10. Semiconductors

10.0 Introduction :

1. The substances whose conductivity lies between conductors and insulators are called as semiconductors:
2. Resistivity of good conductors like silver is of the order of $10^{-7}\ \Omega$ m.
   Resistivity of semiconductors like germanium ranges from 0.4×10^4 to $4 \times 10^4\ \Omega$ m.
   Resistivity of insulators like ceramics ranges from 10^7 to $10^{18}\ \Omega$ m.

10.1 Energy bands in solids or band theory of solids

1. The following are energy bands in solids.

i) **Valence band:** In valence energy band, there are valence electrons. This band may be partially or completely filled with electrons. This band is never empty. In this band electrons are not capable of gaining energy from external electric field. Therefore, the electrons in this band do not contribute to the electric current.

ii) **Conduction band:** In conduction energy band electrons are rarely present. This band is either empty or partially with electrons. In this band, the electrons can gain energy from external electric field. Electrons in this band contribute to the electric current.

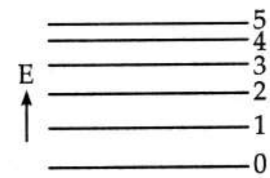
iii) **Forbidden energy gap:** In forbidden energy gap, electrons are not found in this band. This band is completely empty. The minimum energy required for shifting electrons from valence band to conduction band is called as band gap (Eg). If λ is the wavelength of radiation used in shifting the electron from valence band to conduction band, then energy band gap is,

$$E_g = h\nu = \frac{hc}{\lambda}$$

where h is Planck's constant and c is the velocity of light.

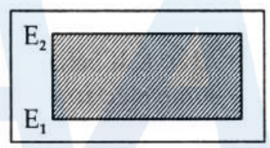
2. Distinction between conductors, insulators and semiconductors on the basis of band theory:

i) In gases, distance between different atoms is large hence energy of an electron of an atom does not change due to other atoms.



Therefore, in gases, electrons of an atom has definite energy levels.

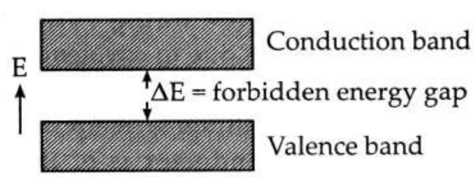
ii) But in solids atoms are very close, hence energy of an electron of an atom changes due to presence of neighboring atoms. Hence in solids, in place of energy levels, we have energy bands. In an energy band, electron may have any energy between E_1 and E_2.



iii) Electrons of outermost orbit of an atom are called valence electron and the band" in which valence electron lie is called valence band.

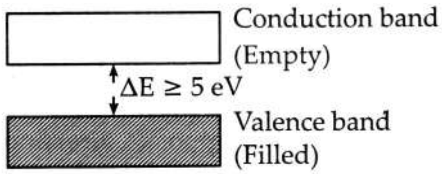
iv) Electrical conduction takes place due to free electrons. These are also called conduction electrons. The band possessed by free electrons is called conduction band."

v) The energy gap between valence band and conduction band is called forbidd.en energy gap.



3. Insulators:

i) An insulator is material that does not contain free electrons. Its electrons are rigidly bound to their atomic nuclei.



ii) The resistivity of an insulator is very high and of the order of 10^7 to 10^{18} Ω m.

iii) The temperature coefficient of an insulator is negative. As the temperature is increased, the resistivity decreases.

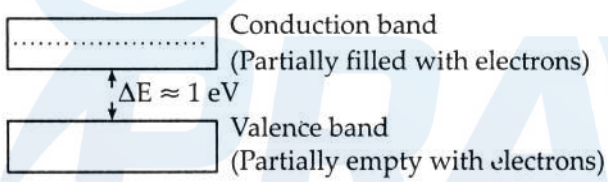
iv) For an insulator there is valence band and conduction band which are separated by a large forbidden energy gap.

The energy gap width is about 5 eV in the case of diamond which is a typical insulator.

The valence band is full and the conduction band is empty.

4. Semiconductors:

i) In semiconductors, the conduction band is partially filled and valence band is partially empty and forbidden energy gap is about 1 eV.



ii) At 0° K it behaves as insulator. At room temperature some electrons becomes free after breaking some of covalent bands, so free electron goes to conduction band and a hole is created in valence band.

iii) Hole is a vacancy of electron. Hole has positive charge and it moves opposite to that of electron.

iv) A semiconductor is a material whose electrical properties lie between those of conductors and insulators.

v) Silicon (Si) and Germanium (Ge) are the typical semiconductors that belong to the IV group of the periodic table. Both are tetravalent.

Silicon has atomic number 14. Its electronic configuration is 2–8–4. Germanium has atomic number 32. Its electronic configuration is 2–8–18–4. In both of them, the binding force between neighbouring atoms is due to covalent bond.

Other examples of semiconductors are lead sulphide, selenium, gallium arsenide etc.

vi) Resistivity of semiconductor is of the order of 10^3 to $10^4\,\Omega$ m.

vii) The temperature coefficient of a semiconductor is negative. If temperature is increased, the resistivity of a semiconductor decreases and its conductivity increases.

viii) At 0° C, very semiconductor behaves as a perfect insulator.

ix) Current flow in semiconductor is due to the flow of conduction electrons in one direction and positively charged holes in the opposite direction.

x) In a pure semiconductor or intrinsic semiconductor, the number of conduction electrons is equal to the number of holes.

xi) Energy bands:

a) A semiconductor has valence and conduction band which are separated by a low forbidden energy gap.

b) The energy gap for germanium is about 0.7 eV and for silicon 1.1eV and for gallium arsenide 1.3 eV.

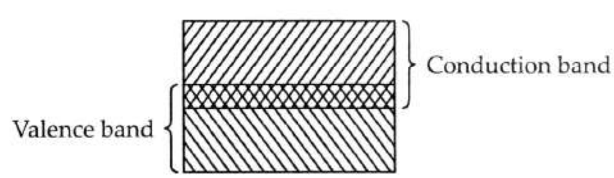
c) Fermi level: The fermi level is defined as the energy level corresponding to the centre of gravity of conduction electrons and holes weighed according to their energies.

In the case of a pure semiconductor (or intrinsic semiconductor), the fermi level lies exactly at the middle of the energy gap.

d) At 0° C, the valence band of semiconductor is full and the conduction band empty.

6. Conductors:

i) A conductor is a material that contains free or valency electrons. The electrons of a conductor are not rigidly bound to their atomic nuclei.



ii) In a conductor, the free electron density is about $10^8/m^3$.

iii) The total current in a conductor is due to flow of electrons.

iv) The resistivity of a good conductor is very low and of the order of 10^{-7} Ω m.

v) The temperature coefficient of a conductor is positive. As the temperature is increased, the resistivity of a conductor increases and conductivity decreases.

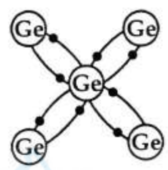
vi) Conductors have valence band and conduction band but they overlap or the forbidden energy gap is zero.

The valence band is full and under the influence of a small p.d. from a battery, the free electrons move to the higher energy state of the conduction band.

10.2 Intrinsic and extrinsic semiconductors

1. Intrinsic semiconductors:

i) Pure semiconductor are called intrinsic semiconductors. Ge and Si in pure form are intrinsic semiconductors.



For silicon, the atomic number Z is 14 and for Germanium atomic number Z is 32.

Germanium (Ge) or silicon (Si) has 4 electrons in its outermost orbit.

ii) All these four electrons are used to form covalent bonds with electrons of neighboring atom hence no free electrons are left.

iii) But due to thermal vibration of atom, out of 10^9 (or 10^{10}) atom, one covalent bond breaks due to which very few free electrons and holes are produced. These are called minority carriers because number of free electrons and holes are very small.

iv) Since in intrinsic semiconductors, number of free electrons and holes is very small hence their electrical conductivity is very small.

v) As the semiconductor crystal is electrically neutral, the number of free electrons is equal to the number of holes.

vi) The conductivity of the semiconductor is given by $\sigma = e\,(n_e\,\mu_e + n_n\,\mu_n)$. Where μ_e and μ_n are respectively the electron and hole mobilities. n, and nn are the electron and hole densities, e is the electronic charge.

vii) If E be the electric field across the semiconductor and v_e and v_n be the drift velocities of electrons and holes then,

$$\mu_e = \frac{v_e}{E} \quad \text{and} \quad \mu_n = \frac{v_n}{E}$$

viii) At low temperature, the electrons are present in valence bands of the semiconductors. As the temperature is increased, a few electrons are raised to conduction band. The fraction of electrons raised to conduction band at temperature T is given by

$$\phi \propto e^{-Eg/kT}$$

Here k – Boltzmann's constant

E_g – Forbidden energy gap

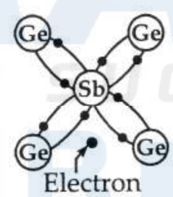
2. **Extrinsic semiconductors:** If an impurity (either an element of yth group or an element of IIIrd group) is mixed (or doped) in pure semiconductors, then their electrical conductivity increases considerably. These impure semiconductors are called extrinsic semiconductors.

The process of adding impurity to pure semiconductors is called as doping.

10.3 n-type semiconductor and p-type semiconductor

1. Extrinsic semiconductors are of two types

1. **n–type semiconductors:** If an element of yth group (e.g. P, As, Sb, Bi etc.) is doped in pure semiconductor (e.g., Si or Ge), we get n–type semiconductors.



These atoms of yth group have five (5) electrons in their outermost orbit, out of which 4 electrons are Sb used to form covalent bonds with the electrons of Ge or Si atom and fifth electron becomes free. Thus a Electron large number of electrons becomes free.

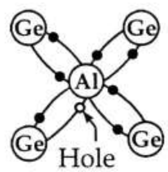
In n–type semiconductors, electrical conduction takes place due to the flow of these free electrons which have negative charge. Hence these are called n–type semiconductors.

The impurity of yth group element is called donor impurity.

A n–type semiconductors has stationary positive ions of donor impurity and equal number of movable free electrons hence a n–type (crystal) semiconductor is electrically neutral.

In n–type semiconductors electrons are majority carriers and holes are minority carriers. Here the impurity is added 1 part in 10^7 parts. In n–type semiconductors, there are 10^{17} free electrons / C.C, In metals there are 10^{23} free electrons /C.C.

ii) **p–type semiconductors:** If an impurity of III[rd] group element (A1 or Boron or Indium) is doped in pure Si or Ge, then we get p–type semiconductors. Al In p–type semiconductors, electric conduction takes place due to holes G Hole G which have positive charge. Due to this reason it is called p–type semiconductors.



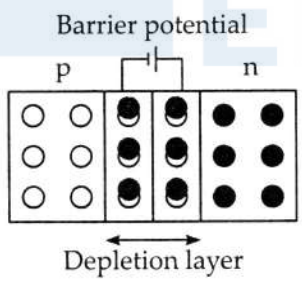
The impurity of IIIrd group element is called acceptor impurity.

Number density of holes in p–type semiconductors is nearly equal to that of acceptor atoms and is very large as compared to number density of electrons.

In p–type semiconductor holes are majority carriers and electrons are minority carriers.

10.4 p-n junction diode

1. If p–type semiconductor is joined with n–type p n semiconductor then the contact region between them is called as p–n junction.



p–n junction behaves as a diode. Depletion layer

2. The surface of contact of p–type and n–type crystal or piece is called junction.
3. **Diffusion:** Some electrons from the n–type and some holes from the p–type migrate or diffuse across the junction. The diffusion of electrons and holes across the junction continues until a potential barrier is developed at the junction which prevents further diffusion.

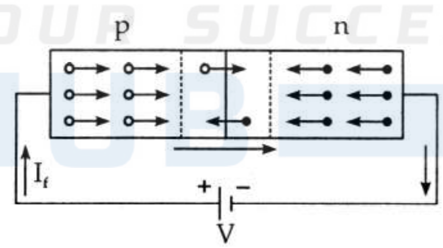
The potential barrier can be increased or decreased by an external voltage. The potential barrier for germanium is about 0.3 V and 0.7 V for silicon.

4. Near the junction when an electron meets a hole, they cancel the effect of each other and as a result, a thin layer at the junction becomes free from any of charge carriers. This layer is called depletion layer. The width of depletion layer is 1 micron.
5. Depletion layer: The depletion layer is a narrow region at the junction, which is free from mobile charges.

   The depletion layer behaves like an insulator.

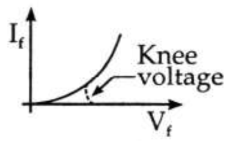
   The width of the depletion layer can be increased. or decreased by applying an external voltage.
6. Due to neutralisation of holes and electrons, the p section becomes slightly negative at the junction and the n section becomes slightly positive. Therefore, a potential barrier is produced across p–n junction called as barrier potential which prevents the further flow of electrons and holes across the junction.
7. The barrier potential for silicon semiconductor is 0.7 V and for germanium semiconductor it is 0.3 V.

Forward bias p–n junction:

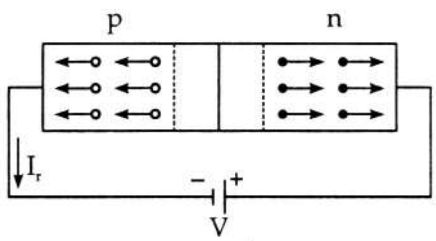


1. When an external battery is connected across p–n junction so that it removes the effect of potential barrier, then it is called forward bias.
2. Now electrons and holes flow across the junction due to which a current is produced which is called forward current (in mA) and potential difference applied is called forward voltage (upto 2 volt).
3. When the forward voltage is less than potential barrier the current flows very slowly and when forward voltage is greater than the potential barrier then current increases too much and as forward voltage increases the value of forward current also increases.

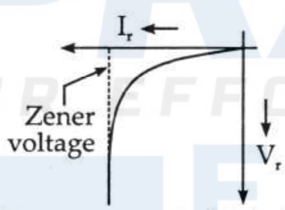
4. **Culin voltage or knee voltage:** That value of forward voltage above which forward current increases It Knee rapidly. (for silicon diode it is 0.7 volt for germanium diode it is 0.3 volt).



Reverse bias p–n junction:



1. When a external battery is connected across p–n diode so that it increases the effect of potential barrier. It is called reverse bias.
2. When reverse bias is applied, the majority carriers do not cross the junction. However a very Zener little amount of current voltage flows due to the motion of minority carriers. This current is called reverse current. It is in µA order.



Potential difference applied in reverse bias is called reverse voltage.

3. In forward bias the forward resistance is very low and in reverse bias reverse resistance is very high.

$R_f \cong 10^2\ \Omega$ $R_r \cong 10^6\ \Omega$ So $R_r >> R_f$

For germanium diodes

$$\frac{R_r}{R_f} = 40000 \text{ and for silicon diode } \frac{R_r}{R_f} = 10^6$$

4. Zener or break down voltage: If the reverse voltage is made very high then at a certain point (or voltage) the reverse current increases abruptly. This voltage is known as Zener or breakdown voltage.

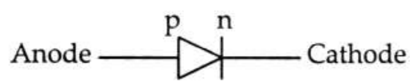
i) When the reverse voltage exceeds a certain voltage called zener voltage or break down voltage, the reverse current increases sharply.

ii) At break down voltage the resistance of the diode will become zero.

iii Zener voltage also depends upon the density of the impurity atoms and may have a value of 1 to 2 volts to several hundred volts.

iv) Semiconductor diodes, made of germanium or silicon are commonly used as power rectifiers.

5. Both forward and reverse bias p–n junction diode do not obey Ohm's law.
6. Symbol of p–n junction diode is as shown in figure.



7. The current in the junction diode on applying voltage V is given by,

$$I = I_s\,(e^{e\ V/kT} - 1)$$

Where, Is – Saturation current in reverse bias
V – voltage across the diode
T – temperature (absolute)
k – Boltzmann's constant

In forward bias $V = +ve$

And in reverse bias, $V = -ve$

So in forward bias $I_f = I_s(e^{eV/kT} - 1)$

So as temperature increases, I_f decreases.

And in reverse bias $I_R = I_s\,(e^{-eV/kT} - 1)$

$$= I_s\left[\frac{1}{e^{eV/kT}} - 1\right]$$

So in reverse bias as temperature increases, I_R increases.

