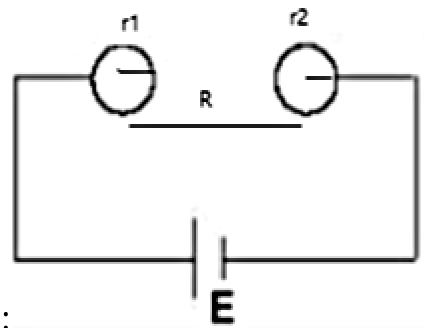
Q1. If the magnetic field of a plane electromagnetic wave is given by (The speed of light $= 3 \times 10^8$ m/s ) $B = 100 \times 10^{-6} \sin\left[2\pi \times 2 \times 10^{15}\left(t - \frac{x}{c}\right)\right]$ then the maximum electric field associated with it is:

(a). $6 \times 10^4 N/C$
(b). $3 \times 10^4 N/C$
(c). $4 \times 10^4 N/C$
(d). $4 \times 10^7 N/C$

Ans. b

Exp.: Relation between $E_0$ and $B_0 E_o = c.B_o$where,$E_o =$ Electric field amplitude$B_o =$ Magnetic field amplitudec $=$ speed of light$c = 3 \times 10^8$ m/s$B_0 = 100 \times 10^{-6}$ Tso we have$E_0 = B_0 \times c= 100 \times 10^{-6} \times 3 \times 10^8 E_0 = 3 \times 10^4 N/C$

Q2. Two metal balls with radii $r_1$ and $r_2$ are at a distance $R$ from each other and are connected to a battery of emf E. D is regarding the interaction between connecting wire,

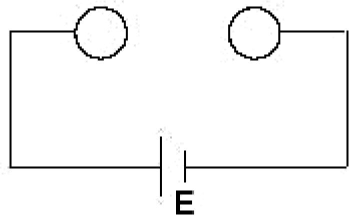



the force of interaction between the balls:

(a). $\frac{16\pi^2 \in_0^2 r_1^2 r_2^2}{R^2 (r_1+r_2)^2}$
(b). $\frac{4\pi \in_0 E r_1 r_2}{R^2 (r_1+r_2)^2}$
(c). $\frac{4\pi \in_0 E^2 r_1^2 r_2^2}{R^2 (r_1+r_2)^2}$
(d). $\frac{2\pi \in_0 E r_1 r_2}{R^2 (r_1+r_2)^2}$

Ans. c

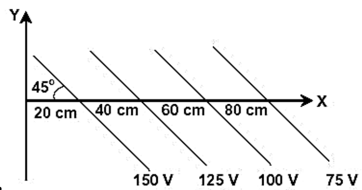
Exp.: The potential difference between the balls should be E. therefore, $\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q_1}{r_1} - \frac{1}{4\pi\epsilon_0} \cdot \frac{Q_2}{r_2} = E$ where $Q_1$ and $Q_2$ are charges on the balls. According to law




of conservation of charge $Q_1 + Q_2 = 0$So, $Q_1 = -Q_2$

$\frac{1}{4\pi\epsilon_0}\left[\frac{Q_1}{r_1} - \frac{Q_2}{r_2}\right] = E\frac{1}{4\pi\epsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_1}{r_2}\right] = E\frac{Q_1}{4\pi\epsilon_0}\left[\frac{r_1+r_2}{r_1r_2}\right] = EQ_1 = \frac{4\pi\epsilon_0 Er_1r_2}{r_1+r_2}$So, from Coulomb's law $F = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q_1Q_2}{R^2}; = \frac{1}{4\pi\epsilon_0} \cdot \frac{16\pi^2C_0^2E^2r_1^2r_2^2}{R^2(r_1+r_2)}F = \frac{4\pi\epsilon_0E^2r_1^2r_2^2}{R^2(r_1+r_2)^2}$

Q3. Some equipotential plane parallel surfaces are shown in figure. The planes are inclined to $x$ -axis by $45^\circ$ and distance from one plane to another plane along $x$ -axis is

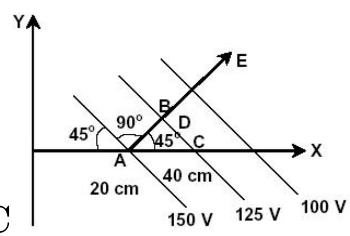



$20\ \mathrm{cm}$. The electric field is:

(a). $177\ \mathrm{V}$ at $135^\circ$ with $\mathrm{x}$ -axis
(b). $125\ \mathrm{V}$ at $45^\circ$ with $\mathrm{x}$ -axis
(c). $177\ \mathrm{V}$ at $45^\circ$ with $\mathrm{x}$ -axis
(d). $125\ \mathrm{V}$ at $135^\circ$ with $\mathrm{x}$ -axis

Ans. c

Exp.: Since electric field is perpendicular to the equipotential surface and is in direction of decreasing potential, accordingly electric field direction has been shown. It makes an



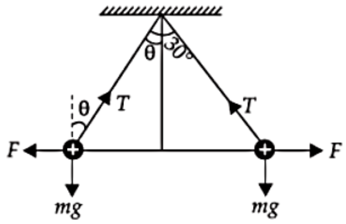

angle of $45^\circ$ with $x$ axis. From $\Delta ABC$ $\cos 45^\circ = \frac{AB}{AC}$or $\frac{1}{\sqrt{2}} = \frac{AB}{20\times10^{-2}}AB = \frac{20\times10^{-2}}{\sqrt{2}}m$;$E = \frac{-dV}{dr} = \frac{25\times\sqrt{2}}{20\times10^{-2}} = \frac{5}{4} \times \frac{1.414}{10^{-2}} = 1.25 \times 1.414 \times 10^2 = 177\mathrm{volt}$

Q4. Two identical charged spheres are suspended by strings of equal lengths. The strings make an angle of 30° with each other. When suspended in a liquid of density $0.8 gcm^{-3}$, the angle remains the same. If density of the material of the sphere is $1.6 gcm^{-3}$, the dielectric constant of the liquid is:

(a). 1
(b). 4

(c). 3
(d). 2

Ans. d

Exp.: 

Initially, the forces acting on each ball are:(i) Tension T(ii) Weight mg(iii) Electrostatic force of repulsion FFor its equilibrium along vertical,Tcosθ = mg ...(I)and along horizontal,Tsinθ = F ...(ii)Dividing equation (ii) by (i), we gettanθ = $\frac{F}{mg}$ ...(iii)When the balls are suspended in a liquid of density σ and dielectric constant K, the electrostatic force will become $\frac{1}{K}$times, i.e., F′ = $\frac{F}{K}$ while weight$mg' = mg - \text{ Upthrust } = mg - V\sigma g \quad [\text{As Upthrust } = V\sigma g] mg' = mg\left[1 - \frac{\sigma}{\rho}\right] \quad \left[\text{As } V = \frac{m}{\rho}\right]$For equilibrium of balls,$\tan\theta' = \frac{F'}{mg'} = \frac{F}{Kmg[1-(\frac{\sigma}{\rho})]}$According to given problem, $\theta' = \theta$From equations (iv) and (iii), we get $K = \frac{1}{\left(1-\frac{\sigma}{\rho}\right)} K = \frac{\rho}{(\rho-\sigma)} = \frac{1.6}{(1.6-0.8)} = 2$

Q5. The ratio of magnetic field and magnetic moment at the centre of a current carrying circular loop is X. When both the current and radius is doubled the ratio will be

(a). $\frac{X}{8}$
(b). $\frac{X}{4}$
(c). $\frac{X}{2}$
(d). $\frac{2}{X}$

Ans. a

Exp.: Given:
The ratio of the magnetic field and magnetic moment at the center of a current-carrying circular loop = X
We have to find the ratio when both the current and radius is doubled.
Magnetic field at the centre of current carrying loop is given by
$B = \frac{\mu_0 I}{2r}$....(i)
where: $I$=current
r=radius
Let M be the magnetic moment of the current carrying loop, so
$M = IA = I\left(\pi r^2\right)$.....(ii) $\quad \left[\text{ as } A = \pi r^2\right]$

Dividing eq. (i) by eq. (ii), we get $\frac{B}{M} = \frac{\mu_0 I}{2r}\left[\frac{1}{I(\pi r^2)}\right]$
$\Rightarrow X = \frac{B}{M} = \frac{\mu_0}{2\pi r^3}$
$X \alpha \frac{1}{r^3}$
Thus, the ratio is independent of current and inversely proportional to the cube of radius. When the radius is doubled i.e. $r' = 2r$, then the new ratio is
$\Rightarrow X' \alpha \frac{1}{8r^3}$
$\Rightarrow X' = \frac{X}{8}$

Q6. The commercial unit of electrical energy is kilowatt-hour (kWh), which is equal to:

(a). 3.6 × $10^6$ J
(b). 3.6 × $10^3$ J

(c). $10^3$ J
(d). 1 J

Ans. a

Exp.: One kilowatt =1000 Watt; and 1 hour =60 × 60 = 3600 second
1 kilowatt-hour (kWh) =1000 × 60 × 60 = 3.6 × $10^6$ Watt-second or joule

Q7. An electric bulb is connected to 220 V generator. The current drawn is 600 mA. What is the power of the bulb?

