CHAPTER : 14

ELECTRONIC DEVICES

STUDY NOTES

- **Classification of materials on the basis of their resistivities:** Conductors have low resistivity (10^{-2} to 10^{-8} Ωm), insulators have high resistivity ($>10^{8}$ Ωm), while semiconductors have intermediate values (10^{5} to 1 Ωm) of resistivity.
- **Semiconductors:** These are the materials that have resistivity higher than metals but less than insulators. They have a considerably lower concentration of charge carriers than metals. Semiconductors may be elemental (Si, Ge) and compound (GaAs, CdS, etc.)
- **Energy bands in solids:** Due to interatomic interactions in a crystal, the electrons of the outer shells are forced to have energies different from those in isolated atoms. Each energy level splits into a number of energy levels forming a continuous band. When an enormously large number of energy levels are closely spaced in a very small energy range, it forms a band known as an **energy band**.
- The highest energy band occupied by the valence electrons is called the valence band and the next empty allowed band is called the conduction band. The gap between these two where no allowed energy level can exist is known as band gap or energy gaps
- **Fermi level:** The highest energy level filled with electrons at absolute zero is called Fermi level and the energy corresponding to this level is called Fermi energy.
- **Difference between conductors, insulators, and semiconductors based on band theory:**
  - **(i) Conductors:** In conductors, the conduction band is partially filled, or the valence and conduction bands overlap partially.

    The energy gap, $E_g = 0$ in this case. Due to this, conductors have high conductivity or low resistivity.
  - **(ii) Insulators:** In insulators, the conduction band is empty and the valence band is filled. The energy gap is large ($E_g > 3$ eV) in this case. Therefore, electrons in the valence band are not able to cross the band gap and reach the conduction band even by applying a strong electric field. Hence , no electrical conduction is possible.
  - **(iii) Semiconductors:** In semiconductors, the conduction band is empty and the valence band is filled. The energy gap is small ($E_g < 3$ eV) in this case. Some electrons from the valence band get thermally excited and reach the conduction band and hence, electrical conductivity is possible. Therefore, semiconductors have small conductivity even at room temperature.
- **Intrinsic semiconductors:** These are pure semiconductors in which the electrical conductivity is due the electrons that are thermally excited from the valence band to the conduction band and in which no impurity atoms are added to increase their conductivity. This conductivity is called intrinsic conductivity. In this case electrons and holes act as the charge carriers. In an intrinsic semiconductor,

$$n_e = n_h = n_i$$

  Where,

  n_e = the concentration of free electrons in conduction band,

  n_h = the concentration of holes in valence band, and

  n_i = the intrinsic carrier concentration.
- **Doping:** It is the process of addition of a impurity to a pure semiconductor so as to increase its conductivity. The impurity atoms added are called **dopants**. They are of two types:

(1) Pentavalent dopants such as As, Sb and P. These are also called donors.

(2) Trivalent dopants such as In, B and Al. These are also called acceptors.

- **Extrinsic semiconductors:** A semiconductor obtained by doping suitable impurity atoms to intrinsic semiconductor to increase its conductivity is called an extrinsic semiconductor. These are of two types:

  (1) *n*-type semiconductors

  (2) *p*-type semiconductors.

- ***n*-type semiconductors:** When trivalent impurity atoms are added to intrinisic semiconductor we obtain n-type semiconductors which have electrons as their majority charge carriers. The pentavalent impurity atoms are called as donors because they donate electrons to the host crystal. Here,

$$n_e \cong N_D > n_e$$

- ***p*-type semiconductors:** When trivalent impurity atoms are added to intrinsic semiconductor we obtain p-type semiconductors which have holes as their majority charge carriers. The trivalent impurity atoms are called as acceptors because they create holes which can accept electrons from the nearby bonds. Here

$$n_h \cong N_A > n_e$$

In any semiconductor, $n_e n_h = n_i^2$

- Whatever the type of semiconductor may be as a whole it is electrically neutral.
- **Holes:** The absence of electron in the bond of a covalently bonded crystal is called a hole. It serves as positive charge carrier.
- **Mobility:** The drift velocity acquired by a charge carrier in a unit electric field is called its electrical mobility and is denoted by μ.

$$\mu = \frac{v}{E}$$

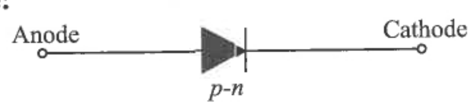
- The mobility of an electron in the conduction band is greater than that of the hole (or electron) in the valence band.
- **Electrical conductivity of a semiconductor:** It is denoted by

$$\sigma = e(n_e\mu_e + n_h\mu_h)$$

- **The conductivity of an intrinsic semiconductor:** It increases exponentially with temperature

$$\sigma = \sigma_0 \exp\left(-\frac{E_g}{2K_BT}\right)$$

- ***p-n* junction:** It is a single crystal of pure semiconductor such as Ge or Si doped in such a manner that one half portion of it becomes *p*-type semiconductor and other half portion becomes *n*- type semiconductor. As soon as a *p-n* junction is formed, the holes from the *p*-region diffuse into the n-region and electrons from *n*-region diffuse into *p*-region. This results in the formation of **potential barrier** V across the junction which opposes the further diffusion of electrons and holes through the junction.
- **Depletion region:** It is the small region in the vicinity of the junction which is depleted of free charge carriers and has only immobile ions.
- **Symbol for a *p-n* junction diode:**



- **Forward biasing of a *p-n* junction:** If the positive terminal of a battery is connected to the *p*-side and the negative terminal to the *n*-side, then the *p-n* junction is said to be forward biased. A *p-n* junction offers a low resistance when it is forward biased. Current is due to diffusion of majority charge carriers. It is of the order of mA.
- **Reverse biasing of a *p-n* junction:** If the positive terminal of a battery is connected to the *n*-side and the negative terminal to the *p*-side, then the *p-n* junction is said to be reverse biased. The potential barrier offers high resistance

during the reverse bias. Current is due to the minority charge carriers. It is called **reverse or leakage current** and flows in the opposite direction. It is of the order of μA

- **Avalanche breakdown:** When a very high reverse bias is applied the minority carrier acquire very high kinetic energy, high enough to break that covalent bond and produce electron hole pair. Many such large number of pairs are formed. This situation is known as avalanche breakdown.
- A junction diode has almost a unidirectional flow of current.
- **Dynamic resistance:** It is the ratio of small change in applied voltage ΔV to the corresponding change in current ΔI. It is given by

$$r_d = \frac{\Delta V}{\Delta I}$$

- **Characteristic of a *p-n* junction diode:** The graph showing the variation of current flowing through a *p-n* junction with the voltage applied across it is called the voltage-current or V-I characteristic of a *p-n* junction.
- **Rectification:** The process of converting a.c. into d.c. is called rectification and the device used for this purpose is called a rectifier.
- **Rectifier:** A junction diode conducts when forward biased and does not conduct when reverse biased. This unidirectional characteristic of the diode enables it to be used as a rectifier.
- A half-wave rectifier uses only a single diode while a full wave rectifier uses two diodes.
- **Photodiode:** It is a junction diode that made from a photosensitive semiconducting material in such a way that light can fall on its junction. It is operated in a reverse bias condition. It is used to detect optical signal
- **Light emitting diode (LED):** It is a forward biased p-n junction which spontaneously converts the supplied electrical energy into optical energy, like infrared and visible light. It is made from a materials like GaAs or InP to emit visible raditation.
- **Solar cell:** It is a junction diode used to convert solar energy into electrical energy. It is works on the principle of photovoltaic effect. The materials used for solar cells are Si and GaAs.
- **Action of a transistor:** When the emitter-base junction of an npn-transistor is forward biased, the electrons are pushed towards the base. As the base region is very thin and lightly doped, most of the electrons cross over to the reverse biased collector. Since few electrons and holes always recombine in the base region, so the collector current I_c is always slightly less then emitter current I_E.

  $$I_E = I_C + I_B$$

  Where I_B is the base current.
- **Three configurations of a transistor :** A transistor can be used in one of the following three configurations:
  (a) Common-base (CB) circuit.
  (b) Common-emitter (CE) circuit.
  (c) Common-collector (CC) circuit.
- **Current Gains of a Transistor :** Usually low current gains are defined :
  (a) **Common base current amplification factor or ac current gain α:** It is the ratio of the small change in the collector current to the small change in the emitter current when the collector-base voltage is kept constant.

  $$\alpha = \left(\frac{\delta I_C}{\delta I_E}\right)_{V_{CB=\text{constant}}}$$

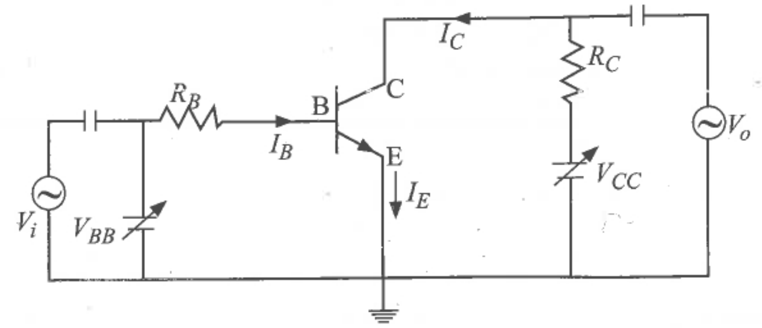
  (b) **Common emitter current amplification factor or ac current gain β:** It is the ratio of the small change in the collector current to the small change in the base current, when the collector emitter voltage is kept constant.

