Answer Book – જવાબવહી

મુખ્ય જવાબવહી	પુરવણી	કુલ
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H.S.C. વિજ્ઞાન પ્રવાહ 24-M-24

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પરીક્ષાર્થી માટે અગત્યની સૂચના

પરીક્ષાર્થીએ જવાબ લખવાનું શરૂ કરતાં પહેલાં પાન નં. 2 પરની સૂચનાઓ અવશ્ય વાંચવી.

મધ્યસ્થ મૂલ્યાંકન કેન્દ્રના ઉપયોગ માટે

G.S. & H.S.E.B. 303 C.E.C.-2024

વિભાગ	પરીક્ષકે આપેલ ગુણ	પરીક્ષકની સહી	પરીક્ષકની નિમણૂક નંબર	સમીક્ષકે આપેલ ગુણ	કો-ઓર્ડિનેટરે આપેલ ગુણ	બોર્ડની કચેરીના ઉપયોગ માટે
A						
B						
C						
કુલ ગુણ અપૂર્ણાંકમાં						
કુલ ગુણ પૂર્ણાંકમાં						
કુલ ગુણ શબ્દોમાં						

વેરીફાયરની સહી	સમીક્ષકની સહી	કો-ઓર્ડિનેટરની સહી
વેરીફાયરનો નિમણૂક નંબર	સમીક્ષકનો નિમણૂક નંબર	કો-ઓર્ડિનેટરનો નિમણૂક નંબર

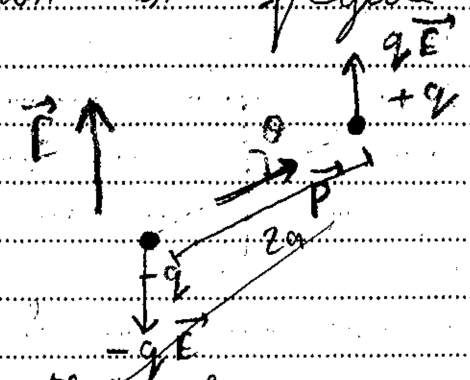
ગુણાંકન

વિભાગ-A		વિભાગ-B		વિભાગ-C	
પ્રશ્ન ક્રમાંક	ગુણ	પ્રશ્ન ક્રમાંક	ગુણ	પ્રશ્ન ક્રમાંક	ગુણ
1		13		22	
2		14		23	
3		15		24	
4		16		25	
5		17		26	
6		18		27	
7		19		મેળવેલ કુલ ગુણ	16
8		20		પરીક્ષકની સહી	
9		21			
10		મેળવેલ કુલ ગુણ	18		
11		પરીક્ષકની સહી		વેરીફાયરની સહી	
12					
મેળવેલ કુલ ગુણ	16	વિભાગ : A + B + C =			50
પરીક્ષકની સહી		પેજ નં. 3 ઉપરના પ્રશ્નના ક્રમવાર મેળવેલ ગુણ મૂકીને મહત્તમ ગુણ ગણતરીમાં લઈ વિભાગવાર દર્શાવવાના રહેશે અને ઉત્તરવહીના મુખ્ય પેજ ઉપર વિભાગવાર ગુણ લખવાના રહેશે.				

SECTION - A

(1) → Consider a dipole $\vec{p}$ placed in an uniform external electric field $\vec{E}$.

→ Let angle between $\vec{p}$ & $\vec{E}$ be θ as shown in figure



$[\vec{p} = (2\vec{a})q]$

→ So the force on $+q$ charge is $+q\vec{E}$ and $-q$ charge is $-q\vec{E}$. As both force are equal & opposite net force on dipole is zero.

→ But net torque (couple) acts on dipole. The magnitude of torque is equal to product of ~~magnitude~~ of any one force and distance between two antiparallel forces

Torque = magnitude of force × perpendicular distance

$$\tau = qE \times (2a \sin\theta)$$
$$= (2aq) E \sin\theta$$
$$= pE \sin\theta$$

