SET 55/1/1/D

MARKING SCHEME

Q. No.	Expected Answer / Value Points	Marks	Total Marks
Set1 Q1 Set2 Q5 Set3 Q4	It is defined as the opposition to the flow of current in ac circuits offered by a capacitor. **Alternatively:** $X_c = \frac{1}{\omega C}$ S.I Unit : ohm	½ ½	1
Set1 Q2 Set2 Q1 Set3 Q5	Zero	1	1
Set1 Q3 Set2 Q2 Set3 Q1	Converging (Convex Lens),(Also accept if a student writes it as a diverging Lens or Concave lens (Since hindi translation does not match with English version)	1	1
Set1 Q4 Set2 Q3 Set3 Q2	Side bands are produced due to the superposition of carrier waves of frequency ω_c over modulating / audio signal of frequency ω_m. **Alternatively:** (Credit may be given if a student mentions the side bands as $\omega_c \pm \omega_m$)	1	1
Set1 Q5 Set2 Q4 Set3 Q3	DE : Negative resistance region AB : Where Ohm's law is obeyed.(Also accept BC)	½ ½	1
Set1 Q6 Set2 Q10 Set3 Q9	Determination of ratio (i) accelerating potential 1 (ii) speed 1 (i) $\lambda = \frac{h}{\sqrt{2mqV}} \Rightarrow V = \frac{h^2}{2mq\lambda^2}$ $m_\alpha = 4m_p$, $q_\alpha = 2q_p$ $\Rightarrow \frac{V_p}{V_\alpha} = \frac{m_\alpha q_\alpha}{m_p q_p}$ $= \frac{4m_p \times 2\, q_p}{m_p q_p}$ $= 8 : 1$	½ ½	

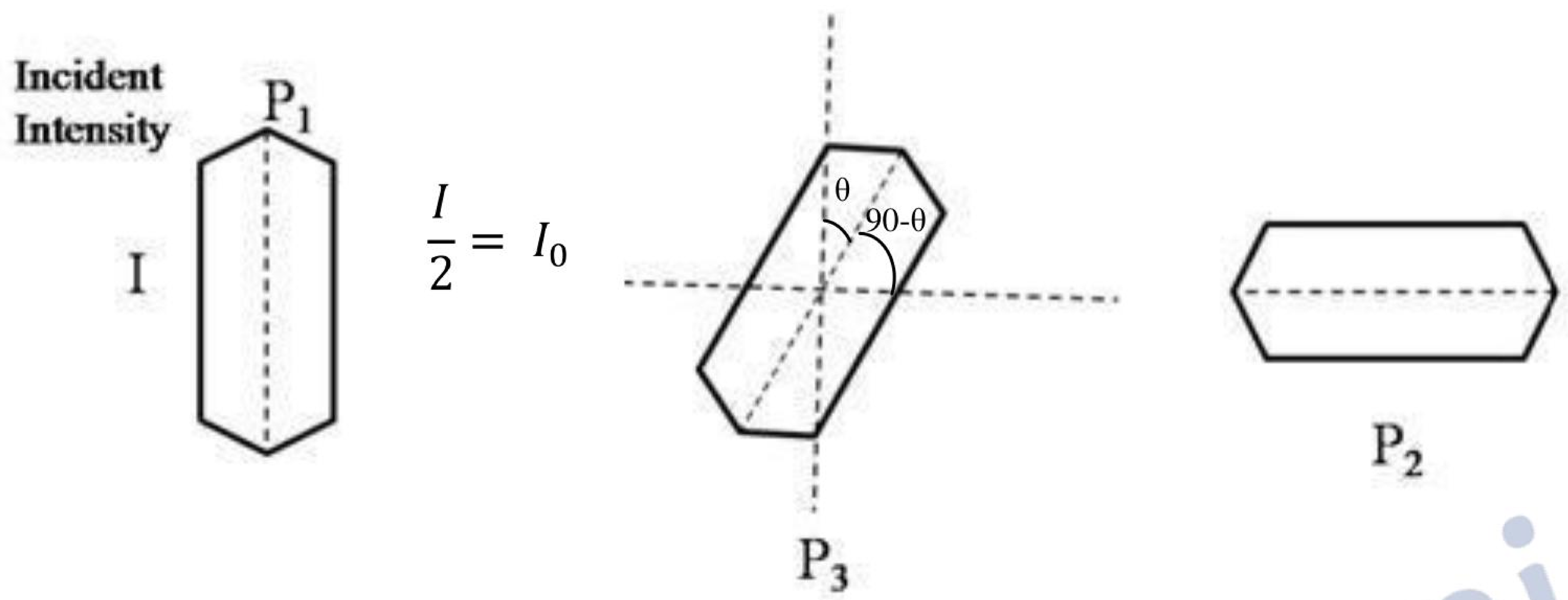
	(ii) $\lambda = \frac{h}{mv}$ => $v = \frac{h}{m\lambda}$ => $\frac{V_p}{V_\alpha} = \frac{m_\alpha}{m_p} = 4$	½ ½	2
Set1 Q7 Set2 Q6 Set3 Q10	Showing that the radius of orbit varies as n^2 2 $\frac{mv^2}{r} = \frac{1}{4\pi \in_0}\frac{e^2}{r^2}$ Or $mv^2r = \frac{1}{4\pi\in_0} e^2$……………………..(i) $mvr = \frac{nh}{2\pi}$ $m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}$ …………………………..(ii) Divide (ii) by (i) mr = $\frac{n^2h^2}{4\pi^2} \times \frac{4\pi\in_0}{e^2}$ $\therefore r = \frac{n^2h^2}{4\pi^2 me^2} . 4\pi \in_0$ $\therefore r \propto n^2$ (Give full credit to any other correct alternative method)	½ ½ ½ ½	2
Set1 Q8 Set2 Q7 Set3 Q6	Distinction between intrinsic & extrinsic semiconductor 2 **Intrinsic Semiconductor**: (i) Without any impurity atoms. (ii) $n_e = n_h$ **Extrinsic Semiconductor**: (i) Doped with trivalent/ pentavalent impurity atoms. (ii) $n_e \neq n_h$ (Any other correct distinguishing features.)	1 1	2
Set1 Q9 Set2 Q8 Set3 Q7	Derivation of the required condition 2		

	$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$	½	
	For concave mirror $f < 0$ and $u < 0$ As object lies between f and $2f$ *(i)* *At* $u = -f$ $\frac{1}{v} = -\frac{1}{f} + \frac{1}{f}$ => $v = \propto$ *At* $u = -2f$		
	=> $\frac{1}{v} = -\frac{1}{f} + \frac{1}{2f} = -\frac{1}{2f}$	½	
	=> $v = -2f$	½	
	=> Hence, image distance $v \geq -2f$	½	2
	Since v is negative therefore the image is real.		
	Alternative Method	½	
	$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$	½	
	For Concave mirror $f < 0, u < 0$ $\because 2f < u < f$ $\Rightarrow \frac{1}{2f} > \frac{1}{u} > \frac{1}{f}$ $\frac{1}{2f} - \frac{1}{f} > \frac{1}{u} - \frac{1}{f} > \frac{1}{f} - \frac{1}{f}$ $\Rightarrow -\frac{1}{2f} - \frac{1}{v} > 0 \qquad \because \frac{1}{u} - \frac{1}{f} = \frac{1}{-v}$		
	$\Rightarrow \frac{1}{2f} < \frac{1}{v} < 0$	½	
	$\Rightarrow v < 0 \qquad \therefore image\ is\ real$	½	
	Also $v > 2f$ image is formed beyond $2f$. (Any alternative correct method should be given full credit.)		2

OR

Finding the expression for intensity	1 ½
Position of polaroid sheet for maximum intensity	½

Let the rotating Polaroid sheet makes an angle θ with the first Polaroid
∴ angle with the other Polaroid will be (90 - θ) ½

