CBSE Class 12 physics

Important Questions

Chapter 14

Electronic Devices

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1 Mark Questions

1.Give the ratio of number of holes and the no. of conduction electrons in an intrinsic semiconductor.

Ans. $\frac{nh}{ne} = 1$ (As in intrinsic semiconductor ne = nh)

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

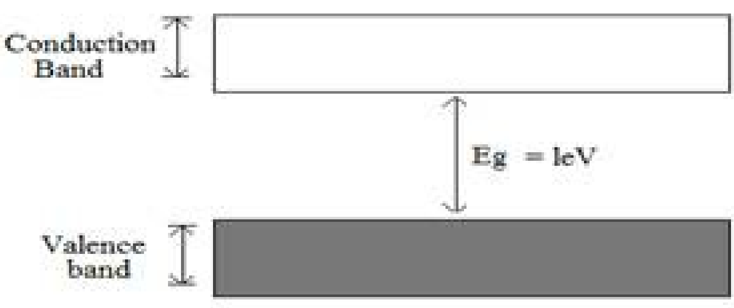
Ans. Pentavalent atoms like Arsenic (As)

3.Doping of silicon with indium leads to which type of semiconductor?

Ans. Indium is a trivalent impurity, thus doping of silicon with indium leads to p-type semiconductor.

4.Draw an energy level diagram for an intrinsic semiconductor?

Ans. In intrinsic semiconductor (ne = nh)



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5. A semiconductor has equal electron and hole concentration of $6 \times 10^{8} m^{-3}$. On doping

with a certain impurity electron concentration increases to $3 \times 10^{12} m^{-3}$. Identify the type of semiconductor after doping?

Ans. As ne > nh, thus resulting semiconductor is of n-type.

6.How does the energy gap of an intrinsic semiconductor vary, when doped with a trivalent impurity?

Ans. When a trivalent impurity is added to an intrinsic semiconductor, an acceptor energy level is created in the forbidden energy gap which lies above the valence band. Due to this electrons easily transformed to the acceptor energy level.

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7. How does width of depletion layer of p.n junction diode change with decrease in reverse bias?

Ans. Decrease in reverse bias will decrease in width of the depletion layer.

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8. Under what condition does a junction diode work as open switch?

Ans. A junction diode works an open switch when it is reverse biased.

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9. Which type of biasing gives a semiconductor diode very high resistance?

Ans. Reverse biasing

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10. If The output of a 2-input NAND gate is fed as the input to a NOT gate

(i) name the new logic gate obtained and

(ii) write down its truth table?

Ans. Logic gate obtained is AND gate.

A	B	Y
0	0	0
0	1	0

1 1	0 1	0 1

11.Define current amplification factor in a common – emitter mode of transistor?

Ans. Ratio of small change in collection current to the small change in base current at constant collector emitter junction voltage is called current amplification factor.

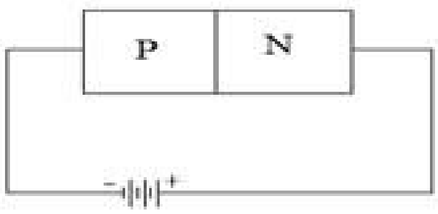
12.Why is a semiconductor damaged by a strong current?

Ans. When a strong current passes through a semiconductor large amount of heat is produced which breaks the covalent bonds in the semiconductor due to which it gets damaged.

2 Mark Questions

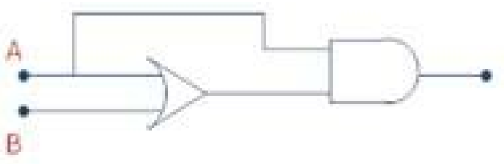
1.Draw a pn junction with reverse bias? Which biasing will make the resistance of a p-n-junction high?

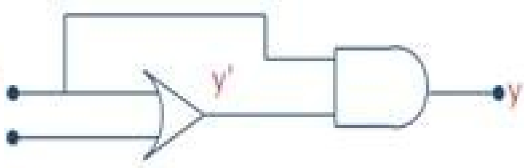
Ans.



Reverse biasing will make the resistance high as it will not allow the current to pass.

2.Write the truth table for the following combination of gates?



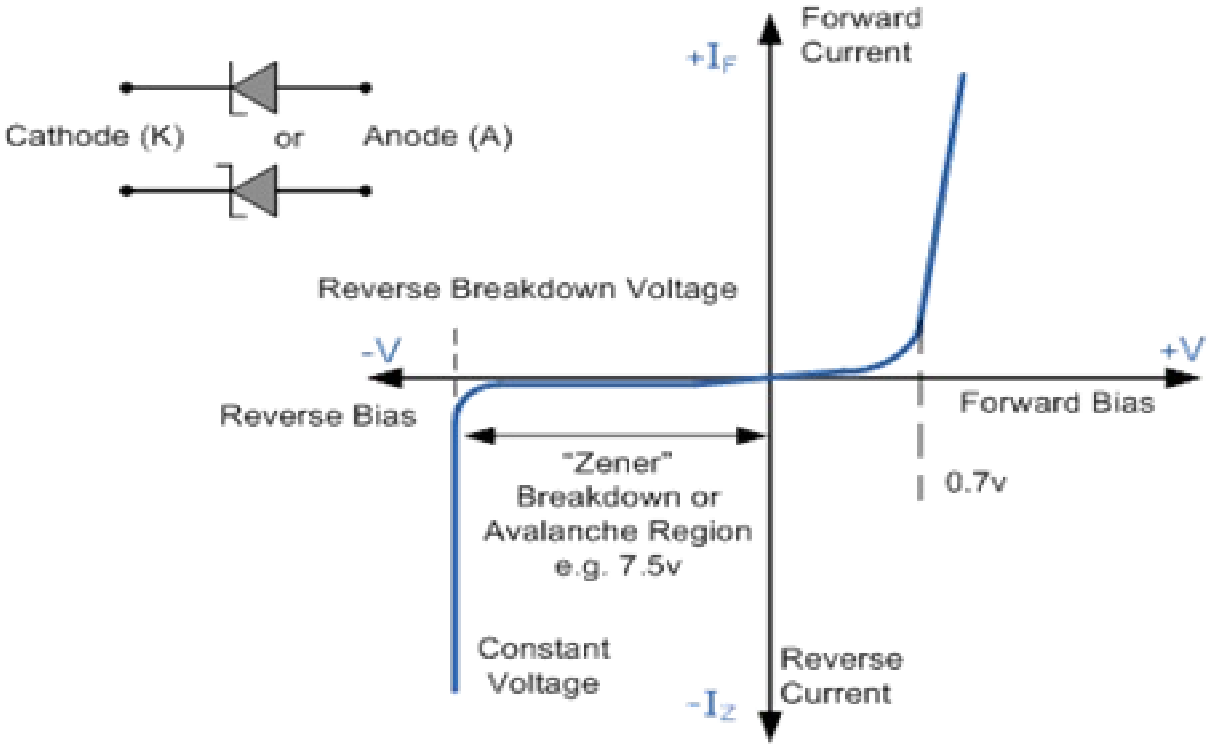


Ans.

