SEMI CON

12th Standard CBSE

Date : 17-Nov-22

Physics

Reg.No. :

Exam Time : 02:00:00 Hrs

Total Marks : 100

62 x 5 = 310

1) For a common emitter transistor amplifier, the audio signal voltage across the collector resistance of 2 k Ω is 2 V.Suppose the current amplification factor of the transistor is 100, find the input signal voltage and base current,if the base resistance is 1 k Ω

2) The number of silicon atoms per m^3 is 5 x 10^{28}. This is doped simultaneously with 5 x 10^{22} atoms per m^3 of Arsenic and 5 x 10^{20} per m^3 atoms of Indium. Calculate the number of electrons and holes. Given that ni = 1.5 x 10^{16} m^{-3}. Is the material n-type or p-type?

3) In an intrinsic semiconductor the energy gap E_g is 1.2 e V.Its hole mobility is much smaller than electron mobility and independent temperature.What is the ratio between conductivity at 600 K and 300 K? Assume that the temperature dependence intrinsic concentration $n_i$is given by

$n_i = n_0 exp\left(\frac{-E_g}{2k_bT}\right)$, *where* n_0 is a constant and $k_B = 8.62 * 10^{-5}$ eV/K

4) Suppose a 'n'-type wafer is created by doping Si crystal having 5×10^{28}atoms/$m^3$with 1 ppm concentration of As.On the surface 200 ppm Boron is added to create $'p'$region in this wafer. Considering $n_i = 1.5 \times 10^{16} m^{-3}$ (i) Calculate the densities of the charge carriers in the $n\&p$ regions. (ii)Comment which carriers would contribute largely for the reverse saturation current when diode is reverse biased.

5) A pure semiconductor germanium or silicon,free of every impurity is called intrinsic semiconductor, At room temperature, a pure semiconductor has a very small number of current carriers (electrons and holes).Hence,its conductivity is low.

When the impurity atoms of valence five or three are doped in a pure semiconductor,we get respectively $n-$ type or $p-$ type extrinsic semiconductor.In case of a doped semiconductor. $n_e n_h = n_i^2$; when $n_e$and n_h are the number density of electrons and holes respectively and $n_i$is the number density of intrinsic charge carriers in a pure semiconductor.The conductivity of extrinsic semiconductor is much higher than that that of intrinsic semiconductor.

Read the above passage and answer the following question:

(i) Name two materials to be doped in pure semiconductor of silicon to get (a) $p-$type semiconductor (b) $n-$type semiconductor

(ii)What do you learn from the above study?

6) $p-n$ junction is a semiconductor diode.It is obtained by bringing$p-$ .type semiconductor include contact with $n-$ type semiconductor .A thin layer is developed at the $p-$junction which is devoid of

any charge carrier but has immobile ions .It is called depletion layer.At the junction a potential barrier appears,which does not allow the movement of majority charge carriers across the junction in the absence of any biasing of the junction.

$p-$n junction offers low resistance when forward biased and high resistance when reverse biased.Read the above paragraph and answer the following questions:

(i) Can we measure the potential barrier of $p-n$ junction by putting a sensitive voltmeter across its terminals?

(ii) What practical lesson do you draw from the above study?

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7) Zener diode is a specially designed $p-n$ junction diode,in which both $p-side$ and $n-side$ of $p-n$ junction are heavily doped.The zener diode is designed to operate in the reverse break down voltage region continuously without being damaged ? Zener diode is used to remove the fluctuations from the given voltage and thereby provides a voltage of constant magnitude (i.e., zener diode is used as voltage regulator).

Read the above paragraph and answer the following questions :

(i) What is the most important use of Zener diode?

(ii)What are the essential conditions for proper working of Zener diode?

(iii)What do you learn from the above study?

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8) Rohan was studying in a science college and was staying with his grandfather. One day,the old torch which was being used by Rohan's grand father stopped working.He asked Rohan to purchase a new torch for him.Rohan himself made a torch using LED with a small recharge battery and gave it to his grand father as a gift.Rohan explained the advantages of LED over a bulb.Rohan's grand father was very happy.

Read the above passage and answer the following questions:

(i) What is LED? Name the two materials used in making LED ,whose light falls in the visible region.

(ii)Why LED is a better choice than a bulb in torch?

(iii) What do you think about the attitude of Rohan towards his grand father ?

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9) Manoj wanted to do social work during vacations.He visited a remote village where there was no electricity.He made up his mind to help the villagers for getting the solar panels.For this he educated the villagers about techonology and uses of solar panels.he requested the villagers to Villagers agreed and applied for the solar panels.They got the same from government at reduced price.When the solar panels started working,the villagers were happy.

Read the passage and answer the following questions:

(i)What is solar panel?

(ii) What is the basic principle of working of a solar cell?

(iii) What are the basic values you assess in Manoj?

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10) Meeta father was driving her to the school.At the traffic signal she noticed that each traffic light was made of many lights instead of a single bulb.When Meeta asked this question to her father's he explained the reason for this.

Answer the following questions based on above information:

(i) What were the values displayed by Meeta and her father?

(ii) What are the tiny lights in traffic signals called and how do these operate?

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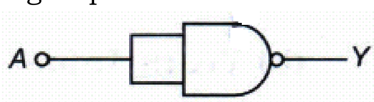
11) Kritika Singh was enjoying TV programme at her home with her younger brother Surya at night. Suddenly, the light went off causing darkness all over. Surya asked her to bring candle along with matchstick to put the TV switch OFF. Kritika at once picked the mobile phone and pressed the button lighting up the surrounding. Her younger brother was surprised and asked, where the light was coming. Kritika proudly showed her mobile.
Read the above passage and answer the following questions:
(i) Which value is displayed by Kritika?
(ii) Name the material used in the formation of LED.
(iii) LED works, in which biasing?

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

13) Ashwin was given 3 semiconductors A, B, and C with respective band gaps of 3 eV, 2 eV and 1 eV for use in a photodetector to detect $\lambda = 1400 \quad nm.$ He found that the photodetector was not working with these semiconductor and did not know. Why? his friend Akash found out the reason for it and explained it to him. Read the above passage and answer the following questions:
(i) Why did the photodetector not work?
(ii) What according to you are the values shown by Akash?

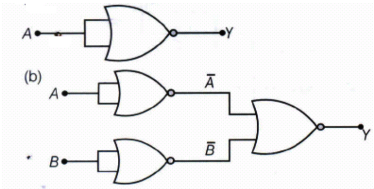
14) Write the truth table for a NAND gate connected as given in the figure. Hence, identity the exact logic operation carried out by this circuit.



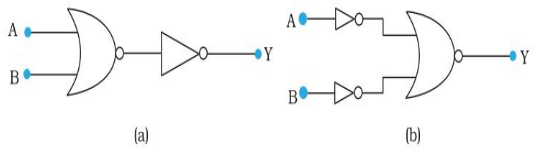
15) Shorya usually enjoyed loud music. One day his music system was not producing very loud sound. Shorya gets disappointed. He discussed his problem with his big brother Kamal. Kamal advised him to connect an amplifier in series with the amplifier of the stereo system. This increased the sound of Shroya's music system considerably. Read the above passage and answer the following questions:
(i) Which value is displayed by Kamal?
(ii) Why the loudness of music system get increased on connecting amplifier?
(iii) Give the equation for current gain in the transistor as an amplifier.

16) Khusbhu Mowar is an electronic engineer. She was working in a project for college exhibition. Her younger sister asked Khushubu about a small black coloured device. which Khusbhu was working on. She clearly explained the working of integrated circuit(I_C) to her sister. Read the above passage and answer the following questions:
(i) What according to you, are the values displayed by Khusbhu?
(ii) What is an integrated circuit? What are the uses of the integrated circuit?
(iii) What do you mean by microprocessor?

17) Write the truth table for the circuits given in Fig. consisting of NOR gates only. Identify the logic operations (OR, AND, NOT) performed by the two circuits.



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

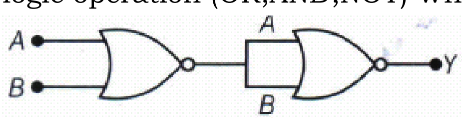


19) (i) Differentiate between three segments of a transistor on the basis of their size and level of doping

(ii) How is a transistor biased to be in active state?

(iii) With the help of necessary circuit diagram, describe briefly how n-p-n transistor in CE configuration amplifies a small sinusoidal input voltage. Write the expression for the AC current gain.

20) Write the truth table for circuit given in figure below consisting of NOR gates and identify the logic operation (OR,AND,NOT) Which this current is performing.



21) Sanjay was preparing an electronic project for science exhibition. He required to light the LED using a 6 V supply. LEDs need only a very small current to make them light and they do not heat up in use. So he put a resistor in series to limit the current. Then there would be p.d. of 4 V across the resistor as there is always 2.0 V across the LED itself when it is conducting. The current should be 10 mA through both LED and the resistor. He could use the resistance by equation, R = V/I to calculate the value of R.

$R = \frac{V}{I} = \frac{4V}{10mA} = \frac{4V}{0.01A} = 400V$

Thus the protecting resistor should be around 400 Ω

(a) What are the values exhibited by Sanjay?

(b) A semiconductor has equal electron and hole concentration of $6 \times 10^8/m^3$. On doping with certain impurity, electron concentration increases to $9 \times 10^{12}/m^3$.

(i) Identify the new semiconductor obtained after doping.

(ii) Calculate the new hole concentration.

(iii) How does the energy gap vary with doping?

22) Sanjay was prparing an electronic project for science exhibition. He required to light the LED using a 6 V supply. LEDs need only a very small current to make them light and they do not heat up in use. So he put a resistor in series to limit the current. Then there would be p.d. of 4 V across the resistor as there is always 2.0 V across the LED itself when it is conducting. The current should

be 10 mA through both LED and the resistor. He could use the resistance by equation, R = V/I to calculate the value of R.

$R = \frac{V}{I} = \frac{4V}{10mA} = \frac{4V}{0.01A} = 400V$

Thus the protecting resistor should be around 400Ω

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23) A student of class 12 was trying to understand the concepts of semiconductors and insulators in terms of energy gaps.