(a). 132 W
(b). 13.2 W
(c). 1320 W
(d). 13200 W

Ans. a

Exp.: Given data, Voltage = 220 V, Current = 600mA = 0.6APower, P = V × I = 220 × 0.6 = 132 W

Q8. Which one of the following solutions is not capable of conducting electricity?

(a). Copper sulphate
(b). Sodium chloride
(c). Sugar
(d). Sodium hydroxide

Ans. c

Exp.: When sugar is added to water, it does not produce ions to facilitate electrical conductivity, Thus we can say Sugar is not capable of conducting electricity.

Q9. A current of 0.6 A is drawn by an electric bulb for 10 minutes. Which one of the following is the amount of electric charge that flows through the circuit?

(a). 6 C
(b). 0.6 C
(c). 360 C
(d). 36 C

Ans. c

Exp.: Given data: Current, $\mathrm{i} = 0.6\ \mathrm{A}$; Time $\Delta\mathrm{t} = 10$ minutes $= 10 \times 60 = 600$ seconds
$\Rightarrow \Delta\mathrm{Q} = \mathrm{i} \times \Delta\mathrm{t}$
$\Rightarrow \Delta\mathrm{Q} = 0.6 \times 600 = 360\mathrm{C}$

Q10. Which one of the following terms cannot represent electrical power in a circuit?

(a). $VI$
(b). $\frac{I^2}{R}$
(c). $I^2R$
(d). $\frac{V^2}{R}$

Ans. b

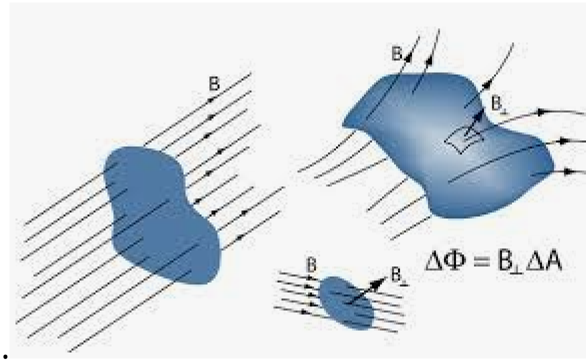
Exp.: Power is given by formula, $P = VI$...(i) and $V = IR$...(ii). Therefore, $P = I^2R$ and $P = \frac{V^2}{R}$ {from (i) and (ii)}

Q11. Gauss's law for magnetism states that, the net _______ through any closed surface is zero.

(a). magnetic susceptibility
(b). magnetic flux
(c). relative magnetic permeability
(d). magnetic intensity

Ans. b

Exp.: Gauss's law for magnetism: The net magnetic flux of the magnetic field must always be zero over any closed surface.




This means that as many field lines should seem to enter the surface as the number of lines leaving it.Net magnetic flux $(\varnothing_{\mathrm{B}})=\sum \mathrm{B} \cdot \Delta \mathrm{A}=0$Integral form: $\int B . n d s=0$Where $B$ is the magnetic field and $A$ is surface area.

Q12. The relationship between relative magnetic permeability '$\mu_r$ of a substance and its magnetic susceptibility $\chi_m$' is given by:

(a). $\mu_{\mathrm{r}}=1-\chi_m$
(b). $\mu_{\mathrm{r}}=1+\chi_m^2$

(c). $\mu_{\mathrm{r}}=1+\chi_m$
(d). $\mu_r=1-\chi_m^2$

Ans. c

Exp.: Magnetic susceptibility $\chi_m$ indicates the intensity or the degree of magnetization (I) of a material in response to the intensity of the magnetizing force $(\mathrm{H})$ of the applied magnetic field (B).It is given as: $\chi_m=\frac{I}{H}$Magnetic permeability is a property of the material that characterizes the amount of magnetizing force (H) that a material experiences under the influence of an applied magnetic field (B).It is given as: $\mu=\frac{B}{H}$ Relative permeability is the ratio of the permeability of the material $(\mu)$ to that of free space $(\mu_0)$.It is given as: $\mu_r=\frac{\mu}{\mu_0}$The net field will be a resultant of magnetization due to applied field $(B_0)$ and magnetization due to induced magnetism $(B_i)B=B_0+B_i$ Where, $B_0=\mu_0 H$ and $B_i=\mu_0 I B=\mu_0(H+I)\Rightarrow \frac{B}{H}=\mu_0\left(1+\frac{I}{H}\right)$Substituting $\mu=\frac{B}{H}$ and $\chi_m=\frac{I}{H}$ in the above equation, we get: $\mu=\mu_0\left(1+\chi_m\right)$
$\Rightarrow \frac{\mu}{\mu_0}=\left(1+\chi_m\right)\Rightarrow \mu_r=\left(1+\chi_m\right)$

Q13. A bar of diamagnetic material placed in an external magnetic field will ___________ field.

(a). pull in the field lines and move from high to low
(b). repel out the field lines and move from low to high
(c). pull in the field lines and move from low to high

(d). repel out the field lines and move from high to low

Ans. d

Exp.: A bar of diamagnetic material placed in an external magnetic field will repel out the field lines and move from high to low field.Diamagnetic Substances: The substances which are weekly magnetized when placed in an external magnetic field, in a direction opposite to the applied field are called diamagnetic substances.Example: Copper, lead, gold, silver, zinc, antimony, bismuth, etc.Properties:

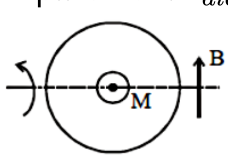
- These substances are repelled by a magnet.
- Atomic orbitals of these substances are completely filled.
- It develops weak magnetization in a direction opposite to the direction of the applied magnetic field.
- As soon as the magnetizing field removed, it loses its magnetization.
- When placed in a non-uniform magnetic field, it tends to move from stronger to weaker regions of the magnetic field.
- When placed in a uniform magnetic field, it aligns itself perpendicular to the direction of the magnetic field.
- Magnetic susceptibility is a small negative value.
- Relative permeability is close to one and always less than 1.
- Magnetic permeability is slightly less compared to free space.