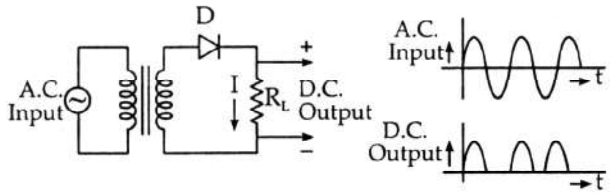
8. Since p–n junction diode offers a low resistance path in forward bias and a high resistance in reverse bias or p–n diode conducts in forward bias and does not conduct in reverse bias. So the junction diode can be used as a rectifier.

10.5 Diode as rectifiers

The process of conversion of A.C. into D.C. is called as rectification. An electronic device which converts A.C. into D.C. is called as rectifier. There are two types of rectifiers.

1. Half wave rectifier:

i) It converts only half cycle of A.C. into D.C.



ii) In positive half cycle of A.C., junction diode remains in forward bias, hence it conducts. In negative half cycle of A.C., junction diode becomes in reverse bias, hence it does not conduct. Thus only half A.C. is converted into D.C.

iii) In half wave rectifier one junction diode is used.

iv) In half wave rectifier half cycle of input a.c. is converted into d.c.

v) The average value of output current is given by,

$$I_{dc} = \frac{I_0}{\pi}$$

vi) The average value of output voltage is given by,

$$V_{de} = \frac{e_0}{\pi}$$

viii) Maximum current $I_0 = \dfrac{e_0}{r_f + R_L}$

where, e_0 - maximum voltage
r_f - internal resistance of the diode
R_L - load resistance.

ix) r.m.s. current $I_{rms} = \dfrac{I_0}{\sqrt{2}}$

x) A.C. power input, $P_{ac} = (I_{rms})^2 \times (r_f + R_L)$
where, I_{rms} = r.m.s. current

xi) D.C. power output $P_{dc} = (I_{dc})^2 \times R_L$
where, I_{dc} = average current.

xii) The efficiency of a half–wave rectifier is defined as the ratio of d.c. power output to the applied input a.c. power.

$$\text{Rectifier efficiency } \eta = \frac{\text{d.c. power output}}{\text{a.c. power input}}$$

$$= \frac{P_{dc}}{P_{ac}} = \frac{0.406 \times R_L}{r_f + R_L}$$

$$= 40.6\ \%$$

where r_f is the diode resistance and R_L is the load resistance.

xiii) The ripple factor of half wave rectifier is the ratio of a.c. current to d.c. current (a.c. voltage to d.c. voltage).

i.e. $$\gamma = \frac{I_{ac}}{I_{dc}} = \frac{V_{ac}}{V_{dc}} = 1.21. \quad \textbf{AND}$$

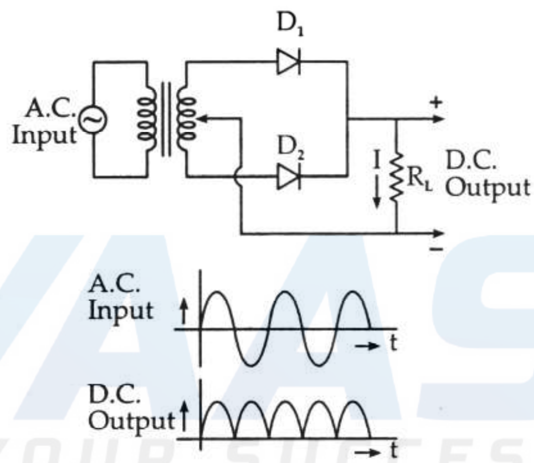
$$\text{Form factor} = F = \frac{I_{rms}}{I_{dc}} = \frac{e_{rms}}{V_{dc}} = \frac{\pi}{2} = 1.57$$

ixx) The ripple frequency of half wave rectifier is equal to the frequency of applied e.m.f.

xx) The value of d.c. component in output voltage is less than the a.c. component.

xxi) The output of rectifier is pulsating d.c. To convert it into perfect d.c. filter circuits are used.

2. Full wave rectifier:



i) To convert full A.C. cycle into D.C., two junction diodes are used which conduct alternately.

ii) In positive half cycle of A.C., diode D_1 remains in forward bias and diode D_2 does not conduct. In negative half cycle of A.C., diode D_2 becomes in forward bias and diode D_1 does not conduct. Thus, both junction diodes conduct alternately and we get D.C. continuously from load resistance R_L.

iii) In full wave rectifier two junction diodes are used.

iv) In full wave rectifier full cycle of input a.c. is converted into d.c.

v) The average value of output current is given by,

$$I_{dc} = \frac{2I_0}{\pi}$$

vi) The average value of output voltage is given by,

$$V_{dc} = \frac{2e_0}{\pi}$$

vii) Maximum current, $I_0 = \dfrac{e_0}{r_f + R_L}$

where e_0 – maximum voltage
r_f – internal resistance of the diode
R_L – load resistance.

viii) r.m.s. current $I_{rms} = \dfrac{I_0}{\sqrt{2}}$

ix) A.C. power input, $P_{ac} = (I_{rms})^2 \times (r_r + R_L)$
where I_{rms} = r.m.s. current

x) D.C. power output, $P_{dc} = (I_{dc})^2 \times R_L$
where I_{dc} = average current.

xi) The efficiency of a full–wave rectifier is defined as the ratio of d.c. power output to the applied input a.c. power.

$$\text{Rectifier efficiency } \eta = \frac{\text{d.c. power output}}{\text{a.c. power input}}$$

$$= \frac{P_{dc}}{P_{ac}} = \frac{0.812 \times R_L}{r_f + R_L}$$

$$= 81.2\ \%$$

where r_f is the diode resistance and R_L is the load resistance.

xii) The ripple factor of full wave rectifier is the ratio of a.c. current to d.c. current (a.c. voltage to d.c. voltage).

i.e. $\gamma = \dfrac{I_{ac}}{I_{dc}} = \dfrac{V_{ac}}{V_{dc}} = 0.482$ **AND**

$$\text{Form factor} = F = \frac{I_{rms}}{I_{dc}} = \frac{e_{rms}}{V_{dc}} = \frac{\pi}{2\sqrt{2}} = 1.1$$

xiii) The ripple frequency of full wave rectifier is twice the frequency of applied e.m.f.

ixx) The value of d.c. component in output voltage is more than the a.c. component.

xx) The output of rectifier is pulsating d.c. To convert it into perfect d.c. filter circuits are used.

Advantages and disadvantages of semiconductor diodes over vacuum diodes :

1. Advantages:

i) Heating battery is not required in junction diodes.

ii) Since no heating is required, the semiconductor diodes are set into operation as soon as the circuit is switched on.

iii) The semiconductor diodes do not produce a humming noise, during the operation.

iv) Semiconductor diodes require low voltage for their operation as compared to vacuum tubes. Hence there is low power consumption.

v) Due to their small size, they are very compact.

vi) They are cheap as compared to vacuum tubes.

vii) They are shock proof.

viii) They have a very long life.

ix) Semiconductor diodes are free from vacuum deterioration trouble.

2. Disadvantages:

i) The main disadvantage of semiconductor diodes is possibility of its breakdown due to rise of temperature and on application of high voltage.

ii) They carry less power.

iii) If large current passes through them, they get heated due to which p–n junction breaks, hence it will not work.

10.6 Zener diode as a voltage regulator

Zener diode :

1. In the reverse bias pn–junction, it has been noted that when the reverse voltage applied to the pn–junction increases, at a critical voltage called as breakdown voltage the reverse current increases sharply to a high value.

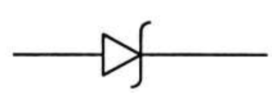
2. The satisfactory explanation of this breakdown of the junction was first given by the American scientist C. Zener. Therefore, breakdown voltage is sometimes called the Zener voltage and the sudden increase in current is called Zener current.

3. The breakdown or Zener voltage depends upon the amount of doping.

4. If the diode is heavily doped, depletion layer will be thin and consequently the breakdown of the junction will occur at a lower reverse voltage.

5. On the other hand, a lightly doped diode has a higher breakdown voltage.

6. A properly doped pn–junction diode which has a sharp breakdown voltage is called a Zener diode. The symbol of Zener diode is as shown in figure.



It should be noted that, it is just like an ordinary diode except that the bar is turned into Z–shape.

7. The following points should be noted about the Zener diode:

   i) A Zener diode is always reverse connected, i.e. it is reverse biased.

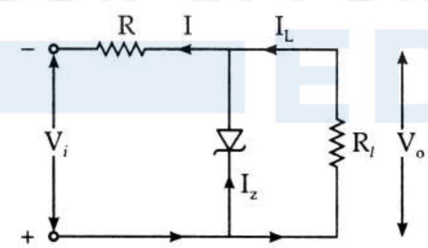
   ii) A Zener diode has sharp breakdown voltage, called Zener voltage (V_z).

   iii) When forward biased, its characteristics are just those of an ordinary diode.

8. **Zener effect:** When applied reverse voltage is breakdown voltage or more, large number of electron hole pairs are generated because they are pulled from covalent bonds therefore current suddenly increases this is called as zener effect.

9. **Avalanche effect:** At breakdown voltage minority current carriers are accelerated in the depletion layer. When they are accelerate, collision with other atoms takes place. This generates new electrons which are again accelerated so more atoms gets ionized and thus a bunch of electrons or a avalanche of electrons is produced which increases the reverse current through zener. This is called as avalanche effect.

10. A Zener diode can be used as a voltage regulator to provide a constant voltage from a source whose voltage may vary over sufficient range. The circuit diagram of use of Zener diode as a voltage regular is as shown in figure.



11. Voltage drop across R = $V_i - V_0$
    and current through R is $I = I_z + I_L$
    Applying Ohm's law we have,

$$R = \frac{V_f - V_0}{I_z + I_L}$$

12. In forward biasing of zener diode small increase in bias voltage causing large increase in current.

13. In reverse biasing as bias voltage increases reverse current decreases and become constant at low value.

14. At the break down, voltage across zener diode remains constant for any current flowing through it.

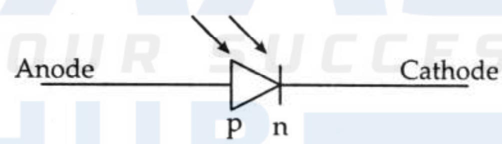
15. Zener diode is used as voltage regulation, so it is called voltage regulator diode.

16. Resistance and zener diode are connected in parallel, therefore, when current through load resistance increases then current through zener diode decreases. A constant voltage is obtained at output.

17. Zener diode is used to protect meters from burning due to overload.

10.7 Photo diode

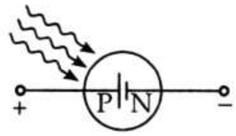
1. "Photo diode is a p–n junction diode constructed with a transparent window so that light can fall on its junction".
2. "Photo diode is an optoelectronic device in which current carriers are generated by photons through photo excitation".
3. Photo diode is always operated in reverse bias.
4. Photo current depends upon intensity of incident radiation and is independent of reverse bias.
5. Photo diodes are used to detect optical signals and used in object counters, optocouplers, used as sensor in remote controlled receivers.
6. Symbol of photo diode is as shown in figure,



10.8 Solar cell

1. Solar cell is a solar energy converter.
2. It is a pn–junction device which converts solar energy into electrical energy.
3. A solar cell consist of a silicon or gallium – arsenide pn–junction diode packed in a can with glass window on top.
4. Current produced in a solar cell is directly proportional to illumination of light.
5. Current produced in a solar cell also depends upon surface of the cell.
6. One cm^2 surface area produces 10 mA current at 1V.
7. A typical solar cell supply a current of 50 mA at 0.45 V.

8. The circuit symbol of solar cell is.



9. **Uses:**

i) Solar cells are used for charging storage batteries in day time, which can supply the power during night times.

ii) The solar cells are also used in artificial satellite to operate the various electrical instruments kept inside the satellite.

iii) They are used for generating electrical energy in cooking food.

iv) Solar cells are used in calculators, wrist watches and light meters (in photography). .

v) Solar cells are used in remote sensors.

vi) Solar cells are used in street lights.

10.9 Light Emitting Diode (LED)

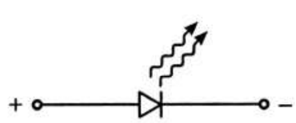
1. When a solid is excited by an electrostatic field then it emits light. This process is known as electro luminescence.

2. Light emitting diode is forward biased pn–junction diode which emits light when recombination of electrons and holes takes place at the junction.

   When the pn–junction is forward biased, the diffusion of majority charge carriers takes place across the junction. The electrons move from n–side to p–side through the junction and holes move from p–side to n–side through the junction. During recombination of electrons and holes, some of this energy difference is given out in the form of light (i.e. photons) and the junction becomes a light source and then it is called as light emitting diode.

3. The colour of the light emitted depends upon the type of material used in making the semiconductor diode as given below. For gallium–arsenide (Ga As) – infrared radiation, gallium–phosphide (Ga P) – red or green light, gallium–arsenide–phosphide (Ga As P) – red or yellow light.

4. The symbol of light emitting diode is as shown in figure.



5. **Uses:**

i) In burglar–alarm systems, infra red LEDs are used.

ii) In calculators and digital watches, LEDs are used for numeric displays.

iii) In the field of optical communication where high radiance Ga As diode are matched into the optical fibre cable.

iv) For displaying letters and numbers or for entering information into optical computer memories.

v) In image sensing circuits for picture phone.

6. **Advantages of light emitting diodes:**

i) It requires very small current.

ii) It operates on low voltage.

iii) Power consumption is very small.

iv) Its action is very fast.

v) It is smaller in size and available in different shapes.

vi) It emits light of different colours.

vii) It emits infrared, visible and ultraviolet light.

viii) It is sturdy and can not easily break.

ix) It has a longer life.

7. **V–I characteristic of LED:**

i) The barrier potential depends on the type of semiconductors used.

ii) For Ga–As–P LED, it is about 1.5 V.

10.10 Transistor action and its characteristicsas an ampllfler

Transistor :

1. The word transistor was derived from transfer of resistance.

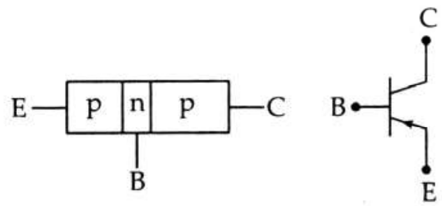
2. The first transistor was designed by John Bardeen, D.W.H. Brattain and W. Shockely in 1948 (They were jointly awarded Nobel prize for the invention).

3. A device which consist of two p–n junctions formed by sandwiching either a p–type or n–type semiconductor between a pair of opposite type, is called as transistor.

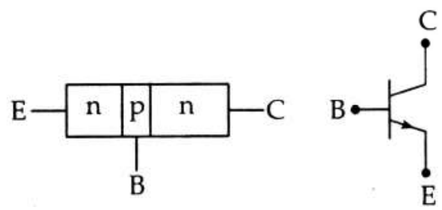
   Transistors are made of extrinsic semiconductors. They are equivalent to triode valve.

4. There are two types of transistors,

i) **p–n–p transistor:** In p–n–p transistor a thin n section is sandwiched between two p sections.



ii) **n–p–n transistor:** In this transistor, a p section is sandwiched between two n sections



5. Remark:

i) A transistor has three sections of dopped semiconductors. The section on the side is called the emitter and the section on the opposite side is called the collector. The middle section is called the base and forms two junctions between the emitter and the collector.

ii) The emitter, the collector arid the base in a transistor perform the same functions as the cathode, the anode and the grid respectively in a triode valve.

iii) The base of the transistor is very thin (about 0.002 cm) and is lightly dopped. The collector is wider than the base or the emitter in order to dissipate heat at the collector junction during transistor operation, The emitter region is more dopped than the collector region.

iv) The emitter a transistor is always in forward bias and the collector is always in reverse bias. The collector current is always less than the emitter current, and $I_e = I_b + I_c$.

v) A transistor transfers current from a low resistance to high resistance in a circuit.

vi) The transistor is a current operated device. The input current controls the output current. In vacuum tubes, like diodes and triodes, the input voltage controls the output current.

vii) In the n–p–n transistor, the majority carriers are electrons. The conventional current flows from collector to base and to emitter. In the p–n–p transistor the majority carriers are holes. The conventional current flows from emitter to base and the collector.

viii) A transistor can be connected to a circuit in three ways a) common base connection b) common emitter connection c) common collector connection.