→ It has direction along $\vec{p} \times \vec{E}$ and so in vector form we have

$$\boxed{\vec{\tau} = \vec{p} \times \vec{E}}$$

→ Thus a dipole experiences a torque in uniform external field

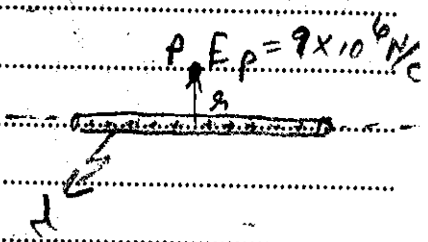
(2) → $|\vec{E}| = 9 \times 10^4$ N/C

$r = 2 \times 10^{-2}$ m $= 2$ cm

$\lambda = ?$

→ Using $E = \dfrac{2K\lambda}{r}$ (where $K = 1/4\pi\varepsilon_0$)

$\therefore E = \dfrac{2(9\times10^9)(\lambda)}{(2\times10^{-2})}$



$\therefore \lambda = \dfrac{(9\times10^4)\times(2\times10^{-2})}{2(9\times10^9)}$

$\lambda = 10^{-7}$ C/m

$= 0.1$ μC/m

$\therefore$ linear charge density is 0.1 μC/m

(3) → Conductivity arises from mobile charge carries

→ In metal mobile charge carriers are electrons, positive ions & electrons in ionised gas and positive & negative ions in electrolyte

→ Mobility(μ) is defined as magnitude of drift velocity per unit electric field

→ $\mu = \dfrac{|\vec{V_d}|}{|\vec{E}|} = \dfrac{V_d}{E}$

→ Using $V_d = \left(\dfrac{eE}{m}\right)\tau$ we get

$$\boxed{\mu = \frac{e\tau}{m}}$$

→ It has unit $m^2 V^{-1} s^{-1}$ (or) Cs/kg

→ Dimensional formula :- $M^{-1} L^0 T^2 A^1$

→ Its SI unit $m^2 V^{-1} s^{-1}$ is 10^4 times CGS unit $cm^2 V^{-1} s^{-1}$.

→ In terms of conductivity we have

$$\boxed{\mu = \frac{\sigma}{ne}}$$

(5) → Magnetic field B
Area A } of solenoid
length l }

→ We know that energy stored in inductor is given by

$$U_B = (1/2) L I^2 \quad —①$$

→ The self inductance of solenoid is

$$L = \mu_0 n^2 A l \quad [\text{In vacuum}] \quad —②$$

→ The magnetic field inside solenoid is

$$B = \mu_0 n I$$

$$\therefore I = \frac{B}{\mu_0 n} \quad —③$$

→ Using ①, ② and ③ :-

$$U_B = \frac{1}{2}(\mu_0 n^2 A l)\left(\frac{B}{\mu_0 n}\right)^2$$

$$= \frac{1}{2} \frac{\mu_0 n^2 A l}{\mu_0^2 n^2} B^2$$

$$\boxed{U_B = \frac{B^2}{2\mu_0}(A l)} \longrightarrow \text{Magnetic energy stored in solenoid}$$

→ Volume of solenoid is $V = Al$
So magnetic energy per unit volume given as

$$U_B = \frac{U}{V} = \frac{U}{A\ell} = \frac{B^2}{2\mu_0}$$

$\therefore \boxed{U_B = \frac{B^2}{2\mu_0}} \longrightarrow$ Magnetic energy per unit volume.

→ This is similar to electrostatic energy stored in capacitor $U_E = \frac{1}{2}\varepsilon_0 E^2$

(6) → $R = 100\ \Omega$

$V_{rms} = 220\ V$

$\nu = 50\ Hz$

(a) $I_{rms} = \frac{V_{rms}}{R}$

$= \frac{220}{100}$

$\boxed{I_{rms} = 2.2\ A} \longrightarrow$ Rms value of current in circuit.

(b) $P = VI$

$= 220\ (2.2)$

$= 484\ W$

$\therefore$ Net power consumed over full cycle $\boxed{P = 484\ W}$

(9) → $\nu = 7.21 \times 10^{14}\ Hz$

$V_{max} = 6 \times 10^5\ m/s$

$\therefore K_{max} = \frac{1}{2} m (V_{max})^2$

$= \frac{1}{2} (9.1 \times 10^{-31}) (36 \times 10^{10})$

$= 163.8 \times 10^{-21}\ J = 1.638 \times 10^{-19}\ J$

Using Einstein's eq^n :-

$\rightarrow$ $K_{max} = h(\nu - \nu_0)$

$\therefore \nu - \nu_0 = \dfrac{K_{max}}{h}$

$\therefore \nu_0 = \nu - \dfrac{K_{max}}{h}$

$\therefore \nu_0 = (7.21 \times 10^{14}) - \left(\dfrac{1.638 \times 10^{-19}}{6.625 \times 10^{-34}}\right)$

