36. (i) Draw the circuit diagram of a **full wave rectifier**. Draw the input and output wave forms.

(ii) Explain the working of a full wave rectifier.

(iii) What is the efficiency of a full wave rectifier?

Ans: (i)





(ii) For the positive half cycles of the input at A, the diode D_1 is forward biased and D_2 reverse biased and a current flows through the diode D_1. Thus an output voltage is produced across load resistor R_L.

For the negative half cycles of input at B, the diode D_1 becomes reverse biased and diode D_2 forward biased and a current flows through the diode D_2. Thus an output is produced across R_L.

Thus there is output for both the positive and negative half cycles of the input AC. So the rectifier is called a full wave rectifier.

(iii) The efficiency of a half wave rectifier is about 81.2%.

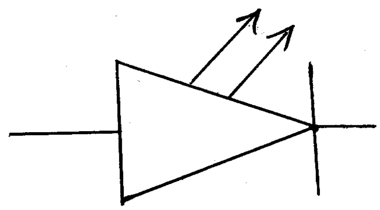
37. Which are the special diodes?

Ans: There four special diodes:

(i) Light emitting Diode
(ii) Photodiode
(iii) Solar Cell
(iv) Zener Diode

38. Explain the principle and working of a Light Emitting Diode (**LED**)

Ans:



When LED is forward biased, electrons from the bottom of the CB falls into the top of the VB and during this, energy equal to Eg (Band gap) is released.

$$E_g = h\nu \qquad \Rightarrow \nu = \frac{E_g}{h}$$

Thus light of frequency υ is emitted. The colour of light emitted from the LED depends on the nature of the semiconductor used (E_g of the semiconductor).

The material used to make LED should have enough no. of electrons and holes i.e., it should be heavily doped.

To produce **visible light**, the LED's should be made with semiconductors having band gap of **1.8eV – 3eV**. The compound semiconductor Gallium Arsenide Phosphide (**$GaAs_{1-x}P_x$**) is used for making LEDs of different colours. **$GaAs_{0.6}P_{0.4}$ (Eg ~ 1.9eV)** is used for **red LED**. GaAs (**Eg ~1.4eV**) is used for making **infrared LED**.

39. What are the **uses of LED**s?

Ans: Used in remote controls, burglar alarm systems, optical communication etc.

40. What are the **advantages of LED**s over conventional incandescent low power lamps?

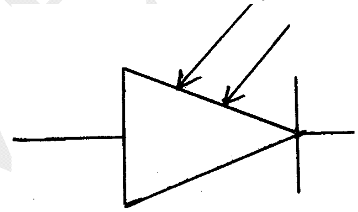
Ans: The following are the advantages:

(i) Low operational voltage and less power.
(ii) Fast action and no warm up time required.
(iii) Emitted light is nearly monochromatic.
(iv) Long life.
(v) Fast on-off switching capacity.

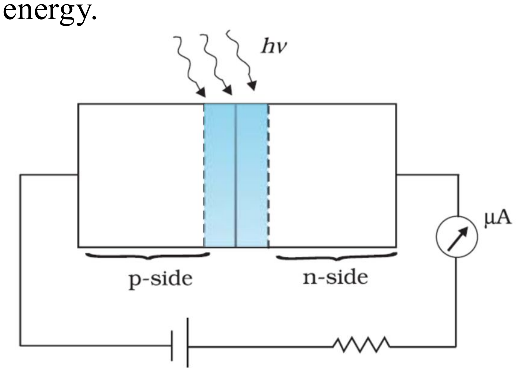
41. Explain the principle and working of a **photodiode**

Ans:

Photodiode is connected in reverse bias with a battery.



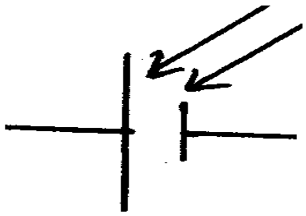
If photon of energy greater than the band gap is incident on the diode, it will excite an electron from the **VB** to the **CB**, creating a hole in the valence band. These additional charge carriers developed near the junction increases the conductivity of the diode. Thus light energy is converted into electric energy.