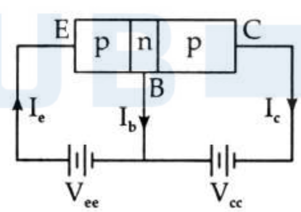
a) **Common base connection :** In this arrangement the input is applied between emitter and base, and output is taken from collector to base.

b) **Common–emitter connection :** In this arrangement, the input is applied between base and emitter and output is taken from collector and emitter. The common emitter arrangement is widely used because of high current gain, high voltage and power gain.

c) **Common collector connection :** In this arrangement, the input is applied between base and collector and output is taken from emitter and collector. This arrangement is used for impedance matching.

6. Action of p–n–p transistors:

i) Here holes are the majority carriers in emitter, they are repelled due to forward bias. And as base is thin and lightly doped, it has low density of electrons. There fore, holes enter in the base region, then only about 5% electron–hole combination takes place. The remaining holes reach the collector under the influence of reverse collector voltage.



ii) Here $I_e - I_b + I_e$

I_e – emitter current ($\simeq$ 1.0 mA)

I_b – base current ($\simeq$ 0.2 mA)

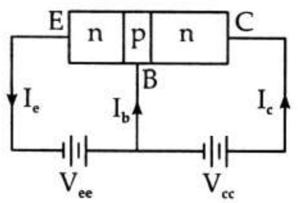
I_e – collector current ($\simeq$ 0.8 mA)

iii) In p–n–p transistor electric conduction takes place by flow of holes.

iv) As a hole reaches the collector, an electron leaves the negative poles collector base battery Vee and neutralise it. At the same time, an electron from some covalent bond in the emitter enters into the positive terminal of V_{ee}, creating a hole in the emitter.

7. **Action of n–p–n transistor:**

i) Electrons being majority carriers in the emitter are repelled due to forward bias towards the base. The base contains holes as majority carriers and so some holes and electrons combine in the base region but the base is lightly doped. Due to this the probability of electron–hole combination in base region is very small (5%). The remaining electrons cross into collector region and enter into the positive terminal of the battery Veeconnected to the collector.



At the same time an electron enters into the emitter from the negative pole of the emitter base battery Vee.

ii) In n–p–n transistor the current is carried inside the transistor as well as in the external circuit by the electrons.

iii) Here also $I_e - I_b + I_e$

I_e – emitter current

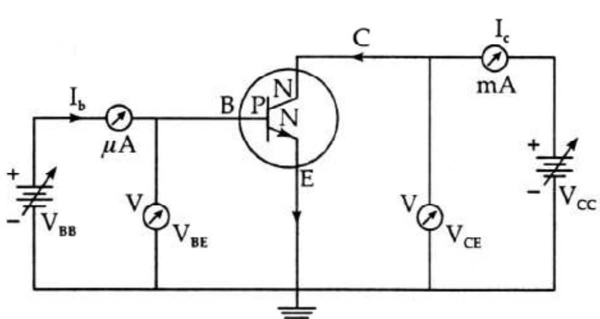
I_b – base current

I_e – collector current

iv) In n–p–n transistors, electric conduction takes place due to the flow of electrons.

v) Because emitter–base is forward biased, the resistance of emitter–base circuit (input circuit) which is called input resistance, is less and since base and collector are in reverse bias hence resistance of base–collector circuit (output circuit) also is called output resistance is more.

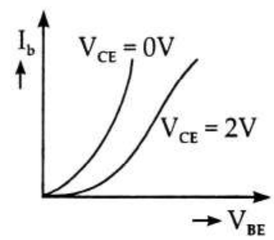
8. **Common emitter characteristics of a transistor:**



The circuit diagram for common emitter configuration of n–p–n transistor for obtaining characteristic curves is shown in figure.

i) **Input characteristics:** The graph of the base current I_b versus the base emitter voltage V_{BE} keeping V_{CE} fixed is called the input characteristic curve.

As long as V_{BE} is less than the barrier voltage, the current I_b the case of forward biased diode.



When V_{BE} is increased to a higher value than the barrier voltage, the current I_b increases sharply by small increase in V_{BE}.

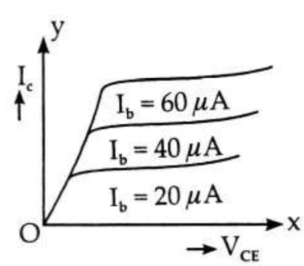
The input characteristics remain almost unaffected by small changes in V_{CE} even if the base current is reverse biased.

The a.c. input resistance of the transistor in common emitter configuration is defined as the slope at a given point on the characteristic curve i.e.

$$R_i = \left(\frac{\Delta V_{BE}}{\Delta I_b}\right)_{V_{CE}} = \text{Constant}$$

The value of R_i is fairly low.

ii) **Output characteristics:** The graphs obtained by plotting the collector. current I_c as a function of V_{CE} for different values of the base current I_b are called the output characteristic curves.



For a given value of collector voltage the base current, large is the collector current.

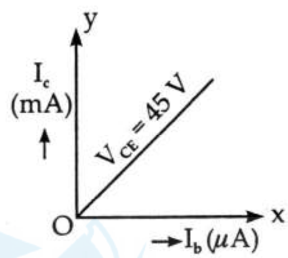
Once the collector voltage V_{CE} exceeds the base voltage V_{BE} the collector current is almost independent of the collector voltage.

The a.c. output resistance (R_0) of the transistor is defined as the ratio between ΔV_{CE} and ΔI_c at constant I_b.

$$\therefore \quad R_0 = \left(\frac{\Delta V_{CE}}{\Delta I_c}\right)_{I_b} = \text{Constant.}$$

The value of R_0 is fairly high.

iii) **Transfer characteristics :** The graph plotted between the output current I, and input current I_b are called transfer characteristics. The common–emitter current amplification factor β is defined as

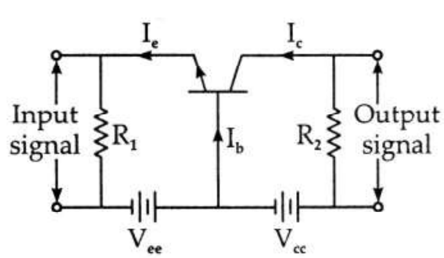


$$\beta = \left(\frac{\Delta I_c}{\Delta I_b}\right)_{V_{CE}} = \text{Constant.}$$

The value of β is fairly high.

Use of transistor as an amplifier:

1. An electronic device which increases the strength of input signal is called as an amplifier. Amplifier is used to increase the amplitude of any signal.
2. When a transistor is to be used as an amplifier, there are three types of the amplifier circuits,
   i) Common base amplifier: In this amplifier, base is common to input as well as to output circuits.
   ii) Common emitter amplifier: Here emitter is common to input as well as to output.
   iii) Common collector amplifier: Here collector is common to input as well as to output.
3. **Common–base amplifier:**



i) Here the emitter is forward biased by using emitter–base battery Vee and due to this resistance of input circuit is small. The collector is reverse biased by using collector–base battery Vec so the resistance of output circuit is large. The input voltage signal which is to be amplified is applied across emitter–base circuit (input circuit) and the amplified output is obtained across the base and collector.

ii) **A.C. current gain (α) :**

$$\alpha = \left(\frac{\text{Change in collector current}}{\text{Change in emitter current}}\right)$$

collector voltage = constant

$$\alpha = \left(\frac{\Delta I_c}{\Delta I_e}\right)_{V_C}$$

iii) **A.C. voltage gain:**

$$A_v = \left(\frac{\text{Change in output voltage}}{\text{Change in input voltage}}\right)$$

$$A_v = \frac{\Delta V_c}{\Delta V_e} \quad \text{.... (i)}$$

Since R_1 – input resistance

ΔV_e - change in input voltage

Then change in emitter current

$$\Delta I_e = \frac{\Delta V_e}{R_1}$$

$$\Delta I_c = \alpha \times \Delta I_e = \alpha \frac{\Delta V_e}{R_1}$$

and change in collector voltage

$$\Delta V_c = \Delta I_c \times R_2 \ (R_2 \text{ – output resistance})$$

$$= a \frac{\Delta V_e}{R_1} \times R_2$$

Now from equation (i),

$$A_v = \frac{\Delta V_c}{\Delta V_e} \quad \text{or} \quad A_v = \alpha \frac{R_2}{R_1}$$

$A_v = \alpha \times$ resistance gain

iv) **A.C. power gain**

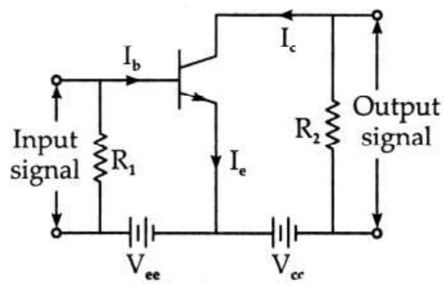
$$\text{Power gain} = \frac{\text{Change in output power}}{\text{Change in input power}}$$

$$= \text{Voltage gain} \times \text{Current gain}$$

Power gain = $\alpha^2 \times \frac{R_2}{R_1}$

In common base amplifier circuit, input and output voltage are in same phase.

4. **Common emitter amplifier:**



i) The low input voltage signal is applied in base emitter circuit (input circuit) and the amplified output is obtained across the collector and emitter.

ii) A.C. current gain (β) : $\beta = \left(\frac{\Delta I_c}{\Delta I_b}\right)_{V_C}$

Its value is quite large as compared to 1 and lies between 150 to 50.

iii) A.C. voltage gain:

$A_v = \beta \times$ Resistance gain

Since $\beta > \alpha$

So voltage gain in CE amplifier is very large as compared to that in CB amplifier.

iv) A.C. power gain:

Power gain = voltage gain × current gain

$= \beta^2 \times$ resistance gain ($\because\ \beta^2 > 0.2$)

So, power gain in CE amplifier is much large than the power gain in case of CB amplifier.

5. In common collector connection, the current gain is defined as

$\gamma = \frac{\delta I_e}{\delta I_b}$ γ is always greater than 1.

6. **Relation between α and β also relation between transistor currents:**

i) For transistor, we know that,

$I_e = I_b + I_c$

ii) If ΔI_e be small change in emitter current which produces small change ΔI_c in collector current and small change ΔI_b is base current, so

$\Delta I_e = \Delta I_b + \Delta I_c$

dividing both sides by ΔI_c we get,

$$\frac{\Delta I_e}{\Delta I_c} = \frac{\Delta I_b}{\Delta I_c} + 1$$

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

$$\frac{1}{\beta} = \frac{1}{\alpha} - 1 = \frac{1-\alpha}{\alpha}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

iii) $\beta = \frac{\alpha}{1-\alpha}, \quad \alpha = \frac{\beta}{1+\beta}$

and $\gamma = 1 + \beta = \frac{1-\alpha}{\alpha}$

iv) $I_c = \beta I_b = \alpha I_e = \left(\frac{\beta}{1+\beta}\right) I_e$

v) $I_b = \frac{I_c}{\beta} = \frac{I_e}{1+\beta} = (1-\alpha) I_e$

vi) $I_e = \frac{I_c}{\alpha} = \left(\frac{1+\beta}{\beta}\right)$

$I_e = (1+\beta) I_b = \frac{I_b}{1-\alpha}$

vii) $I_e : I_b : I_c = 1 : (1-\alpha) : \alpha$

7. **Remark :** Differences between transistor and triode

Advantage of transistor over triode are,

i) Transistors are robust, cheap and very small in size.

ii) As no heating filament is required, so there is no heating delay and no heating power is needed.

iii) Very low operating voltage can be used.

iv) As transistors consume little power, they have a high circuit efficiency.

v) They are capable of sustaining mechanical shocks as they are solid crystals.

vi) They have long life.

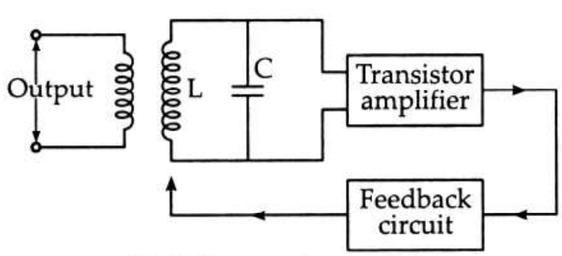
The only disadvantage of transistor is that they can be damaged by overheating so that they are not suitable for large currents (where triode can be used).

10.11 Transistor as a switch

1. Both the npn and pnp bipolar transistors can be made to operate as an "ON/OFF" type solid state switch for controlling high power devices such as motors, lamps.
2. When transistor is operated in cut off region or saturation region, it works as a switch.
3. In cutoff region of transistor both "thejunctions are reverse biased.
4. In saturation region of transistor both the junctions are forward biased.
5. The transistor switch is essential component of all digital logic circuits.
6. Transistor switches are used in power electronics.
7. Transistor switches have the advantage of high speed of operation and convenience of electronic control.

10.12 Oscillators

1. An electronic device that generates oscillations (sinusoidal wave) of desired frequency is known as an oscillator.
2. As the term oscillator indicates the generation of a frequency, but it should be noted that it does not create energy but it acts as an energy converter. It receives de energy and changes it into an ac energy of desired frequency. The frequency of oscillations depends upon the constant of the device (L and C).
3. **Block diagram of an oscillator:** The block diagram of an oscillator is as shown in figure. It consists of (a) tank circuit, (b) transistor amplifier, (c) feedback circuit.



Block diagram of an oscillator

4. **Feedback circuit:** It is a circuit which receives output of the transistor and supplies correct amount of energy to LC circuit to meet the losses.
5. The frequency of oscillations is given by,

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

By changing the value of Lor C or both, oscillations of any desired frequency can be obtained.

6. **Advantages:** Oscillations can be produced by mechanical devices but oscillators have the following main advantages

i) An oscillator is a non rotating device consequently, there is little wear and tear and hence longer life.

ii) Due to absence of rotating parts, the operation of an oscillator is quite silent.

iii) An oscillator can produce waves from small (20 Hz) to extremely high frequencies (100 MHz).

iv) The frequency of oscillations can be easily changed.

v) It has a very high efficiertcy.

7. **Types of oscillators:**

i) According to the nature of generated waveform.
   a) Sinusoidal or harmonic oscillators.
   b) Relaxation or non–sinusoidal oscillators.

ii) According to the frequency of the generated signal.
   a) Audio frequency oscillators (20 Hz to 20 kHz)
   b) Radio frequency oscillators (20 kHz to 30 MHz)
   c) High frequency oscillators (30 MHz to 300 MHz)
   d) Ultra high frequency oscillators (300 MHz to 3 GHz).
   e) Micro wave oscillators (3 GHz to several GHz)

iii) According to component used.
   a) RC oscillators
   b) LC oscillators
   c) Crystal oscillators

8. **Uses of oscillators:**

i) They are used in radio and T.V. transmitters and receivers i.e. in various telecommunication applications.

ii) They are used in many electronic equipments, i.e. laboratory test equipments.

10.13 Logic gates

1. **Analogue signal:** A continuous time varying current or voltage signal is called analogue signal.
2. **Digital signal:** The signal which have two levels of current or voltages (represented by 0 and 1) are called digital signals.
3. **Logic gates:** A digital circuit with one or more input signals but only one output signal is called a logic gate. OR A digital circuit which either allows a signal to pass through or stops it, is called as a logic gate.
4. The logic gates are the building blocks of a digital system. Each logic gate follows a certain logical relationship between input and output voltage.
5. There are three basic logic gates:

i) OR gate

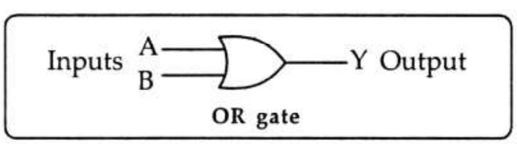
ii) AND gate and

iii) NOT gate.

6. **Truth table:** It is a table that shows all possible input combinations and the corresponding output combinations for a logic gate. It is also called a table of combinations.
7. **Boolean expression:** George Boole invented a kind of algebra which deals with logical statements that have only two values, namely either a true or a false value. The logical statements are called Boolean variables.

OR gate:

1. An OR gate is a logic gate which has two or more than two inputs but only one output. The output Y of an OR gate is LOW when all inputs are LOW. The output Yof an OR gate is HIGH if any or all the inputs are HIGH.
2. It is called OR gate because the output is high if any or all the inputs are high. For the same reason, an OR gate is sometimes called 'any or all' gate.
3. Figure shows the logic symbol of OR gate.