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

- **Relations between α and β:** The current gains α and β are related as,

$$\alpha = \frac{\beta}{1+\beta} \text{ and } \beta = \frac{\alpha}{1+\alpha}$$

- **Transistor as an amplifier :** An amplifier is a circuit which is used for increasing the voltage, current or power of alternating form. A transistor can be used as an amplifier.



- **AC current Gain :** AC current gain is defined as,

$$\beta_{ac} \text{ or } A_1 = \left[\frac{\delta I_C}{\delta I_B}\right]_{V_{CE=\text{constant}}}$$

- **DC Current Gain:** DC current gain is defined as,

$$\beta_{dc} = \left[\frac{I_C}{I_B}\right]_{V_{CE=\text{constant}}}$$

- **Voltage Gain of an Amplifier:** It is defined as,

$$A_v = \frac{V_0}{V_1} = \frac{\text{A small change in output voltage}}{\text{A small change in input voltage}}$$

$$A_v = \frac{\delta V_{CE}}{\delta V_{BE}}$$

$$A_v = \beta_{ac}\frac{R_{out}}{R_{in}} = A_i.A_r$$

i.e., Voltage gain = Current gain × Resistance gain

- **Power Gain of an Amplifier:** It is defined as,

$$A_p = \frac{\text{Output power}}{\text{Input power}} = \text{current} \times \text{voltage gain}$$

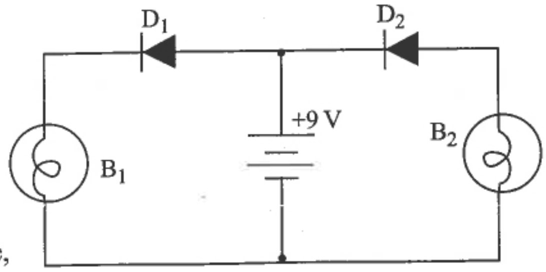
or $A_p = A_i.A_v = \beta_{ac}^2.\frac{R_{out}}{R_{in}}$

QUESTION BANK

MULTIPLE CHOICE QUESTIONS

1. Sneha increased the temperature of a semiconductor by some means. She noticed a rise in the conductivity of the semiconductor. What is the reason behind this?
   (a) number density of free current carriers increases.
   (b) relaxation time increases.
   (c) both number density of carriers and relaxation time increase.
   (d) number density of current carriers increases, relaxation time decreases but effect of decrease in relaxation time is much less than increase in number density.

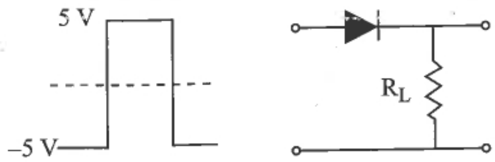
2. In the following diagram, which bulb will glow and why?



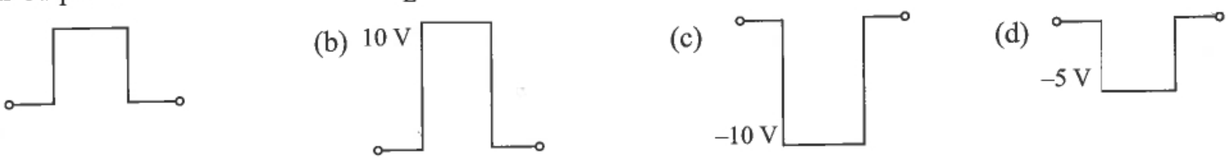
(a) Bulb B_1 glows as, D_1 diode is forward biased.
(b) Bulb B_2 glows as, D_2 diode is forward biased.
(c) Both the bulb will glow as both diodes are forward biased
(d) No bulb will glow as both diodes are reverse biased.

3. Based on the type of bonding solids are of four different types, i.e, ionic, covalent, metallic and vanderwall's solids. Which class of solid is most likely to produce a semiconductor?
(a) Vanderwall's solids (b) Ionic solids (c) Covalent solids (d) Metallic solids

4. If in a *p-n* junction, a square input signal of 10 V is applied as shown in figure,



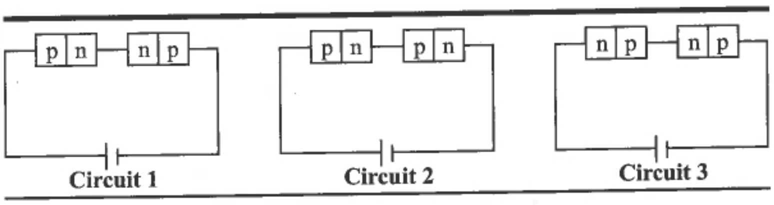
Then output across load resistance R_L will be



5. A photon of wavelength less than 2480 nm is incident on a semiconductor. If its electrical conductivity increases, then its band gap (in nm) is :
(a) 0.9 (b) 0.7 (c) 0.5 (d) 1.1

6. The device that can act as a complete electronic circuit is
(a) junction diode (b) integrated circuit (c) junction transistor (d) zener diode

7. Two identical p-n junctions may be connected in series with a battery in three ways, as shown in figure.



The potential drops across the two *p-n* junctions are equal in
(a) circuit 1 and circuit 2 (b) circuit 2 and circuit 3
(c) circuit 3 and circuit 1 (d) circuit 1 only.

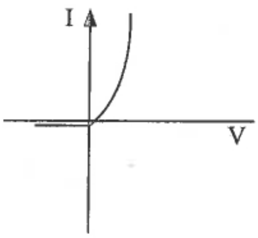
8. In a *p-n* junction diode, not connected to any circuit
(a) the potential is the same everywhere
(b) the *p*-type side is at a higher potential than the *n*-type side
(c) there is an electric field at the junction directed from the *n*-type side to the *p*-type side.
(d) there is an electric field at the junction directed from the *p*-type side to the *n*-type side.

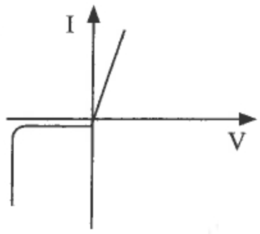
9. During an experiment, a piece of copper and another of germanium are cooled from room temperature to 77 K. The resistance of
(a) each of these decreases
(b) copper strip increases and that of germanium decreases
(c) copper strip decreases and that of germanium increases
(d) each of these increases

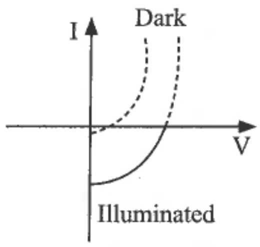
10. The manifestation of band structure in solids is due to
   (a) Heisenberg's uncertainty principle
   (b) Pauli's exclusion principle
   (c) Bohr's correspondence principle
   (d) Boltzmann's law

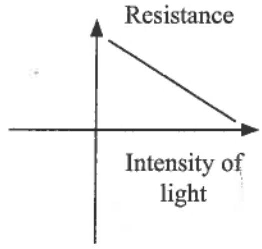
11. Carbon, silicon and germanium have four valence electrons each. At room temperature which one of the following statements is most appropriate?
   (a) the number of free electrons for conduction is significant only in Si and Ge but small in C
   (b) the number of free conduction electrons is significant in C but small in Si and Ge
   (c) the number of free conduction electrons is negligibly small in all the three
   (d) the number of free electrons for conduction is significant in all the three.

12. I-V characteristics of different semiconductor devices are given below.
   Identify them in the order (i), (ii), (iii) and (iv)

(i)


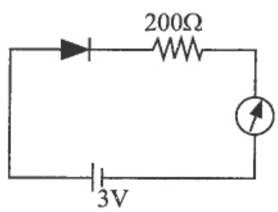
(ii)


(iii)


(iv)


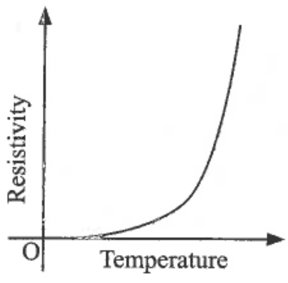
   (a) Zener diode, Solar cell, simple diode, light dependent resistance.
   (b) Simple diode, zener diode, solar cell,light dependent resistance.
   (c) Zener diode, Simple diode, light dependent resistance, solar cell.
   (d) Solar cell, light dependent resistance, zener diode, simple diode.