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

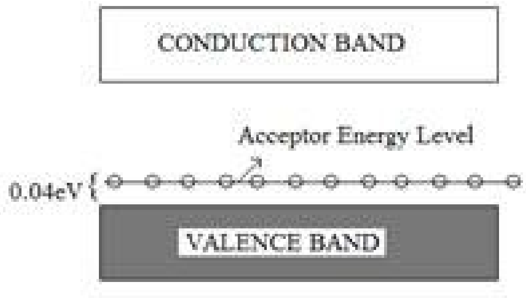
3.Draw the voltage current characteristics of a zener diode?

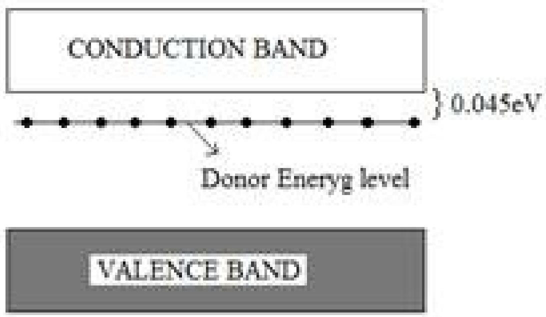
Ans.



4.For a extrinsic semiconductor, indicate on the energy band diagram the donor and acceptor levels?

Ans. N-type Extrinsic Semiconductor P-type Extrinsic Semiconductor





5.What do you mean by depletion region and potential barrier in junction diode?

Ans.A layer around the junction between p and n-sections of a junction diode where charge carriers electrons and holes are less in number is called depletion region. The potential difference created across the junction due to the diffusion of charge carriers across the junction is called potential barrier.

6.A transistor has a current gain of 30. If the collector resistance is 6kΩ, input resistance is 1kΩ, calculate its voltage gain?

Ans. Given $Rin = 1k\Omega$

$Rout = 6k\Omega$

$\therefore Rgain = \frac{6}{1} = 6$

$\therefore$ Voltage gain = current gain $\times$Rgain

Voltage gain = 30$\times$6 = 180

7. What are the advantages and disadvantages of semiconductor devices over vacuum tubes?

Ans. Advantages – Semiconductor devices are very small in size as compared to the vacuum tubes. It requires low voltage for their operation

Disadvantage – Due to the rise in temperature and by applying high voltage it can be damaged.

8.The base of a transistor is lightly doped. Explain why?

Ans. In a transistor, the majority carries form emitter region moves towards the collector region through base. If base is made thick and highly doped, majority carriers will combine with the other carriers within the base and only few is collected by the collector which leads to small output collector current. Thus in order to have large output collector current, base is made thin and lightly doped.

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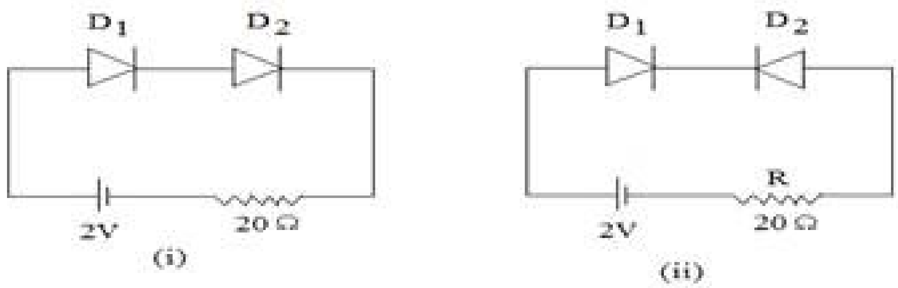
9. Determine the currents through resistance R of the circuits (i) and (ii) when similar diodes $D_1 and\ D_2$ are connected as shown in the figure.



Ans. In figure (i) $D_1 and\ D_2$ are forward biased

$$\Rightarrow I = \frac{V}{R} = \frac{2}{20} = 0.1A$$

In figure (ii) D_1 is forward biased but D_2 is reverse biased due to which $D_1 and\ D_2$ offers infinite resistance

$$\therefore I = 0$$

10.What do you mean by hole in a circuit? Write its two characteristics?

Ans.A vacancy created in a covalent bond in a semiconductor due to the release of electron is known as hole in a semiconductor.

Characteristics of hole

(i) Hole is equivalent to a positive electronic charge.

(ii) Mobility of hole is less than that of an electron

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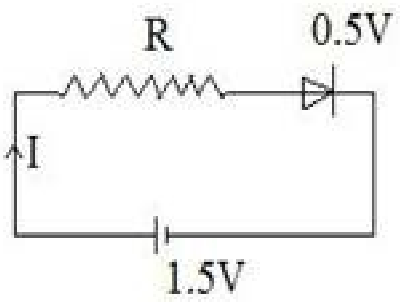
11. Diode used in the figure has a constant voltages drop at 0.5V at all currents and

a maximum power rating of 100mW. What should be the value of the resistance R, connected in series for maximum current?



Ans. $P = 100mW = 100 \times 10^{-3}$

$V = 0.5V$

$P = VI$

$\Rightarrow I = \frac{P}{V} = \frac{100 \times 10^{-3}}{0.5}$

I = 0.2A

For the given circuit

IR = + 0.5 – 1.5 = 0

I R = 0.5

IR=0.5-1.5

IR-1=0

0.2 x R=1

$$R = \frac{1}{0.2} = 5\Omega$$

$$R = 5\Omega$$

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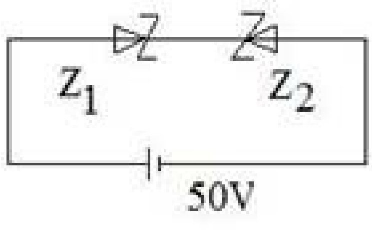
12. Zener diode Z_1 has saturation current of 20A and reverse breakdown voltage of 100V where as the corresponding value of Z_2 are 40 μ A and 40. Find the current through the circuit?



Ans. Here Z_1 is forward biased where as Z_2 reverse biased hence Z_1 behaves as a conductor and reverse saturation current will flow from Z_2

Thus $R_{Z_2} = \frac{40}{40 \times 10^{-6}}$

$R_{Z_2} = 10^6 \Omega$

Now 50V will appear across Z_2 so

$I = \frac{50}{10^6}$

$I = 50 \times 10^{-6} A$

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13. In an n-type silicon, which of the following statement is true:

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

(b) Electrons are minority carriers and pentavalent atoms are the dopants.

