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1. A battery of emf E and internal resistance r is connected to an external circuit. The potential drop within the battery is proportional to :

(a) current in the circuit ✓
(b) total resistance of the circuit
(c) emf of the battery
(d) power dissipated in the circuit

2. The momentum of a photon of wavelength λ is :

(a) $\frac{h\lambda}{c^2}$
(b) $\frac{h\lambda}{c}$
(c) $\frac{h}{\lambda}$ ✓
(d) zero

3. Two thin long parallel wires A and B are separated by a distance r and carry current I each in the same direction. The force per unit length exerted by A on wire B is :

(a) $\frac{\mu_0 I}{2r}$, attractive
(b) $\frac{\mu_0 I^2}{2\pi r}$, repulsive
(c) $\frac{\mu_0 I^2}{2\pi r}$, attractive ✓
(d) $\frac{\mu_0 I}{2\pi r}$, repulsive

4. Two wires of equal length and radii r and 2r are connected in series. Their resistivities are 2ρ and ρ respectively. For the same current passing through the combination, the potential drop across their ends will be in the ratio of :

(a) 2 : 1
(b) 1 : 2
(c) 4 : 1
(d) 8 : 1 ✓

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5. A capacitor is charged by a battery. Between the plates, during process of charging :

(a) only displacement current exists.

(b) only conduction current exists.

(c) both displacement current and conduction current exist.

(d) no current exists.

6. In the wave picture of light, the intensity I of light is related to the amplitude A of the wave as :

(a) $I \propto \sqrt{A}$

(b) $I \propto A$

(c) $I \propto A^2$

(d) $I \propto \frac{1}{A^2}$

7. For the forward biasing of a p-n junction diode, which of the following statements is *not* correct ?

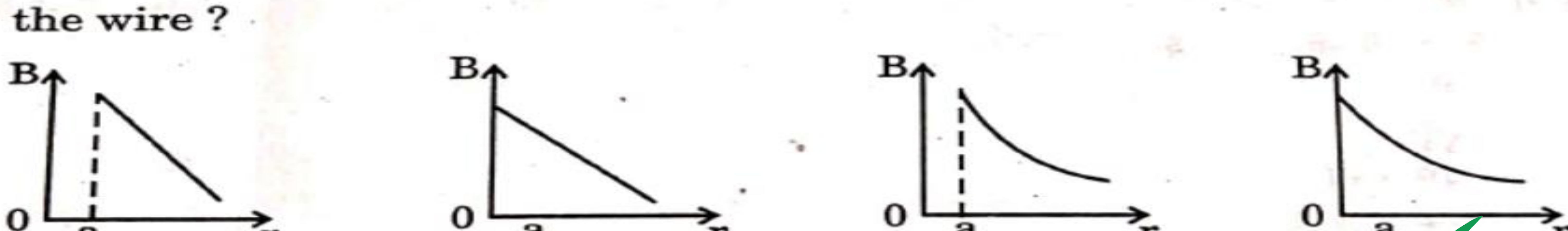
(a) The potential barrier decreases.

(b) Minority carrier injection occurs.

(c) Width of depletion layer increases.

(d) Forward current is due to the diffusion of both holes and electrons.

8. Which of the following graphs correctly represents the variation of the magnitude of the magnetic field outside a straight infinite current carrying wire of radius 'a', as a function of distance 'r' from the centre of the wire ?



(a) (b) (c) (d)

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9. Light of frequency $6{\cdot}4 \times 10^{14}$ Hz is incident on a metal of work function 2·14 eV. The maximum kinetic energy of the emitted electrons is about :

(a) 0·25 eV

(b) ✓ 0·51 eV

(c) 1·02 eV

(d) 0·10 eV

10. A voltage signal is described by :

$$v = V_0 \quad \text{for } 0 \le t \le \frac{T}{2}$$
$$= 0 \quad \text{for } \frac{T}{2} \le t \le T$$

for a cycle. Its rms value is :

(a) ✓ $\frac{V_0}{\sqrt{2}}$

(b) V_0

(c) $\frac{V_0}{2}$

(d) $\sqrt{2}\ V_0$

11. At a certain temperature in an intrinsic semiconductor, the electrons and holes concentration is $1{\cdot}5 \times 10^{16}$ m^{-3}. When it is doped with a trivalent dopant, hole concentration increases to $4{\cdot}5 \times 10^{22}$ m^{-3}. In the doped semiconductor, the concentration of electrons (n_e) will be :

(a) 3×10^{6} m^{-3}

(b) 5×10^{7} m^{-3}

(c) ✓ 5×10^{9} m^{-3}

(d) $6{\cdot}75 \times 10^{38}$ m^{-3}

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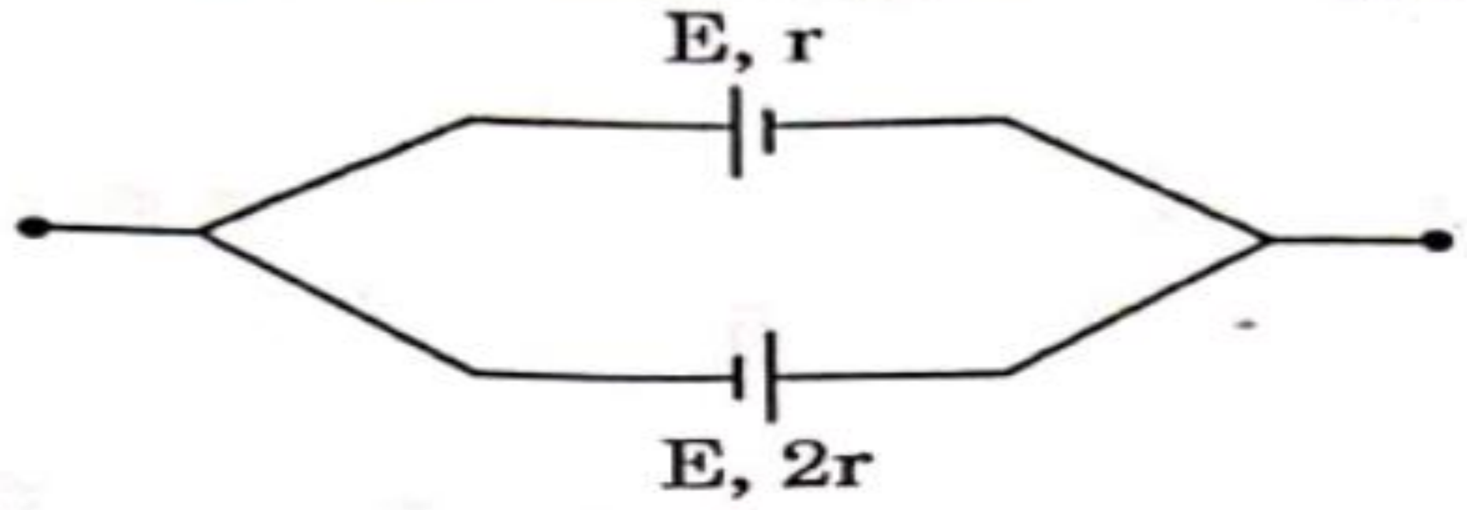
12. In a single-slit diffraction experiment, the width of the slit is halved. The width of the central maximum, in the diffraction pattern, will become :
(a) half
(b) twice ✔
(c) four times
(d) one-fourth

13. The ratio of maximum frequency and minimum frequency of light emitted in Balmer series of hydrogen spectrum, in Bohr's model is :
(a) $\frac{11}{9}$
(b) $\frac{9}{5}$ ✔
(c) $\frac{11}{7}$
(d) $\frac{16}{7}$

14. Two cells of emf E each and internal resistances r and 2r are connected in parallel as shown in the figure. The equivalent emf of the combination is :



(a) zero
(b) $\frac{E}{2}$
(c) $\frac{E}{3}$ ✔
(d) E

15. An inductor, a capacitor and a resistor are connected in series across an ac source of voltage. If the frequency of the source is decreased gradually, the reactance of :
(a) both the inductor and the capacitor decreases.
(b) inductor decreases and the capacitor increases. ✔
(c) both the inductor and the capacitor increases.
(d) inductor increases and the capacitor decreases.

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*Questions number **16** to **18** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

16. *Assertion (A):* The nucleus $^{7}_{3}X$ is more stable than the nucleus $^{4}_{3}Y$. D

Reason (R): $^{7}_{3}X$ contains more number of protons.

17. *Assertion (A) :* The internal resistance of a cell is constant. A

Reason (R) : Ionic concentration of the electrolyte remains same during use of a cell.

18. *Assertion (A) :* When radius of a circular loop carrying a steady current is doubled, its magnetic moment becomes four times. A

Reason (R): The magnetic moment of a circular loop carrying a steady current is proportional to the area of the loop.

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19. Explain the property of a p-n junction which makes it suitable for rectifying alternating voltages. Differentiate between a half-wave and a full-wave rectifier. 2

(19) Section-B

Ans: P-n junction has specific working in forward and reverse bias. It allows to flow current in forward (+ve half cycles) while it does not pass current in reverse bias (−ve half cycle). (1)

Half wave rectifier	Full wave rectifier
1) It consist of single diode which work only in positive half cycle.	1) It consist of two diode which can work in both forward and reverse bias.
2) It gives 40.6 %. efficiency	2) It gives 81.2 %. efficiency

20. (a) Draw a graph showing the variation of binding energy per nucleon as a function of mass number A. The binding energy per nucleon for heavy nuclei (A > 170) decreases with the increase in mass number. Explain. 2

OR

(b) Using Bohr's postulates, obtain the expression for radius of n^{th} stable orbit in a hydrogen atom. 2

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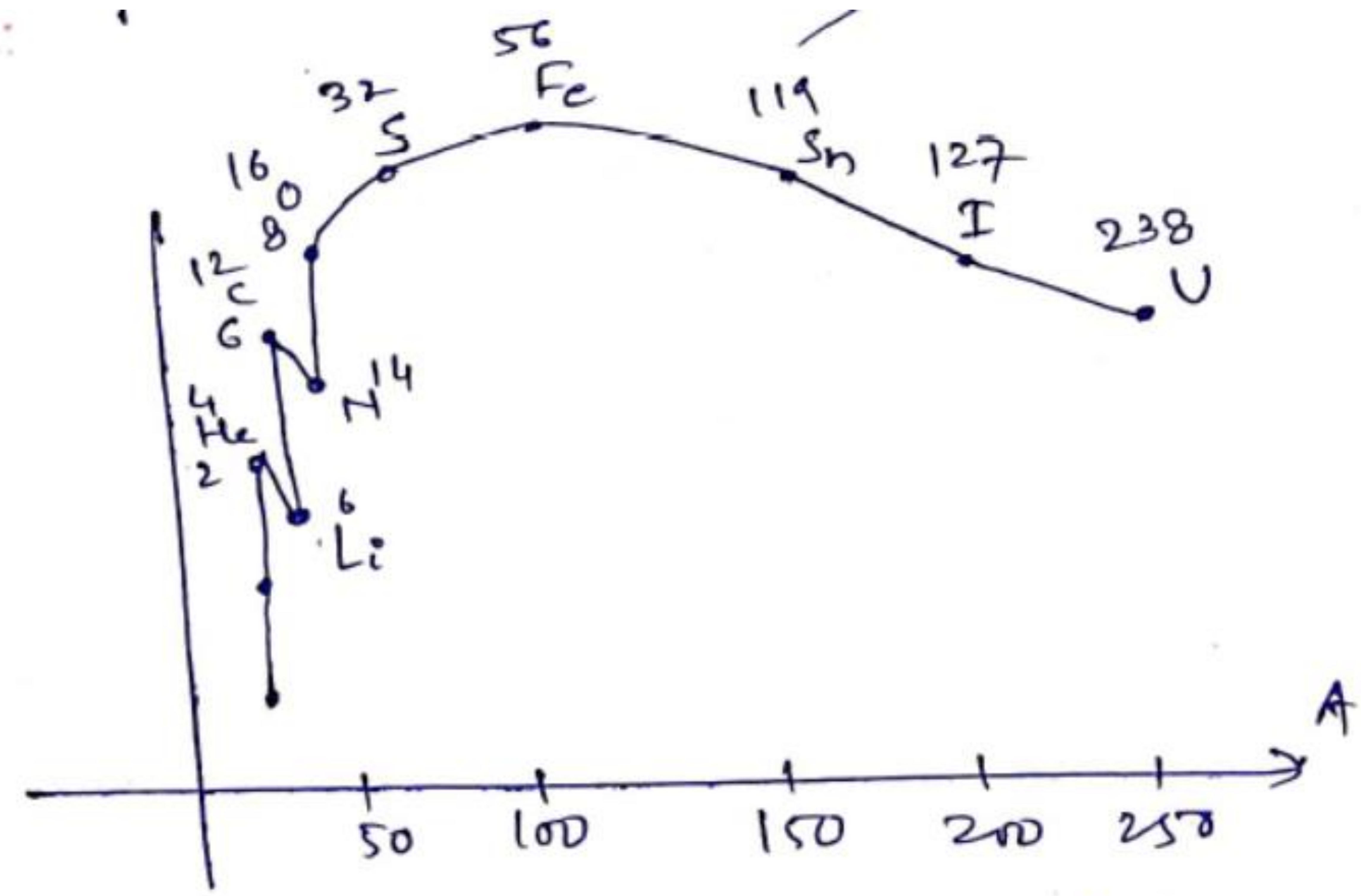
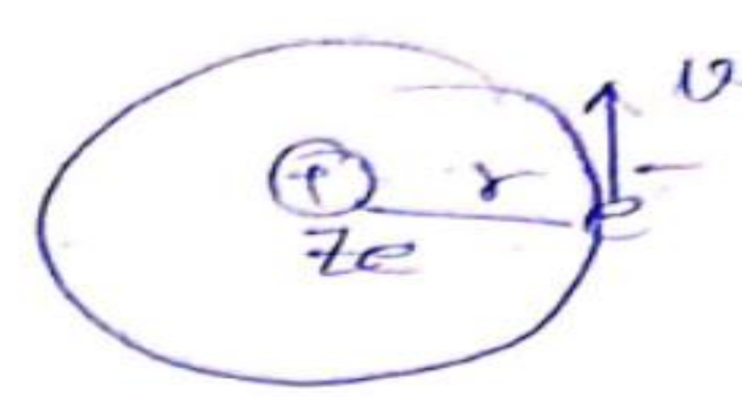
(a)



Explanation: For heavy nuclei (A > 170) B.E/A decreases because number of neutron is greater than proton.

(b) According to Bohr's model –

(2)



$F_{electrostatic} = F_{centripetal}$

$\frac{1}{4\pi\epsilon_0}\frac{Ze \cdot e}{r^2} = \frac{mv^2}{r}$

$\frac{KZe^2}{r} = mv^2 \quad \left\{\because \frac{1}{4\pi\epsilon_0} = K\right\}$

$r = \frac{KZe^2}{mv^2}$ —— (1)

Using Bohr's postulate $L = \frac{nh}{2\pi}$ (Conservation of Angular momentum)

$mvr = \frac{nh}{2\pi}$

$v = \frac{nh}{2\pi mr}$ —— (11)

Using (1) & (2)

$r = \frac{kZe^2}{m \cdot \frac{n^2h^2}{4\pi^2 m^2 r^2}} \Rightarrow r = \frac{kZe^2 \times 4\pi^2 m r^2}{n^2h^2}$

$\Rightarrow \boxed{r = \frac{n^2h^2}{4\pi^2 mkZe^2}}$

for H-atom $Z = 1$

$\boxed{r_n = \frac{n^2h^2}{4\pi^2 mke^2}}$

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21. What is meant by the term 'displacement current' ? Briefly explain how this current is different from a conduction current. *2*

(21) → Ans.