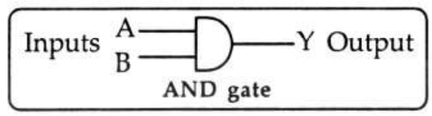


4. Boolean expression for OR gate is $Y = A + B$ (The + sign in Boolean algebra refers to the logical OR function).
5. **Truth table**

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

AND gate:

1. The AND gate is a logic gate which has two or more than two inputs but only one output. The output Y of AND gate is low if any or all inputs are low.
2. It is called AND gate because output is high only when all the inputs are high. For this reason, the AND gate is sometimes called' all or nothing gate'.
3. Figure shows the logic symbol of AND gate.

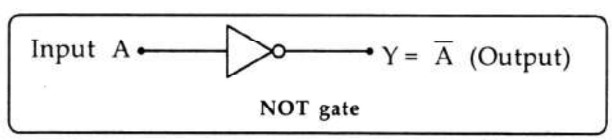


4. Boolean expression for AND gate is $Y = A . B$ (The · dot stands for logical AND operation.)
5. **Truth table:**

A	B	$Y = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

NOT gate or Inverter:

1. The NOT gate or inverter is the simplest of all logic gates. It has only one input and one output, where the output is opposite to the input. The NOT gate is also called inverter because it inverts the input.
2. Figure shows the symbol of NOT gate. Note that small bubble on the inverter symbol represents inversion.

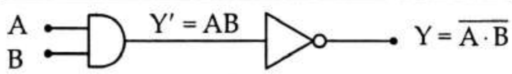


3. Boolean expression for NOT gate is Y= A. It should be noted that the bar above the input A represents inversion.
4. **Truth table:**

A	$Y = \overline{A}$
0	1
1	0

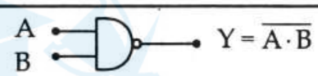
NAND gate:

1. NAND gate is a combination of AND gate and NOT gate. In other words, output of AND gate connected to the input of NOT gate as shown in figure.



NAND gate

2. The output of a NAND gate is opposite to the AND gate. The symbol of NAND gate is as shown in figure.



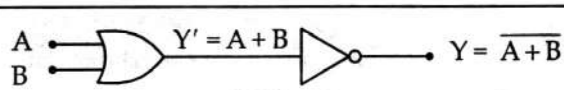
Symbol of NAND gate

3. The boolean expression for NAND gate is $Y = \overline{A\ .\ B}$.
4. **Truth table:** The truth table for NAND gate is developed by inverting the outputs of the AND gate. Note that output from a NAND gate is always 1 except when all of the inputs are 1.

Input		Output	
A	B	AND Y'	NAND $Y = \overline{A \cdot B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

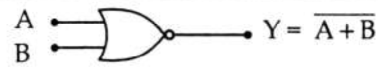
NOR gate:

1. NOR gate is a combination of OR gate and NOT gate. In other words, output of OR gate is connected to the input of NOT gate as shown in figure.



NOR gate

2. The output of NOT gate is opposite to' the OR gate. The symbol of NOR gate is as shown in figure.



Symbol of NOR gate

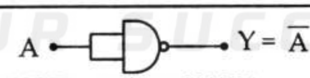
3. The Boolean expression for NOR gate is $Y = \overline{A+B}$
4. **Truth table:** The truth table for NOR gate is developed by inverting the outputs of the OR gate. Note that the output of NOR gate is 1 when all the inputs are 0.

Input		Output	
A	B	OR(Y')	NOR($Y = \overline{A+B}$)
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

NAND gate as a universal gate:

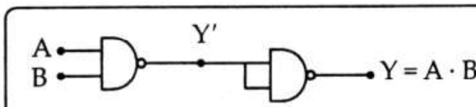
The NAND gate is called as universal gate, because with the repeated use of NAND gate we can construct any basic gate or other logic gates.

1. **NOT gate from NAND gate:** The construction of NOT gate using NAND gate is as shown in figure.



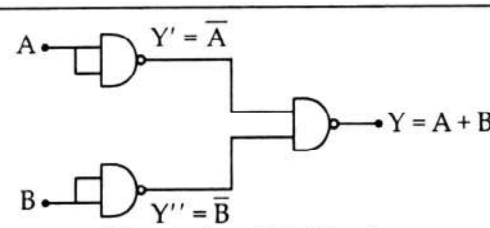
NOT gate from NAND gate

2. **AND gate from NAND gates:** The construction of AND gate using NAND gates is as shown in figure.



AND gate from NAND gate

3. **OR gate from NAND gates:** The construction of OR gate using NAND gates is as shown in figure.



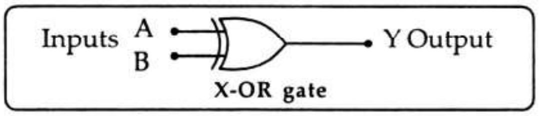
OR gate from NAND gate

Additional information

1. Exclusive OR gate / X–OR gate:

a) The X–OR gate is a logic gate which has two inputs only. The output Y of X–OR gate is high if either input is high.

b) Figure shows the logic symbol of X–OR gate.



X-OR gate

c) Boolean expression for X–OR gate is

$Y = A \oplus B$

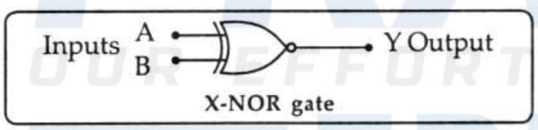
d) **Truth table:**

A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

2. Exclusive NOR gate / X–NOR gate:

a) The X–NOR gate is a logic gate which has two inputs only. The output Y of X–NOR gate is high if both inputes are same.

b) Figure shows the logic symbol of X–NOR gate.



X-NOR gate

c) Boolean expression for X–NOR gate is

$Y = A \oplus B$

d) **Truth table:**

A	B	$Y = A \oplus B$
0	0	1
0	1	0
1	0	0
1	1	1

3. De Morgan's Theorems:

a) De Morgan's first theorem states that complement of a sum is equal to the product of the complements

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

b) De Morgan's second theorem states that complement of a product is equal to the sum of the complements i.e. $\overline{A} \cdot \overline{B} = \overline{A} + \overline{B}$

Uses of logic gates:

i) Every digital circuit or instrument or system is made up of logic gates.

ii) They are used in automatic control system in industry, where certain operation is performed after checking status of sensors.

iii) Arithmetic and logic unit of computers and calculators uses logic gates.

❍❍❍

MULTIPLE CHOICE QUESTIONS

10.1 Energy bands in solids or band theory of solids

1. The main distinction between conductors, semiconductors and insulators is concerned with
   a) binding energy of free electrons
   b) work function of free electrons
   c) width of forbidden energy band
   d) temperature coefficient of resistance
2. In an insulator
   a) the valence band is partially filled with electrons
   b) conduction band is partially filled with electrons
   c) conduction band is empty and the valence band is filled with electrons
   d) conduction band is filled with electrons and valence band empty
3. If copper and germanium are cooled to 70 K from room temperature, then
   a) resistance of copper increases while that of germanium decreases
   b) resistance of copper decreases while that to germanium increases
   c) resistance of both decreases
   d) resistance of both increases
4. The electrons in the atoms of an element, which determine its chemical and electrical properties are called
   a) valence electrons b) conduction electrons
   c) free electrons d) bound electrons
5. What is the order of forbidden energy gap in eV in the energy bands of silicon?
   a) 0.5 eV b) 1.1 eV
   c) 2.1 eV d) 3.5 eV
6. If the energy gap between the conduction band and valence band of a substance is of the order of 0.7 eV, then the substance is
   a) a conductor b) semiconductor
   c) an insulator d) a super conductor
7. When a metal is heated, it emits predominantly
   a) mesons b) protons
   c) neutrons d) electrons
8. Generally, the number of electrons in the valence shell of good conductors is
   a) equal to 4 b) less than 3
   c) more than 3 d) more than 8
9. In a crystal, the permitted energy states of electrons are present
   a) in the conduction band and the forbidden gap
   b) only in the forbidden gap
   c) in the valence band and conduction band
   d) in the forbidden gap and the valence band
10. There is no hole current in good conductors, because
    a) they do not have valence band
    b) they do not have conduction band
    c) their valence and conduction bands overlap
    d) their valence bands overlap only
11. The energy band gap is maximum in
    a) copper b) an insulator
    c) germanium d) a super conductor
12. The forbidden energy gap in an intrinsic semiconductor is
    a) very large
    b) zero
    c) very small
    d) half of the forbidden gap in a conductor
13. In a good conductor, the energy levels in a valence band
    a) are partially filled
    b) are completely filled
    c) overlap with conduction band
    d) both 'a' and 'c'
14. A solid having uppermost energy band partially filled with electrons is called
    a) an insulator b) a semiconductor
    c) a conductor d) none of these
15. At ordinary temperature, an increase in temperature, increases the conductivity of
    a) a semiconductor b) a conductor
    c) a super conductor d) an insulator
16. The width of the forbidden band will be small in
    a) metals b) insulators
    c) semiconductors d) good conductors
17. Electrons in the outermost shell of an atom are called
    a) conduction electrons
    b) valence electrons
    c) donor electrons
    d) active electrons
18. In intrinsic semiconductor at room temperature,

number of electrons and holes are

a) equal b) zero
c) unequal d) infinite

19. Fermi energy is the
a) minimum energy of electrons in a metal at 0 K
b) maximum energy of electrons in a metal at 0 K
c) minimum energy of electrons in a metal at 0°C
d) maximum energy of electrons in a metal at 0°C

20. In which of the following band an electron cannot lie in a crystal ?
a) Conduction band b) Forbidden band
c) Valence band d) All of these

21. In a pure conductor, the value of the forbidden energy gap is
a) 0.5 eV b) 1.1 eV
c) zero d) 2.3 eV

22. The forbidden energy gap in a semiconductor is of the order of
a) 0.1 eV b) 0.5 eV
c) 1 eV d) 10 eV

23. If there is no hole current in a substance, if must be
a) an insulator
b) a conductor
c) an n-type semiconductor
d) a p-type semiconductor

24. Which one of the following is an amorphous solid?
a) Rubber b) Plastic
c) Glass d) All of these

25. In an insulator, the forbidden energy gap between the valence band and conduction band is of order of
a) 5 eV b) 10 eV
c) 2 MeV d) 5 MeV

26. What is the forbidden gap for germanium crystal at 0K?
a) 0.067 eV b) 6.57 eV
c) 0.67 eV d) 2.67 eV

27. The band of maximum energy in which electrons are present is called the
a) conduction band b) valence band
c) forbidden band d) none of these

28. The forbidden gap in the energy bands of silicon is of the order of
a) 0.5 eV b) 1.1 eV
c) 2.6 eV d) 4 eV

29. At absolute zero temperature the forbidden gap of conductor is
a) zero b) 0.67 eV
c) 1.1 eV d) 6 eV

30. There is a small energy gap between the conduction and valence bands of
a) copper b) silver
c) silicon d) aluminium

31. If the temperature of semiconductor is increased the number of electrons in the valence band will
a) increase b) same
c) decrease d) either 'a' or 'b'

32. In good conductors, the energy gap between the valence and conduction bands is
a) zero b) one
c) infinite d) very large

33. If the temperature of semiconductor will increase then the forbidden gap will
a) increase b) decrease
c) remain same d) either 'a' or 'b'

34. What is the name of the level formed due to the impurity atom in the forbidden energy gap near the valence band in a p-type semiconductor?
a) Conduction level b) Forbidden level
c) Donor level d) Acceptor level

35. The valence band and the conduction band of a substance overlap at ordinary temperatures. The substance may be
a) a p-type semiconductor
b) a conductor
c) an insulator
d) an n-type semiconductor

36. The Ge behaves as semiconductor even though all electrons in the valence band form covalent bonds? It is caused by the large width of
a) valence band b) conduction band
c) forbidden band d) none of these

10.2 Intrinsic and extrinsic semiconductors

37. The most commonly used semiconductors are
a) wool and glass
b) copper and brass
c) glass and ebonite
d) germanium and silicon

38. The behavior of pure Ge crystal, at absolute zero temperature is that it behaves as

a) perfect conductor b) perfect insulator
c) semiconductor d) none of these

39. The conductivity of semiconductors
a) is independent of temperature
b) decreases with increases of temperature
c) increases with increase of temperature
d) varies unpredictably with temperature

40. The free electron model of metallic solid does not explain
a) range of resistivities
b) behaviour of insulators
c) behaviour of semiconductors
d) creation of holes on crystals

41. A pure semiconductor
a) has low resistance
b) allows adequate current to pass through it
c) is an intrinsic semiconductor
d) all of these

42. Majority carriers in semiconductors are
a) holes in n-type and p-type both
b) electron in n-type and p-type both
c) holes in n-type and electrons in p-type
d) holes in p-type an electrons in n-type

43. In a semiconductor, the mobility of holes is
a) less than that of electrons
b) equal to that of electrons
c) greater than that of electrons
d) not related to the movement of electrons

44. Which of the following is a typical example of a semiconductor?
a) Mica b) Quartz
c) Platinum d) Germanium

45. A hole in semiconductor is different from an electron, because it is
a) massless
b) an antiparticle
c) negatively charged vacancy
d) positively charged vacancy

46. Doping materials are called impurities, because they
a) make semiconductor less pure
b) change chemical properties
c) alter the crystal structure
d) change the number of charge carriers

47. The movement of a hole is brought about by the vacancy being filled by a/an
a) free electron b) valence electron
c) atomic core d) none of these

48. The electrical conductivity of p-type semiconductor is determined by the number of
a) holes b) electrons
c) valence band d) conduction band

49. The electrical conductivity of intrinsic and p-type semiconductor increases with increase in
a) volume b) density
c) pressure d) temperature

50. In germanium crystal, a hole is provided by an impurity of
a) covalent b) monovalent
c) trivalent d) tetravalent

51. When n-type of semiconductor is heated
a) number of electrons increases while that of holes decreases
b) number of holes increases while that of electrons decreases
c) number of electrons and holes remain same
d) number of electrons and holes increase equally

52. The number of electrons in the valence shell of a semiconductor is
a) 1 b) 2
c) 3 d) 4

53. The resistivity of a semiconductor at room temperature is in between
a) 10^{10} to 10^{12} Ω cm b) 10^{6} to 10^{8} Ωcm
c) 10^{-3} to 10^{6} Ω cm d) 10^{-2} to 10^{-5} Ω cm

54. Which of the following is correct about the nature of net charge on n-type semiconductor?
a) it is negative nature
b) it is positive nature
c) it is neutral
d) either 'a' or 'b'

55. A pure semiconductor has
a) an infinite resistance at 0 °C
b) a finite resistance which does not depend upon temperature
c) a finite resistance which decrease with temperature
d) a finite resistance which increases with temperature

10.3 n-type semiconductor and p-type semiconductor

56. In a p-type semiconductor, the majority carriers

are

a) holes b) neutrons
c) electrons d) positrons

57. To obtain p-type germanium semiconductor, it must be doped with
a) arsenic b) antimony
c) indium d) phosphorus

58. An n-type semiconductor is
a) neutral b) positively charged
c) negatively charged d) none of these

59. An n-type germanium is obtained, on doping intrinsic germanium, by
a) silicon b) sulphur
c) aluminium d) phosphorous

60. In an n-type semiconductor, the concentration of minority carriers mainly depends upon
a) doping technique
b) number of donor atoms
c) temperature of the material
d) quality of intrinsic material

61. When arsenic is added as an impurity to silicon, the resulting material is
a) n-type semiconductor
b) p-type semiconductor
c) n-type conductor
d) none of these

62. Semiconductors of both p-type and n-type are produced by
a) ionic solids b) metallic solids
c) covalent solids d) molecular solids

63. Semiconductor is damaged by the strong current due to
a) lack of free electron
b) excessof electrons
c) excess of protons
d) none of these

64. A p-type semiconducto.r is
i) a silicon crystal doped with arsenic impurity
ii) a silicon crystal doped with aluminium impurity
iii) a germanium crystal doped with boron impurity
iv) a germanium crystal doped with phosphorus impurity
a) (i) and (ii) are correct
b) (ii) and (iii) are correct
c) (i) and (iv) are correct
d) only (i) is correct

65. A hole in a p-type semiconductor is
a) an excess electron b) a missing electron
c) a missing atom d) a donor level

66. In an n-type semiconductor donor level is
a) above the conduction band of the host crystal
b) below the valence band of the host crystal
c) close to the conduction band of the host crystal
d) close to the valence band of host crystal

67. Regarding p-type and n-type semiconductor, which of the following statements is true?
a) n-type semiconductors have free electrons in majority
b) n-type semiconductors have holes in majority
c) the concentrations of electrons and holes are equal in both n-type and p-type semiconductors
d) n-type semiconductor has excess negative charge

