SHIKSHA CLASSES

Subject : Physics **BOARD ANSWER PAPER** **Total Marks : 20**
Class : XII **Topic: 16. Semiconductor Devices**

Section (A)

Q. 1. (a) Select and write the most appropriate answer from given alternatives in each sub-question [5]

1. Hole is

Ans : d) A vacancy created when an electron leaves a covalent bond.

2. At O^0K, intrinsic semiconductor behaves as

Ans : **(b)** a perfect insulator

3. In a semiconducting material the mobilities of electron and holes are μ_e and μ_h respectively. Which of the following is true?

Ans : a) $\mu_e > \mu_h$ electron is ligher than holes.

4. The forbidden energy gap in the energy bands of germanium at room temperature is about

Ans : c) 0.67 eV

5. When n-p-n transistor is used as an amplifier?

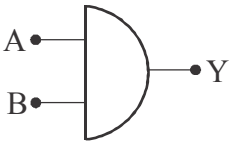
Ans : a) Electrons move from base to collector

(b) Very short answer type Question [2]

1) Give the logic symbol & Boolean expression of AND gate.

Ans. : AND Gate :

Logic Symbol



Boolean expression : $Y = A \cdot B$

2. Why is the base of transistor made thin and lightly doped?

Ans. : In a transistor the base is made very thin and is lightly doped with an impurity, so as to enable the collector to collect about 95% of the holes or electrons coming from the emitter side.

Section (B)

Q. 2. Attempt any three . [6]

1. What is meant by Ripple factor? State its formula.

Ans : Ripple Factor is the ratio of rms value of ac component present in the rectified output to the average value of rectified output. It is a dimensionless quantity and denoted by γ. Its value is always less than unity.

Ripple Factor Formula

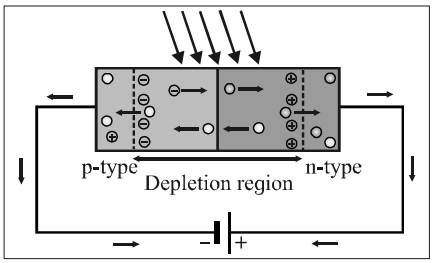
$$\gamma = \frac{\sqrt{(I_{rms})^2 - (I_{dc})^2}}{I_{dc}}$$

where I_{rms} = average value of current

I_{dc} = value of dc current

2. Explain the working of photo cell.

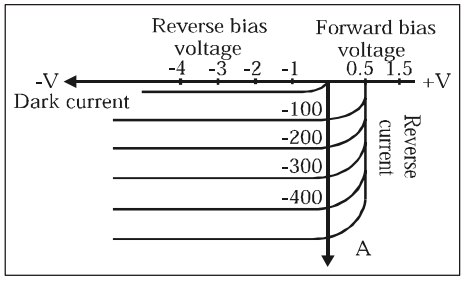
Ans :



schematically shows working of a photodiode.

When a p-n junction is illuminated, electron-hole pairs are generated in the depletion region. The energy of the incident photons should be larger than the band gap of the semiconductor material used to fabricate the photodiode. The electrons and the holes are separated due to the intrinsic electric field present in the depletion region. The electrons are attracted towards the anode and the holes are attracted towards the cathode. More carriers are available for conduction and the reverse current is increased. *The reverse current of a photodiode depends on the intensity of*

the incident light. Thus, the reverse current can be controlled by controlling the concentration of the minority carriers in the junction. Figure shows the I-V characteristic of a photodiode. It clearly shows the relation between intensity of illumination and the reverse current of a photodiode.



The I-V characteristic of a photodiode.

The total current passing through a photodiode is the sum of the photocurrent and the dark current. Figure shows the graphical relation between the reverse current of a photodiode and the intensity of illumination incident on the photodiode. The sensitivity of the device can be increased by minimizing the dark current.

As you can see from the curve, reverse current increases initially with increase in the intensity of illumination. It reaches a constant vlue after certain voltage is reached. *This constant value is called the saturation current of the photodiode.*

3. Define : (i) Intrinsic semiconductor and (ii) Extrinsic semiconductor.

Ans: **i) Intrinsic semiconductor :** Extremely pure semiconductor is called intrinsic semiconductor

ex. silicon, Germanium

ii) Extrinsic semiconductor :

A semiconduclor obtained after adding desirable impurity atoms in the intrinsic semiconductor are called extrinsic semiconductor.