(c) Holes are minority carriers and pentavalent atoms are the dopants.

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

Ans. The correct statement is **(c)**.

In an n-type silicon, the electrons are the majority carriers, while the holes are the minority carriers. An n-type semiconductor is obtained when pentavalent atoms, such as phosphorus, are doped in silicon atoms.

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14. Which of the statements given in Exercise 14.1 is true for p-type semiconductors.

Ans. The correct statement is **(d).**

In a p-type semiconductor, the holes are the majority carriers, while the electrons are the minority carriers. A p-type semiconductor is obtained when trivalent atoms, such as aluminium, are doped in silicon atoms.

15. Carbon, silicon and germanium have four valence electrons each. These are characterised by valence and conduction bands separated by energy band gap respectively equal to $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$ Which of the following statements is true?

(a) $(E_g)_{Si} < (E_g)_{Ge} < (E_g)_C$

(b) $(E_g)_C < (E_g)_{Ge} > (E_g)_{Si}$

(c) $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$

(d) $(E_g)_C = (E_g)_{Si} = (E_g)_{Ge}$

Ans. The correct statement is **(c)**.

Of the three given elements, the energy band gap of carbon is the maximum and that of germanium is the least.

The energy band gap of these elements are related as: $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$

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16. In an unbiased p-n junction, holes diffuse from the p-region to n-region because

(a) free electrons in the n-region attract them.

(b) they move across the junction by the potential difference.

(c) hole concentration in p-region is more as compared to n-region.

(d) All the above.

Ans. The correct statement is **(c)**.

The diffusion of charge carriers across a junction takes place from the region of higher concentration to the region of lower concentration. In this case, the p-region has greater concentration of holes than the n-region. Hence, in an unbiased p-n junction, holes diffuse from the p-region to the n-region.

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17. When a forward bias is applied to a p-n junction, it

(a) raises the potential barrier.

(b) reduces the majority carrier current to zero.

(c) lowers the potential barrier.

(d) None of the above.

Ans. The correct statement is **(c)**.

When a forward bias is applied to a p-n junction, it lowers the value of potential barrier. In the case of a forward bias, the potential barrier opposes the applied voltage. Hence, the potential barrier across the junction gets reduced.

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18. For transistor action, which of the following statements are correct:

(a) Base, emitter and collector regions should have similar size and doping concentrations.

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

(c) The emitter junction is forward biased and collector junction is reverse biased.

(d) Both the emitter junction as well as the collector junction are forward biased.

Ans. The correct statement is **(b)**, **(c)**.

For a transistor action, the junction must be lightly doped so that the base region is very thin. Also, the emitter junction must be forward-biased and collector junction should be reverse-biased.

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19. For a transistor amplifier, the voltage gain

(a) remains constant for all frequencies.

(b) is high at high and low frequencies and constant in the middle frequency range.

(c) is low at high and low frequencies and constant at mid frequencies.

(d) None of the above.

Ans. The correct statement is **(c)**.

The voltage gain of a transistor amplifier is constant at mid frequency range only. It is low at high and low frequencies.

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

Ans. Input frequency = 50 Hz

For a half-wave rectifier, the output frequency is equal to the input frequency.

$\therefore$ Output frequency = 50 Hz

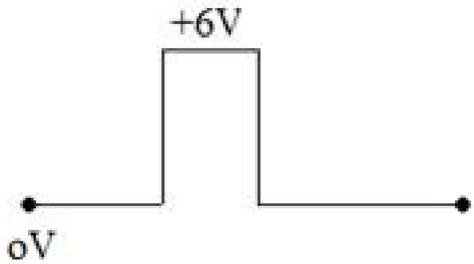
For a full-wave rectifier, the output frequency is twice the input frequency.

$\therefore$ Output frequency = 2×50 = 100 Hz

3 Mark Questions

1. What is an ideal diode? Draw the output wave form across the load resistor R, if the input waveform is as shown in the figure.

Ans. An ideal diode has zero resistance when forward biased and an infinite resistance when it is reverse biased. Output wave from is



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2. With the help of a labeled circuit diagram, explain full wave rectification using junction diode. Draw input and output wave forms?

Ans. Full wave rectifier consists of two diodes and a transformer with central tap. For any half cycle of a.c. input only one diode is forward biased where as the other one is reverse biased.

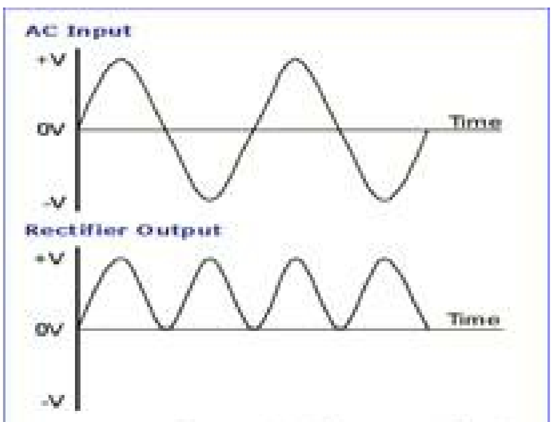
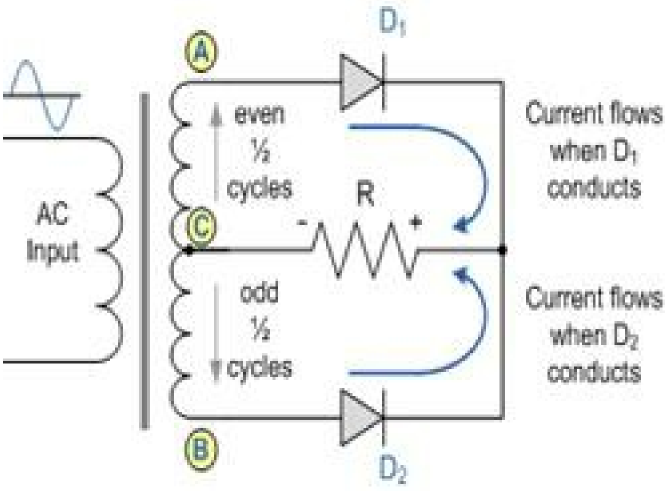
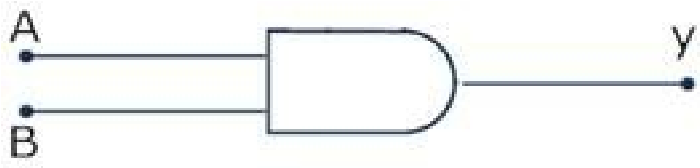


Figure 4: Full-wave rectification



Suppose for positive half of a.c. input diode D_1 is forward biased and D_2 is reverse biased, then the current will flow across D_1 where as for negative half of a.c. input diode D_2 is forward biased and the current flows across D_2. Thus for both the halves output is obtained and current flows in the same direction across load resistance R_2 and thus a.c. is converted into d.c.