(a) How would you explain these concepts to the students ?

(b) What values should we imbibe from this in our daily life ?

24) A student of class 12 was trying to understand the concepts of semiconductors and insulators in terms of energy gaps.

What values should we imbibe from this in our daily life ?

25) Anita was thinking that C, Si and Ge have same lattice structure, but C is insulator while Si and Ge are intrinsic semiconductors. For its answer she met her friend Sunita. Sunita explained her that the four bonding electrons of C, Si and Ge lie respectively in the second, third and fourth orbit. So, energy required to take out an electron from these atoms known as ionisation energy Ig will be the least for Ge, followed by Si and the highest for the least for Ge, followed by Si and the highest for C. Hence number of free electrons for conduction in Ge and Si are significant while negligibly small for C.

(a) What are the values shown by Sunita ?

(b) If a pure silicon crystal has $5 \times 10^{28} atoms/m^{3}$. It is doped by 1ppm concentration of pentavalent arsenic.

If $n_1 = 1.5 \times 10^{16}/m^3$, then calculate the number of electrons and holes.

26) Anita was thinking that C, Si and Ge have same lattice structure, but C is insulator while Si and Ge are intrinsic semiconductors. For its answer she met her friend Sunita. Sunita explained her that the four bonding electrons of C, Si and Ge lie respectively in the second, third and fourth orbit. So, energy required to take out an electron from these atoms known as ionisation energy Ig will be the least for Ge, followed by Si and the highest for the least for Ge, followed by Si and the highest for C. Hence number of free electrons for conduction in Ge and Si are significant while negligibly small for C.

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27) Sudha reads in class-XII Science. She has read semiconductor in his NCERT physics text book. On the basis of such book she knows that electronic appliances operate at very low voltage. But at home she observes daily that her father using wall socket of 220 V for charging mobiles. She is confused and put her doubt in front of teacher. The teacher explains her doubt properly. Now she is satisfied and shares the knowledge with her classmates.

(a) What are the values displayed by Sudha ?

(b) What is the principle of a charger ?

(c) How does the d.c. current gain of a transistor change, if the width of the base region is increased ?

28) Sudha reads in class-XII Science. She has read semiconductor in his NCERT physics text book. On the basis of such book she knows that electronic appliances operate at very low voltage. But at home she observes daily that her father using wall socket of 220 V for charging mobiles. She is confused and put her doubt in front of teacher. The teacher explains her doubt properly. Now she is satisfied and shares the knowledge with her classmates.
What is the principle of a charger ?

29) Shalini's mother wants to purchase a TV set. Shalini and her mother visited electronic shops to look for some branded TV. The dealer showed them so many TVs such as LCD and LED TVs. Now they were confused which set to buy. Finally after discussing with friends, reading revelent magazines and searching the internet shalini convinced her mother for purchasing LED TV.
(a) What are the values displayed by Shalini ?
(b) What is a LED ?
(c) Which semiconducting material can be used for constructing LED ?

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Which semiconducting material can be used for constructing LED ?

31) Prakash finds his friend Rakesh connecting his new television set directly to a awitch board. Prakash advises Rakesh not to do so and to connect the television through a voltage stabilizer.
(a) Identify the diode used in voltage regulator and give its symbol.
(b) What values dis, Prakash exhibit in the siuation described ?

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What values dis, Prakash exhibit in the siuation described ?

33) How is a transistors biased to be in active state ?

34) (a) Explain with the help of a diagram, how a depletion layer and barrier potential are formed in a junction diode
(b) Draw a circuit diagram of full wave rectifier. Explain its working and draw input and output waveforms full wave rectifier. Explain its working and draw input and output waveforms

35) (a) Draw the circuit arrangement for studying the V - I characteristics of a p-n junction diode in (i) forward and (ii) reverse bias. Briefly explain how the typical V - I characteristics of a diode are obtained and draw these characteristics.
(b) With the help of necessary circuit diagram explain the working ot a photo diode used for detecting optical signals.

36) (a) Describe briefly, with the help of a diagram, the role of the two important processes involved in the formation of a p-n junction.
(b) Name the device which is used as a voltage regulator. Draw the necessary circuit diagram and explain its working.

37) (a) Draw the circuit diagram of an n-p-n transistor with emitter-base junction forward biased and collector-base junction reverse biased. Describe briefly how the motion of charge carriers in the transistor constitutes the emitter current (I_E), the base current (I_B) and the collector current (I_C). Hence deduce the relation $I_E = I_B + I_C$.
(b) Explain with the help of a circuit diagram how a transistor works as an amplifier.

38) (a) Explain briefly, with the help for a circuit diagram how an n-p-n transistor in C.E. configuration is used to study input and output characteristics.
(b) Describe briefly the underlying principle of a transistor amplifier working as an oscillator.Hence, use the necessary circuit diagram to explain how self-sustained oscillations are achieved in the oscillator.

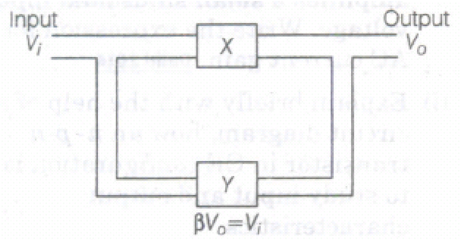
39) Draw a simple circuit of a CE transistor amplifier. Explain its working. Show that the voltage gain,$A_{V,}$ of the amplifier is given by $A_V = -\frac{\beta_{ac} R_L}{I_i}$, where β_{ac} is the current gain, R_L is the load resistance and r_1 is the input resistance of the transistor. What is the significance of the negative sign in the expression for the voltage gain?

40) The current in the forward bias is known to be more (~mA) than the current in the reverse bias (~μA), then why photodiodes is to operate in reverse bias. Rajiv did not know its cause. So he requested his friend Sanjiv for its answer. Sanjiv explained him that in case of n-type semiconductor, the majority carrier (electron) density n is considerably larger than the minority hole density p, i.e., n > > p. On illumination, if the excess electrons and holes generated be Δn and Δp respectively, then
$n' = n + \Delta n \quad and \quad p' = p + \Delta p$
Here $\Delta n = \Delta p \quad and \quad n >> p$. Hence the fractional change $\frac{\Delta n}{n}$ would be much less than $\frac{\Delta p}{p}$.
In general, we can state that the fractional change due to the photo-effects on the minority carrier dominated reverse bias current is more easily measurable than the fractional change in the forward bias current. So, photodiodes are preferably used in the reverse bias condition for measuring light intensity.
(a) What values are noticed in Sanjiv ?
(b) For a CE transistor amplifier, the audio signal voltage across the collector resistance of 2 kΩ is 2 V. Current amplification factor of the transistor is 100. Find the input signal voltage and the base current, if its resistance is 1kΩ.

41) (i) Explain briefly with the help of a circuit diagram, how an n-p-n transistor in CE configuration is used to study input and output characteristics.
(ii) Describe briefly the underlying principle of a transistor amplifier working as an oscillator. Hence, use the necessary circuit diagram to explain how self sustained oscillations are achieved in the oscillator.

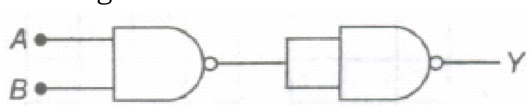
42) (i) Why is the base region of a transistor thin and lightly doped?
(ii) Draw the circuit diagram for studying the characteristics of an n-p-n transistor in common-emitter configuration.
Sketch the typical (a) input.and (b) output characteristics this configuration.
(iii) Describe briefly, how the output characteristics can be used to obtain the current gain in the transistor?

43) The set-up shown below can produce an AC output without any external input signal. Identify the components 'X' and 'Y' of this set up. Draw the circuit diagram for this set-up. Describe briefly its working



44) (i) Draw the circuit for studying the input and output characteristics of a transistor in CE configuration. Show how from the output characteristics the information about the current amplification factor (β_{AC}) can be obtained.
(ii) Draw a plot of the transfer characteristics (V_0 versus V_i) for a base-biased transistor in CE configuration.

45) (i) Using the necessary circuit diagram, draw the transfer characteristics of a base-biased transistor in CE configuration. With the help of these characteristics, explain briefly how the transistor can be used as an amplifier?
(ii) Why are NAND gate called universal gates? Identify the logical operations carried out by the circuit given as below.



46) (i) Draw a circuit diagram to study the input and output characteristics of an n-p-n transistor in its common-: emitter configuration. Draw the typical input and output characteristics.
(ii) Explain with the help of a circuit diagram, the working of an n-p-n transistor as a common-emitter amplifier.

47) Draw a circuit diagram of an n- p-n transistor with its emitter base junction forward biased and base- collector junction reverse biased. Describe briefly its working. Explain, how a transistor in active state exhibits a low resistance at its emitter-base junction and high resistance at its base-collector junction?

48) Draw a labelled circuit diagram of a base-biased transistor in common-emitter configuration. Plot the transfer characteristics of this base biased transistor indicating the different regions of its operation.

49) Draw the circuit diagram of a base-biased n-p-n. transistor in CE configuration. Explain, how this circuit is used to obtain the transfer characteristic V_o - V_i characteristic.

(ii) The typical output characteristics I_C versus V_{CE} of an n-p-n transistor in CE configuration is shown in the figure. Calculate

(a) the output resistance r_0 and

(b) the current amplification factor β_{AC}

50) Sorya usually enjoyed loud music. One day his music system was not producing very loud sound. Sorya get disappointed. He discussed his problem with his big brother Kamal. Kamal advised him to connect an amplifier in series with the amplifier of stereo system. This increased the sound of Sorya music system .considerably

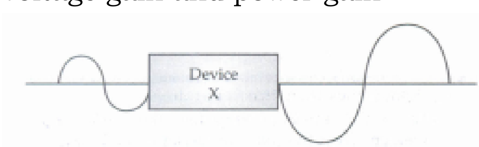
Read the above passage and answer the following questions.

(i) Which values is displayed by Kamal? .

(ii) Why the loudness of music system get increased on connecting amplifier?

(iii) Give the equation for current gain in the transistor as an amplifier.