Q14. A circular coil has moment of inertia $0.8\ kgm^2$ around any diameter and is carrying current to produce a magnetic moment of $20\ Am^2$. The coil is kept initially in a vertical position and it can rotate freely around a horizontal diameter. When a uniform magnetic field of $4T$ is applied along the vertical, it starts rotating around its horizontal diameter. The angular speed the coil acquires after rotating by $60^\circ$ will be:

(a). $10$
(b). $11.5$
(c). $9.8$
(d). $12$

Ans. a

Exp.: Given: $I_{dia} = 0.8kg/m^2$, $M = 20Am^2$



By energy conservation, $\Rightarrow U_i + K_f = U_i + K_f$
$-MB\cos 60^\circ + 0 = -MB\cos 0^0 + (\frac{1}{2})I\omega^2$
$(-\frac{MB}{2}) + MB = (\frac{1}{2})I^2$
$\omega = \sqrt{\frac{MB}{I}} = \sqrt{\frac{20\times4}{0.8}} = \sqrt{100} = 10rad/s$

Q15. An electron is moving with a speed of $3 \times 10^{-7}\ \mathrm{m/s}$ in a magnetic field of $6 \times 10^{-4}\ \mathrm{T}$ perpendicular to its path. What will be the radium of the path? What will be the frequency and the energy in keV?[Given: mass of electron $= 9 \times 10^{-31}\ \mathrm{kg}$, charge $\mathrm{e} = 1.6 \times 10^{-19}\mathrm{C}, 1\mathrm{eV} = 1.6 \times 10^{-19}\ \mathrm{J}$]

(a). $0.2812\ \mathrm{m}, 16.97\ \mathrm{MHz}$ and $2531\ \mathrm{keV}$

(b). $0.3812\ \mathrm{m}, 6.97\ \mathrm{MHz}$ and $2330\mathrm{keV}$

(c). $0.812\ \mathrm{m}, 6.00\ \mathrm{MHz}$ and $2130\mathrm{keV}$
(d). None of the above

Ans. a

Exp.: Given: $v = 3 \times 10^7\ \mathrm{m/s}, \mathrm{B} = 6 \times 10^{-4}\ \mathrm{T};\ \mathrm{m_e} = 9 \times 10^{-31}\ \mathrm{kg}, \mathrm{e} = 1.6 \times 10^{-19}\mathrm{C}$
$1\mathrm{eV} = 1.6 \times 10^{-19}\ \mathrm{J}$
The radius of the circular path, $r = \frac{m_e \mathrm{v}}{|e|\mathrm{B}} = \frac{(9\times10^{-31})(3\times10^7)}{(1.6\times10^{-19})(6\times10^{-4})} = \frac{2.7}{9.6} = 0.2812\ \mathrm{m}$
The frequency of revolution, $f = \frac{|e|B}{2\pi m_e} = \frac{(1.6\times10^{-19})(6\times10^{-4})}{2\times3.142\times(9\times10^{-31})}$
$= \frac{9.6}{18\times3.142} \times 10^8 = 16.97\ \mathrm{MHz}$
Since the magnetic force does not change the kinetic energy of the charge,
$\mathrm{KE} = \frac{1}{2}\ \mathrm{m_e v^2}$
$= \frac{1}{2}(9 \times 10^{-31})(3 \times 10^7)^2 = \frac{81}{2} \times 10^{-17}\ \mathrm{J} = \frac{81}{2(1.6\times10^{-19})} \times 10^{-17}\mathrm{eV} = \frac{8.1}{3.2} \times 10^3$
$= 2531\ \mathrm{keV}$

Q16. In a potentiometer, for a cell of emf $1.5\ V$, the balance point is obtained at $42.0\ cm$ length. If the cell is replaced by another cell, the balance point is obtained at $63.0\ cm$ length. Find the emf of the second cell.

(a). $2.25\ V$
(b). $1.25\ V$
(c). $5.75\ V$
(d). $7.65\ V$

Ans. a

Exp.: Given,Emf of the cell, $E_1 = 1.5V$Balance point of the potentiometer, $l_1 = 42\ cm$ The cell is replaced by another cell of emf $E_2$.New balance point of the potentiometer, $l_2 = 63\ cm$The balance condition is given by the relation, $\frac{E_1}{E_2} = \frac{l_1}{l_2}$
$E_2 = E_1 \times \frac{l_2}{l_1} = 1.5 \times \frac{63}{42} = 2.25\ V$Therefore, emf of the second cell is $2.25\ V$.

Q17. Let the length of a potentiometer wire be $10\ cm$ and cell of emf $E$ is balanced at a length $\frac{10}{3}\ cm$ from the positive end of the wire. If the length of the wire is increased by $5\ cm$, at what distance (in $cm$ ) from positive end will the same cell give a balance point?

(a). $2\ cm$
(b). $5\ cm$
(c). $4\ cm$
(d). $6\ cm$

Ans. b

Exp.: Let $E_0$ be the potential difference applied across the total length $l(= 10\ cm)$ of potentiometer wire,Potential gradient in the first case $= \frac{E_0}{l}$As per question,
$E = \frac{l}{3}\left(\frac{E_0}{l}\right) = \frac{E_0}{3} \ldots .$ (i)Potential gradient in second case $= \frac{E_0}{\frac{3l}{2}} = \frac{2E_0}{3l}$If $x$ is the desired length of potentiometer to balance the emf $E$ of the cell, then
$E = x \times \frac{2E_0}{3l} \ldots \ldots$ (ii)From (i) and (ii), we have$\frac{E_0}{3} = x \times \frac{2E_0}{3l}$or $x = \frac{l}{2} = \frac{10}{2} = 5\ cm$

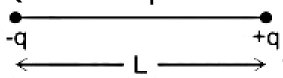
Q18. The potential difference across $70\ cm$ length of a potentiometer wire balances the potential difference across a $2\Omega$ coil supplied by a cell of emf $2\ V$ and internal resistance $r$ ohms. When a $1\Omega$ coil is placed in parallel with the $2\Omega$ coil, $50\ cm$ of the potentiometer wire is needed to balance the potential difference. across the parallel combination. Find $r$
.

(a). $r = 0.5\Omega$
(b). $r = 0.3\Omega$
(c). $r = 0.1\Omega$
(d). $r = 0.2\Omega$

Ans. a

Exp.: Let $r$ be the internal resistance of the cell.In the first case: Current sent by cell through $2\Omega$ coil,$I_1 = \frac{\text{em.f.}}{\text{total resistance}} = \frac{2}{2+r}$Potential drop acorss $2\Omega$ coil,
$V_1 = 2 \times I_1 = 2 \times \frac{2}{2+r} = \frac{4}{2+r}$Now, $V_1 = 70\ cm$or $\frac{4}{2+r} = 70 \ldots$ (i)In the second case: Let $R_p$ be the resistance of the parallel combination of $2\Omega$ and 1 coils. Then,
$R_p = \frac{2\times1}{2+1} = \frac{2}{3}\Omega$Current sent by the cell through $R_{p'}I_2 = \frac{\text{e.m.f.}}{\text{total resistance}} = \frac{2}{(\frac{2}{3})+r}$

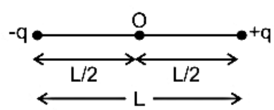
Potential drop across $R_p V_2 = R_p \times I_2 = \frac{2}{3} \times \frac{2}{(\frac{2}{3})+r} = \frac{4}{2+3r}$Now, $V_2 = 50\ cm$or $\frac{4}{2+3r} = 50 \ldots$ (ii)Dividing the equation (i) by (ii), we have $\frac{4}{2+r} \times \frac{2+3r}{4} = \frac{70}{50}$or $r = 0.5\Omega$

Q19. Two point charges $-q$ and $+q$ are placed at a distance of $L$, as shown in the figure.


The magnitude of electric field intensity at a distance $R(R >> L)$ varies as :

(a). $\frac{1}{R^4}$
(b). $\frac{1}{R^6}$
(c). $\frac{1}{R^2}$
(d). $\frac{1}{R^3}$

Ans. d

Exp.: As we know that:Electric dipole moment is $= P = \Sigma p_i = \Sigma q \cdot dx =$ charge $\times$ distanceIf it is zero then we have to test its quadrupole moment for the electric field.Given: two charges $+q$ and $-q$ placed at distance $L$.Electric monopole moment is $= m = -q + q = 0$Here electric monopole moment becomes zero so we have to calculate its electric dipole moment.We are free to consider origin anywhere because the monopole moment is zero.