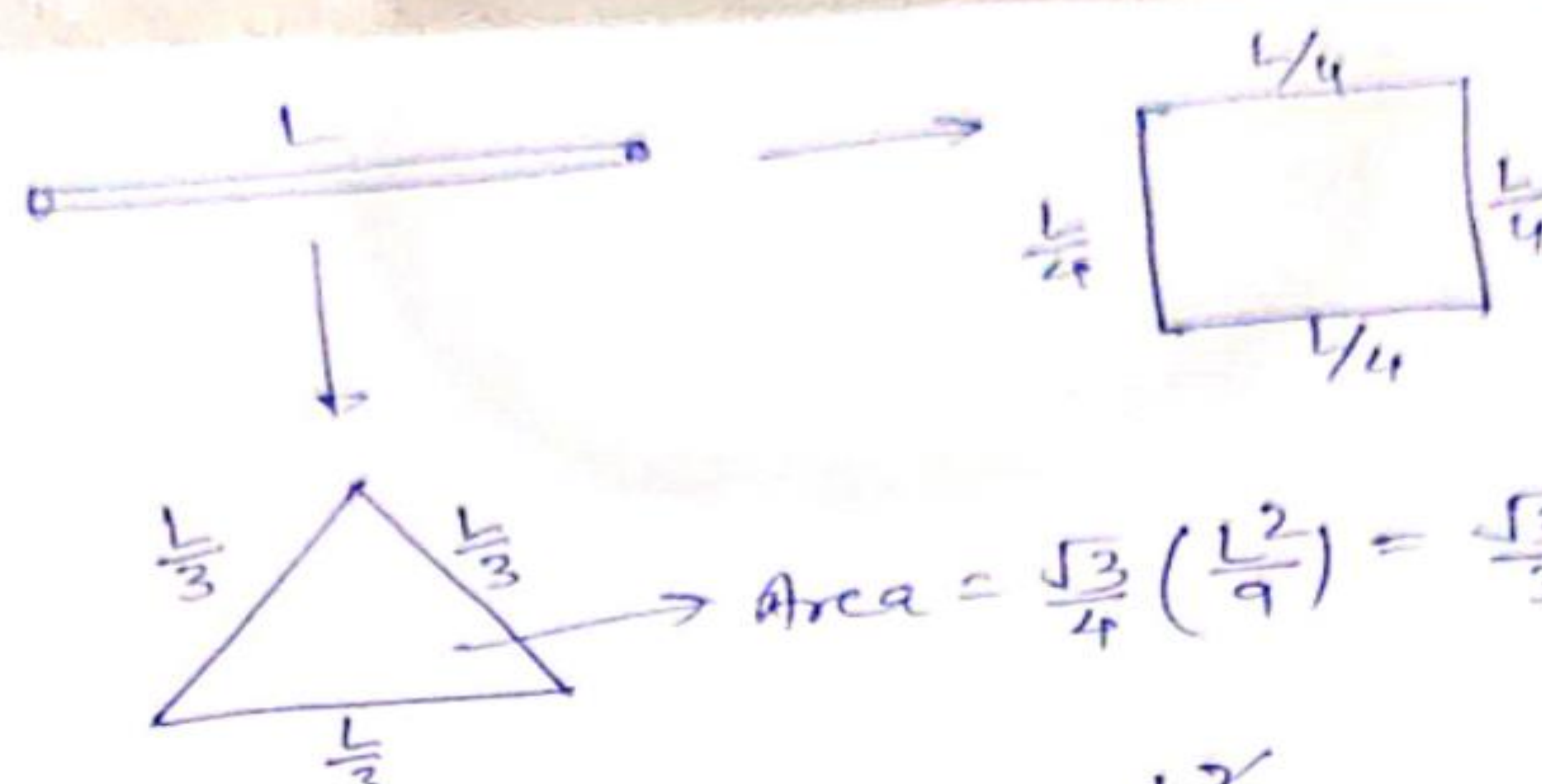
Displacement Current :- It is define as rate of change of electric displacement field.

Mathematically - $\boxed{I_d = \epsilon_0 \frac{d\phi_E}{dt}}$ $\quad \phi_E = \vec{E} \cdot \vec{A}$ → Electric flux

Explaination : Displacement current depends on changing electric field but Conduction current is due to the flow of electrons in a circuit. It exist even if electron flow at constant rate.

22. A wire of length L is bent round in the form of (i) a square, and then (ii) an equilateral triangle. If current I is passed through each of them, find the ratio of magnetic moment of the square loop to that of the triangle. *2*

(22) (3)



Area = $\frac{L^2}{16}$

Area = $\frac{\sqrt{3}}{4}\left(\frac{L^2}{9}\right) = \frac{\sqrt{3}L^2}{36}$

$$\frac{M_{square}}{M_{triangle}} = \frac{I \cdot A_{sq}}{I \cdot A_{triangle}} = \frac{L^2}{16 \times \frac{\sqrt{3}L^2}{36}} = \frac{36}{\sqrt{3}\,16} = \frac{9}{4\sqrt{3}}$$

or $\frac{3\sqrt{3}}{4}$

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23. (a) State Huygens' principle. How did Huygens explain the absence of the backwave ? *2*

OR

(b) Use Huygens' principle to show reflection/refraction of a plane wave by (i) concave mirror, and (ii) a convex lens. *2*

(23) Solution:-

(a) Hyygen's Principle -

(i) Every point on a given wavefront may be considered as a source of secondary wavelets which spread out with the speed of light in that medium

(ii) The new wavefront is the forward envelope of the secondary wavelets at that instant

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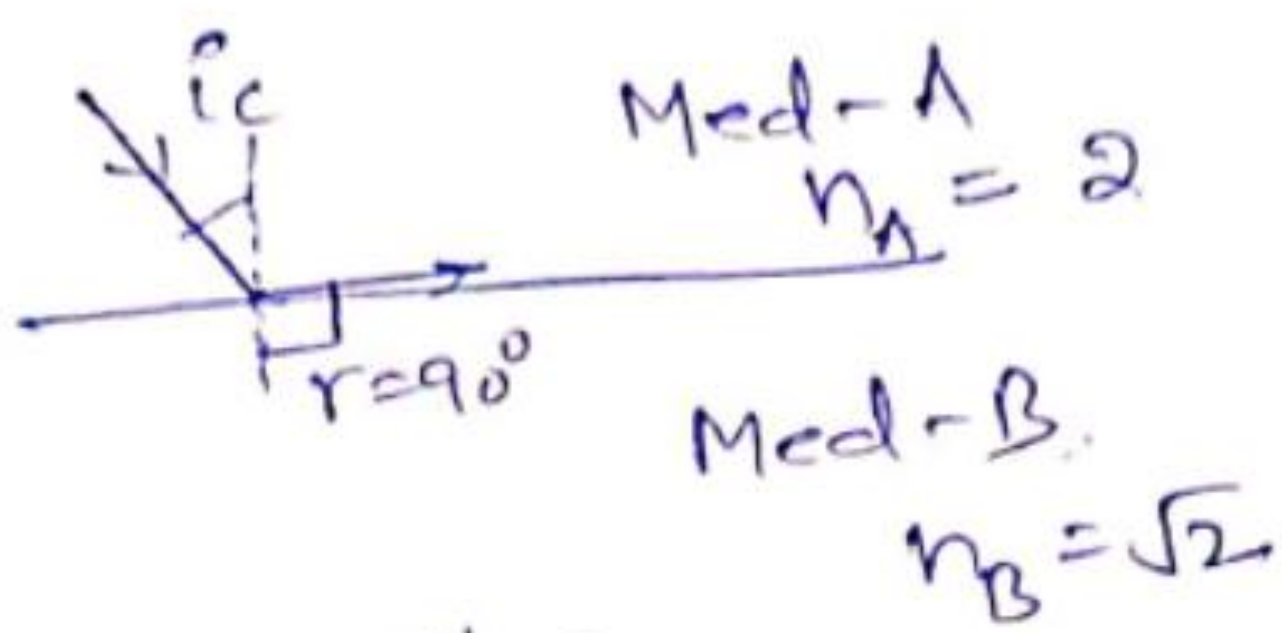
24. The refractive indices of two media A and B are 2 and $\sqrt{2}$ respectively. What is the critical angle for their interface ? 2

(24) (4)



Using Snell's law.

$$n_A \sin i_c = n_B \sin 90°$$

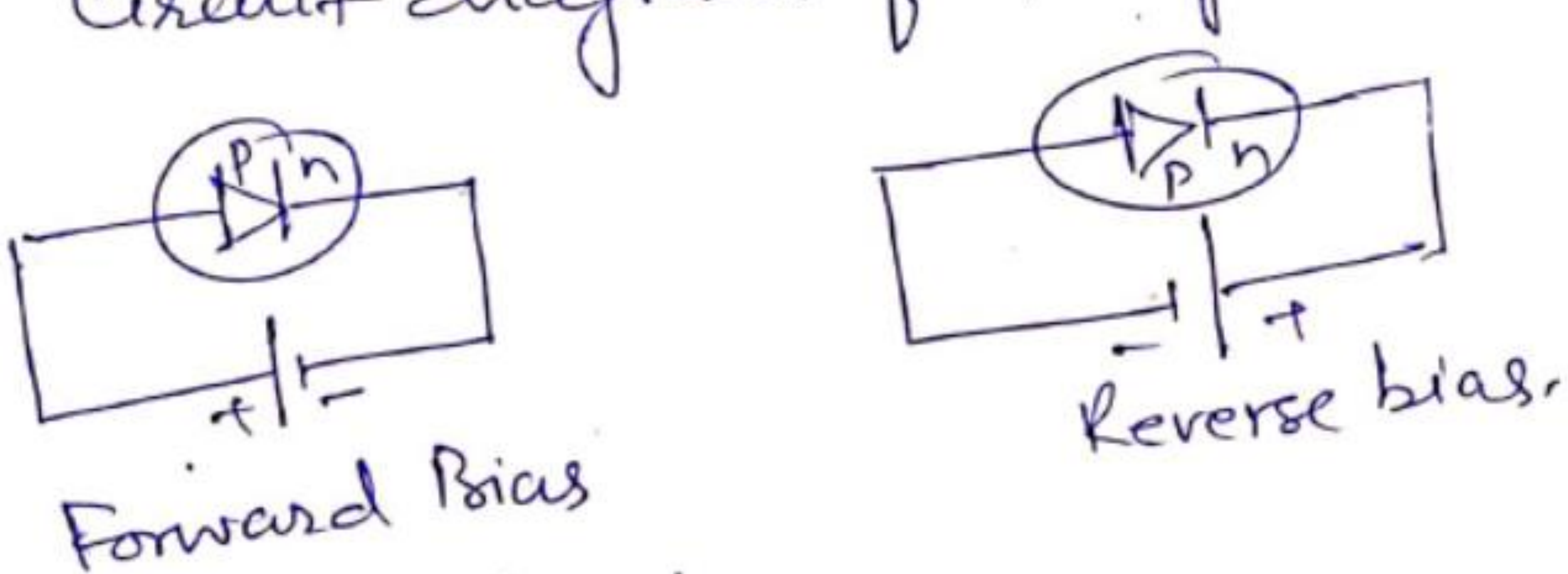
$$2 \sin i_c = \sqrt{2} \times 1$$

$$\sin i_c = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}}$$

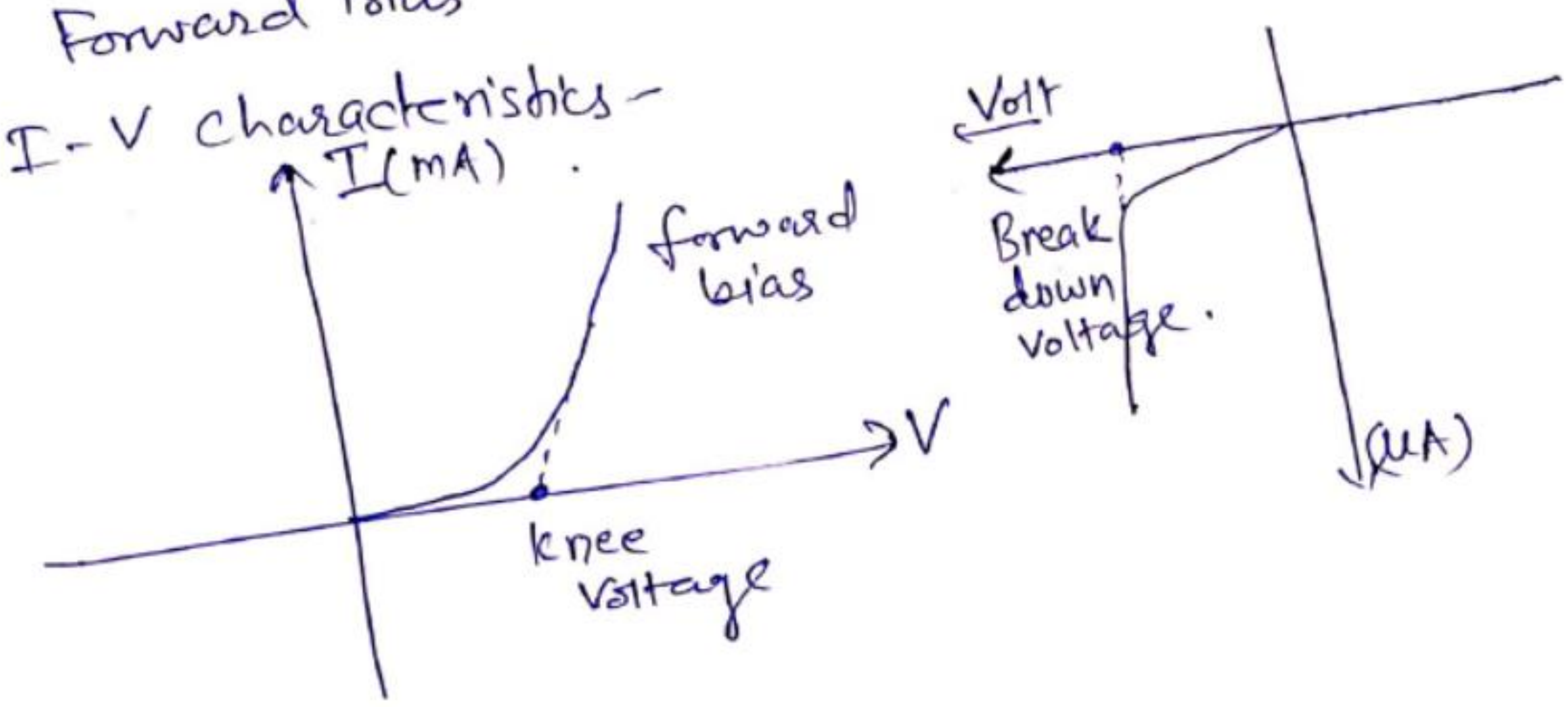
$$\boxed{i_c = 45°}$$ Ans

25. Draw a circuit diagram of a p-n junction diode in (a) forward biasing, and (b) reverse biasing. Draw the V – I characteristics for each case. 2

(25) Circuit diagram of p-n junction –



I-V characteristics –



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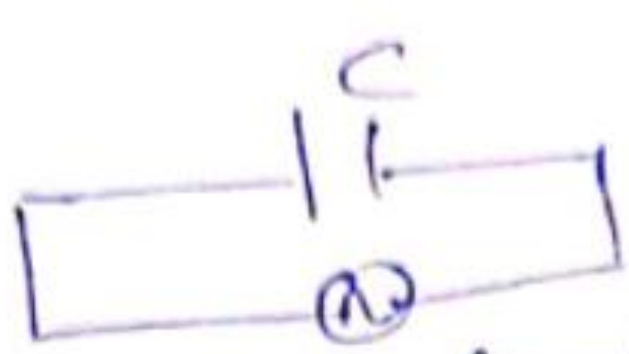
26. (a) An ac source $v = v_m \sin \omega t$ is connected across an ideal capacitor. Derive the expression for the (i) current flowing in the circuit, and (ii) reactance of the capacitor. Plot a graph of current i versus ωt. *3*

OR

(b) A series combination of an inductor L, a capacitor C and a resistor R is connected across an ac source of voltage in a circuit. Obtain an expression for the average power consumed by the circuit. Find power factor for (i) purely inductive circuit, and (ii) purely resistive circuit. *3*

(26) (a) (5)



Using Kirchhoff's law.

