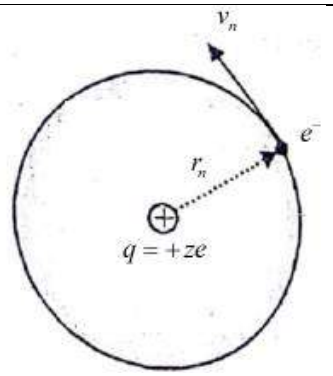
PHYSICS – BOARD EXAM – SET – 3

55/1/3

Q. NO	SOLUTION	TOTAL MARKS
	SECTION – A	
1.	(A) 1.47	
2.	(A) Red colour	
3.	(D) The stability of atom was established by the model	
4.	$\frac{KE_1}{KE_2} = \frac{1-0.5}{2-0.5} = \frac{0.5}{1.5} = 1:3 \longrightarrow (c)$	
5.	(D) Material of the turns of the coil	
6.	(C) decrease in relaxation time	
7.	(C) p.d. across the bigger resistor is greater	
8.	(D) $\frac{F}{8}$	
9.	(A) no net charge is enclosed by the surface	
10.	(B) lesser than the focal length of eyepiece	
11.	Four	
12.	Integral **OR** Nucleons	
13.	$\sqrt{3}$	
14.	Attracted	

15.	Eddy	
16.	$\frac{R_2}{R_1} = \left(\frac{A_2}{A_1}\right)^{\frac{1}{3}} \Rightarrow R_2 = 3.6\left(\frac{64}{27}\right)^{\frac{1}{3}} = 3.6 \times \frac{4}{3}$ $= 4.3$ Fermi **OR** $\frac{\lambda_p}{\lambda_e} = \frac{\frac{h}{m_p v_p}}{\frac{h}{m_e v_2}} = \frac{m_p}{m_e} \times \frac{v_p}{v_e} = \frac{1.67 \times 10^{-27}}{9.1 \times 10^{-31}} = 1.8 \times 10^{23}$	
17.	M_2 has greater value of work function due to higher value of threshold frequency.	
18.	LEDs must have band gap in the order of 1.8 eV to 3 eV but Si & Ge have band gap less than 1.8 eV so these cannot be used to fabricate LEDs.	
19.	Conduction current is established by actual movement of free electrons through a metallic conductor while displacement current is established by polarization of molecules of a dielectric under the influence of an external electric field.	
20.	Decreases.	
	SECTION – B	
21.	Depletion layer: It is a layer of immobile ions formed near the p-n junction by diffusion of majority charge carriers and electron-hole recombination. Potential barrier: It is the potential difference developed across the junction when diffusion current & drift current attains equilibrium across the junction. (a) When forward biased, width of depletion layer decreases. (b) And value of barrier potential also reduces as $v_0 - v$.	

22.



Centripetal force = Electrostatic attraction between nucleus & e^-

$$\Rightarrow \quad \frac{mv_n^2}{r_n} = \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{(ze)(e)}{r_n^x}$$

$$\Rightarrow \quad mv_n^2 r_n = \frac{ze^2}{4\pi\varepsilon_0} \qquad \ldots (1)$$

By Bohr II postulali,

Angular momentum of e^-

$$mv_n r_n = \frac{nh}{2\pi} \qquad \ldots (2)$$

$$(1) \div (2) \Rightarrow \frac{mv_n^2 r_n}{mv_n r_n} = \left(\frac{ze2}{4\pi\varepsilon_0}\right) \times \frac{2\pi}{rh}$$

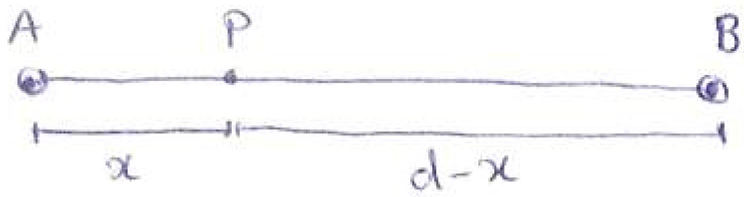
$\Rightarrow$ speed of $e^- \Rightarrow v_n = \dfrac{ze^2}{2\varepsilon_0 nh}$

OR

Emission of photoelectrons is a phenomenon that is excited externally by incidence of photons on metal surface to provide necessary energy to eject e^- from metal.

Emission of β^- particles is totally spontaneous in which no external excitation is involved. An unstable nucleus emits an e^- (β particle) to become stable. Also, in photoelectron emission, radiation energy is absorbed by metal atoms while in β-particle emission, radiation energy is released.

23.