13. To check whether the given diode is working or not, a demonstrator designed the following circuit. What will be the reading of the ammeter if the diode is silicon diode?

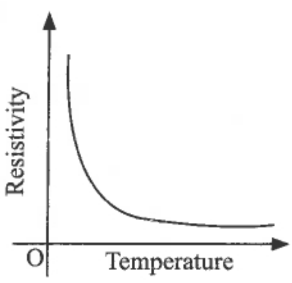


   (a) 15 mA   (b) 11.5 mA
   (c) 13.5 mA   (d) 0 mA

14. To assess the student, teacher drew the following graphs.



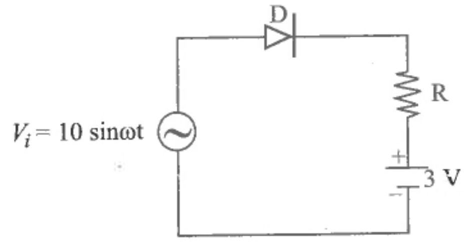
(A)

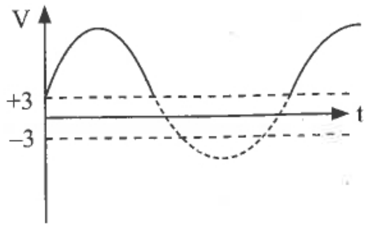


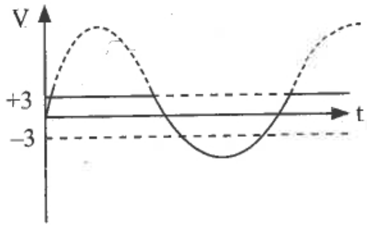
(B)

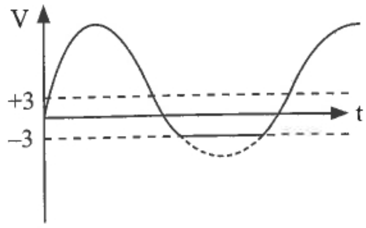
Teacher declares the graph belongs to either copper or silicon. Identify them.
   (a) A belongs Silicon, B belongs copper   (b) A belongs copper, B belongs silicon
   (c) There is some error in the graph   (d) None of these

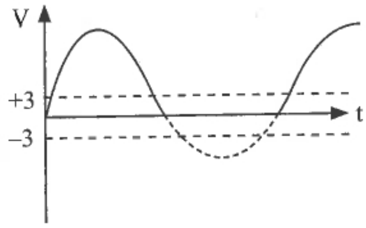
15. What will be the waveform of the output voltage across R of the following circuit, assuming the diode is ideal one



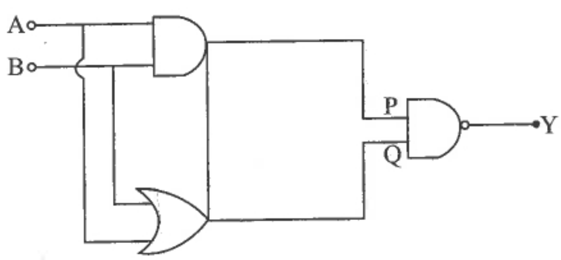
(a)


(b)


(c)


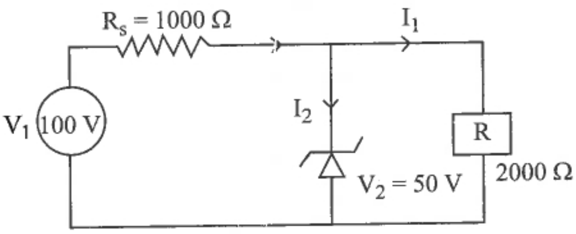
(d)


16. Find all the combination of input A,B in following sequence circuit we will get output as 1.



(a) (1,1), (0,1), (1,0)
(b) (1,0), (1,1), (0,0)
(c) (0,0), (1,0), (0,1)
(d) (0,1), (1,1), (0,0)

17. Calculate I_Z of the given circuit.



(a) 0.1 mA (b) 0.15 mA (c) 25 mA (d) 0.05 mA

18. If the ratio of the concentration of holes to that of electrons in a semiconductor is 5/4 and the ratio of currents is 7/5, then what is the ratio of their drift velocities?

(a) $\frac{5}{8}$ (b) $\frac{7}{4}$ (c) $\frac{4}{5}$ (d) $\frac{4}{7}$

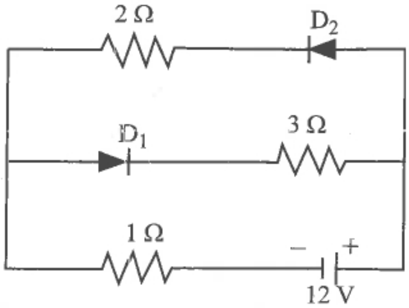
19. In an unbiased *p-n* junction, electrons diffuse from *n*-region to *p*-region because

(a) electrons travel across the junction due to potential difference
(b) electron concentration in region is more as compared to that in *p*-region
(c) only electrons move from *n* to *p*-region and not the vice-versa
(d) holes in *p*-region attract them.

20. In the middle of the depletion layer of reverse biased p-n junction, the

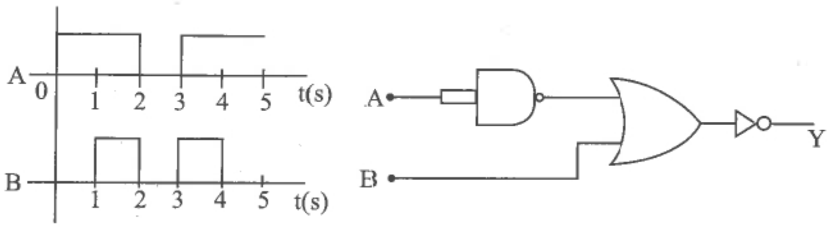
(a) electric field is zero (b) potential is zero
(c) potential is maximum (d) electric field is maximum.

21. Find the current flowing in the given circuit



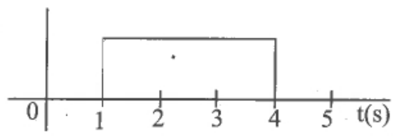
(a) 1.71 A (b) 2.0 A (c) 2.31 A (d) 1.33 A

22. Identify the output signal Y in the given combination of gates.

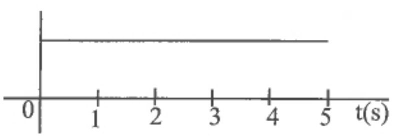


(a)

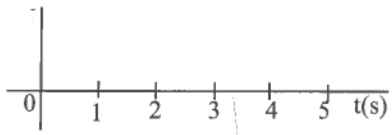
(b)



(c)



(d)



23. What happens when the doping level of extrinsic semiconductors is increased?

(a) Fermi-level of both *p*-type and *n*-type semiconductors will go upward for $T>T_FK$ and downward for $T<T_FK$, where T_F is Fermi temperature

(b) Fermi-level of *p*-type semiconductor will go upward and Fermi-level of *n*-type semiconductors will go downward

(c) Fermi-level of *p* and *n*-type semiconductors will not be affected.

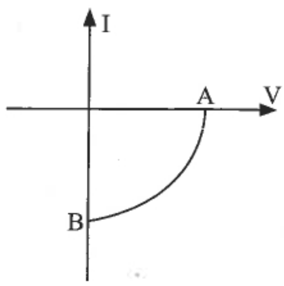
(d) Fermi-level of *p*-type semiconductors will go downward and Fermi-level of *n*-type semiconductor will go upward

24. A LED is constructed by using a material having band gap 1.9 eV. Find out the wavelength and colour of light emitted by it.

(a) 654 nm and orange colour (b) 654 nm and red colour

(c) 1046 nm and red colour (d) 1046 nm and red colour.

25. The given graph represents the V-I characteristic for a semiconductor device.



Which of the following statement is correct?