$= 7.21 \times 10^{14} - 0.247 \times 10^{15}$

$= (7.21 - 2.47) \times 10^{14}$

$= 4.73 \times 10^{14}$ Hz

$\therefore$ Threshold Frequency $\nu_0 = 4.73 \times 10^{14}$ Hz

(10) $\rightarrow$ Energy in ground state of H atom $E_i = \dfrac{-13.6}{(1)^2}$ eV

$E_i = -13.6$ eV

$\rightarrow$ Energy in state with $n = 4$ $E_f = \dfrac{-13.6}{(4)^2}$ eV

$E_f = -0.85$ eV

$\therefore$ Energy of emitted photon $= h\nu$

Also $h\nu = E_f - E_i$ [Bohr's postulate]

$\therefore h\nu = 13.6 - 0.85$

$= 12.75$ eV

$\therefore \nu = \dfrac{12.75 (1.6 \times 10^{-19})}{(6.625 \times 10^{-34})}$

$= 3.078 \times 10^{15}$ Hz

Frequency $\nu = 3.08 \times 10^{15}$ Hz

→ Wavelength $\lambda = \frac{c}{\nu}$

$\lambda = \frac{3 \times 10^8}{3.08 \times 10^{15}}$

$= 0.9742 \times 10^{-7}$ m

$\boxed{\lambda = 97.42 \text{ nm}}$

∴ ~~Frequency~~ of emitted photon $= 3.08 \times 10^{15}$ Hz
Wavelength of emitted photon $= 97.42$ nm

(12) → $n_i = 1.5 \times 10^{16}$ ~~atom~~/m^3
doping level is 1 ppm
Total atoms $= 5 \times 10^{28}$ atom/m^3

→ ∴ $n_e = (10^{-6})$ (atoms total)

$n_e = (5 \times 10^{28}) \times (1 \times 10^{-6})$

$= 5 \times 10^{22}$ electron/m^3

Using equation; $n_e n_h = (n_i)^2$

∴ $n_h = \frac{(1.5 \times 10^{16})^2}{(5 \times 10^{22})}$

$= \frac{2.25 \times 10^{32}}{5 \times 10^{22}}$

$= 0.45 \times 10^{10}$

$= 4.5 \times 10^{9}$ holes/m^3

∴ Number density of holes $= 4.5 \times 10^{9}\ m^{-3}$
Number density of electrons $= 5 \times 10^{22}\ m^{-3}$

10

SECTION-B

(13) → Radius $R = 12\ cm$

$R = 0.12\ m$

Charge $Q = 1.6 \times 10^{-7} C$

(a) Inside sphere electric field is zero

$\boxed{\vec{E_1} = \vec{0}\ N/C}$

This is the case as inside conductor electric field is always zero.

(b) Just outside sphere electric field is same as that on surface of the sphere and let it be $\vec{E_2}$:-

$|\vec{E_2}| = \frac{KQ}{R^2}$ (where $K = \frac{1}{4\pi\varepsilon_0}$)

$|\vec{E_2}| = \frac{(9\times10^{9})(1.6\times10^{-7})}{(0.12)^2}$

$= 1000 \times 10^{2}$

$= 10^{5}\ N/C$

$\vec{E_2}$ is radially outwards along radius ~~vec~~ vector.

(c) At $r = 18\ cm$

$r = 0.18\ m$

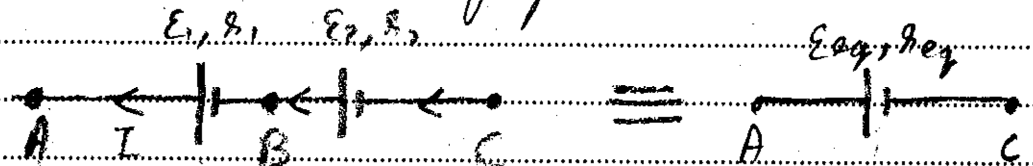
Let electric field be $\vec{E_3}$

$\therefore |\vec{E_3}| = \frac{KQ}{r^2}$

$$|\vec{E_3}| = \frac{9\times10^9 \times 1.6\times10^{-7}}{(0.18)^2}$$
$$= 444.44\times10^2$$
$$= 4.44\times10^4\ N/C$$

$\therefore$ $\vec{E_3}$ is along radius vector radially outwards

(14) → Consider two cells of ~~equivalent~~ emf ε_1 & ε_2 respectively and internal resistances r_1 & r_2 connected in series as shown in figure.