3.Name the gate shown in the figure and write its truth table?



Ans. It is AND gate and its truth table is

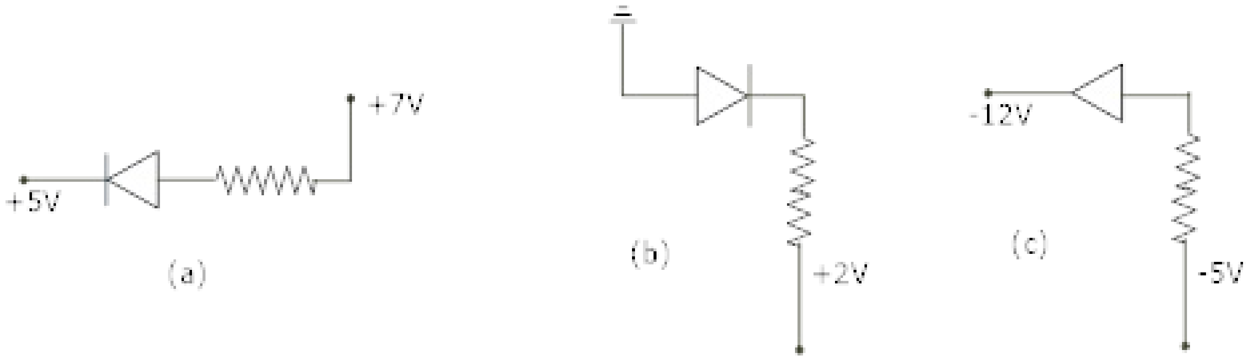
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

4. In the following diagrams indicate which of the diodes are forward biased and which are reverse bias?

Ans.(a) Forward Biased

(b) Reverse Biased

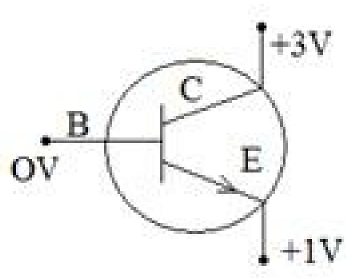
(c) forward Biased



5.In the given figure, is

(i) The emitter base

(ii) collector base forward or reverse biased? Justify.

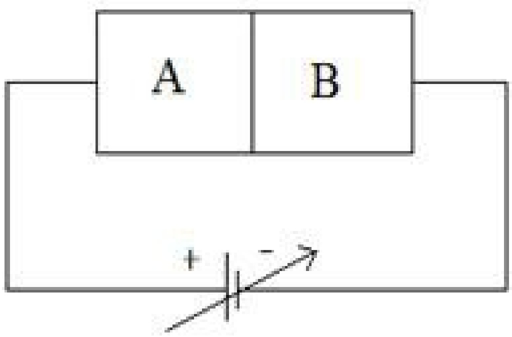


Ans. Figure shows n-p-n transistor

(i) Emitter is reversed biased because n-region is connected to higher potential.

(ii) Collector is also reversed biased because n-region of p-n junction is at higher potential than p-region.

6.Two semiconductor materials A and B shown in the figure are made by doping germanium crystal with arsenic and indium respectively. The two are joined end to end and connected to a battery as shown.

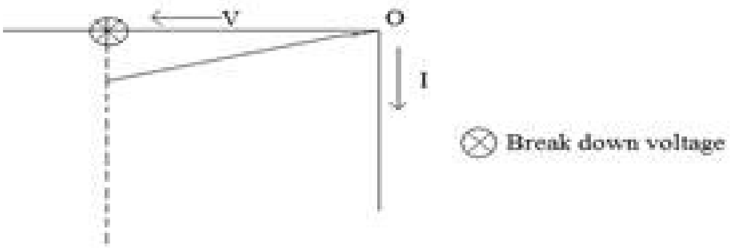


(a) Will the junction be forward biased or reverse biased? Justify

(b) Sketch a V-I graph for this arrangement

Ans. Material A is n-type as it is doped with pentavalent impurity and material B is p-type as it is doped with trivalent impurity. As a result the junction becomes reverse biased because positive terminal of the battery is connected to n-type and negative terminal to the p-type hence it is reversed biased.

V-I graph for the given circuit



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7. Calculate emitter current for which $\beta = 100$ **and** $I_\beta = 20\mu A$ **?**