$q = CV$

$q = C \cdot V_m \sin \omega t$

then Current $i = \frac{dq}{dt} = C \cdot V_m \cdot \omega \cos \omega t$

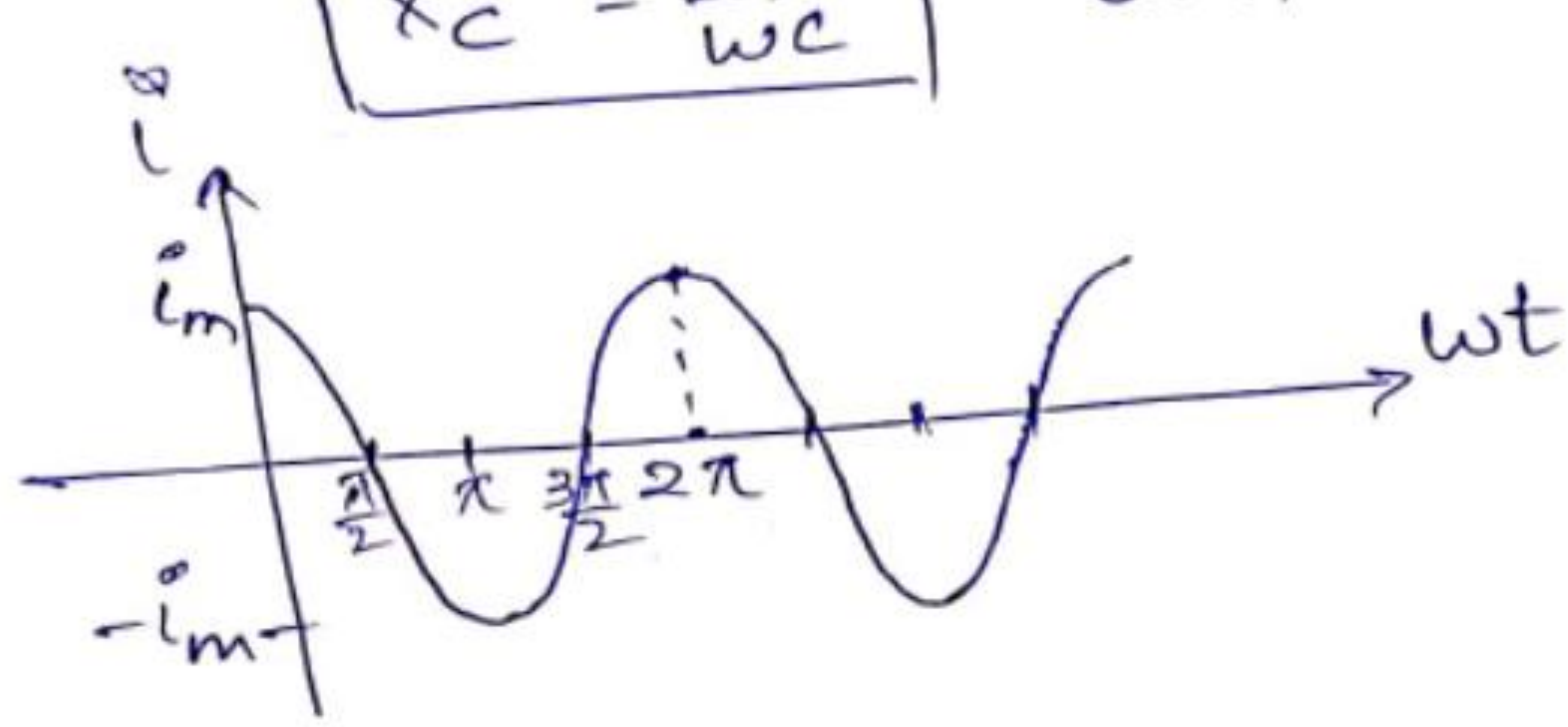
So $i = \frac{V_m}{(1/\omega C)} \cos \omega t$

$i = \left(\frac{V_m}{X_C}\right) \sin\left(\omega t + \frac{\pi}{2}\right)$

or $\boxed{i = i_m \sin\left(\omega t + \frac{\pi}{2}\right)}$

where X_C = Reactance of Capacitor

$\boxed{X_C = \frac{1}{\omega C}}$ unit is ohm.



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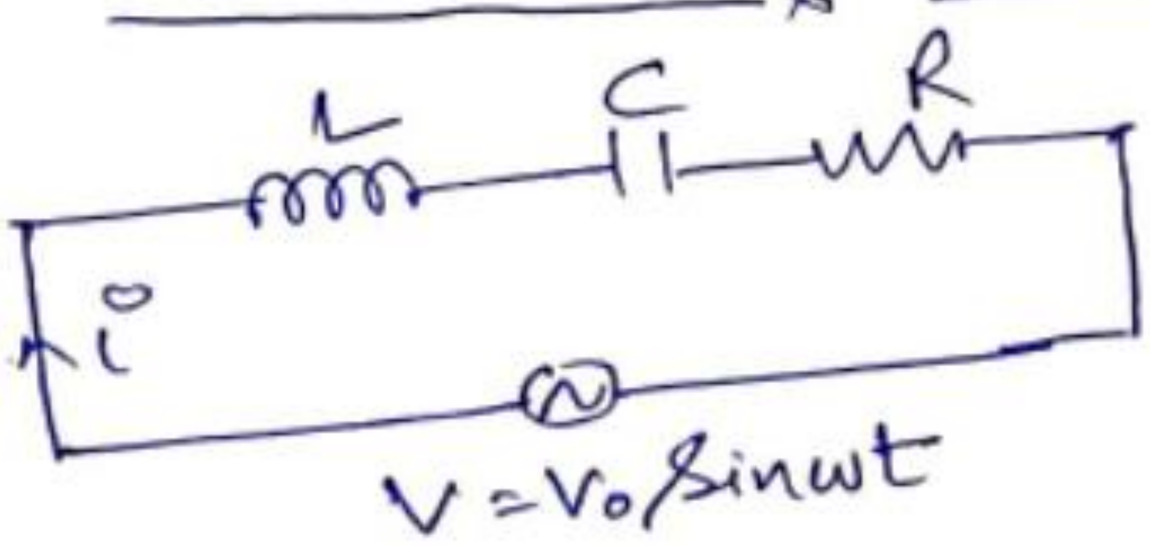
(b) L-C-R (series) Combination -



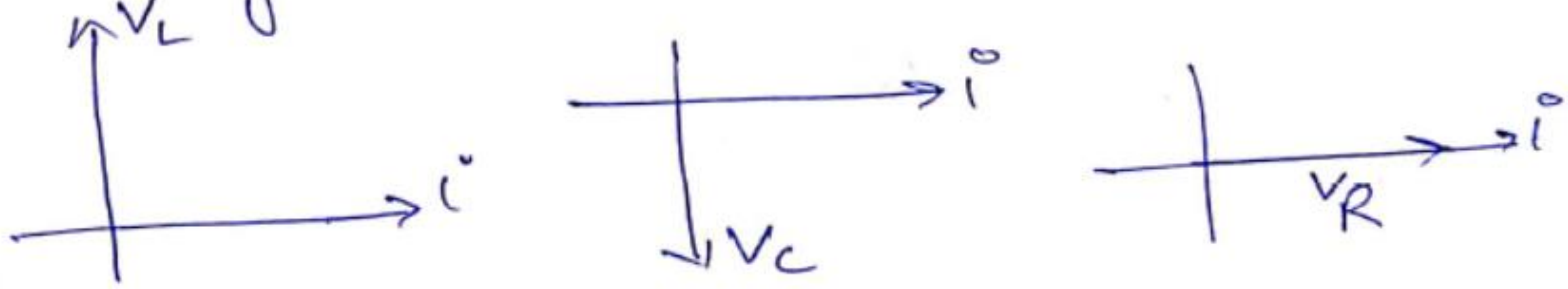
$V_L = L\frac{di}{dt}$ $V_C = \frac{q}{C}$ $V_R = i \cdot R$

Using Kirchhoff's law -

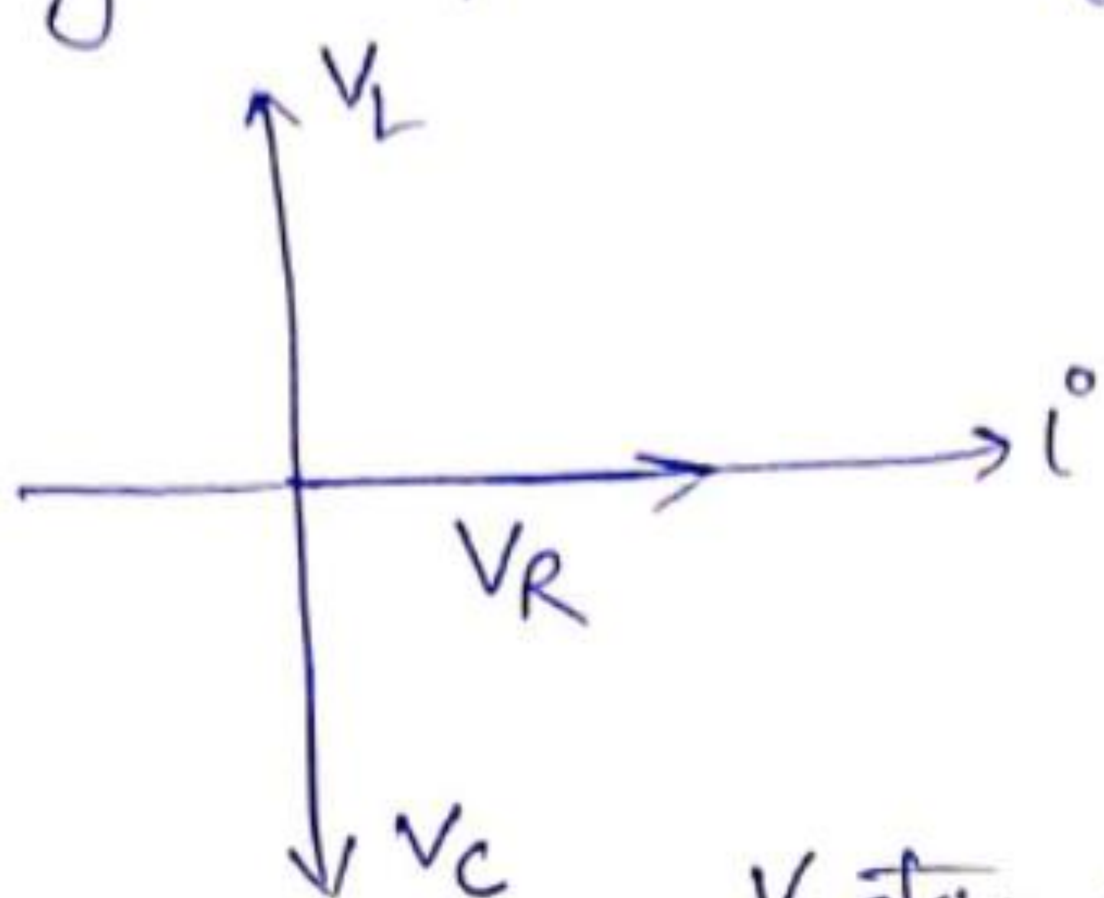
$V_L + V_C + V_R = V$

$L\frac{di}{dt} + \frac{q}{C} + iR = V_0 \sin\omega t$

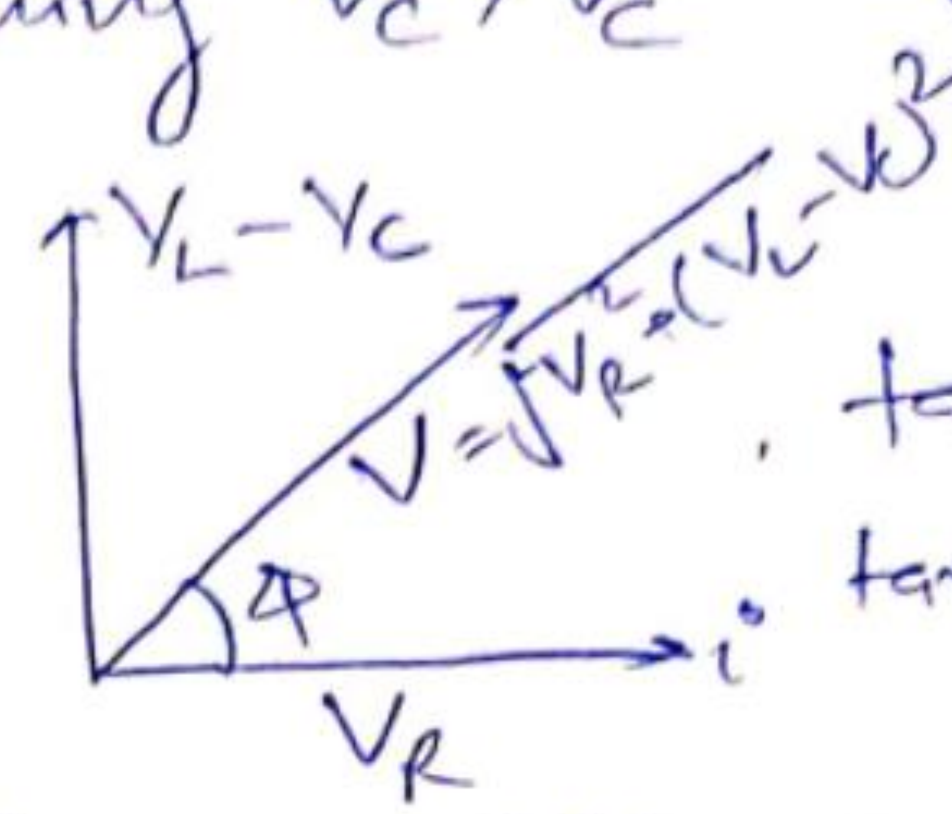
Solution of L-C-R using phasor diagram - Consider i (current) as a phasor



Adding all phasor we get - assuming $V_L > V_C$



$\Rightarrow$



$\tan\phi = \frac{V_L - V_C}{V_R}$

$\tan\phi = \frac{X_L - X_C}{R}$

Vector sum of phasor voltage

$V_L + V_C + V_R = V$

then its magnitude - $V = \sqrt{V_R^2 + (V_L - V_C)^2}$

or $i \cdot Z = \sqrt{i^2R^2 + i^2(X_L - X_C)^2}$

(impedance) $Z = \sqrt{R^2 + (X_L - X_C)^2}$

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now Current in Circuit from phasor diagram is -

$$i = \frac{V_0}{Z} \sin(\omega t - \phi) \quad \text{where} \quad \phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

or $i = i_0 \sin(\omega t - \phi)$ $\quad i_0 = \frac{V_0}{Z}$

Power $= V \times i$

$$P_{average} = \langle V \cdot i \rangle$$

$$= \langle V_0 i_0 \sin\omega t \sin(\omega t - \phi) \rangle$$

$$= \frac{V_0 i_0}{2} \langle 2 \sin\omega t \sin(\omega t - \phi) \rangle$$

$$= \frac{V_0 i_0}{2} \cdot \cos\phi$$

$$P_{av} = V_{rms} I_{rms} \cos\phi$$

where $\cos\phi$ = power factor.

where $\cos\phi = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}}$

for purely inductive $R = 0$ $X_C = 0$ $\cos\phi = 0$

for purely Capacitive $R = 0$ $X_L = 0$ $\cos\phi = 0$

Ans

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27. (a) (i) Prove that the nuclear density is same for all nuclei.

(ii) Draw a plot of potential energy of a pair of nucleons as a function of their separation. Draw two inferences from this plot. *3*

OR

(b) (i) Draw a graph to show the variation of the number of scattered particles detected (N) in Geiger-Marsden experiment as a function of scattering angle (θ).