51) (i) Figure shows the input waveform which is converted by a device 'X' into an output waveform. Name the device and explain its working using the proper circuit. Derive the expression for its voltage gain and power gain

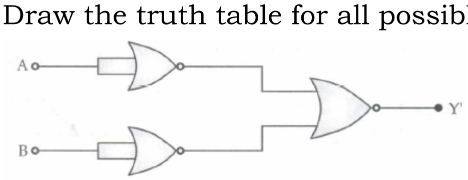


(ii) Draw the transfer characteristic of base biased transistor in CE configuration. Explain clearly which region of the curve is used in an amplifier

52) (i) Explain briefly, with the help of circuit diagram, the working of a full wave rectifier. Draw its input and output waveforms.

(ii) Identify the logic gate equivalent to the circuit shown in the figure.

Draw the truth table for all possible values of inputs A and B.



53) From the output characteristics shown in Fig.(b), calculate the values of β_{ac} and β_{dc} of the transistor when V_{CE} is 10 V and I C = 4.0 mA

54) the V_{BB} supply can be varied from 0 V to 5.0 V. The Si transistor has β_{dc} = 250 and R_B = 100 kΩ, R_C = 1 KΩ, V_{CC} = 5.0 V. Assume that when the transistor is saturated, V_{CE} = 0 V and V_{BE} = 0.8 V. Calculate

(a) the minimum base current, for which the transistor will reach saturation. Hence,

(b) determine V_1 when the transistor is 'switched on'.

(c) find the ranges of V_1 for which the transistor is 'switched off' and 'switched on'.

55) Justify the output waveform (Y) of the OR gate for the following inputs A and B given Fig

56) Take A and B input waveforms similar to that in Example. Sketch the output waveform obtained from AND gate.

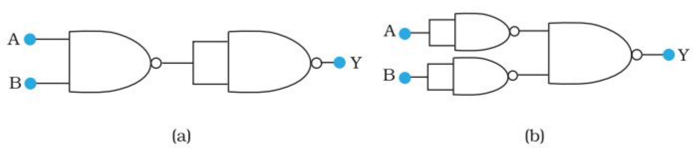
57) Sketch the output Y from a NAND gate having inputs A and B given below

58) In a p-n junction diode, the current I can be expressed as

$$I = I_0 \exp\left(\frac{eV}{2k_BT} - 1\right)$$

where I_0 is called the reverse saturation current, V is the voltage across the diode and is positive for forward bias and negative for reverse bias, and I is the current through the diode, kB is the Boltzmann constant (8.6×10^{-5} eV / K)
and T is the absolute temperature. If for a given diode $I_0 = 5 \times 10^{-12}$ A and T = 300 K, then
(a) What will be the forward current at a forward voltage of 0.6 V?
(b) What will be the increase in the current if the voltage across the diode is increased to 0.7 V?
(c) What is the dynamic resistance?
(d) What will be the current if reverse bias voltage changes from 1 V to 2 V?

59) You are given two circuits as shown in Fig. which consist of NAND gates. Identify the logic operation carried out by the two circuits.



60) (a) State briefly the processes involved in the formation of p-n junction explaining clearly how the depletion region is formed.
(b) Using the necessary circuit diagrams, show how the V-I characteristics of a p-n junction are obtained in
(i) Forward biasing
(ii) Reverse biasing
How are these characteristics made use of in rectification?

61) Explain briefly with the help of necessary diagrams, the forward and the reverse biasing of a p-n junction diode. Also draw their characteristic curves in the two cases.

62) (a) Distinguish between an intrinsic semiconductor and a p-type semiconductor. Give reason why a p-type semiconductor is electrically neutral, although $n_h >> n_e$.
(b) Explain, how the heavy doping of both p- and n- sides of a p-n junction diode results in the electric field of the junction being extremely high even with a reverse bias voltage of a few volts. Explain, with the help of a circuit diagram, how this property is used in voltage regulator.

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62 x 5 = 310

1) Given:

Output voltage, V_o = 2 V, output resistance, R_o = 2 k Ω, base resistance, R_i = 1 k Ω

Current amplification factor, β = 100

Then input signal voltage is calculated as:

$$\frac{V_0}{V_i} = \frac{R_0}{R_i} \times \beta \Rightarrow \frac{2}{V_i} = \frac{2}{1} \times 100$$

$$\Rightarrow V_i = 10\text{mV}$$

Now, collector current is

$$I_C = \frac{V_0}{R_0} = \frac{2}{2} = 1mA$$

Therefore, base current is

$$I_B = \frac{I_C}{\beta} = \frac{1mA}{100} = 10\mu A$$

2)

Number of silicon atoms, N = 5 x 10^{28} atoms/m^3

Number of arsenic atoms, n_{As} = 5 x 10^{22} atoms/m^3

Number of indium atoms, n_{In} = 5 x 10^{20} atoms/m^3

Number of thermally-generated electrons, n_i = 1.5 x 10^{16} electrons/m^3

Number of electrons, n_e = 5 x 10^{22} − 1.5 x 10^{16} ≈ 4.99 x 10^{22}

Number of holes = n_h

In thermal equilibrium, the concentrations of electrons and holes in a semiconductor are related as:

$n_e n_h = n_i^2$

$$\therefore n_h = \frac{n_i^2}{n_e}$$

$$= \frac{\left(1.5 \times 10^{16}\right)^2}{4.99 \times 10^{22}} \approx 4.51 \times 10^9$$

Therefore, the number of electrons is approximately 4.99 x 1022 and the number of holes is about 4.51 x 109. Since the number of electrons is more than the number of holes, the material is an n-type semiconductor.

3)

Energy gap of the given intrinsic semiconductor, $E_g = 1.2$ eV

The temperature dependence of the intrinsic carrier-concentration is written as:

$$n_i = n_0 \exp\left[-\frac{E}{2k_B T}\right]$$

Where,

k_B = Boltzmann constant = 8.62 x 10^{-5} eV / K

T = Temperature

n_0 = Constant

Initial temperature, T_1 = 300 K

The intrinsic carrier-concentration at this temperature can be written as:

$$n_{i1} = n_0 \exp\left[-\frac{E_g}{2k_B \times 300}\right] \quad \text{............(i)}$$

Final temperature, T_2 = 600 K

The intrinsic carrier-concentration at this temperature can be written as:

$$n_{i2} = n_0 \exp\left[-\frac{E_g}{2k_B \times 600}\right] \quad \text{............(ii)}$$

The ratio between the conductivities at 600 K and at 300 K is equal to the ratio between the respective intrinsic carrier-concentrations at these temperatures.

$$\frac{n_{i2}}{n_{i1}} = \frac{n_0 \exp\left[-\frac{E_g}{2k_B 600}\right]}{n_0 \exp\left[\frac{E_g}{2k_B 300}\right]}$$

$$= \frac{\exp E_g}{2k_B}\left[\frac{1}{300} - \frac{1}{600}\right] = \exp\left[\frac{1.2}{2 \times 8.62 \times 20^{-5}} \times \frac{2-1}{600}\right]$$

$$= \exp[11.6] = 1.09 \times 10^5$$

Therefore, the ratio between the conductivities is 1.09 x 10^5.

---

4)

(i)When As is implanted in Si-crystal, n-type wafer is created. The no of majority carrier electrons due to doping of As is

$$n_e = N_D = \frac{1}{10^6} \times 5 \times 10^{28} = 5 \times 10^{22}/m^{-3}$$

No of minority carriers (holes) in $n-$ type wafer is

$$n_h = \frac{n_1^2}{n_e} = \frac{(1.5 \times 10^{16})^2}{5 \times 10^{22}} = 0.45 \times 10^{10}/m^3$$

when B is implanted in Si-crystal p-type wafer is created with no of holes

$$n_h = N_A = \frac{200}{10^6} \times (5 \times 10^{28}) = 1 \times 10^{25}/m^3$$

Minority carriers (electrons) created in the p-type wafer is

$$n_e = \frac{n_1^2}{n_h} = \frac{(1.5 \times 10^{16})^2}{1 \times 10^{25}} = 2.25 \times 10^{10}/m^3$$

When $p-n$a junction is reverse biased, the minority carrier holes of $n-$ region wafer ($n_h = 0.45 \times 10^{10}/m^3$) would contributte more to the reverse saturation current than minority carrier than minority carrier electrons ($n_e = 2.25 \times 10^7/m^3$)

---

5)

(i) (a) The doping of pure silicon with boron or aluminium will give us $p-$ type semiconductor

(b) The doping of pure silicon with arsenic or phosphorous will give us $n-$ type semiconductor.

(ii) From the above study, we find that to get better output current ,pure semiconductor has to be adopted with suitable (impurity) atoms.Similarly,in day to day life,the appearence of right kind of persons(leaders) in society can improve their lot.

6)

(i) We cannot measure the potential barrier of $p-n$junction by putting a sensitive voltmeter across its terminals because there are no free electrons or holes in the depletion layer.And in the absence of forward biasing, the depletion layer offers infinite resistance.

(ii) From the above study,we find that when some move supports the tendency of majority of the people , the resistance/(opposition) is lowered and output current (desired result) is large (appreciable) However , when some move is against the tendency of majority of people,it suffers rough weather.

7)

(i) The most important use of zener diode is in marking the constant voltage power supply.

(ii)The essential conditions for proper working of Zener diode are as follows:

(a) The Zener diode must be reverse biased

(b) The Zener diode must have voltage greater than Zener break down voltage.

(c) The Zener diode is to be used in a circuit where current is less than the maximum Zener current limited by the power rating of the given Zener diode.

(iii) To be happy in life,one has to be like a Zener diode which evens out all fluctuations and displays a constant output.Ups and downs are part of life.One who evens them out is successful and happy.

8)

LED stands for light emitting diode . The following materials are used in making LEDs whose light falls in the visible region : (a) Gallium-Phosphide(Gap)-giving red or green light (b) Gallium-arsenide-phosphide (GaAsp)-giving red or yellow light.

(ii) LED is better than conventional bulb as the torch with LED is handy and light.It gives intense light and consumes less power.