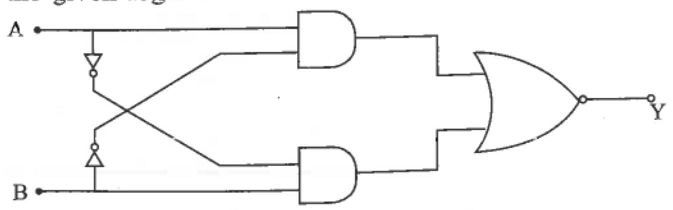
(a) It is V-I characteristic for solar cell where point A represents open circuit voltage and point B short circuit current

(b) It is for a solar cell and points A and B represent open circuit voltage and current, respectively

(c) It is for a photodiode and points A and B represent open circuit voltage and current,respectively

(d) It is for a LED and points A and B represents open circuit voltage and short circuit current respectively

26. Identify the truth table of the given logic circuit



(a)

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

(b)

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

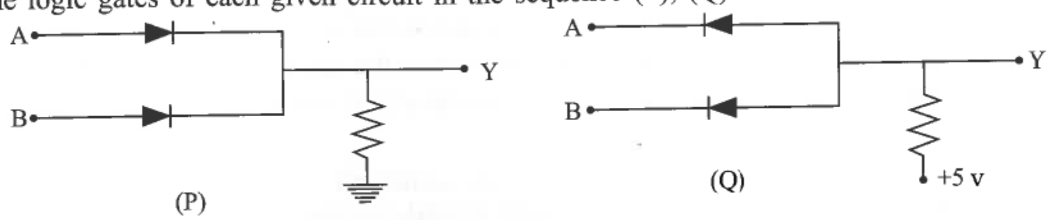
(c)

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

(d)

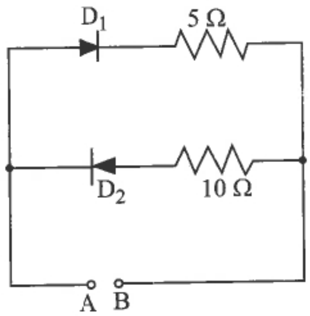
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

27. Identify the logic gates of each given circuit in the sequence (P), (Q).



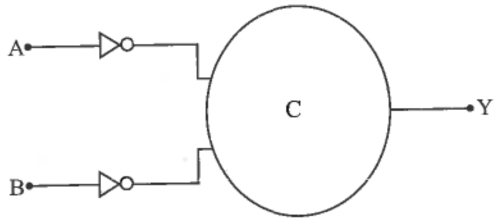
(a) OR gate, AND gate
(b) AND gate, OR gate
(c) NAND gate, NOR gate
(c) NAND gate, AND gate

28. A 2 V battery is connected across AB as shown in the figure. The value of the current supplied by the battery when in one case battery's positive terminal is connected to A and in other case when positive terminal of battery is connected to B will respectively be



(a) 0.4 A to 0.2 A
(b) 0.1 A and 0.2 A
(c) 0.2 A and 0.4 A
(d) 0.2 A and 0.1 A

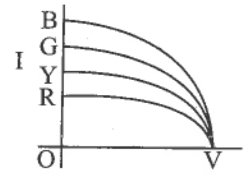
29. A teacher asked his pupil to design a circuit with two inputs such that the output Y is high only when both the inputs are high. Teacher designed the following circuit partially and asked the pupil to complete it to get the desired results. Which gate should be used at C?

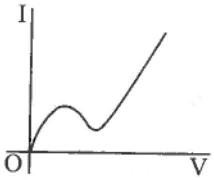


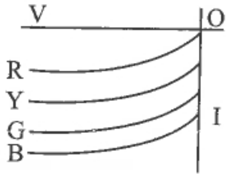
(a) AND GATE
(b) NAND GATE
(c) OR GATE
(d) NOR GATE

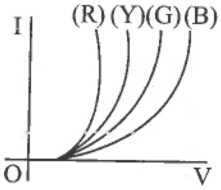
30. The difference between a conductor and an insulator is
(a) while there are a large number of electrons in a conductor, there are very few electrons in an insulator
(b) the conduction band is overlapping with the valence band for the insulator
(c) the bands are overlapping for a conductor
(d) the bands are separated in a conductor as well

31. The V-I characteristic of an LED is

(a) 

(b) 

(c) 

(d) 

32. A source of frequency 50 Hz is supplied to a full wave rectifier. The fundamental frequency in the ripple would be

(a) 25 Hz (b) 50 Hz (c) 100 Hz (d) 70.7 Hz

33. A major application of zener diode is voltage regulation. In the given circuit identify which resistor is experiencing voltage regulation. Also find the value of R_L for which the zener diode is in the zener region.

(a) $R_L;\frac{(V_i-V_L)}{(n+1)I_L}$ (b) $R_L;\frac{(V_i+V_L)}{(n+1)I_L}$ (c) $R_S;\frac{(V_i-V_L)}{(n+1)I_L}$ (d) $R_S;\frac{(V_i+V_L)}{(n+1)I_L}$

34. A Si specimen is made into *p*-type semiconductor by doping on an average one indium atom per 6×10^7 silicon atoms. If the number density of atoms in Si be $6 \times 10^{28}/(m^3)$, what is the number of indium atoms per cm^3?

(a) 10^{12} (b) 10^{15} (c) 10^{18} (d) 10^{20}

35. If no external voltage is applied across *p-n* junction, there would be

(a) no electric field across the junction
(b) an electric field pointing from *n*-type to *p*-type side across the junction
(c) an electric field pointing from *p*-type to *n*-type side across the junction
(d) a temporary electric field during formation of *p-n* junction that would subsequently disappear.

36. Choose the only false statement from the following:

(a) substances with energy gap of the order of 10 eV are insulators
(b) the conductivity of a semiconductor increases with increase in temperature
(c) in conductors the valence and conduction bands may overlap
(d) the resistivity of a semiconductor increases with increase in temperature.

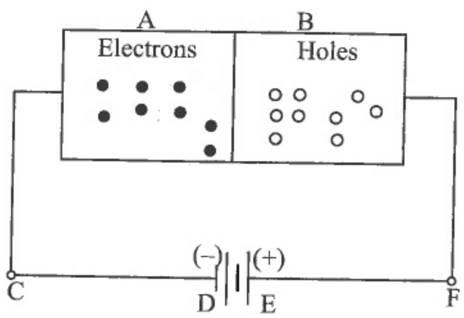
37. To a germanium crystal an equal number of aluminium and indium atoms are added. Then

(a) it remains an intrinsic semiconductor (b) it becomes an *n*-type semiconductor
(c) it becomes a *p*-type semiconductor (d) it becomes an insulator.

38. If a student measured a potential difference of 0.5 V across the junction of a diode that does not depend on current and is connected in series with resistance of 20 ohm across source. If 0.1 A current passes through resistance, then what is the voltage of the source?

(a) 1.5 V (b) 2.5 V (c) 2.0 V (d) 5 V

Directions. (Q. Nos 39-40) Base your answer to the following questions on the diagram below, which represents a germanium semiconductor device.



39. In the diagram, section B represents the

(a) *n*-type germanium (b) *p*-type germanium (c) anode (d) diode

40. The bias of the pn junction shown in the diagram is

(a) C to D (b) reverse (c) E to F (d) forward

41. For using a photodiode as a photodetector, it is invariably reverse biased because
(a) The power consumption is much reduced compared to forward biased condition
(b) Only when the photodiode is reverse biased the incident photons produce electron-hole pairs
(c) Only if the diode is reverse biased light variations can be converted into current variations
(d) When photons are incident on the diode, the fractional change in the reverse current is much greater than the fractional change in the forward current. So it makes detection easier.

42. What accounts for the flow of charge carriers in forward and reverse biasing of silicon pn diode?
(a) drift in forward bias and diffusion in reverse bias
(b) drift in reverse bias and diffusion in forward bias
(c) drift in both reverse and forward bias
(d) diffusion in both forward and reverse bias

43. LED's when directly connected to high voltage batteries gets damaged.
Sikha while doing her science project wanted to make a circuit that contains a LED and a limiting resistor R with a battery of 6 V. She has to design the circuit in such a way that the voltage drop across the LED is 2 V and it passes a current of 10 mA through it. What should be value of R?
(a) 40 kΩ (b) 4 kΩ (c) 200 Ω (d) 400 Ω

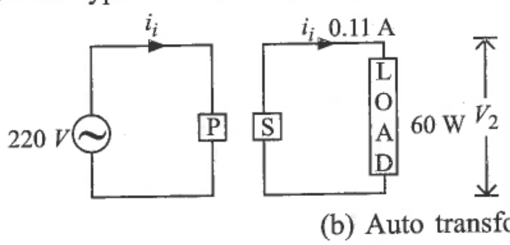
44. A semiconductor has electron and hole mobilities μ_e and μ_h, respectively. If its intrinsic carrier density is n_i then what will be the value of hole concentration n_h for which conductivity will be minimum at a given temperature?
(a) $n_i\sqrt{\frac{\mu_e}{\mu_h}}$ (b) $n_e\sqrt{\frac{\mu_e}{\mu_h}}$ (c) $n_i\sqrt{\frac{\mu_h}{\mu_e}}$ (d) $n_e\sqrt{\frac{\mu_h}{\mu_e}}$

