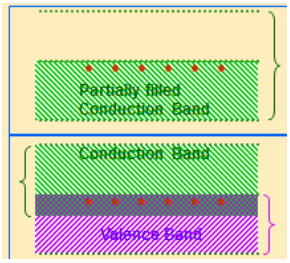
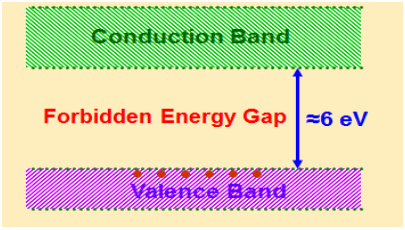
9. ELECTRONIC DEVICES

GIST

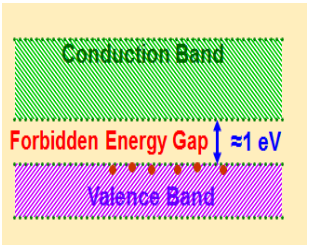
- In metals, the conduction band and valence band partly overlap each other and there is no forbidden energy gap.
- In insulators, the conduction band is empty and valence band is completely filled and forbidden gap is quite large = 6 eV. No electron from valence band can cross over to conduction band at room temperature, even if electric field is applied. Hence there is no conductivity of the insulators.
- In semiconductors, the conduction band is empty and valence band is totally filled. But the forbidden gap between conduction band and valence band is quite small, which is about 1 eV. No electron from valence band can cross over to conduction band. Therefore, the semiconductor behaves as insulator. At room temperature, some electrons in the valence band acquire thermal energy, greater than energy gap of 1 eV and jump over to the conduction band where they are free to move under the influence of even a small electric field. Due to which, the semiconductor acquires small conductivity at room temperature



Metals



Insulators



Semiconductors

Distinction between Intrinsic and Extrinsic Semiconductor

Intrinsic		Extrinsic	
1	It is pure semiconducting material and no impurity atoms are added to it	1	It is prepared by doping a small quantity of impurity atoms to the pure semiconducting material.
2	Examples are crystalline forms of pure silicon and germanium.	2	Examples are silicon and germanium crystals with impurity atoms of arsenic, antimony, phosphorous etc. or indium, boron, aluminum etc.
3	The number of free electron in conduction band and the number of holes in valence band is exactly equal and very	3	The number of free electrons and holes is never equal. There is excess of electrons in n-type semiconductors and excess of holes in p-type

	small indeed.		semiconductors.
4	Its electrical conductivity is low	4	Its electrical conductivity is high.
5	Its electrical conductivity is a function of temperature alone.	5	Its electrical conductivity depends upon the temperature as well as on the quantity of impurity atoms doped in the structure.

Distinction between n-type and p-type semiconductors

n-type semiconductors			p-type semiconductors
1	It is an extrinsic semiconductors which is obtained by doping the impurity atoms of Vth group of periodic table to the pure germanium or silicon semiconductor.	1	It is an intrinsic semiconductors which is obtained by doping the impurity atoms of III group of periodic table to the pure germanium or silicon semiconductor.
2	The impurity atoms added, provide extra electrons in the structure, and are called donor atoms.	2	The impurity atoms added, create vacancies of electrons (i.e. holes) in the structure and are called acceptor atoms.
3	The electrons are majority carriers and holes are minority carriers.	3	The holes are majority carriers and electrons are minority carriers.
4	The electron density (n_e) is much greater than the hole density (n_h)i.e. $n_e >> (n_h)$	4	The hole density (n_e) is much greater than the electron density (n_h)i.e. $n_h >> n_e$
5	The donor energy level is close to the conduction band and far away from valence band.	5	The acceptor energy level is close to valence band and is far away from the conduction band.
6	The Fermi energy level lies in between the donor energy level and conduction band.	6	The Fermi energy level lies in between the acceptor energy level and valence band.

P-n junction diode

Two important processes occur during the formation of p-n junction diffusion and drift. The motion of majority charge carriers give rise to diffusion current.

Due to the space charge on n-side junction and negative space charge region on p-side the electric field is set up and potential barrier develops at the junction Due to

electric field e- on p-side moves to n and holes from n-side to p-side which is called drift current.

In equilibrium state, there is no current across p-n junction and potential barrier across p-n junction has maximum value.

The width of the depletion region and magnitude of barrier potential depends on the nature of semiconductor and doping concentration on two sides of p-n junction.

Forward Bias

P-n junction is FB when p-type connected to the +ve of battery and n-type connected to –ve battery

Potential barrier is reduced and width of depletion layer decreases.

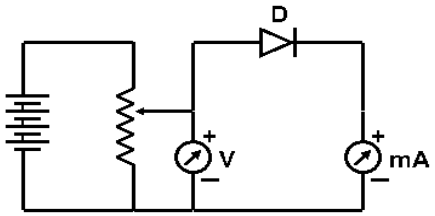
Reverse Bias

P-n junction in RB p-type connected to the –ve battery and n-type connected to +ve

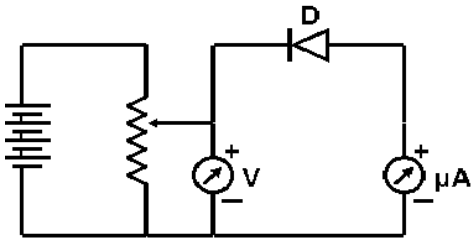
Resistance of p-n junction is high to the flow of current.

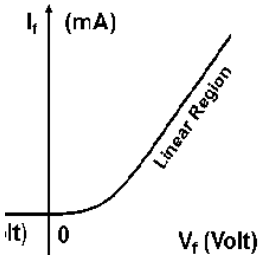
Diode Characteristics:

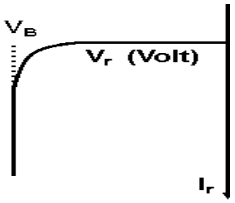
Forward Bias:



Reverse Bias:

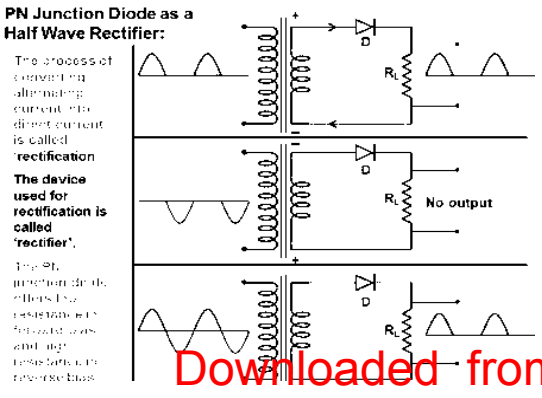




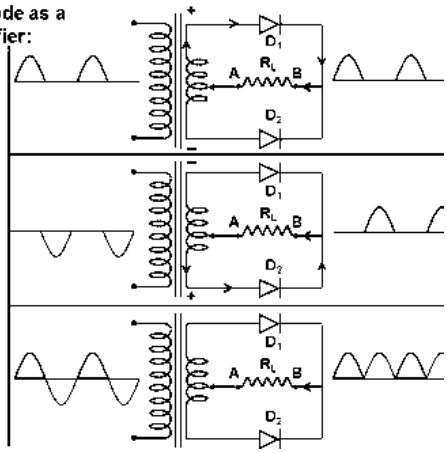


0 (μA)

R**rectification**



PN Junction Diode as a Full Wave Rectifier:



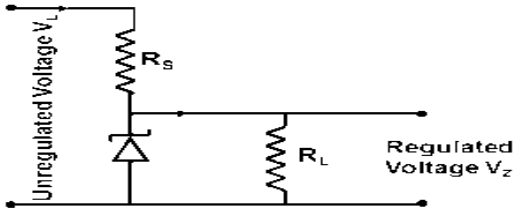
When a p-n diode rectifies both halves of the AC wave it is called **full wave rectifier** .

During the positive half cycle of the input ac signal, the diode D_1 conducts and current is through BA.

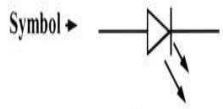
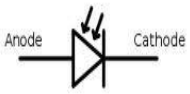
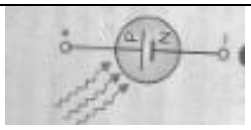
During the negative half cycle, the diode D_2 conducts and current is through **BA.**

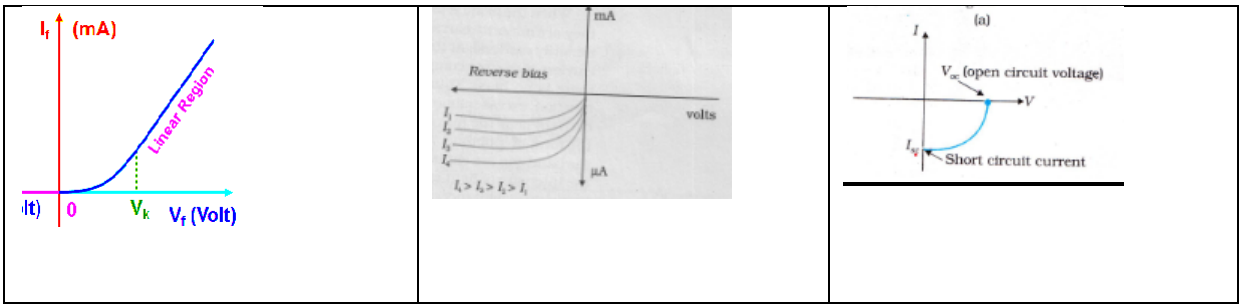
Zener Diode

- Heavily doped
- Depletion Region is $< 10^{-6}$ m
- Electric Field is very high (5×10^{6} V/m)
- Reverse biased
- Internal Field emission or field ionisation

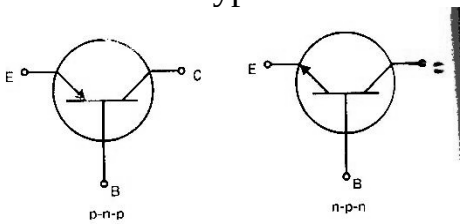


Zener Diode as a Voltage Regulator

LED	PHOTODIODE	SOLARCELL
		
Forward biased	Reverse biased	No external baising,It generates emf when solar radiation falls on it.
Recombination of electrons and holes take place at the junction and emits e m radiations	Energy is supplied by light to take an electron from valence band to conduction band.	Generation of emf by solar cells is due to three basic process generation of e-h pair,separation and collection
It is used in Burglar alarm, remote control	It is used in photo detectors in communication	It is used in satellites,space vechicles calculators.

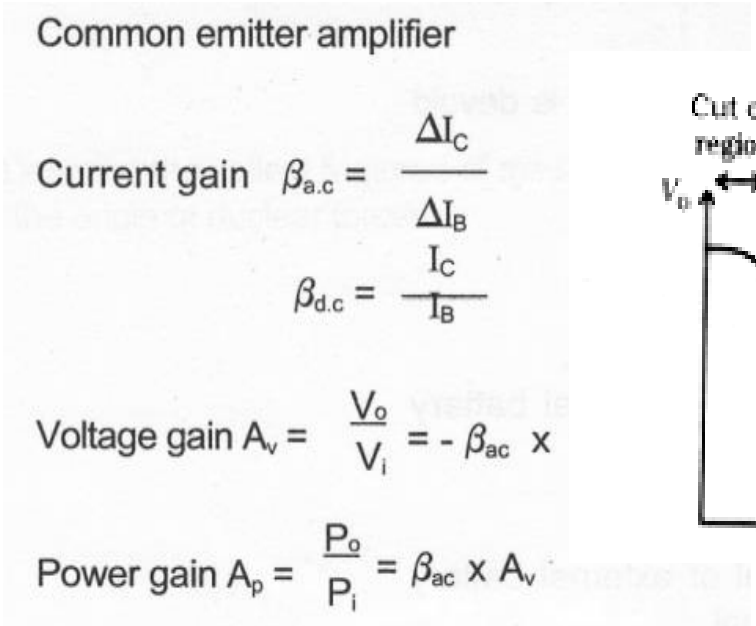


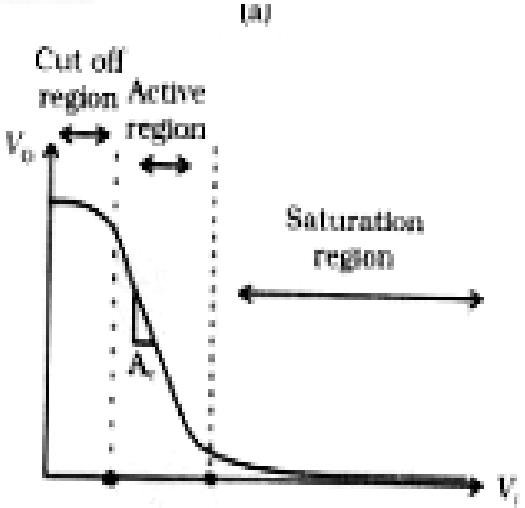
- There are two types of transistor – NPN & PNP