(ii) Discuss briefly two conclusions that can be drawn from this graph and how they lead to the discovery of nucleus in an atom. *3*

(27) Nuclear Density (ρ) (7)

(i)

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

let m be the mass of a nucleon and A be the mass number So total mass = mA

formula for radius is $R = R_0 (A)^{1/3}$ $R_0 = 0.52\,A$ $A = $ Mass ↑

$$\rho = \frac{mA}{\text{Volume}} = \frac{mA}{\frac{4}{3}\pi R^3}$$

$$\rho = \frac{mA}{\frac{4}{3}\pi R_0^3 A} \Rightarrow \rho = \frac{3m}{4\pi R_0^3} = \text{Constant}$$

* assuming shape of nucleus is spherical in nature.

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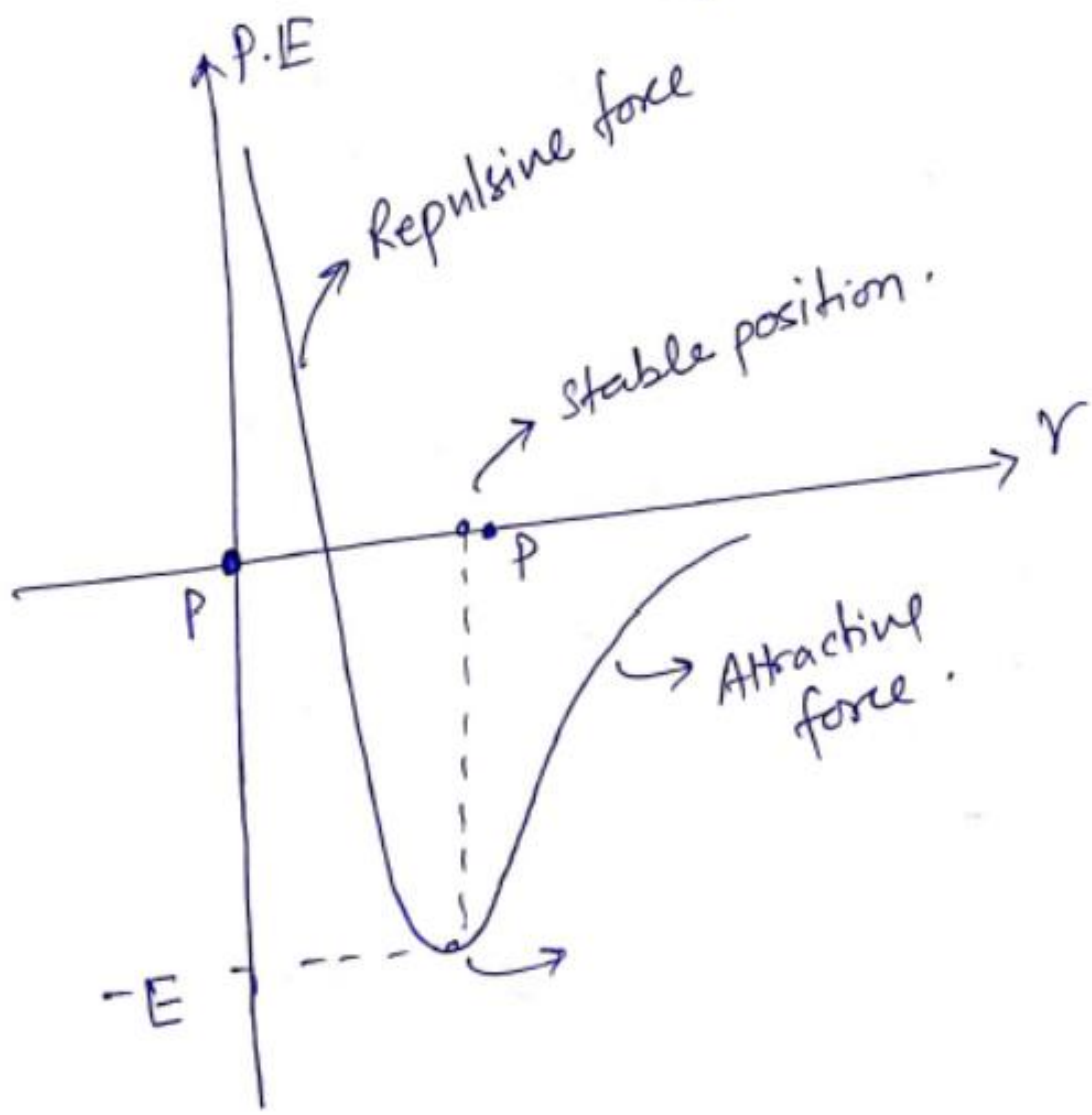
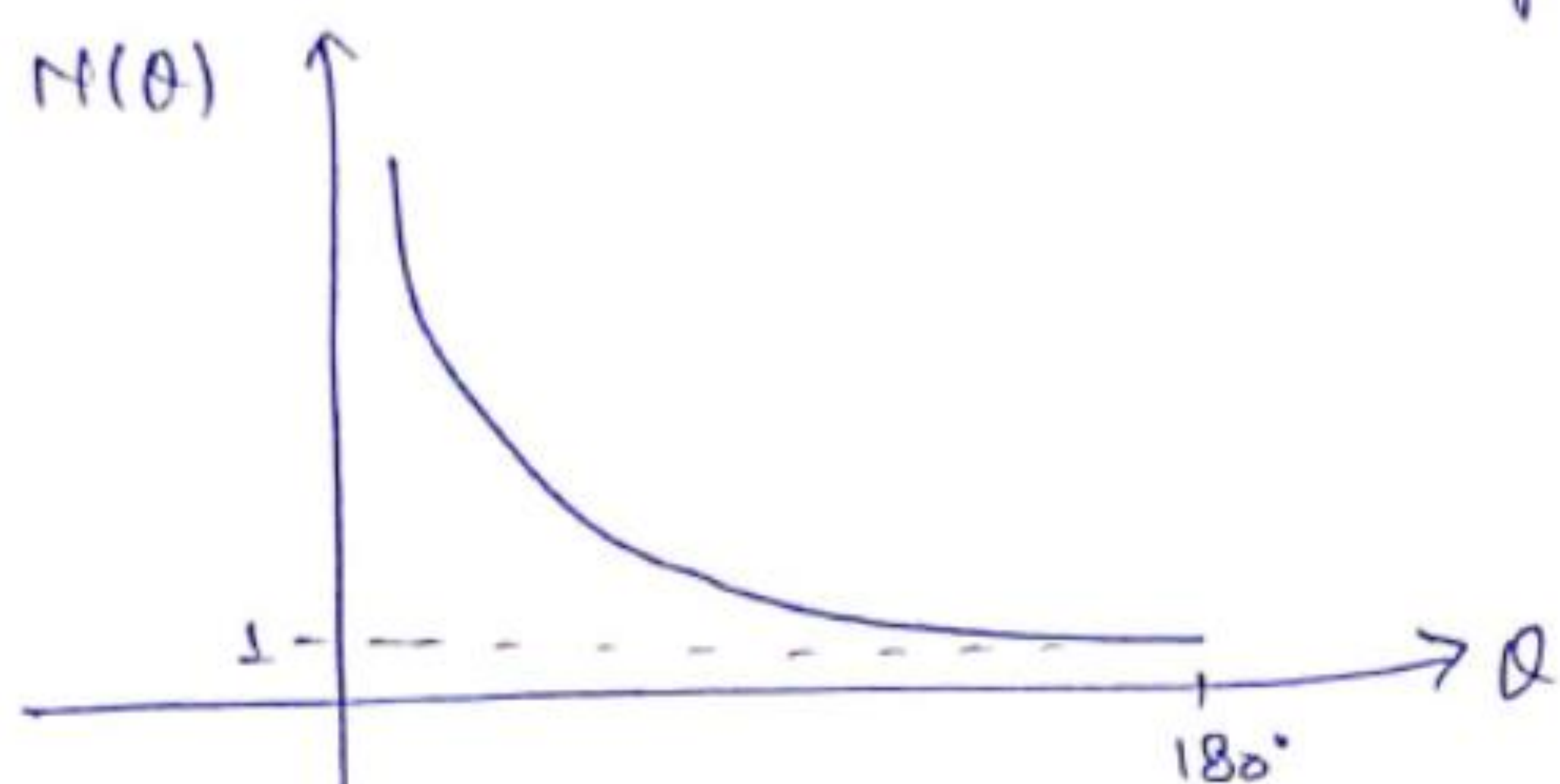
(ii) Potential Energy of pair of nucleons -



(27) (b) Graph b/w number of scattered particles (N) Vs Scattering Angle (θ). (3)



Two Conclusion -

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(ii)

(a) It shows that ~~at~~ large number of α-particle is passed without deviating (or at very small scattering angle). which tells large space is vacant in ~~nucleus~~ atom.

(b) Accidentaly 1 α-particle is scattered at an angle 180°. which shows that α-particle is collides with heavy point which is positive in nature and hole mass of atom is concentrated.

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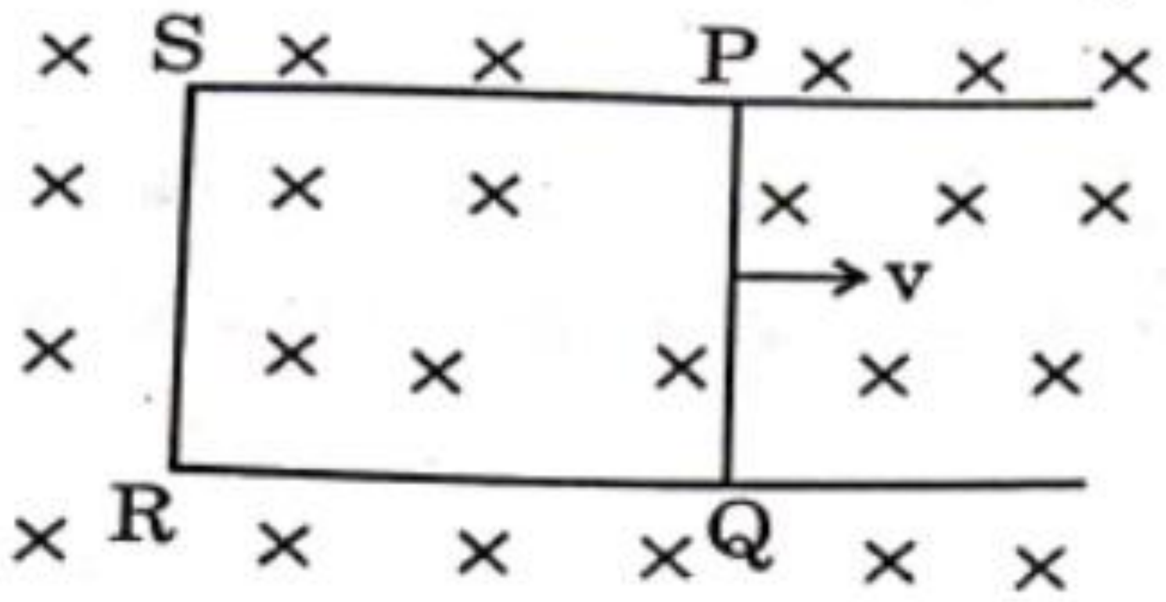
28. The figure shows a rectangular conductor PQRS in which the arm PQ of length 10 cm and resistance 0·4 Ω is free to move. It is kept in a uniform magnetic field B = 0·2 T acting perpendicular into the plane of PQRS. If arm PQ is moved with a velocity v of 5 cm/s as shown, find : *3*

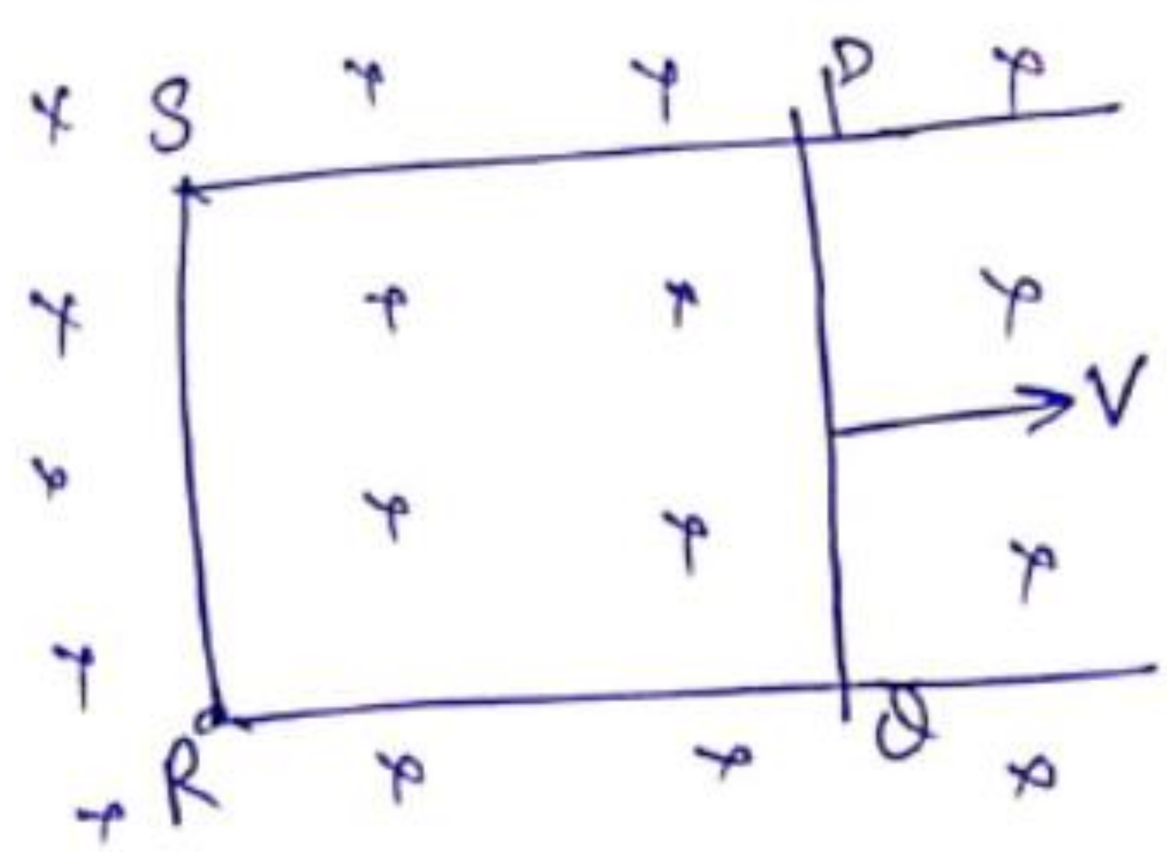


(a) the current induced in the loop, and

(b) the power required to move the arm.

(Resistances of arms PS, SR and RQ are negligible.)

(28)



$l_{PQ} = 10cm = 0.1m.$

$R_{PQ} = 0.4$ ohm. $B = 0.2T$

$v = 5$ cm/sec.

So motional emf

$\varepsilon = Bvl$

$\varepsilon = 0.2 \times \frac{5}{100} \times 0.1$

$\varepsilon = \frac{0.1}{100} = 10^{-3} = 1$ mVolt

$I_{induced} = \frac{\varepsilon}{R}$

$= \frac{1 \text{ m Volt}}{0.4}$

$= 2.5$ mA

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(28) (b) Power required to move arm –

$$\text{Power} = \varepsilon \times i$$

$$= Bvl \times \frac{\varepsilon}{R} \Rightarrow Bvl \cdot \left(\frac{Bvl}{R}\right)$$

$$P = \frac{B^2 v^2 l^2}{R}$$

$$P = \frac{(0.2)^2 \times \left(\frac{5}{100}\right)^2 \times (0.1)^2}{0.4}$$

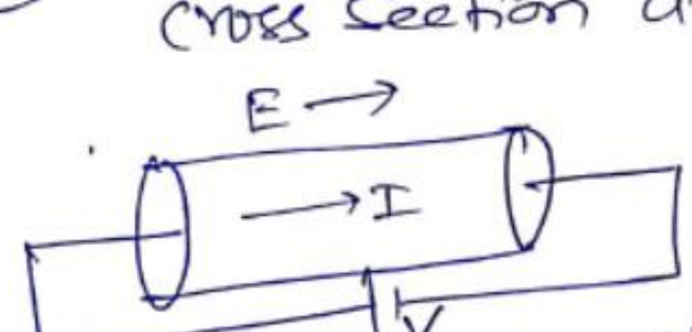
$$= \frac{0.04 \times 25 \times 10^{-4} \times 10^{-2}}{4 \times 10^{-1}}$$

$$= \frac{4 \times 25 \times 10^{-8}}{4 \times 10^{-1}} \Rightarrow 25 \times 10^{-7} \text{ watt}$$

or 2.5×10^{-6} watt **Ans**.