45. In photodiodes, current in an external circuit is __________ to the incident power. The light is absorbed __________ with distance and is __________ to the absorption coefficient.
(a) Proportional, exponentially, proportional
(b) Proportional, logarithmically, inversely proportional
(c) Inversely proportional, exponentially, unrelated
(d) None of the above

46. Which of the following controls the current in a zener diode?
(a) Zener diode resistance (b) Potential barrier
(c) Reverse bias voltage (d) External circuits

47. In Zener diode, for currents greater than the knee current, the V-I curve is almost
(a) a straight line parallel to y-axis
(b) a straight line parallel to x-axis
(c) equally inclined to both the axes with a positive slope
(d) equally inclined to both the axes with a negative slope

48. For the given circuit, comment on the type of transformer used:



(a) Auxiliary transformer (b) Auto transformer
(c) Step-up transformer (d) Step down transformer

49. Solar cells work on the principle of __________.
(a) Isolation and opto coupling (b) Isolation
(c) Photovoltaic (d) Upto coupling

50. A fairy light containing a series RED/GREEN multi-colour LED is switched fast enough between two polarities, it will produce __________ colour
(a) Green (b) Red (c) Orange (d) Yellow

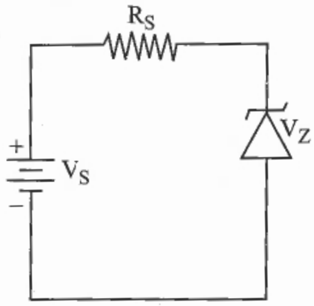
51. Which among these statement is incorrect about LED?
(a) It needs small power for operation
(b) It emits light
(c) It uses materials like gallium and arsenide
(d) It uses materials like silicon and germanium

52. In a photodiode, carriers are generated in the ____________.
(a) p region
(b) depletion region
(c) n region
(d) terminal of the diode

53. In a semiconductor, it is observed that $(3/4)^{th}$ of the current is carried by electrons and $(1/4)^{th}$ by holes. If the drift speed of the electron is two times that of holes, the relation between electron and hole concentration is
(a) $n=3p$
(b) $n=1.5p$
(c) $n=2p$
(d) $p=1.5n$

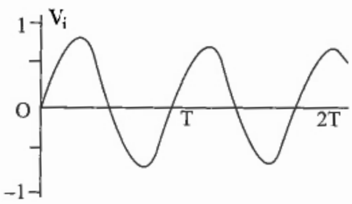
54. By studying the I-V characteristics of a *p-n* junction diode, the current
(a) gets saturated for small forward biased voltage
(b) never gets saturated for forward biased voltage
(c) is strictly zero for any forward biased voltage
(d) is strictly zero for any reverse biased voltage

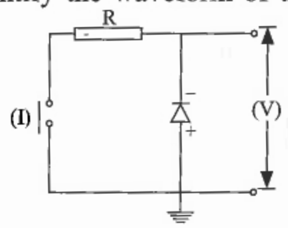
55. A zener diode and a resistor R_s are connected to $V_s = 40$ V supply as shown in figure. The zener diode has a zener voltage $V_Z = 15$ V and power rating of 0.5 W. What should be the minimum value of R_s in order to prevent diode from getting damaged?



(a) 750 Ω
(b) 1050 Ω
(c) 540 Ω
(d) 250 Ω

56. A sinusoidal input is given to the circuit shown below. Identify the waveform of the output.





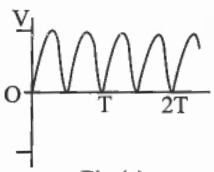


Fig (a)

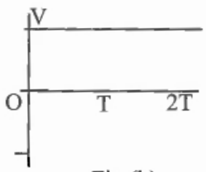


Fig (b)

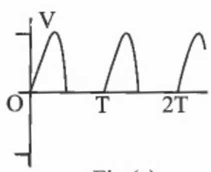


Fig (c)

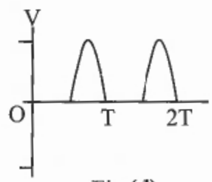


Fig (d)

(a) Fig (a)
(b) Fig (b)
(c) Fig (c)
(d) Fig (d)

57. Identify which one of the following circuits represents a full wave rectifier.

Figure 1

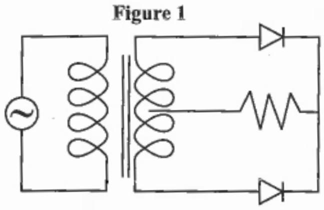


Figure 2

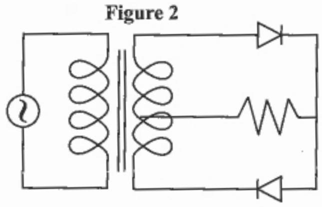


Figure 3

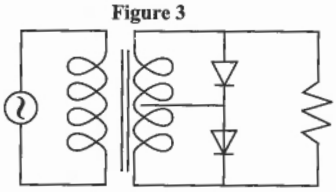
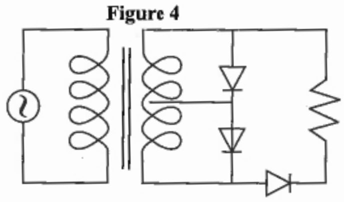


Figure 4

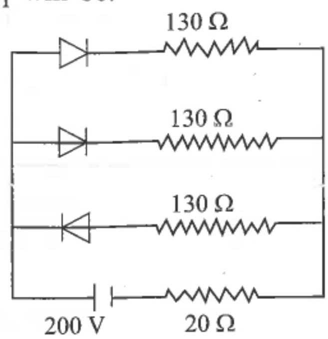


(a) Fig 1
(b) Fig 2
(c) Fig 3
(d) Fig 4

58. The current voltage relation of diode is given by $I = (e^{100V/T} - 1)$mA, where the applied voltage V is in volts and the temperature T is in degree kelvin. If a student makes an error measuring ± 0.01 V while measuring the current of 5 mA at 300 K, what will be the error in the value of current on mA?

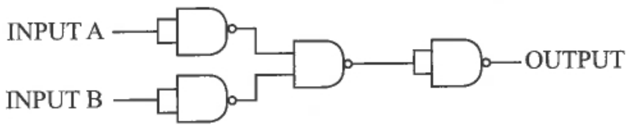
(a) 0.2 mA (b) 0.02 mA (c) 0.5 mA (d) 0.05 mA

59. A circuit connection as shown in the figure is made. Each diode has a forward bias resistance of 30 Ω and infinite resistance in reverse bias. The current I_1 will be:



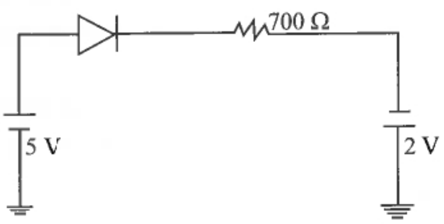
(a) 2.73 A (b) 2 A (c) 2.35 A (d) 3.75 A

60. A student connected 4 NAND gates and made the circuit as shown in the figure. What is the equivalent gate of this logic circuit?



(a) AND gate (b) OR gate
(c) NOR gate (d) NOT gate

61. Find the current flowing through the circuit shown in the figure



(a) 100 mA (b) 5 mA (c) 70 mA (d) 10 mA

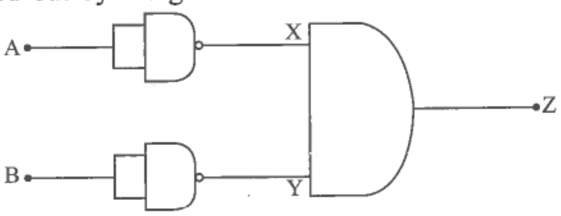
62. Read the statement and choose the appropriate answer from the options given below.

Statement I: By doping silicon semiconductor with Arsenic, the electron density increases.

Statement II: The *n*-type semiconductor has net negative charge.

(a) Statement -I is true but Statement - II is false. (b) Statement -I is false but Statement - II is true.
(c) Both Statement I and Statement II are true. (d) Both Statement I and Statement II are false.

63. Which logic operation is carried out by the given circuit?



(a) OR (b) AND (c) NOR (d) NAND

64. What is the reason behind breakdown in a reverse biased *p-n* junction diode?

(a) Large velocity of the minority charge carriers if the doping concentration is small.
(b) Large velocity of the minority charge carriers if the doping concentration is large.
(c) Strong electric field in a depletion region if the doping concentration is small.
(d) Weak electric field in the depletion region if the doping concentration is large.