68. The forbidden energy gap is maximum in
a) metals b) super conductors
c) insulators d) semiconductors

69. When boron is added as an impurity to silicon, the resulting material is
a) n-type conductor
b) n-type semiconductor
c) p-type conductor
d) p-type semiconductor

70. In p-type semiconductor the majority and minority charge carriers are respectively
a) protons and electrons
b) electrons and protons
c) electrons and holes
d) holes and electrons

10.4 p-n junction diode

71. When a p-n junction diode is forward biased, the flow of current across the junction is mainly due to
a) drift of charges
b) diffusion of charges
c) both drift and diffusion of charges
d) depends on the nature of the material

72. If the forward voltage in a p-n junction diode is increased, the width of depletion layer will
a) decrease b) increase
c) not change d) increase slightly

73. For rectifying an action, we use
a) choke b) diode

c) transformer d) condenser

74. In a semiconducting diode, reverse biased current is due to drift of free electrons and holes caused by
a) impurity atoms b) crystal structure
c) thermal excitations d) none of these

75. The depletion layer in the p-n junction is caused by
a) drift of holes
b) drift of electrons
c) diffusion of carriers
d) migration a impurity ions

76. A p-n junction diode is said to be forward biased, when a potential difference is applied across p and n-regions and making
a) p region positive and n region negative
b) making p region negative and n region positive
c) both p and n regions positive
d) both p and n regions negative

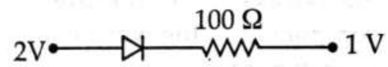
77. A diode converts A.C. voltage into
a) an A.C. voltage with a different peak value
b) a D.C. voltage with a constant value
c) a two directional pulsating voltage with a constant r.m.s. value
d) an unidirectional pulsating voltage that keeps on dropping to zero in between

78. A p-n junction diode can not be used
a) as a rectifier
b) for amplifying an A.C. signal
c) for getting radiation of light
d) as a detector of light intensity

79. When a p-n junction diode is reverse biased, the flow of current across the junction is mainly due to
a) diffusion of charges
b) drift of charges
c) both drift and diffusion of charges
d) depends upon the nature of the material

80. In a p-n junction diode, holes diffuse from the p-region to the n-region because
a) the free electrons in the n-region attract them
b) they are swept across the junction by the potential difference
c) there is greater concentration of holes in the p-region then the n-region
d) there is lesser concentration of holes in the p-region than the n-region

81. Assuming that the junction diode is ideal, the current in arrangement shown in figure is



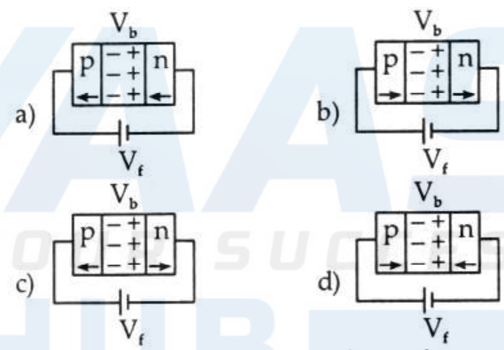
a) 2 mA b) 5 mA
c) 10 mA d) 20 mA

82. The depletion region in a p-n junction diode contains
a) impurity ions b) minority carriers
c) majority carriers d) no charged bodies

83. If the forward voltage in a diode is increased, the length of depletion layer will
a) increase b) decrease
c) remain constant d) either 'a' or 'b'

84. What is the number of junctions in a semiconductor diode?
a) One b) Two
c) Three d) Infinite

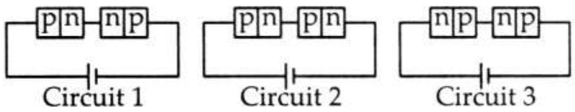
85. In the case of forward biasing of p-n junction, which one of the following figures correctly depicts the direction of flow of carriers?



86. In a p-n junction, when p-channel is connected to the +ve terminal and n-channel is connected to the –ve terminal of a battery, then the set-up is called
a) unbiased b) backward biased
c) forward biased d) negatively biased

87. Flow of current across a forward biased p-n junction is mainly due to
a) drift of charges
b) diffusion of charges
c) diffusion and drift of charges
d) all of these

88. 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 junction are equal in



a) circuit 1 only
b) circuit 1 and circuit 2
c) circuit 2 and circuit 3
d) all of these circuits

89. The potential barrier at a p-n junction is due to charges on either side of the junction. These charges are
a) fixed donor b) fixed acceptor
c) infinite donor d) both a and b

90. In a p-n junction diode, if the junction current is zero, it means that
a) the potential barrier has disappeared altogether
b) there are no carriers crossing the junction from one end to another
c) number of majority carriers and minority carriers crossing the junction are equal
d) number of majority carriers exceed the minority carriers closing the junction

91. In semiconductor diode, p side is earthed and n side is applied on potential of –2 V. The diode shall
a) not conduct b) conduct
c) partially conduct d) breakdown

92. Diode current is a function of
a) temperature b) holes
c) electrons d) none of these

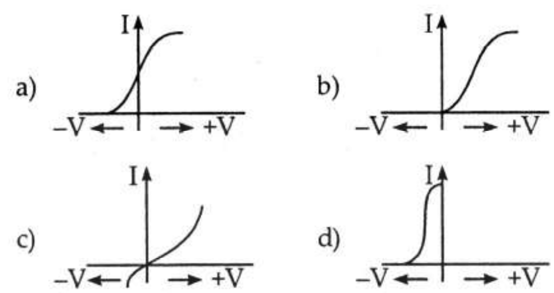
93. In a p-n junction there is no appreciable current if
a) p-section is made positive and n-section negative
b) a potential difference is applied across the junction making p-section negative and n-section positive
c) a potential difference is applied across the junction
d) it is impossible

94. When a p-n junction diode is reverse biased
a) electrons and holes are attracted towards each other and move towards the depletion region.
b) electrons and holes move away form the depletion region
c) height of the potential barrier decreases
d) no change in the current takes place

95. In the depletion region of an unbiased p-n junction diode there are
a) only holes
b) both electrons and holes
c) only fixed ions
d) none of these

96. On increasing the reverse bias to a large value in a p-n junction diode, current
a) increases, slowly b) increases suddenly
c) remains fixed d) decreases slowly

97. Applying different potential at the ends of p-n junction, current is measured for increasing potential. Which curve shows the relationship between current and potential



98. The dominant mechanisms for motion of charge carriers in forward and reverse biased silicon p-n junctions are
a) drift in forward bias and diffusion in reverse bias
b) diffusion in forward bias and drift in reverse bias
c) diffusion in both forward and reverse bias
d) drift in both forward and reverse bias

99. Avalanche breakdown is obtained in a p-n junction when there is
a) forward bias b) reverse bias
c) zero bias d) very high bias

100. If a p-n junction diode is 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 form the p-type side to the n-type side

101. The cause of the potential barrier in a p-n junction diode is

a) depletion of positive charges near the junction

b) concentration of positive charge near the junction

c) depletion of negative charges .near the junction

d) concentration of positive and negative charges near the junction

102. A semiconductor device is connected in a series circuit with a battery and a resistance. A current is found to pass through the circuit. If the polarity of the battery is reversed, the current drops to almost zero. The device may be

a) a p-n junction

b) an intrinsic semiconductor

c) a p-type semiconductor

d) a n-type semiconductor

10.5 Diode as rectifiers

103. In a half-wave rectifier the r.m.s. value of A.C. component of the wave is

a) less than zero

b) less than D.C. Value

c) equal to D.C. value

d) greater than D.C. value

104. The current obtained from a simple filterless rectifier is

a) varying direct current

b) constant direct current

c) direct current mixed with alternating current

d) eddy current

105. A rectifier is used to convert

a) high current into low current

b) low current into high current

c) D.C. current into A.C. current

d) A.c. current into D.C. current

106. When two semiconductors of p and n-type are brought into contact, they form a p-n junction which act like a

a) conductor b) oscillator

c) amplifier d) rectifier

107. The diode is also used as

a) an amplifier b) a modulator

c) a rectifier d) an oscillator

108. When output current is in one direction only, but is continuously varying in value, then it is called

a) anode current

b) direct current

c) alternating current

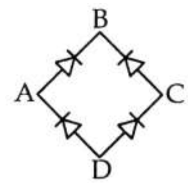
d) pulsating direct current

109. A half-wave rectifier is being used to rectify an alternating voltage of frequency 50 Hz. The number of pulses of rectified voltage obtained in one second is

a) 20 b) 30

c) 50 d) 150

110. In the diagram, the input is across the terminals A and C and the output is across B and D.



a) zero

b) same as input

c) full-wave rectified

d) half-wave rectified

111. When there is current during only one-half of the A.C. input cycle in a circuit, then it is called

a) an amplifier b) an oscillator

c) full-wave rectifier d) half-wave rectifier

10.6 Zener diode as a voltage regulator

112. Avalanche breakdown in a semiconducting diode occurs when

a) the forward current exceeds a certain value

b) forward bias exceeds a certain value

c) reverse bias exceeds a certain value

d) the depletion region is reduced to zero

113. When a zener diode is used as a voltage stabiliser, it is connected

1) in series with a load

2) in parallel with a load

3) in forward bias

4) in reverse bias

a) 1 and 3 are correct

b) 2 and 4 are correct

c) 1 and 4 are correct

d) 2 and 3 are correct

114. Zener diode is used for

a) rectification of voltage

b) stabilisation of voltage

c) amplification of current

d) producing electromagnetic oscillation

115. Zener breakdown occurs only when

a) it is lightly doped
b) the temperature is increased
c) it is forward biased
d) it is reverse biased

116. For the proper functioning of a zener diode as a voltage stabiliser it should be always
a) forward biased
b) reverse biased
c) lightly doped
d) connected in series with the load resistance

117. The value of the zener current
a) is determined by the zener voltage
b) is always in the a microampere range
c) does not depends upon the temperature
d) is limited by the external circuit resistance

118. Once a zener diode is taken in its breakdown region, there is not much change in its
a) current b) resistance
c) voltage d) capacitance

119. A general purpose diode is more likely to suffer avalanche breakdown rather than zener breakdown because
a) its leakage current is small
b) it has low reverse resistance
c) it has strong co-volent bonds
d) it is lightly doped

120. Zener diode is operated in the
a) forward region b) breakdown region
c) depletion region d) none of the above

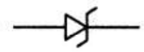
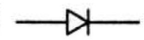
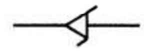
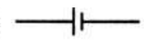
121. Zener breakdown occurs
a) mostly in intrinsic semiconductors
b) due to rupture of co-volent bonds
c) in lightly doped junctions
d) due to thermally generated majority carriers

122. Zener breakdown will occur if
a) impurity level is high
b) impurity level is low
c) impurity is less in n side
d) impurity is less in p side

123. Zener diode is used
a) as a amplifier b) as a rectifier
c) as a oscillator d) as a voltage regulator

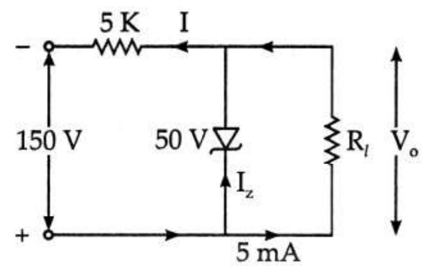
124. A p-n junction diode which has sharp breakdown voltage is
a) zener diode b) photo diode
c) varacator diode d) pin diode

125. The correct symbol for zener diode is

a)  b) 
c)  d) 

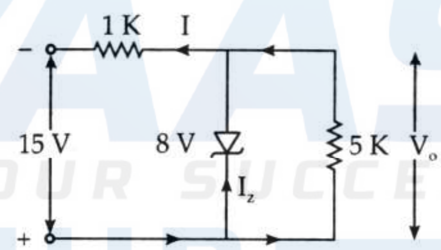
126. Avalanche breakdown is due to
a) collision of minority charge carrier
b) depletion layer thickness increase
c) DL thickness decreases
d) none of the above

127. What is the zener current in the following circuit?



a) 10 mA b) 15 mA
c) 20 mA d) 25 mA

128. What is the value of the output vol-tage V_0 in the following ze-ner circuit?



a) 7 V b) 8 V
c) 15 V d) 23 V

10.7 Photo diode

129. A pn junction diode in which current carriers are generated by
a) photos b) LED
c) solar cell d) zener diode

130. A pn junction diode in which light is allowed to fall in its junction is
a) zener diode b) LED
c) solar cell d) photo diode

131. Photodiode is always operated in
a) forward bias b) reverse bias
c) unbiased d) none of these

132. In photodiode current depends on

a) frequency b) intensity
c) doping d) pressure

133. Photo diodes are used is
a) demodulation of optical signals
b) electronic counters
c) sensors in remote controlled receivers
d) all of these

134. Which of the following device is used in optocouplers
a) zener diode b) photo diode
c) solar cell d) LED

10.8 Solar cell

and

10.9 Light Emitting Diode (LED)

135. An LED is a
a) forward biased p-n junction diode
b) reverse biased p-n junction diode
c) photodiode
d) pin diode

136. The colour of light emitted by a LED depends upon
a) its forward bias
b) its reverse bias
c) the material of the semiconductor
d) the amount of forward or reverse current

137. A solar cell converts solar energy into
a) heat energy b) chemical energy
c) electric energy d) light energy

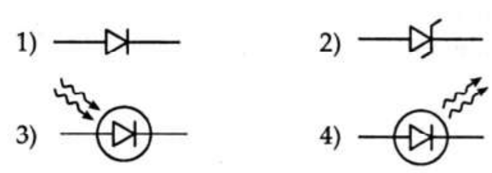
138. GaAs is used to prepare
a) a zener diode b) a light emitting diode
c) a transistor d) a hall wave rectifier

139. A solar cell works on the principle of
a) photoelectricity
b) photographic camera
c) photovoltaic conversion
d) photosynthesis

140. The most commonly used semiconducting material used to prepare a solar cell is
a) Gallium arsenide b) Indium arsenide
c) Cadmium arsenide d) Silicon

141. LEDS used for giving infrared radiations are prepared from
a) silicon dioxide
b) gallium arsenide [Ga As]
c) gallium phosphide [Ga P]
d) gallium arsenide phosphide [Ga As P]

142. A light emitting diode is shown as



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

143. A light emitting diode is
a) always used in forward biased condition
b) always used in reverse biased condition
c) never used in forward biased condition
d) used in both forward and reverse biased positions depending upon its application

144. The on/off time or switching time of light emitting diodes is of the order of
a) a micro second b) a nano second
c) a milli second d) one second

145. A solar cell is a p-n junction operating in
a) reverse bias condition
b) unbiased condition
c) forward bias condition
d) in both forward and reverse bias condition

V.I. characteristics of LED

146. Barrier potential of Ga-As-P LED is
a) 0.7 V b) 1.0 V
c) 0.3 V d) 1.5 V

147. V-I characteristics of LED is similar to forward bias characteristics of
a) zener diode b) pn junction diode
c) solar cell d) photo diode

148. Which of the following is advantage of LED?
a) low cost
b) low operating voltage
c) longer working life and instant starting
d) all of these

149. Which of the following material is used to produce infrared LED's?
a) Ga As b) Ga P
c) Ga As P d) all of these

10.10 Transistor action and its characteristics

Transistors

150. The emitter of a transistor is doped the heaviest, because it

a) receives the input
b) is supplier of charge carriers
c) dissipates minimum power
d) should have low resistance

151. A transistor is preferable to a triode valve when used in amplifier because it
i) can withstand larger changes in temperature
ii) has a higher input impedance
iii) can handle larger powers
iv) does not require a heater.
Say if only
a) (i), (ii) and (iii) are correct
b) (i) and (iii) are correct
c) (ii) and (iv) are correct
d) (iv) is correct

152. The current gain of a transistor is defined as
a) the ratio of change in collector current to the change in emitter current for a constant value of collector voltage in a common base arrangement
b) the ratio of charge in collector current to the change in base current for a constant collector voltage in a common collector arrangement
c) the ratio of change in collector current to the change in base current for constant collector voltage in a common emitter arrangement
d) the ratio of change in emitter current to the change in collector current for a constant emitter voltage in a common emitter arrangement

153. Transistors may not replace vacuum tubes in all uses because
a) transistors require longer warm-ups than vacuum tubes
b) vacuum tubes are more resistant to shock and vibration than transistors
c) vacuum tubes can handle greater power than transistors
d) transistors use high voltage