→ Let current I be flowing through the circuit. Let V_{AB} and V_{BC} denote potential drop across AB & BC respectively
→ Let V_{AC} denote potential drop across A and C.
$\therefore$ By using Kirchoff's law

$$V_{AB} = V_A - V_B = \varepsilon_1 - Ir_1$$
$$V_{BC} = V_B - V_C = \varepsilon_2 - Ir_2$$

Also $V_{AC} = V_A - V_C$
$$= \cancel{V_A + V_B}(V_A - V_B) + (V_B - V_C)$$
$$= \varepsilon_1 - Ir_1 + \varepsilon_2 - Ir_2$$
$$V_{AC} = (\varepsilon_1 + \varepsilon_2) - I(r_1 + r_2) \equiv V \quad -(1)$$

→ Let these two cells be replaced by a single cell of emf ε_{eq} and internal resistance r_{eq}

$\therefore \varepsilon_{eq} - I r_{eq} = V_{AC} \equiv V$ [By Kirchhoff's law] — (2)

$\therefore$ Now comparing both equations we get

$$\boxed{\begin{aligned} \varepsilon_{eq} &= \varepsilon_1 + \varepsilon_2 \\ r_{eq} &= r_1 + r_2 \end{aligned}}$$

→ Thus we can conclude that

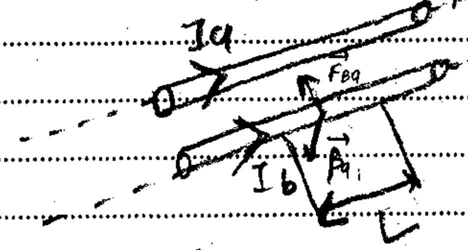
(i) Equivalent emf of series combination of two cells is algebraic sum of individual emf

→ If current is entering positive terminal of any cell its emf is taken as negative

(ii) Equivalent resistance of series combination of two cells is sum of individual internal resistances

(15) → Consider two long parallel conductors carrying current I_a and I_b respectively.

→ Let the medium between them be vacuum and seperated by d distance



Both Currents in same direction

→ Let cross-sectional area of both the conductors be small and negligible in comparision to their length.

→ So magnetic field due to conductor a at all points on conductor b is given by

$$B_a = \frac{\mu_0 I_a}{2\pi d}$$

→ The force on a segment of length L of conductor b is given as

$$F_{ba} = \left(\frac{\mu_0 I_a}{2\pi d}\right)(L)(I_b$$

$$F_{ba} = \frac{\mu_0 I_a I_b L}{2\pi d}$$

The direction is found by using right hand thumb rule and is towards conductor a as magnetic field B_a is downwards

→ The force per unit length is given as

$$f_{ba} = \frac{F_{ba}}{L} = \frac{\mu_0 I_a I_b}{2\pi d}$$

→ Similarly force on conductor 'a' due to conductor 'b' can also be found and we get result.

$$\boxed{\overrightarrow{F_{ba}} = -\overrightarrow{F_{ab}}}$$

This shows newton's third law is valid.

→ Here current in same direction (like) attract each other while current in opposite direction (unlike) repel each other

→ Like current attract each other & unlike current repel each other

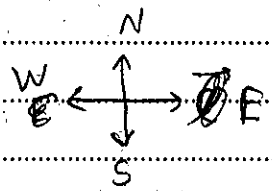
→ Definition of 1 Ampere :-

→ 1 Ampere is the value of steady current that when maintained between two long parallel conductors (straight) seprated by a distance 1 metre in vacuum experience a force of 2×10^{-7} newton per unit length

$$f_{ba} = \frac{F_{ba}}{L} = \frac{\mu_0}{2\pi} \frac{(1)(1)}{(1)}$$

$$f_{ba} = \underline{2 \times 10^{-7}\ N/m}$$

(16) → $l = 10\,m$ (East to west)
$v = 5\,m/s$ (Downward)
$\theta = 90^\circ$ between $\vec{V}$ & $\vec{B}$
$H_e = 3 \times 10^{-5}\ Wb/m^2$