29. Obtain a relation between the current flowing in a conductor and drift velocity of electrons in it. Hence, obtain Ohm's law. 3

(29) Consider a conductor of length l and cross section area = A.



According to definition of current

$$I = \frac{q}{t} \quad —(1)$$

let charge density of conducting wire is $n = \frac{N}{\text{Volume}} \Rightarrow N = n \cdot A \cdot l$.

So total charge $= (n \cdot A l) \cdot e$

$$q = n \cdot e A l \cdot \quad —(2)$$

So Current $I = \frac{n \cdot e A l}{t}$ —(3)

assuming single e^- is moving from one end to another then its ave. velocity $v_d = \frac{l}{t}$

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Using Eqn (3)

$$\boxed{I = n e A V_d}$$

where
$n \rightarrow$ charge density.
$e \rightarrow$ charge of electron
$A \rightarrow$ Area of cross section.
$V_d \rightarrow$ Drift velocity.

Now as we know Current density -

$$J = \frac{I}{A} \Rightarrow J = \frac{n e A V_d}{A}$$

$$J = n e \frac{eE}{m} \tau$$

So $$J = \frac{ne^2\tau}{m} E \Rightarrow \boxed{J = \sigma E}$$

if V is potential drop across then $E = \frac{V}{l}$

$$J = \frac{\sigma V}{l} \Rightarrow \frac{I}{A} = \frac{1}{\rho}\frac{V}{l}$$

$$\Rightarrow I\left(\rho \frac{l}{A}\right) = V$$

$$\Rightarrow IR = V \text{ or } \boxed{V = IR}$$

↓ ohm's law.

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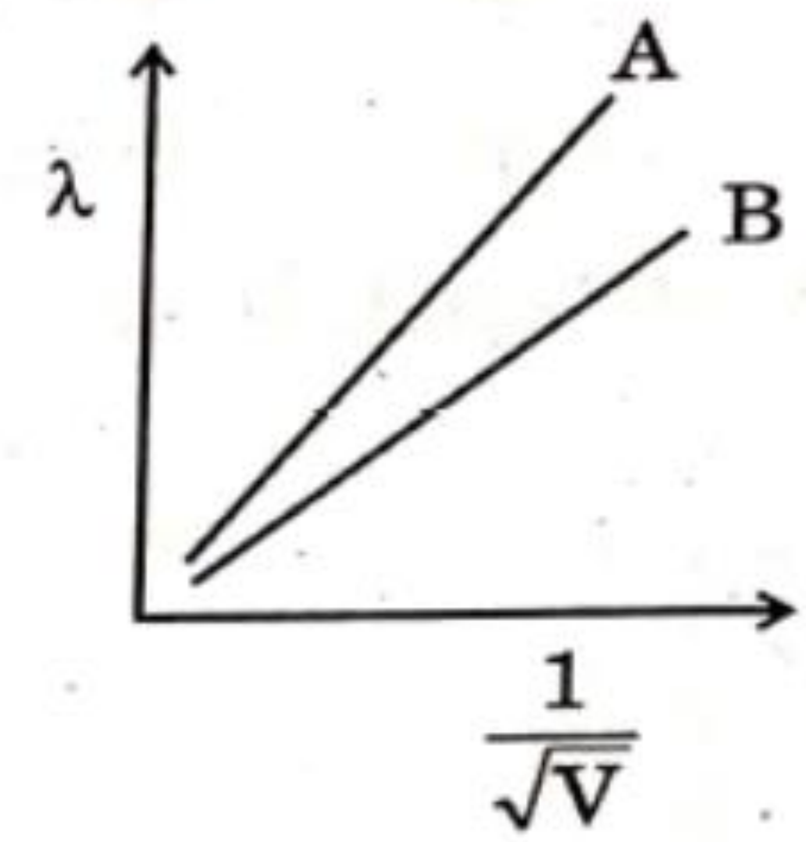
30. (a) The figure shows de Broglie wavelength (λ) for two particles A and B having same charges but different masses as a function of $\frac{1}{\sqrt{V}}$, where V is the potential through which the particles are accelerated.



(i) Which of them is heavier and why ?

(ii) What does the slope of the line represent ?

(b) Calculate the momentum of an electron having de Broglie wavelength of 3·0 Å. *3*

(30) According to de-broglei -

$\lambda = \frac{h}{p}$ p = momentum -

· if a charge particle is accelerated through potential difference V then -

$\frac{p^2}{2m} = q \cdot V \Rightarrow p = \sqrt{2mq \cdot V}$

So $\lambda = \frac{h}{\sqrt{2mq \cdot V}} \Rightarrow \lambda = \left(\sqrt{\frac{h^2}{2mq}}\right) \cdot \frac{1}{\sqrt{V}}$

$\boxed{\lambda \propto \frac{1}{\sqrt{V}}}$ $\Rightarrow$ Slope $= \sqrt{\frac{h^2}{2mq}}$

now Slope of A is greater then B.

So $m_A < m_B$

Slope of graph represent $= \frac{h}{\sqrt{2mq}}$

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(11)

(30) (b) De-Broglie wave length of electron is 3 Å then its momentum

Using $p = \frac{h}{\lambda} \Rightarrow p = \frac{6.63 \times 10^{-34}}{3 \times 10^{-10}}$

$$p = 2.21 \times 10^{-24} \text{ kg m/s}$$

31. (a) (i) Draw a ray diagram showing the formation of a real image of an object placed at a distance 'u' in front of a concave mirror of radius of curvature 'R'. Hence, obtain the relation for the image distance 'v' in terms of u and R.

(ii) A 1·8 m tall person stands in front of a convex lens of focal length 1 m, at a distance of 5 m. Find the position and height of the image formed. *5*

OR

(b) (i) Draw a ray diagram showing refraction of a ray of light through a triangular glass prism. Hence, obtain the relation for the refractive index (μ) in terms of angle of prism (A) and angle of minimum deviation (δ_m).

(ii) The radii of curvature of the two surfaces of a concave lens are 20 cm each. Find the refractive index of the material of the lens if its power is – 5·0 D. *5*

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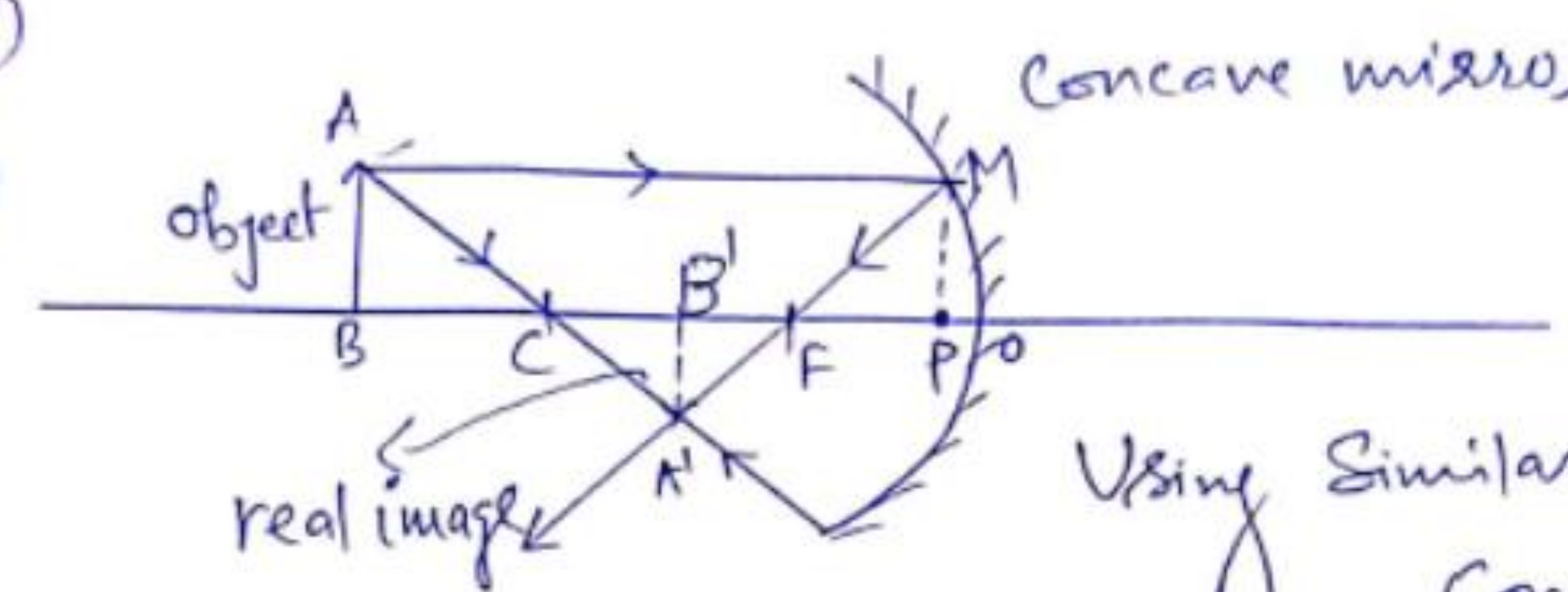
31 (a) (i)



$OB = -u \qquad OC = -R$

$OB' = -v \qquad OF = -f$

Consider paraxial rays - assuming P is lying on O.

Using Similar triangle Concept -

$\Delta ABC \cong A'B'C$

$$\frac{AB}{A'B'} = \frac{BC}{B'C} \quad \text{— (I)}$$

Similarly - $\Delta A'B'F \cong \Delta MPF$

$$\frac{A'B'}{MP} = \frac{B'F}{FP} \quad \text{— (II)}$$

Since $AB = MP$. and $FP = FO = -f$.

$$\frac{MP}{A'B'} = \frac{FP}{B'F} \Rightarrow \frac{AB}{A'B'} = \frac{FP}{B'F} \quad \text{— (III)}$$

Using (I) & (III)

$$\frac{BC}{B'C} = \frac{FP}{B'F} \Rightarrow$$

$$\frac{-u-(-R)}{-R-(-v)} = \frac{-f}{-v-(-f)} \Rightarrow \frac{R-u}{v-R} = \frac{f}{v-f}$$

Using $R = 2f$.

Solving we get - $\boxed{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}}$

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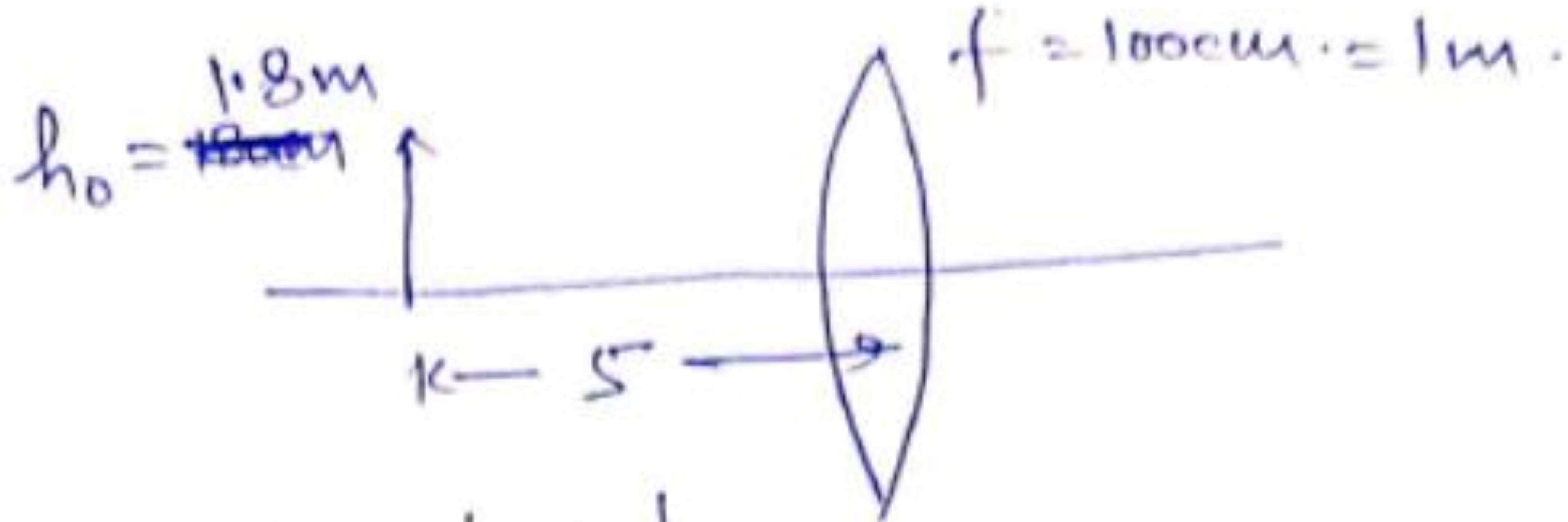
(ii) (12)



$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} - \frac{1}{-5} = \frac{1}{1} \Rightarrow \frac{1}{v} = 1 - \frac{1}{5} = \frac{4}{5}$$

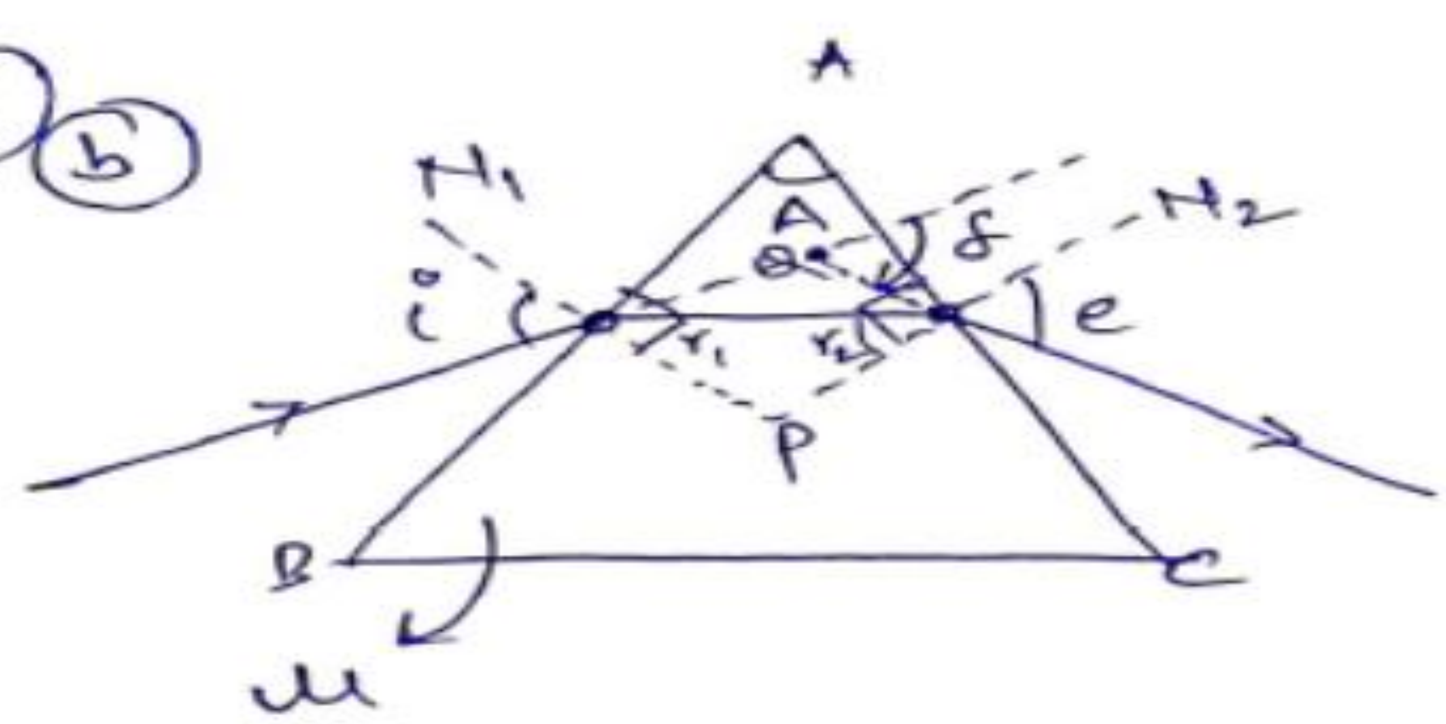
$$V = \frac{5}{4} m.$$

Using $\frac{h_i}{h_o} = \frac{V}{u} \Rightarrow \frac{h_i}{1.8} = \frac{5}{4 \times 5}$

$$h_i = \frac{1.8}{4} = 0.45m.$$

Ans.