65. Which statement is incorrect regarding depletion region of a diode?
(a) In the depletion region, there are no mobile charges
(b) In the depletion region, equal number of holes and elections exist, making the region
(c) In the depletion region, recombination of holes and electrons has taken place
(d) In the depletion region, immobile charged ions exist

66. During rectification of an input signal, it was first fed into a half wave rectifier. The obtained output signal had a frequency 50 Hz. What will be the frequency of the output signal, if the same input signal is fed into a full wave rectifier?
(a) 50 Hz (b) 150 Hz (c) 300 Hz (d) 100 Hz

67. Students were given a task to design a two input logic gate such that the output is high when at least any one of the two inputs is high. They were provided with NOR gates only. What is the minimum number of NOR gates required to design the required logic gate and what is the required logic gate?
(a) 2, AND (b) 2, OR (c) 3, OR (d) 3, AND

68. On application of an electric field across a semiconductor
(a) electrons move from lower energy level to higher energy level in the valence band
(b) electrons move from higher energy level to lower energy level in the conduction band
(c) holes in the valence band move from higher energy level to lower energy level
(d) holes in the valence band move from lower energy level to higher energy

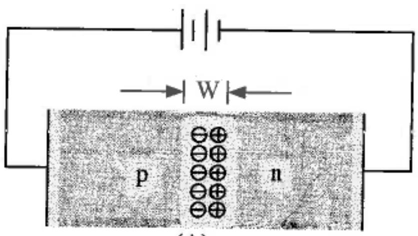
69. Among the following devices, which one can be used to detect a weak current?
(a) A tester using a bulb in a tester (b) A tester using a LED in a tester
(c) A tester using magnetic effects of current (d) both (b) and (c)

70. A LED is ______________.
(a) lightly doped (b) heavily doped
(c) Intrinsic semiconductor (d) Zener diode

71. Which of the following statements is incorrect regarding LEDs?
(a) LED has fast action (b) LED has high warm-up time
(c) LED has a low operational voltage (d) LED has a long life

72. What is the reason behind emission of light in LEDs?
(a) Breaking of covalent bonds (b) Collisions
(c) Recombination of carriers (d) None of these

73. The following graph (B) represents the barrier potential of a *p-n* junction diode in the forward bias condition as shown in figure (A) :



(A)

(B)

Which of the following option is the correct match?
(a) 1- when a low voltage battery is connected in the circuit, 2- when a high voltage battery is connected in the circuit and 3- when no battery is connected in the circuit.
(b) 1- when a high voltage battery is connected in the circuit, 2- when a low voltage battery is connected in the circuit and 3- when no battery is connected in the circuit.
(c) 1- when no battery is connected in the circuit, 2- when a low voltage battery is connected in the circuit and 3- when a high voltage battery is connected in the circuit.
(d) None of the above

74. Which of the following device carriers are not generated by photons(photo-excitation)?

(a) Photodiodes (b) Solar cells (c) LEDs (d) Zener diodes

75. A pn junction was formed with a heavily doped (10^{18} cm^{-3}) p-region and lightly doped (10^{14} cm^{-3}) n-region. Which of the following statement(s) is(are) correct?

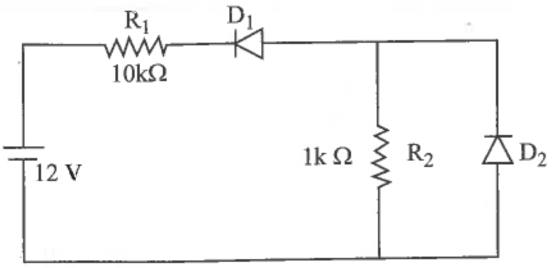
(a) The width of the depletion layer will be more in the n-side of the junction

(b) The width of the depletion layer will be more in the p-side of the junction

(c) The width of the depletion layer will be same on both side of the junction

(d) If the pn-junction is reverse biased, then the width of the depletion region decreases.

76. In the following circuit, D_1 and D_2 are identical diodes with forward voltage drop of 0.6 Volts and Reverse Breakdown voltage of 5 Volts



The current through resistor R_2 is approximately

(a) zero (b) 0.7 mA (c) 0.2 mA (d) 5 mA

77. A Zener diode, when used in voltage stabilization circuits, is biased in

(a) reverse bias region below the breakdown voltage (b) reverse breakdown region

(c) forward bias region (d) forward bias constant current mode

78. Drift current in semiconductors is due to

(a) only the electric field

(b) only the carrier concentration gradient

(c) both the electric field and the carrier concentration gradient

(d) neither the electric field nor the carrier concentration gradient

79. In an n-type silicon crystal at room temperature, which of the following can have a concentration 4×10^{19} cm^{-3}?

(a) Dopant atoms (b) Holes (c) Silicon atoms (d) Valence electrons

80. The electron and hole concentrations in an intrinsic semiconductor are n_i per cm^3 at 300 K. Now, if acceptor impurities are introduced with a concentration of N_A per cm^3 (where, $N_A >> n_i$), the electron concentration per cm^3 at 300 K will be

(a) n_i (b) $n_i + N_A$ (c) $N_A - n_i$ (d) n_i^2 / N_A

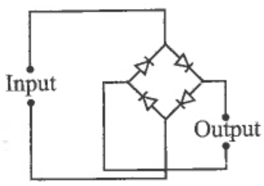
81. The concentration of minority carriers in an extrinsic semiconductor under equilibrium is

(a) directly proportional to the doping concentration (b) inversely proportional to the doping concentration

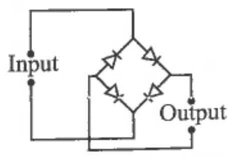
(c) directly proportional to the intrinsic concentration (d) inversely proportional to the intrinsic concentration

82. The correct full wave rectifier circuit is

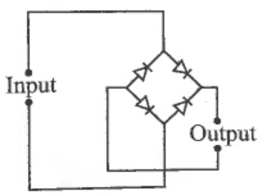
(a)



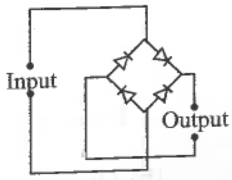
(b)



(c)



(d)



83. Consider the following statements regarding the magnitude of barrier potential of

1. It is independent of temperature
2. It depends on difference between Fermi levels on two sides of junction
3. It depends on forbidden energy-gap on two types of semiconductors
4. It depends on impurity concentration in p and n-type semiconductor

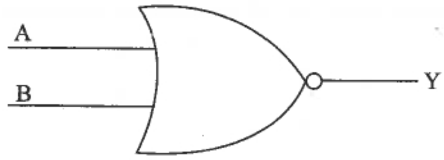
Which of the statements given above is/are correct?

(a) 1, 2 and 3 (b) 1 and 2 (c) 1 and 3 (d) 2, 3 and 4

84. The Boolean expression $P + \bar{P}Q$ where P and Q are the inputs to a circuit, represents the following logic gate:

(a) NAND (b) OR (c) AND (d) NOT

85. What is the minimum number of NAND gates are required to make the logic gate given below?

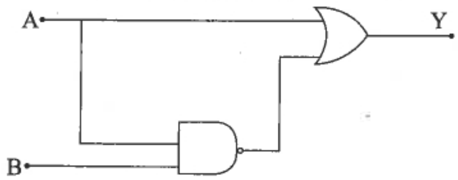


(a) 3 (b) 4 (c) 5 (d) 6

86. The logic behind 'NAND' gate is that it gives

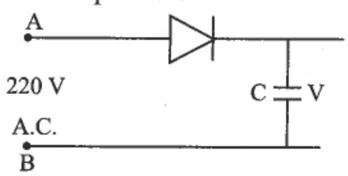
(a) High output when both the inputs are low
(b) High output when both the inputs are high
(c) Low output when both the inputs are low
(d) Low output when both the inputs are high

87. What is the output of the combination of gates shown in the figure?



(a) $A + \bar{A}B$ (b) $AB + \bar{A}B$ (c) $A + B + \bar{A}B$ (d) $AB + B + \bar{A}B$

88. Instead of a DC supply a 220 V AC supply is connected between points A and B as shown in figure. What will be the potential difference V across the capacitor?



