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<td>Q.1</td>
<td>Define the term 'Mobility' of charge carriers in a conductor. Write its S.I. unit.</td>
<td>Ans.1 Mobility is defined as “magnitude of the drift velocity of charge carrier per unit Electric field”. $\mu = \frac{</td>
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<td>Q.2</td>
<td>The carrier wave is given by $C(t) = 2\sin(\beta \pi t)$ volt. The modulating signal is a square wave as shown. Find modulation index.</td>
<td>Ans.2 The generalised equation of a carrier wave is given below: $c(t) = A_c \sin \omega_c t$ The generalised equation of a modulating wave is given below: $c_m(t) = A_c \sin \omega_c t + \mu A_c \sin \omega_m t \sin \omega_c t$ On comparing this with the equations of carrier wave and modulating wave, we get: Amplitude of modulating signal $A_m = 1\ V$ Amplitude of carrier wave $A_c = 2\ V$ $\therefore \mu = \frac{A_m}{A_c} = \frac{1}{2} = 0.5$</td>
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<td>Q.3</td>
<td>&quot;For any charge configuration, equipotential surface through a point is normal to the electric field.” Justify.</td>
<td>Ans.3 We know that the work done ($W$) in moving a test charge along an equipotential surface is zero. $W = Fs \cos \theta = 0$ Where, $F$ is the electric force and $s$ is the magnitude of displacement of the charge. For nonzero displacement, this is possible only when $\cos \theta$ is equal to 0 i.e. $\cos \theta = 0, \theta = 90^\circ$ Thus, the force acting on the point charge is perpendicular to the equipotential surface. Hence, For any charge configuration, equipotential surface through a point is normal to the electric field.</td>
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<td>Q.4</td>
<td>Two spherical bobs, one metallic and the other of glass, of the same size are allowed to fall freely from the same height above the ground. Which of the two would reach earlier and why?</td>
<td>Ans.4 In glass there is no effect of electromagnetic induction due to the presence of earth’s magnetic field, unlike the case of metallic ball. A glass bob is non-conducting, while a metallic bob is conducting. It will only experience the earth’s gravitational force. So, the glass bob will reach the ground earlier.</td>
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<td>Q.5</td>
<td>Show the variation of resistivity of copper as a function of temperature in a graph.</td>
<td>Ans.5 The variation of resistivity of copper as a function of temperature is shown in figure. It has “parabolic nature”.</td>
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</table>
Q.6 A convex lens is placed in contact with a plane mirror. A point object at a distance of 20 cm on the axis of this combination has its image coinciding with itself. What is the focal length of the lens?

Ans.6 A convex lens is placed in contact with a plane mirror. It means the point of object is placed at the centre of the curvature of the lens.

\[ f = \frac{R}{2} \]  where \( R \) is the distance between the centre of the curvature and \( f \) is the focal length.

\[ R = 20 \text{ cm} \]  \( . \) Focal length of the lens = \( \frac{20}{2} = 10 \text{ cm} \)

Q.7 Write the expression, in a vector form, for the Lorentz magnetic force \( F \) due to a Charge moving with velocity \( V \) in a magnetic field \( B \). What is the direction of the Magnetic force ?

Ans.7 The Lorentz magnetic force is given by:

\[ \vec{F} = q(\vec{V} \times \vec{B}) \]

The direction of the magnetic force is perpendicular to the plane containing the velocity vector and magnetic field vector.

Q.8 The figure given below shows the block diagram of a generalized communication System. Identify the element labeled 'X' and write its function.

Ans.8 Here X is “Channel”. It connects the transmitter to the receiver.

Q.9 Out of the two magnetic materials, ‘A’ has relative permeability slightly greater than unity while ‘B’ has less than unity. Identify the nature of the materials ‘A’ and ‘B’. Will their susceptibilities be positive or negative?