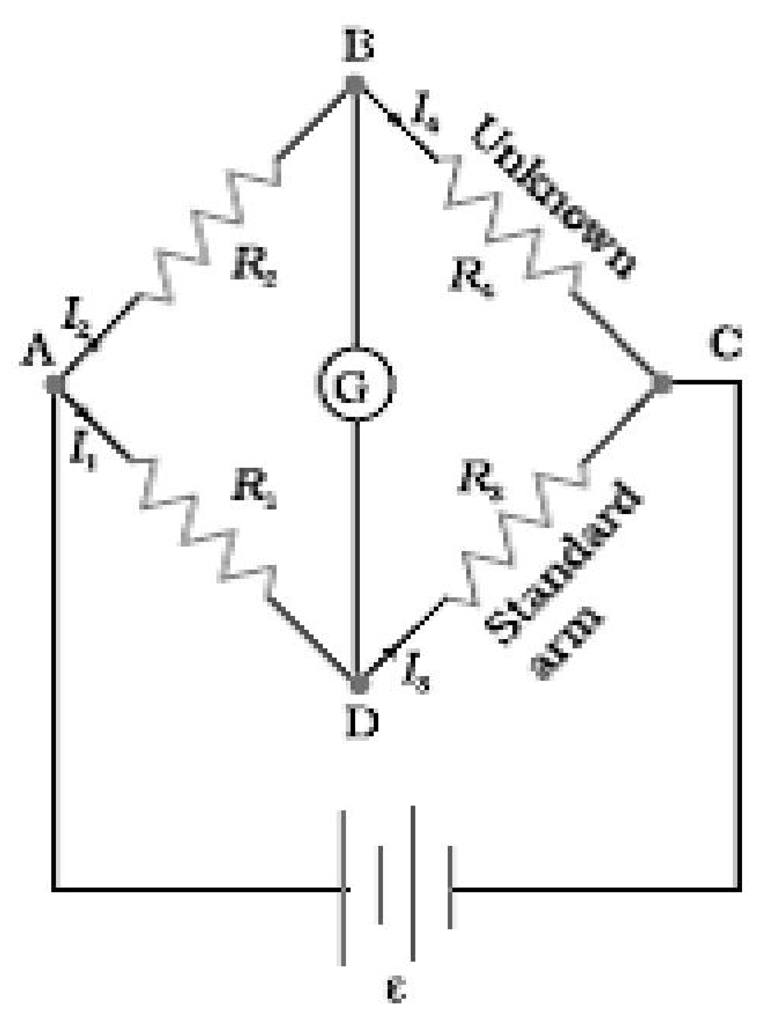


½

Applying Malus's law between $P_1 and P_3$
$I' = I_0 cos^2\theta$
Between P_3 and P_2
$I'' = (I_0 cos^2\theta) cos^2(90 - \theta)$ ½
$I'' = \frac{I_0}{4}.sin^2 2\theta$
∴Transmitted intensity will be maximum when $\theta = \frac{\pi}{4}$ ½ 2

Set1 Q10
Set2 Q9
Set3 Q8

Obtaining condition for the balance Wheatstone bridge	2

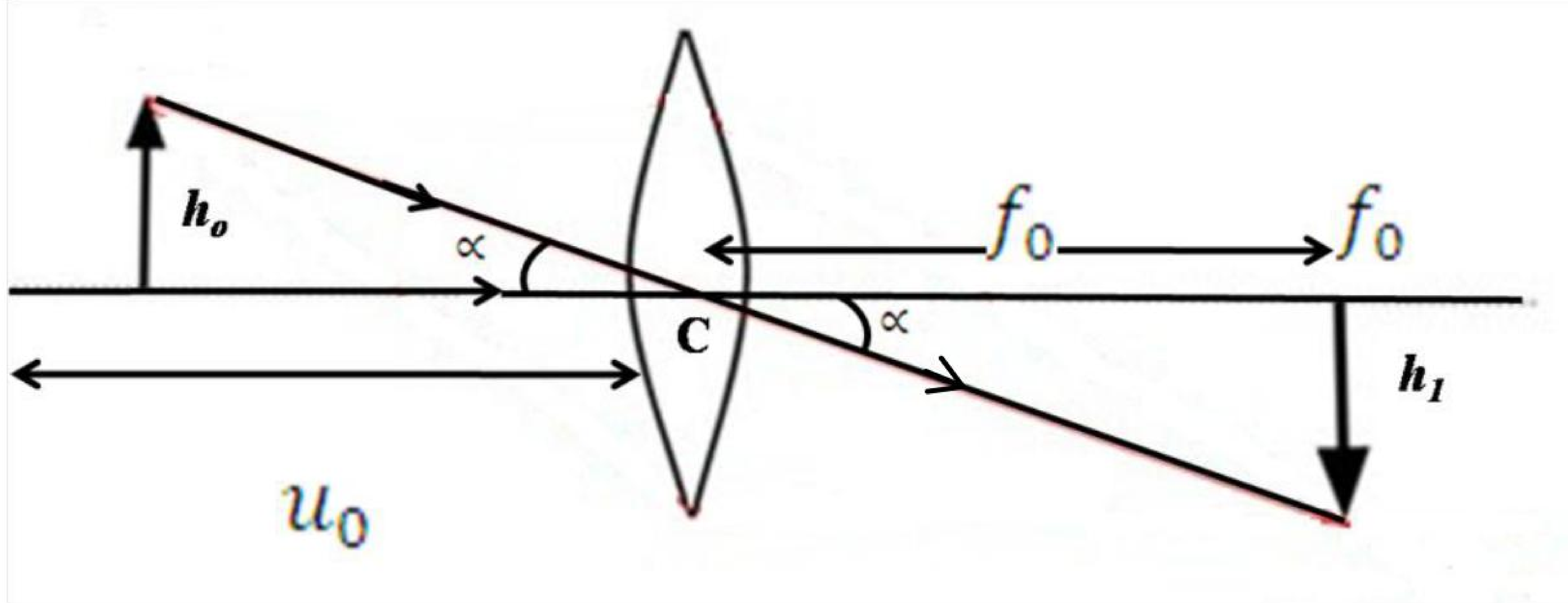


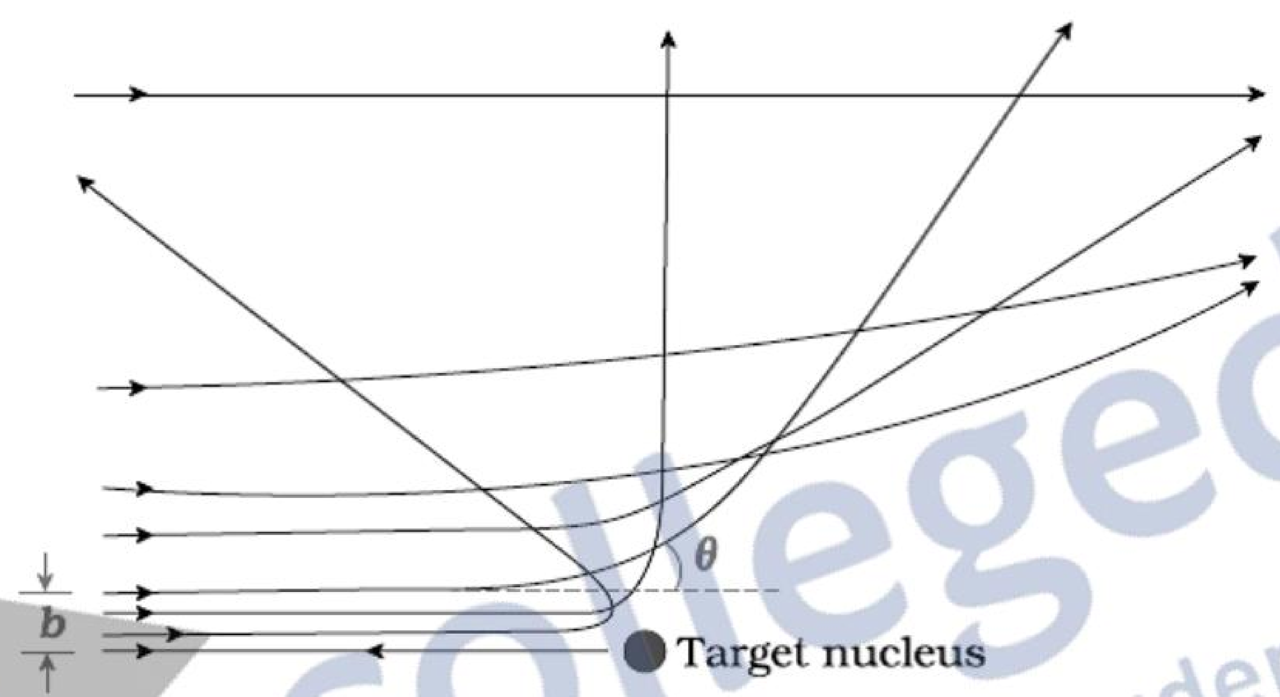
½

Applying Kirchoff's loop rule to closed loop ADBA

$-I_1R_1 + 0 + I_2R_2 = 0$ ($I_g = 0$) ….(i) ½

	For loop CBDC $-I_2R_4 + 0 + I_1R_3 = 0$ ....(ii) => from equation (i) $\frac{I_1}{I_2} = \frac{R_1}{R_2}$ From equation (ii) $\frac{I_1}{I_2} = \frac{R_4}{R_3}$ $\therefore \frac{R_1}{R_2} = \frac{R_4}{R_3}$	 ½ ½	 2
Set1 Q11 Set2 Q19 Set3 Q16	Name of the parts of e.m. spectrum for a,b,c ½+ ½ + ½ Production ½+ ½ + ½ (a) Microwave Production : Klystron/magnetron/Gunn diode (any one) (b) Infrared Radiation Production : Hot bodies / vibrations of atoms and molecules (any one) (c) X-Rays Production : Bombarding high energy electrons on metal target/ x-ray tube/inner shell electrons(any one).	 ½ ½ ½ ½ ½ ½	 3
Set1 Q12 Set2 Q20 Set3 Q17	(i) Calculation of angular magnification 1 ½ (ii) Calculation of image of diameter of Moon 1 ½ Angular Magnification $m = \frac{f_o}{f_e}$ $= \frac{15}{10^{-2}} = 1500$	 1 ½	