(a) 220 V (b) 110 V (c) 0 V (d) $220\sqrt{2}$ V

89. A solar cell operates in

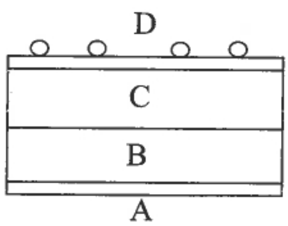
(a) reverse bias condition
(b) unbiased condition
(c) forward bias condition
(d) in both forward and reverse bias condition

90. During the collection of electron hole pairs, holes are collected by

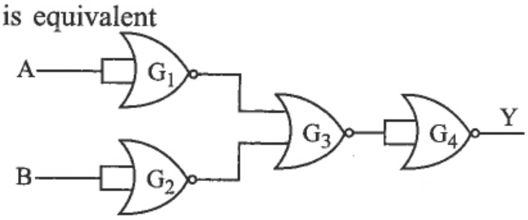
(a) Front contact (b) Back contact
(c) Si-wafer (d) Finger electrodes

91. Which region of the solar cell is coated with metal?

(a) A (b) B
(c) C (d) D



92. The logic circuit shown below is equivalent



(a) AND (b) OR (c) NOR (d) NAND

93. Fig-I shows a logic gate circuit with two inputs A and B and the output C. The voltage waveforms of A, B and C are shown in Fig. II

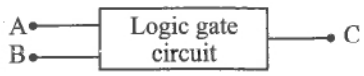
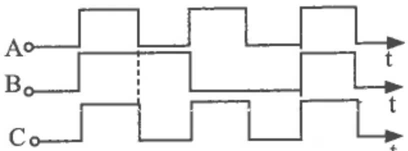


Fig. I



Waveforms of the logic gate
Fig. II

Output is

(a) A (b) A+B (c) AB (d) B

94. The I-V characteristic of solar cell lies in

(a) 1st quadrant (b) 2nd quadrant (c) 3rd quadrant (d) 4th quadrant

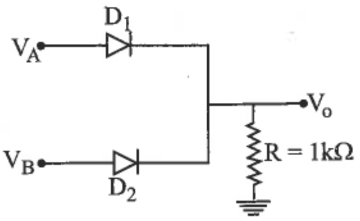
95. Name the material that can be used to produce infrared LED?

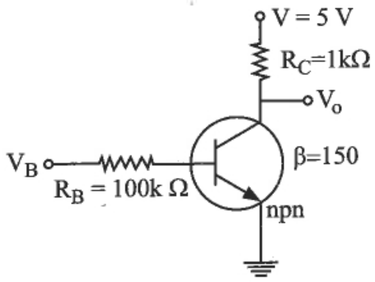
(a) Si (b) GaAs (c) CdS (d) PbS

96. The band gap of the semiconductors to be used as LED is

(a) 0.5 eV (b) 1 eV (c) 1.5 eV (d) 1.8 eV

97. If V_A and V_B are the input voltages (either 5 V or 0 V) and V_o is the output voltage then the two gates represented in the following circuit (A) and (B) are :





(a) AND and OR gate (b) OR and NOT gate
(c) NAND and NOR gate (d) AND and NOT gate

98. For a transistor α and β are given as $\alpha = I_C/I_E$ and $\beta = I_C/I_B$. Then the correct relation between α and β will be:

(a) $\alpha = \frac{1-\beta}{\beta}$ (b) $\beta = \frac{\alpha}{1-\alpha}$ (c) $\alpha\beta = 1$ (d) $\alpha = \frac{\beta}{1-\beta}$

99. For a transistor in CE mode to be used as an amplifier, it must be operated in

(a) Both cut-off and saturation (b) Saturation region only
(c) cut-off region only (d) the active region only

100. An npn transistor operates as a common emitter amplifier, with a power gain of 60 dB. The input circuit resistance is 100 Ω and the output load resistance is 10 kΩ. The common emitter current gain β is :

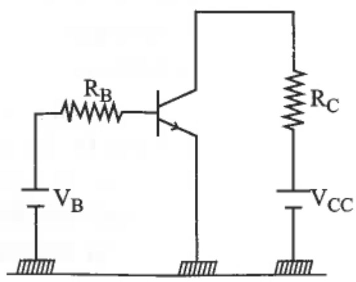
(a) 10^4 (b) 10^2 (c) 6×10^2 (d) 60

101. An npn transistor is used in common emitter configuration as an amplifier with 1 kΩ load resistance. Signal voltage of 10 mV is applied across the base-emitter. This produces a 3mA change in the collector current and 15μA change in the base current of the amplifier.

The input resistance and voltage gain are :

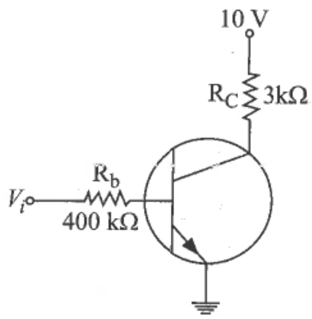
(a) 0.67 kΩ, 200 (b) 0.33 kΩ, 1.5
(c) 0.67 kΩ, 300 (d) 0.33 kΩ, 300

102. A common emitter amplifier circuit, built using an npn transistor, is shown in the figure. Its dc current gain is 250, R_C = 1kΩ and V_{CC} = 10 V. What is the minimum base current for V_{CE} to reach saturation?



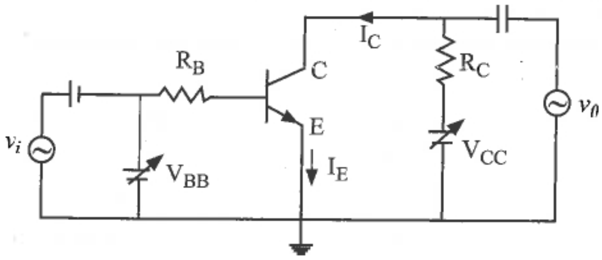
(a) 100 μA (b) 7 μA
(c) 40 μA (d) 10 μA

103. In the circuit shown in figure, when the input voltage of the base resistance is 10 V, V_{be} is zero and V_{ce} is also zero. Value of β is



(a) 133
(b) 154
(c) 196
(d) 105

104. In the figure, given that V_{BB} supply can vary from 0 to 5.0 V, V_{CC} = 5V, β_{dc} = 200, R_B = 100 kΩ , R_C = 1 kΩ and V_{BE} = 1.0 V. The minimum base current and the input voltage at which the transistor will go to saturation, will be respectively:



(a) 20 μA and 2.8 V (b) 25 μA and 2.8 V (c) 20 μA and 3.5 V (d) 25 μA and 3.5 V

105. In a common emitter configuration with suitable bias, it is given that R_L is the load resistance and R_{BE} is small signal dynamic resistance (input side). Then, voltage gain, current gain and power gain are given, respectively, by :

β is current gain, I_B, I_C, I_E are respectively base, collector and emitter currents:

(a) $\beta\frac{R_L}{R_{BE}}, \frac{\Delta I_E}{\Delta I_B}, \beta^2\frac{R_L}{R_{BE}}$ (b) $\beta^2\frac{R_L}{R_{BE}}, \frac{\Delta I_C}{\Delta I_B}, \beta\frac{R_L}{R_{BE}}$ (c) $\beta^2\frac{R_L}{R_{BE}}, \frac{\Delta I_C}{\Delta I_E}, \beta^2\frac{R_L}{R_{BE}}$ (d) $\beta\frac{R_L}{R_{BE}}, \frac{\Delta I_C}{\Delta I_B}, \beta^2\frac{R_L}{R_{BE}}$

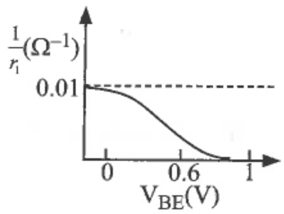
106. The current gain of a common emitter amplifier is 69. If the emitter current is 7.0 mA, collector current is :

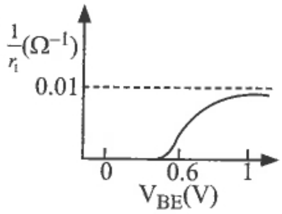
(a) 9.6 mA (b) 6.9 mA (c) 0.69 mA (d) 69 mA

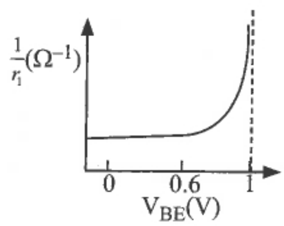
107. The phase difference between the input and the output voltages of a *npn* common emitter amplifier circuit is:

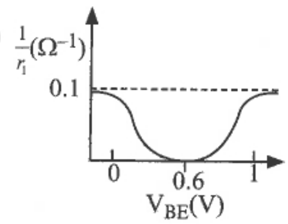
(a) 180° (b) 45° (c) 90° (d) 135°

108. A realistic graph depicting the variation of the reciprocal of input resistance in an input characteristics measurement in a common emitter transistor configuration is :

(a)


(b)


(c)


(d)


109. In a *npn* transistor , an experimentalist connected one resistor in the input side and another resistor on the output side. The ratio (R) of output resistance r_o, and the input resistance r_i should the range of:

(a) R ~ $10^2 - 10^3$ (b) R ~ 1 – 10 (c) R ~ 0.1 – 0.01 (d) R ~ 0.1 – 1.0

110. An unknown transistor needs to be identified as a npn or pnp type. A multimeter, with + ve and – ve terminals, is used to measure resistance between different terminals of a transistor. If terminal 2 is the base of the transistor then which of the following is correct for a pnp transistor?