Ans.9 For A, \( \mu_r > 1 \)

For B, \( \mu_r < 1 \)

For a paramagnetic material, the relative permeability lies between

\[ 1 < \mu_r < 1 + \varepsilon \]  and its susceptibility lies between \( 0 < \chi < \varepsilon \)

For a diamagnetic material, the relative permeability lies between \( 0 \leq \mu_r < 1 \) and its susceptibility lies between \( -1 < \chi < 0 \)

Here, \( \mu_r \) and \( \chi \) refer to the relative permeability and susceptibility.

Hence, ‘A’ is a paramagnetic material and its susceptibility is positive and ‘B’ is a diamagnetic material and its susceptibility is negative.

Q.10 Given a uniform electric field \( \vec{E} = 5 \times 10^3 \hat{i} \text{ N/C} \), find the flux of this field through a Square of 10 cm on a side whose plane is parallel to the y-z plane. What would be the Flux through the same square if the plane makes a 30° angle with the x-axis?

Ans.10 Electric flux, \( \phi = \vec{E} \cdot \vec{A} = EA \cos \theta \)

\[ \vec{E} = 5 \times 10^3 \hat{i} \text{ N/C} \]

\[ \vec{A} = (10 \text{ cm})^2 \hat{i} = 10^{-2} \hat{i} \text{ m}^2 \]

\[ \phi = \left( 5 \times 10^3 \hat{i} \right) \cdot \left( 10^{-2} \hat{i} \right) \]

\[ \Rightarrow \phi = 50 \text{ Weber} \]

Q.11 For a single slit of width “a”, the first minimum of the interference pattern of a Monochromatic light of wavelength \( \lambda \) occurs at an angle of \( \lambda/a \). At the same angle of \( \lambda/a \) we get a maximum for two narrow slits separated by a distance “a”. Explain.

Ans.11 Condition for first minimum in single slit diffraction is \( \theta \approx 1/a \), so in first case we get minima. Whereas in case of two narrow slits separated by distance a, first maximum Occurs at angle \( \theta \approx 1/a \), so in second case we get a minima.

Q.12 Write the truth table for the combination of the gates shown. Name the gates used.

Ans.12 Gate: R – OR Gate

S – AND Gate
Identify the logic gates marked 'P' and 'Q' in the given circuit. Write the truth table for the combination.

Q.13 State Kirchhoff’s rules. Explain briefly how these rules are justified.

Ans.13 Kirchhoff’s First Law – Junction Rule
In an electrical circuit, the algebraic sum of the currents meeting at a junction is always zero i.e. \( \Sigma i = 0 \)

Justification: Conservation of charge

Kirchhoff’s Second Law – Loop rule: The Algebraic sum of changes in the potential around any closed loop involving resistors and cells in the loop is zero. i.e. \( \Sigma \Delta V = 0 \), where \( \Delta V \) is the changes in potential.

Justification: Conservation of energy
Q.14 A capacitor 'C', a variable resistor 'R' and a bulb 'B' are connected in series to the ac Mains in circuit as shown. The bulb glows with some brightness. How will the glow of the bulb change if (i) a dielectric slab is introduced between the plates of the capacitor, Keeping resistance R to be the same; (ii) the resistance R is increased keeping the same capacitance?  

**Ans.14** (i) If the dielectric slab is introduced between the plates of the capacitor, its capacitance will increase. Hence the potential drop across the capacitor will decrease. As a result, the potential drop across the bulb will increase. **Therefore the bulb will glow brighter.**  
(ii) As the resistance (R) is increased, the potential drop across the resistor will increase. As a result, The glow of the bulb will decrease.

Q.15 State the underlying principle of a cyclotron. Write briefly how this machine is used to accelerate charged particles to high energies.  

**Ans.15** The underlying principle of a cyclotron states that an oscillating electric field can be used to accelerate a charge particle to high energy. A normal Magnetic field acts on the charged particle and makes them move in a circular path. While moving from one D to another; particle is acted upon by the alternating electric field, and is accelerated by this field, which increases the energy of the particle.