	 Angular size of the moon = $\left(\frac{3.48 \times 10^6}{3.8 \times 10^8}\right) = \frac{3.48}{3.8}$ x 10^{-2}radian ∴ Angular size of the image = $\left(\frac{3.48}{3.8} \times 10^{-2} \times 1500\right)$ = radian Diameter of the image = $\frac{3.48}{3.8} \times 15 \times focal\ length\ of\ eye\ piece$ $= \frac{3.48}{3.8} \times 15 \times 1cm$ =13.7cm (Also accept alternative correct method.)	½ ½ ½	3
Set1 Q13 Set2 Q21 Set3 Q18	(i) Einstein's Photoelectric equation ½ (ii) Important features ½ + ½ (iii) Derivation of expressions for λ_0 and work function 1½ $hv = \varphi_{o} + k_{max}$ or $hv = hv_0 + \frac{1}{2}mv_{max}^2$ Important features (i) k_{max} $depends\ linearly\ on\ frequency\ v$. (ii) Existence of threshold frequency for the metal surface. (Any other two correct features.) $hv = \varphi_{o} + k_{max}$ $\frac{hc}{\lambda_1} = \frac{hc}{\lambda_0} + k_{max}$ --------------(i) $\frac{hc}{\lambda_2} = \frac{hc}{\lambda_0} + 2k_{max}$ --------------(ii) From (i) and (ii) $\frac{2hc}{\lambda_1} - \frac{hc}{\lambda_2} = \frac{hc}{\lambda_0}$	½ ½ ½ ½	

	$\frac{1}{\lambda_0} = \left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)$ $\lambda_0 = \frac{\lambda_1 \lambda_2}{2\lambda_2 - \lambda_1}$ Work function $\varphi_o = \frac{hc}{\lambda_0} = \frac{hc(2\lambda_2 - \lambda_1)}{\lambda_1 \lambda_2}$	½ ½	3
Set1 Q14 Set2 Q22 Set3 Q19	(i) Drawing of trajectory 1 (ii) Explanation of information on the size of nucleus ½ (iii) Proving that nuclear density is independent of A 1 ½  Only a small fraction of the incident $\alpha -$ particles rebound. This shows that the mass of the atom is concentrated in a small volume in the form of nucleus and gives an idea of the size of nucleus. Radius of nucleus $R = R_0 A^{\frac{1}{3}}$ Density $= \frac{mass}{volume}$ $= \frac{mA}{\frac{4}{3}\pi R^3}$ where, m: mass of one nucleon A: Mass number $= \frac{mA}{\frac{4}{3}\pi (R_0 A^{\frac{1}{3}})^3}$ $= \frac{3m}{4\pi {R_0}^3}$ => Nuclear matter density is independent of A	1 ½ ½ ½ ½	3

OR

Distinction between nuclear fission and nuclear fusion	½ + ½
Showing release of energy in both processes	½
Calculation of release of energy	1 ½

The breaking of heavy nucleus into smaller fragments is called nuclear fission; the joining of lighter nuclei to form a heavy nucleus is called nuclear fusion. ½ + ½

Binding energy per nucleon, of the daughter nuclei, in both processes, is more than that of the parent nuclei. The difference in binding energy is released in the form of energy. In both processes some mass gets converted into energy. ½

Alternativey:
In both processes, some mass gets converted into energy.

Energy Released

Q = [$m\,({}^2_1H) + m\,({}^3_1H) - m({}^4_2He) - m(n)$] x 931.5 MeV ½

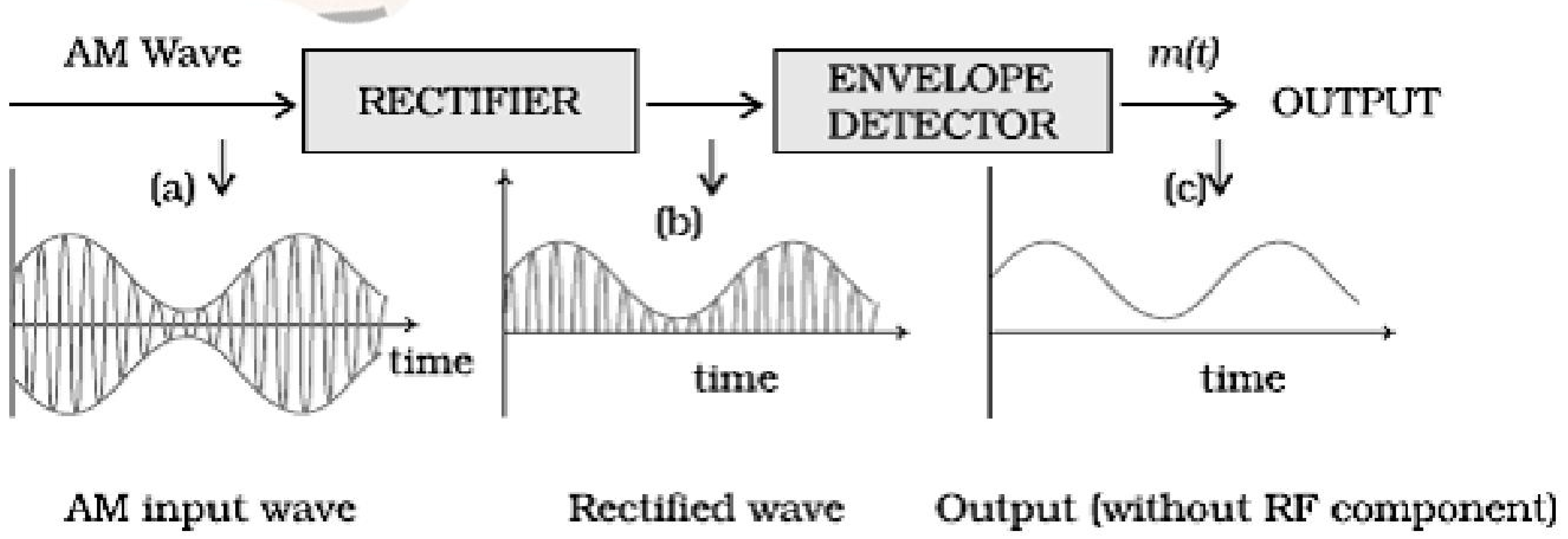
= [2.014102 + 3.016049 – 4.002603 – 1.008665] x 931.5 MeV ½

= 0.018883 x 931.5 MeV ½ 3

= 17.59 MeV

Set1 Q15
Set2 Q11
Set3 Q20

Drawing Block diagram of detector	1
Showing detection of Message signal from Input AM Wave	2