Ans. $\beta = 100$,

$I_B = 20\,\mu A = 20 \times 10^{-6} A$

$B = \dfrac{I_C}{I_B}$

$I_C = BI_B = 100 \times 20 = 2000\,\mu A$

Using $I_E = I_B + I_C$

$I_E = 20 \times 10^{-6} + 2000\,\mu A$

$I_E = 2020\,\mu A$

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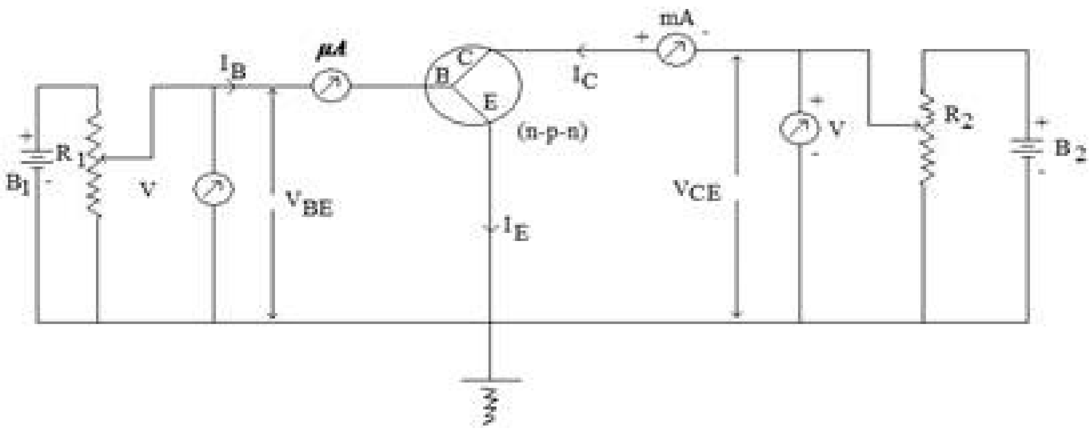
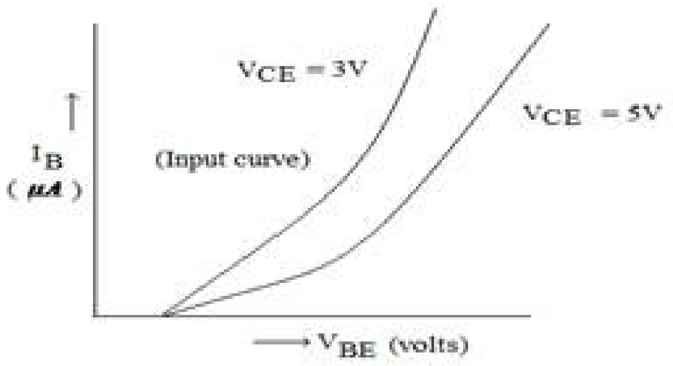
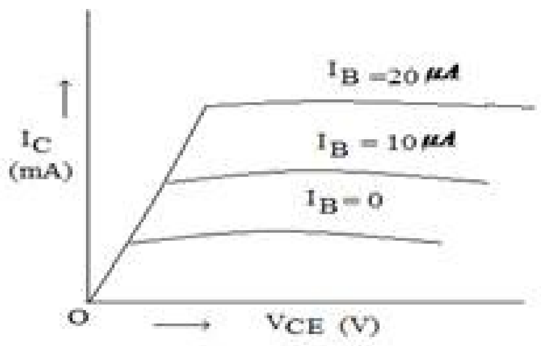
8. Draw the circuit diagram for common – emitter transistor characteristics using N-P-N transistor? Draw the input and output characteristic curve ?

Ans.



Input characteristic curve is the variation of base current I_B (Input) with base – emitter voltage (VEB) at constant collector emitter voltage (V_{CE}).





output characteristics is the variation of the collector current (I_C) with collector emitter voltage (V_{CE}) at constant base current (I_B) is called output characteristics.

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9. For a CE-transistor amplifier, the audio signal voltage across the collected resistance of 2 $k\Omega$ 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 $k\Omega$.

Ans. Collector resistance, $R_C = 2\,\text{k}\Omega = 2000\Omega$

Audio signal voltage across the collector resistance, *V* = 2 V

Current amplification factor of the transistor, β = 100

Base resistance, $R_B = 1\,\text{k}\Omega = 1000\,\Omega$

Input signal voltage = V_i

Base current = I_B

We have the amplification relation as:

Voltage amplification $= \frac{V}{V_1} = \beta \frac{R_c}{R_B}$

$$V_i = \frac{VR_B}{\beta R_C}$$

$$= \frac{2 \times 1000}{100 \times 2000} = 0.01V$$

Therefore, the input signal voltage of the amplifier is 0.01 V.

Base resistance is given by the relation:

$$R_B = \frac{V_i}{I_B}$$

$$= \frac{0.01}{1000} = 10 \times 10\mu^{-6}\text{A}$$

Therefore, the base current of the amplifier is 10 μA

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10. 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.

Ans. Voltage gain of the first amplifier, V_1 = 10

Voltage gain of the second amplifier, V_2 = 20

Input signal voltage, V_i = 0.01 V

Output AC signal voltage = V_o

The total voltage gain of a two-stage cascaded amplifier is given by the product of voltage gains of both the stages, i.e.,

$V = V_1 \times V_2$

$= 10 \times 20$ = 200

We have the relation:

$$V = \frac{V_0}{V_1}$$

$V_0 = V \times V_i$

$= 200 \times 0.01$ = 2 V

Therefore, the output AC signal of the given amplifier is 2 V.

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

Ans. Energy band gap of the given photodiode, *Eg* = 2.8 eV

Wavelength, λ = 6000 nm = $6000 \times 10^{-9}\ m$

The energy of a signal is given by the relation:

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

Where,

h = Planck's constant

= $6.626 \times 10^{-34}\ Js$

c = Speed of light

= $3 \times 10^8\ m/s$

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

$= 3.313 \times 10^{-20}\ J$

= $3.313 \times 10^{-20}\ J$

But $1.6 \times 10^{-19}\ J$ = 1 eV

$\therefore E = 3.313 \times 10^{-20}\ J$

$$= \frac{3.313\times10^{-20}}{1.6\times10^{-19}} = 0.207 eV$$

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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12. The number of silicon atoms per m^3 is 5×10^{28}. This is doped simultaneously with 5×10^{22} atoms per m^3 of Arsenic and 5×10^{20} per m^3 atoms of Indium. Calculate the number of electrons and holes. Given that $n_i = 1.5\times10^{16}\ m^{-3}$. Is the material n-type or p-type?

Ans. Number of silicon atoms, $N = 5 \times 10^{28}\ atoms/m^3$

Number of arsenic atoms, $n_{As} = 5\times10^{22}\ atoms/m^3$

Number of indium atoms, $n_{In} = 5\times10^{20}\ atoms/m^3$

Number of thermally-generated electrons, $n_i = 1.5\times10^{16}\ electrons/m^3$

Number of electrons, $n_e = 5\times10^{22} - 1.5\times10^{16} \approx 4.99\times10^{22}$

Number of holes = n_h

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

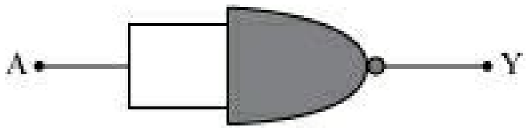
$$n_e n_h = n_i^2$$

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

$$= \frac{\left(1.5\times10^{16}\right)^2}{4.99\times10^{22}} \approx 4.51\times10^{9}$$

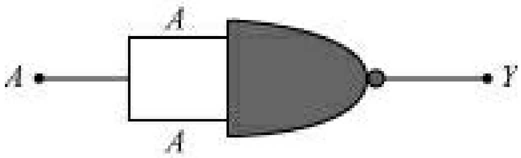
Therefore, the number of electrons is approximately 4.99×10^{22} and the number of holes is about 4.51×10^{9}. Since the number of electrons is more than the number of holes, the material is an n-type semiconductor.

13.Write the truth table for a NAND gate connected as given in Fig. 14.45.