- Applications of transistor

(1) Transistor as a switch (2) Transistor as an amplifier (3) Transistor as an oscillator





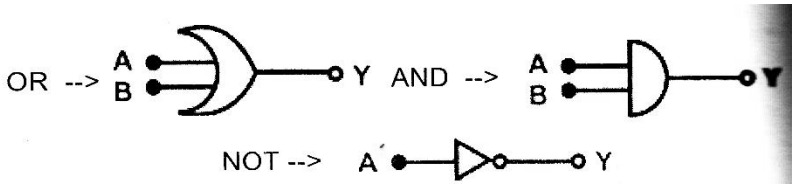
Transistor-Amplifier_ An amplifier is a device which is used for increasing the amplitude of variation of alternating voltage or current or power,thus it produces an enlarged version of the input signal.

For Circuit diagram refer NCERT diagram

Digital Electronics –Logic Gates

- The three basic Logic Gates are

(1) OR Gate: OUTPUT Y= A + B
(2) AND Gate: OUTPUT Y=A.B
(3) NOT GATE: OUTPUT Y=Y'



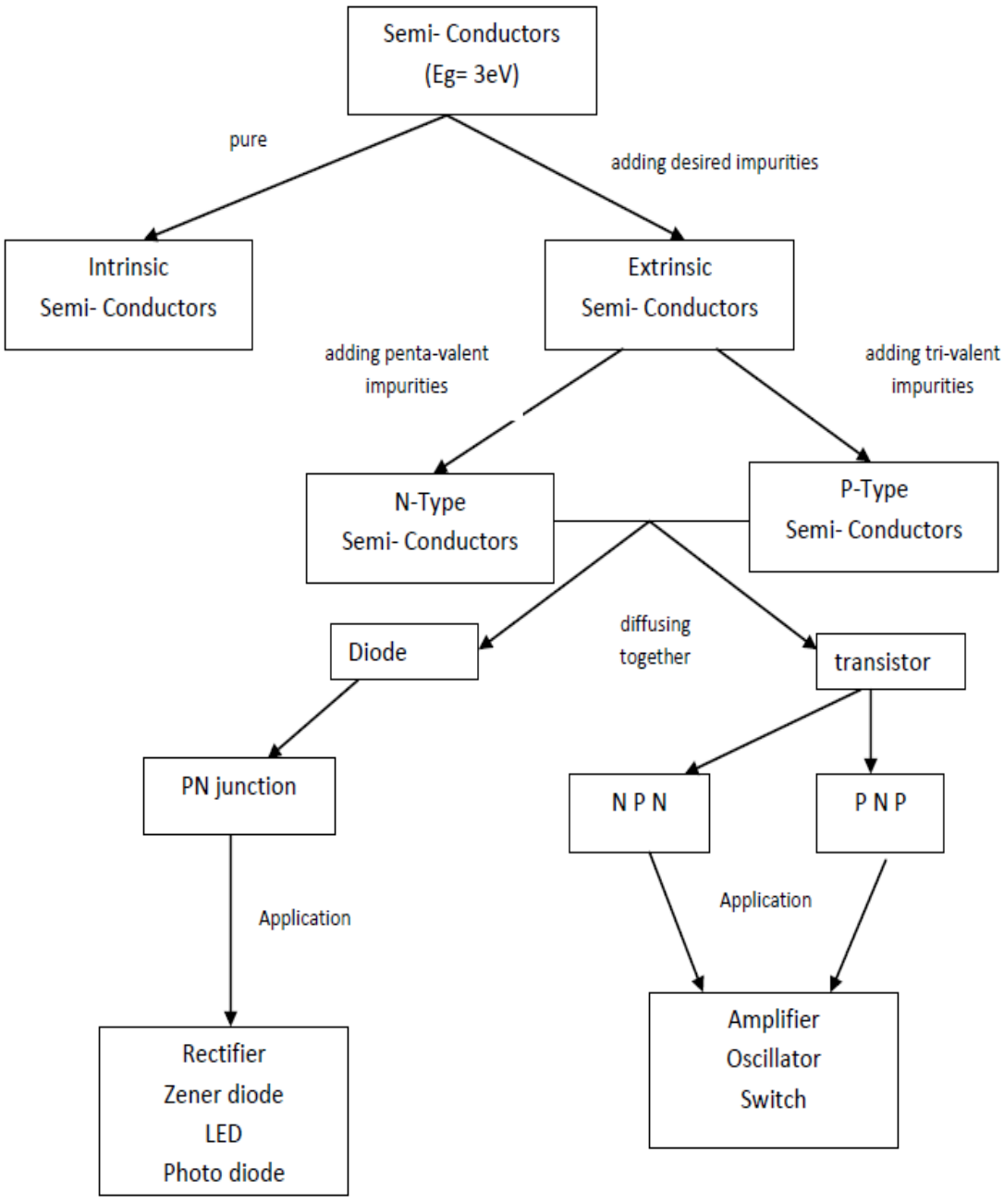
COMBINATION OF GATES

(1) NOR GATE: OUT PUT Y = $\overline{A + B}$

(2) NAND GATE: OUT PUT Y= $\overline{A \,.\, B}$

CONCEPT MAP

Semiconductor and electronic devices



QUESTIONS

SEMICONDUCTORS

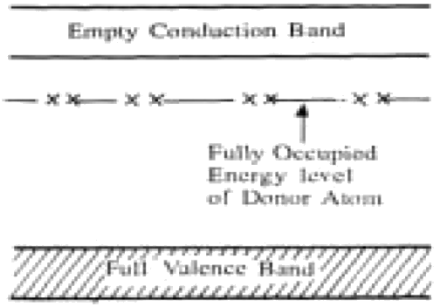
1. What is the order of energy gap in an intrinsic semiconductor? (1)
2. How does the energy gap vary in a semiconductor when doped with penta - valent element? (1)
3. How does the conductivity change with temperature in semiconductor?(1)
4. What type of semiconductor we get when: Ge is doped with Indium? Si is doped with Bismuth? (1)
5. In a semiconductor concentration of electron is 8 x $10^{13}cm^{-3}$ and holes 5 x 10^{12} cm^{-2} : is it P or N type semiconductor? (1)
6. Draw energy gap diagram of a P Type semiconductor? (1)
7. What is Fermi energy level? (1)
8. Energy gap of a conductor, semiconductor, insulator are E1, E2, E3 respectively. Arrange them in increasing order. (1)
9. Name the factor that determines the element as a conductor or semiconductor? (1)
10. Why semiconductors are opaque to visible light but transparent to infrared radiations? (2)