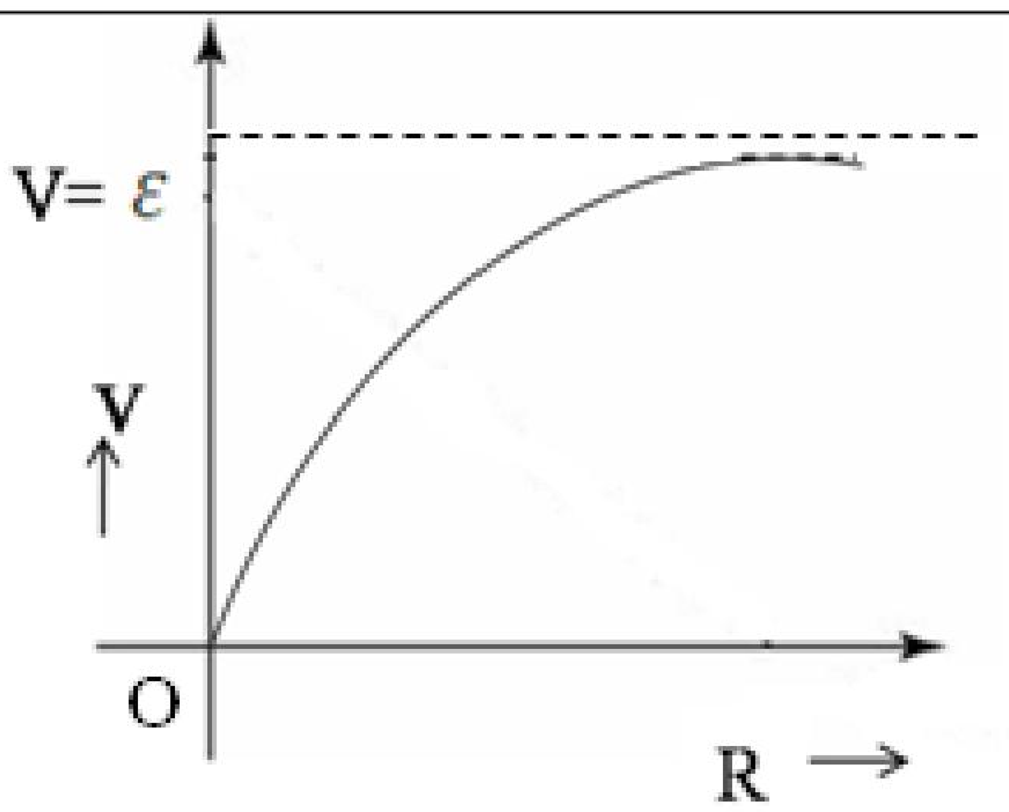


1
1+1
1

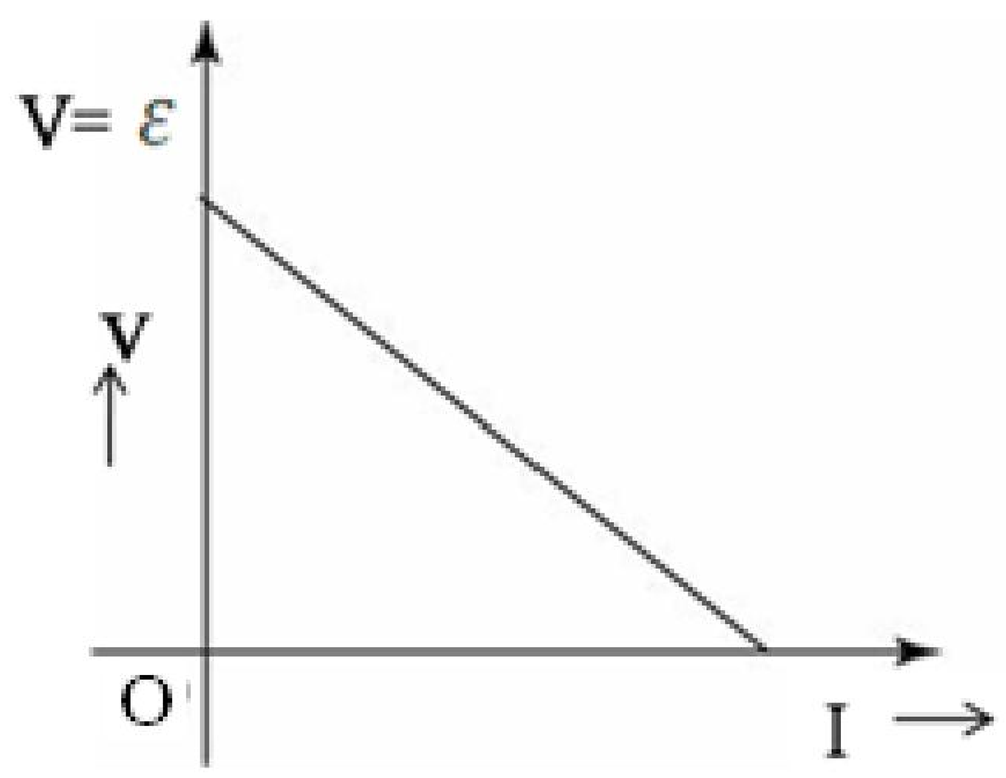
[**Note:** Award these 3 marks irrespective of the way the student attempts the question.] 3

Set1 Q16
Set2 Q12
Set3 Q21

Drawing of Plots of Part (i) & (ii)	½ + ½
Finding the values of emf and internal resistance	1 + 1



½



½

(If the student just writes the relations V=$\varepsilon - IR$ and V= $\frac{\varepsilon R}{R+r}$ but does not draw the plots, award ½ mark.)

$I = \frac{E}{R+r}$

$I = \frac{E}{4+r}$

=> E = 4 + r …..(i) ½

Also

$0.5 = \frac{E}{9+r}$

$E = 4.5 + 0.5\ r$ …..(ii) ½

From equation (i) & (ii)

$4 + r = 4.5 + 0.5$ r ½

$\therefore r = 1\ \Omega$

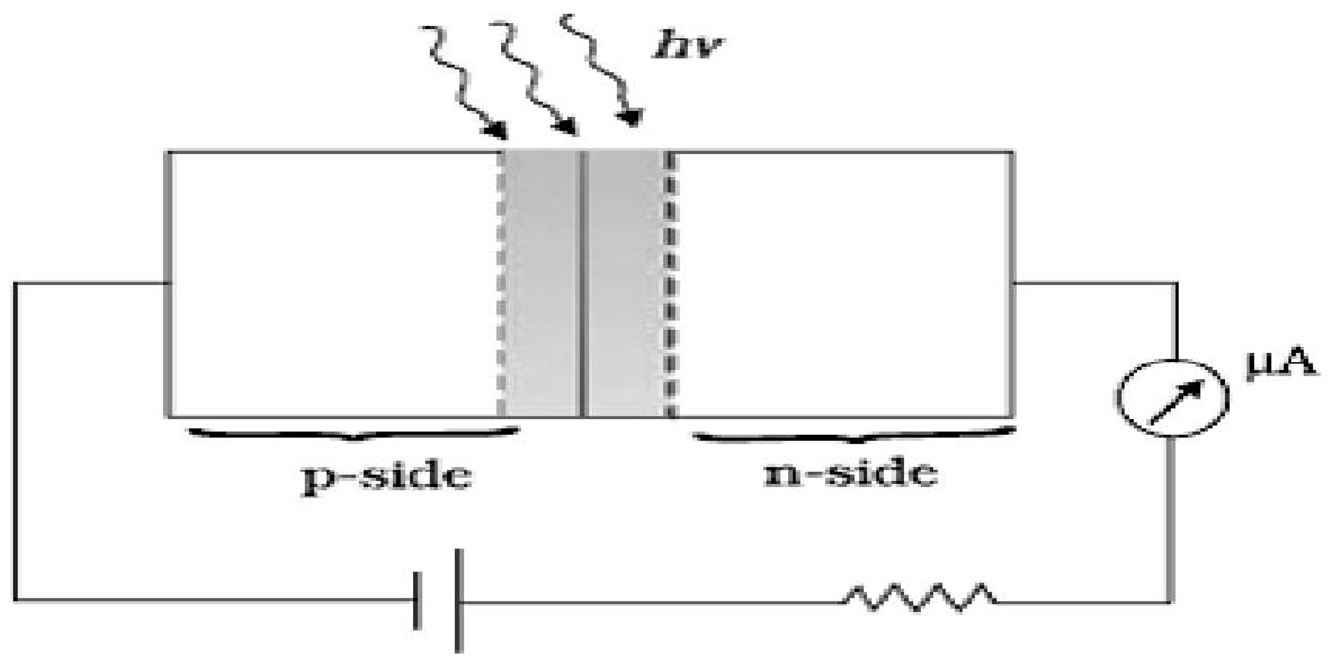
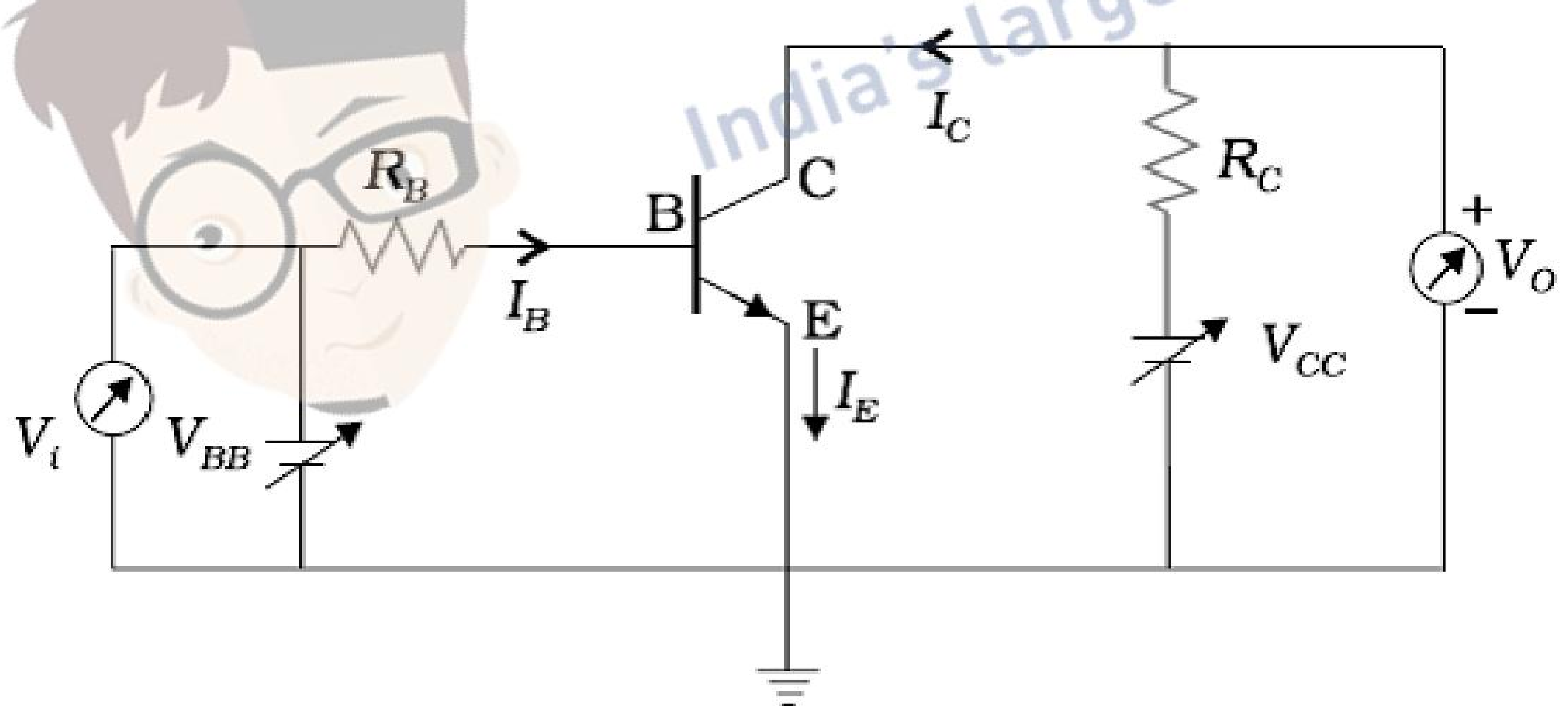
Using this value of r, we get ½