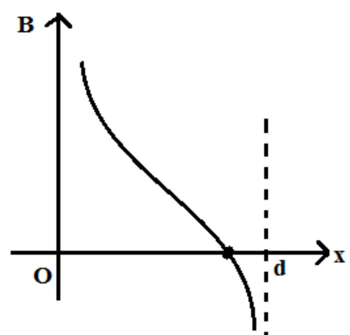
$$\dot{B_P} = \dot{B_A} + \dot{B_B} = \frac{\mu_0 I}{2\pi x}\text{(upwards)} + \frac{\mu_0 I}{2\pi(fx)}\text{(down)}$$

$$= \frac{\mu_0 I}{2\pi}\left[\frac{1}{x} - \frac{1}{d-x}\right]$$

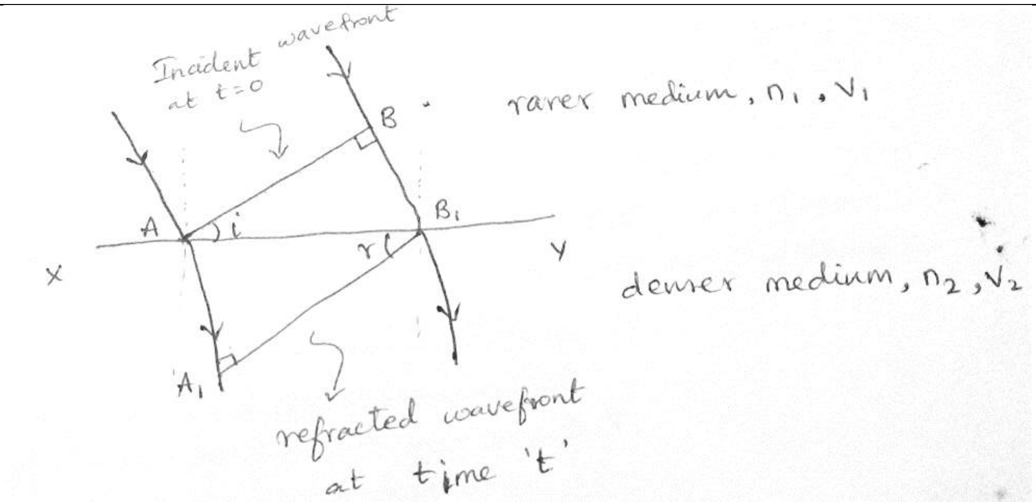
$$= \frac{\mu_0 I}{2\pi}\left[\frac{d-x-x}{x(d-x)}\right] = \frac{\mu_0 I}{2\pi}\left(\frac{d-2x}{x(d-x)}\right)\text{upwards}$$

As $B_A > B_B$

(b)



24. Wavefront: It is a locus of all the disturbances oscillating with energy in same phase at a given instant.



A plane wavefront AB is incident in rarer medium at instant t = 0 on interface XY separating it from a denser medium. When wavelet A is on interface, B is at a distance BB, from it. It takes t time to cover the distance $BB_1 = v_1 t$ to reach on interface XY. Mean while, the wavelet from A reaches to point A_1 covering a distance $AA_1 = v_2 t$ in denser medium.

To locate A_1, draw a secondary wavelet with radius $AA_1 = v_2 t$ & centre A. Draw tangent from B, onto this sec. wavelet intersecting at A_1.

A_1B_1 is refracted wavefront at instant t.

$i =$ angle of incidence

$r =$ angle of refraction.

$$\therefore\ \Delta ABB_1 \Rightarrow \sin i = \frac{BB_1}{AB_1}$$

$$\Delta AA_1B_1 \Rightarrow \sin r = \frac{AA_1}{AB_1}$$

$$\therefore \quad \frac{\sin i}{\sin r} = \frac{BB_1}{AA_1} = \frac{v_1 t}{v_2 t} = \frac{v_1}{v_2}$$

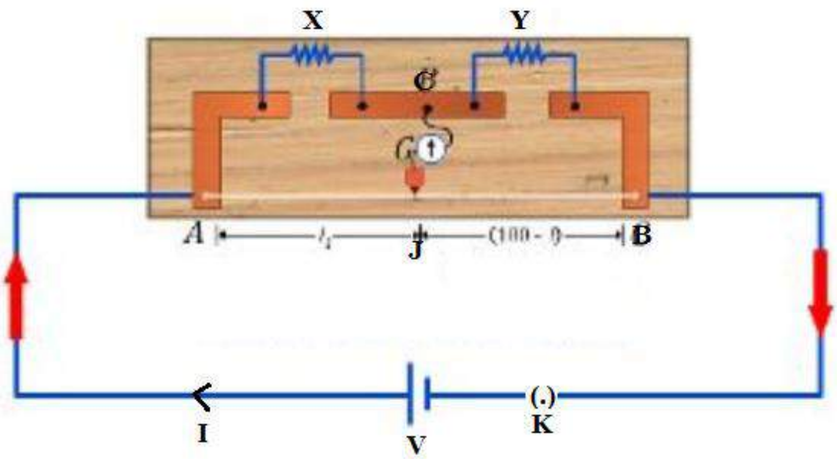
$$\therefore \quad \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \text{constant}$$

Which is Snell's law.