Q.16 An electric dipole of length 4 cm, when placed with its axis making an angle of 60° with a uniform electric field, experiences a torque $4\sqrt{3}$ Nm. Calculate the potential energy of the dipole, if it has charge ±8 nC.  

**Ans.16** As we know that  
\[
\tau = pE\sin\theta \\
4\sqrt{3} - pE\sin60^\circ = pE \frac{\sqrt{3}}{2} \\
\Rightarrow pE = -s \\
\text{Potential energy} \\
-8 \times \cos 60^\circ = -4J \\
\]

Q.17 A proton and a deuteron are accelerated through the same accelerating potential. Which one of the two has (a) greater value of de-Broglie wavelength associated with it, and (b) less momentum? Give reasons to justify your answer.  

**Ans.17** (a) According to de-Broglie wavelength is  
\[
\lambda \propto \frac{1}{\sqrt{\text{mass} \cdot \text{charge}}} \\
\text{Mass of proton}(m) \neq \text{Mass of deuteron}(2m) \text{ and charges are equal. Therefore } \lambda_p > \lambda_d \text{ for same accelerating potential.} \\
\text{(b) Momentum, } p = \frac{h}{\lambda} \\
\text{Since } \lambda_p > \lambda_d \\
\text{Therefore momentum of proton < momentum of deuteron.}
Q.18  (i) Monochromatic light of frequency $6.0 \times 10^{14}$ Hz is produced by a laser. The power emitted is $2.0 \times 10^{-3}$ W. Estimate the number of photons emitted per second on an average by the source.

(ii) Draw a plot showing the variation of photoelectric current versus the intensity of incident radiation on a given photosensitive surface.

Ans.18  (i) Energy $E=nh\nu$

\[
\text{Power} = nh\nu
\]

\[
2 \times 10^{-3} = n \times 6.6 \times 10^{-34} \times 6 \times 10^{14}
\]

$n = 5.03 \times 10^{15}$ photons/ Sec.

Q.19  A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. Upto which energy level the hydrogen atoms would be excited? Calculate the wavelengths of the first member of Lyman and first member of Balmer Series

Ans.19

\[
E_n = \frac{-13.6}{n^2} \text{ eV}
\]

Energy required to excite hydrogen atoms from ground state to the second excited state

\[
= E_{\text{final}} - E_{\text{initial}}
= -1.51 - (-13.6) = 12.09 \text{ eV}
\]

i.e. hydrogen atoms would be excited upto third energy level (i.e n=3) second excited state.

\[
= E_{\text{final}} - E_{\text{initial}}
= -1.51 - (-13.6) = 12.09 \text{ eV}
\]

\[
-1.51 \text{ eV}
\]

\[
-3.4 \text{ eV}
\]

\[
-13.6 \text{ eV}
\]

Rydberg formula for the spectrum of the hydrogen atom is given below:

\[
\frac{1}{\lambda} = R \left[ \frac{1}{n_i^2} - \frac{1}{n_f^2} \right]
\]

Where, R is the Rydberg constant ($R=1.097 \times 10^7$)

For 1st member of Lyman Series, n=1 and n=2

\[
\frac{1}{\lambda} = 1.097 \times 10^7 \left[ \frac{1}{1^2} - \frac{1}{2^2} \right]
\]

\[
\lambda = \frac{122 \text{ nm}}{}
\]

For 1st member of Balmer Series, n=2 and n=3

\[
\frac{1}{\lambda} = 1.097 \times 10^7 \left[ \frac{1}{2^2} - \frac{1}{3^2} \right]
\]

\[
\lambda = 656.3 \text{ nm}
\]

Q.20  When Sunita, a class XII student, came to know that her parents are planning to rent out the top floor of their house to a mobile company she protested. She

Ans.20 (1) Electromagnetic radiations emitted by an antenna can cause

(a) Cardiac problem
tried hard to convince her parents that this move would be a health hazard. Ultimately her parents agreed:

1. In what way can the setting up of transmission tower by a mobile company in a residential colony prove to be injurious to health?
2. By objecting to this move of her parents, what value did Sunita display?
3. Estimate the range of e.m. waves which can be transmitted by an antenna of height 20 m. (Given radius of the earth: 6400 km)

(b) Cancer
(c) Giddiness and headache
(2) By objecting to this move of her parents, what value did Sunita display towards the health and environment.
(3) Range of the transmitted antenna, \( d = \sqrt{2hR} \)

Where \( h \) is the height of antenna
And \( R \) is the radius of the earth.

\[
R = 6400 \text{ km} = 64 \times 10^5 \text{ m}
\]
\[
d = \sqrt{2 \times 20 \times 64 \times 10^5}
\]
\[
d = 16000 \text{ m}
\]

Q.21 A potentiometer wire of length 1 m has a resistance of 10 Ω. It is connected to a 6 V battery in series with a resistance of 5 Ω. Determine the emf of the primary cell which gives a balance point at 40 cm.

Ans.21 Total resistance of the circuit \( R = 10 + 5 = 15 \text{Ω} \)

\[
I = \frac{V}{R + R'}
\]
\[
= \frac{6}{10 + 5} \text{ A} = 0.4 \text{ A}
\]

Potential drop across the potentiometer wire
\( V = IR \)
\( V = 0.4 \times 10 = 4 \text{ volt} \)

Emf of the cell, \( e = \frac{V_0}{l} \)
\( l = 40 \text{ cm}, \ L = 1\text{m} = 100\text{cm} \)
\( e = \frac{4.0 \times 4}{100} = 1.6 \text{ V} \)

Q.22 (a) Draw a labelled ray diagram showing the formation of a final image by a compound microscope at least distance of distinct vision.

(b) The total magnification produced by a compound microscope is 20. The magnification produced by the eye piece is 5. The microscope is focussed on a certain object. The distance between the objective and eyepiece is observed to be 14 cm. If least distance of distinct vision is 20 cm, calculate the focal length of the objective and the eye piece.

Ans.22

\[
f_o = \text{focal length of objective,} \\
u_o = \text{object distance from objective} \\
v_i = \text{image distance from objective} \\
D = \text{distance of least distinct vision} \\
L = \text{length of the microscope}
\]
Q.23 (a) A mobile phone lies along the principal axis of a concave mirror. Show, with the help of a suitable diagram, the formation of its image. Explain why magnification is not uniform.
(b) Suppose the lower half of the concave mirror's reflecting surface is covered with an opaque material. What effect this will have on the image of the object? Explain.

Ans.23

(a) The position of the image of different parts of the phone, depends on their location with respect to the mirror, so magnification is non-uniform. From the figure BC = B'C, the images of the other parts of the phone are getting magnified in accordance with their 'object distance' from the mirror.
(b) As the laws of reflection are true for all points of the mirror, the height of the whole image will be produced. However, as the area of the reflecting surface has been reduced, the image intensity will be reduced i.e. image will be less bright.

Q.24 (a) Obtain the expression for the energy stored per unit volume in a charged parallel plate capacitor.
(b) The electric field inside a parallel plate capacitor is E. Find the amount of work done in moving a charge q over a closed rectangular loop a b c d a.

Ans.24 (a) \( \int dW = \frac{q}{C} dq \)
And \( V = \frac{q}{C} \)
So, \( dW = \frac{q}{C} dq \)
Total work done in storing the charge \( Q \) is,
\[
\int dW = \int_0^Q \frac{q}{C} dq = W = \frac{1}{2} \frac{q^2}{C} \bigg|_0^Q = \frac{Q^2}{2C}
\]
Since, \( Q = CV \)
Therefore, \( W = \frac{1}{2} CV^2 \)
(a) Derive the expression for the capacitance of a parallel plate capacitor having plate area \( A \) and plate separation \( d \).