$E = 5V$ 3

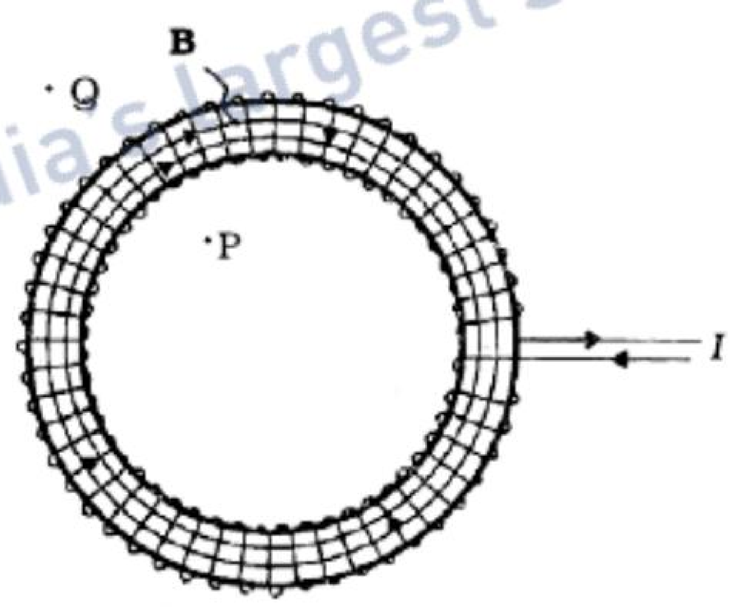
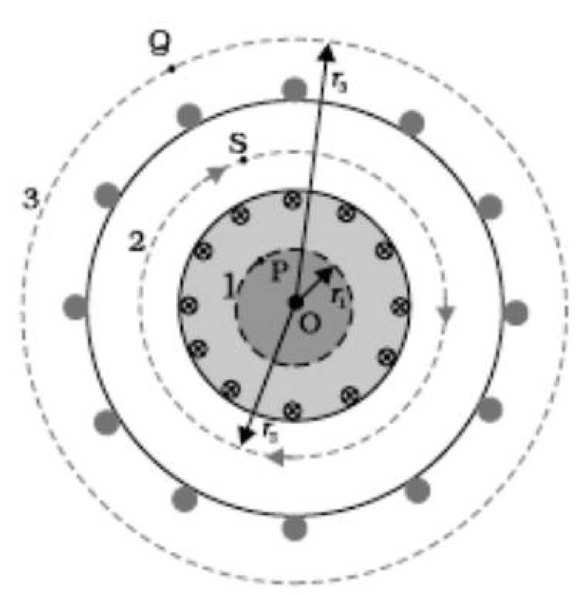
Set1 Q17 Set2 Q13 Set3 Q22	Determination of C_1 and C_2 2 Determination of Charge on each capacitor in parallel combination ½ + ½		

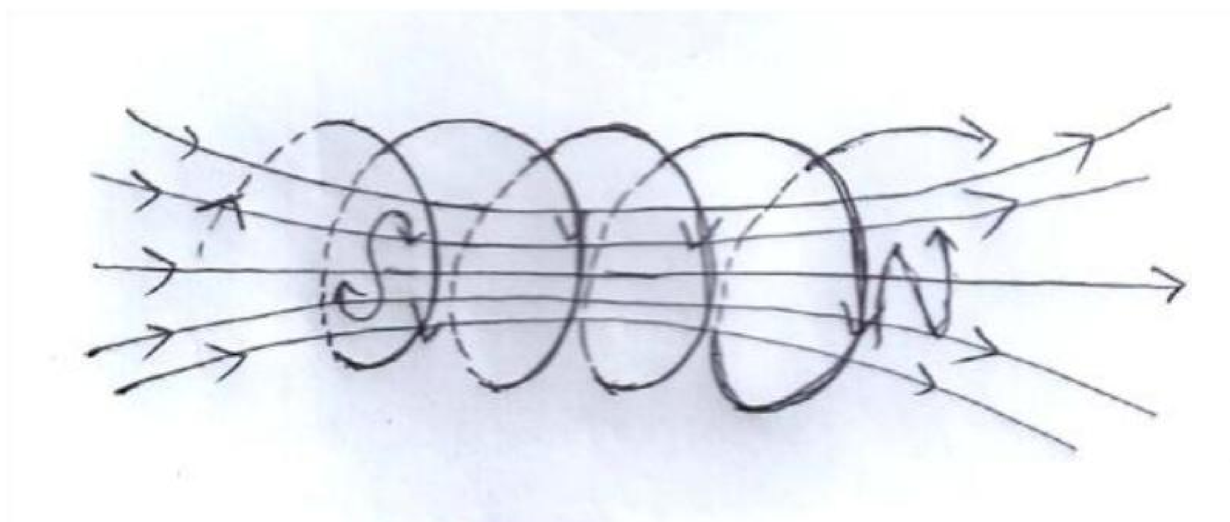
	Energy stored in a capacitor $E = \frac{1}{2} CV^2$ In series combination $0.045 = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(100)^2$ $=> \frac{C_1C_2}{C_1+C_2} = 0.09 \times 10^{-4}$ ……(i) In Parallel combination $0.25 = \frac{1}{2}(C_1+C_2)\,(100)^2$ $=> C_1+C_2 = 0.5 \times 10^{-4}$ ……(ii) On simplifying (i) & (ii) $C_1 C_2 = 0.045 \times 10^{-8}$ $(C_1-C_2)^2 = (C_1+C_2)^2 - 4C_1C_2$ $= (0.5 \times 10^{-4})^2 - 4 \times 0.045 \times 10^{-8}$ $= 0.25 \times 10^{-8} - 0.180 \times 10^{-8}$ $(C_1-C_2)^2 = 0.07 \times 10^{-8}$ $(C_1-C_2) = 2.6 \times 10^{-5} = 0.26 \times 10^{-4}$ …..(iii) From (ii) and (iii) we have $=> C_1 = 0.38 \times 10^{-4}$ F & $C_2 = 0.12 \times 10^{-4}$ F Charges on capacitor C_1 and C_2 in Parallel combination $Q_1 = C_1V = (0.38 \times 10^{-4} \times 100) = 0.38 \times 10^{-2}$ C $Q_2 = C_2V = (0.12 \times 10^{-4} \times 100) = 0.12 \times 10^{-2}$ C [Note: If the student writes the relations/ equations $E = \frac{1}{2} CV^2$	½ ½ ½ ½ ½ ½	