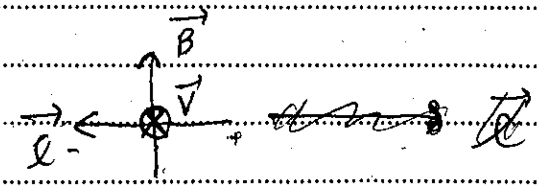


ⓐ Here $\vec{V}$, $\vec{B}$ & $\vec{l}$ are perpendicular to each other

∴ Induced emf $\varepsilon = \underline{B v l}$

$$\varepsilon = (H_e) v l$$
$$= (3 \times 10^{-5})(5)(10)$$
$$= 1.5 \times 10^{-3}\ V$$
$$= 1.5\ mV$$

ⓑ Direction of emf is from west to east



ⓒ East end of wire is at higher potential

(18) (a) $R_1 = 10\ cm$

$R_2 = -15\ cm$

$f = 12\ cm.$

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \left[\text{Lens Maker's } eq^n\right]$$

$$\frac{1}{12} = \left(\frac{n_2 - 1}{1}\right)\left(\frac{1}{10} + \frac{1}{15}\right)$$

$$\frac{1}{12} = (n_2 - 1)\left(\frac{3+2}{30}\right)$$

$$n_2 - 1 = 1/2$$

$$n_2 = 3/2 = 1.5$$

∴ Refractive index of material of lens is equal to 1.5

(b) $f_1 = 20\ cm$ (in air)

$n_{wa} = 1.33$

$n_{ga} = 1.5$

Let focal length in water be f_2

∴ Using lens Maker's equation :-

$$\frac{1}{f_1} = \left(\frac{n_{ga} - 1}{1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad —(1)$$

$$\frac{1}{f_2} = \left(\frac{n_{ga} - n_{wa}}{n_{wa}}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad —(2)$$

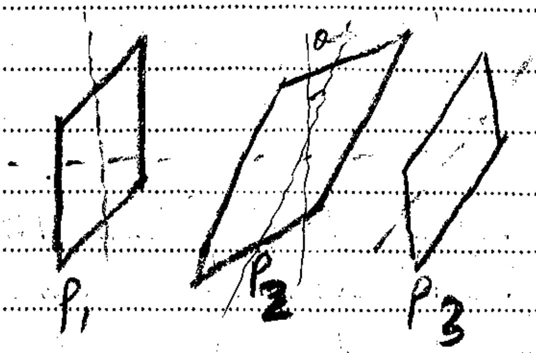
Taking ratios of (1) & (2) we get

$$\frac{f_2}{f_1} = \frac{(n_{ga} - 1)(n_{wa})}{(n_{ga} - n_{wa})}$$

$$\Rightarrow f_2 = f_1\left(\frac{1.33\,(0.5)}{0.17}\right) = 3.91\,(20)$$

→ $f_2 = \underline{78.23}$ cm → Focal length in water

(19)



Consider two polaroids P_1 & P_3 at 90° with each other.

→ Let a third polaroid P_2 be at an angle θ with polaroid P_1 as shown in figure

→ Let Unpolarised light incident on polaroid P_1. Let I_0 be intensity of polarised light between P_1 & P_2

→ ∴ Intensity of light between P_2 & P_3 can be found using Malus law

$$I_1 = I_0 \cos^2(\theta)$$

Similarly as angle between P_1 & P_2 is θ and P_1 and P_3 is 90°, the angle between P_2 and P_3 is 90 − θ.

$$\therefore I = I_1 \sin^2\theta \qquad [\cos^2(90-\theta) = \sin^2\theta]$$

∴ Finally we get :-

$$I = I_0 \cos^2\theta \sin^2\theta$$

$$= \frac{I_0}{4}(4\sin^2\theta \cos^2\theta)$$

$$I = \frac{I_0}{4}(2\sin\theta\cos\theta)^2$$

$\therefore I = \frac{I_0}{4} \sin^2(2\theta)$

$\therefore$ Maximum intensity occurs when $\theta = \pi/4$ $\boxed{I_{max} = I_0/4}$

Thus intensity of transmitted light varies with value of θ.