(31) (b)



from quadilateral –

$A + N_1 + N_2 + P = 360°$

$A + 90 + 90 + P = 360$

$A + P = 180$ —(I)

$\angle N_2N_1P + \angle P + \angle N_1N_2P = 180°$

$r_1 + P + r_2 = 180$ —(II)

Using (I) & (II) $A + P = r_1 + r_2 + P$

$\Rightarrow \boxed{r_1 + r_2 = A}$

Also $\delta = i - r_1 + e - r_2$

$\delta = i + e - (r_1 + r_2)$

$\boxed{\delta = i + e - A}$

Under Condition of minimum deviation –

$i = e$ & $r_1 = r_2 = r$.

So $\delta_{min} = i + i - A \Rightarrow 2i = A + \delta_m$

$$i = \left(\frac{A + \delta_m}{2}\right)$$

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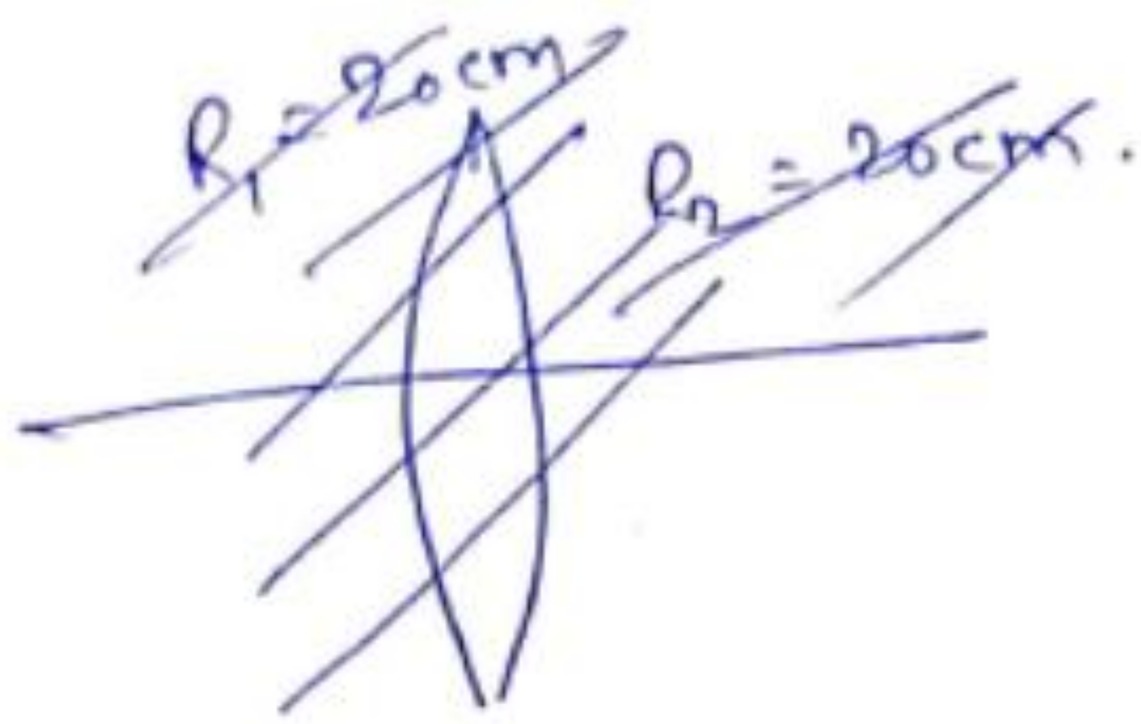
$r_1 + r_2 = A \Rightarrow 2r = A \Rightarrow r = A/2$

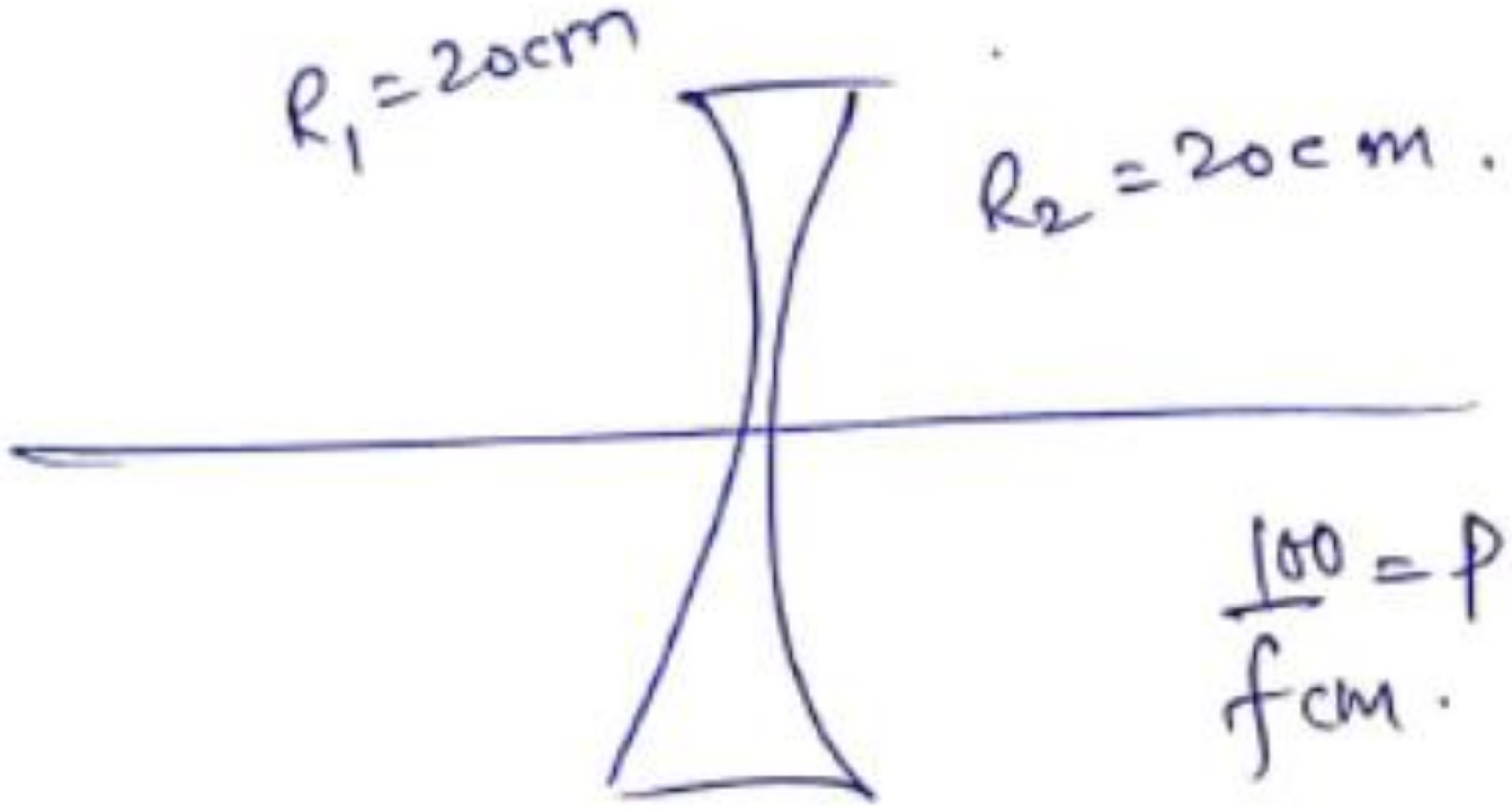
Using Snell's Law at any one of the face

$1 \sin i = \mu \sin r$

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin(A/2)}$$

31 (b) (ii)





$$\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{100}{f\,cm} = P \Rightarrow \frac{1}{f} = \frac{5}{100} = \frac{1}{20}$$

$$\frac{1}{-20} = (\mu-1)\left(\frac{1}{-20} - \frac{1}{20}\right)$$

$$-\frac{1}{20} = (\mu-1)\left(-\frac{1}{10}\right)$$

$$\mu - 1 = 0.5$$

$$\mu = 1.5$$

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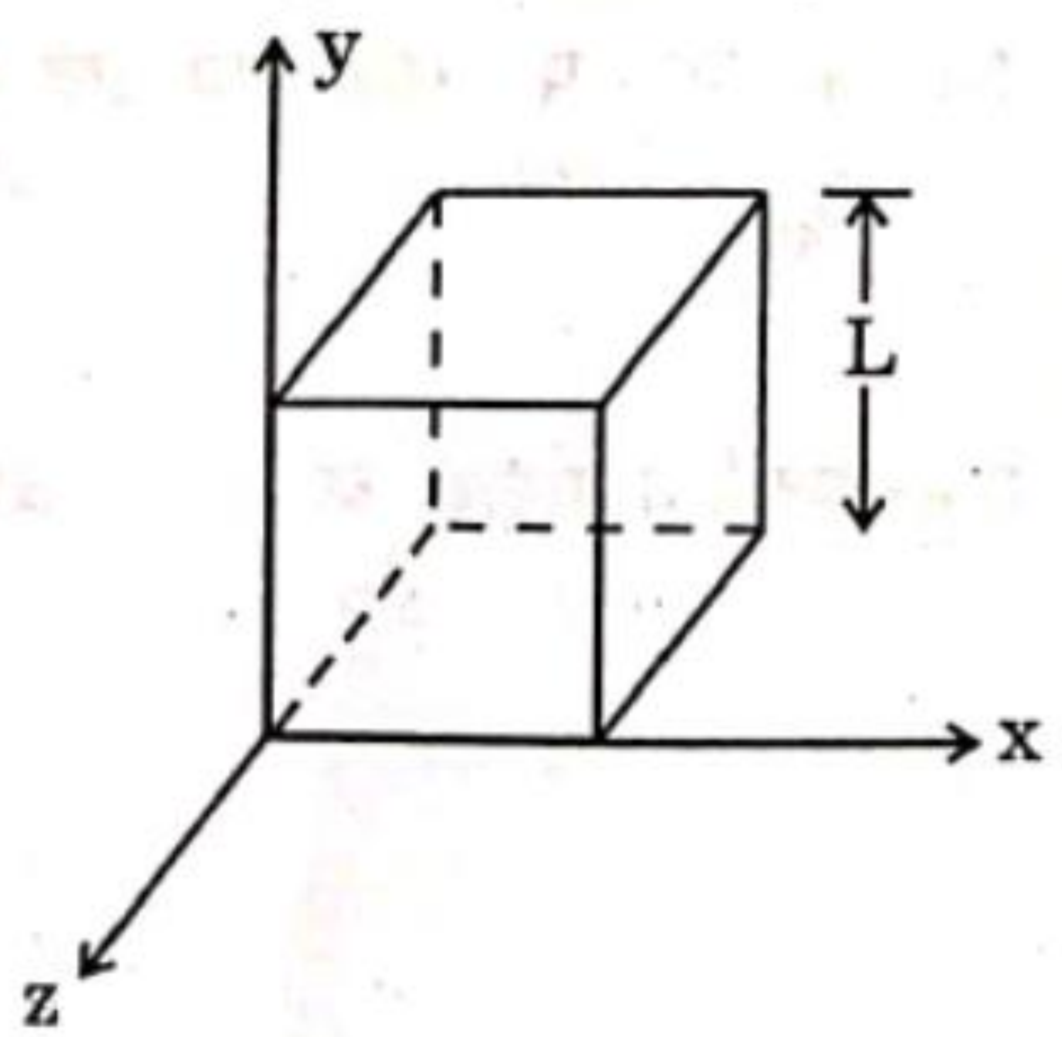
32. (a) (i) Define electric flux and write its SI unit.

(ii) Use Gauss' law to obtain the expression for the electric field due to a uniformly charged infinite plane sheet.

(iii) A cube of side L is kept in space, as shown in the figure. An electric field $\vec{E} = (Ax + B)\,\hat{i}\,\frac{N}{C}$ exists in the region. Find the net charge enclosed by the cube. *5*



OR

(b) (i) Define electric potential at a point and write its SI unit.

(ii) Two capacitors are connected in series. Derive an expression of the equivalent capacitance of the combination.

(iii) Two point charges + q and – q are located at points (3a, 0) and (0, 4a) respectively in x-y plane. A third charge Q is kept at the origin. Find the value of Q, in terms of q and a, so that the electrostatic potential energy of the system is zero. *5*

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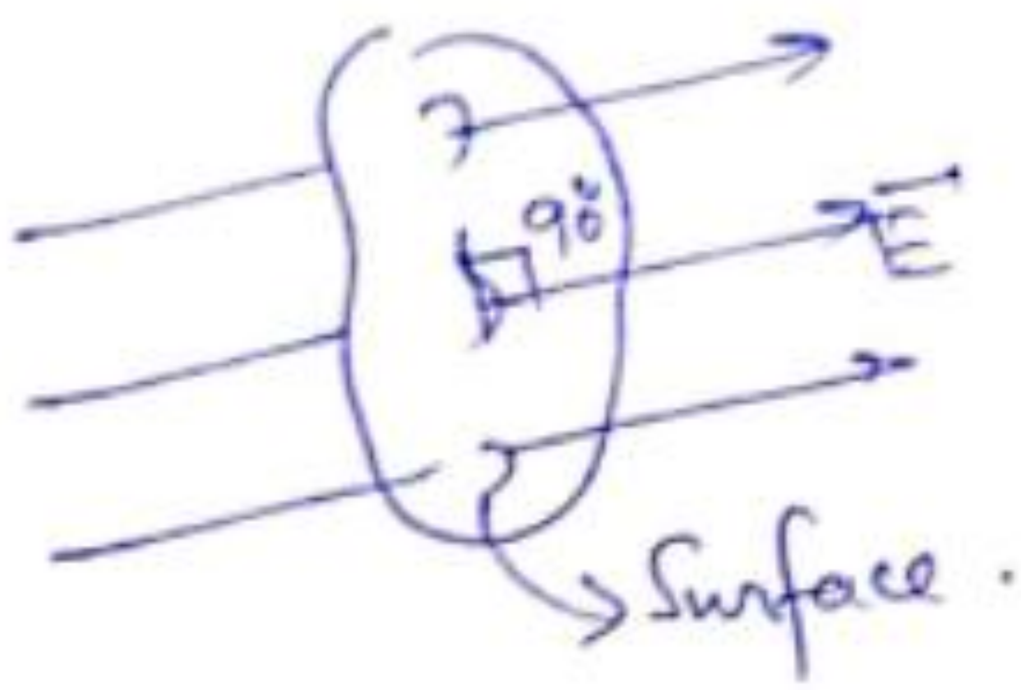
(32) (a) (14)