(iii)Rohan had a great love and respect for his grand father.He proved it by making a torch for him using new technology . By this act,Rohan earned more love and affection from his grand father

9)

(i) Solar panel is a panel having large number of solar cells fitted side by side on it.

(ii) Solar cell is basically a solar energy concerter.It is a $p-n$junction device which converts solar energy into electrical energy .If this energy is stored in a capacitor,it can be used for glowing bulbs.

(iii) Manoj displayed his will to do something for society.Trough his shear in a capacitor,it can be used for glowing bulbs.

(iii) Manoj displayed his will to do something for soceity.Through his shear efforts,he got electricity within the reach of villagers, who were suffering otherwise.?The work of Manoj was highly appreciated by villagers.

10)

(i) Meeta is curious and have a quality of learning.Meeta's father is a helping hand to her daughter and have good knowledge about the scientific facts.

(ii) Meeta's father told that these are LED nd their power consumption is very low

(iii)LED is a heavily doped $p-n$ junction diode which under forward bias emits spontaneous radiation.The order of minimum band gap of an LED to emit light in the visible region is about $1.8 eV$

11)

(i) Kritika is a creative and intelligent girl. She has good knowledge of Physics.

(ii) The semiconductor material is used in the formation of LED.

(iii) LED works in forward biasing i.e. n-type is connected to a negative terminal of the battery and p-type is connected with positive terminal of the battery.

12)

Energy band gap of the given photodiode, E_g = 2.8 eV

Wavelength, λ = 6000 nm = 6000 x 10^{-9} m

The energy of a signal is given by the relation:

$$E = \frac{hc}{\lambda}$$

Where

h = Planck's constant

= 6.626 x 10^{-34} Js

c = Speed of light

= 3 x 10^{8} m/s

$$E = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{6000 \times 10^{-9}}$$

= 3.313 x 10^{-20} J

But 1.6 x 10^{-19} J = 1 eV

∴ E = 3.313 x 10^{-20} J

$$= 3.313 \times \frac{10^{-20}}{1.6 \times 10^{-19}} = 0.207 \text{eV}$$

The energy of a signal of wavelength 6000 nm is 0.207 eV, which is less than 2.8 eV − the energy band gap of a photodiode. Hence, the photodiode cannot detect the signal.

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13)

(i) Energy related to wavelength λ is

$$E = \frac{hc}{\lambda} = \frac{6.634 \times 10^{-34} \times 3 \times 10^{8}}{1400 \times 10^{-9}} = 1.42 \times 10^{-19} J$$

$$E = \frac{1.42 \times 10^{-19}}{1.6 \times 10^{-19}} = 0.88 eV \; [\therefore 1 eV = 1.6 \times 10^{-19} J]$$

The photodetector does not work because the energy related to wavelength, 0.8eV is less than band gaps of semiconductor A, B, and C.(ii) The value of Akash are:

(a) helping tendency.

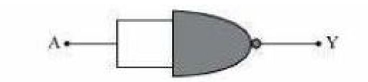
(b) presence of mind.

(c) high degree of awareness.

(d) concern for his friend.

---

14) *A* acts as the two inputs of the NAND gate and *Y* is the output, as shown in the following figure.



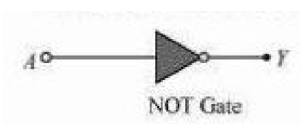
Hence, the output can be written as:

$Y = \overline{A.A} = \bar{A} + \bar{A} = \bar{A}$

The truth table for equation (*i*) can be drawn as:

A	$Y(= \bar{A})$
0	1
1	0

This circuit functions as a NOT gate. The symbol for this logic circuit is shown as:



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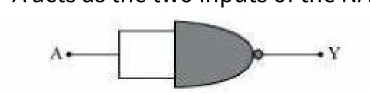

Hence, the output can be written as:

$Y = \overline{A.A} = \bar{A} + \bar{A} = \bar{A}$

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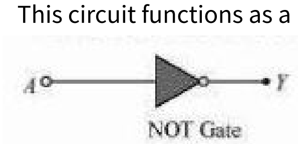

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15)

(i) Kamal is caring for his younger brother. He is an intelligent boy.

(ii) On connecting two amplifiers in series, its amplification gain gets multiplied. Hence, the loudness of music system increases.

(iii) Current gain in the transistor as an amplifier is given by

$$\beta_{AC} = \frac{\Delta I_C}{\Delta I_B}$$

where ΔI_C = change in collector current

ΔI_B = change in base current.

---

16)

(i) Khusbhu is intelligent, cooperative and has good knowledge of electronic devices.

(ii) An integrated circuit is a small device in which different components of electronics circuits such as a diode, transistor, resistors, inductor, etc., are fabricated together in a small chip.

Since it can operate a wide range of functions simultaneously it is used in computer, television, cars, CD players, cell phones, etc.

(iii) The microprocessor is an IC that process all information in a computer.

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17)

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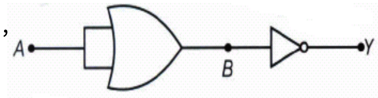


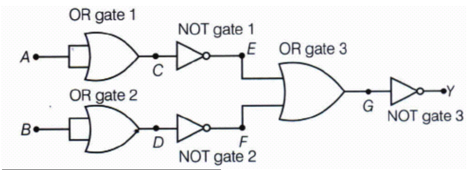
(a) Split the gate

A	B	Y
0	0	1
1	1	0

B is the output of OR gate and input of NOT gate. So, the gate resembles to NOT gate as A is input and Y is output

A	Y
0	1
1	0

(b) Split the gate,



A	B	C	D	E	F	G	Y
0	0	0	0	1	1	1	0
0	1	0	1	1	0	1	0
1	0	1	0	0	1	1	0
1	1	1	1	0	0	0	1

C is output of OR gate 1 and input of NOT gate 1

D is the output of OR gate 2 and input of NOT gate 2

E is the output of NOT gate 1; F is the output of NOT gate 2

G is the output of OR gate 3 and input of the NOT gate 3

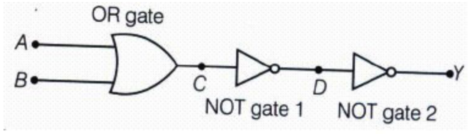
The truth table resembles to AND gate as A and B inputs and Y is output

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

This operation is AND gate.

18)

(a) Split the gate,



The truth table for the given circuit is as shown below:

A	B	C	D	Y
0	0	0	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	0	1

Here, for given A and B as inputs, C is the output of OR gate and input of NOT gate 1, D is the output of NOT gate 1 and input of NOT gate 2, then Y is finally output.

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

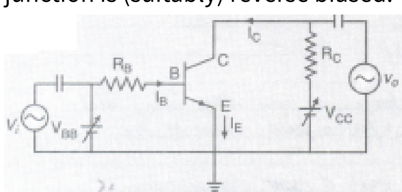
This is same as OR gate. So, this circuit acts as OR gate.

19)

(a) Emitter: It is of moderate size and heavily doped

Base: It is very thin and lightly doped Collector : It is moderately doped and larger in size.

(b) Transistor is said to be in active state when its emitter-base junction is (suitably) forward biased and base-collector junction is (suitably) reverse biased.



(c)When a small sinusoidal voltage is superposed on the dc base biased, the base current will have sinusoidal variation superimposed on the value of I_E .As a consequence, the collector current also will have sinusoidal variations, superimposed on the

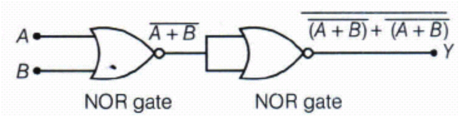
Value of $I_{C,}$ producing corresponding (amplified) changes in the value of V_0 .

ac current gain,

$$\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CB}}$$

20)

A and B are the inputs of the given circuit.The output of the first NOR gate $\overline{A+B}$ .It can be observed from the figure, that the outputs of the first NOR gate becomes the input of the second one.



Hence, the output of the combination is given as

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

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

= (A + B).(A + B)

= A + B

the truth table for this operation is given as

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

This is the truth table of an OR gate.Hence, the circuit functions as an OR gate.

21) (a) The values exhibited by sanjay are :

(i) Presence of mind

(ii) High degree of general awareness.

(b) (i) n - type ,

(ii) $4 \times 10^4/m^3$,

(iii) Energy gap decreases with doping

Here,$n_i = 6 \times 10^8 m^{-3}$; $n_e = 9 \times 10^{12} m^{-3}$

$$n_h = \frac{n_i^2}{n_e} = \frac{\left(6 \times 10^8\right)^2}{9 \times 10^{12}} = 4 \times 10^4 m^{-3}$$

As, after doping, $n_e > n_h$ so the new semiconductors is n-type. Energy gap decreases with doping.

22) (i) New semiconductor must be n-type, because the electron concentration increases.

(ii) Given,

$n_i = 6 \times 10^8/m^3$

$n_e = 9 \times 10^{12}/m^3$

$n_e n_h = n_i^2$

$$\Rightarrow n_h = \frac{n_i^2}{n_e} = \frac{(6 \times 10^8)^2}{9 \times 10^{12}}$$

$$= \frac{36 \times 10^{16}}{9 \times 10^{12}}$$

$= 4 \times 10^4/m^3$

23) (a) By drawing energy band gap.

(b) (i) Ready to change with a little push.

(ii) Redy/Eager to learn and move to a higher level.

24) (i) Ready to change with a little push.

(ii) Redy/Eager to learn and move to a higher level.

25) (a) The values shown by Sunita are :

(i) High degree of general awareness

(ii) Ability to convince someone

(iii) Helping and caring nature.