154. In n-p-n transistor, the p-type crystal acts as
a) base only b) collector only
c) emitter only d) all of these

155. A transistor is used in the common emitter mode as an amplifier. Then
a) the base-emitter junction is forward biased
b) base-collector junction is reverse biased
c) the input single is connected in series with the voltage applied to bias the base emitter junction
d) all of these

156. Which of the following element is used in making transistors ?
a) Silicon b) Cadmium
c) Tungsten d) Molybdenum

157. The arrow head on the transistor symbol always points in the direction of
a) holes flow in the emitter region
b) electrons flow in the emitter region
c) minority carrier flow in the emitter region
d) majority carrier flow in the emitter region

158. In an n-p-n transistor, the emitter current is
a) equal to the base current
b) slightly more than the collector current
c) equal to the collector current
d) slightly less than the collector current

159. In case of an n-p-n transistor, the collector current is always less than the emitter current, because
a) emitter side is forward biased
b) collector side is reverse biased
c) a few electrons are lost in the base
d) a few electrons are lost in the emitter

160. In a transistor circuit, the emitter current is 50 mA and base current is 2 mA. the collector current is
a) 25 mA b) 48 mA
c) 100 mA d) 552 mA

161. In p-n-p transistor, the p type crystal acts as
a) base only b) collector only
c) emitter only d) either 'b' or 'c'

162. npn-transistors are preferred to pnp-transistors because they have
a) low cost
b) low dissipation of energy
c) capable of handling large power
d) electrons have high mobility than holes and hence high mobility of energy

163. How is the emitter base junction in the transistor biasing?
a) Forward biased b) Reverse biased
c) First 'a' then 'b' d) First 'b' then 'a'

164. In a transistor with normal bias, the emitter junction has
a) high resistance b) low resistance
c) infinite resistance d) no resistance

165. The main current, crossing the collector junction in a normally biased n-p-n transistor, is
a) hole current b) drift current

c) base current d) diffusion current

166. Which of the following is not the disadvantage of transistor over a triode?

a) Low efficiency b) Higher efficiency

c) Higher noise level d) Higher sensitivity

167. A radio or T.V.set which uses valves does not start operating immediately when it is switched on, whereas a set containing only transistors does operate immediately because

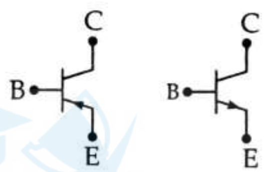
a) transistor set has a lower resistance

b) valve set operates at higher voltage

c) filaments of valves take time to heat up

d) all of these are true

168. The following represent standard symbol for transistors if



a) both represent p-n-p transistors

b) both represent n-p-n transistors

c) first is p-n-p while second is n-p-n transistor

d) first is n-p-n while second is p-n-p transistor

169. The emitter base junction is forward biased and the base collector junction is reverse biased, in order to use a transistor as

a) choke b) rectifier

c) amplifier d) transformer

170. The part of a transistor, which is heavily doped to produce a large number of majority carriers, is

a) base b) emitter

c) collector d) none of these

171. In a transistor, I_c = 20 mA, I_b = 1mA. What will be the value of a ?

a) 20/21 b) 1/20

c) 21/20 d) 20

172. In a p-n-p transistor the emitter current is 10 mA and the collector current is 9 mA. Then the base current is

a) 19 mA b) 10 mA

c) 9 mA d) 1 mA

173. In a p-n-p transistor, the n-type crystal works as a

a) gate b) base

c) collector d) emitter

174. In p-n-p transistor the base current is 1 mA and the collector current is 10 mA. The emitter current is

a) 9 mA b) 10 mA

c) 11 mA d) 12 mA

175. In n-p-n transistor the emitter current will be equal to

a) collector current

b) base current

c) sum of the collector and base current

d) difference of collector and base current

Transistor as an amplifier

176. The relationship between a andB is given by

a) $\alpha = \beta$ b) $\alpha = \frac{1}{\beta}$

c) $\beta = \frac{\alpha}{1-\alpha}$ d) $\beta = \frac{\alpha}{1+\alpha}$

177. For a transistor, working as common emitter amplifier, the current gain is 45. What will be the current gain when the same transistor is worked as common base amplifier?

a) 9.8 b) 0.98

c) 0.098 d) 0.0098

178. To use a transistor as an amplifier

a) no biasing voltages are required

b) both the junctions are forward biased

c) both the junction are reverse biased

d) the emitter base junction is forward biased and the base collector junction is reverse biased

179. The difference in the working of an amplifier and a step up transformer is

a) amplifier increases the power where as the transformer does not

b) amplifier decreases the power where as the transformer increases the power

c) amplifier keeps the power constant where as the transformer decreases the power

d) amplifier keeps the power constant where as the transformer increases the power

180. The transistor working as common base amplifier, current gain is 0.97 and base current is 0.12 mA. The collector current is

a) 5 mA b) 3.88 mA

c) 3 mA d) 0.12 mA

181. Which of the following is not a parameter defined for a transistor amplifier?

a) Current gain b) Energy gain
c) Power gain d) Resistance gain

182. In a silicon transistor a change of 7.89 mA in the emitter current produces a change of 7.8 mA in the collector current, the base current must change by
a) 0.9 μA b) 9 μA
c) 90 μA d) 900 μA

183. The value of current gain (β)
a) is always less than 1
b) is always infinity
c) is always greater than 150
d) lies between 50 and 150

184. The current gain β may be defined as, the ratio of change in collector current to the change in base current at constant collector voltage, in an arrangement of
a) common base b) common emitter
c) common collector d) none of these

185. In a transistor, the value of α is always
a) less than 1 b) equal to 1
c) greater than 1 d) unpredictable

186. For a transistor, in a common base arrangement the alternating current gain a is given by such that, V_c = constant
a) $\frac{\Delta I_c}{\Delta I_b}$ b) $\frac{\Delta I_b}{\Delta I_c}$
c) $\frac{\Delta I_c}{\Delta I_b}$ d) $\frac{\Delta I_e}{\Delta I_c}$

187. In which of the configuration of a transistor. The power gain is highest
a) common base b) common emitter
c) common collector d) same in all of three

188. When npn transistor is used as an amplifier, then
a) electrons move from base to collector
b) electrons move form emitter to base
c) electrons move from collector to base
d) holes move from base to emitter

189. In a common emitter amplifier, the input resistance is 200 Ω and load resistance is 40 kΩ. If the current gain is 80, the voltage gain of the amplifier is
a) 1.6×10^2 b) 1.6×10^3
c) 1.6×10^4 d) 1.6×10^5

190. In which of the following transistor amplifier voltage gain is the highest?
a) Common base b) Common emitter
c) Common collector d) All of these

191. In a common emitter amplifier, the input resistance is 1 kΩ and load resistance is 10 kΩ. If the current gain is 100, the voltage gain of the amplifier is
a) 1000 b) 100
c) 10000 d) 10

192. For a transistor in common emitter configuration, the current amplification factor is 4. If the change in base current be 6 mA, then the change in collector current will be
a) 2.4 mA b) 3.6 mA
c) 24 mA d) 36 mA

193. For a transistor in common emitter configuration, the current amplification factor is 4. If the transistor is connected in the common base connection and change in emitter current be 6 mA, then the collector current will be
a) 2.4 mA b) 3.6 mA
c) 4.8 mA d) 7.2 mA

194. For a common emitter configuration, the base current is 60 μA and the collector current is 6 mA. The current gain of transistor is
a) 30 b) 60
c) 100 d) 200

195. The reverse currents corresponding to reverse voltages 10 V and 20 V are 25 μA and 50 μA respectively. The reverse resistance is
a) 40 kΩ b) 40 kΩ
c) 400 kΩ d) 4 μΩ

196. In an n-p-n transistor, the base current is 100 μA and the collector current is 10 mA. The emitter current is
a) 1.01 mA b) 10.1 mA
c) 0.101 mA d) 0.0101 mA

197. The knee voltage of a p-n junction diode is 0.8 V and the width of the depletion layer is 2 μm. The electric field in the depletion layer is
a) 4 MV/m b) 0.4 MV/m
c) 4kV/m d) 0.4 kV/m

198. If the forward bias voltage of a p-n junction diode is changed form 0.7 V to 2.2 V,the forward current changes by 1.5 mA, then the forward resistance of diode will be

a) 100 Ω b) 500 Ω
c) 1000 Ω d) 5000 Ω

199. The collector supply in a common emitter amplifier is 8 V and the voltage drop across the load of 800 Ω is 0.4 V. If the current gain for common base be α = 0.96, then the base current will be
a) 15 μA b) 21 μA
c) 25 μA d) 30 μA

200. In an n-p-n transistor, the current gain for common emitter configuration is 80. If the emitter current be 8.1 mA, then the base current will be
a) 0.1 μA b) 0.01 μA
c) 0.1 mA d) 0.01 mA

201. The current gain of a transistor in common emitter configuration is 80. If the emitter current be 8.1 mA, then the collector current will be
a) 8.1 mA b) 8.0 mA
c) 0.1 mA d) 1.0 mA

202. In a transistor 108 electrons enter at the emitter in 10^{-4} s, out of which 2% electron go to the base. The current transfer ratio in common base configuration is
a) 98 b) 2
c) 0.98 d) 0.2 mA

203. In the common emitter configuration of n-p-n transistor 10^{10} electrons enter the emitter in 1 μs and 2% of the electrons are lost to the base. The current gain of the amplifier is
a) 2 b) 98
c) 1 d) 49

204. The current gain of an amplifier in the common emitter configuration is 80. The current gain in common base configuration is
a) 0.399 b) 0.609
c) 0.708 d) 0.988

205. A common emitter amplifier has current gain 70. Its load resistance is 5 kΩ and input resistance is 500 Ω. The voltage gain is
a) 500 b) 700
c) 1000 d) 1400

206. In a common base transistor circuit, the current gain is 0.98. On changing the emitter current by 5.00 mA, the change in collector current is
a) 0.196 mA b) 2.45 mA
c) 4.9 mA d) 3.1 mA

10.11 Transistor as a switch

207. When transistor is operated in cut off region or in saturation region, it works as a
a) switch b) rectifier
c) amplifier d) oscillator

208. Transistor as a switch is used for controlling high power devices in
a) motors b) rectifiers
c) cars d) buses

209. When transistor is used as switch, in saturation region of transistor both junctions are
a) forward biased b) reverse biased
c) unbiased d) none of these

210. When transistor is used as switch, in cut off region of transistor both junctions are
a) reverse biased b) forward biased
c) unbiased d) none of these

211. Transistor switches have the advantage of
a) high speed operation
b) low speed operation
c) low cost
d) low working life

10.12 Osc illators

212. Generally an oscillator is nothing but an amplifier with a
a) negative feedback
b) positive feedback
c) large gain
d) positive or negative feedback

213. i) An amplifier is necessarily an oscillator too
ii) An oscillator is necessarily an amplifier too
Then
a) only 'a' is correct
b) both 'a' and 'b' are correct
c) both 'a' and 'b' are wrong
d) only 'b' is correct

214. An electronic device which converts ac into de is called
a) amplifier b) rectifier
c) oscillator d) induction coil

215. An electronic device that generates oscillations of desired frequency is
a) oscillator b) transformer
c) voltage regulator d) rectifier

216. Which of the following is the part of oscillator?
a) Tank circuit b) Amplifier
c) Feedback circuit d) All of these

217. Tank circuit of oscillator consists of
a) L and C in parallel b) RC in series
c) L and C in series d) RC in parallel

218. The frequency of oscillations in an oscillator is
a) $f = \frac{1}{\sqrt{2\pi LC}}$ b) $f = \frac{1}{2\pi\sqrt{LC}}$
c) $f = \frac{\sqrt{LC}}{2\pi}$ d) $f = \frac{1}{R}\sqrt{\frac{L}{C}}$

219. In oscillator feedback circuit is used to minimise
a) energy losses b) eddy currents
c) resistance d) none of these

220. In transistor as an oscillator which of the following feedback is used
a) positive feedback b) negative feedback
c) both 'a' and 'b' d) neither 'a' nor 'b'

221. In an oscillator when the signal from the output circuit is applied to input of the circuit then it called
a) feedback b) ripple factor
c) form factor d) refractive index

222. If phase of feedback is in phase with input then it is called
a) positive feedback b) negative feedback
c) both 'a' and 'b' d) neither 'a' nor 'b'

223. The condition to sustained oscillation is given by
a) Barkhausen criterion of oscillation
b) Rayleigh criterion of oscillation
c) Planck's criterion of oscillation
d) Compton criterion of oscillation

224. For sustained oscillation the product of gain of amplifier (A) and feedback factor (B) is
a) equal to 1 b) less than 1
c) greater than 1 d) cannot be predicted

225. Which of the following is condition for damped oscillation?
a) $A.\beta = 1$ b) $A.\beta > 1$
c) $A.\beta < 1$ d) both 'b' and 'c'

226. Which of the following is advantage of oscillator over alternators?
a) It has a high efficiency
b) The frequency of oscillation can be easily changed
c) It has wide range i.e., from 20 Hz to 100 MHz
d) All of these

227. Oscillators are used in
a) T. V. transmitters and receivers
b) radio transmitters and receivers
c) telecommunication applications
d) all of these

228. In an oscillator circuit $L = 10^{-3}$ H, and $C = 2\ \mu F$. The frequency of oscillation is
a) 3.5 kHz b) 2.5 kHz
c) 10 kHz d) 15 kHz

229. In the circuit of transistor as an amplifier, tank circuit consists of inductance of 450 mH and capacitance of 9 μF. The.frequency of oscillation is nearly
a) 80 Hz b) 40 Hz
c) 80 kHz d) 40 kHz

230. Block diagram of oscillator consists of
a) tank circuit b) amplifier circuit
c) feed back circuit d) all of these

10.13 Logic gates

231. If A = 1, B = 0 then in terms of Boolean algebra, $A + \overline{B}$ equals
a) A b) B
c) $\overline{A}$ d) $\overline{A + B}$

232. In Boolean expression which gate is expressed as $y = \overline{A + B}$?
a) OR gate b) NAND gate
c) AND gate d) NOR gate

233. In Boolean expression, which gate is expressed as $y = \overline{A.B}$?
a) NOT gate b) AND gate
c) NAND gate d) NOR gate

234. To which logic gate does the truth table given below correspond ?

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

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

235. To which logic gate does the truth table given below correspond ?

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

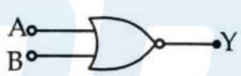
a) OR gate b) AND gate
c) NAND gate d) NOR gate

236. To which logic gated does the truth table given below correspond ?

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

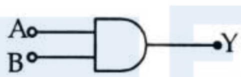
a) AND gate b) NAND gate
c) NOR gate d) XOR gate

237. Which gate is represented by the symbolic diagram given here



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

238. Which gate is represented by the symbolic diagram given here



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

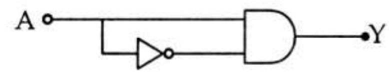
239. Digital circuit can be made by repetitive use of
a) OR gates b) NOT gates
c) AND gates d) NAND gates

240. What is the value of $A + \bar{A}$ in the Boolean algebra?
a) 0 b) 1
c) A d) $\bar{A}$

241. What is the value of $A.\bar{A}$ in Boolean algebra
a) 0 b) 1
c) A d) $\bar{A}$

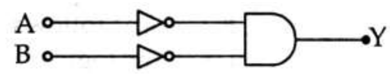
242. Which of the following is/are NOT equal to 1 in Boolean algebra
a) A + 1 b) $A + \bar{A}$
c) $A . \bar{A}$ d) none of these

243. What is the Boolean expression for the gate circuit shown in figure?



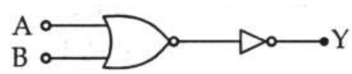
a) A.0 = 0 b) A.A = 0
c) A.1 = A d) A.A = A

244. What is the output Y of the gate circuit shown in figure?



a) $\overline{A.B}$ b) $\bar{A}.\bar{B}$
c) $\overline{\bar{A}.B}$ d) $\overline{A.\bar{B}}$