(21) By conservation of angular momentum

$$L = \frac{nh}{2\pi} = mvr \quad \& \quad \frac{mv^2}{\cancel{r}} = \frac{e^2}{4\pi\varepsilon_0 r^{\cancel{2}}}$$

Total energy $E = \frac{-e^2}{8\pi\varepsilon_0 r_n}$

→ Kinetic energy $= \frac{1}{2}mv^2 = -\left(\frac{-e^2}{8\pi\varepsilon_0 r_n}\right)$

$$\therefore \frac{1}{2}\frac{(mvr)^2}{mr^2} = \frac{e^2}{8\pi\varepsilon_0 r_n}$$

$$\therefore r_n = \frac{(nh/2\pi)^2 \, 8\pi\varepsilon_0}{2\,(e^2)}$$

$$\boxed{r_n = \frac{n^2h^2\varepsilon_0}{\pi e^2 m}}$$

→ Total energy $E = \frac{-e^2}{8\pi\varepsilon_0\left(\frac{n^2h^2\varepsilon_0}{\pi e^2 m}\right)}$

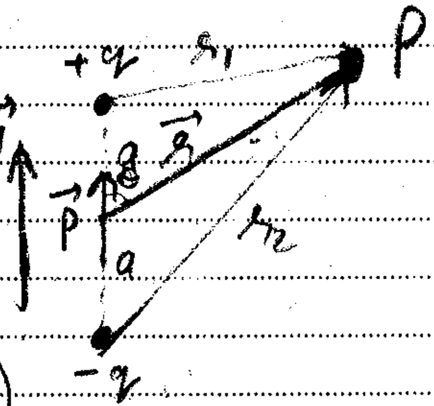
$$\boxed{E = -\frac{me^4}{8\varepsilon_0 n^2 h^2}}$$

Thus are eq^n of total energy & radius for hydrogen atom

SECTION-D

(22) → Consider a dipole as shown in figure. Let us consider a point P as shown in figure.
→ Let dipole be placed such that centre of dipole be at origin
→ Let position vector $\vec{r}$ of point P be at an angle θ with y axis as in figure
→ Let distance between +q & P be r_1 and -q & P be r_2. So we have potential at point P as

$$V_P = \frac{Kq}{r_1} - \frac{Kq}{r_2}$$



(where $K = 1/4\pi\varepsilon_0$)

$$V_P = Kq\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

Using geometry we have:-

$$r_1^2 = a^2 + r^2 - 2ar\cos\theta$$
$$r_2^2 = a^2 + r^2 + 2ar\cos\theta$$

Now taking $r >> a$ and neglecting $(a/r)^2$:-

$$r_1^2 = r^2\left(\left(\frac{a}{r}\right)^2 + 1 - 2\frac{a}{r}\cos\theta\right)$$

$$\rightarrow r_1^2 \approx r^2\left(1 - 2\frac{a}{r}\cos\theta\right)$$

Similarly $r_2^2 = r^2\left(\left(\frac{a}{r}\right)^2 + 1 + 2\left(\frac{a}{r}\right)\cos\theta\right)$

$r_2^2 \approx r^2\left(1 + 2\left(\frac{a}{r}\right)\cos\theta\right)$

Taking square root we get

$r_1 = r\left(1 - \frac{2a}{r}\cos\theta\right)^{1/2}$

$r_2 = r\left(1 + \frac{2a}{r}\cos\theta\right)^{1/2}$

$\therefore$ Using these equations to get $1/r_1 - 1/r_2$

$$\frac{1}{r_1} - \frac{1}{r_2} = \frac{1}{r\left(1 - \frac{2a}{r}\cos\theta\right)^{1/2}} - \frac{1}{r\left(1 + \frac{2a}{r}\cos\theta\right)^{1/2}}$$

$$= \frac{1}{r}\left(\left(1 - \frac{2a}{r}\cos\theta\right)^{-1/2} - \left(1 + \frac{2a}{r}\cos\theta\right)^{-1/2}\right)$$