OR

Ace to lens maker's formula

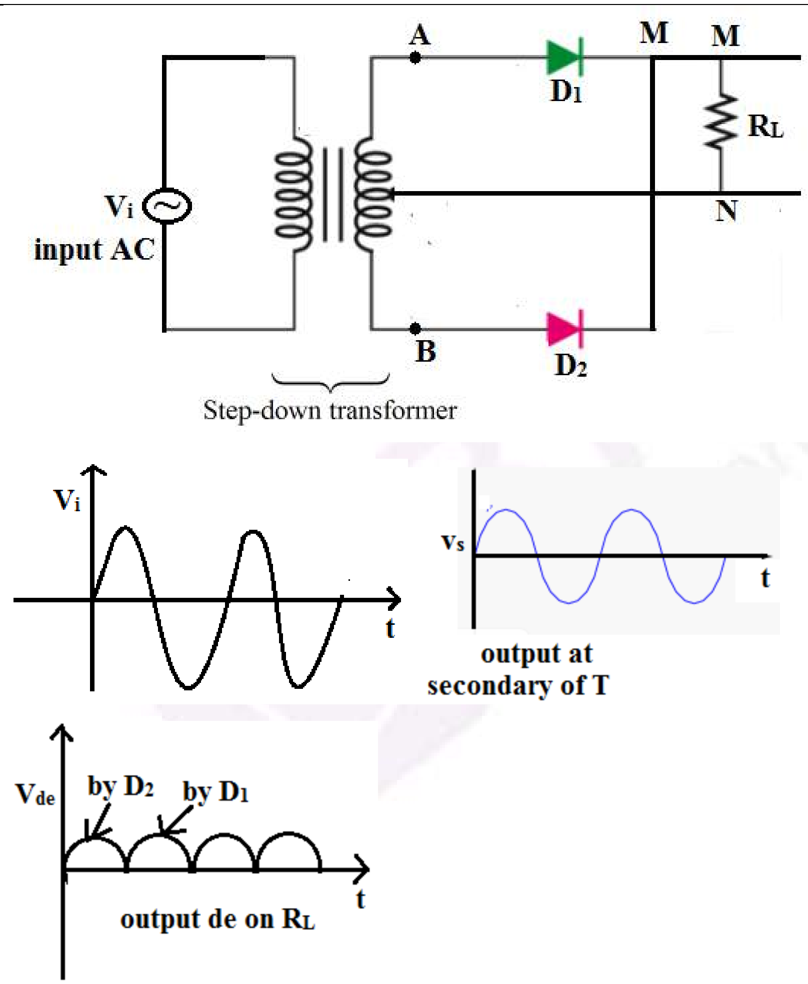
	$\frac{1}{v}-\frac{1}{u}=(n_{21}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ … (1) When object is at placed at infinity, $u=\infty$ Image is obtained at focus $v=f$ Using these values in Eq (1) $\frac{1}{f}-\frac{1}{\infty}=(n_{21}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ $\Rightarrow \frac{1}{f}=(n_{21}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ … (2) $\therefore$ By Eq (1) & (2) $\Rightarrow$ $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$	
25.	Half-life: It is the time interval after which the activity of a radioactive sample reduces to half of initial value. $\because$ $R=\lambda N$ $\Rightarrow$ $\frac{R_1}{R_2}=\frac{\lambda_1}{\lambda_2}\times\frac{N_1}{N_2}$ $\because$ $\lambda=\frac{0.693}{T_{\frac{1}{2}}}\Rightarrow\frac{\lambda_1}{\lambda_2}=\frac{T_2}{T_1}$ $\therefore$ $\frac{R_1}{R_2}=\frac{T_2}{T_1}\times\frac{N_1}{N_2}$	
26.	$C_1=\frac{K\varepsilon_0 A}{d}$ $C_2=$ parallel combination of two capacitors $=\frac{K_1\varepsilon_0\left(\frac{A}{2}\right)}{d}+\frac{K_2\varepsilon_0\left(\frac{A}{2}\right)}{d}$	

	$=\dfrac{\varepsilon_0 A}{2d}(K_1+K_2)$ $\because C_1=C_2 \Rightarrow K=\dfrac{K_1+K_2}{2}$	
27.	Meter bridge works on the condition of balanced wheatstone bridge condition.  X = Unknown resistance Y = known resistance $l=$ balancing length Then $X=Y\dfrac{l}{100-l}$	
	SECTION – C	
28.	(a) $v=\dfrac{1}{\sqrt{\mu_0\mu_r\varepsilon_0\varepsilon_r}}=\dfrac{c}{\sqrt{\mu_r\varepsilon_r}}$ (b) (i) Microwaves 10^{-1} to 10^{-3} $m=\lambda$ (ii) Infrared $10-4$ *to* 10^{-6} $m=\lambda$ $(>700\,nm)$	
29.	(a) Due to redistribution of light energy because of interference of light which undergo constructive & destructive interference at difference points.	

(b) The polaroid molecule absorb and retransmit only those light vectors which are incident parallel to their pass axis. Hence, light beyond polaroid is obtained with reduced intensity.

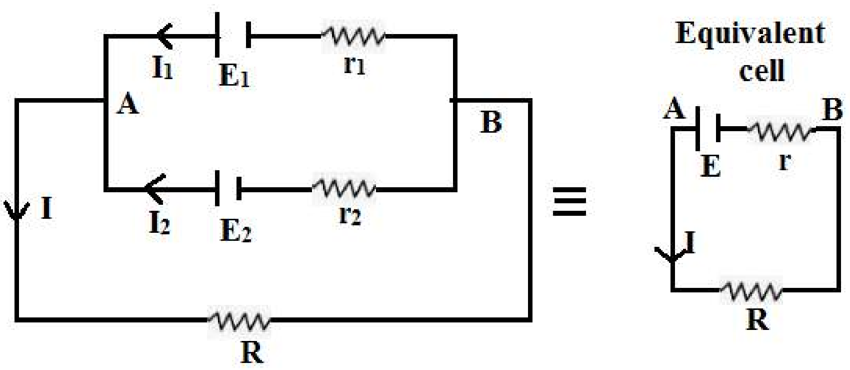
(c) White light has different component with different wavelength & hence all components undergo constructive interference at the central position to give white maximum but around it the positions of destructive interference for one component is overlapped by constructive component of other colour. Hence coloured fringes are observed around the central maximum.