__Use:__ photo diode is used as light detector in camera and other optical instruments.

42. Explain the construction and working of a **solar cell.**

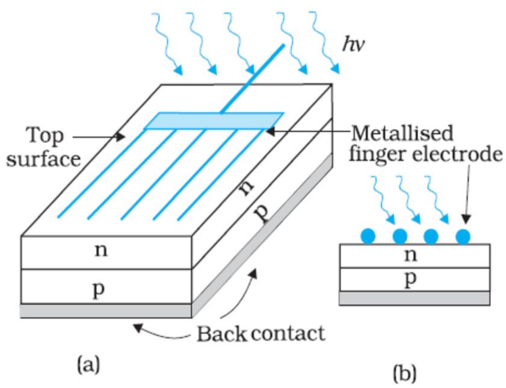
Ans:



Solar cell is a junction diode used to convert solar energy into electrical energy.

The n- region is thin and transparent and the p – region is thick.

The p-end is coated with a metal (**back contact**). A metal finger electrode (or metallic grid) is deposited at the n-end. This acts as a **front contact**.

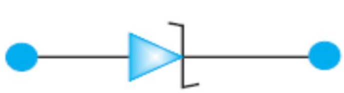


When light falls on the n –region, it reaches the junction and electron hole pairs are created close to the junction. **These electrons and holes are separated by the potential barrier at the junction**. Electrons are swept to the n- side and holes to the p- side. Electrons are collected by the front contact and the holes by the back contact. Thus p-side becomes positive and n- side becomes negative giving rise to **photovoltage**.

<u>**Note:**</u> - solar cell does not need any biasing.

43. Explain the principle and working of a **Zener Diode**

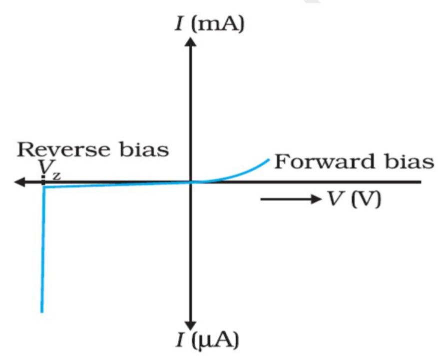
Ans:



Zener diode is used in the reverse bias, in the breakdown region. **Zener diode has a sharp break down voltage. In the break down region, the voltage across the diode remains constant for a wide range of current.**

44. Explain Zener breakdown

Ans: The zener diode is heavily doped. So the depletion layer is very thin ($d < 10^{-6}$m). So the electric field at the junction becomes very large even for a small reverse voltage about 5V.



$$E = \frac{V}{d} = \frac{5}{10^{-6}} = 5 \times 10^{6}\ V/m$$

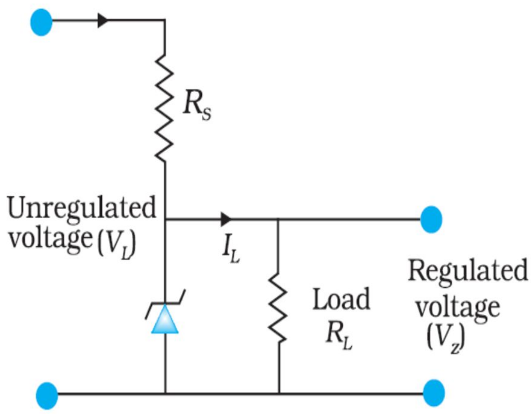
This electric field is enough to carry out internal field emission. At a particular voltage called the Zener voltage, the valence electrons from the host atoms on the p-side are pulled out and these electrons are accelerated to the n-side. Thus the current increases to a large value but can be controlled by using some external resistances.

45. Explain how a Zener diode acts as a **voltage Regulator (stabilizer)**

Ans: The Zener diode is used as a voltage regulator because **in the break down region, the voltage across the diode remains constant for a wide range of current.**

When the dc supply voltage increases beyond the break down voltage, the current through the circuit increases and the voltage drop across R_Z increases. But the voltage across the Zener diode remain constant.

When the supply voltage



decreases, the current through the circuit decreases, voltage drop across R_Z decreases keeping the Zener voltage constant.

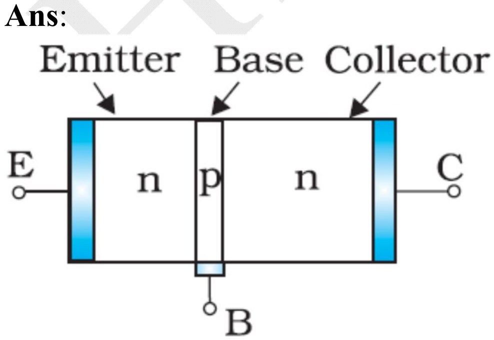
46. What is a transistor? Who invented transistor? Which are the two types of transistors?