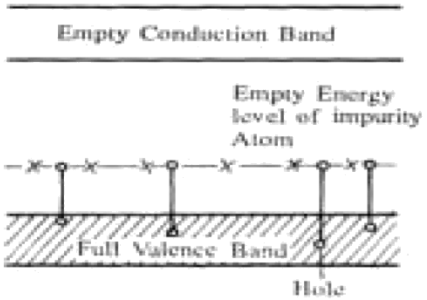
Ans: The photons of infrared radiation have smaller energies, so they fail to excite the electrons in the valence band. Hence infrared radiations pass through the semiconductors as such; i.e. a semiconductor is transparent to infrared radiation

11. The ratio of number of free electrons to holes n_e/n_h for two different materials A and B are 1 and <1 respectively. Name the type of semiconductor to which A and B belongs. (2)

Ans: If $n_e/n_{h\,=1}$. Hence A is intrinsic semiconductor. If $n_e/n_h<1$, $n_e<n_h$ hence B is P-type.

12. Differentiate the electrical conductivity of both types of extrinsic semiconductors in terms of the energy band picture. (2)



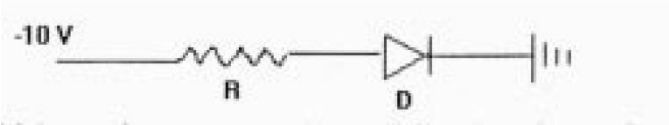


P-N JUNCTION DIODE

1. How does the width of depletion layer change, in reverse bias of a p-n junction diode? (1)

2. Draw VI characteristic graph for a Zener diode? (1)

3. In a given diagram, is the diode reverse (or) forward biased? (1)



Ans: Reverse biased.

4. Why Photo diode usually operated at reverse bias? (2)

5. State the factor which controls wave length and intensity of light emitted by LED. (2)

Ans: (i) Nature of semi-conductor
(ii) Forward Current

6. With the help of a diagram show the biasing of light emitting diode. Give two advantages over conventional incandescent Lamp. (2)

Ans: Mono chromatic, Consume less power.

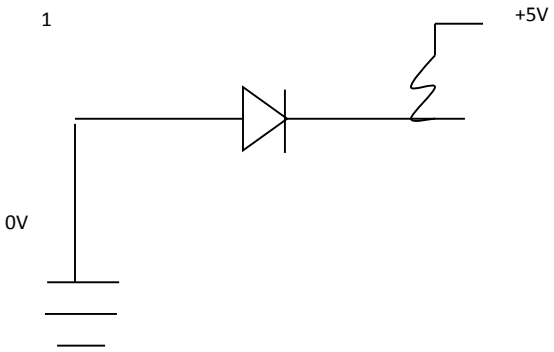
8. Draw a circuit diagram to show, how is a photo diode biased? (2)

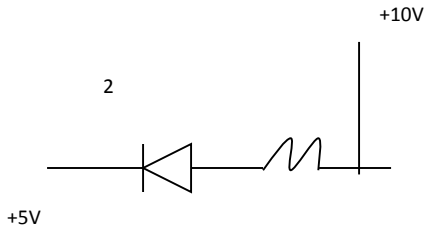
9. Pure SI at 300K have equal electron and holes concentration 1.5 x 10^{16} per m^3. Doping by Indium increases hole concentration to 4.5 x 10^{22} per m^3. Calculate new electron concentration.

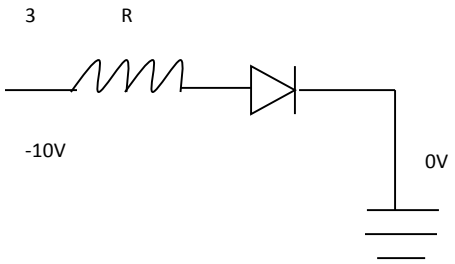
Ans: $n_e n_h = n_i^2$ (2)

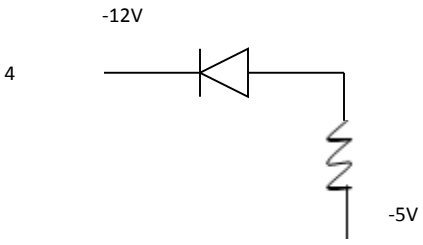
10. What is an ideal diode? Draw its output wave form.

11. In the following diagram, identify the diodes which are in forward biased and which are in reversed biased.









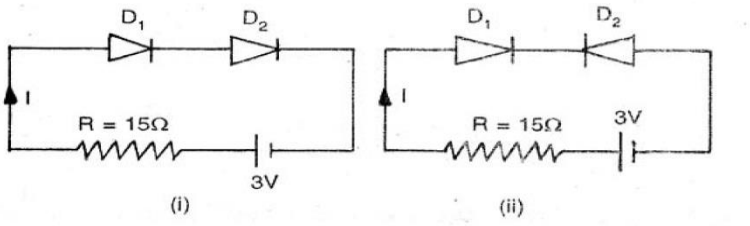
12. A semiconductor has equal electron and hole concentrations of $6x10^8/m^3$. On doping with a certain impurity, the electron concentration increases to $9x10^{12}/ m^3$. (2)

(i) Identify the new semiconductor obtained after doping.
(ii) Calculate the new hole concentrations.

Ans: (i) n-type semiconductor.