As we have assumed $a << r$

$\therefore$ $a/r << 1$ and so we use

Binomial theorem and get

$$\frac{1}{r_1} - \frac{1}{r_2} = \frac{1}{r}\left(1 + \frac{1}{2}\left(\frac{2a\cos\theta}{r}\right) - \left(1 - \frac{1}{2}\left(\frac{2a\cos\theta}{r}\right)\right)\right)$$

$$= \frac{1}{r}\left(1 + \frac{a}{r}\cos\theta - 1 + \frac{a}{r}\cos\theta\right)$$

$$= \frac{2a\cos\theta}{r^2}$$

Thus potential at point p is given as

$$V_p = Kq\left(\frac{2a\cos\theta}{r^2}\right)$$

$\therefore V_p = \frac{K(2aq)\cos\theta}{r^2}$

$V_p = \frac{Kp\cos\theta}{r^2}$ [Using $p = 2aq$]

$$\therefore \boxed{\begin{aligned} V_p &= \frac{K\vec{p}\cdot\hat{r}}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\cdot\hat{r}}{r^2} \\ V_p &= \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2} \end{aligned}} \quad (a << r)$$

Thus the above equation gives the value of potential at point P

(a) At any point on equator the angle $\theta = \pi/2$ and so at all points on equator

$V_p = 0\,V$

→ Thus equator forms an equipotential surface with $V_p = 0\,V$

(b) At any point on axis

$V_p = \pm\frac{Kp}{r^2} = \pm\frac{p}{4\pi\varepsilon_0 r^2}$ $(r >> a)$

Here we chose '+' or '−' depending upon the angle θ.

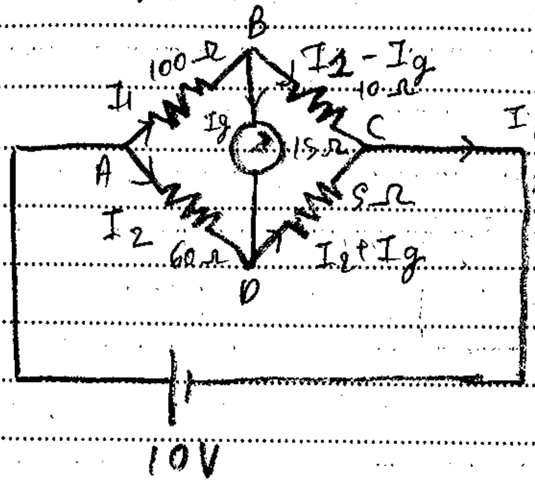
For $\theta = 0° \longrightarrow V_p = Kp/r^2$ $(r >> a)$

$\theta = 180° \longrightarrow V_p = -Kp/r^2$ $(r >> a)$

→ The potential due to dipole has an angular symmetry. If we rotate $\vec{r}$ about $\vec{p}$ the all points P on cone so obtained are equivalent to P

→ The potential of dipole drops as $1/r^2$ while of point charge drops as $1/r$

(23)



→ Let current in circuit be as shown in figure
→ Let current across galvanometer be I_g.

→ By using Kirchoff's loop rule

(i) Loop ABDA :-

$$-100 I_1 - 15 I_g + 60 I_2 = 0$$
$$20 I_1 + 3 I_g - 12 I_2 = 0 \quad \text{[Taking 5 common]}$$
$$\therefore \frac{(20 I_1 + 3 I_g)}{12} = I_2 \quad \text{— (1)}$$

(ii) Loop BCDB :-

$$-10 I_1 + 10 I_g + 5 I_2 + 5 I_g + 15 I_g = 0$$
$$-10 I_1 + 5 I_2 + 30 I_g = 0$$
$$2 I_1 - I_2 - 6 I_g = 0$$
$$\therefore I_g = \frac{(2 I_1 - I_2)}{6} \quad \text{— (2)}$$