245. What is the name of the gate obtained by the combination shown in figure?

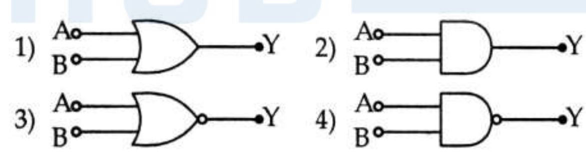


a) NAND b) OR
c) NOT d) XOR

246. What is the name of the gate obtained by the combination shown in figure?

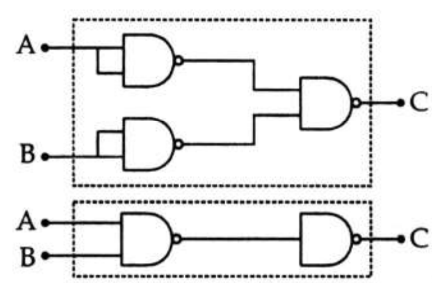
a) NAND b) NOR
c) NOT d) XOR

247. Given below are four logic gate symbol (Fig.). Those for OR, NOR and NAND are respectively



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

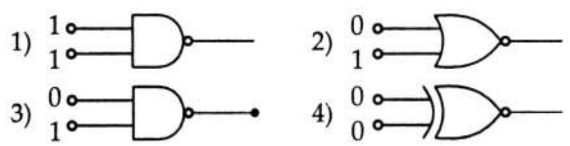
248. The combination of 'NAND' gates shown here under (Figure) are equivalent to



a) an OR gate and an AND gate respectively
b) an AND gate and a NOT gate respectively
c) an AND gate and an' OR gate respectively
d) an OR gate and a NOT gate respectively

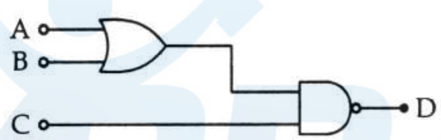
249. How many NAND gates are used to form AND gate
a) 1 b) 2
c) 3 d) 4

250. Which of the following gates will have an output of 1 ?



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

251. For the given combination of gates, if the logic states of inputs A, B, C are as follows A = B = C = 0 and A = B = 1, C = 0 then the logic states of output D are



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

252. The following truth table corresponds of the logic gate

A	0	0	1	1
B	0	1	0	1
X	0	1	1	1

a) NAND b) OR
c) AND d) XOR

253. Boolean algebra is essentially based on
a) truth b) logic
c) symbol d) numbers

254. The logic behind 'NOR' gate is that it gives
a) high output when both the inputs are low
b) low output when both inputs are low
c) high output when both the inputs are high
d) none of these

255. A logic gate is an electronic circuit which
a) makes logic decisions
b) allows electrons flow only in one direction
c) works binary algebra
d) alternates between 0 and 1 values

256. How many NAND gates are used to form an OR gate?
a) 1 b) 4
c) 2 d) 3

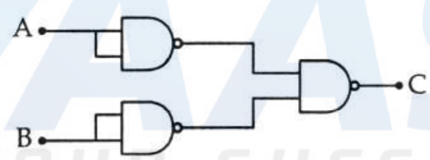
257. How many NOR gates are used to form an AND gate
a) 1 b) 2
c) 3 d) 4

258. What will be the input of A and B for the Boolean expression $(\overline{A+B}).(\overline{A.B}) = 1$
a) 0, 0 b) 0, 1
c) 1,0 d) 1, 1

259. If A and B are two inputs in AND gate, then AND gate has an output 1when the values of A and B are
a) A = 0, B = 0 b) A = 1, B = 1
c) A = 1, B = 0 d) A = 0, B = 1

260. The Boolean equation of NOR gate is
a) C = A + B b) C = A + B
c) C = A.B d) C = A.B

261. The combination of the gates shown in the figure below produces

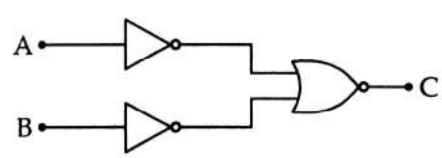


a) NOR gate b) OR gate
c) AND gate d) XOR gate

262. The output of a NAND gate is 0
a) if both inputs are 0
b) if one input is 0 and the other input is 1
c) if both inputs are 1
d) either if both inputs are 1or if one of the inputs is 1 and the other 0

263. A gate in which all the inputs must be low to get a high output is called
a) A NAND gate b) An inverter
c) A NOR gate d) An AND gate

264. Which logic gate is represented by the following combination of logic gates



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

265. The output of OR gate is 1
a) if both inputs are zero
b) if either or both inputs are 1
c) only if both input are 1
d) if either input is zero

266. Which of the following logic gate is an universal gate
a) OR b) NOT
c) AND d) NOR

267. NAND gate is the combination of
a) AND gate and NOT gate
b) AND gate and OR gate
c) OR gate and NOT gate
d) NOT gate and NOT gate

268. The truth table

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

corresponds to
a) NAND gate b) NOR gate
c) AND gate d) NOT gate

269. Which one of the following gates can be served as a building block for any digital circuit ?
a) OR b) AND
c) NOT d) NAND

270. The logic behind 'NAND' gate is that it gives
a) high output when both the inputs are low
b) low output when both the inputs are high
c) high output when both the inputs are high
d) none of these

271. An electronic circuit with one or more than one input but only one output is
a) logic gate b) canada gate
c) oscillator d) rectifier gate

272. If A and B are two inputs in OR gate, then OR gate has an output of 0 when the values of A and B are
a) $A = 0, B = 0$ b) $A = 1, B = 1$
c) $A = 1, B = 0$ d) $A = 0, B = 1$

273. The Boolean equation of OR gate is
a) $C = A + B$ b) $C = \overline{A + B}$
c) $C = A.B$ d) $C = \overline{A.B}$

274. NOR gate is a combination of
a) OR gate and NOT gate
b) OR gate and AND gate
c) OR gate and OR gate
d) none of these

275. The given truth table is for

A	X
0	1
1	0

a) OR gate b) AND gate
c) NOT gate d) none of these

276. The only function of a NOT gate is to
a) stop a signal
b) replacement of a signal
c) invert an input signal
d) act as a universal gate

277. The output of a two input ORgate is 0 only when its
a) either input is one b) bothinputs are one
c) either input is zero d) both inputs are zero

278. An AND gate
a) implements logic addition
b) is equivalent to a series switching circuit
c) is equivalent to a parallel switching circuit
d) is a universal gate

279. Digital circuits can be made by respective use of
a) AND gates b) OR gates
c) NOT gates d) NOR gates

280. To get NOT gate from NAND gate; we need
a) one NAND gate
b) two NOT gates obtained from NAND gates
c) one NAND gate and one NOT gate obtained from NAND gate
d) 3 NAND gates and one No.T gate obtained from NAND gate

Examples for practice

281. In an unbiased p-n junction diode the thickness of the depletion layer is 7×10^{-6} m and the potential barrier is 0.7 V. The electric field in this region is
a) $10^{6}\ Vm^{-1}$ b) $10^{5}\ Vm^{-1}$
c) $10^{-4}\ Vm^{-1}$ d) $10^{3}\ Vm^{-1}$

282. In silicon diode, the reverse current increases from 10 μA to 20 μA.When the reverse voltage changes from 2V to 4V. Find the reverse a.c. resistance of the diode

a) 3×10^{-5} Ω b) 2×10^{5} Ω
c) 1×10^{5} Ω d) 4×10^{5} Ω

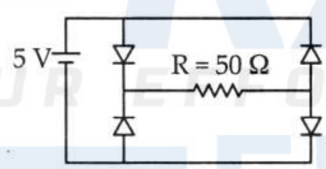
283. A p-n junction diode can with stand currents up to 10 mA under forward bias, the diode has a potential difference of 0.5V across it which is assumed to be independent of current. What is the maximum voltage of the battery used to forward bias the diode when a resistance of 200 Ω is connected in series with it ?

a) 3.5 V b) 2.5 V
c) 6.5 V d) 4.5 V

284. An a.c. voltage of peak value 20 V is connected in series with a silicon diode and a load resistance of 500 Ω. The forward resistance of the diode is 10 Ω and the barrier voltage is 0.7 V. Find the peak current through diode and the peak voltage across the load.

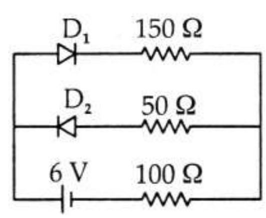
a) 37.8 mA, 18.9 V b) 5 mA, 30V
c) 30 mA, 5 V d) 2 mA,2 V

285. Four silicon diodes are connected as shown in the figure. Assuming the diodes to be ideal. The current through the resistor R is



a) 0.2 A b) 0.1 A
c) 0.3 A d) 0.5 A

286. The circuit shown in the figure contains two diodes each with a forward resistance of 50 Ω and with infinite reverse resistance. If the battery voltage is 6V, find the current through the 100 Ω resistance is



a) 0.01 A b) 0.02 A
c) 0.03 A d) 0.04 A

287. In a half wave rectifier output is taken across a 90 Ω load resistor. If the resistance of diode in forward biased condition is 10 Ω, the efficiency of rectification of a.c. power into d.c. power is

a) 40.6% b) 81.2%
c) 73.08% d) 36.54%

288. In a full wave rectifier output is taken across a load resistor of 800 Ω. If the resistance of the diode in forward biased condition is 200 Ω, the efficiency of rectification of a.c. power into d.c. power is

a) 64.96% b) 40.6%
c) 81.2% d) 80%

289. If a change of 100 μA in the base current of an n-p-n transistor causes a change of 10 mA in the collector current, what is the a.c. current gain of the transistor ?

a) 100 b) 200
c) 300 d) 400

290. For a transistor connected in common emitter mode, the voltage drop across the collector is 2.5V and p is 50. Find the base current if Rc is 2 kΩ.

a) 10 μA b) 15 μA
c) 20 μA d) 25 μA

291. In a n-p-n transistor 10^{10} electrons enter the emitter in 10^{-6} s. 2% of the electrons are lost in the base. Calculate the current transfer ratio.

a) 0.88 b) 0.98
c) 0.78 d) 0.87

292. A p-n-p transistor is used CE amplifier mode in a amplifier circuit. A change of 40 μA in the base circuit brings a change of 2 mA in collector current and 0.04V in base emitter voltage. Find (i) input resistance (R_{in}) (ii) base current amplification factor (P).

a) 1000 Ω, 50 b) 2000 Ω, 40
c) 5000 Ω, 20 d) none of these

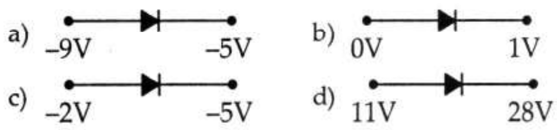
293. The current gain 'a' of a transistor is 0.95. What would be the change in collector current corresponding to a change of 0.4 mA in the base current in a common emitter arrangement?

a) 7.6 mA b) 6.6 mA
c) 5.6 mA d) 8.6 mA

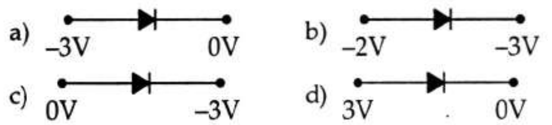
294. A transistor connected in common emitter configuration has input resistance R_{in} = 2 kΩ and load resistance of 5 kΩ. If P = 60 and an input signal 12 mV is applied, calculate the resistance gain, voltage gain and power gain.

a) 2.5, 150, 9000 b) 4.5, 150, 9000
c) 2.5, 200, 9000 d) 2.5, 150, 9500

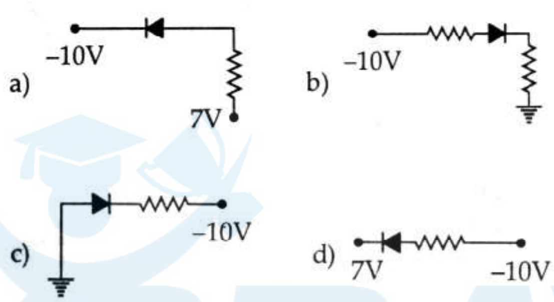
295. Which of the following diodes is forward biased?



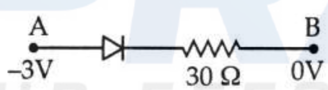
296. Which of the following diodes is reverse biased?



297. In which of the following figure the junction diode is reverse biased ?

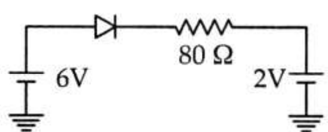


298. In the figure shown current passing through the diode is



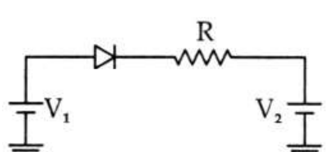
a) 0.1 A b) 0.02 A
c) zero d) 0.01 A

299. The resistance of the diode in the forward biased condition is 20 Ω and infinity in the reverse biased condition. The current in the circuit is



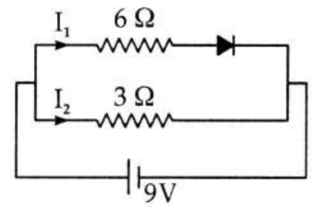
a) 0.08 A b) 0.1 A
c) 0.04 A d) zero

300. Find the current through the diode if $V_1 > V_2$, R is resistance offered by diode in forward bias



a) 0 b) $\frac{V_1 + V_2}{R + r}$
c) $\frac{V_1 - V_2}{R + r}$ d) none of these

301. If an ideal diode is used in the given circuit, find the current through each resistance.



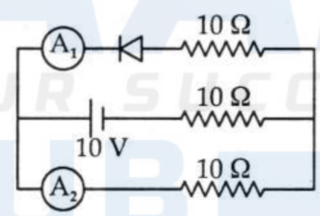
a) $I_1 = \frac{9}{6}$ A; $I_2 = 3$ A

b) $I_1 = 3$A ; $I_2 = \frac{3}{2}$ A

c) $I_1 = \frac{2}{3}$ A; $I_2 = \frac{1}{3}$ A

d) $I_1 = \frac{1}{3}$ A; $I_2 = \frac{2}{3}$ A

302. In the figure shown the readings of the ammeters A_1 and A_2 are respectively.



a) $\frac{1}{3}$ A and $\frac{1}{3}$ A
b) zero and 1 A
c) zero and 0.5 A
d) 0.5 A and zero

303. In an NPN transistor circuit the collector current is 10 mA. If only 90% of emitted electrons reach the collector, then
a) $I_B = -1$ mA b) $I_C = 1$mA
c) $I_E = 11$ mA d) $I_E = 9$mA

304. In a p-n-p transistor circuit, the collector current is 10 mA. If 95% of the electrons emitted reach the collector, what is base current?
a) 0.35 mA b) 0.25 mA
c) 0.4 mA d) 0.53 mA

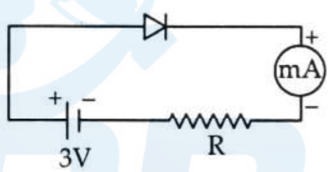
305. In a p-n-p transistor in CB circuit, the emitter current changes from 0.6 mA to 0.4 rrtA, when the base emitter voltage is changed from 0.68 V to 0.64 V. The input resistance of the transistor is

a) 100 Ω b) 200 Ω
c) 300 Ω d) 400 Ω

306. The input resistance of a transistor is 665 Ω. Its base current is changed by 15 uA which causes a change of 2 mA in collector current. If this amplifier is used as a CE amplifier with a load resistance of 5 kΩ, what is the voltage gain of the transistor ?

a) 1002 b) 1004
c) 1006 d) 1008

307. A silicon diode is forward biased, as shown in figure by connecting it to a battery of 3 V, 100 mA. If knee voltage of 0.7 V and current of 20 mA is passing through the diode, then value of resistance is



a) 110 Ω b) 110 Ω
c) 105 Ω d) 115 Ω

308. In a p-n-p transistor operating as amplifier with common emitter configurations a change in base current from 100 uA to 200 uA produces a change in collector current from 10 mA to 18 mA. Calculate the current grain of transistor

a) 12.5×10^{-3} b) 25×10^{-3}
c) 80 d) 98

309. A p-n-p transistor is used as a common base amplifier as V_{eb} = 3V. When its emitter current changes from 13.55 mA to 20.15 mA its collector current changes from 13.4 mA to 19.9 mA. Its current gain will be

a) 9.849 b) 0.8489
c) 98.49 d) 0.9849

Questions given in MHT-CET

310. The major constituent of transistor are

a) salts b) transistor
c) conductors d) semiconductors

311. If the current gain is 100, then the emitter current in a transistor for a base current of 5 mA, is

a) 0.505 A b) 1.505 A
c) 2.505 A d) 3.505 A

312. Rectification is the process for the conversion of

a) a.c. into d.c.
b) d.c. into a.c.
c) low a.c. into high a.c.
d) low d.c. into high d.c.