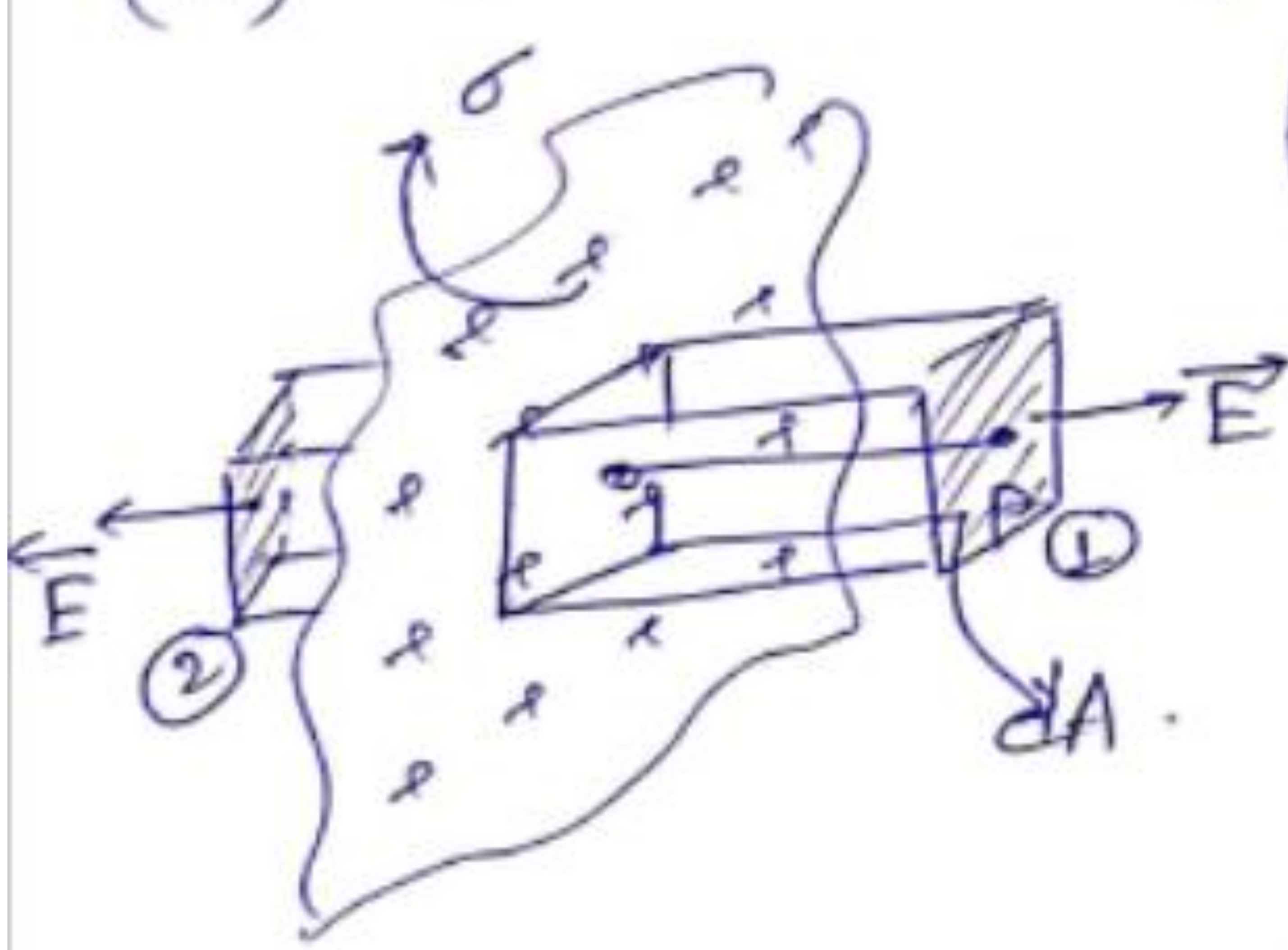
(i) Electric flux: Number of electric field lines passing perpendicular to close surface is called electric flux. It is represented by Φ.

$$\boxed{\Phi = \vec{E} \cdot \vec{A}}$$



It is a scalar quantity.
Its S.I unit is Volt.meter.

(ii) Consider an infinite charged plane sheet.



from fig. E-field is perpendicular to shaded portion.
Assuming Cubical gaussian surface as shown –

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{en}}{\epsilon_0}.$$

$$\oint_1 \vec{E} \cdot d\vec{A} + \int_2 \vec{E} \cdot d\vec{A} = \frac{\sigma \cdot A}{\epsilon_0}$$

$$E \cdot A + E \cdot A = \frac{\sigma \cdot A}{\epsilon_0}$$

$$2EA = \frac{\sigma \cdot A}{\epsilon_0}$$

$$\boxed{E = \frac{\sigma}{2\epsilon_0}}$$

$q_{en} = \sigma \cdot A$

assuming E-field is constant on both side of surface.

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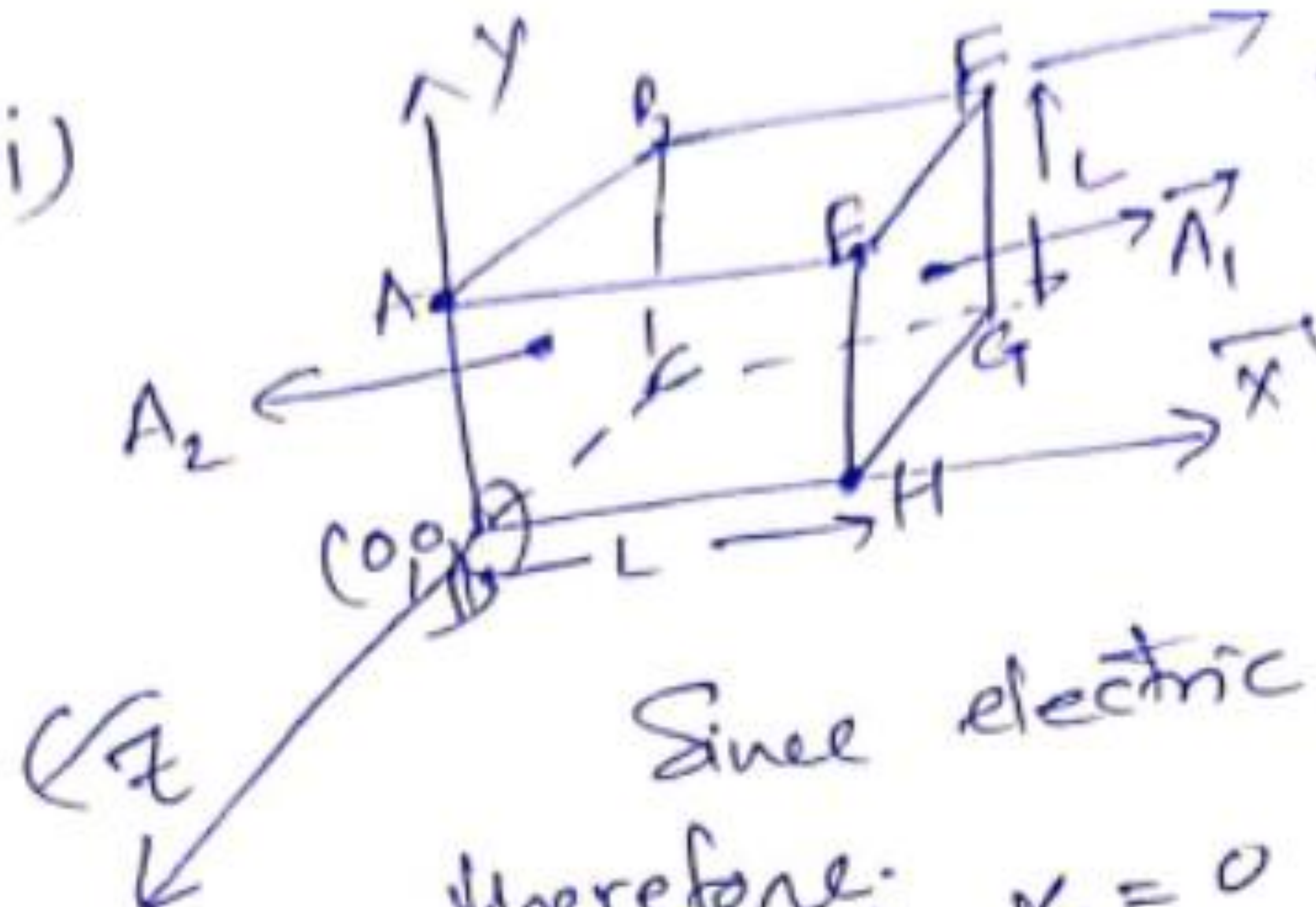
(32) (iii)



$\vec{E} = (Ax + B)\hat{i}$ /C

Since electric field is along x-axis

therefore at $x = 0$ $E_{(0)} = B$

$x = L$ $E_{(L)} = AL + B$

Surface EFGH $\vec{A}_1 = L^2\hat{i}$. $\vec{A}_2 = -L^2\hat{i}$.

So $Q_{net} = \epsilon_0(\vec{E}_1\cdot\vec{A}_1 + \vec{E}_2\cdot\vec{A}_2)$

$= \epsilon_0[B\cdot L^2 - (AL+B)L^2]$

$= \epsilon_0 L^2[B - AL - B]$

$$\boxed{Q_{net} = -A\epsilon_0 L^3}$$

OR

(32) (i) Electric potential is define as amount of work done is bringing a unit charge from infinity to any electric field.

$$\boxed{V_{\infty\to r} = \frac{(W.D)_{\infty\to r}}{q_0}}$$

S.I unit is Volt. or Joule/Coulomb.

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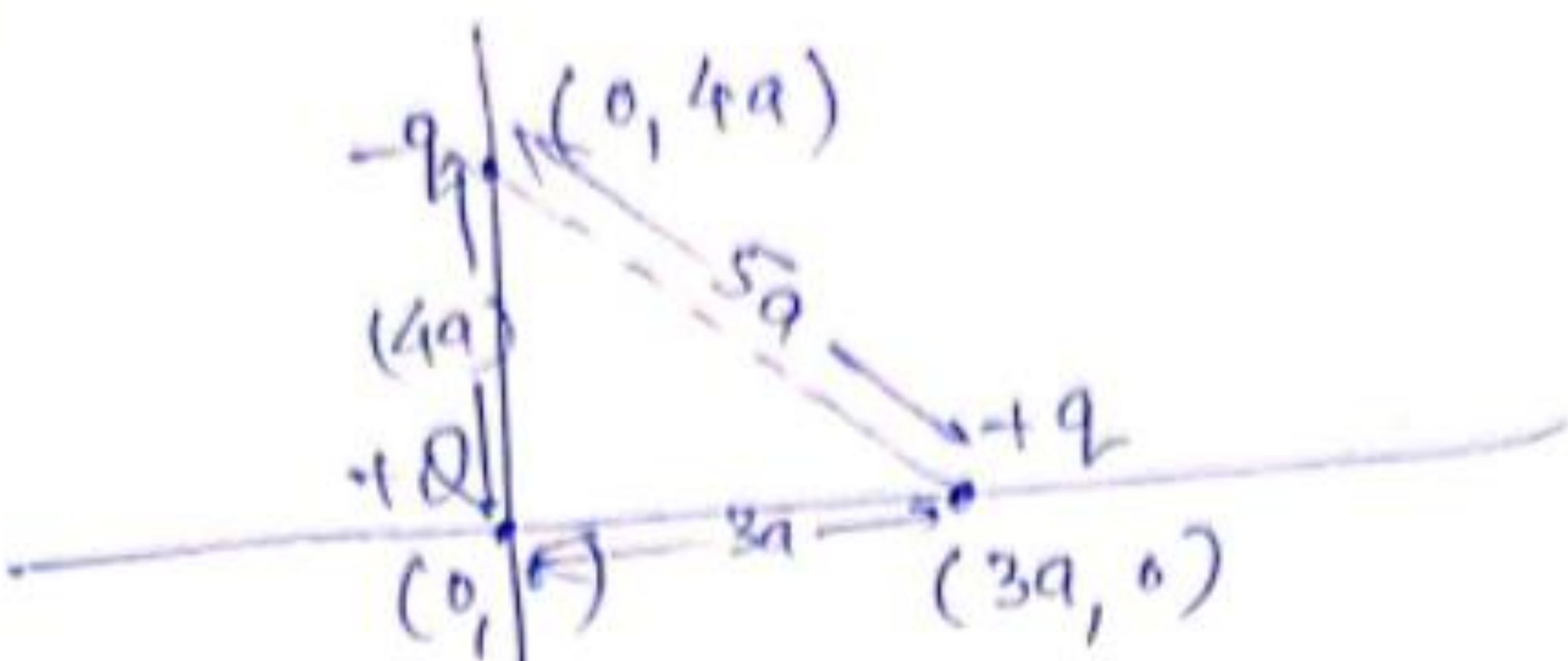
(ii)

In Series charges on each Capacitor is Same - but potential drop is different.

$$V = V_1 + V_2$$

$$\frac{q}{C_{eq}} = \frac{q}{C_1} + \frac{q}{C_2} \Rightarrow \boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}}$$

(iii) (16)



Electrostatic Potential energy of System -

$$U = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q(-q)}{4a} + \frac{1}{4\pi\epsilon_0} \frac{qQ}{3a} + \frac{1}{4\pi\epsilon_0} \frac{q(-q)}{5a}$$

Since $U = 0$

$$0 = -\frac{Qq}{4a} + \frac{qQ}{3a} - \frac{q^2}{5a}.$$

$$\frac{q^2}{5a} = \frac{-3Qq + 4Qq}{12a}$$

$$\frac{q}{5} = \frac{Q}{12} \Rightarrow \boxed{Q = \frac{12}{5}q}$$

Ans.

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33. (a) (i) Write the principle and explain the working of a moving coil galvanometer. A galvanometer as such cannot be used to measure the current in a circuit. Why ?

(ii) Why is the magnetic field made radial in a moving coil galvanometer ? How is it achieved ? *5*

OR

(b) (i) Derive an expression for magnetic field on the axis of a current carrying circular loop.