(b) Two charged spherical conductors of radii \( R_1 \) and \( R_2 \) and when conducting wire acquire charges \( q_1 \) and \( q_2 \) respectively. Find the ratio of their surface charge densities in terms of their radii.

This work is stored as electrostatic energy in the capacitor.
So, \( U = \frac{1}{2} CV^2 \)
Energy stored per unit volume =
\[
\frac{1}{2}CV^2 = \frac{1}{2} \varepsilon_0 \left( \frac{qA}{d} \right) (Ed)^2
\]
\[
- \frac{1}{2} \varepsilon_0 E^2
\]

(b) Work done in moving the charge \( q \) from \( a \) to \( b \), and from \( c \) to \( d \) is zero because Electric field is perpendicular to the displacement.
Work done from \( b \) to \( c \) = - Workdone from \( d \) to \( a \)
\[
W = F \times d
\]
Where, \( F \) is the force exerted on the charge, \( E \) is the electric field
Net Displacement = 0
So, \( W = 0 \)

(a)

Electric field between the plates of capacitor,
\[
E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0}
\]
Potential Difference,
\[
V = Ed = \frac{Qd}{A\varepsilon_0}
\]
Capacitance,
\[
C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d}
\]
(b) The surface charge density of a spherical conductor is,
\[
\sigma = \frac{Q}{4\pi r^2}
\]
When two charged spherical conductors are connected by a conducting wire, they
Q.25  
(a) State Ampere's circuital law, expressing it in the integral form.
(b) Two long coaxial insulated solenoids, S1 and S2 of equal lengths are wound one over the other as shown in the figure. A steady current "I" flows through the inner solenoid S1 to the other end B, which is connected to the outer solenoid S2 through which the same current "I" flows in the opposite direction so as to come out at end A. If \( n_1 \) and \( n_2 \) are the number of turns per unit length, find the magnitude and direction of the net magnetic field at a point (i) inside on the axis and (ii) outside the combined system.

\[
\frac{\alpha_1}{\alpha_2} = \frac{q_1 / 4\pi R_1^2}{q_2 / 4\pi R_2^2} = \frac{q_1 R_2^2}{q_2 R_1^2} = \frac{R_1}{R_2} \times \frac{R_2^2}{R_1^2} = \frac{R_2}{R_1}
\]

Ans.25  
(a) The integral form of Ampere's circuital law is,
\[ \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 i \]
(b) \[ B = \mu_0 n I \]
   (i) Inside on the axis
   Magnitude of net magnetic field
   \[ \mathbf{B} = \mathbf{B}_1 - \mathbf{B}_2 \]
   \[ B = \mu_0 (n_1 - n_2) I \]
   (ii) Outside the combined system
   Outside the solenoid the net magnetic field is zero.

Q.26  
Answer the following:
(a) Name the electromagnetic waves which are suitable for radar systems used in aircraft navigation. Write the range of frequency of these waves.
(b) If the earth did not have atmosphere, would its average surface temperature be higher or lower than what it is now? Explain.
(c) An electromagnetic wave exerts pressure on the surface on which it is incident. Justify.

Ans.26  
(a) Microwaves are suitable for radar systems used in aircraft navigation. Frequency range: \( 10^{10} \) to \( 10^{12} \) Hz
(b) In the absence of atmosphere, there would be no greenhouse effect on the surface of the Earth. Therefore average surface temperature will be lower.
(c) Because, electromagnetic waves carry both energy and momentum, therefore, they exert pressure on the surface on which they are incident.

Q.27  
(a) Deduce the expression \[ N = N_0 e^{-\lambda t} \] for the law of radioactive decay.
(b) \( \beta^+ \) decay of \( ^{22}_{11}\text{Na} \). Also write the basic nuclear process underlying this decay.
(i) Is the nucleus formed in the decay of the nucleus \( ^{22}_{11}\text{Na} \) an isotope or isobar?