30.



For +ve half cycle of AC input, terminal A or transformer T will be as low voltage relative centre tap terminal C & B at high voltage. So, D_1 will be reverse biased & D_2 will be forward biased. Diode D_2 conducts to give an output across R_L through M. For –ve half cycle of input AC, A will be at high voltage & B will be at low voltage to make D_1 forward and D_2 reverse biased. D_1 conducts to give an output across R_L with same polarity.

31. (a)



Potential difference across A & B

$$V = V_A - V_B = E_1 - I_1 r_1 \qquad \ldots (1)$$

$$V = V_A - V_B = E_2 - I_2 r_2 \qquad \ldots (2)$$

$$\Rightarrow \qquad I_1 = \frac{E_1}{r_1} - \frac{V}{r_1} \qquad \ldots (3) \quad \text{(from (1))}$$

$$I_2 = \frac{E_2}{r_2} - \frac{V}{r_2} \qquad \ldots (4) \quad \text{(from (2))}$$

For Equivalent cell $I = \frac{E}{r} - \frac{V}{r}$ … (5)

$$\because \qquad I = I_1 + I_2$$

$$\therefore \qquad \frac{E}{r} - \frac{V}{r} = \left(\frac{E_1}{r_1} - \frac{V}{r_1}\right) + \left(\frac{E_2}{r_2} - \frac{V}{r_2}\right)$$

$$= \left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

Comparing we get $\frac{1}{r} = \frac{1}{r_1} + \frac{1}{r_2}$

$\therefore$ Equivalent internal resistance is

$$r = \frac{r_1 r_2}{r_1 + r_2}$$

Also $\frac{E}{r} = \frac{E_1}{r_1} + \frac{E_2}{r_2} = \frac{E_1 r_2 + E_2 r_1}{r_1 r_2}$

$\therefore$ Equivalent emf is

$$E = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$$

(b)

$$E = \frac{5\times 2 + 5\times 2}{2+2} = 5\,\text{V}$$

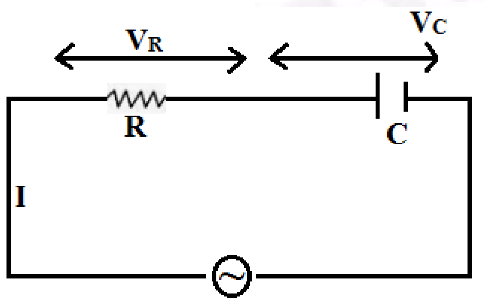
$$r = \frac{2\times 2}{2+2} = 1r$$

$$I = \frac{E}{R+r} = \frac{5}{10+1} = \frac{5}{11}A$$

$\therefore$ Voltage across $R \Rightarrow V = IR = \frac{5}{11}\times 10 = \frac{50}{11}V = 4.54V$

32. (a) $z = \sqrt{R^2 + X_C^2}$ = impedance

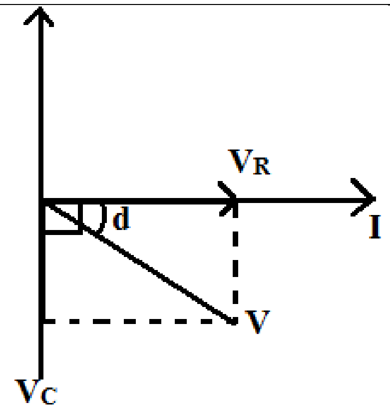
$$\therefore\ I = \frac{V}{Z} = \frac{v_1 \sin\omega t}{\sqrt{R^2 + X_C^2}}$$



$$v = v_0 \sin\omega t$$

$V_R = IR,$ $V_C = IX_C$

In phase of 1 lags I by $\frac{\pi}{2}$



$$V = \sqrt{V_R^2 + V_C^2}$$

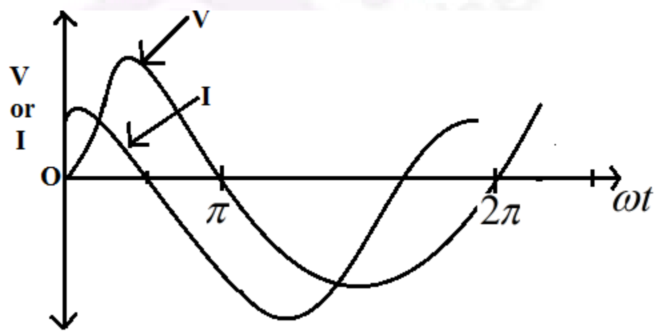
$$= \sqrt{(IR)^2 + (IX_C)^2}$$

$$\Rightarrow \qquad I = \frac{V}{\sqrt{R^2 + X_C^2}} = \frac{r_0 \sin \omega t}{\sqrt{R^2 + X_C^2}}$$