(ii) $n_e n_h = n_i^2 \Rightarrow n_h = \frac{6x10^8 \, x6x10^8}{} = 4x10^4 \, perm^2$

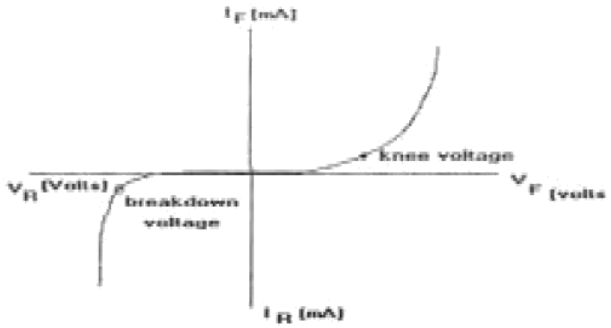
13. Determine the current through resistance "R" in each circuit. Diodes D1 and D2 are identical and ideal. 2



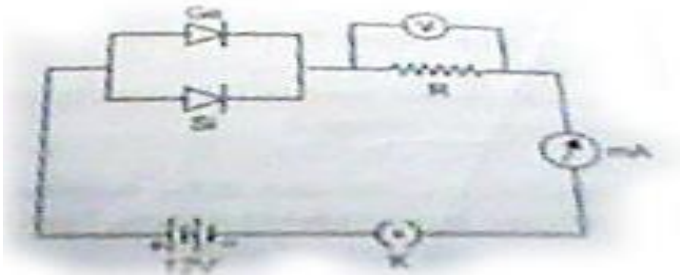
Ans: In circuit (i) Both D1 and D2 are forward biased hence both will conduct current and resistance of each diode is "0".Therefore I = 3/15 = 0.2 A

(i) Diode D1 is forward bias and D2 is reverse bias, therefore resistance of diode D1 is "0" and resistance of D2 is infinite. Hence D1 will conduct and D2 do not conduct. No current flows in the circuit.

14. From the given graph identify the knee voltage and breakdown voltage. Explain? (2)



15. Germanium and silicon junction diodes are connected in parallel. A resistance R, a 12 V battery, a milli ammeter (mA) and Key(K) is closed, a current began to flow in the circuit. What will be the maximum



reading of voltmeter connected across the resistance R? (2)

Ans: The potential barrier of germanium junction diode is 0.3v and silicon is 0.7V, both are forward biased. Therefore for conduction the minimum potential difference across junction diode is 0.3V.Max.reading of voltmeter connected across R=12-0.3=11.7V.

16. A Zener diode has a contact potential of .8Vin the absence of biasing .It undergoes breakdown for an electricfield of 10V/m at the depletion region of p-n junction.If the width of the depletion region is 2.4μm?What should be the reverse biased potential for the Zener breakdown to occur? 2

*18. A germanium diode is preferred to a silicon one for rectifying small voltages. Explain why? (2)

Ans: Because the energy gap for Ge (Eg = 0.7 ev) is smaller than the energy gap for Si (Eg = 1.1eV) or barrier potential for Ge<Si.

19. On the basis of energy band diagrams, distinguish between metals, insulators and semiconductors. (3)

SPECIAL DEVICES

*1. A photodiode is fabricated from a semiconductor with a band gap of 2.8eV.can it Can it detect a wavelength of 600nm?Justify? (2)

Ans: Energy corresponding to wavelength 600 nm is

$E=hc/\lambda = \frac{6.6\times10^{-34}\times3\times10^{8}}{600\times10^{-9}}$ joule = 0.2eV.

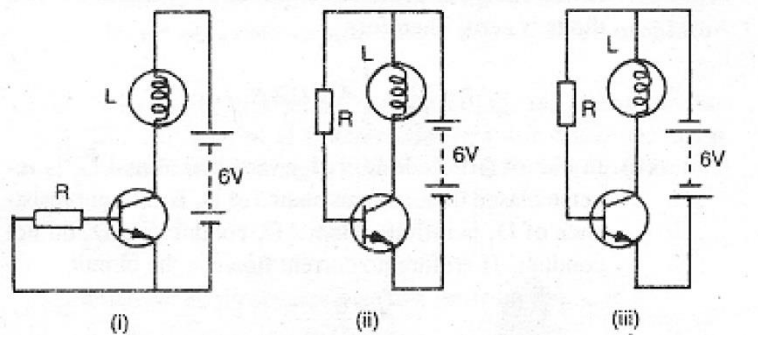
It cannot detect because $E<E_g$

2. Which special type of diode acts as voltage regulator? Give the symbol. Draw its V-I characteristics. (3)

TRANSISTORS

1. How does the dc current gain of a transistor change, when the width of the base region is increased? (1)

*2. In only one of the circuits given below, the lamp "L" glows. Identify the circuit? Give reason for your answer? (2)



Ans: In fig (i) emitter –base junction has no source of emf. Therefore Ic =0, bulb will not glow. In fig (ii) emitter – base junction is forward biased; therefore lamp "L" will glow.

(iii) emitter – base junction is received biased so the bulb will not glow.

*3. Why do we prefer NPN transistor to PNP for faster action? (2)

Ans: For faster action NPN Transistor is used. In an NPN transistor, current conduction is mainly by free electron, whereas in PNP type transistor, it is mainly holes. Mobility of electrons is greater than that of holes.

4. In which mode, the cut off, active or saturation, the transistor is used as a switch? Why? (2)

Ans: Cut off & saturation (deleted for March 2015)

5. In NPN transistor circuit, the collector current is 5mA. If 95% of the electrons emitted reach the collector region, what is the base current? (2)

Here,

I_c=95% of Ie = (95 / 100) I_e

I_e = (100 / 95) × 5 mA = 5.26mA,

I_e=I_c+ I_b

I_b = 0.25 mA

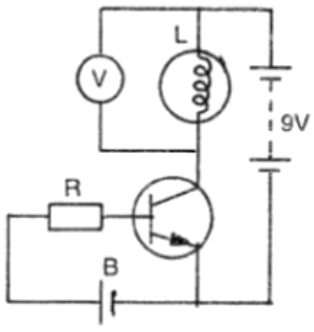
6. A student has to study the input and output characteristics of a n-p-n silicon transistor in the common emitter configuration. What kind of a circuit arrangement should she use for this purpose? Draw the typical shape of input characteristics likely to be obtained by that student.

(Ans: Fig 14.29, pg 493 & 494 NCERT-Part-2 physics

7. Which of input and output circuits of a transistor has a higher resistance and why? (3)

Ans: The output circuit of a transistor has a higher resistance. Hint: The ratio of resistance of output circuit (r_0) is 10^4 times that of input circuit ie $r_o = 10^4 r_i$;

*8. In the circuit diagram given below, a volt meter is connected across a lamp. What changes would occur at lamp "L" and voltmeter "V", when the resistor R is reduced? Give reason for your answer. (3)



Ans: In the given circuit, emitter –base junction of N-P-N transistor is forward

biased.

When "R" decreases, I_E increases. Because $I_C = I_E - I_B$. Therefore I_C will also increase. Hence bulb will glow with more brightness and voltmeter reading will increase.