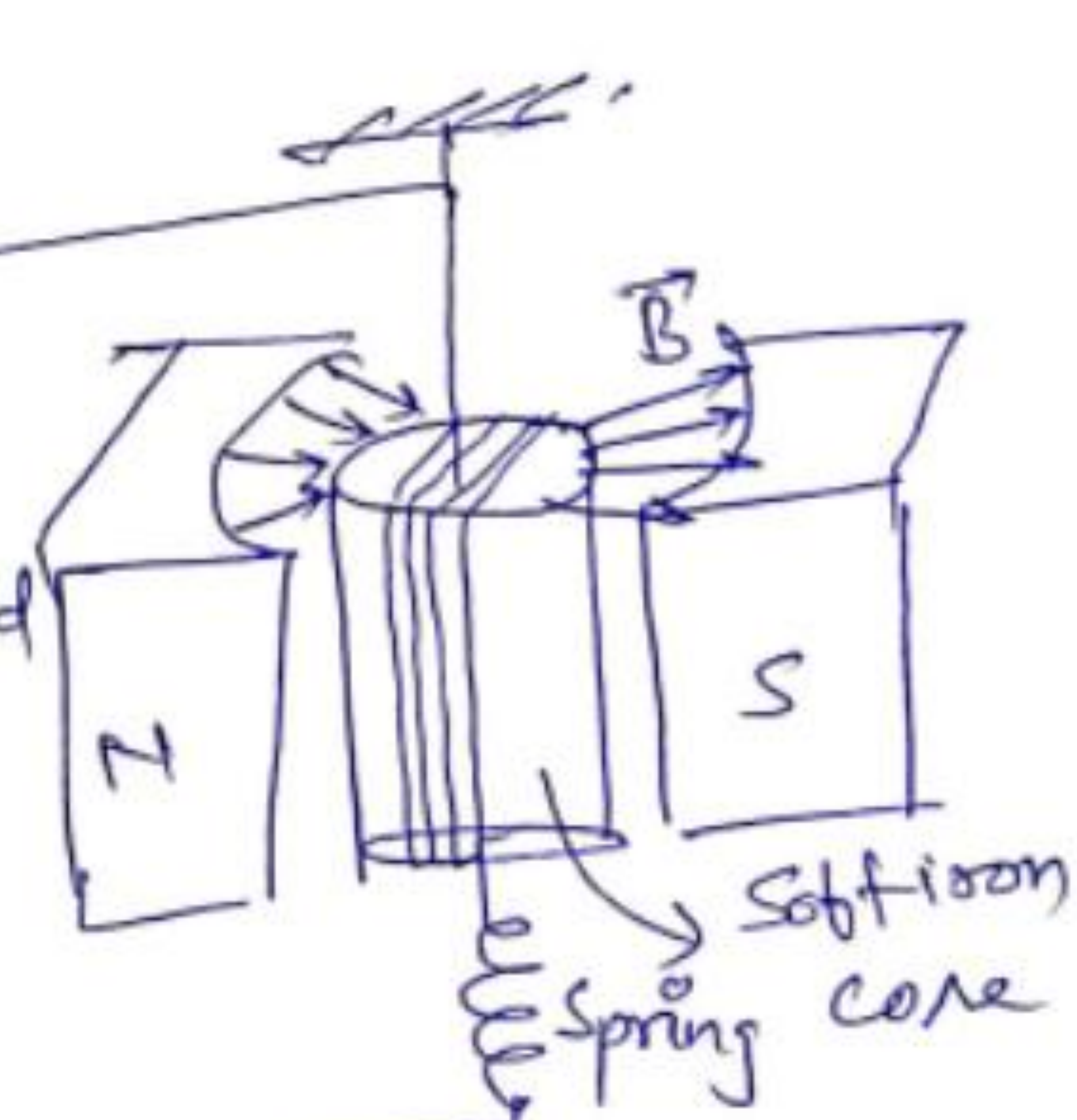
(ii) Write any two points of difference between a diamagnetic and a paramagnetic substance. *5*

Q.33. Galvanometer:

Principle: It is based on the principle of deflection produced when current is flowing through it.

$i \propto \theta$

Working: when current flows through coil then torque produces $\tau = NIAB$.



This torque twist the spring attached at bottom connected with cylinder.

The twist produced in spring is define as $C = K \cdot \theta$

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where C = Couple twisting. θ = Deflection. (17)
k = twisting Const.

In equilibrium – $\tau = C$

$$NIAB = k \cdot \theta$$

$$I = \left(\frac{k}{N \cdot AB}\right) \cdot \theta$$

$$\boxed{I \propto \theta}$$

where $\frac{k}{NAB}$ = Galvanometer sensitivity Constant.

A Galvanometer is not use to measure the Current in circuit because it is directly based on deflection ~~so~~ Concept. it is very Sensitive. for small amount of current deflection in Galvanometer is maximum. Hence when large Current pass through it, it ~~will~~ may get damaged.

(ii) Magnetic field in galvanometer is made radial to Concentrate the field in a circular region uniformly in all direction. and hence make it linear in angular direction.
It is achieved by placing semicircular magnet around Cylindrical rod (core).

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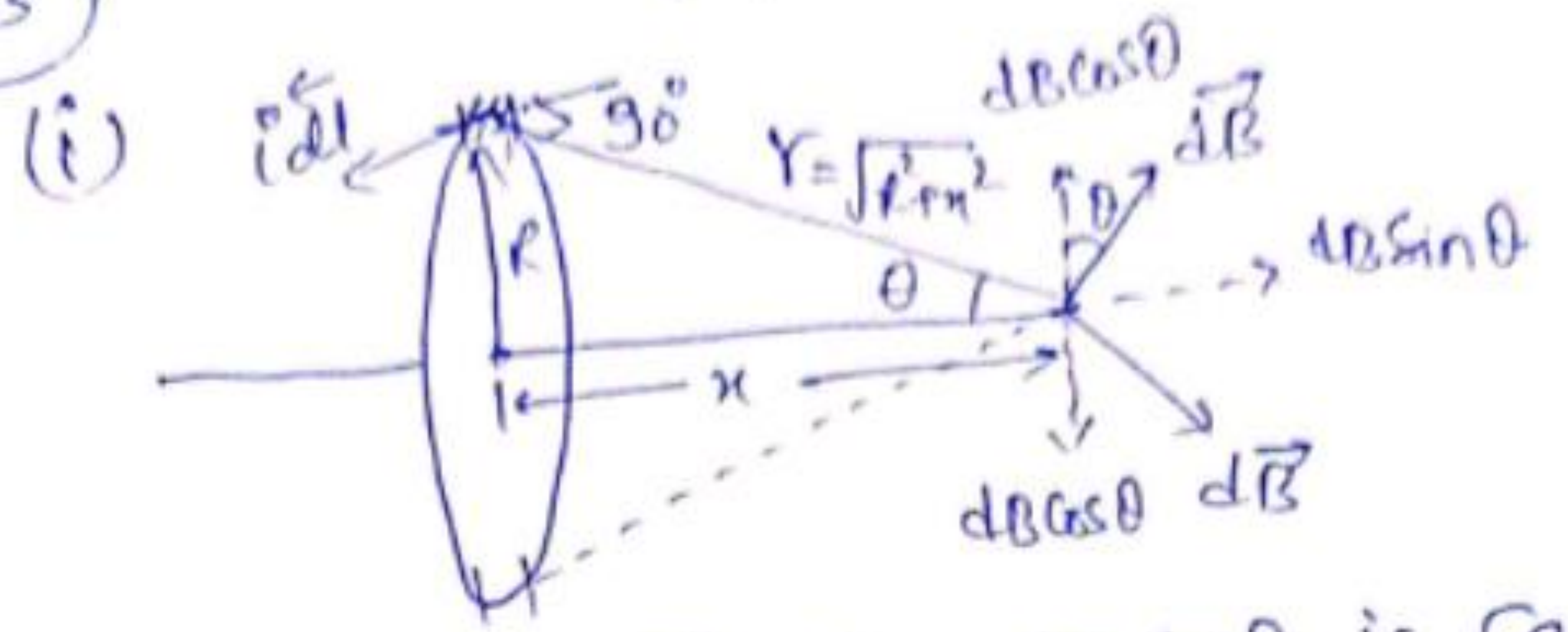
(33) OR (18)

(i)



Component of $d\vec{B}$ i.e. $dB\cos\theta$ is cancled out but $dB\sin\theta$ add up and gives resultand magnetic field

Using Biot-Savart law –

$$\sin\theta = \frac{R}{\sqrt{R^2+x^2}}$$

$$B = \frac{\mu_0}{4\pi}\int \frac{i\,dl\,\sin 90^\circ}{r^2}\sin\theta$$

$$B = \frac{\mu_0}{4\pi}\int \frac{i\,dl}{R^2+x^2}\cdot\frac{R}{\sqrt{R^2+x^2}}$$

$$B = \frac{\mu_0 i R}{4\pi(R^2+x^2)^{3/2}}\int dl \qquad \oint dl = 2\pi R$$

$$\boxed{B = \frac{\mu_0 i \cdot R^2}{2(R^2+x^2)^{3/2}}}$$

(ii)

Diamagnet	Paramagnet
① Magnetic Susceptibility is negative	1) Magnetic Susceptibility is small & positive
② Temperature independent	2) Temperature dependent.

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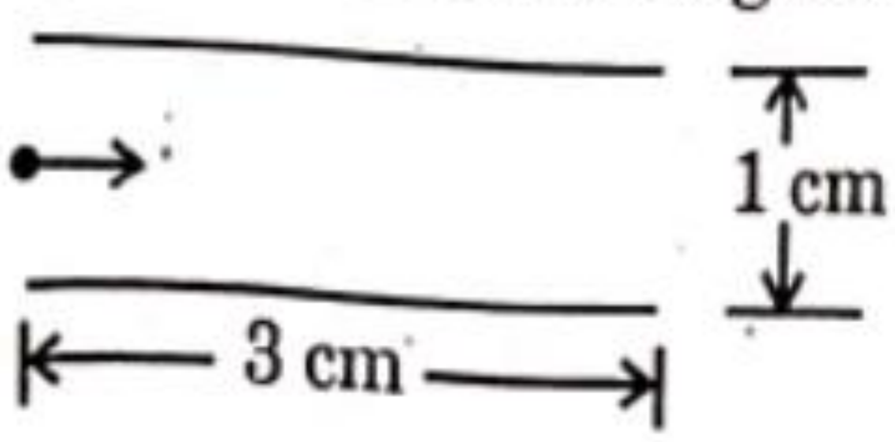
34. A beam of electrons moving horizontally with a velocity of 3×10^7 m/s enters a region between two plates as shown in the figure. A suitable potential difference is applied across the plates such that the electron beam just strikes the edge of the lower plate.



Answer the following questions based on the above :

(a) How long does an electron take to strike the edge ? *1*

(b) What is the shape of the path followed by the electron and why ? *1*

(c) Find the potential difference applied. *2*

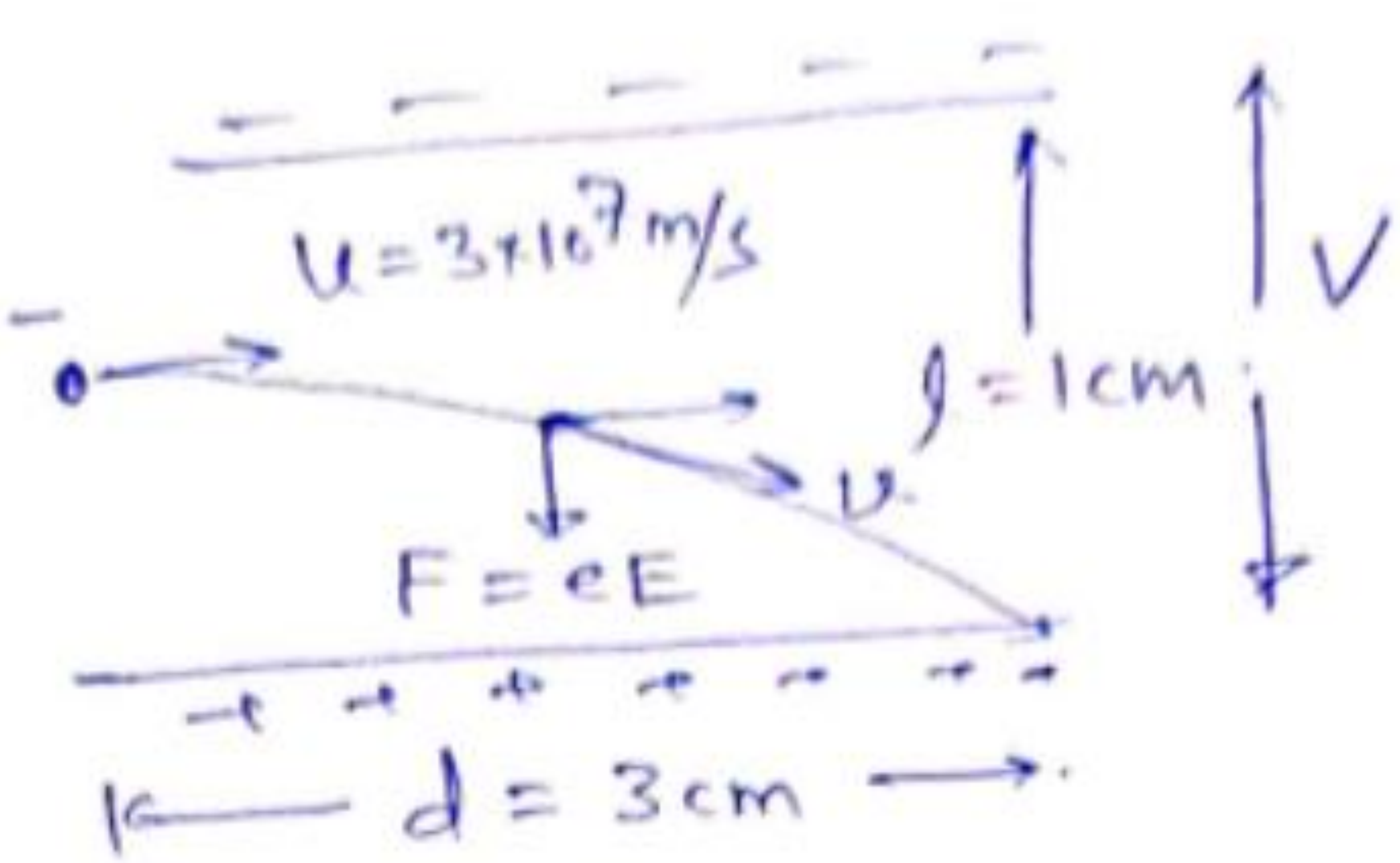
OR

(c) Find the magnitude and direction of the magnetic field which should be created in the space between the plates so that the electron beam goes straight undeviated. *2*

Section - E

(34)

(13)



$E = \frac{V}{y} = 100V$

$ma = eE$

$a = \frac{e \times 100V}{m}$

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$u_x = 3\times10^7$ m/s.

$t = \frac{d}{u_x} = \frac{3\times10^{-2}}{3\times10^7}$

(a) $t = 10^{-9}$ sec

At any instant –

$y = u_y t + \frac{1}{2}a_y t^2$

$y = \frac{1}{2}\cdot\frac{eE}{m}\cdot\frac{x^2}{u_x^2}$

(b) $y \propto x^2$ path is parabola.

(c) Using – $y = 0.5$ cm.

$0.5\times10^{-2} = \frac{1}{2}\times\frac{1.6\times10^{-19}\cdot E\times10^{-18}}{9.1\times10^{-31}}$

$5\times10^{-3} = \frac{1}{2}\times\frac{1.6}{9.1}\times E\times10^{-37+31}$

$\frac{9.1}{1.6}\times10\times10^{-3} = E\times10^{-6}\ 10^{-3}$

$E = \frac{9.1\times10}{1.6\times10^{-3}} = \frac{9.1\times10^4}{1.6}$

$\frac{V}{100} = \frac{9.1}{1.6}\times10^4 \ 100$

$V = \frac{9.1\times100}{1.6} = 568.75$ Volt.

OR

(c) Since $\vec{E}$ is perpendicularly upward. if we create magnetic field outward perpendicularly to plane then e^- will go straight undeviated.

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35. Diffraction of light is bending of light around the corners of an object whose size is comparable with the wavelength of light. Diffraction actually defines the limits of ray optics. This limit for optical instruments is set by the wavelength of light. An experimental arrangement is set up to observe the diffraction pattern due to a single slit.

Answer the following questions based on the above :

(a) How will the width of central maximum be affected if the wavelength of light is increased ? *1*

(b) Under what condition is the first minimum obtained ? *1*

(c) Write two points of difference between interference and diffraction patterns. *2*

OR

(c) Two students are separated by a 7 m partition wall in a room 10 m high. If both light and sound waves can bend around obstacles, how is it that the students are unable to see each other even though they can converse easily ? *2*

Q.35. In Diffraction pattern obtain on screen. (20)

Width of Central maxima is $= 2\beta$.

$= 2 \cdot \frac{\lambda D}{a}$

a = slit width
D = Distance b/w slit & screen.
λ = wavelength

if we increase the wavelength of light fringe width increases.

(b) If we divided slit width (AB) into two equal half then at any point on screen path difference will be -

$$\frac{d}{2} \sin\theta = \frac{\lambda}{2}$$

$$\Rightarrow \boxed{d\sin\theta = \lambda}.$$

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(C)

Interference	Diffraction
1) It Consist of ~~Source~~ two slit as a coherent Source of light	1) It consist of Single slit.
2) Intencity of all maxima's is same	2) In this case central maxima is brighter then others.