Electric dipole moment is $= P =$ charge $\times$ distance (with directions)The electric field is towards for negative charge and away from the positive charge.Dipole moment $= P = q(\frac{L}{2})(\hat{i}) + (-q)(\frac{L}{2})(-\hat{i}) = qL(\hat{i})$so here, the dipole moment is non-zero. we know that for dipole moment electric field varies as $E \propto \frac{1}{R^3}$

Q20. A series LCR circuit with inductance $10\ H$, capacitance $10\ \mu F$, resistance $50\ \Omega$ is connected to an ac source of voltage, $V = 200 \sin(100\ t)$ volt. If the resonant frequency of the LCR circuit is $\nu_o$ and the frequency of the ac source is $\nu$, then:

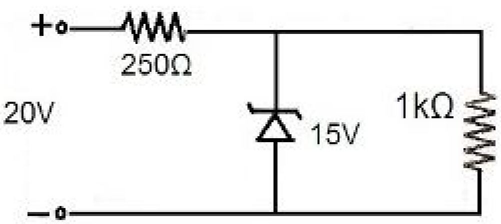
(a). $\nu_o = \frac{50}{\pi} Hz, \nu = 50 Hz$
(b). $\nu = 100 Hz; \nu_o = \frac{100}{\pi} Hz$
(c). $\nu_o = \nu = 50 Hz$
(d). $\nu_o = \nu = \frac{50}{\pi} Hz$

Ans. d

Exp.: We know, The resonant frequency of LCR circuit $\Rightarrow \nu_o = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} \cdots$ (1)The

frequency of ac source is $= \nu = \frac{\omega}{2\pi} \cdots$ (2)Here, $V = 200\sin(100t) = 200\sin(\omega t)$Given, $L =$ inductance $= 10\ H$, resistance $R = 50\ \Omega$, capacitance $(C) = 10\ \mu F$, angular velocity $= \omega = 100\ rad/s V = 200\sin(100t)$Resonant frequency $=$ ?, the frequency of ac source $=$ ?From equation (1) we get:Resonant frequency, $\nu_o = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$
$\Rightarrow \nu_o = \frac{\frac{1}{2\times 3}}{14}\sqrt{\frac{1}{10\times 10\times 10^{-6}}} = \frac{50}{\pi}\nu_o = \frac{50}{\pi}\ldots$ (3)The frequency of ac source $= \nu = \frac{\omega}{2\pi} = \frac{100}{2\pi} = \frac{50}{\pi}Hz$

Q21. A zener diode, having breakdown voltage equal to $15\ \mathrm{V}$, is used in a voltage regulator circuit shown in figure. the current through the diode is:




(a). 10mA
(b). 5mA
(c). 20mA
(d). 40mA

Ans. b

Exp.: Voltage accross zener diode is $15\ \mathrm{V}$.Thus voltage across $250\Omega$ resistance will be: $V = 20\ \mathrm{V} - 15\ \mathrm{V} = 5\ \mathrm{V} R = 250\Omega$Current through $250\Omega$ resistance $= \frac{V}{R}$ $= \frac{5}{250} = 20\ \mathrm{mA}$ Voltage across load resistance of $1\mathrm{k}\Omega$ is $15\mathrm{V}$ thus current through $1\mathrm{k}\Omega$ will b: $\frac{15}{1000} = 15\ \mathrm{mA}$So, Current through Zener = Current through $250\Omega$ resistance $-$ Current through $1\mathrm{k}\Omega$ resistance $\therefore$ Current through Zener $= 20 - 15 = 5\ \mathrm{mA}$

Q22. Calculate the displacement current between square plates in which electric field changes at the rate of $5\times 10^{12}\mathrm{Vm}^{-1}\ \mathrm{s}^{-1}$. Side of plates is $2.0\ \mathrm{cm}$.

(a). $35.4mA$
(b). $17.7mA$
(c). $27.7mA$
(d). $0mA$

Ans. b

Exp.: Given:Change in an electric field, $\frac{dE}{dt} = 5\times 10^{12}\mathrm{Vm}^{-1}\ \mathrm{s}^{-1}$,Side of the plate $(\mathrm{i}) = 2\ \mathrm{cm} = 2\times 10^{-2}\ \mathrm{m}$,and $\epsilon_0 = 8.85\times 10^{-12}\mathrm{C}^2\ \mathrm{N}^{-1}\ \mathrm{m}^{-2}$The area of the plate is:Area of square = (side)$^2$ $A = 2 \times 10^{-2} \times 2 \times 10^{-2} = 4 \times 10^{-4}$ mWe know that displacement current is given as:$I_d = \epsilon_0 A \times \frac{dE}{dt}$Put all given values in above formula: $I_d = 8.85 \times 10^{-12} \times 4 \times 10^{-4} \times 5 \times 10^{12} = 177 \times 10^{-4} A = 17.7 \text{ mA}$

Q23. Which of the following effect is not related to the electromagnetic waves?

(a). Doppler effect
(b). Magnus effect
(c). Interference
(d). Diffraction

Ans. b

Exp.: The Magnus effect is not related to electromagnetic waves.

- The force exerted on a rapidly spinning cylinder or sphere moving through air or another fluid in a direction at an angle to the axis of spin is called the Magnus effect.
- This force is responsible for the swerving of balls when hit or thrown with spin.

The Doppler effect is the change in the observed frequency of an (electromagnetic) wave due to relative motion of the source and observer.Interference occurs when several waves are added together provided that the phase differences between them remain constant over the observation time.Diffraction takes place with sound; with electromagnetic radiation, such as light, X-rays, and gamma rays; and with very small moving particles such as atoms, neutrons, and electrons, which show wavelike properties.
Therefore, Magnus effect is our required answer.

Q24. The flux of electric field through closed conducting plate changes with time as $\phi_E = \left(50t^2 + 10t + 2\right) Vm$ then, the value of displacement current into medium of $\epsilon_0$ at $t = 2$ sec is:

(a). $210\epsilon_0$
(b). $100\epsilon_0$
(c). $110\epsilon_0$
(d). $50\epsilon_0$

Ans. a

Exp.: Given:$\phi_E = \left(50t^2 + 10t + 2\right) Vm$We know that:The expression for displacement current is given by,$i_d = \epsilon_0 \frac{d\phi_E}{dt} = \epsilon_0 \frac{d\left(50t^2+10t+2\right)}{dt} = \epsilon_0 (100t + 10)$For $t = 2$ sec,

$i_d = \epsilon_0(100 \times 2 + 10) = \epsilon_0(200 + 10) = 210\epsilon_0 = 210\epsilon_0 A$

Q25. A coil of wire of radius R has 200 turns and self – inductance of 108 mH. The self – inductance of a similar coil of 500 turns will be:

(a). 375 mH
(b). 527 mH
(c). 675 mH
(d). None of these

Ans. c

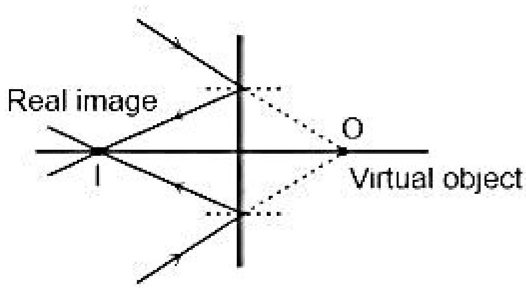
Exp.: Given:Self-inductance of first coil $(L_1) = 108\mathrm{mH}$,Radius of both coils are same i.e., $r_1 = r_2 = r$,Number of turns of the first coil $(\mathrm{N}_1) = 200$, andNumber of turns of the second coil $(\mathrm{N}_2) = 500$The Self-induction for the first coil is:$L_1 = \frac{\mu_0 N_1^2 \pi r^2}{2} \quad \cdots(1)$The Self-induction for the second coil is:$L_2 = \frac{\mu_0 N_2^2 \pi r^2}{2} \quad \cdots(2)$On dividing equation (1) and (2), we get:$\frac{L_2}{L_1} = \left(\frac{N_2}{N_1}\right)^2 L_2 = L_1\left(\frac{N_2}{N_1}\right)^2 = 108 \times \left(\frac{500}{200}\right)^2 = 108 \times 6.25 = 675\mathrm{mH}$

Q26. The image we see in plane mirror is:

(a). Real and thus can be photographed
(b). Virtual and nearer than the object
(c). Virtual and is laterally inverted
(d). Real but cannot be photographed

Ans. c

Exp.: A plane mirror is a mirror with a flat (planar) reflective surface.




The characteristics of an image formed in a plane mirror:

- The image formed by the plane mirror is virtual and erect i.e. image cannot be projected or focused on a screen.
- The distance of the image ‘behind’ the mirror is the same as the distance of the object in front of the mirror.
- The size of the image formed is the same as the size of the object.