Ans.27  
(a) \[ \frac{dN}{dt} = -\lambda N \]
(a) (i) Two independent monochromatic sources of light cannot produce a sustained interference pattern. Give reason.
(ii) Light waves each of amplitude "a" and frequency "ω", emanating from two coherent light sources superpose at a point. If the displacements due to these waves is given by \(y_1 = a \cos \omega t\) and \(y_2 = a \cos (\omega t + \varphi)\) where \(\varphi\) is the phase difference between the two, obtain the expression for the resultant intensity at the point.
(b) In Young's double slit experiment, using monochromatic light of wavelength \(λ\), the intensity of light at a point on the screen where path difference is \(λ\), is \(K\) units. Find out the intensity of light at a point where path difference is \(λ/3\).

OR

(a) How does one demonstrate, using a suitable diagram, that unpolarised light when passed through a Polaroid gets polarised?
(b) A beam of unpolarised light is incident on a glass-air interface. Show, using a suitable ray diagram, that light reflected from the interface is totally polarised, when \(μ = \tan i_B\) where \(μ\) is the refractive index of glass with respect to air and \(i_B\), is the Brewster's angle.

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<td>(a) (i) Two independent monochromatic sources of light will not have a constant phase difference. So, these source will not be coherent and would not produce a sustained interference pattern.</td>
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<td>(ii) The intensity of light (at a point on the screen where path difference is (λ)) is (K) units. Find out the intensity of light at a point where path difference is (λ/3).</td>
<td>(ii) The intensity of light (at a point on the screen where path difference is (λ)) is (K) units. So, intensity of light at a point where path difference is (λ/3) is (4a^2\cos^2\frac{\varphi}{2}).</td>
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OR

(a) How does one demonstrate, using a suitable diagram, that unpolarised light when passed through a Polaroid gets polarised?
(b) A beam of unpolarised light is incident on a glass-air interface. Show, using a suitable ray diagram, that light reflected from the interface is totally polarised, when \(μ = \tan i_B\) where \(μ\) is the refractive index of glass with respect to air and \(i_B\), is the Brewster's angle.
The phenomenon of restricting the vibration of light (electric vector) in a particular direction perpendicular to the direction of wave propagation is called polarisation of light. When unpolarised light is passed through a Polaroid, only those vibrations of light pass through the crystal, crystal (AB). All other vibrations are absorbed and intensity of the emerging light is reduced.

From figure:

\[ \angle CBQ + \angle QBD = 90^\circ \]

\[ (90 - \theta_B) + (90 - \theta) = 90^\circ \]

\[ r + \theta = 90^\circ \]

We have, Snell’s law,

\[ \mu = \frac{\sin \theta_B}{\sin \theta} = \frac{\sin(90 - \theta_B)}{\sin \theta_B} = \frac{\cos \theta_B}{\tan \theta_B} \]

Q.29 (a) Describe a simple experiment (or activity) to show that the polarity of emf induced in a coil is always such that it tends to produce a current which opposes the change of magnetic flux that produces it.

Ans.29 (a) According to Lenz's law, the polarity of the induced emf is such that it opposes a change in magnetic flux responsible for its production.
(b) The current flowing through an inductor of self inductance \( L \) is continuously increasing. Plot a graph showing the variation of

(i) Magnetic flux versus the current
(ii) Induced emf versus \( \frac{dl}{dt} \)
(iii) Magnetic potential energy stored versus the current.

OR

(a) Draw a schematic sketch of an ac generator describing its basic elements. State briefly its working principle. Show a plot of variation of

(i) Magnetic flux and
(ii) Alternating emf versus time generated by a loop of wire rotating in a magnetic field.

(b) Why is choke coil needed in the use of fluorescent tubes with ac mains?

When a bar magnet is brought close to the coil (fig a), the approaching North Pole of the bar magnet increases the magnetic flux linked to it. This produces an induced emf which produces (or tends to produce, if the coil is open) an induced current in the anti-clockwise sense. The face of the coil, facing the approaching magnet, then has the same polarity as that of the approaching pole of the magnet. The induced current, therefore, is seen to oppose the change of magnetic flux that produces it.