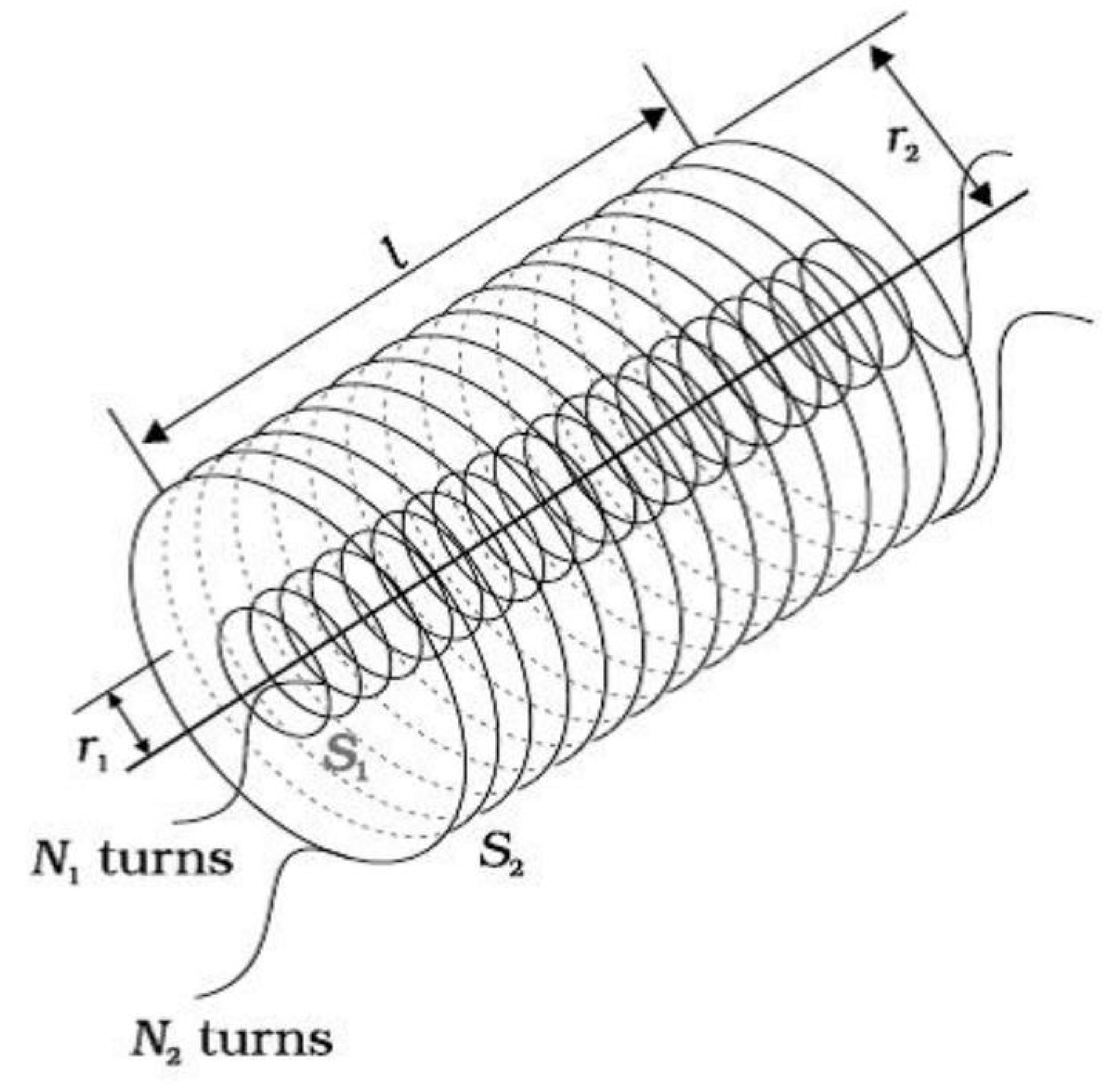
	And $0.045 = \frac{1}{2}\left(\frac{C_1C_2}{C_1+C_2}\right)(100)^2$ $0.25 = \frac{1}{2}(C_1+C_2)(100)^2$ But is unable to calculate $C_1 and\ C_2$, award him/her full 2 marks. Also if the student just writes $Q_1 = C_1V = C_1(100)$ and $Q_2 = C_2V = C_2(100)$ Award him/her one mark for this part of the question.]		3
Set1 Q18 Set2 Q14 Set3 Q11	Working Principle 1 Finding the required resistance 1 Finding the resistance *G* of the Galvanometer 1 Working Principle: A current carrying coil experiences a torque when placed in a magnetic field which tends to rotate the coil and produces an angular deflection. $V = I\,(G + R_1)$ $\frac{V}{2} = I\,(G + R_2)$ $=> \ 2 = \frac{G+R_1}{G+R_2}$ $=> G = R_1 - 2R_2$ Let R_3 be the resistance required for conversion into voltmeter of range 2V $\therefore 2V = I_g\,(G + R_3)$ Also $V = I_g\,(G + R_1)$ $\therefore 2 = \frac{G+R_3}{G+R_1}$ $\therefore R_3 = G + 2R_1 = R_1 - 2R_2 + 2R_1 = 3R_1 - 2R_2$	1 ½ ½ ½ ½	3
Set1 Q19 Set2 Q15 Set3 Q12	Fabrication of photodiode ½ Working with suitable diagram 1 ½ Reason 1 It is fabricated with a transparent window to allow light to fall on diode. When the photodiode is illuminated with photons of energy ($h\upsilon > E_g$) greater than the energy gap of the semiconductor, electron – holes pairs are generated.These gets separated due to the Junction electric field (before they recombine) which produces an emf.	½ 1	