- The image is laterally inverted, i.e. left hand appears to be the right hand when seen from the plane mirror.
- If the object moves towards (or away from) the mirror at a certain rate, the image also moves towards (or away from) the mirror at the same rate.

From the above, it is clear that the image we see in the plane mirror is virtual and is laterally inverted.

Q27. According to the New Cartesian Sign Convention, which one of the following is correct is respect of the formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$, where symbols have their usual meanings?

(a). It applies only to spherical mirrors
(b). It applies only to spherical lenses
(c). It applies to spherical mirrors as well as spherical lenses
(d). It is an invalid formula

Ans. a

Exp.: Mirror Formula: The following formula is known as the mirror formula, which provided a relationship between focal length $(f)$, image distance $(v)$, and objects distant $(u)$ as shown below:$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$The above formula is valid for spherical mirrors only.

Q28. Which one of the following statements is not correct for light rays?

(a). Light travels at different speeds in different media
(b). Light travels at almost 300 million metres per second in air
(c). Light speeds down as it leaves a water surface and enters the air
(d). Light speeds up as it leaves a glass surface and enters the air

Ans. c

Exp.: "Light speeds down as it leaves a water surface and enters the air" is not correct for light rays.

- The bending of the ray of light passing from one medium to the other medium is called refraction.
- The refraction of light takes place on going from one medium to another because the speed of light is different in the two media.
- The greater the difference in the speeds of light in the two media, the greater will be the amount of refraction.
- A medium in which the speed of light is more is known as an optically rarer medium and a medium in which the speed of light is less is known as an optically denser medium.

- Light travels at almost 300 million metres per second in air.
- Light speeds up as it leaves a glass surface and enters the air.

Q29. A glass prism splits white light into different colours. This phenomenon is called dispersion of light by prism. Which one of the following statements is correct?

(a). Red light will deviate the most and it is because of the reflection of light
(b). Violet light will deviate the most and it is because of the refraction of light
(c). Red light will deviate the most and it is because of the refraction of light
(d). Violet light will deviate the most and it is because of the reflection of light

Ans. b

Exp.: As we know, the bending of light is inversely proportional to the wavelength of the light.Bending $\propto \frac{1}{\text{Wavelength}}$ Different colours bend differently on passing through a prism and the bending of colour depends on wavelength. Higher wavelengths bend less, whereas shorter wavelength bend more.Out of all violet has the least wavelength and hence it bends the most and red has the highest wavelength, so it bends the least.

Q30. When light scattered by a molecule and the frequency of the scattered light is changed, this phenomenon is called:

(a). Rayleigh scattering
(b). Raman effect
(c). Photoelectric effect
(d). Rutherford scattering

Ans. b

Exp.: When light scattered by a molecule and the frequency of the scattered light is changed, this phenomenon is called Raman effect.

- The Raman Effect is the phenomenon of scattering of light by molecules present in a medium.
- When a beam of light travels through a transparent object, a small fraction of the light gets scattered in directions other than where it should.
- The scattering occurs due to the difference in wavelength of light as it enters into the medium.

Q31. The work function of Cesium is 2.27eV. The cut-off voltage which stops the emission of electrons from a cesium cathode irradiated with light of 600nm wavelength is:

(a). 0.00206785 eV
(b). -0.206785 eV
(c). 0.206785 eV
(d). 2.06785 eV

Ans. d

Exp.: Given:$\lambda = 600 \text{ nm}$We know that$c = 3 \times 10^8 \text{ m/s}$$h = 4.1357 \times 10^{-15} \text{eV}$The energy of the photon with a wavelength lambda is given by $E = \frac{hc}{\lambda}$Where $h$ is the planck's constant$c$ is the speed of light$\lambda$ is the wavelengthPut the values in formula given above.$E = \frac{4.1357 \times 10^{-15} \times 3 \times 10^8}{600 \times 10^{-9}} = \frac{4.1357 \times 3}{6} = 2.06785 \text{ eV}$

Q32. Two photons of the same frequency are produced due to the annihilation of a proton and antiproton. Wavelength of the proton so produced is:

(a). $1.1 \times 10^{-14} \text{ m}$
(b). $1.3 \times 10^{-15} \text{ m}$
(c). $1.7 \times 10^{-17} \text{ m}$
(d). $1.9 \times 10^{-19} \text{ m}$

Ans. b

Exp.: Two photons of the same frequency are produced due to the annihilation of a proton and antiproton.
We know that: $c = 3 \times 10^8$ m/sMass of a proton $= 1.67 \times 10^{-27}$ KgAccording to einstein law, $E = mc^2$Put the values in above formula.$E = \left(2 \times 1.67 \times 10^{-27}\right) \times \left(3 \times 10^8\right)^2 \text{ J}$ $= 3.006 \times 10^{-10} \text{ J}$Also We know that De-brogli equation.$2h\nu = E \text{ or } 2h\frac{c}{\lambda} = E$ $\therefore \lambda = \frac{2hc}{E}$Put the values in above formula.$= \frac{2 \times 6.62 \times 10^{-34} \times 3 \times 10^8}{3.006 \times 10^{-10}} \text{ m} = 1.323 \times 10^{-15} \text{ m}$ $= 1.3 \times 10^{-15} \text{ m}$

Q33. Monochromatic light of frequency $6.0 \times 10^{14} \text{ Hz}$ is produced by a laser. The power emitted is $2.0 \times 10^{-3} \text{ W}$. How many photons per second, on average, are emitted by the source?

(a). $3.0 \times 10^{10}$

(b). $5.0 \times 10^{15}$

(c). $7.0 \times 10^{12}$

(d). $9.0 \times 10^{12}$

Ans. b

Exp.: We know that, $h = 6.63 \times 10^{-34}$ J s
Each photon has energy,
$E = hv = \left(6.63 \times 10^{-34} \text{ Js}\right)\left(6.0 \times 10^{14} \text{ Hz}\right) = 3.98 \times 10^{-19} \text{ J}$
If N is the number of photons emitted by the source per second, the power P transmitted in the beam equals N times the energy per photon E, so that P = N E. Then,
$N = \frac{P}{E} = \frac{2.0 \times 10^{-3} \text{ W}}{3.98 \times 10^{-19} \text{ J}} = 5.0 \times 10^{15}$ photons per second.

Q34. A Proton and an alpha particle both are accelerated through the same potential difference. The ratio of corresponding de-Broglie wavelengths is:

(a). $2\sqrt{2}$
(b). $\frac{1}{2\sqrt{2}}$
(c). $2$
(d). $\sqrt{2}$

Ans. a

Exp.: The de-Broglie wavelength of a particle of mass $\mathrm{m}$ and moving with velocity $\mathrm{v}$ is given by, $\lambda = \frac{\mathrm{h}}{\mathrm{mv}} \quad (\because \mathrm{p} = \mathrm{mv})$de-Broglie wavelength of a proton of mass $\mathrm{m_1}$ and kinetic energy $\mathrm{k}$ is given by, $\lambda_1 = \frac{h}{\sqrt{2}\,\mathrm{m_1 k}} \quad (\because \mathrm{p} = \sqrt{2\mathrm{mk}})$
$\Rightarrow \lambda_1 = \frac{\mathrm{h}}{\sqrt{2\,\mathrm{m_1 qV}}} \ldots\ldots \text{(i)} \quad [\because \mathrm{k} = \mathrm{qV}]$For an alpha particle mass $\mathrm{m_2}$ carrying charge $\mathrm{q_0}$ is accelerated through potential $\mathrm{V}$, then, $\lambda_2 = \frac{\mathrm{h}}{\sqrt{2\,\mathrm{m_2 q_0}\,\mathrm{V}}}$ $\because$ For $\alpha-$ particle $\left({}_2^4\mathrm{He}\right)$ :
$q_0 = 2q$ and $m_2 = 4m_1$. $\therefore \lambda_2 = \frac{\mathrm{h}}{\sqrt{2 \times 4\,\mathrm{m_1} \times 2\mathrm{q} \times \mathrm{V}}} \ldots\ldots \text{(ii)}$ The ratio of corresponding wavelength, from Eqs. (i) and (ii), we get, $\frac{\lambda_1}{\lambda_2} = \frac{\mathrm{h}}{\sqrt{2\,\mathrm{m_1 qV}}} \times \frac{\sqrt{2 \times \mathrm{m_1} \times 4 \times 2\mathrm{qV}}}{\mathrm{h}} = \frac{4}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}}$
$\Rightarrow \frac{\lambda_1}{\lambda_2} = 2\sqrt{2}$