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

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



NAND Gate

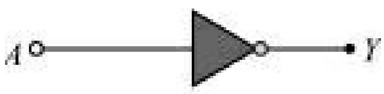
Hence, the output can be written as:

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

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

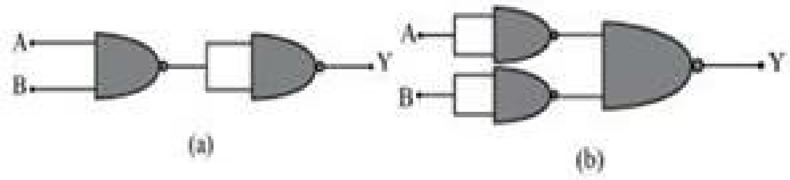
A	***Y*** $\left(=\overline{A}\right)$
0	1
1	0

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



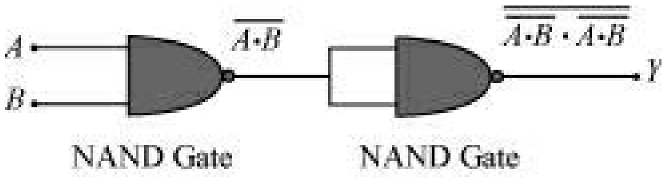
NOT Gate

14. You are given two circuits as shown in Fig. 14.46, which consist of NAND gates. Identify the logic operation carried out by the two circuits.



Ans. 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 $\overline{A \cdot B}$, as shown in the following figure.

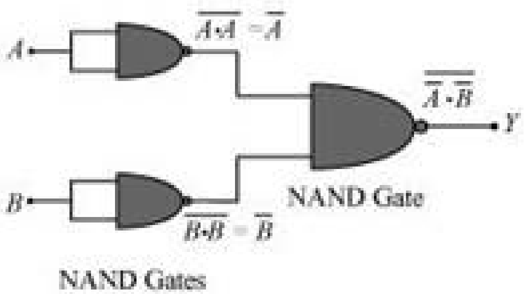


Hence, the output of the combination of the two NAND gates is given as:

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

Hence, this circuit functions as an AND gate.

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



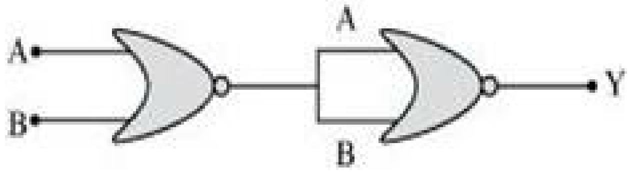
Hence, the output of the combination of the NAND gates will be given as:

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

Hence, this circuit functions as an OR gate.

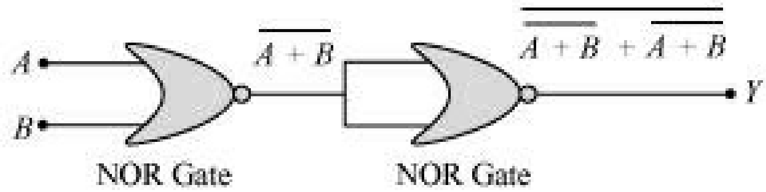
15.Write the truth table for circuit given in Fig. 14.47 below consisting of NOR gates and

identify the logic operation (OR, AND, NOT) which this circuit is performing.



(Hint: A = 0, B = 1 then A and B inputs of second NOR gate will be 0 and hence Y=1. Similarly work out the values of Y for other combinations of A and B. Compare with the truth table of OR, AND, NOT gates and find the correct one.)

Ans.*A* and *B* are the inputs of the given circuit. The output of the first NOR gate is $\overline{A+B}$. It can be observed from the following figure that the inputs of the second NOR gate become the out put of the first one.



Hence, the output of the combination is given as:

$$\overline{\overline{A+B}+\overline{A+B}} = \overline{\overline{A}\cdot\overline{B}+\overline{A}.\overline{B}}$$

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

The truth table for this operation is given as:

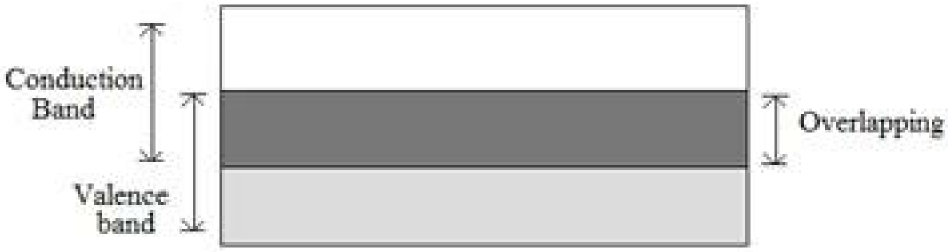
A	*B*	*Y*(=*A*+*B*)
0	0	0
0	1	1
1	0	1
1	1	1

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

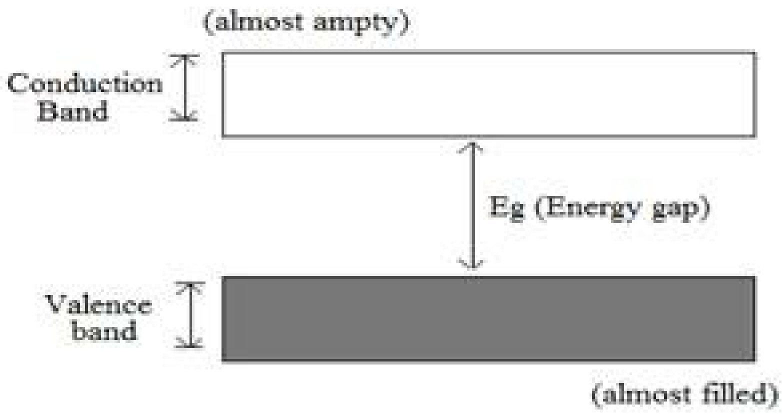
5 Mark Questions

1.Distinguish between conductors, insulators and semiconductors on the basis of energy band diagrams?

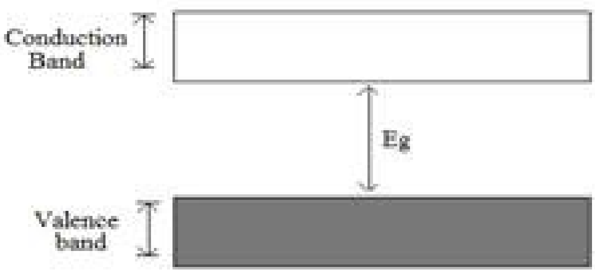
Ans. Conductor – Conduction band in a conductor is either partially filled or conduction and valence band overlaps each other. There is no energy gap in a conductor.



Insulators – conduction band and valence band of all insulator are widely separated by and energy gap of the order 6 to 9eV Also conduction band of an insulator is almost empty.



Semiconductor – In semiconductors the energy gap is very small i.e. about 1ev only.



2.The following truth table gives the output of a 2-input logic gate.