(b) Given

$n_i = 1.5 \times 10^{16}/m^3$

$n = 5 \times 10^{28} atoms/m^3$

$n_e = \frac{1}{10^6} \times n = \frac{5 \times 10^{28}}{10^6}$

$= 5 \times 10^{22}/m^3$

$n_e n_h = n_i^2$

$\Rightarrow n_h = \frac{n_i^2}{n_e} = \frac{(1.5 \times 10^{16})^2}{5 \times 10^{22}}$

$= \frac{2.25 \times 10^{32}}{5 \times 10^{22}} = 4.5 \times 10^9/m^3$

26) Given,

$n_i = 1.5 \times 10^{16}/m^3$

$n = 5 \times 10^{28} atoms/m^3$

$n_e = \frac{1}{10^6} \times n = \frac{5 \times 10^{28}}{10^6}$

$= 5 \times 10^{22}/m^3$

$n_e n_h = n_i^2$

$\Rightarrow n_h = \frac{n_i^2}{n_e} = \frac{(1.5 \times 10^{16})^2}{5 \times 10^{22}}$

$= \frac{2.25 \times 10^{32}}{5 \times 10^{22}} = 4.5 \times 10^9/m^3$

27) (a) The values displayed by Sudha are :

(i) Curiosity

(ii) Creativity

(iii) Sharing knoledge

(b) Charger acts as rectifier, which changes a.c. input signal into unisirectional d.c. output signal.

(c) Value of current gain decreases on increasing the width of base region.

28) Charger acts as rectifier, which changes a.c. input signal into unisirectional d.c. output signal.

29)

(a) The values displayed by Shalini are :

(i) Creativity

(ii) Curiosity

(iii) Sharing Knowledge.

(b) LED means light emitting diode which emits light of chateristic wavelength when conducting.

(c) We can use that semiconducting material for which forbidden energy gap is 1.8 eV or more so that light photons emitted lie in visible light range.

30)

We can use that semiconducting material for which forbidden energy gap is 1.8 eV or more so that light photons emitted lie in visible light range.

31)

(a) Zener diode.

(b) Helpful and concerned, practical application of theoretical knowledge.

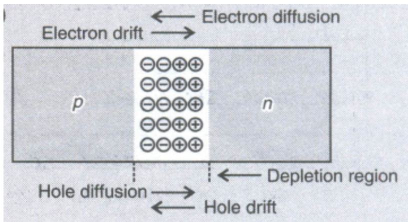
32)

Helpful and concerned, practical application of theoretical knowledge.

33)

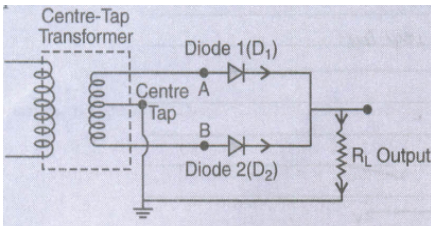
Transistor is said to be in active active state when its emitter-base junction is forward biased and base-collector junction is reverse biased.

34)



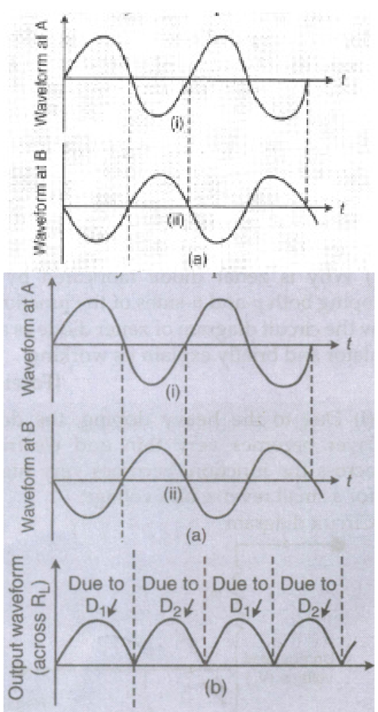
(a) Due to the diffusion of electrons and the holes, from their majority zone to minority zone, a layer of positive and negative space charge region on either side on the junction is formed. This is called the depletion region.

The loss of electrons, from n-region and gain of electrons by the p-region, causes a difference of potential across the junction. This tends to prevent the movement of charge carriers across the junction and is, therefore, termed as barrier potential.

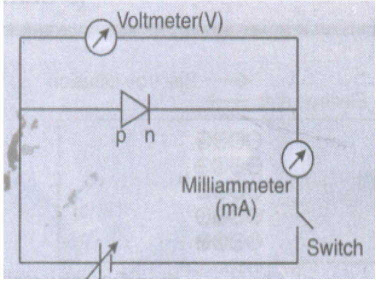


For positive half cycle of input ac, one of the two diodes gets forward biased and conducts and output current is obtained across the load RL, For negative half cycle of input ac, the other diode

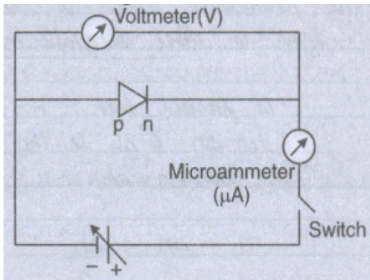
gets forward biased and thus output current is obtained due to it. Therefore, output is obtained for both the cycles of input ac.



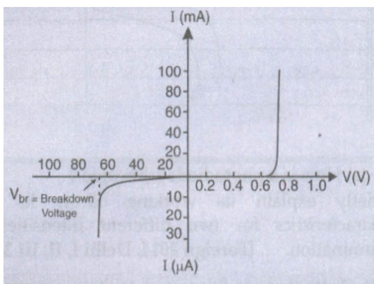
35)



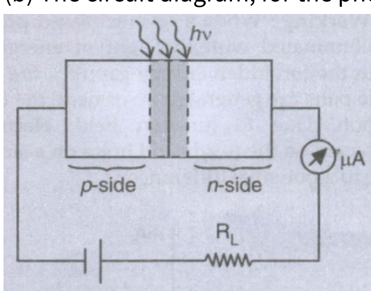
Reverse biasing



The VI characteristics are obtained by connecting the battery, to the diode, through a potentiometer (or rheostat). The applied voltage to the diode is changed. The values of current, for different values of voltage, are noted and a graph between V and I is plotted. The V-I characteristics, of a diode, have the form shown here.



(b) The circuit diagram, for the photodiode, is shown here.



The photodiode is illuminated by optical signal, whose photon energy is greater than the energy gap of the semiconductor used.

The electric field, at the junction, separates the electrons and holes and thus gives rise to an emf.

When an external load is connected, a (photo) current flows through it. The magnitude of this current is proportional to the intensity of light incident on the photodiode.

36)

The two processes are

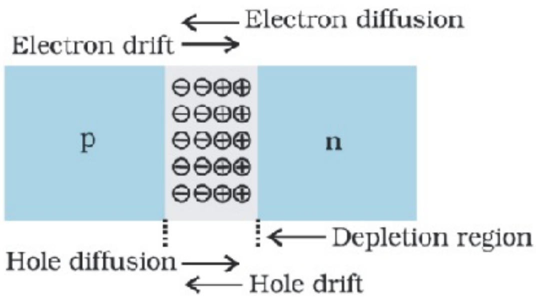
(i) Diffusion

(ii) Drift

Diffusion : Holes diffuse from p-side to n-side (p $\rightarrow$ n) and electrons diffuse from n-side to p-side (n $\rightarrow$ p)

Drift: The motion of charge carriers, due to the applied electric field $(\vec{E})$ which results in drifting of holes along E and of electrons opposite to that of electric field $(\vec{E})$.

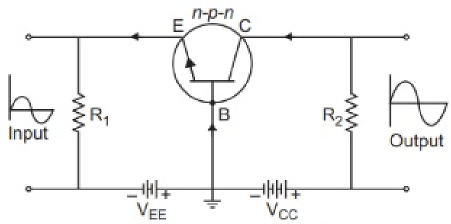
(b) Name of device: Zener Diode



Working:

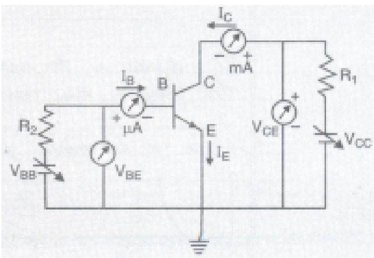
Any increase I decrease in the input voltage results in an increase I decrease of the voltage drop across R,; without any change in voltage across the Zener diode. Thus Zener diode acts as voltage regulator.

37)



n-p-n Comman base configuration

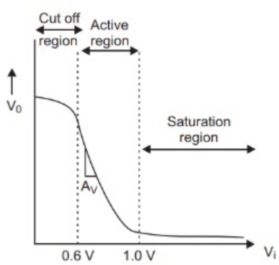
(a) The circuit diagram is shown here:



The emitter-base junction, being forward biased, the majority charge carriers (electrons), from the emitter, flow into the base region constituting the emitter current (I_E) The base region, being very thin, only a (very) small fraction, of these (small base current (I_B). 1 The majority of these charge carriers, are attracted by the (reverse biased) collector. These make up the collector current (I_C)

I_E=I_C+IB

The circuit diagram of a transistor, working as an amplifier, in its C $_E$ mode, is shown here.



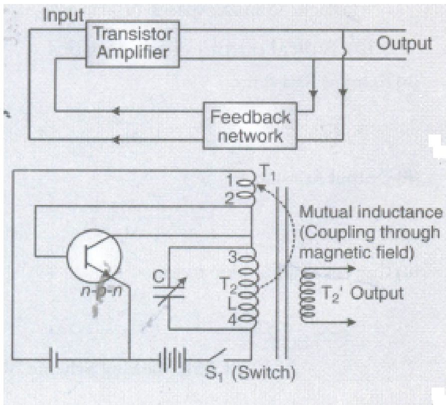
If a small sinusoidal voltage is superimposed on the dc base bias by connecting the source of this signal in series with V_{BB} supply. Then the base current will have sinusoidal variations superposed on the values I_B . as a consequence the collector current also will have sinusoidal variation superimposed on the value of I_C producing in turn corresponding change in the output voltage V_0 .

38)

For input characteristics;

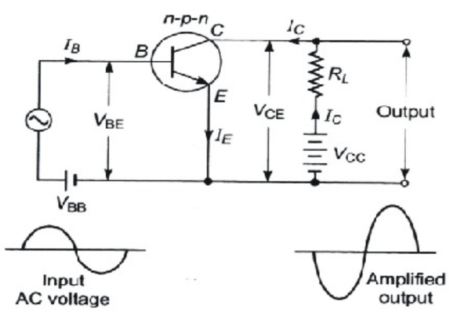
At constant V_{CE} , for different values of V_{BE} , different values of $I_B$are obtained. At I_B are obtained. At constant I_B ,for different values of V_{CE} , different values of I_C are obtained.

b) A portion of output power is returned at the input in same phase as that of starting power; hence the output in the oscillator gets self-sustained. This is termed as positive feedback.