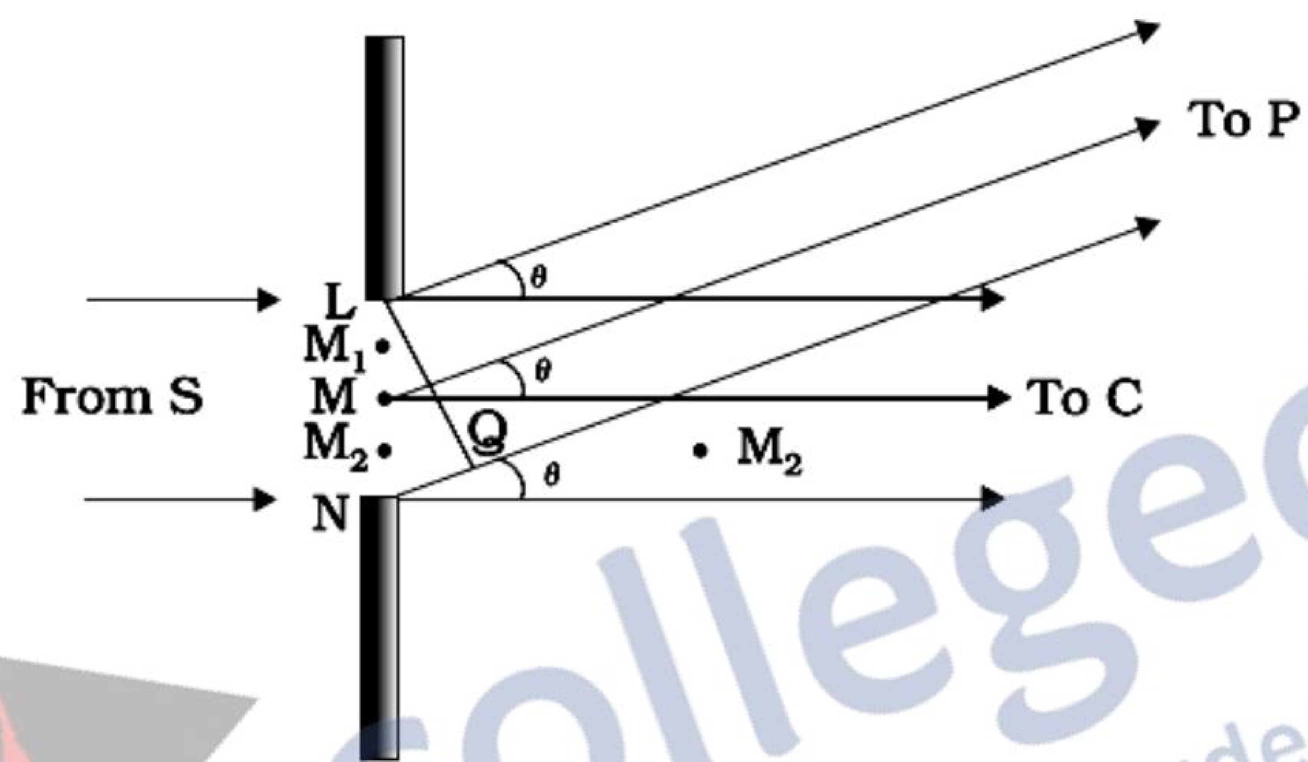
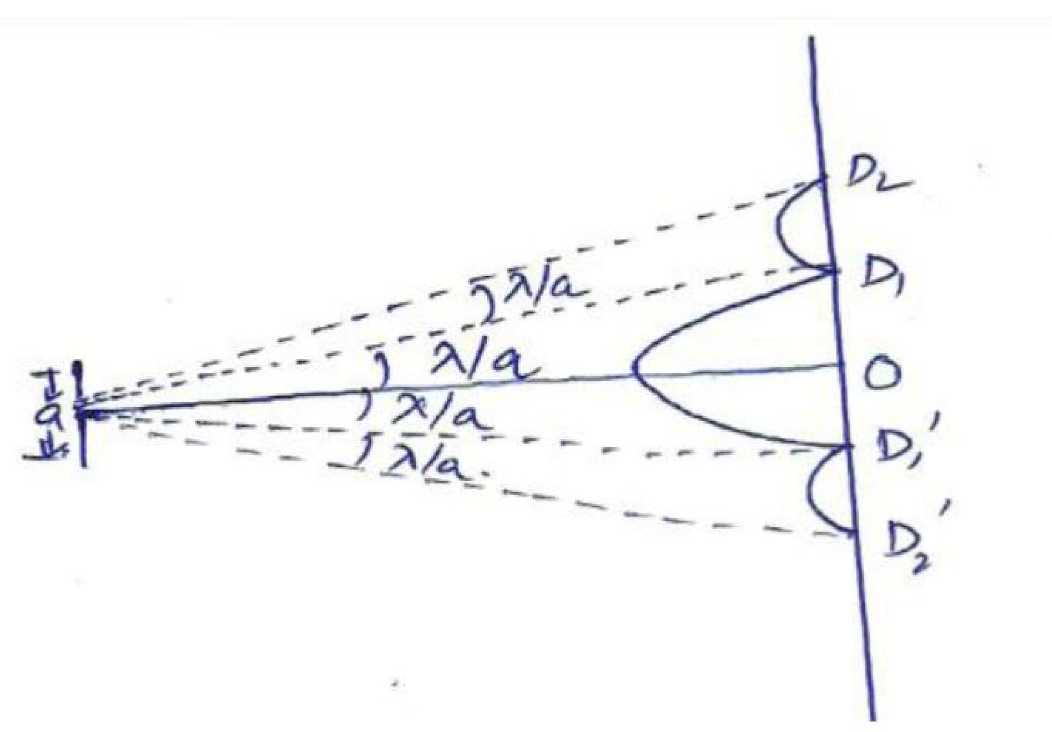
		½	
	Reason: It is easier to observe the change in the current, with change in light intensity, if a reverse bias is applied. **Alternatively**, The fractional change in the minority carrier current, obtained under reverse bias, is much more than the corresponding fractional change in majority carrier current obtained under forward bias.	1	3
Set1 Q20 Set2 Q16 Set3 Q13	Circuit diagram of Transistor amplifier in CE-configuration 1 ½ Definition and determination of (i) Input resistance 1 ½ (ii) Current amplification factor		
		1 ½	
	Input reisistance $R_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$	½	
	Current amplification factor $\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$	½	

	The value of input resistance is determined from the slope of I_B verses V_{BE} plot at constant V_{CE}. The value of current amplification factor is obtained from the slope of collector Ic verses V_{CE} plot using different values of I_B. (If a student uses typical charateristics to determine these values, full credit of one mark should be given)	½	3
Set1 Q21 Set2 Q17 Set3 Q14	Finding the spacing between two slits 1 Effect on wavelength and frequency of reflected and refracted light 2 (a) Angular width of fringes $\theta = \lambda/d$, where d = separation between two slits Here $\theta = 0.1^\circ = 0.1 \times \frac{\pi}{180}$ radian $\therefore d = \frac{600\times10^{-9}\times180}{0.1\times\pi} m$ $= 3.43 \times 10^{-4} m$ $= 0.34 m$ (b) **For Reflected light:** Wavelength remains same Frequency remains same **For Refracted light:** Wavelength decreases Frequency remains same	½ ½ ½ ½ ½ ½	3
Set1 Q22 Set2 Q18 Set3 Q15	Change in the Brightness of the bulb in cases (i), (ii) & (iii) ½ + ½ + ½ Justification ½ + ½ + ½ **(i) Increases** $X_L = \omega L$ As number of turns decreases, L decreases, hence current through bulb increases. / Voltage across bulb increases. **(ii) Decreases** Iron rod increases the inductance which increases X_L, hence current through the bulb decreases./ Voltage across bulb decreases. **(iii) Increases** Under this condition ($X_C = X_L$) the current through the bulb will become maximum / increase.	½ ½ ½ ½ ½ ½	3
Set1 Q23 Set2 Q23 Set3 Q23	(i) Name of device and Principle of working ½ + 1 (ii) Possibility and explanation ½ (iii) Values displayed by students and teachers 1+1		

	(i) Transformer Working Principle: Mutual induction Whenever an alternative voltage is applied in the primary windings, an emf is induced in the secondary windings. (ii) No, There is no induced emf for a dc voltage in the primary (iii) Inquisitive nature/ Scientific temperament (any one) Conceren for students / Helpfulness / Professional honesty(any one) (Any other relevant values)	½ 1 ½ 1 1	 4
Set1 Q24 Set2 Q26 Set3 Q25	(a) Statement of Ampere's circuital law — 1 Expression for the magnetic field — 1 ½ (b) Depiction of magnetic field lines and specifying polarity — ½ + ½ Showing the solenoid as bar magnet — 1 ½ (a) Line integral of magnetic field over a closed loop is equal to the μ_0 times the total current passing through the surface enlosed by the loop . Alternatively $\oint \vec{B}.\vec{dl} = \mu_0 I$  (a)  (b) Let the current flowing through each turn of the toroid be *I*. The total number of turns equals $n.(2\pi r)$ where *n* is the number of turns per unit length. Applying Ampere's circuital law, for the Amperian loop, for interior points.	 1 ½	

	$\oint \vec{B}.\vec{dl} = \mu_0(n2\pi rI)$		
	$\oint Bdl\cos 0 = \mu_0 n\, 2\pi rI$	½	
	$=> B \text{ x } 2\pi r = \mu_0 n\, 2\pi rI$		
	$B = \mu_0 nI$	½	
	(b)		
		½ + ½	
	The solenoid contains N loops, each carrying a current I. Therefore, each loop acts as a magnetic dipole. The magnetic moment for a current I, flowing in loop of area (vector) **A** is given by **m** = I**A**	½ ½	
	The magnetic moments of all loops are aligned along the same direction. Hence, net magnetic moment equals N1**A.**	½	5
	OR		
	(a) Definition of mutual inductance and S.I. unit — 1 ½ (b) Derivation of expression for the mutual inductance of two long coaxial solenoids — 2 ½ (c) Finding out the expression for the induced emf — 1		
	(a) $\phi = MI$ Mutual inductance of two coils is equal to the magnetic flux linked with one coil when a unit current is passed in the other coil.	1	
	Alternatively, $e = -M\frac{dI}{dt}$ Mutual inductance is equal to the induced emf set up in one coil when the rate of change of current flowing through the other coil is unity.		
	SI unit : henry / (Weber ampere^{-1}) / (volt second ampere^{-1})		