A B output

0 0 1

01 0

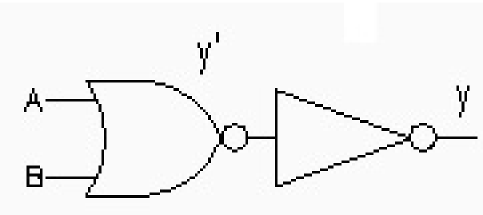
10 0

11 0

Identify the logic gate used and draw its logic symbol. If the output of this gate is fed

as input to a NOT gate, name the new logic gate so formed?

Ans. The gate is NOR gate. If the output of NOR gate is connected to a NOT gate then the figure will be



New truth table is

A B Y

000

011

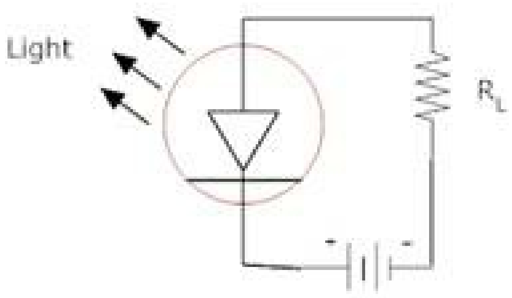
101

111

It is the truth table of OR gate

3.With the help of a diagram, show the biasing of a light emitting diode (LED). Give its two advantages over conventional incandescent lamps?

Ans. Light emitting diode is forward biased i.e. energy is released at the junction.



<u>Advantages of LED</u>

(1) They are used in numerical displays as compact in size.

(2) It works at low voltage and has longer life than incandescent bulbs.

4.The input resistance of a silicon transistor is 665 Ω. Its base current is changed by 15 μ A, which results in the change in collector current by 2mA. This transistor is used as a common emitter amplifier with a load resistance of 5k Ω. Calculate current gain (βac).

Ans.(1) Trans conductance (gm) (2) voltage gain (Av) of the amplifier.

Here $\Delta I_B = 15\mu A = 15\times10^{-6} A$

$\Delta I_C = 2mA = 2\times10^{-3} A$

$Rin = 665\Omega, R_2 = 5k\Omega = 5\times10^3 \Omega$

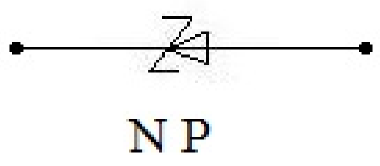
$$\beta ac = \frac{\Delta I_C}{\Delta I_B} = \frac{2\times10^{-3}}{15\times10^{-6}} = 133.3$$

(1) Trans conductance, gm = $\frac{\beta ac}{Rin} = \frac{133.3}{665} = 0.2\Omega^{-1}$

(2) Voltage gain (Av) = $gmR_L = 0.2 \times 5 \times 10^3 = 1000$

5.Draw the symbol for zener diode? Zener diodes have higher dopant densities as compared to ordinary p-n junction diodes. How dos it affect the (i) width of the depletion layer (i) junction field?

Ans. Symbol for zener diode



(i) Width of the depletion layer of zener diode becomes very small due to heavy doping of p and n-regions

(ii) Junction field will be high.

6.A P-N-P transistor is used in common – emitter mode in an amplifier circuit. A change of $40\mu A$ in the base current brings a change of 2mA in collector current and 0.04V in base – emitter voltage. Find (i) input resistance (ii) current amplification factor (β) . If a load resistance of 6kΩ is used, then find voltage gain?

Ans. $\Delta I_B = 40\mu A = 40 \times 10^{-6} A$

$\Delta I_C = 2mA = 2 \times 10^{-3} A$

$\Delta V_{BE} = 0.04V$

$R_L = 6k\Omega = 6 \times 10^3 \Omega$

$$Rin = \frac{\Delta V_{BE}}{\Delta I_B} = \frac{0.04}{40\times10^{-6}} = 1\times10^3\Omega = 1k\Omega$$

$$\beta = \frac{\Delta \upsilon_C}{\Delta I_B} = \frac{2\times10^{-3}}{40\times10^{-6}} = 50$$

Voltage gain $= \beta {}^{RL}/_{Ri} = \frac{50\times6\times10^3}{1\times10^3} = 300$

7.A semiconductor has equal electron and whole concentration of $6\times10^8\ /\ m^3$ **.**

On doping with certain impurity, electron concentration increases to $8\times10^{12}\ /\ m^3$ **.**

(i) Identify the new semiconductor

(ii) Calculate the new whole concentration.

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

Ans.(i) New semiconductor obtained is N-type because

(ii) $nenh = ne^2$

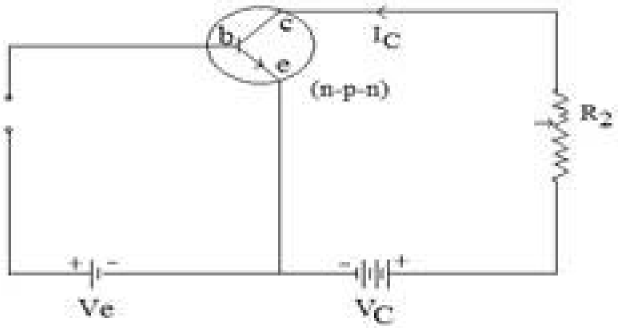
$$nh = \frac{ni^2}{ne} = \frac{36\times10^{16}}{8\times10^{12}}$$

$$nh = 4.5\times10^4\ /\ m^3$$

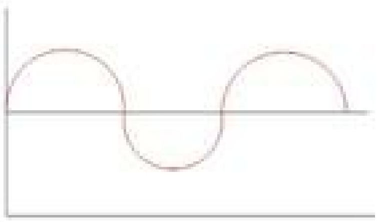
(iii) Energy gap decreases due to creation of donor level in between the valence band and the conduction band.

8.Draw a labeled circuit diagram of a common emitter transistor amplifier. Draw the input and the output wave forms and also state the relation between input and output signal?

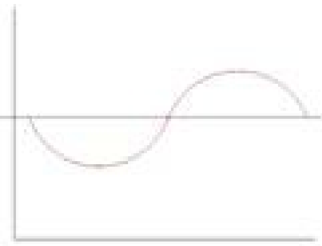
Ans.



Input wave from



Output wave form



Relation – output waveform has 180^o phase reversal as compared to input and also the output is being amplified.

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

$$n_{i=}n_o \exp\left[-\frac{Eg}{2k_BT}\right]$$

where n_0 is a constant.

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

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

$$n_i = n_o \exp\left[-\frac{Eg}{2k_BT}\right]$$

Where k_B = Boltzmann constant = $8.62\times10^{-5} eV/K$

T = Temperature

n_0 = Constant

Initial temperature, T_1 = 300 K

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

$$n_{i1} = n_0 \exp\left[-\frac{E_g}{-2k_B\times300}\right] \dots (1)$$

Final temperature, T_2 = 600 K

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

$$n_{i2} = n_0 \exp\left[-\frac{E_g}{-2k_B\times600}\right] \dots (2)$$

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.