$\phi =$ phase diff bet V & I

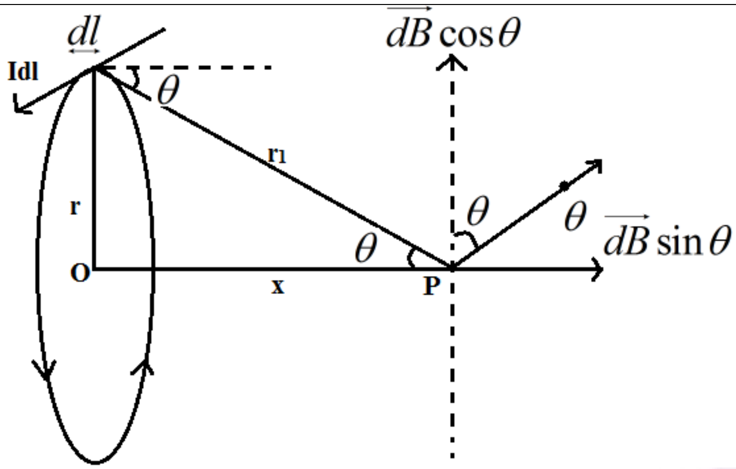
$$\tan \phi = \frac{V_C}{V_R} = \frac{X_C}{R}$$

(b)



33. (a) Magnetic moment $\overrightarrow{M} = Ni\left(\pi r^2\right)\hat{n}$

(b)



Magnetic field at point P(x, 0, 0) due to $I\overrightarrow{dl}$

$$\overrightarrow{dB} = \frac{\mu_0}{4\pi}\frac{Idl\sin 90^\circ}{r_1^2} \text{ along PQ}$$

For entire coil $\int \overrightarrow{dB}\cos\theta = 0$

$$\therefore \quad \vec{B} \text{ at P} \Rightarrow B = \int dB\sin\theta = \frac{\mu_0 I \sin R}{4\pi R^2}\int_0^{2\pi r} dl$$

$$= \frac{\mu_0 I}{4\pi r_1^2} \times \frac{r}{r_1} \times (2\pi r)$$

$$\Rightarrow \quad \vec{B} = \frac{\mu_0 I r^2}{2\left(r^2+x^2\right)^{\frac{3}{2}}}\hat{i}$$

Coil has N turns then

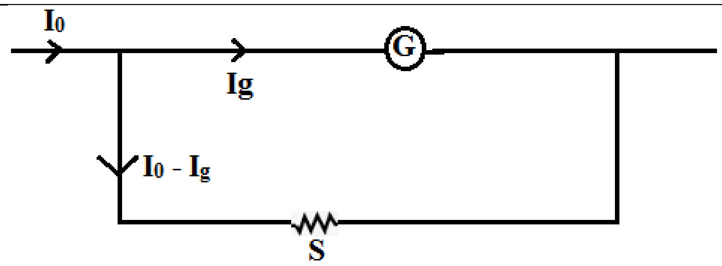
$$\vec{B} = \frac{\mu_0 INr^2}{2\left(r^2+x^2\right)^{\frac{3}{2}}}\hat{i}$$

(OR)

(a) Current sensitivity: It is defined as the amount of deflection produced per unit magnitude of current passes.

$$C_S = \frac{\phi}{I} \text{ or } C_S = \frac{NAB}{\mu_r}$$

(b) (i)



(G) can be converted into an ammeter by connected a small stunt resistance parallel to (G) coil so that

$$IgG = \left(I_0 - I_g\right)S$$

$$\therefore \qquad S = \frac{IgG}{I_0 - I_g}$$

(ii) Effective resistance of (A) $\Rightarrow \dfrac{GS}{G+S}$

34. The binding energies per nucleon of the parent nucleus, the daughter nucleus and α-particle are 7.8 MeV, 7.835 MeV and 7.07 MeV, respectively. Assuming the daughter nucleus to be formed in the unexcited state and neglecting its share in the energy of the reaction, find the speed of the emitted α-particle. (Mass of α-particle $= 6.68 \times 10^{-27}$ kg)

Energy released = Q = 7.835 × 231 + 7.07 × 4 – 7.8 × 235

$$\Rightarrow Q = 1809.885 + 28.28 - 1833$$

$$= 5.165\, MeV$$

$$= 5.165 \times 1.6 \times 10^{-13}\, J$$

This energy will be taken away by $\alpha-$particle as kinetic energy.