9. The base current of a transistor is 105 µA and collector current is 2.05 mA. (3)

a) Determine the value of β , Ie , and α

b) A change of 27 µA in the base current produces a change of 0.65 mA in the collector current. Find β a.c.

Ib = 105 × 10 $^{-6}$A Ic = 2.05 × 10 $^{-3}$A

$\beta = Ic / Ib$

= 19.5

Also,

Ie = Ib += 2.155 × 10 $^{-3}$ A

Ic

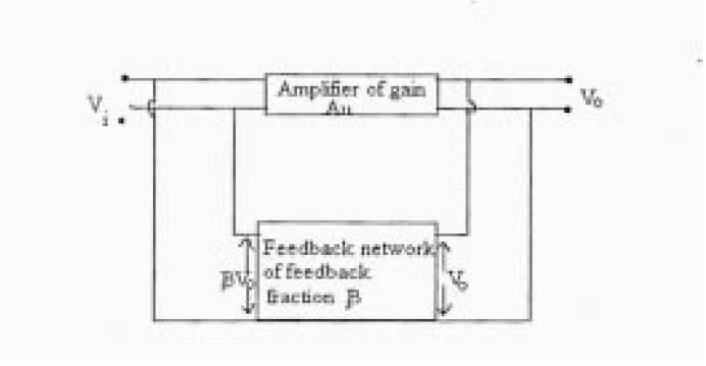
$\alpha = Ic / Ie = 0.95$

$\Delta Ib = 27\mu A = 27 \times 10^{-6}$ A

$\beta^{ac} = \Delta Ic / \Delta Ib = 24.1$

10. Under what conditions an amplifier can be converted in to an oscillator? Draw a suitable diagram of an oscillator. (3)

Hint: 1. when feedback is positive. 2. When feedback factor k is equal to l /A_v.



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11. Explain through a labeled circuit diagram, working of a transistor, as an amplifier in common emitter configuration. Obtain the expression for current gain, voltage gain and power gain. (3)

12. Draw a circuit diagram to study the input and output characteristic of an NPN transistor in common emitter configuration. Draw the graphs for input and output characteristics. (3)

13. Define trans conductance of a transistor. (2)

Ans: $g_m = \Delta I_C/\Delta V_B$

14. How does the collector current change in junction transistor if the base region has larger width?

Ans: Current decreases. (2)

15. The input of common emitter amplifier is 2KΩ. Current gain is 20. If the load resistances is

5KΩ. Calculate voltage gain trans conductance.

(3)

Ans: $g_m = \beta / RI$, $Av = \beta RL/RI$

16. Define input, output resistance, current amplification factor, voltage amplification factor, for common emitter configuration of transistor. (3)

17. A change 0.2 mA in base current, causes a change of 5mA in collector current in a common emitter amplifier.

(i) Find A.C current gain of Transistor.

(ii) If input resistance 2KΩ and voltage gain is 75. Calculate load resistance used in circuit.

β AC current gain = $\beta \Delta$**Ic / Δ Ib** (3)

19. In a transistor the base current is changed by 20μA. This results in a change of 0.02V in base emitter voltage and a change of 2mA in collector current.

(i) Find input resistance, (3)

(ii) Trans conductance.

20. With the help of circuit diagram explain the action of a transistor. (3)

21. Draw the circuit diagram to study the characteristic of N-P-N transistor in common emitter configuration. Sketch input – output characteristic for the configuration. Explain current gain, voltage gain. (3)

22. Draw the transfer characteristics of a transistor in common emitter configuration. Explain briefly the meaning of the term active region and cut off region in this characteristic. (3)

23. Explain with the help of a circuit diagram the working of N-P-N transistor as a common emitter amplifier. Draw input and output wave form. (3)

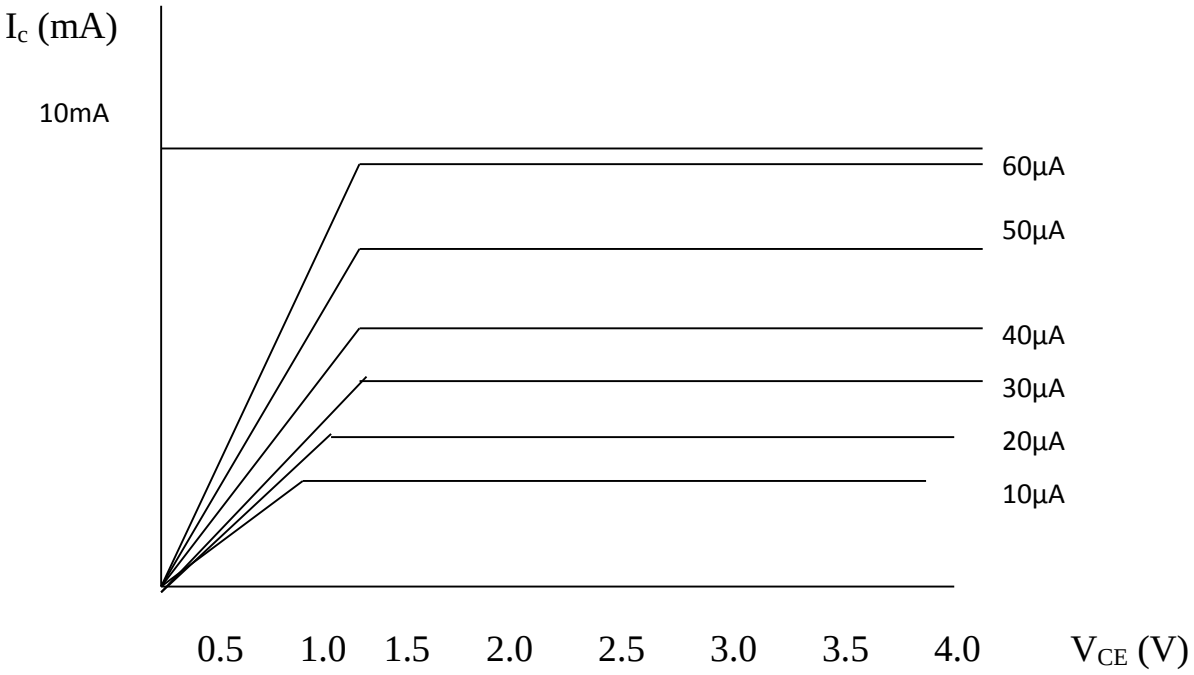
24. Draw a labeled circuit diagram of common emitter amplifier using P-N-P transistor. Define voltage gain and write expression. Explain how the input and output voltage are out of phase 180^o for common emitter transistor amplifier.