4. State any four advantages of solar cell.

Ans : i) Solar cell is free from all kinds of pollutions.

ii) Solar cell are highly durable

iii) it has no maintenance

iv) They have greater life

v) They are portable

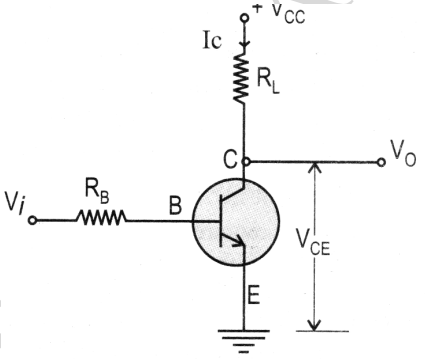
vi) No chemical or pure is required for its operation.

Section (C)

Q. 3. Attempt any one . [3]

1) Explain the working of a transistor as a switch.

Ans: When transistor is operated in cut off region or saturation region, it works as a switch



applying Kirchoff's voltage low to output part we get,

$Vcc = I_C R_L + V_{CE}$

or

$V_{CE} = V_{cc} - I_C R_L$

When Vi = 0 ; $I_b = 0$ and hence $I_c = 0$

$\therefore$ V_{CE} = Vcc = (Source voltage)

That is, when Vi = 0, No current flows through transistor and load R.L. Entire voltage develops across transistor (Vce = Vce). This condition is similar to open switch.

(i.e. Ic = 0, V_0 = Vcc) = source voltage

When Vi is positive and greater than 0.7 V the base current flow that forces transistor into saturation and large current flow through transistor and load R_L.

The entire source voltage gel developed across the load R_L and very low voltage drops across transistor (V_{CE} = 0.2V)

This condition is similar to closed switch (On)

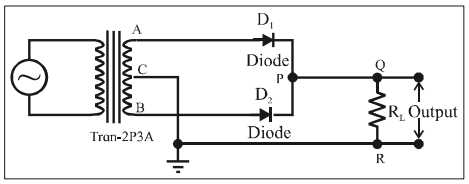
i.e. $I_C = \frac{V_{EC}}{R_L}$ & $V_0 = V_{CE} = 0.2$ V

2) Explain the construction and working of full wave rectifier.

Ans: **Full Wave Rectifier:**

The output of a half wave rectifier is available only in alternate positive half cycles of the AC input. All negative half cycles are lost and the efficiency of a half wave rectifier is very poor. Therefore, a rectifier circuit using two diodes is more useful.

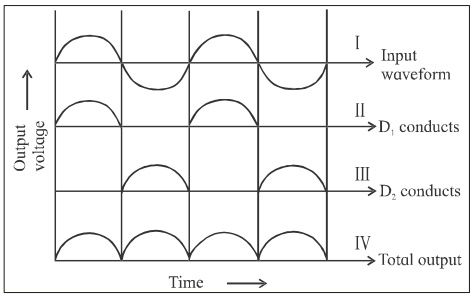
In a full wave rectifier, current flows through the load in the same direction during both the half cycles of input AC voltage. This is because, the full wave rectifier circuit consists of two diodes conducting alternately. Figure shows typical circuit of a full wave rectifier. The circuit consists of a centre tapped transformer and diodes D_1 and D_2.



Circuit diagram for full wave rectifier.

The diodes D_1 and D_2 are connected such that D_1 conducts in the positive half cycle and D_2 conducts in the negative half cycle of the input voltage. During the positive half cycle of the input voltage, the point A is at a higher potential than that of the point B and the diode D_1 conducts. The current through the load resistance R_L follows the path APQRC as shown in Fig. During the negative half cycle of the input voltage, point B is at higher potential than point A and the diode D_2 conducts. The current through the load resistance R_L follows the path BPQRC. Thus, the current flowing through the load resistance is in the same direction during both the cycles.

The input and output waveforms of a full wave rectifier are shown in Fig. First waveform is input AC. The second wave form shows the output when the diode D_1 conducts and the third waveform shows the output when diode D_2 conducts. The fourth waveform shows the total output waveform of the full wave rectifier.



Waveforms of input and output signals for a full wave rectifier.

Section (D)

Q. 4. Attempt any one . [4]

1) a) Write the Boolean expression for i) OR gate ii) AND gate iii) NAND gate.

Ans: **OR Gate:** An OR gate has two or more inputs and one output. *It is also called logical addition*. The output Y is 1 or high when either input A or input B or both are 1, that is, if any one of the input is high or both inputs are high, the output is '1' or high. The symbol and the truth table for an OR gate are shown in Fig. 16.28. The Boolean expression for an OR gate is : Y = A + B

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

OR gate symbol and its Truth table.