Q35. The surface of a metal is illuminated with the light of $400 \text{ nm}$. The kinetic energy of the ejected photoelectrons was found to be $1.68\text{eV}$. The work function of the metal is: $(hc = 1240\text{eVnm})$

(a). $3.09\mathrm{eV}$
(b). $1.42\mathrm{eV}$
(c). $1.51\mathrm{eV}$
(d). $1.68\mathrm{eV}$

Ans. b

Exp.: As we know that the Einstein's photo-electric equation is given by, $K_{\max} = h\nu - \phi_0 \ldots\ldots (1)$Also we know that the frequency of a light wave is given by $\nu = \frac{c}{\lambda} \ldots\ldots (2)$Substituting the value from (2) to (1), we get:$K_{\max} = \frac{hc}{\lambda} - \phi_0$So the work function of the metal is given by$\phi_0 = \frac{hc}{\lambda} - K_{\max} \ldots\ldots\ (3)$ According to the question,$\lambda = 400\ \mathrm{nm}, K_{\max} = 1.68\mathrm{eV}, hc = 1240\mathrm{eV}\cdot\mathrm{nm}$Putting these values in (3) we get,$\phi_0 = \frac{1240}{400} - 1.68 \Rightarrow \phi_0 = 1.42\mathrm{eV}$Thus the work function of the metal comes out to be equal to $1.42\mathrm{eV}$.

Q36. Two free protons are separated by a distance of 1 Å. If they are released, the kinetic energy of each proton when at infinite separation is:

(a). $5.6\times10^{-19}\ \mathrm{J}$
(b). $11.5\times10^{-19}\ \mathrm{J}$
(c). $23.0\times10^{-19}\ \mathrm{J}$
(d). $46.0\times10^{-19}\ \mathrm{J}$

Ans. b

Exp.: Given:Distance between the free protons, $r = 1$ Å$= 1\times10^{-10}\ \mathrm{m}$Initially kinectic energy of the proton is zero and electric potential energy is maximum.At infinite separation, potential energy is zero and all the energy is converted into kinetic energy (using law of conservation of energy)i.e., $2\ \mathrm{K} = \mathrm{U}$Where, $K$ is kinetic energy of each proton.$K = \frac{1}{2}U = \frac{1}{2}\frac{e^2}{4\pi\epsilon_0 \mathrm{I}}$.....(1)Where,$e = 1.6\times10^{-19}\mathrm{C}$ (charge on the proton) $\epsilon_0 = 8.85\times10^{-12}\mathrm{C}^2\ \mathrm{N}^{-1}\ \mathrm{m}^{-2}$ (permittivity of free space)Put all the given values in (1)

$$K = \frac{1}{2}\times\frac{\left(1.6\times10^{-19}\mathrm{C}\right)^2}{\left(10^{-10}\ \mathrm{m}\right)}\times\frac{1}{4\pi\epsilon_0}\ \text{Also, } \frac{1}{4\pi\epsilon_0} = 9\times10^9\mathrm{Nm}^2\mathrm{C}^{-2}$$

$$\Rightarrow K = \frac{1}{2}\times\frac{\left(1.6\times10^{-19}\mathrm{C}\right)^2}{\left(10^{-10}\ \mathrm{m}\right)}\times9\times10^9\mathrm{Nm}^2\mathrm{C}^{-2}\Rightarrow K = 11.5\times10^{-19}\ \mathrm{J}$$

Q37. As per the Bohr model, the minimum energy (in eV) required to remove an electron from the ground state of a double ionized Li atom (Z = 3) is:

(a). -122.4 eV
(b). -12.24 eV

(c). 122.4 eV
(d). 12.24 eV

Ans. a

Exp.: As we know,Energy of the $\mathrm{nth}$ orbit by Bohr was given by:$E_n = R_H \times \frac{Z^2}{n^2} eV$where, $E =$ energy$R_H =$ Rydberg's Constant$Z =$ atomic number $= 3$ (for lithium)$n =$ number of orbitPutting the values, in above equation, we getEnergy of the first shell $(n = 1)$ in hydrogen atom:$z = 1 - 13.6eV = R_H \times \frac{1^2}{1^2} R_H = -13.6\mathrm{eV}$To find energy value of electron in the excited state of $Li^{2+}$ is:$Li : 1s^2 2s^1 Li^{2+} : 1s^1 Z = 3, n = 1$
$E_n = -13.6 \times \frac{3^2}{12} \mathrm{eV} = -122.4\mathrm{eV}$

Q38. The electron in a hydrogen atom makes a transition of $n_1$ to $n_2$, where $n_1$ and $n_2$ are the principal quantum number of the two states. The time period of the electron in the initial state is eight times that in the final state. Then according to Bohr's atomic model, the possible value of $n_1$ and $n_2$ are:

(a). $n_1 = 4$ and $n_2 = 2$
(b). $n_1 = 8$ and $n_2 = 2$
(c). $n_1 = 5$ and $n_2 = 2$
(d). $n_1 = 6$ and $n_2 = 2$

Ans. a

Exp.: Given $T_1 = 8T_2$ and $Z = 1$ (for hydrogen)We know that the time period for the electron moving in the $n^{\mathrm{th}}$ orbit is given as,$\Rightarrow T_n = \frac{4\epsilon_o^2 n^3 h^3}{mZ^2 e^4}$ ... (1)Where $\epsilon_0 =$ permittivity, $h =$ Planck's constant, $m =$ mass of the electron, $Z =$ atomic number and $e =$ charge on the electron By equation 1 , the time period of the electron in the hydrogen atom is given as $(Z = 1)$,$\Rightarrow T_n = \frac{4\epsilon_o^2 n^3 h^3}{m \times 1^2 \times e^4} \Rightarrow T_n \propto n^3$ ...(2)By equation 2 , $\Rightarrow T_1 \propto n_1^3$ ...(3)$\Rightarrow T_2 \propto n_2^3$ ...(4)By equation 3 and equation 4 ,$\Rightarrow \frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} \Rightarrow \frac{n_1^3}{n_2^3} = \frac{8T_2}{T_2}$
$\Rightarrow \frac{n_1}{n_2} = \frac{2}{1} \Rightarrow n_1 = 2n_2$By equation 5 when $n_2 = 2$,$\Rightarrow n_1 = 2 \times 2 \Rightarrow n_1 = 4$

Q39. A difference of 2.3 eV separates two energy levels in an atom. What is the frequency of radiation emitted when the atom makes a transition from the upper level to the lower level?

(a). $5.6 \times 10^{14}$ Hz
(b). $6.6 \times 10^{14}$ Hz
(c). $7.6 \times 10^{14}$ Hz

(d). $5.6 \times 10^{-14}$ Hz

Ans. a

Exp.: Separation of two energy levels in an atom $E = 2.3\text{eV}$
$= 2.3 \times 1.6 \times 10^{-19} = 3.68 \times 10^{-19}$ J
Let $v$ be the frequency of radiation emitted when the atom transits from the upper level to the lower level.
We have the relation for energy as: $E = hv$, where
$h =$ Planck's constant $= 6.62 \times 10^{-34}\text{Js}$
$\therefore v = \frac{E}{h} = \frac{3.68 \times 10^{-19}}{6.62} \times 10^{-32} = 5.55 \times 10^{14}\text{Hz}$, Thus the frequency of the radiation is $5.6 \times 10^{14}$ Hz.

Q40. Suppose India had a target of producing by $2020$ AD, $200,000$ MW of electric power, ten percent of which was to be obtained from nuclear power plants. Suppose we are given that, on average, the efficiency of utilization (i.e., conversion to electric energy) of thermal energy produced in a reactor was $25\%$. How much amount of fissionable uranium would our country need per year by $2020$? Take the heat energy per fission of $^{235}\text{U}$ to be about $200$ MeV.