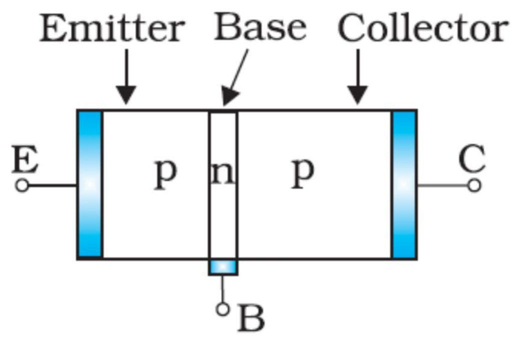
Ans: Transistor is obtained by the sand - witching of two p – n junctions. Transistor is invented by: J Bardeen and W.H. Brattain.
There are two types of transistors
(i) pnp and (ii) npn

Note: *There are different types of transistors but our study is limited to* ***BJT: B****ipolar* ***J****unction* ***T****ransistor*

47. Which are the three regions in of a transistor?

Ans:



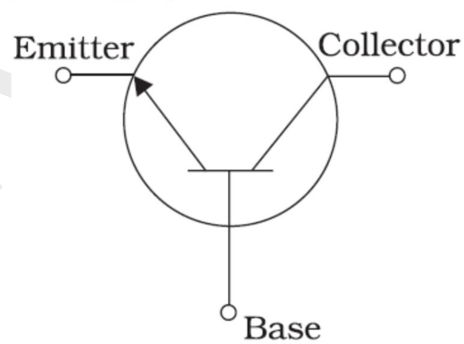


The three regions are:
Emitter, Base and Collector.
Collector is larger in size than emitter, which is larger than base.
Emitter is heavily doped, base is lightly doped and collector is moderately doped.

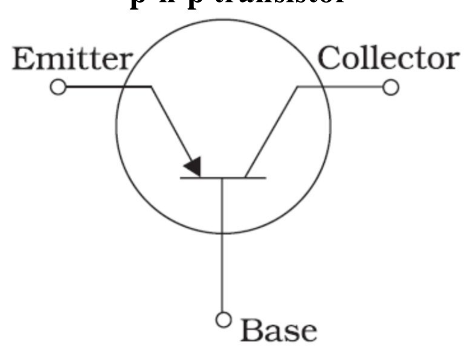
48. Draw the symbol of **n-p-n** and **p-n-p** transistors

Ans:

n-p-n transistor



p-n-p transistor

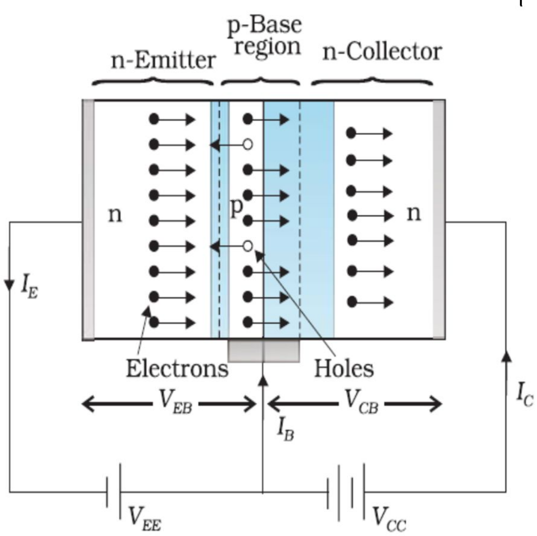


49. How a transistor is biased?

Ans: The emitter base junction is forward biased and the collector base junction is reverse biased.

50. Explain the **action of an n-p-n transistor**

Ans: The emitter base junction is forward biased and the collector base junction is reverse biased. Due to the repulsion by the forward biasing, the electrons from the emitter moves towards the base region. This constitutes the emitter current (I_E). Some of the electrons combine with the holes in the base region. This constitutes the base current. The rest of the electrons move towards the collector. This constitutes collector current.



$I_E = I_B + I_C$

Emitter base junction acts as a low resistance while the collector base junction acts as a high resistance.