AND Gate :

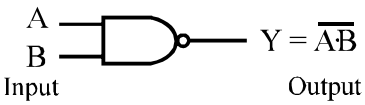
Input A	Input B	Output Y
0	0	0
0	1	0
1	0	0
1	1	1

AND gate symbol and its Truth table

An AND gate has two or more inputs and one output. *The AND operation represents a logical multiplication.* The output Y of AND gate is high or 1 only when

input A and input B are both 1 or both are high simultaneously. The logic symbol and truth table for this gate are given in Fig. The Boolean expression for an AND gate is : $Y = A \cdot B$

NAND Gate : The NAND gate is formed by connecting the output of a NOT gate to the input of an AND gate. *The output of a NAND gate is exactly opposite to that of an AND gate*. If the inputs A and B are both high or '1', the output Y is negation, i.e., the output is low or '0'. The gate derives its name from this NOT-AND behaviour. Figure shows the symbol and the truth table of a NAND gate. The Boolean expression for a NAND gate is: $Y = A \cdot B$



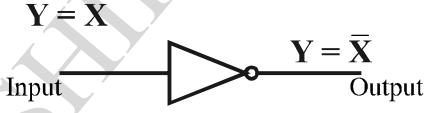
Input A	Input B	Output Y
0	0	1
0	1	1
1	0	1
1	1	0

NAND gate symbol and its Truth table.

b) Why is a NOT gate known as an inverter?

Ans: **NOT Gate :** This is the most basic logic gate. It has one input and one output. It produces a 'high' output or output '1' if the input is '0'. When the input is 'high' or '1', its out put is 'low' or '0'. That is, it produces a negated version of the input at its output. This is why it is also known as an inverter. The symbol and the truth table for a NOT gate is shown in Fig. The Boolean equation of a NOT gate is:

$Y = \overline{X}$



Input	Output
X	Y
0	1
1	0

NOT gate symbol and its Truth table

OR

2) a) State any four uses of LEDs. Explain the working of transistor.

Ans: Four uses of LED's :

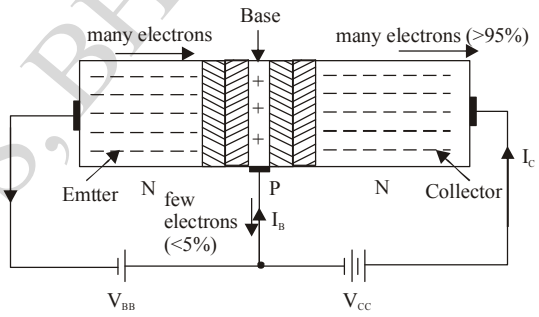
i) LEDs are used as status indicators on various instruments.

ii) It is used in traffic cotrol light system.

iii) It is used as light source in optical fibre communications.

iv) They are used as brake indicators in bikes an vehicles.

Working of transistors : Transistor is semiconductor device having there dropped regions and two junctions. The three doped regions are emitter, base and connector.



When E.B. Junction is forward biased and C-B junction is reverse biased.

E-B junction is forward biased and $V_{BE} > 0.7$ V. Large no. of electrons enter the base as the base is very thin and lightly doped it has few holes. Few electrons from emitter, recombine with these holes and come out as base current. But, most of the emitter injected electrons. Find reverse biased C-B junction and enter collector, then the move into positive terminal of source vcc. that produces large collector current.

More than 95% emitter injected electrons enter into the collator and less than 5% recombine with the holes in base.

i.e. I_C much more than I_B.

Slight change in variation in I_B produces large change in IC.

b) Draw a neat labelled circuit diagram to study the characteristics of transistor in common emitter configuration.

Ans: For transistor,

$I_E = I_B + I_C$ (with $I_C \cong I_E$) ..... (i)

For a transistor

i) αdc (alpha) - the ratio of collector current to emitter current.

$$\alpha dc = \frac{I_C}{I\varepsilon}$$

ii) βdc = (beta, current gain) - The ratio of collector current to base current.

$$P_{dc} = \frac{1_C}{1_B}$$

Equation (i) We have

$I_E = I_B + I_C$

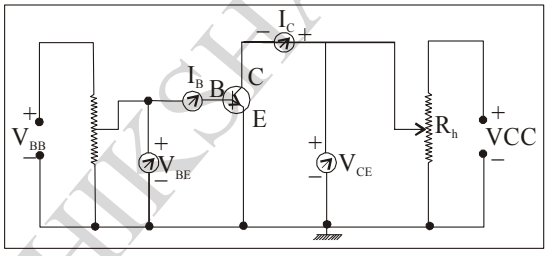
Dividing by I_C throughout

$$\frac{I_E}{I_C} = \frac{I_B}{I_C} + 1$$

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

$$\alpha dc = \frac{\beta_{dc}}{1+\beta_{dc}} \text{ or}$$

$$\beta dc = \frac{\alpha_{dc}}{1-\alpha_{dc}}$$



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