313. A semiconductor is damaged by a strong current, because

a) excess of electrons
b) decrease in electrons
c) lack of free electrons
d) none of these

314. In the working of n-p-n transistor, the number of free electrons which recombine with holes in the base layer is about

a) 97 % of the number injected into the base
b) 50 % of the number injected into the base
c) 3 % of the number injected into the base
d) 25 % of the number injected into the base

315. The carriers in base region of a p-n-p transistor are

a) minority carriers b) majority carriers
c) both 'a' and 'b' d) electrons

316. What is the process of introduction of impurity in semiconductor?

a) Drooping b) Doubling
c) Doping d) Duping

317. In a p-n junction, numbers of junction are

a) 1 b) 0
c) 2 d) 4

318. Bond in nand p-type semiconductor is

a) covalent b) ionic
c) metallic bond d) co-ordinate bond

319. In common emitter amplifier, the emitter base junction is

a) forward bias b) reverse bias
c) insulator d) none of these

320. p-type semiconductor and n-type semiconductor are formed by

a) metallic ions b) molecular solids
c) covalent solids d) ionic solids

321. Frequency of given ac signal is 50 Hz. When it connected to half wave rectifier, numbers of output pulses given by rectifier within one second are

a) 50 b) 25

c) 100 d) 150

322. What is amount of doping in transistor?
a) Emitter is moderately doped, collector is heavily doped and base is lightly doped
b) Emitter is moderately doped, collector is lightly doped and base is heavily doped
c) Emitter is heavily doped, collector is lightly doped and base is moderately doped
d) Emitter is heavily doped, collector is moderately doped and base is lightly doped

323. To obtain n-type semiconductor, the impurity introduced is
a) Arsenic b) Aluminium
c) Silicon d) Indium

324. Emitter base and collector base junction in n-p-n transistor are
a) forward biased and reverse biased respectively
b) reverse biased and forward biased respectively
c) both forward biased
d) both reverse biased

325. Rectifier is used to
a) convert de to ac
b) amplify a weak signal
c) convert ac to de
d) generate intermittent voltage

326. How many electrodes there in a transistor?
a) 2 b) 3
c) 4 d) 5

327. Increase in temperature of a semiconductor, will be
a) increase the conductivity
b) decrease the conductivity
c) not effect the conductivity
d) reduce the conductivity to zero

328. Which of the following is used as acceptor type impurity?
a) antimony b) arsenic
c) boron d) phosphorus

329. In p-n-p transistor, what can the n terminal act as?
a) collector only
b) emitter only
c) base only
d) either collector or emitter

330. A pure semiconductor is known as
a) extrinsic semiconductor
b) intrinsic semiconductor
c) p - type semiconductor
d) n - type semiconductor

331. In a semiconductor, acceptor impurity is
a) antimony b) indium
c) phosphorous d) arsenic

332. Avalanche breakdown in a Zener diode takes place due to
a) thermal energy
b) light energy
c) magnetic field
d) accelerated minority charge carriers

333. The energy band gap (difference between conduction band and valence band) in semiconductors is
a) 0 eV b) 1 eV
c) 5 eV d) none of these

334. LED is a pn junction diode which is
a) forward biased
b) either forward biased or reverse biased
c) reverse biased
d) neither forward baised nor reverse biased

335. Which of the following is not necessary for oscillator?
a) external input source
b) amplifier
c) feed back circuit
d) tank circuit

336. In reverse bias pn-junction diode depletion layer width
a) decreases b) increases
c) remains constant d) can not be predicted

337. In an insulator
a) the valence band is partially filled with electrons
b) conduction band is partially filled with electrons
c) conduction band is empty and the valence band is filled with electrons
d) conduction band is filled with electrons and valence band empty

338. If the output of two NAND gates is given to input of NAND gate. Then the truth table will be of
a) NOR gate b) OR gate
c) AND gate d) XOR gate

339. In a n-type semiconductor, which of the following statement is true
a) electrons are minority carriers and pentavalent atoms are dopants

b) holes are minority carriers and pentavalent atoms are dopants

c) holes are majority carriers and trivalent atoms are dopants

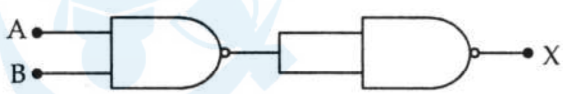
d) electrons are majority carriers and trivalent atoms are dopants

340. In a common emitter (CE) amplifier having a voltage gain G, the transistor used has transconductance 0.03 mho and current gain 25. If the above transistor is replaced with another one with transconductance 0.02 mho and current gain 20, the voltage gain will be

a) 1.5 G b) $\frac{1}{3}$ G

c) $\frac{5}{4}$ G d) $\frac{2}{3}$ G

341. The output (X) f the logic circuit shown in figure will be



a) $X = \overline{A \cdot B}$ b) $X = A \cdot B$

c) $X = \overline{A + B}$ d) $X = \bar{\bar{A}}.\bar{\bar{B}}$

342. In insulators (C.B. is conduction band and V.B. is valence band)

a) V.B. is partially filled with electrons

b) C.B. is partially filled with electrons

c) C.B. is empty and V.B. is filled with electrons

d) C.B. is filled with electrons and V.B. is empty

343. In common base circuit of a transistor, current amplification factor is 0.95. Calculate the emitter current if base current is 0.2 mA

a) 2 mA b) 4 mA

c) 6 mA d) 8 mA

344. Which logic gate produces 'LOW' output when any of the inputs is 'HIGH' ?

a) AND b) OR

c) NAND d) NOR

345. For a transistor, the current $\alpha_{dc} = \frac{69}{70}$. The current gain β_{dc} is

a) 66 b) 67

c) 69 d) 71

❍❍❍

Answers

1. (c)	2. (c)	3. (b)	4. (a)	5. (b)	6. (b)	7. (d)	8. (d)	9. (c)	10. (c)
11. (b)	12. (c)	13. (d)	14. (c)	15. (a)	16. (c)	17. (b)	18. (a)	19. (b)	20. (b)
21. (c)	22. (c)	23. (b)	24. (d)	25. (a)	26. (c)	27. (b)	28. (b)	29. (a)	30. (c)
31. (c)	32. (a)	33. (c)	34. (d)	35. (b)	36. (c)	37. (d)	38. (b)	39. (c)	40. (a)
41. (c)	42. (d)	43. (a)	44. (d)	45. (d)	46. (b)	47. (b)	48. (a)	49. (d)	50. (c)
51. (d)	52. (d)	53. (c)	54. (c)	55. (c)	56. (a)	57. (c)	58. (a)	59. (d)	60. (c)
61. (a)	62. (c)	63. (b)	64. (b)	65. (b)	66. (c)	67. (a)	68. (c)	69. (d)	70. (d)
71. (b)	72. (a)	73. (b)	74. (a)	75. (c)	76. (a)	77. (d)	78. (b)	79. (b)	80. (c)
81. (c)	82. (d)	83. (b)	84. (a)	85. (d)	86. (c)	87. (b)	88. (c)	89. (d)	90. (c)
91. (b)	92. (a)	93. (b)	94. (b)	95. (b)	96. (b)	97. (c)	98. (b)	99. (b)	100. (c)
101. (d)	102. (a)	103. (d)	104. (c)	105. (d)	106. (d)	107. (c)	108. (d)	109. (c)	110. (c)
111. (d)	112. (c)	113. (b)	114. (b)	115. (d)	116. (b)	117. (d)	118. (c)	119. (d)	120. (b)
121. (b)	122. (b)	123. (d)	124. (a)	125. (a)	126. (a)	127. (b)	128. (b)	129. (a)	130. (d)
131. (b)	132. (b)	133. (d)	134. (b)	135. (a)	136. (c)	137. (c)	138. (b)	139. (c)	140. (d)
141. (b)	142. (b)	143. (a)	144. (b)	145. (b)	146. (d)	147. (b)	148. (d)	149. (a)	150. (b)
151. (d)	152. (a)	153. (c)	154. (a)	155. (d)	156. (a)	157. (a)	158. (b)	159. (c)	160. (b)
161. (d)	162. (d)	163. (a)	164. (b)	165. (b)	166. (a)	167. (c)	168. (c)	169. (c)	170. (b)
171. (a)	172. (d)	173. (b)	174. (c)	175. (c)	176. (c)	177. (b)	178. (d)	179. (a)	180. (a)
181. (b)	182. (c)	183. (c)	184. (b)	185. (a)	186. (c)	187. (b)	188. (b)	189. (c)	190. (c)
191. (a)	192. (c)	193. (c)	194. (c)	195. (c)	196. (b)	197. (b)	198. (c)	199. (b)	200. (c)
201. (b)	202. (c)	203. (d)	204. (d)	205. (b)	206. (c)	207. (a)	208. (a)	209. (a)	210. (a)
211. (a)	212. (b)	213. (d)	214. (b)	215. (a)	216. (d)	217. (a)	218. (b)	219. (a)	220. (a)
221. (a)	222. (a)	223. (a)	224. (a)	225. (d)	226. (d)	227. (d)	228. (a)	229. (a)	230. (d)
231. (a)	232. (d)	233. (c)	234. (b)	235. (c)	236. (d)	237. (d)	238. (a)	239. (d)	240. (b)
241. (a)	242. (c)	243. (b)	244. (b)	245. (b)	246. (a)	247. (c)	248. (a)	249. (b)	250. (c)
251. (d)	252. (b)	253. (b)	254. (a)	255. (a)	256. (d)	257. (c)	258. (a)	259. (b)	260. (b)
261. (b)	262. (c)	263. (c)	264. (c)	265. (b)	266. (d)	267. (a)	268. (b)	269. (d)	270. (b)
271. (a)	272. (a)	273. (a)	274. (a)	275. (c)	276. (c)	277. (d)	278. (b)	279. (d)	280. (a)
281. (b)	282. (b)	283. (b)	284. (a)	285. (b)	286. (b)	287. (d)	288. (a)	289. (a)	290. (d)
291. (b)	292. (a)	293. (a)	294. (a)	295. (c)	296. (a)	297. (b)	298. (c)	299. (c)	300. (c)
301. (a)	302. (c)	303. (c)	304. (d)	305. (b)	306. (a)	307. (d)	308. (c)	309. (d)	310. (d)
311. (a)	312. (a)	313. (a)	314. (c)	315. (d)	316. (c)	317. (a)	318. (a)	319. (a)	320. (c)
321. (a)	322. (d)	323. (a)	324. (a)	325. (c)	326. (b)	327. (a)	328. (c)	329. (c)	330. (b)
331. (b)	332. (d)	333. (a)	334. (a)	335. (a)	336. (b)	337. (c)	338. (b)	339. (b)	340. (d)
341. (b)	342. (c)	343. (b)	344. (d)	345. (c)					

Hint / Solutions

81. $I = \dfrac{V}{R} = \dfrac{1}{100} = 10\text{ mA}$

160. $I_c = I_e - I_b = 50 - 2 = 48\text{ mA}$

171. $\alpha = \dfrac{I_c}{I_e} = \dfrac{I_c}{I_e + I_b} = \dfrac{20}{20+1} = \dfrac{20}{21}$

172. $I_b = I_e - I_c = 10 - 9 = 1\text{ mA}$

174. $I_e = I_c + I_b = 10 + 1 = 11\text{ mA}$

177. $\alpha = \dfrac{\beta}{\beta+1} = \dfrac{45}{45+1} = \dfrac{45}{46} = 0.98$

180. $\alpha = \dfrac{I_c}{I_e} = \dfrac{I_c}{I_c + I_b}$

$\therefore\ I_c = \alpha\,(I_c + I_b)$

$\therefore\ I_c = \dfrac{I_b}{1-\alpha} = \dfrac{0.12}{1-0.97}$

$= 3.88\text{ mA}$

182. $I_b = I_e - I_c$

$= 7.89 - 7.8$

$= 0.09\text{ mA}$

$= 90\ \mu\text{A}$

189. $A_v = \beta\,\dfrac{R_o}{R_i} = \dfrac{80 \times 40 \times 10^3}{200}$

$= 1.6 \times 10^4$

191. $A_v = \beta\,\dfrac{R_o}{R_i} = \dfrac{100 \times 10 \times 10^3}{1 \times 10^3}$

$= 1000$

281. $E = \dfrac{V}{d} = \dfrac{0.7}{7 \times 10^{-6}} = 1 \times 10^5\text{ V/m}$

282. $r_r = \dfrac{\delta V}{\delta I} = \dfrac{2}{10 \times 10^{-6}} = 0.2 \times 10^6\ \Omega.$

283. $I = \dfrac{V_c - V_b}{R}$

$V_e - V_b = I \cdot R$

$V_c = IR + V_b$

$= 10 \times 10^{-3} \times 200 + 0.5 = 2.5\text{ V}.$

284. $I_0 = \dfrac{e_0 - V_b}{R + r_f} = \dfrac{20-0.7}{500+10} = 37.8\text{ mA}$

Now, $V_0 = I_0 \cdot R_l$

$= 37.8 \times 10^{-3} \times 500$

$= 18.9\text{ V}.$

285. $I = \dfrac{V}{R} = \dfrac{5}{50} = 0.1\text{ A}.$

286. $I = \dfrac{V}{R + r_f} = \dfrac{6}{250+50} = 0.02\text{ A}.$

287. $\eta = 0.406 \times \dfrac{R_l}{R_l + r_f} = \dfrac{0.406 \times 90}{90+10}$

$= 36.54\%.$

288. $\eta = 0.812 \times \dfrac{R_l}{R_l + r_f} = \dfrac{0.812 \times 800}{800+200}$

$= 64.96\%.$

289. $\beta = \dfrac{I_c}{I_b} = \dfrac{10 \times 10^{-3}}{100 \times 10^{-6}} = 100$

290. $I_c = \dfrac{V_c}{R_l} = \dfrac{2.5}{2 \times 10^3}$

$I_c = 1.25\text{ A}$

$\beta = \dfrac{I_c}{I_b}$

$\therefore\ I_b = \dfrac{I_c}{\beta} = \dfrac{1.25}{50} = 25\ \mu\text{A}.$

291. $I_c = 98\%\text{ of } I_e$

$\therefore\ \propto = \dfrac{I_c}{I_e} = 98\% = 0.98.$

292. $R_i = \dfrac{V_{be}}{I_b}$

$= \dfrac{0.04}{40 \times 10^{-6}} = 1000\ \Omega$

$\beta = \dfrac{I_c}{I_b} = \dfrac{2 \times 10^{-3}}{40 \times 10^{-6}} = 50$

293. $\propto = \dfrac{I_c}{I_e}$

$\propto = \dfrac{I_c}{I_c + I_b}$

$\propto I_c + \propto I_b = I_c$

$I_c = \left(\dfrac{\propto}{1-\propto}\right) I_b$

$= \dfrac{0.95 \times 0.4}{1-0.95} = 7.6\text{ mA}.$

294. $A_r = \dfrac{R_0}{R_i}$

$= \dfrac{5}{2} = 2.5$

$A_v = \beta \cdot \dfrac{R_0}{R_i} = 60 \times 2.5$

$= 150$

$A_p = A_v \times \beta = 150 \times 60$

$= 9000.$

339. Holes are minority carriers and pentavalent atoms are depands.

340. $\Delta_v = \beta \dfrac{R_{out}}{R_{in}} \Rightarrow G = 25 \dfrac{R_{out}}{R_1}$ ..... (i)

$g_m = \dfrac{\beta}{R_1}$

$\Rightarrow R_1 = \dfrac{\beta}{g_m} = \dfrac{25}{0.03}$

$G = 25 \dfrac{R_{out}}{25} \times 0.03$ .... (ii)

$G' = 20 \dfrac{R_{out}}{20} \times 0.02$ .... (iii)

$G' = \dfrac{2}{3} G$

341.

342. From the classification of solid substances on the basis of band theory. For balanced wheatstone's network.

343. Given, $\propto = 0.95$, $I_e = ?$, $I_b = 0.2$ mA

$\propto = \dfrac{I_c}{I_e} = \dfrac{I_e - I_b}{I_e}$

$\propto I_e = I_e - I_b$

$I_b = I_e - \propto I_e$

$I_b = I_e(1 - \propto)$

$I_e = \dfrac{I_b}{1 - \propto}$

$= \dfrac{0.2}{1 - 0.95} = \dfrac{0.2}{0.05} = 4$ mA.

345. $\beta = \dfrac{\propto}{1 - \propto} = \dfrac{\frac{69}{70}}{1 - \frac{69}{70}} = \dfrac{\frac{69}{70}}{\frac{1}{70}}$

$\beta = 69.$