(3)

25. The output characteristic of transistor is shown.

(i) Find current amplification

(ii) Output Resistance

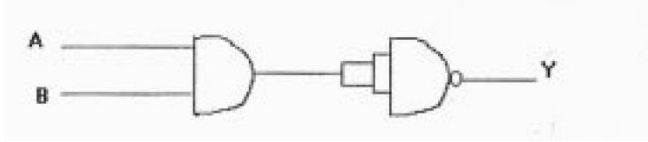


LOGIC GATES

*1. Modern technology use poly silicon instead of metal to form the gate. Why? (1)

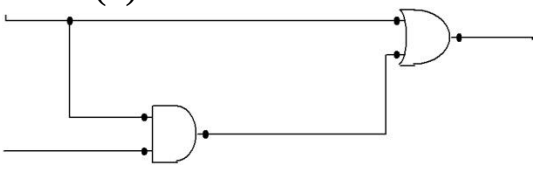
Ans: Poly silicon has high conductivity compared to metal.

2. Identify the logic gate; Give its truth table and output wave form? (1)



Ans: NAND GATE.

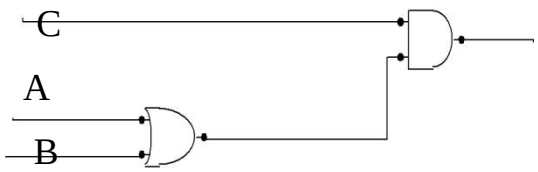
*3. Draw the logic circuit and the output wave form for given output Y=0, 0, 1, 1 (2)



Ans: The output of the AND gate is Y = A.B consequently the input of the OR gate are A and A.B . Then the final Y = A + A.B

Input for AND gate		Output of AND gate	Input of OR gate		output of OR gate
A	B	Y= A.B	A	Y	Y = A + Y
0	0	0	0	0	0
0	1	0	0	0	0
1	0	0	1	0	1
1	1	1	1		1

*4. Construct the truth table for the Boolean equation Y=(A+B).C and represent by logic circuit. (2)

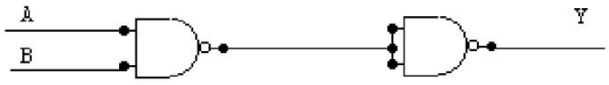


Ans: The output of OR gate is A+B. Consequently, the inputs of AND gate are A+B & C Hence the Boolean equation for the given circuit is Y=(A+B).C

A	B	C	Y'=A+B	Y=(A+B).C=Y'.C
0	0	0	0	0
0	0	1	0	0
0	1	0	1	0
0	1	1	1	1
1	0	0	1	0
1	0	1	1	1
1	1	0	1	0
1	1	1	1	1

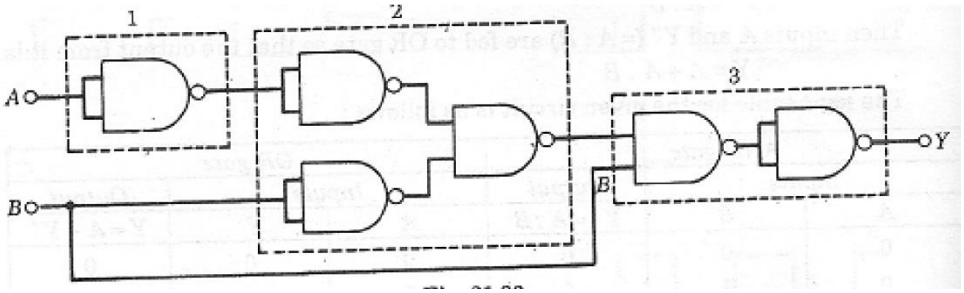
5. Construct AND gate using NAND GATE and give its truth table? (2)

Ans: AND Gate using NAND GATE:-



A	B	Y= A.B
0	0	0
0	1	0
1	0	0
1	1	1

6. Identify which basic gate OR, AND and NOT is represented by the circuits in the dotted lines boxes 1,2 and 3. Give the truth table for the entire circuit for all possible values of A and B? (3)

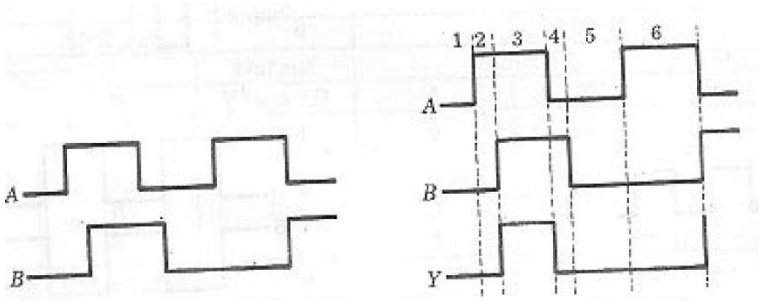


Ans: The dotted line box 1 represents a NOT gate. The dotted line box 2 represents an OR gate. Here we use de Morgan's theorem. The dotted line 3 represents AND gate.

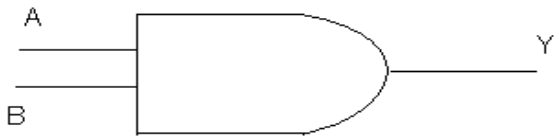
7. Two input waveforms A and B shown in figure (a) and (b) are applied to an AND gate. Write the output (3)

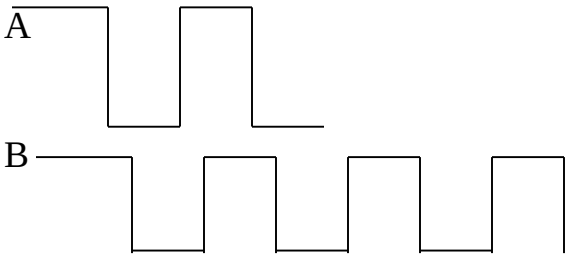
Time interval	1	2	3	4	5	6
Input A	0	1	1	0	0	1
Input B	0	0	1	1	0	0
Output Y = A.B	0	0	1	0	0	0

Input waveform



8. A circuit symbol of a logic gate and two input wave forms A and B are shown.
   a) Name the logic gate
   b) Give the output wave form