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

$$= \exp \frac{E_g}{2k_B}\left[\frac{1}{300} - \frac{1}{600}\right]$$

$$= \exp\left[\frac{1.2}{2 \times 8.62 \times 10^{-5}} \times \frac{2-1}{600}\right]$$

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

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

10.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 *I0* 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, *k* Bis 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?

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

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

Where,

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

T = Absolute temperature = 300 K

k_B = Boltzmann constant = $8.6\times10^{-5}eV/K = 1.376\times10^{-23}JK^{-1}$

V = Voltage across the diode

(a) Forward voltage, V = 0.6 V

$$\therefore \text{Current, } I = 5\times10^{-12}\left[\exp\left(\frac{1.6\times10^{-19}\times0.6}{1.376\times10^{-23}\times300}\right)-1\right]$$

$$=5\times10^{-12}\times\exp[22.36]=0.0256\text{A}$$

Therefore, the forward current is about 0.0256 A.

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

$$=5\times10^{-12}\left[\exp\left(\frac{1.6\times10^{-19}\times0.7}{1.376\times10^{-23}\times300}\right)-1\right]$$

$$=5\times10^{-12}\times\exp[26.25]=1.257\text{A}$$

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

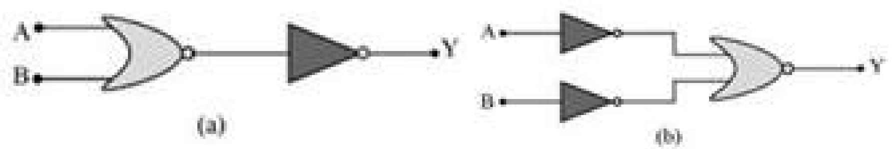
= 1.257 - 0.0256 = 1.23 A

(c) Dynamic resistance $=\dfrac{Change\ in\ voltage}{Change\ in\ current}$

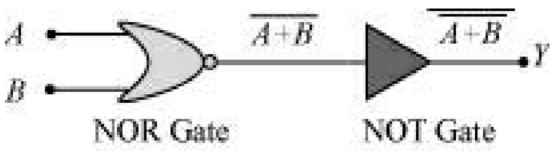
$$=\frac{0.7-0.6}{1.23}=\frac{0.1}{1.23}=0.081\Omega$$

(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.

11. You are given the two circuits as shown in Fig. 14.44. Show that circuit (a) acts as OR gate while the circuit (b) acts as AND gate.



Ans.(a) *A* and *B* are the inputs and *Y* is the output of the given circuit. The left half of the given figure acts as the NOR Gate, while the right half acts as the NOT Gate. This is shown in the following figure.



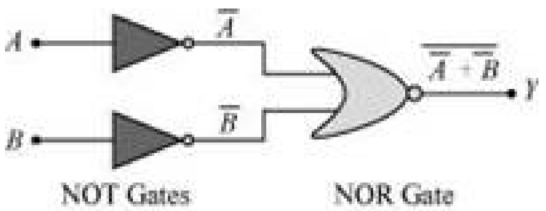
Hence, the output of the NOR Gate = $\overline{A+B}$

This will be the input for the NOT Gate. Its output will be $\overline{\overline{A+B}}$ = $A + B$

$\therefore Y = A + B$

Hence, this circuit functions as an OR Gate.

(b) *A* and *B* are the inputs and *Y* is the output of the given circuit. It can be observed from the following figure that the inputs of the right half NOR Gate are the outputs of the two NOT Gates.



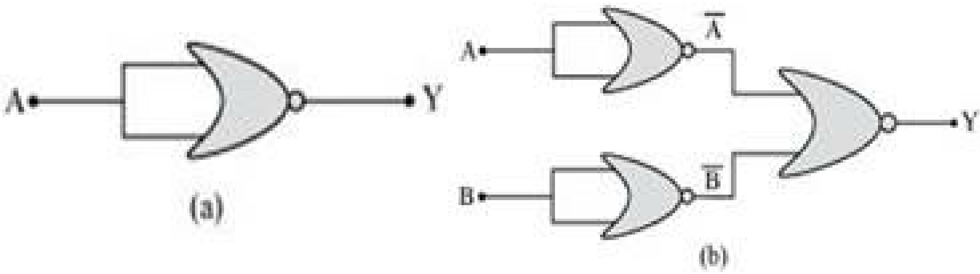
Hence, the output of the given circuit can be written as:

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

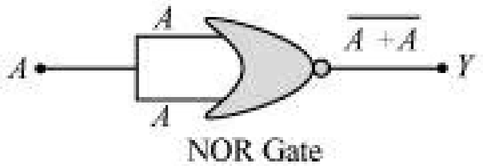
Hence, this circuit functions as an AND Gate.

12.Write the truth table for the circuits given in Fig. 14.48 consisting of NOR gates only.

Identify the logic operations (OR, AND, NOT) performed by the two circuits.



Ans.(a)*A* acts as the two inputs of the NOR gate and *Y* is the output, as shown in the following figure. Hence, the output of the circuit is $\overline{A+A}$.



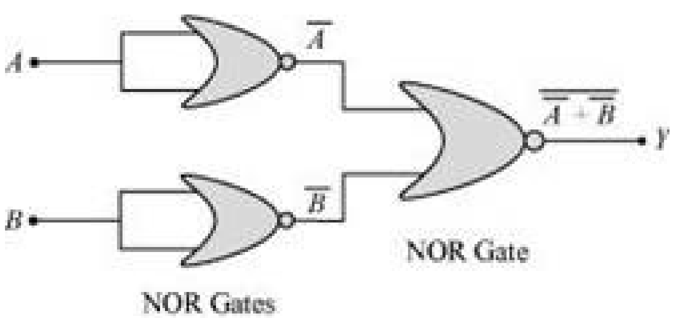
Output, $Y = \overline{A+A} = \overline{A}$

The truth table for the same is given as:

A	$Y\left(=\overline{A}\right)$
0	1
1	0

This is the truth table of a NOT gate. Hence, this circuit functions as a NOT gate.

(b) *A* and *B* are the inputs and *Y* is the output of the given circuit. By using the result obtained in solution **(a)**, we can infer that the outputs of the first two NOR gates are $\overline{A} \; and \; \overline{B}$,as shown in the following figure.



$\overline{A} \; and \; \overline{B}$ are the inputs for the last NOR gate. Hence, the output for the circuit can be written as:

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

The truth table for the same can be written as:

A	***B***	***Y***$(= \mathrm{A} - B)$
0	0	0
0	1	0
1	0	0
1	1	1

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