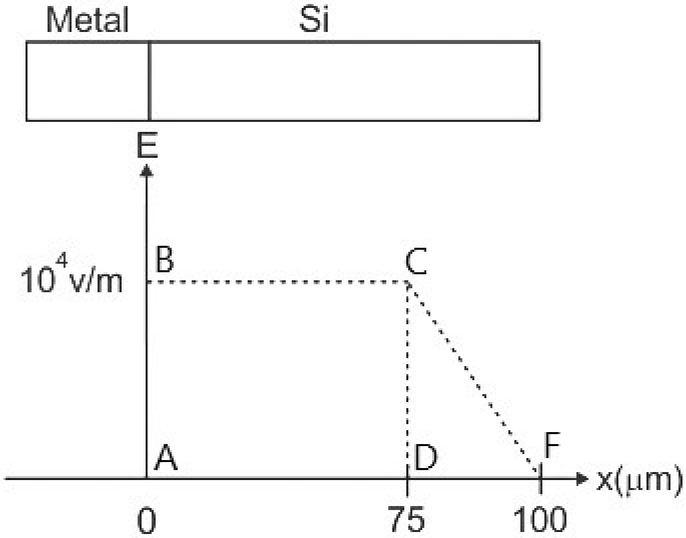
(a). $5.076 \times 10^{4}$ kg
(b). $3.076 \times 10^{4}$ kg
(c). $4.076 \times 10^{4}$ kg
(d). $1.076 \times 10^{4}$ kg

Ans. b

Exp.: Amount of electric power to be generated, $P = 2 \times 10^{5}\text{MW}$, $10\%$ of this amount has to be obtained from nuclear power plants.
$\therefore$ Amount of nuclear power, $P_1 = \frac{10}{100} \times 2 \times 10^{5} = 2 \times 10^{4}\text{MW} = 2 \times 10^{4} \times 10^{6}$ J/s
$= 2 \times 10^{10} \times 60 \times 60 \times 24 \times 365$ J/y
Heat energy released per fission of a $^{235}\text{U}$ nucleus, $E = 200\text{MeV}$
Efficiency of a reactor $= 25\%$. Thus, the amount of energy converted into the electrical energy per fission is calculated $\frac{25}{100} \times 200 = 50\text{MeV}$
$= 50 \times 1.6 \times 10^{-19} \times 10^{6} = 8 \times 10^{-12} J = 50 \times 1.6 \times 10^{-19} \times 10^{6} = 8 \times 10^{-12} J$
Number of atoms required for fission per year:
$\frac{2 \times 10^{10} \times 60 \times 60 \times 24 \times 365}{8 \times 10^{-12}} = 78840 \times 10^{24}$ atoms , 1 mole i.e., $235$ g of $\text{U}^{235}$ contains $6.023 \times 10^{23}$ atoms.
$\therefore$ Mass of $6.023 \times 10^{23}$ atoms of $U^{235} = 235$ g $= 235 \times 10^{-3}$ kg

$= \frac{235 \times 10^{-3}}{6.023 \times 10^{23}} \times 78840 \times 10^{24}$, Thus the mass of uranium needed per year is $3.076 \times 10^4$ kg.

Q41. Consider a metal-semiconductor junction. The variation of the electric field inside the semiconductor is shown in the figure below. The built-in potential (in volts) is equal




to:

(a). 0.665
(b). 0.875
(c). 1.12
(d). 0.934

Ans. b

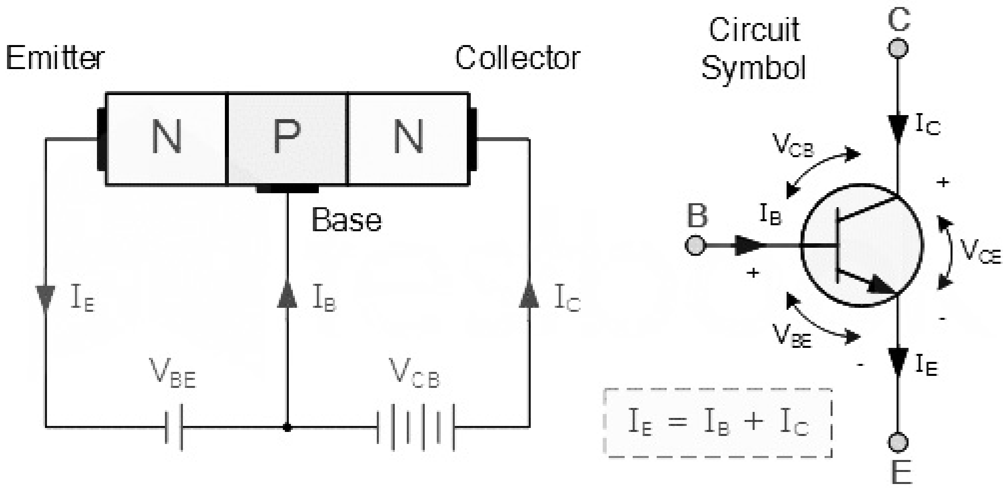
Exp.: Given:$AD = 75 \times 10^{-6} m AB = 10^4 v/m DC = 10^4 v/m DF = 25 \times 10^{-6} m$Built in potential at the junction is equal to area under the electric field curve at the junction. $V_{bi} = \text{ Area of ABCD} + \text{ Area of CDF} V_{bi} = (AD \times AB) + \left(\frac{1}{2} \times CD \times DF\right)$Put the given values in above formula, we get:
$V_{bi} = \left(75 \times 10^{-6} \times 10^4\right) + \left(\frac{1}{2} \times 25 \times 10^{-6} \times 10^4\right) = 75 \times 10^{-2} + 12.5 \times 10^{-2}$
$= 87.5 \times 10^{-2} = 0.875 \text{ V}$

Q42. In a transistor the collector current is always less than the emitter current because:

(a). collector side is reverse - biased and the emitter side is forward biased
(b). a few electrons are lost in the base and only remaining ones reach the collector
(c). collector being reverse biased, attracts less electrons
(d). collector side is forward-biased and emitter side is reverse-biased

Ans. a

Exp.: In a transistor the collector current is always less than the emitter current because collector side is reverse - biased and the emitter side is forward biased.




From the above figure, it is clear that in order to operate the emitter-base junction of the transistor it must be forward biased and the collector-base junction is reverse biased.As the emitter-base junction is forward biased due to the repulsion many electrons repel from the emitter to the base and some electrons may combine with the holes which are the majority charge carriers and the rest of the electrons reach the collector, which in turn means Collector current is less than the emitter current.

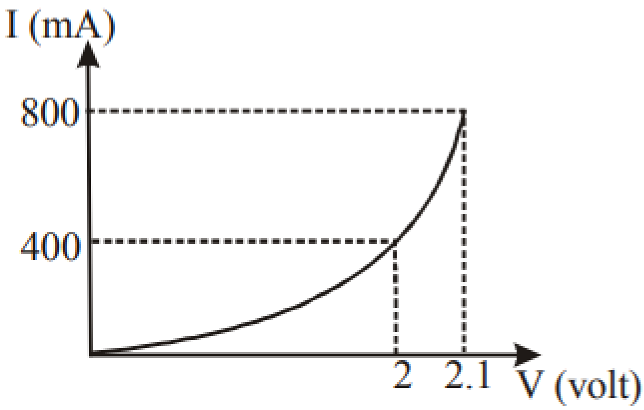
Q43. In a common base mode if the collector and base current are 1.95 mA and 0.5 mA, then the emitter current will be:

(a). 2.0 mA
(b). 1.90 mA
(c). 2.45 mA
(d). 0.05 mA

Ans. c

Exp.: Given:$\mathrm{I_B} = 1.95\ \mathrm{mA}, \mathrm{I_C} = 0.5\ \mathrm{mA}$As we know,The electrical relationship between the three transistor currents is$\mathrm{I_E} = \mathrm{I_B} + \mathrm{I_C}$Put the given values in above formula: $\mathrm{I_E} = 1.95 + 0.5 \Rightarrow \mathrm{I_E} = 2.45\ \mathrm{mA}$Therefore, emitter current will be $2.45\ \mathrm{mA}$.