51. Which are the three transistor configurations?

Ans:

1. <u>Common Base configuration (CB)</u>

Current Amplification factor $\alpha = \dfrac{\Delta I_C}{\Delta I_E}$

2. **<u>Common Emitter configuration (CE)</u>**

Current Amplification factor $\beta = \dfrac{\Delta I_C}{\Delta I_B}$

3. <u>Common Collector configuration (CC)</u>

Current Amplification factor $\gamma = \dfrac{\Delta I_E}{\Delta I_B}$

52. Derive the relation between α and β

Ans:

we have $\alpha = \dfrac{I_C}{I_E}$..............(1)

and $\beta = \dfrac{I_C}{I_B}$..............(2)

$\Rightarrow I_C = \beta I_B$..............(3)

We know

$I_E = I_B + I_C$..............(4)

substituting (3) in (4)

$I_E = I_B + \beta I_B$

$I_E = I_B(\beta + 1)$... ... ... (5)

But $\alpha = \dfrac{I_C}{I_E} = \dfrac{\beta I_B}{(\beta + 1) I_B}$

$\Rightarrow \alpha = \dfrac{\beta}{(\beta + 1)}$

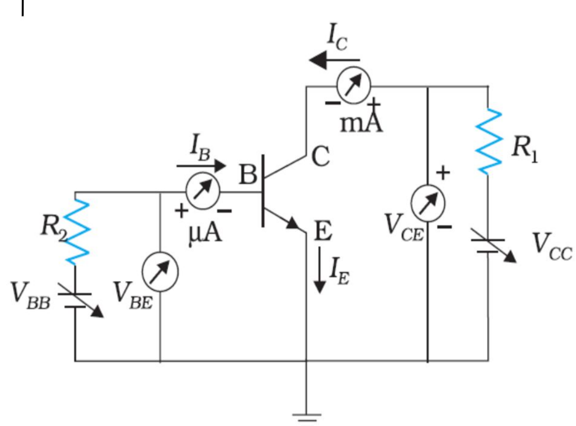
similarly we get

$\beta = \dfrac{\alpha}{1 - \alpha}$

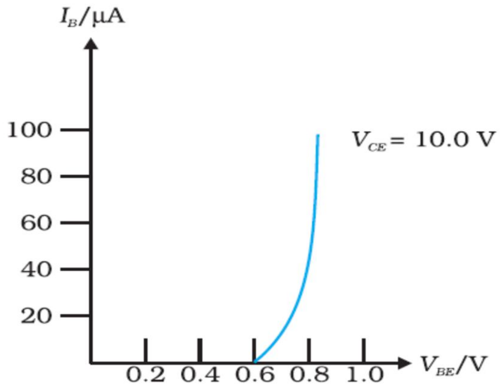
$$\alpha = \frac{\beta}{(\beta + 1)}, \beta = \frac{\alpha}{1 - \alpha}$$

53. Give the circuit diagram of transistor in CE configuration. And draw the common emitter **transistor characteristics**.

Ans:



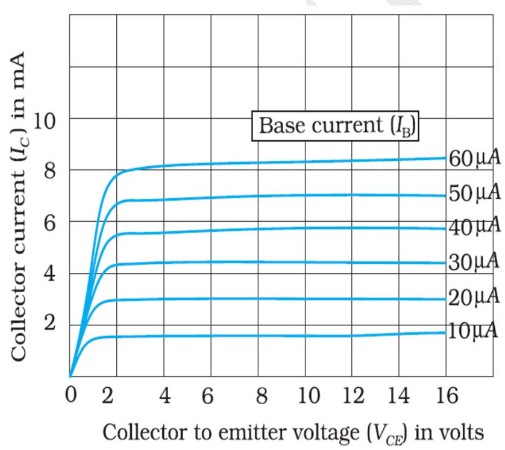
Input characteristics



Input characteristics is the graph between input voltage (**V_{BE}**) and input current (**I_B**) at constant **V_{CE}**.
The reciprocal of the slope of the graph gives the input resistance.

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

Its value changes with the operating current in the transistor.
The value of input resistance can be a few hundreds to a few thousand ohms.



Output characteristics

It is the graph between output voltage (**V_{CE}**) and output current (**I_C**) at constant input current (**I_B**).
For small values of V_{CE}, I_C increases almost linearly. This happens because the collector base junction is not reverse biased and the transistor is not in the active state.
The reciprocal of the slope of the linear part of the output characteristics gives the output resistance.
The output resistance is of the order of 100 kΩ

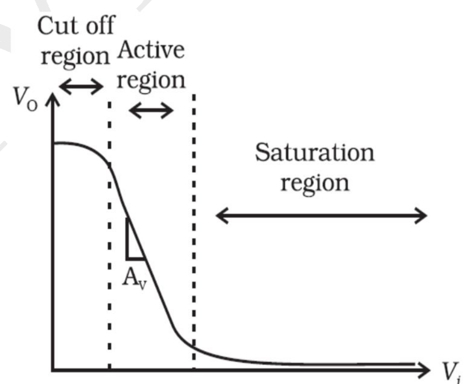
$$\text{Output resistance} \quad r_0 = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$$