As the switch S_1 is closed, a surge of collector current flows through coil $T_{2,}$ which causes a changing magnetic flux around it. Hence a portion of the output is fed, back to the coil $T_{1,}$as a result of the positive feedback. The emitter current, therefore, starts oscillating.

39)



While finding gain for CE configuration we should mind that it will depend upon the load resistance, input resistance as well as output will be inverted.

Working In the circuit, emitter is forward biased and collector is reversed biased. This makes input resistance (R_{in},) very low and output resistance (Rout) high. During the positive half cycle of input AC decrease the forward bias.

Hence, emitter current, I_E and by transistor action collector current decreases. This tend to increase the collector voltage which is given

by $V_0=V_{CE}=V_{CC}-I_CR_L$

The high value of RL produces large change in V_o corresponding to low change in V_i. Thus, amplified pulse is obtained at collector.

$$\frac{\Delta V_{CE}}{\Delta V_{BE}} = \frac{(\Delta I_C) R_L}{(\Delta I_B) V_i}.$$

40) (a) The values noticed in Sanjiv are :

(i) High degree of general awareness.

(ii) Ability to convince someone.

(Hi)Helping and caring nature.

(b) Given, $R_C = 2k\Omega; V_C = 2V; \beta = 100;$

$R_B = k\Omega$

Output current, $I_C = \frac{V_C}{R_C} = \frac{2}{2000} = \frac{1}{1000}A$

=1 mA

Current gain, $\beta = \frac{I_C}{I_B} \Rightarrow Thus, basecurrent,$

$I_B = \frac{I_C}{\beta} = \frac{10^{-3}}{100} = 10\mu A$

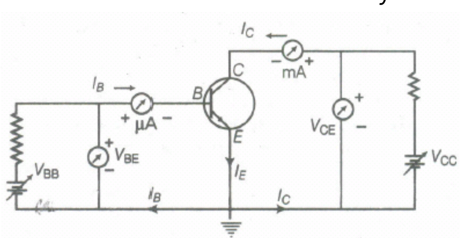
Input signal voltage,

$V_B = I_B \times R_B = 10^{-5} \times 1000V$

= 10 MV

41)

Common-emitter Transistor Characteristics To study the characteristics of an n-p-n transistor in common-emitter mode, required circuit is shown in the figure. Here, base-emitter circuit is forward biased with battery VSE and emitter- collector circuit is reverse biased with battery Vcc.



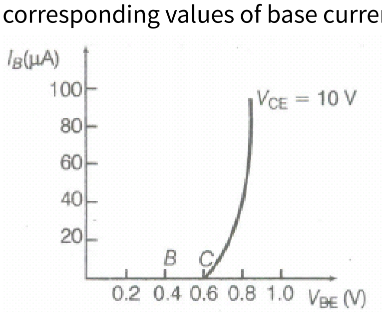
From circuit diagram, we come across to know that it is made up of two sections, i.e. input and output.

These two characteristics can be studied as shown below:

(a) Emitter or Input Characteristics A graphical relation between the emitter voltage and the emitter current by keeping collector voltage constant is called input characteristics of the transistor.

Adjust collector-emitter voltage at a suitable high value V_{CE}(say = + 10 V). It is necessary so as to make the base-collector junction reverse biased.

Now, with the help of rheostat gradually increases, the value of base-emitter voltage V_{BE} in small steps and note the corresponding values of base current I_B.

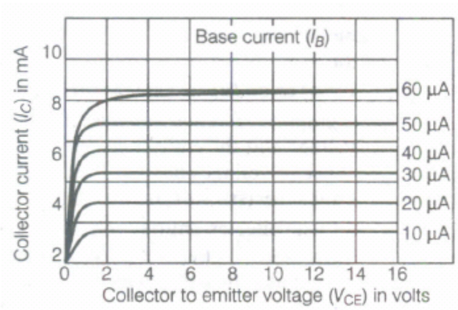


Input resistance It is defined as the ratio of change in base-emitter voltage (ΔV_{BE}) to the resulting change in the base current (Δ_{IB}) at constant collector-emitter voltage (V_{CE})' It is reciprocal of slope of I_B-V_{BE} curve.

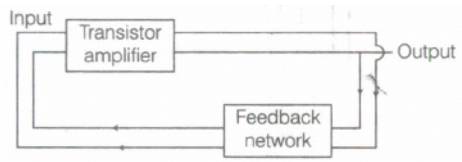
Input resistance, $R_i = \left(\frac{\Delta VB_E}{\Delta I_B}\right)_{V_{CE}}$

Collector or Output Characteristics A graphical relation between the collector voltage and collector current by keeping base current constant is called output characteristics of the transistor. To study output characteristics of transistor we keep value of base current I_B fixed (say at 10μA) with the help of V_{BE} Now, gradually change the value of V_{CE} and note the values of collector current I_c.

The output characteristics are as shown below:



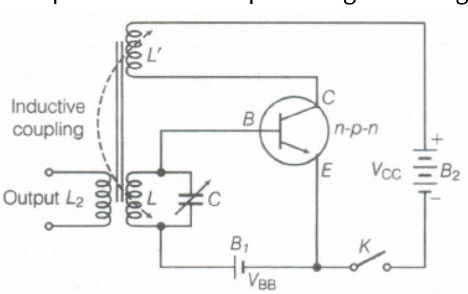
(ii) Feedback When a portion of the output power is returned back to the input.in phase this is termed as positive feedback.



Feedback network The phenomenon of mutual inductance is used to take a part of output in coil (L') back into input coil (L).

When the switch K is closed, collector current begin to flow through L', which in turn increases the magnetic flux linked with L' and hence with L. This leads to produce an induce emf in L, which increases the forward bias. This also increases the base current and hence collector current along with the charging of capacitor takes place with upper plate as positive.

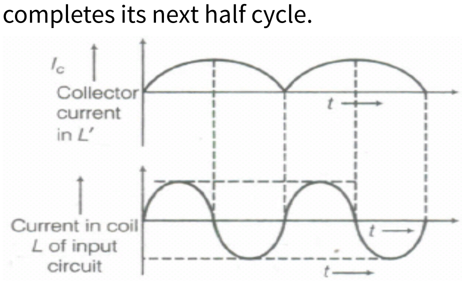
This phenomenon is repeated again and again till the collector current reaches to its maximum value.



Circuit diagram of transistor as an oscillator

At maximum value of I_c current through L' does not change and therefore flux remains unchanged and emf in L' and L reduces to zero. Now, the discharging of capacitor begins through L. The positivity of upper plate decreases and forward bias decrease, which results in the form of decrease in base current and hence, decrease in collector current. This phenomenon repeats till collector current reduces to zero and emf in the coil L also reduces to zero.

Thus, the time duration in which collector current grows from zero to maximum, the current in coil L of tank circuit complete its half cycle. The duration in which collector current reduces from maximum to zero, the current in L' completes its next half cycle.



Rise and fall of currents

Thus, the AC of desired frequency and amplitude can be obtained by taking appropriate value of inductance, capacitance and strength of battery B.

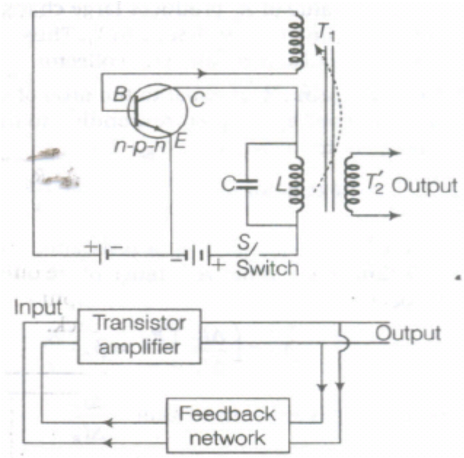
42)

Thin and lightly doped base region contains a smaller number of majority charge carriers, reducing rate of recombination resulting small I_B and collector current almost equal to I_E resulting large voltage and power gain.

43)

X⟶Amplifier, Y⟶Feedback network

Transistor as an oscillator: In an oscillator, the output at a desired frequency is obtained without applying any external input voltage. The common emitter n -p - n transistor as an oscillator is shown in the following figure. A variable capacitor C of suitable range is connected in parallel to coil L to give the variation in frequency.



Oscillator action

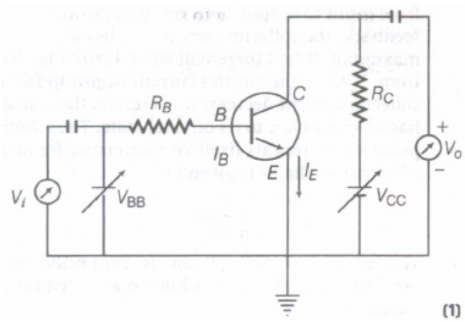
As in an amplifier, the base-emitter junction is forward biased while the base collector junction is reverse biased. When the switch S is put on, a surge of collector, current flows in the coil T_2 The inductive coupling between coil T_2 and Ii cause a current to flow in the emitter circuit i.e., feedback from input to output. As a result of positive feedback, the collector current reaches at maximum. When there will be no further feedback from T_2 to Ii, the emitter current begins to fall and collector current decreases. Therefore, the transistor has reverted back to its original state. The whole process now repeats itself.The resonance frequency (f) of the oscillator is given by

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

The tank of tuned circuit is connected in the oscillator side. Hence, it is known as tuned collector oscillator.