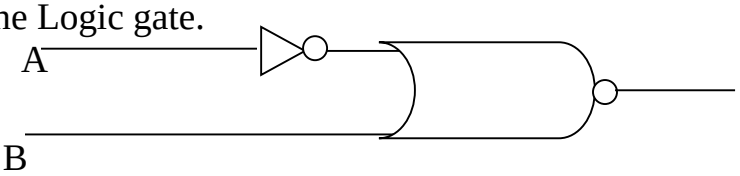




a. Name the logic gate
b. Give the output wave form
(3)

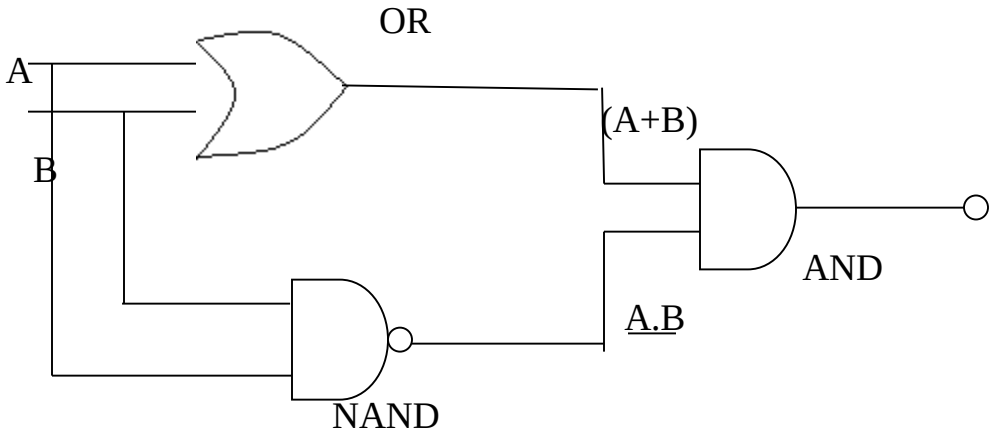
Ans: Current amplifier = Δ**Ic / Δ Ib = 9.5 – 2.5 / 50 x 10** $^{-6}$

1. Identify the Logic gate.



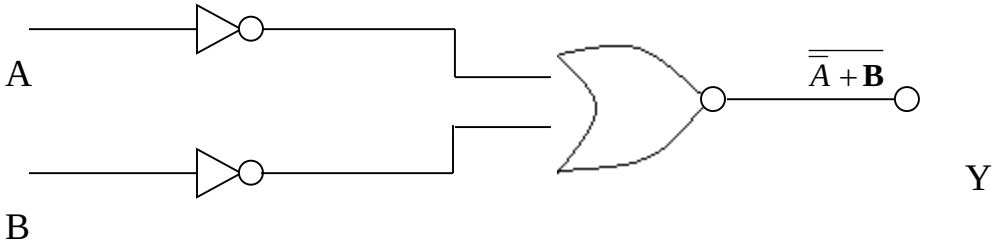
Y = $\overline{\overline{A}+\mathbf{B}}$

2. Identify the Logic gate



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

3. Identify the gate:



Ans: AND Gate

VALUE BASED QUESTIONS

1. Ritu's grandparents were planning to go for a long trip to Kashi from their home town Nagpur. Ritu's father asked the grandparents to take one mobile phone with them. But the grandparents denied it telling that they were practiced to live without it. Now Ritu took much effort to convince the grandparents and finally they agreed. What are the values exhibited by ritu?The circuits in mobile phones essentially contain transistors. If two transistor amplifiers of voltage gain 20 and 5 are cascaded in series, find the voltage gain of the combination.

2. Ritu's relatives planned to have DJ programme till midnight for her brother's marriage. Hearing this Ritu opposes the plan and tells that latenight programme will disturb the sleep of neighbouring people. The relatives got convinced. Here what are the social values exhibited by her.
The amplifier systems used in DJ programme uses transistor amplifier in common emitter configuration. Calculate the collector current and emitter current if the base current is 50 μA and current gain is 4.

3. Two students namely Ranjan and Praveen was asked to take up a project on efficient lighting for road ways, cycle paths and bus lanes. They found LED IS THE BEST source for the above said reasons. They collected the information from various sources and submitted the project about its working, advantages and its applications by presenting with a good working model.

a) By seeing these two students, what kind of qualities you want adopt from them.

b) Explain LED with neat diagram and draw its symbol.

(**ANS:** a) Initiative, curiosity, punctuality, obedience & b) Refer NCERT text book)

4. I went out for shopping with my mother; during purchase of vegetables I noticed that the Vendor used a digital weighing machine. On another shop, I

noticed the vendor was using an ordinary weighing machine. So I used to go to the shop with digital machine. I remembered having studied about Logic Gates where, digital codes are used.

a) What do you mean by Logic Gate? Mention the basic universal gates.

b) What is the value, in your opinion, that I created by the above incident.

(**ANS:** a) –Refer NCERT Text book;

c) concentration and observation in the class room, retaining capacity, co-relating of what was taught with the real life incident)

5. Arun and Naveen studying in KENDRIYA VIDYALAYA watched the film "Swadesh" together getting inspiration from the film,they realized the need of the hour for the conservation of energy. Together they decided to do something for the nation. With the help of their school teachers and principal they arranged an exhibition to depict the various renewable sources of energy and the applications of it.

a) What values must have highlighted so that the youngsters are motivated?

b) Explain the working of a solar cell with a neat diagram.

(ANS: a) Need to conserve energy with the motto of sustainable development in fulfilling the needs of the present generation without compromising the need of the future generation, taking an initiative, bringing awareness among the students and the society. (b) Refer NCERT text book)

6.Suraj was aware of the government policy regarding the supply of solar panels at subsidised rates.During summer vacations ,when he reached his village to stay with his grandparents for a fortnight,this idea struck him and persuaded his grandfather to apply for solar panels. a.) What are the values observed in Suraj? B.) Expain the principle of working of solar cells

ANS: a.)progressive mentality,well versed with current affairs. B.)Refer the NCERT text book.

7.Biju was learning about LED in his electronic class.He decided to make an LED torch as a project. His instructor appreciated his efforts .He gifted this torch to his grandmother. A.)What are the values observed in Biju? B.)Why is LED better than normal torch bulb?

ANS: a.)Sharp,enthusiastic,applies the newly learnt knowledge for a beneficial cause,care for elders. B.)Refer the NCERT text book.