$$\therefore \qquad \frac{1}{2}mv^2 = Q$$

$\Rightarrow$ Speed of $\alpha-$particle

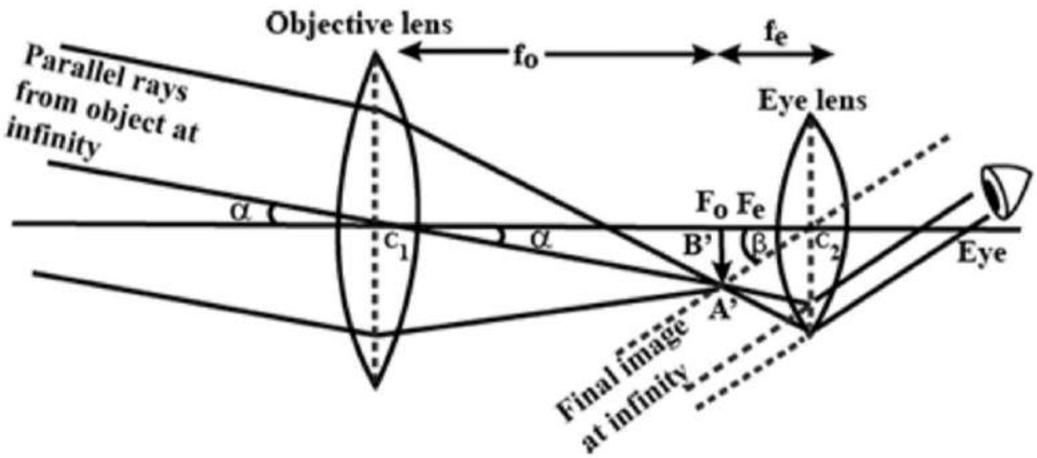
$$v = \sqrt{\frac{5.165 \times 1.6 \times 10^{-13} \times 2}{6.68 \times 10^{-27}}}$$

$$= \sqrt{\frac{16.528}{6.68} \times 10^{14}} = \sqrt{2.474} \times 10^{7}$$

$$= 1.573 \times 10^{7}\ \text{m/s}$$

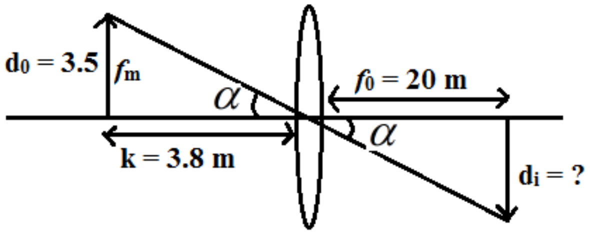
SECTION – D

35. (a)



Resolving power $= \dfrac{D}{1.22\lambda}$

(b) (i) $m = -\dfrac{f_0}{f_e} = -\dfrac{20}{10-2} = -2000$

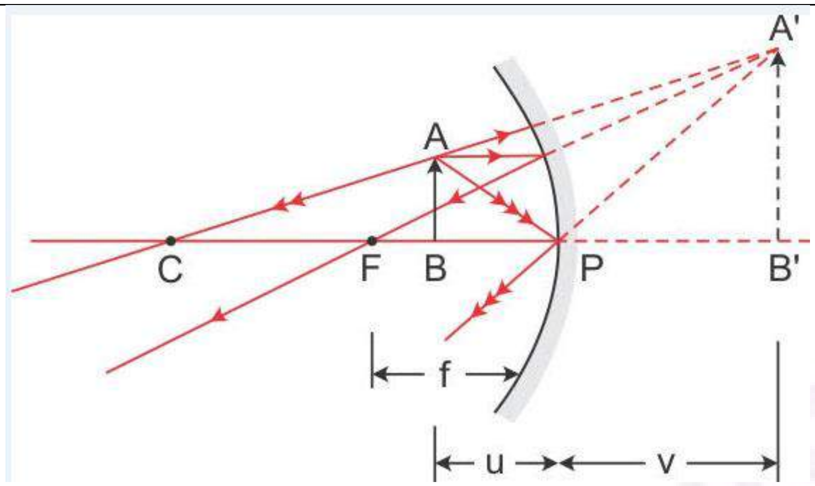


$\tan\alpha = \dfrac{d_0}{u} = \dfrac{di}{f_0}$

$\Rightarrow d_i = \dfrac{3.5\times10^6}{3.8\times10^8}\times 20 = 0.18m$

(OR)

(a)



$$\Delta ABC \sim \Delta A_1B_1C \Rightarrow \frac{A_1B_1}{AB} = \frac{A_1C}{AC} = \frac{(+v)+(-R)}{(-R)-(-u)} \quad \ldots (1)$$

$$\Delta ABP \sim \Delta A_1B_1P \Rightarrow \frac{A_1B_1}{AB} = \frac{A_1P}{AP} = \frac{+v}{-u} \quad \ldots (2)$$

$$(1) = (2) \Rightarrow \frac{v-R}{-R+u} = \frac{v}{-u}$$

$$\Rightarrow \quad -uv + uR = -vR + uv$$

$$\Rightarrow \quad uR + vR = 2uv$$

$$\div \text{ by } uvR \Rightarrow \frac{1}{v} + \frac{1}{u} = \frac{2}{R}$$

$$\because \quad R = 2f \quad \therefore \frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

(b) $$\frac{1}{f} = (1.5-1)\left(\frac{1}{20} - \frac{1}{\infty}\right) = \frac{0.5}{20} = \frac{5}{200} = \frac{1}{40}$$

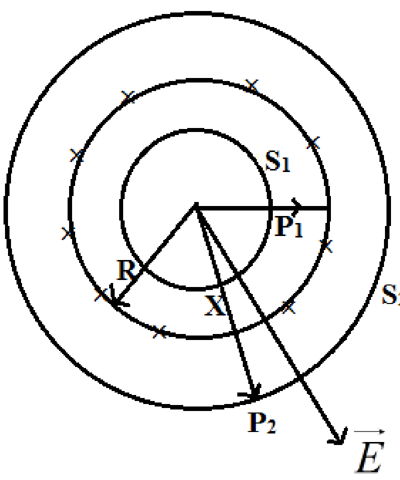
$$\therefore \; f = 40 \text{ cm}$$

Now $\frac{1}{f}=\frac{1}{v}-\frac{1}{u} \Rightarrow v=\frac{fu}{f+u}=\frac{40\times -30}{40-30}$

$\Rightarrow v=\frac{-40\times 30}{10}=-120\,cm$

Image is virtual, erect and enlarged in front of lens 120 cm away.