Transistor as a device

54. Draw the **transfer characteristics** of a transistor. Also give the circuit diagram used for that. Explain the working of a transistor in CE configuration as a **switch**

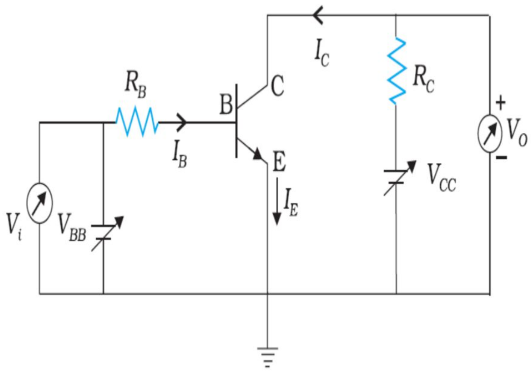
Ans:

$V_i - V_0$ curve or transfer characteristics



When a transistor is used in the cut off or saturation state, it acts as a switch.
If it is operated in the active region, it acts as an amplifier.

Circuit diagram



Applying Kirchhoff's voltage rule to the input and output sides of the circuit, we get

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

and $V_{CE} = V_{CC} - I_C R_C$

$[\therefore V_{CE} + I_C R_C = V_{CC}]$

V_{BB} is the d.c input voltage V_i and V_{CE} is the d.c output voltage V_0. So, we have

$V_i = I_B R_B + V_{BE}$

And $V_0 = V_{CC} - I_C R_C$

In the case of an npn silicon transistor, as long as the input V_i is less than 0.6V, the transistor will be in the cut off state and current I_C will be zero.

Hence $V_0 = V_{CC}$

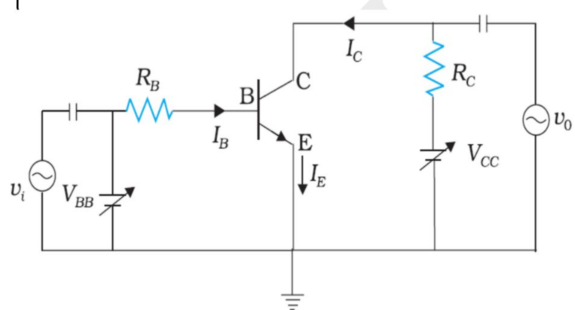
When V_i becomes greater than 0.6V, the transistor is in active state with some current I_C in the output path and the output V_0 decreases and the term $I_C R_C$ increases. With increase of V_i, I_C increases almost linearly and so V_0 decreases linearly till its value becomes less than about 1 V.

Beyond this, the change becomes non–linear and the transistor goes to saturation state. With further increases in V_i, the output voltage decreases further towards zero though it never becomes zero.

Very low inputs switch off the transistor but the output is high and very high voltages switch on the transistor but the output is low.

55. By drawing a circuit diagram, explain the working of a **CE transistor amplifier**. Give the expressions for the current gain, voltage gain and power gain.

Ans: **Amplifier is a device used to increase the amplitude of electrical signals.**



To operate the transistor as an amplifier we have to fix the operating point (the values of V_{CE} and I_B) somewhere in the middle of the active region.

The small sinusoidal voltage (ac signal) which is to be amplified is applied in series with V_{BB}. Then the base current will have sinusoidal variations superimposed on the value of I_B. We have $\Delta I_C = \beta \Delta I_B$, so the changes in the base current are amplified and we get amplified sinusoidal variations superimposed on the value of I_C. Large capacitor C_0 is used at the output to block dc voltages. The output is taken between the collector and the ground.

Current gain

$$\beta_{a.c} = \frac{\Delta I_C}{\Delta I_B}$$

Voltage gain

Applying Kirchhoff's voltage rule, to the input loop in the absence of signal , we have

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

When a signal v_i is applied, the changes in the voltages V_{BE} and $I_B R_B$ are respectively $\Delta \mathbf{I_B r_i}$ and $\Delta \mathbf{I_B R_B}$.