44)

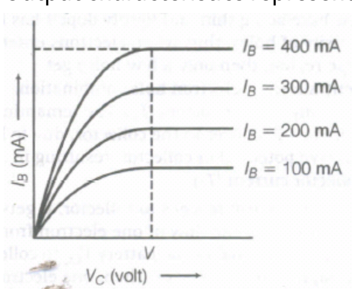
The circuit is as sh
own below:



Current amplification factor (β_{AC}) is the ratio of change in collector current (ΔI_C) to the change is based current (ΔI_B) at constant collector voltage, i.e

$\beta_{AC} = \frac{\Delta I_C}{\Delta I_B}|_{\text{VCE=constant}}$

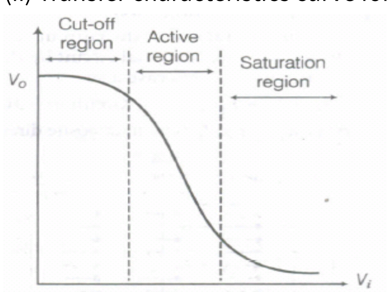
Output characteristics represent the variation of I_C with V_C keeping 1_B constant



From above graph at V_C = V, the value of collector current increases with the increase in the base current, I_B, Thus

$\beta_{AC} = \frac{\Delta I_C}{\Delta I_B}|_{\text{VCE=constant}}$

(ii) Transfer characteristics curve for a base-biased transistor in CE configuration.



Hence, low input give high output and high input gives low output.

45)

The active region of a transfer characteristics curve can be used to explain the transistor as an amplifier.

The resistance of output circuit is large being in reverse bias and resistance of input circuit is low being in forward bias.

When input voltage, VBE comes in active region, Ie flows in output and Vo varies significantly as $V_o = V_{CE} = V_{CC} - I_C R_L$ This change in output voltage.is obtained as amplified form.

(ii) NAND gates are termed as universal gates because all three basic gates namely AND, OR and NOT can be made using NAND gate.

The given circuit perform the logic operations of AND gate as Y=$\overline{\overline{(A.B)}}$=A.B

46)

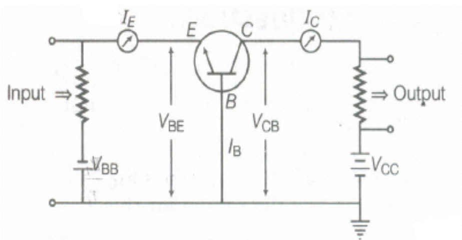
Working of n-p-n transistor as CE amplifier In the circuit, output resistance is very high whereas input resistance is very low being reverse and forward bias, respectively. When current, Ie grows in output circuit, potential difference across the collector decreases significantly as per relation

$V_o=V_{CE}=V_{CC}-I_CR_L$

When input voltage is fed into input circuit, V_{EB} changes, which in turn change I_B and I_E. By transistor action, I_C change and thus, output voltage changes in amplified manner.

47)

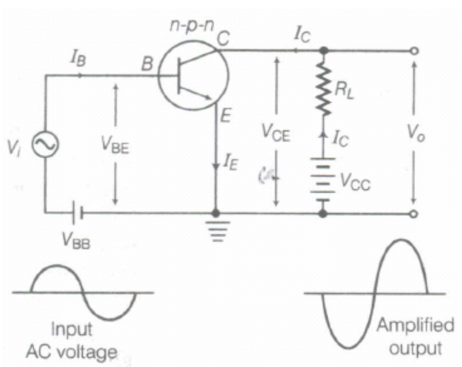
n-p-n transistor in CB configuration Since, the base is common in input and output circuits, therefore transistor is connected in CB



Working When input voltage, V_{BE} is sufficient to make flow of emitter current, collector current flows in output circuit. In this condition, the circuit is said to be in active state.

The small change in VEB' produces sufficient change in emitter current and hence, in collector current. The input circuit offers very small resistance as ample change in emitter current occurs corresponding to small change in input voltage. This lead to produce large change in output voltage inspite of smaller change in collector current ($I_E < I_C$) This shows that output circuit offer high resistance.

48)



n-p-n transistor as a common emitter amplifier

49) For n-p-n transistor in CE configuration circuit diagram.

The output resistance (ro)

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

From the given graph, at I_B = 60 μA

V_{CE} = 2V, V_{CE} = 16 V

Collector current changes from 8 mA to 8.5mA,

ΔV_{CE}=16-2=14V

ΔI_C=8.5-8=0.5 mA=5 x 10^{-4} A

∴ $$\left(\frac{\Delta V_C}{\Delta I_C}\right)_{I_B=60\mu A} = \frac{14}{5\times 10^{-4}}$$

r_o=2.8 x 10^4 Ω

r_o=28kΩ

(b) The current amplification factor

∴ $$\beta_{AC} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE=constant}}$$

At V_{CE}=2V, I_B=10μA to 60μA

∴ ΔI_B=(60-10)=50 μA

I_C changes from 1.5mA to 8 mA

∴ ΔI_C=8-1.5=6.5 mA

⇒ $$\beta_{AC} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}} = \frac{6.5\times 10^{-3}A}{50\times 10^{-6}A}$$

$\beta_{AC} = \frac{6.5\times 10^3}{50} = 1.3 \times 10^2 \Rightarrow \beta_{AC}$=130

50)

(i) Kamal is caring for his younger brother, good subject knowledge helps him to develop application skill.

(ii) On connecting two amplifiers in series, its amplification gains get multiplied. Hence loudness of music system increases.

(iii) Current gain in the transistor as an amplifier is given by $\beta_{AC} = \frac{\Delta I_C}{\Delta I_B}$

where, ΔI_C=change in collector current

ΔI_B=change in base current

51) Device X⟶CE Amplifier

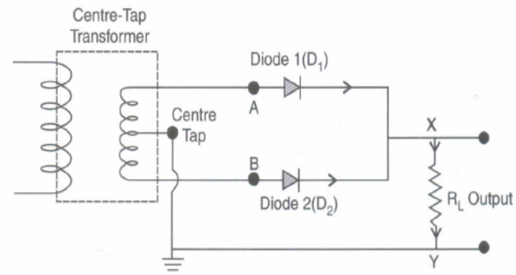
Power gain A_p of the transistor may be expressed as:

AC power gain (A_p) = Current gain (β_{AC}) x Voltage gain (A_v)

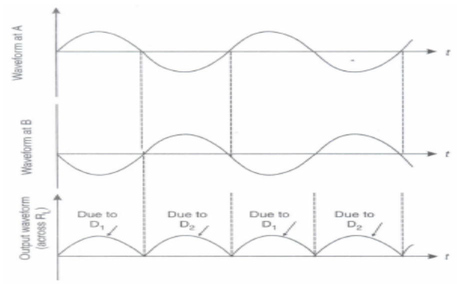
$$A_P = \beta_{AC}^2 \frac{R_L}{R}$$

As power is always positive, hence power gain A_p is always positive.

52)



During first half cycle of input a.c., one diode will act as forward biased and conduct, while other diodes which is reverse biased will not conduct. In other half cycles of input signal, the reverse biased diode will get forward biased and hence will conduct while other diode gets reverse biased and will not conduct. In such case, we will achieve unidirectional output voltage for positive and negative half cycle.



(ii) Identification: AND Gate

Truth Table

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

53)

$$\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}, \quad \beta_{dc} = \frac{I_C}{I_B}$$

For determining β_{ac} and β_{dc} at the stated values of V_{CE} and I_C one can proceed as follows. Consider any two characteristics for two values of I_B which lie above and below the given value of I_C. Here I_C = 4.0 mA. (Choose characteristics for I_B= 30 and 20 μA.) At V_{CE} = 10 V we read the two values of I_C from the graph. Then

$\Delta I_B = (30 - 20)\mu\text{A} = 10\mu\text{A}, \Delta I_C = (4.5 - 3.0)\text{mA} = 1.5 \text{ mA}$

Therefore, $\beta_{ac} = 1.5 \text{ mA}/10\mu\text{A} = 150$

For determining βdc, either estimate the value of I_B corresponding to I_C = 4.0 mA at V_{CE} = 10 V or calculate the two values of βdc for the two characteristics chosen and find their mean.

Therefore, for I_C = 4.5 mA and I_B = 30 μA

$\beta_{dc} = 4.5 \text{ mA}/30\mu\text{A} = 150$

and for I_C = 3.0 mA and I_B = 20 μA

$\beta_{dc} = 3.0 \text{ mA}/20\mu\text{A} = 150$

Hence,$\beta_{dc} = (150 + 150)/2 = 150$

54)

Given at saturation $V_{CE} = 0$ V, $V_{BE} = 0.8$ V

$V_{CE} = V_{CC} - I_{CR}$

$I_C = V_{CC}/R_C = 5.0\text{ V}/1.0\text{k}\Omega = 5.0\text{ mA}$

Therefore $I_B = I_C/\beta = 5.0\text{ mA}/250 = 20\mu\text{A}$

The input voltage at which the transistor will go into saturation is given by

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

$= 20\mu\text{A} \times 100\text{k}\Omega + 0.8\text{ V} = 2.8\text{ V}$

The value of input voltage below which the transistor remains cutoff is given by

$V_{IL} = 0.6$ V, $V_{IH} = 2.8$ V

Between 0.0 V and 0.6 V, the transistor will be in the 'switched off' state. Between 2.8 V and 5.0 V, it will be in 'switched on' state.

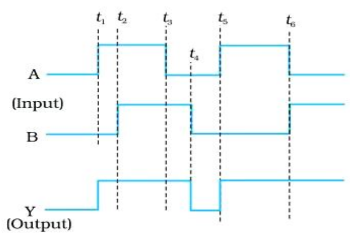
Note that the transistor is in active state when I_B varies from 0.0 mA to 20 mA. In this range .In this range, $I_C = \beta I_B$ is valid.

In the saturation range, $I_C \leq \beta I_B$.