Q44. The I-V characteristic of a P-N junction diode is shown below. The approximate dynamic resistance of the p-n junction when a forward bias voltage of 2 volts is applied is:




(a). 1 Ω
(b). 0.25 Ω
(c). 0.5 Ω
(d). 5 Ω

Ans. b

Exp.: From the given graph:$V_1 = 2\ V V_2 = 2.1\ V I_1 = 400\ mA I_2 = 800\ mA$Dynamic resistance of the $\mathrm{p-n}$ junction diode is:$\mathrm{R} = \frac{\mathrm{V_2 - V_1}}{\mathrm{I_2 - I_1}}$Put all the given values in the above equation:$= \frac{2.1-2}{(800-400)\times 10^{-3}} = \frac{1}{4} = 0.25\Omega$

Q45. The ripple factor in a half-wave rectifier is:

(a). 1.21
(b). 0.48
(c). 0.6
(d). None of these

Ans. a

Exp.: We know that, ripple factor is given by:$r = \sqrt{\left(\frac{V_{rms}}{V_{DC}}\right)^2 - 1}$Where $V_{rms}$ stands for $AC$ voltage and $V_{DC}$ stands for output DC voltage.The above equation can also be rearranged to give ,Ripple factor (r)$r = \sqrt{\left(\frac{I^2 rms}{I_{DC}^2}\right) - 1}$For a half wave rectifier, we know it operates only in half cycle. Therefore the current and voltage values will be halved from the original to provide desired output.Thus, we get, $I_{rms} = \frac{I_m}{2}$ and $I_{DC} = \frac{I_m}{\pi}$.

Substituting this on the above formula we get, $r=\sqrt{\left(\frac{I^2{}_{rms}}{I_{DC}^2}\right)-1} \Rightarrow r=\sqrt{\frac{\left(\frac{I^2{}_m}{4}\right)}{\left(\frac{I^{22}}{\pi^2}\right)}-1}$

$\Rightarrow r=\sqrt{\left(\frac{\pi^2-4}{4}\right)-1}=1.21$ ( For a standard half wave-rectifier)

Q46. Which of the following is not a transducer?

(a). Loudspeaker
(b). Microphone
(c). Amplifier
(d). All of these

Ans. c

Exp.: Transducer is a device used for converting one form of energy into another. Therefore, the term transducer is applied to gramophone pickups, microphones and loudspeakers but not for the amplifier.

Q47. A TV tower has a height of $75 \mathrm{m}$. The maximum distance and area up to which this TV transmission can be received is (Radius of the Earth $=6400 \mathrm{~km}$):

(a). $3018 \mathrm{km}^2$
(b). $3000 \mathrm{km}^2$
(c). $2800 \mathrm{km}^2$
(d). $2500 \mathrm{km}^2$

Ans. a

Exp.: Distance upto which the transmission could be viewed is: $\mathrm{d}=\sqrt{2 \mathrm{hR}}$
$\mathrm{d}=\sqrt{2 \times 0.075 \times 6.4 \times 10^3}=31 \mathrm{~km}$ Total area over which the transmission could be viewed is:
$\mathrm{A}=2 \pi \mathrm{hR}=2 \times 3.14 \times 0.075 \times 6.4 \times 10^3=3018 \mathrm{km}^2$

Q48. A TV transmission tower has a height of $140 \mathrm{~m}$ and the height of the receiving antenna is $40 \mathrm{~m}$. What is the maximum distance upto which signals can be broadcasted from this tower in LOS (Line of Sight) mode? (Given: radius of earth $=6.4 \times 10^6 \mathrm{~m}$ )

(a). $65 \mathrm{~km}$
(b). $48 \mathrm{~km}$
(c). $40 \mathrm{~km}$
(d). $80 \mathrm{~km}$

Ans. a

Exp.: Maximum distance upto which signal can be broadcasted is,
$\mathrm{d}_{\max }=\sqrt{2 \mathrm{Rh}_{\mathrm{T}}}+\sqrt{2 \mathrm{Rh}_{\mathrm{R}}}$
where $\mathrm{h}_{\mathrm{T}}$ and $\mathrm{h}_{\mathrm{R}}$ are heights of transmitter tower and height of receiver respectively.
Putting all values, we get $d_{\max }=\sqrt{2 \times 6.4 \times 10^{6}}[\sqrt{140}+\sqrt{40}]=65 \mathrm{~km}$

Q49. A TV transmission tower antenna is at a height of $20\ m$. How much service area can it cover if:
(i) at ground level
(ii) At a height of 25 m?
Calculate the percentage increase in area covered in case.

(a). (i) $803.84\ km^{2}$, (ii) $33.9\ km$, Percentage change $348.9\%$
(b). (i) $801.39\ km^{2}$, (ii) $30.9\ km$, Percentage change $352.9\%$
(c). (i) $806.39\ km^{2}$, (ii) $33.9\ km$, Percentage change $354.9\%$
(d). (i) $807.39\ km^{2}$, (ii) $34.9\ km$, Percentage change $351.9\%$

Ans. a

Exp.: (i) Receiving antenna is at ground level.
Range of transmitting Antenna $=\sqrt{2 \mathrm{hR}}=\sqrt{2 \times 20 \times 6.4 \times 10^{6}} \mathrm{~m}$
Range $\left(r_{1}\right)=\sqrt{4 \times \times 10^{6}}=2 \times 8 \times 10^{3} \mathrm{~m}=16 \mathrm{~km}$
Area covered by transmitting antenna $=\pi(\text { range })^{2}=3.14 \times 16 \times 16=803.84 \mathrm{~km}^{2}$
(ii) Receiving antenna is at $\mathrm{h}_{\mathrm{T}}=25 \mathrm{~m}$ from ground.
Range due to both antenna $\left(\mathrm{r}_{2}\right)=\sqrt{2 \mathrm{h}_{\mathrm{T}} \mathrm{R}}+\sqrt{2 \mathrm{h}_{\mathrm{r}} \mathrm{R}}$
$\mathrm{r}_{2}=\sqrt{2 \times 20 \times 6.4 \times 10^{6}}+\sqrt{2 \times 12 \times 6.4 \times 10^{6}}=16 \times 10^{3}+5 \times 8 \sqrt{2 \times 10^{5}}$
$=16 \times 10^{3}+40 \sqrt{20 \times 10^{4}}=16 \times 10^{3}+40 \times 10^{2} \times \sqrt{20}$
$=16 \mathrm{~km}+17.9 \mathrm{~km}=33.9 \mathrm{~km}$
Area covered by both transmitting and receiving antenna
$=\pi r_{2}^{2}=3.14 \times 33.9 \times 33.9=3608.52 \mathrm{~km}^{2}$
Percentage increase in area in 2 transmissions $=\frac{\Delta \mathrm{A}}{\mathrm{A}} \times 100$
$=\frac{(3608.52-803.84)}{803.84} \times 100=\frac{2804 \times 100}{803.84}=3848.9 \%$

Q50. A modulated signal $C_{m}(t)$ has the form $C_{m}(t)=$ $30 \sin 300 \pi t+10(\cos 200 \pi t-\cos 400 \pi t)$. The carrier frequency $f_{c}$, the modulating frequency (message frequency) $f_{\omega}$ and the modulation index $\mu$ are respectively given by :

(a). $150 Hz ; 50 Hz$ and $\frac{5}{3}$

(b). $150 Hz; 50 Hz$ and $\frac{2}{3}$
(c). $150 Hz; 60 Hz$ and $\frac{2}{3}$
(d). $140 Hz; 50 Hz$ and $\frac{2}{3}$

Ans. b

Exp.: Comparing the given equation with standard modulated signal wave equation,
$m = A_c \sin \omega_c t + \frac{\mu A_c}{2} \cos(\omega_c - \omega_s) t - \frac{\mu A_c}{2} \cos(\omega_c + \omega_s) t \mu \frac{A_c}{2} = 10 \Rightarrow \mu = \frac{2}{3}$ (modulation index)$A_c = 30 \omega_c - \omega_s = 200\pi \omega_c + \omega_s = 400\pi \Rightarrow f_c = 150, f_s = 50 Hz$ and $\mu = \frac{2}{3}$