$$\mathbf{V_{BB} + v_i = V_{BE} + \Delta I_B r_i + I_B R_B + \Delta I_B R_B}$$

Therefore, the ac input signal voltage can be written as

$$\mathbf{v_i = \Delta I_B (R_B + r_i).}$$

Applying Kirchhoff's voltage rule to the output loop,we have

$$V_0 = V_{CC} - I_C R_c$$

The change in I_c due to change in I_B causes a change in the output voltage ΔV_{CE}

$$\Delta V_{CE} = \Delta V_{CC} - \Delta I_C R_C$$

Since V_{CC} is constant, $\Delta V_{CC} = 0$

$\therefore$ The ac output signal votage,

$$v_o = \Delta V_{CE} = -\Delta I_C R_C$$

The voltage gain is given by,

$$A_V = \frac{v_o}{v_i} = \frac{-\Delta I_C R_C}{\Delta I_B (R_B + r_i)}$$

$$= -\left(\frac{\Delta I_C}{\Delta I_B}\right)\frac{R_C}{(R_B + r_i)}$$

$$A_V = -\beta_{a.c}\frac{R_C}{(R_B + r_i)}$$

Power gain

Power gain = Voltage gain × Current gain

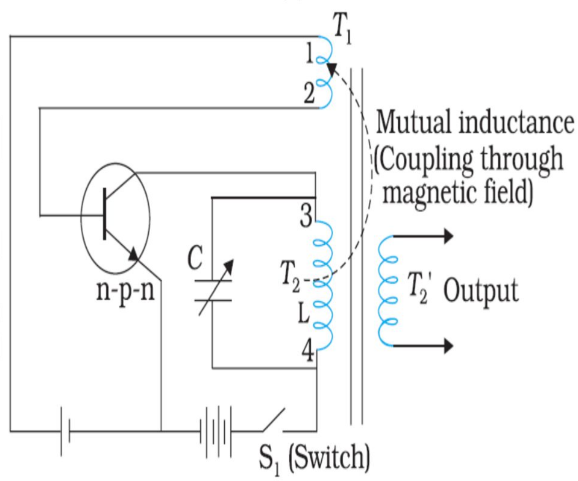
$$A_P = -\beta_{ac}\frac{R_C}{R_B + r_i} \times \beta_{ac}$$

$$= -\beta^2_{ac}\frac{R_C}{R_B + r_i}$$

56. Explain the working of a **transistor as an oscillator**.

Ans: An oscillator is a device used to produce electrical oscillations of desired frequency without using an external ac input signal.

Circuit diagram



An oscillator contains 3 parts:

(i) **Oscillatory circuit or tank circuit or tuned circuit**

A parallel combination of an inductor L and a capacitor C acts as the tank circuit. This LC circuit produces electrical oscillations of frequency,

$$f = \frac{1}{2\pi\sqrt{LC}}$$

But the oscillations produced by an LC circuit are damped oscillations. The feedback circuit compensates for the damping.

(ii) **Feedback circuit**

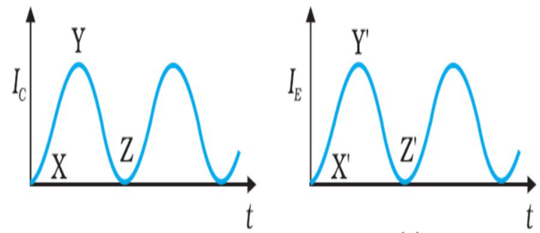
A portion of the output power is returned back (fed back) in to the input in phase with the input power. This is called positive feedback. The feedback can be achieved by inductive coupling.

(iii) **Amplifier**

A transistor in CE configuration is used as amplifier. The transistor amplifies the fed back voltage.

Working

When V_{CC} is switched on, the collector current starts increasing through the coil L. Due to back emf in the coil it cannot reach the full amplitude instantaneously. Due to mutual induction emf is induced in the coils T_1 and T_2'. The emf across T_2' is the output. The emf across T_1 is fed back to the input. This positive feedback increases the emitter current of the amplifier and the collector current also increases. Thus due to continuous positive feedback the collector current goes on increasing and reaches the maximum value (transistor becomes saturated). Now since the collector current has a constant value, no mutual induction occurs. Without continued feedback the collector current begins to fall. However, the decrease in collector current through the coil L induces emf in T_1. But this emf is in the opposite direction and it decreases the emitter current. So the collector current again decreases. This causes a further decrease in the emitter current and transistor goes to the cut-off state. Then I_E and I_C both become zero. The transistor now reached back to the original state. The whole process now repeats itself. The oscillation of collector current is shown in the diagram.



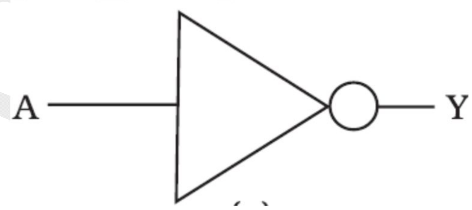
Digital Electronics and Logic gates

57. What are logic gates? What are their uses?

Ans: Logic gates are the building blocks of digital electronics which process the digital signal in a specific manner.