36. (a)



S_1 & S_2 are two Gaussian spheres respectively for points

$P_1(x<R)$ & $P_2(x>R)$

(i) By Gauss law,

Net outward flux through S_1

$\phi=\oint_{S_1}\vec{E}.\vec{dA}=\frac{q_1}{\varepsilon_0} \rightarrow$ charge enclosed by $S_1=-0$

$\Rightarrow E=0$

(ii) Net outward flux through S2

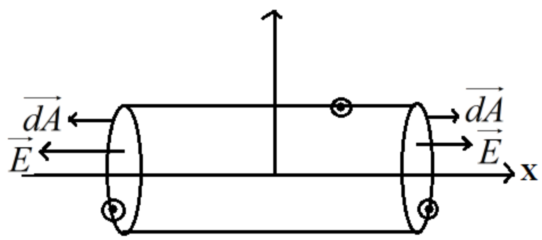
$\phi=\oint_{S_2}\vec{E}.\vec{dA}=\frac{q_2}{\varepsilon_0} \rightarrow$ charge enclosed by $S_1=\sigma\left(4\pi R^2\right)$

$\Rightarrow E\oint_{S_2}dA=\frac{\sigma\left(4\pi R^2\right)}{\varepsilon_0}$

$\because \quad \oiint_{S_2} dA = 4\pi x^2 \Rightarrow E = \frac{\sigma\left(4\pi R^2\right)}{\left(4\pi r^2\right)\varepsilon_0}$

$\Rightarrow E = \frac{\sigma R^2}{\varepsilon_0 x^2}$

(b)



(i) $d = d_1 + d_2 + d_3$

$= E\left(\pi r^2\right) + E\left(\pi r^2\right) + 0$

$= 2E\pi r^2$

$= 2\times 200\times 3.14\times\left(5\times 10^{-2}\right)^2$

$= 31400\times 10^{-4} = 3.14\ N - \frac{m^2}{C}$

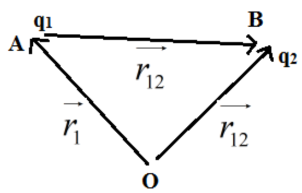
(ii) Net charge $q = d\varepsilon_0$

$q = 3.14\times 8.854\times 10^{-12}$

$= 27.8\times 10^{-12} C$

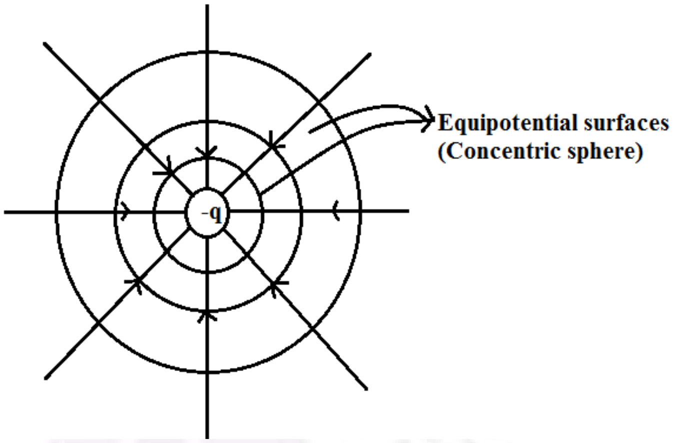
(OR)

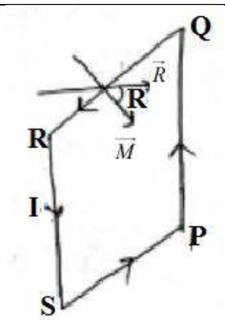
(a)



$r_{12} = |\dot{r}_{12}| = |\dot{r}_2 - \dot{r}_1|$

Work done to bring q_1 from ∞ in electric field

	$\vec{E_1} \Rightarrow W_1 = q_1 V\left(\vec{r_1}\right)$ Work done to bring q_2 in field $\overrightarrow{E_K}$ & of field of q_2 $W_2 = q_2 V\left(\vec{r_2}\right) + \frac{kq_1 i_2}{r_{12}}$ ∴ Potential energy of system $U = W_1 + W_2 = q_1 V\left(\vec{r_1}\right) + q_2 V\left(\vec{r_2}\right) + \frac{kq_1 q_2}{\lvert \vec{r_2} - \vec{r_1} \rvert}$ (b)  (c) W = Energy of system $= U_{12} + U_{13} + U_{23}$ $= \frac{k}{r}\left(q_1 q_2 + q_2 q_3 + q_1 q_3\right)$ $= \frac{9\times10^{9}}{10\times10^{-2}}\left(\left(+1\right)\times\left(-1\right)+\left(+1\right)\left(+2\right)+\left(-1\right)\left(+2\right)\right)\times10^{-12}$ $= 9\times10^{-2}\left(-1+2-2\right) = -0.09J$	
37.	(a)	