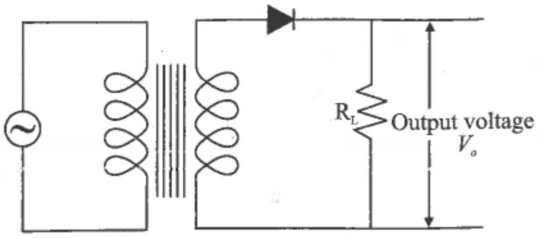
(a) + ve terminal 1, –ve terminal 2, resistance high (b) + ve terminal 2, –ve terminal 1, resistance high
(c) + ve terminal 3, –ve terminal 2, resistance high (d) + ve terminal 2, –ve terminal 3, resistance low

111. A working transistor with its three legs marked P,Q and R is tested using a multimeter. No conduction is found between P and Q. By connecting the common (negative) terminal of the multimeter to R and the other (positive) terminal to P or Q, some resistance is seen on the multimeter. Which of the following is true for the transistor?

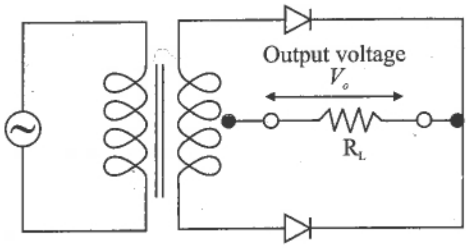
(a) It is an npn transistor with R as base (b) It is an pnp transistor with R as collector
(c) It is an pnp transistor with R as emitter (d) It is an npn transistor with R as collector

INPUT TEXT BASED MCQs

1. *If an alternating voltage is applied across a diode the current flows only in that part of the cycle. When the diode is forward biased. This property is used to rectify alternating voltages and the circuit used for this purpose is called a rectifier. A half wave rectifier uses only a single diode while a full wave rectifier uses two diodes as shown in figures (a) and (b)*



(a) Half wave rectifier

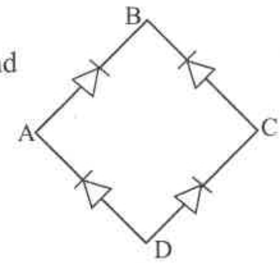


(b) Full wave rectifier

(i) If the rms value of sinusoidal input to a full wave rectifier is $\frac{V_o}{\sqrt{2}}$ then the rms value of the rectifier's output is

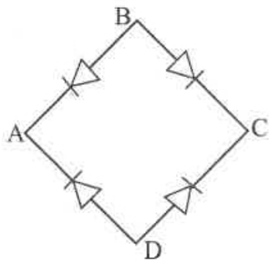
(a) $\frac{V_o}{\sqrt{2}}$ (b) $\frac{V_o^2}{\sqrt{2}}$ (c) $\frac{V_o^2}{2}$ (d) $\sqrt{2}V_o^2$

(ii) In the diagram the input ac is across the terminals A and C. The output across B and D is



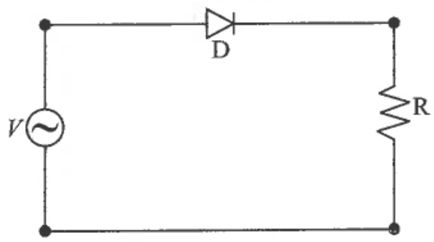
(a) same as the input
(b) half wave rectified
(c) zero
(d) full wave rectified

(iii) A bridge rectifier is shown in figure. Alternating input is given across A and C. If output is taken across BD, then it is



(a) zero
(b) same as input
(c) half wave rectified
(d) full wave rectified

(iv) A *p-n* junction (D) shown in the figure can act as a rectifier. An alternating current source (V) is connected in the circuit. The current (I) in the resistor (R) can be shown by.



(a) 

(b) 

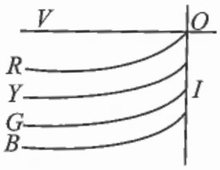
(c) 

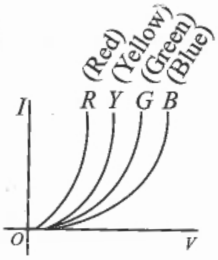
(d) 

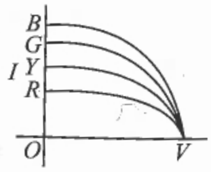
(v) With an ac input from 50 Hz power line, the ripple frequency is
(a) 50 Hz in the dc output of half wave as well as full wave rectifier
(b) 100 Hz in the dc output of half wave as well as full wave rectifier
(c) 50 Hz in the dc output of half wave and 100 Hz in dc output of full wave rectifier
(d) 100 Hz in the dc output of half wave and 50 Hz in the dc output of full rectifier.

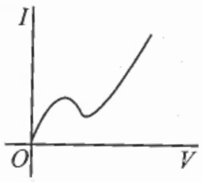
2. *Light emitting diode is a heavily doped p-n junction which under forward bias emits spontaneous radiation. The diode is encapsulated with a transparent cover so that emitted light can come out. The V-I characteristics of a LED is similar to that of a Si junction diode. But the threshold voltages are much higher and slightly different for each colour.*

(i) The I-V characteristic of an LED is

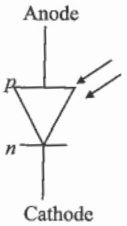
(a)


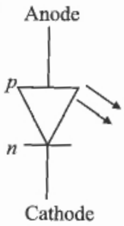
(b)


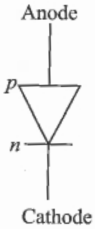
(c)


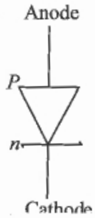
(d)


(ii) The schematic symbol of light emitting diode is (LED)

(a)


(b)


(c)


(d)


(iii) An LED is constructed from a *p-n* junction based on a certain Ga-As-P semi conducting material whose energy gap is 1.9 eV. Identify the colour of the emitted light.

(a) Blue (b) Red (c) Violet (d) Green

(iv) Which one of the following statement is not correct in the case of light emitting diodes?

(a) It is a heavily doped p-n junction.
(b) It emits light only when it is forward biased
(c) It emits light only when it is reverse biased
(d) The energy of the light emitted is less than the energy gap of the semiconductor used.

(v) The energy of radiation emitted by LED is

(a) greater than the band gap of the semiconductor used
(b) always less than the band gap of the semiconductor used
(c) always equal to the band gap of the semiconductor used
(d) equal to or less than the band gap of the semiconductor used

ANSWERS

1. (d)	**2.** (a)	**3.** (a)	**4.** (a)	**5.** (c)	**6.** (b)	**7.** (b)	**8.** (c)	**9.** (c)	**10.** (b)
11. (a)	**12.** (b)	**13.** (b)	**14.** (b)	**15.** (a)	**16.** (c)	**17.** (c)	**18.** (b)	**19.** (b)	**20.** (a)
21. (b)	**22.** (a)	**23.** (d)	**24.** (b)	**25.** (a)	**26.** (d)	**27.** (a)	**28.** (a)	**29.** (d)	**30.** (c)
31. (d)	**32.** (c)	**33.** (a)	**34.** (b)	**35.** (b)	**36.** (d)	**37.** (c)	**38.** (b)	**39.** (b)	**40.** (d)
41. (d)	**42.** (b)	**43.** (d)	**44.** (a)	**45.** (a)	**46.** (b)	**47.** (b)	**48.** (c)	**49.** (c)	**50.** (d)
51. (d)	**52.** (b)	**53.** (b)	**54.** (b)	**55.** (a)	**56.** (c)	**57.** (b)	**58.** (a)	**59.** (b)	**60.** (c)
61. (d)	**62.** (a)	**63.** (c)	**64.** (a)	**65.** (c)	**66.** (d)	**67.** (b)	**68.** (c)	**69.** (d)	**70.** (b)
71. (b)	**72.** (c)	**73.** (c)	**74.** (d)	**75.** (a)	**76.** (b)	**77.** (b)	**78.** (c)	**79.** (d)	**80.** (d)
81. (b)	**82.** (c)	**83.** (d)	**84.** (b)	**85.** (b)	**86.** (d)	**87.** (a)	**88.** (d)	**89.** (b)	**90.** (b)
91. (a)	**92.** (d)	**93.** (a)	**94.** (d)	**95.** (b)	**96.** (d)	**97.** (b)	**98.** (b)	**99.** (d)	**100.** (b)
101. (c)	**102.** (c)	**103.** (a)	**104.** (d)	**105.** (a)	**106.** (b)	**107.** (a)	**108.** (c)	**109.** (b)	**110.** (a)
111. (a)									

Input Text Based MCQs

1. (i) (a), (ii) (d), (iii) (a), (iv) (c), (v) (c) **2.** (i) (b), (ii) (b), (iii) (b), (iv) (c), (v) (d)