58. Draw the logic symbol, truth table and give the Boolean expression of a **NOT** gate (Inverter).

Ans:



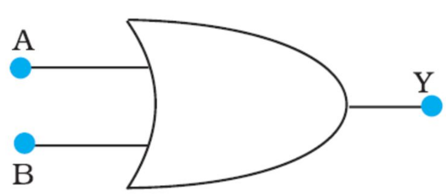
Boolean expression $Y = \overline{A}$

Truth Table

Input **A**	Output **$Y = \overline{A}$**
0	1
1	0

59. Draw the logic symbol, truth table and give the Boolean expression of an **OR** gate

Ans:



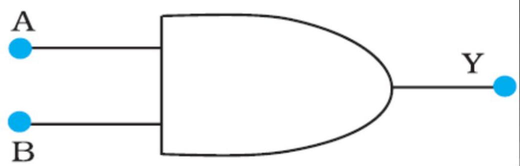
Boolean expression $Y = A + B$

Truth Table

Input		Output
A	**B**	**Y = A + B**
0	0	0
0	1	1
1	0	1
1	1	1

60. Draw the symbol, truth table and give the Boolean expression of an **AND** gate

Ans:



Boolean expression $Y = A \cdot B$

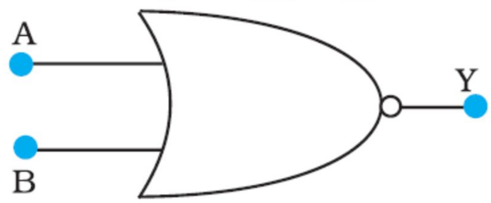
Truth Table

Input		Output
A	B	Y = A . B
0	0	0
1	0	0
0	1	0
1	1	1

Combination of gates

61. Draw the logic symbol, truth table and give the Boolean expression of a **NOR** gate

Ans:



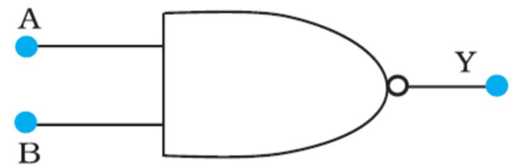
Boolean expression $Y = \overline{A + B}$

Truth Table

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

62. Draw the logic symbol, truth table and give the Boolean expression of a **NAND** gate

Ans:



Boolean expression $Y = \overline{A \cdot B}$

Truth Table

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

Note: -

❖ NOT, OR, and AND gates are fundamental or basic gates.

❖ NAND and NOR gates are called universal gates.

63. Explain reverse breakdown of a diode.

Ans: If we increase the reverse voltage to high values, at a particular voltage (called breakdown voltage) the electric field at the junction becomes strong enough to carry out internal field emission. Then the electrons in the covalent bonds of the host atoms at the p-side of the diode are pulled out. And the reverse current increases very sharply. If the current is not controlled by external resistances, the diode gets damaged due to overheating.

64. What is the relation between the frequency of input and output in a

(i) Half wave rectifier

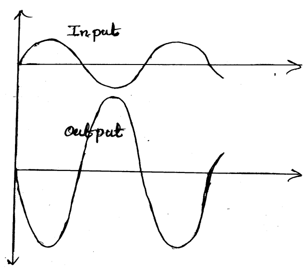
(ii) Full wave rectifier

Ans: (i) In a half wave rectifier the input frequency and the output frequency are the same.

(ii) In a full wave rectifier the output frequency is double the input frequency.

65. Draw the input and output of a common emitter transistor amplifier.

Ans:



66. Explain the phase difference between the input and output in a CE amplifier.

Ans: In a CE amplifier we have,

$V_0 = V_{CC} - I_C R_c$

For a low input applied to the amplifier, I_B is low and hence I_C also is low. But from the above equation it is clear that for low I_C the output is high. Similarly, for high input the output is low. Thus there is a phase difference of 180^0 between the input and output.

Problems

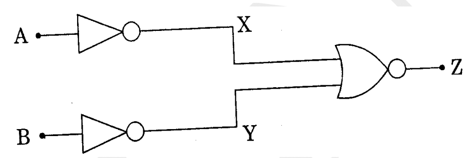
1. In half-wave rectification, what is the output frequency if the input frequency is **50Hz**. What is the output frequency of a full wave rectifier for the same input frequency?

2. For a CE-transistor amplifier, the audio signal voltage across the collector resistance of 2 kΩ is 2V. Suppose the current amplification factor of the transistor is 100, find the input signal voltage and base current, if the base resistance is 1kΩ.