$PQ = RS = l$

$PS = QR = b$

Area A $= lb$

$\vec{M} \times I\vec{A}$

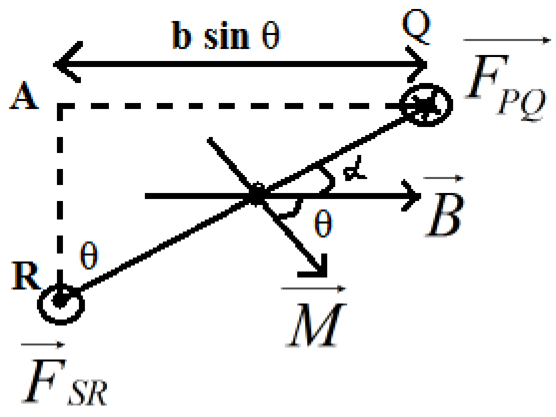
$\overrightarrow{F_{PQ}} = IlB \otimes$

$\overrightarrow{F_{RS}} = IlB\Theta$

$\overrightarrow{F_{QR}} = IbB\sin(90° - \theta) = IbB\cos\theta$ up

$\overrightarrow{F_{SP}} = IbB\sin(90° - \theta) = IbB\cos\theta$ down

Only $\overrightarrow{F_{PB}}$ & $\overrightarrow{F_{RS}}$ form a couple to apply torque on loop



$\tau = F_{PQ}(AQ) = (IlB)(B\sin\theta)$

$$= I\left(lb\right)B\sin\theta$$

$$\Rightarrow \ \tau = MB\sin\theta$$

Magnetic field is taken radial in Galvanometer coil in order to create $\theta = 90°$ at every orientation of coil in the magnetic field so that current varies linearly with deflection.

(b) $qV = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2qV}{m}}$

$$\because \vec{v} = vi \perp \vec{B}\left(= Bj\right)$$

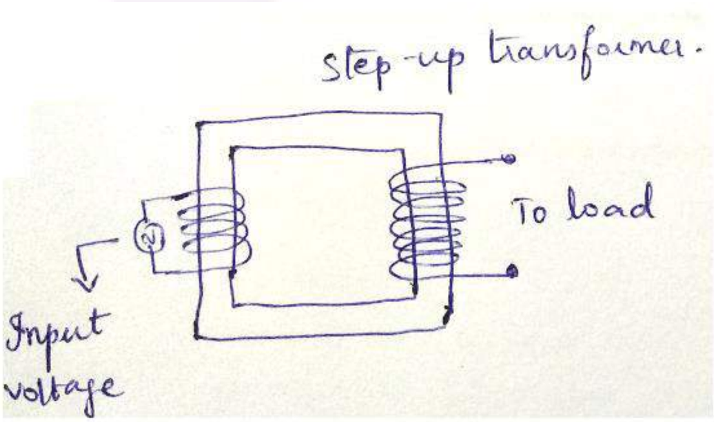
$\therefore$ Particle deflects along circular path of radius $r = \frac{mv}{qB} = \frac{m}{qB}\sqrt{\frac{2qv}{m}} = \frac{1}{B}\sqrt{\frac{2mv}{q}}$

$$r = \frac{1}{2\times10^{-3}}\sqrt{\frac{2\times6.4\times10^{-27}\times10^{4}}{2\times1.6\times10^{-19}}}$$

$$= \frac{1}{2\times10^{-3}}\times2\times10^{-2} = 10^{1}m = 10\,m$$

(OR)

(a)



AC voltage v_i is applied at primary P of transformer (with turns N_P).

By self induction, pot diff developed is

$$e_P = -N_P \frac{d\phi}{dt} = v_i$$

Also, by mutual induction, pot diff developed in secondary (turns N_S)

$$e_S = -N_S \frac{d\phi}{dt} = v_0 = \text{output AC voltage}$$

Here $\frac{d\phi}{dt} =$ time rate of charge of magnetic flux of each turn

$$\therefore \frac{e_S}{e_S} = \frac{N_S}{N_P} = \frac{v_0}{v_i}$$

(i) Core is laminated to block or minimize the paths of eddy currents to minimize heat loss against resistance of core.

(ii) Thick copper wire is used in order to reduce the resistance of transformer coil to minimize heat loss.

(b) (i) $F = ilB = \left(\frac{Blv}{R}\right) lB = \frac{B^2 l^2 v}{R}$

$$= \frac{(0.4)^2 \times (20\times10^{-2})^2 \times (10\times10^{-2})}{0.1}$$

$$= 640\times10^{-4+2+1} = 6.4\times10^{-3}\,N$$

(ii) Power = $P = Fv = \frac{B^2 l^2 v^2}{R}$

$$= 6.4\times10^{-3}\times10\times10^{-2}$$

	$= 6.4\times10^{-4}$ watt	