Using eqn (1) & (2) we get

$$\frac{20 I_1 + \left(\frac{2 I_1 - I_2}{6}\right) 3}{12} = I_2$$

$$20I_1 + I_1 - \frac{I_2}{2} = 12I_2$$

$$21 I_1 = \frac{I_2}{2} + 12I_2$$

$$21 I_1 = 12.5 I_2$$

$$I_1 = \frac{12.5 I_2}{21}$$

$$\boxed{I_1 = \frac{25 I_2}{42}} \quad — (3)$$

(iii) Loop ABC-E-A :-

$$-100I_1 - 10I_1 + 10I_g + 10 = 0$$

$$-10I_1 - I_1 + I_g + 1 = 0$$

$$-11I_1 + I_g + 1 = 0 \quad — (4)$$

Using (3) & (2) :-

$$6I_g = 2I_1 - I_2$$

$$= 2I_1 - \frac{42I_1}{25}$$

$$6I_g = \frac{8I_1}{25}$$

$$I_g = \frac{4I_1}{75}$$

$\therefore$ ~~$+\frac{11(75)I_g}{4} + I_g = -1$~~

~~$277 I_g = 2$~~

Using $I_1 = 75I_g/4$ in (4) :-

$$-\frac{75(11)I_1}{4} + \frac{4I_g}{4} = -1$$

$$-\frac{821 I_g}{4} = -1$$

$$I_g = 4/821$$

$$\therefore I_g = 0.00487 A$$
$$= 4.87 mA$$

(24) $v_m = 283 V$
$f = 50 Hz$
$R = 3 \Omega$
$L = 25.48 mH.$
$C = 796 \mu F$

$\omega = 2\pi f$
$= 2\pi(50)$
$= 314 rad/s$

(a) $X_C = \frac{1}{\omega C} = \frac{1}{314(796 \times 10^{-6})} = 4.00089 \Omega$

$\approx 4 \Omega$

$X_L = \omega L = 314(25.48 \times 10^{-3})$
$= 8.00072 \Omega$
$\approx 8 \Omega$

$\therefore Z = \sqrt{R^2 + (X_C - X_L)^2}$
$= \sqrt{(3)^2 + (8-4)^2}$

$Z = \sqrt{9 + 16}$
$= \sqrt{25} = 5 \Omega$ → Impedance

(b) $\tan\phi = \frac{X_C - X_L}{R}$
$= \frac{4-8}{3} = \frac{-4}{3}$

$\phi = \tan^{-1}(-4/3) = -53^{\circ}$

$\therefore$ Voltage leads current by phase 53° and so '−' sign appears.

(c) $P = VI\cos\phi = \frac{V^2}{Z}\left(\frac{R}{Z}\right)$

$= \left(\frac{283}{\sqrt{2}}\right)^2 \left(\frac{3}{25}\right)$ $\left[I = \frac{V}{Z}\right]$

$= 4805.34\ W$

$\approx 4.8\ KW$

(d) Power factor $\cos\phi = R/Z$

$\cos\phi = R/Z$

$= 3/5$

$\cos\phi = 0.6$

(26) $P = 100\ W$

Total 2 kg of Deuterium

2 atom of deuterium $\rightarrow$ 3.27 MeV energy.

$\therefore$ Total atoms of deuterium in 2kg $N = \left(\frac{W}{M}\right) N_A$

Molar mass of deuterium $= 2\ g/mol$.

$\therefore$ Atoms total $N = \left(\frac{2000}{2}\right)(N_A)$

$= 6.023 \times 10^{26}$ atoms

Supplementary/પુરવણી

04(S) - M - 24

વિષય	054 PHYSICS
તારીખ	11/03/2024

★ અહીંથી જ લખવાનું શરૂ કરવું. ★

વિભાગ..................

પ્રશ્ન ક્રમાંક

Energy $= 3.27$ MeV
$= 5.232 \times 10^{-13}$ J

* 2 atom $\longrightarrow 5.232 \times 10^{-13}$ J
6.023×10^{26} atom $\longrightarrow$ x J

$\cancel{x = \frac{5.232 \times 10^{-13}}{6.023 \times 10^{26} \times 2} = 0.434 \times 10}$

$x = \frac{5.232 \times 10^{-13} \times 6.023 \times 10^{26}}{2}$

Total energy $= 15.75 \times 10^{13}$ J

$P = {}^{U}/_{t} \Rightarrow \boxed{t = {}^{P}/_{U}}$

$\therefore$ Time it runs 100 W bulb $= \frac{15.75 \times 10^{13}}{3.16 \times 10^{7} (100)}$

$= 4.98 \times 10^{4}$ ~~years~~ year

~~year~~

[Here we used $P = {}^{E}/_{t}$]

વિભાગ..................

પ્રશ્ન ક્રમાંક

$\therefore$ 100 W electric bulb runs for about 4.78×10^4 years

[1 year $= (365.25)(24)(3600)$
$= 3.16 \times 10^7$ s]

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