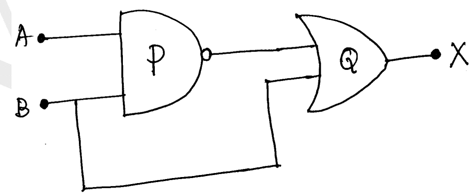
3. Two amplifiers are connected one after the other in series (cascaded). The first amplifier has a voltage gain of 10 and the second has a voltage gain of 20. If the input signal is 0.01 volt, calculate the output ac signal voltage.

4. A p-n photodiode is fabricated from a semiconductor with band gap of 2.8 eV. Can it detect a wavelength of 6000 nm?

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

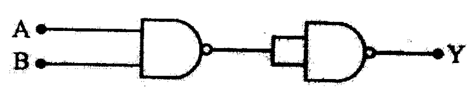


6. (i) Identify the logic gates marked P and Q in the given logic circuit.

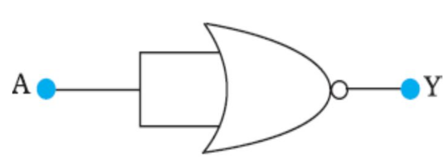


(ii) Write down the output at X for the inputs A=0, B=0 and A=1, B=1

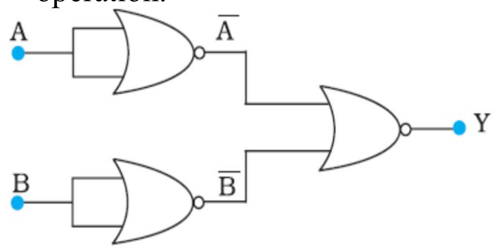
7. Identify the logic gate represented by the circuit as shown and write its truth table.



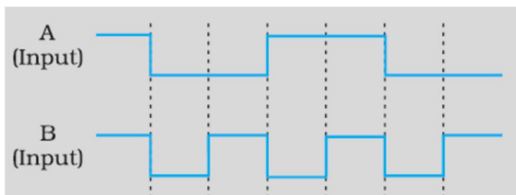
8. Write the truth table for the given circuit and identify the logic operation.



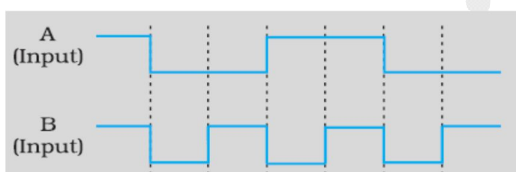
9. Write the truth table for the given circuit and identify the logic operation.



10. Draw the output wave form of an AND gate for the following inputs A and B

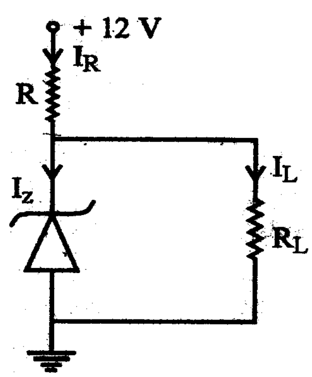


11. Draw the output wave form of a NOR gate for the following inputs A and B

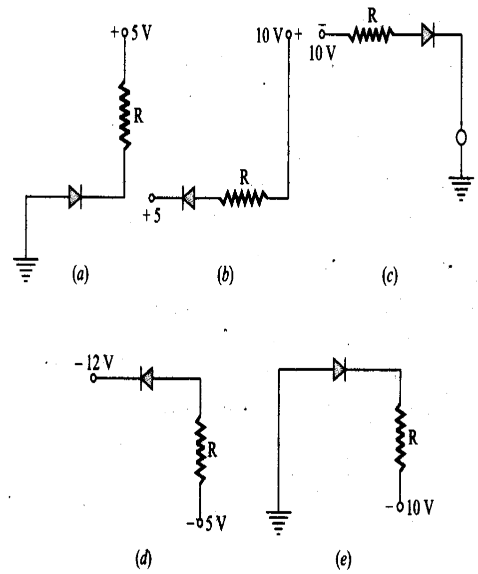


12. How a zener diode is different from an ordinary p-n junction diode.

13. What is the voltage drop across the resistor **R** in the circuit given below? The zener diode has a breakdown voltage of 6.2V.



14. State which of the following diodes are forward biased and which are reverse biased?



15. What are the possible range of α and β?

16. Why positive feedback is applied in an oscillator?

17. Why the common emitter configuration of a transistor is preferred in amplifier?

18. Calculate the current gain of the transistor in the CE configuration from the output characteristics shown.