55) Note the following

At $t < t_1$	A = 0, B = 0;	Hence Y = 0
For t_1 to t_2	A = 1, B = 0;	Hence Y = 1
For t_2 to t_3	A = 1, B = 1;	Hence Y = 1
For t_3 to t_4	A = 0, B = 1;	Hence Y = 1
For t_4 to t_5	A = 0, B = 0;	Hence Y = 0
For t_5 to t_6	A = 1, B = 0;	Hence Y = 1
For $t > t_6$	A = 0, B = 1;	Hence Y = 1

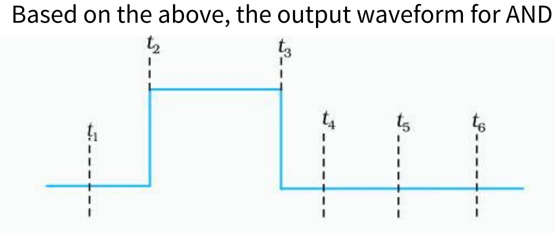
Therefore the waveform Y will be as shown in the Fig



56)

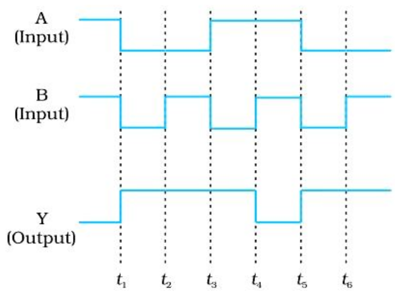
For $t < t_1$;	A = 0, B = 0;	Hence Y = 0
For t_1 to t_2 ;	A = 1, B = 0;	Hence Y = 0
For t_2 to t_3 ;	A = 1, B = 1;	Hence Y = 1
For t_3 to t_4 ;	A = 0, B = 1;	Hence Y = 0
For t_4 to t_5 ;	A = 0, B = 0;	Hence Y = 0
For t_5 to t_6 ;	A = 1, B = 0;	Hence Y = 0
For $t > t_6$;	A = 0, B = 1;	Hence Y = 0

Based on the above, the output waveform for AND gate can be drawn as given below.



57)

For $t < t_1$;	A = 1, B = 1;	Hence Y = 0
For t_1 to t_2;	A = 0, B = 0;	Hence Y = 1
For t_2 to t_3;	A = 0, B = 1;	Hence Y = 1
For t_3 to t_4;	A = 1, B = 0;	Hence Y = 1
For t_4 to t_5;	A = 1, B = 1;	Hence Y = 0
For t_5 to t_6;	A = 0, B = 0;	Hence Y = 1
For $t > t_6$;	A = 0, B = 1;	Hence Y = 1



58)

(a) In a p-n junction diode, the expression for current is given as:

$$I = I_0 \exp\left(e\frac{V}{2k_BT} - 1\right)$$

Where,

I_0 = Reverse saturation current = 5 x 10^{-12} A

T = Absolute temperature = 300 K

k_B = Boltzmann constant = 8.6 x 10^{-5} eV / K = 1.376 x 10^{-23} J K^{-1}

V = Voltage across the diode

Forward voltage, V = 0.6 V

Current, I

$$\therefore \quad = 5 \times 10^{-12}\left[\exp\left(\frac{1.6 \times 10^{-19} \times 0.6}{1.376 \times 10^{-23} \times 300}\right) - 1\right]$$

$$= 5 \times 10^{-12} \times \exp[22.36] = 0.0256A$$

Therefore, the forward current is about 0.0256 A.

(b) For forward voltage, V' = 0.7 V, we can write:

$$I' = 5 \times 10^{-12}\left[\exp\left(\frac{1.6 \times 10^{-19} \times 0.7}{1.376 \times 10^{-23} \times 300}\right) - 1\right]$$

$$= 5 \times 10^{-12} \times \exp[26.25] = 1.257 \text{ A}$$

Hence, the increase in current, $\Delta I = I' - I$

= 1.257 − 0.0256 = 1.23 A

(c) Dynamic resistance $= \frac{\text{Change in voltage}}{\text{Change in Current}}$

$$= \frac{0.7 - 0.6}{1.23} = \frac{0.1}{1.23} = 0.081\Omega$$

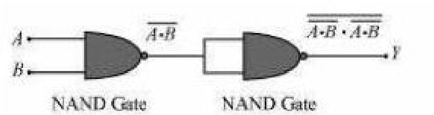
(d) If the reverse bias voltage changes from 1 V to 2 V, then the current (I) will almost remain equal to I_0 in both cases.

Therefore, the dynamic resistance in the reverse bias will be infinite.

59)

In both the given circuits, A and B are the inputs and Y is the output.

(a) The output of the left NAND gate will be , $\overline{A.B}$ as shown in the following figure.

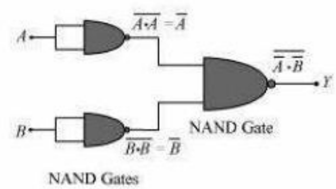


Hence, the output of the combination of the two NAND gates is given as:

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

Hence, this circuit functions as an AND gate.

(b) $\bar{A}$ is the output of the upper left of the NAND gate and $\bar{B}$ is the output of the lower half of the NAND gate, as shown in the following figure.



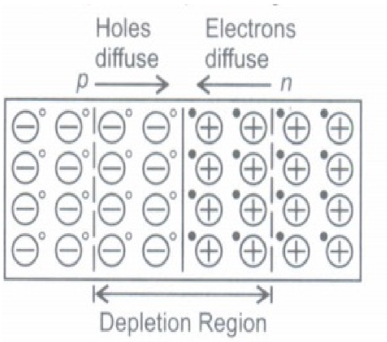
Hence, the output of the combination of the NAND gates will be given as:

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

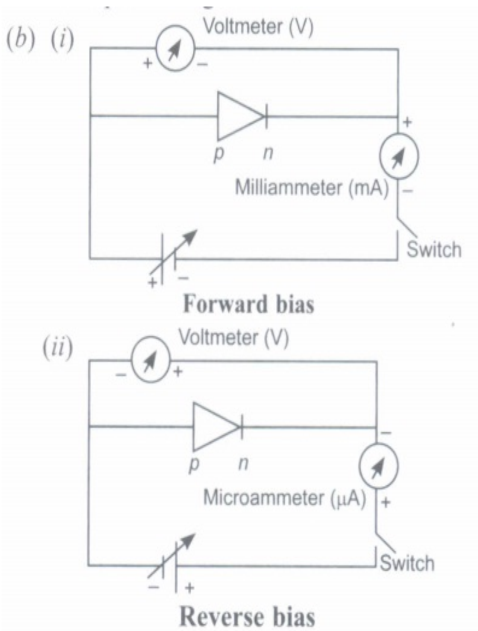
Hence, this circuit functions as an OR gate.

60)

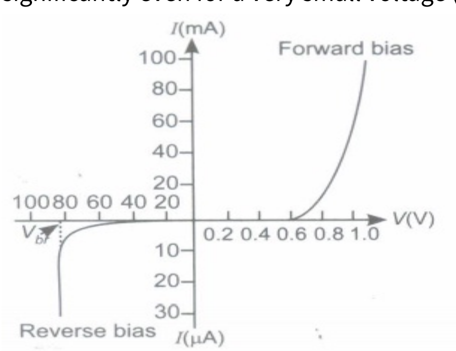
(a) The two processes involved are diffusion and drift. As a result of concentration gradient, holes diffuse from p-side to n-side and free electrons diffuse from n-side to p-side. The moment charge carriers cross the junction and leave behind the ionised atoms, i.e. the acceptors on p-side (-ve ions) and the donors on n-side (+ve ions) of the junction.



The space charge region on either side of the junction where there are no free charges is known as depletion region.

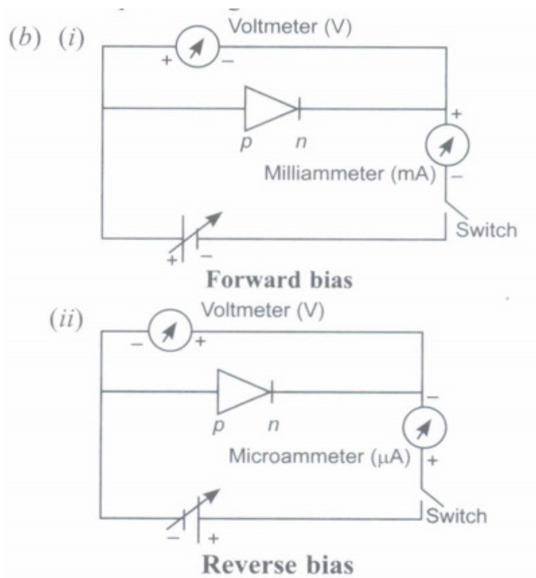


The battery is connected to the silicon diode through a potentiometer (or rheostat), so that the applied voltage can be changed. For different values of voltages, the value of current is noted. In forward bias the current increases at a negligibly slow rate till the voltage, across the diode reaches the threshold voltage. After this the current increases significantly even for a very small voltage (This threshold voltage is -0.2 V for Ge and -0.7 V for Si diode).



Now, in reverse bias, the current is very small (-μA) and almost remains constant for large change in bias voltage till the bias voltage reaches the breakdown voltage. At this reverse bias voltage, the current suddenly increases.

61)



62)

(a) In case of an intrinsic semiconductor the number density of free electrons is equal to number density of holes. There are no external impurity atoms in the intrinsic semiconductors and the conductivity is low in comparison to that of doped (extrinsic semiconductors). When the intrinsic semiconductor is doped with acceptor impurity atoms, a p-type semiconductor is formed. In case of p-type semiconductor, $n_h >> n_e$. Therefore, the conductivity of p-type semiconductor is higher than that of the intrinsic semiconductor.

The number of negatively charged immobile ions is equal to the number of oppositively charged holes. Therefore, p type semi-conductor is electrically neutral.

(b) The heavy doping of p and n sides of a p-njunction results into a reduced width of depletion region. As, for the same value of barrier potential, the width decreases and the electric field across the junction Increases.

i.e. $V = Ed \Rightarrow E = \frac{V}{d}$

As, the electric field of the junction acquires very high value for a large variation of current, the potential difference in breakdown region remains almost same.

This property of zener diode is used in voltage regulation. Zener diode as a voltage regulator.

The unregulated de is given as an input through a series resistor R_s . The zener is always kept under reverse bias. As the input voltage increases, the current through resistance R_s and zener increases. This causes more voltage rise in resistance R_s keeping the voltage across Z the same. This is possible, as at zener voltage, the current increases without any change in potential. As the input drops, the current through resistance R_s and Z drops causing no change in voltage across zener. Thus, at both higher and lower potential inputs, a regulated output is obtained.