(b) (i) Since \( \Phi = LI \) where, \( I = \) Strength of current through the coil at any time \( \Phi = \) Amount of magnetic flux linked with all turns of the coil at that time and, \( L = \) Constant of proportionality called coefficient of self induction

(ii) induced emf,

\[
e = -\frac{d\Phi}{dt} = -\frac{d}{dt}(LI)
\]

i.e., \( e = -L\frac{dl}{dt} \)

(iii) magnetic potential energy, \( U = \frac{1}{2}LI^2 \)
(a) Principle: It is based on the phenomenon of electromagnetic induction.

Construction:

Main parts of an ac generator; Armature – The rectangular coil ABCD; Filled Magnets – Two pole pieces of a strong electromagnet; Slip Rings – The ends of the coil ABCD are connected to two hollow metallic rings R1 and R2.; Brushes – B1 and B2 are two flexible metal plates or carbon rods. They are fixed and are kept in tight.

Working: It works on the process of electromagnetic induction, i.e. when a coil rotates continuously in a magnetic field, the effective area of the coil, linked (normally) with the magnetic field lines, changes continuously with time. This variation of magnetic flux with time results in the production of an (alternating) emf in the coil.

(i) Magnetic flux versus time

\[ \phi = NBA \cos \omega t \]

(ii) Alternating emf versus time

\[ e = NAB\omega \sin \omega t \]

\[ = e_0 \sin \omega t \]
Q.30 (a) State briefly the processes involved in the formation of p-n junction explaining clearly how the depletion region is formed.
(b) Using the necessary circuit diagrams, show how the V-I characteristics of a p-n junction are obtained in
(i) Forward biasing
(ii) Reverse biasing
How these characteristics are made use of in rectification?

OR

(a) Differentiate between three segments of a transistor on the basis of their size and level of doping.
(b) How is a transistor biased to be in active state?
(c) With the help of necessary circuit diagram, describe briefly how n-p-n transistor in CE configuration amplifies a small sinusoidal input voltage. Write the expression for the ac current gain.

Ans.30 (a) As we know that n-type Semiconductor has more concentration of electrons than that of a hole and p-type semiconductor has more concentration of holes than an electron. Due to the difference in concentration of charge carriers in the two regions of p-n junction, the holes diffuse from p side to n side and electrons diffuse from n side to p side. When an electron diffuses from n to p, it leaves behind it an ionised donor on n side. The ionised donor is immobile as it is bound by the surrounding atoms. Therefore, a layer of positive charge is developed on the n side of the junction. Similarly, a layer of negative charge is developed on the p side. Hence, a space charge region is formed on either side of the junction, which has immobile ions and is devoid of the charge carrier called as depletion layer or depletion region.

(i) p-n junction diode under forward bias

P-side is connected to the positive terminal and n-side to the negative terminal. The V-I characteristics of pn junction in forward bias is shown below:
(ii) p-n junction diode under reverse bias

Positive terminal of battery is connected to n-side and negative terminal to p-side. The V-I characteristics of p-n junction diode in reverse bias is shown below:

(a) Emitter: It is of moderate size and heavily doped
Base: It is very thin and lightly doped
Collector: It is moderately doped and larger in size

(b) Transistor is said to be in active state when its emitter-base junction is (suitably) forward biased and base-collector junction is (suitably) reverse biased.

(c) When a small sinusoidal voltage is superposed on the dc base bias, the base current will have sinusoidal variation superimposed on the value of $I_B$.
As a consequence, the collector current also will have sinusoidal variations, superimposed on the value of IC, producing corresponding (amplified) changes in the value of V0.
ac current gain $\beta_{ac} = \left( \frac{\Delta I_c}{\Delta I_b} \right)_{V_{CE}}$