	(Any one)	½	
	(b) .  	½	
	Let a current I_2 flow through S_2.This sets up a magnetic flux ϕ_1 through each turn of the coil S_1. Total flux linked with S_1 $N_1\,\phi_1 = M_{12}I_2$ ....(i) where M_{12} is the mutual inductance between the two solenoids	½	
	Magnetic field due to the current I_2 in S_2 is $\mu_0 n_2 I_2$.	½	
	Therefore, resulting flux linked with S_1. $N_1\,\phi_1 = [(n_1\ell)\pi r_1^2](\mu_0 n_2 I_2)$ ....(ii)	½	
	Comparing (i) & (ii),we get $M_{12}I_2 = (n_1\ell)\pi r_1^2(\mu_0 n_2 I_2)$ $\therefore M_{12} = \mu_0 n_1 n_2\ \pi r_1^2 \ell$	½	
	(c) Let a magnetic flux be (ϕ_1) linked with coil C_1 due to current (I_2) in coil C_2; We have : $\phi_1 \propto I_2$ $\Rightarrow \phi_1 = MI_2$		

	$\therefore \frac{d\phi_1}{dt} = M\frac{dI_2}{dt}$ $\Rightarrow e = -M\frac{dI_2}{dt}$	½ ½	5
Set1 Q25 Set2 Q24 Set3 Q26	(a) Explanation of diffraction pattern using Huygen's construction 2 (b) Showing the angular width of first diffraction fringe as half of the central fringe 2 (c) Explanation of decrease in intensity with increasing n 1 (a).  We can regard the total contribution of the wavefront LN at some point P on the screen, as the resultant effect of the superposition of its wavelets like LM, MM_2, M_2N. These have to be superposed taking into account their proper phase differences .We, therefore,get maxima and minima ,i.e a diffraction pattern, on the screen. (b)  Condition for first minimum on the screen $a \, Sin\theta = \lambda$ $\Rightarrow \theta = \lambda/a$ $\therefore$ angular widthof the central fringe on the screen (from figure)	 1 1 ½ ½	

$= 2\,\theta = 2\,\lambda/a$ ½

Angular width of first diffraction fringe (From fig) $= \lambda/a$ ½

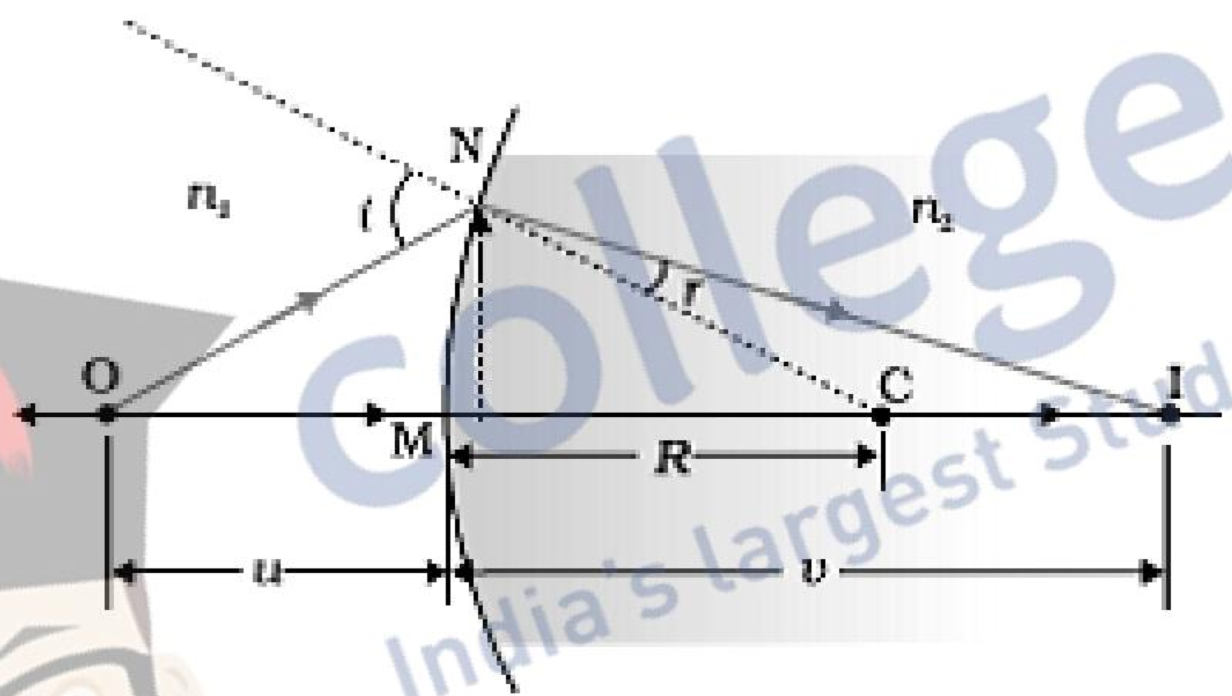
Hence angular width of central fringe is twice the angular width of first fringe.

Maxima become weaker and weaker with increasing n. This is because the effective part of the wavefront, contributing to the maxima, becomes smaller and smaller, with increasing n . 1 5

OR

a)	Drawing the ray diagram showing the image formation	1
	Derivation of relationship	2
b)	Ray diagram	½
	Similar relation	½
	Derivation of lens maker's formula	1

(a)



1

(Deduct ½ mark for not showing direction of propagation of ray)

For small angles

$\angle NOM \simeq \tan \angle NOM = \frac{MN}{OM}$

$\angle NCM \simeq \tan \angle NCM = \frac{MN}{MC}$ ½

$\angle NIM \simeq \tan\ \angle NIM = \frac{MN}{MI}$

In ΔNOC, $\angle i\ \angle NOM + \angle NCM$

$\therefore \angle i = \frac{MN}{OM} + \frac{MN}{MC}$ …(i) ½

Similarly

$\angle r = \angle NCM - \angle NIM$

$$= \frac{MN}{MC} - \frac{MN}{MI} \qquad \text{...(ii)}$$

Using Snell's Law

$n_1 \sin i = n_2 \sin r$

For small angles

$n_1 i^{\theta} = n_2 r$

Substituting for i and r, we get

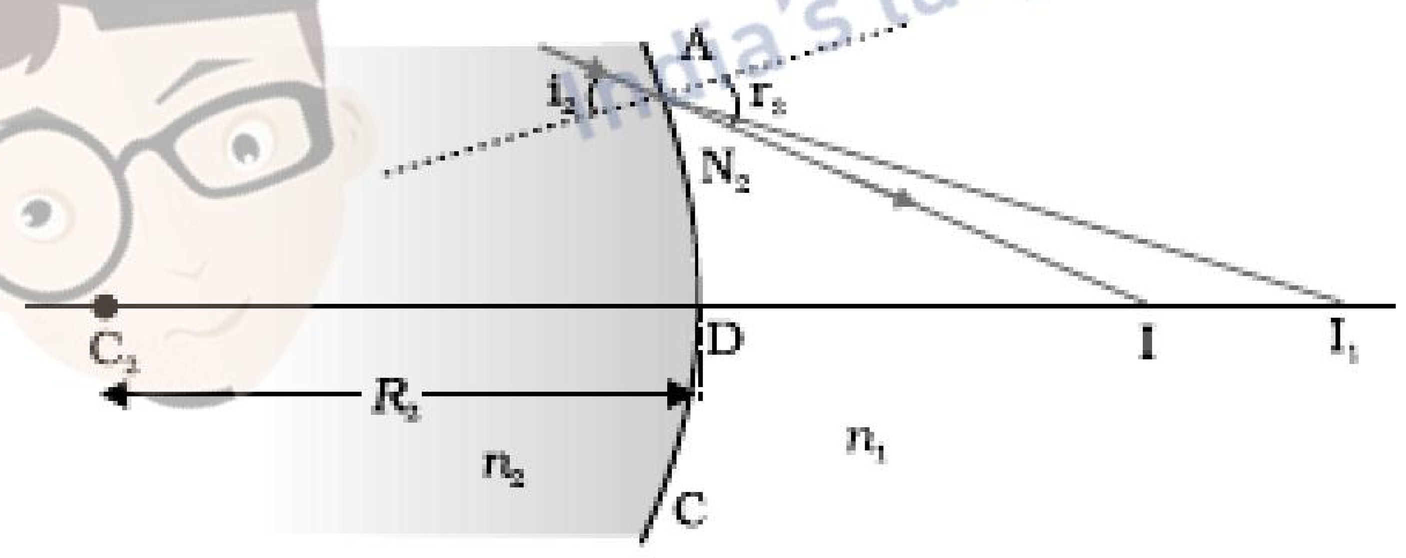
$\frac{n_1}{OM} + \frac{n_2}{MI} = \frac{n_2 - n_1}{MC}$ ½

Here, *OM* = -*u* , *MI* = + *v*, *MC* = +*R*

Substituting these ,we get

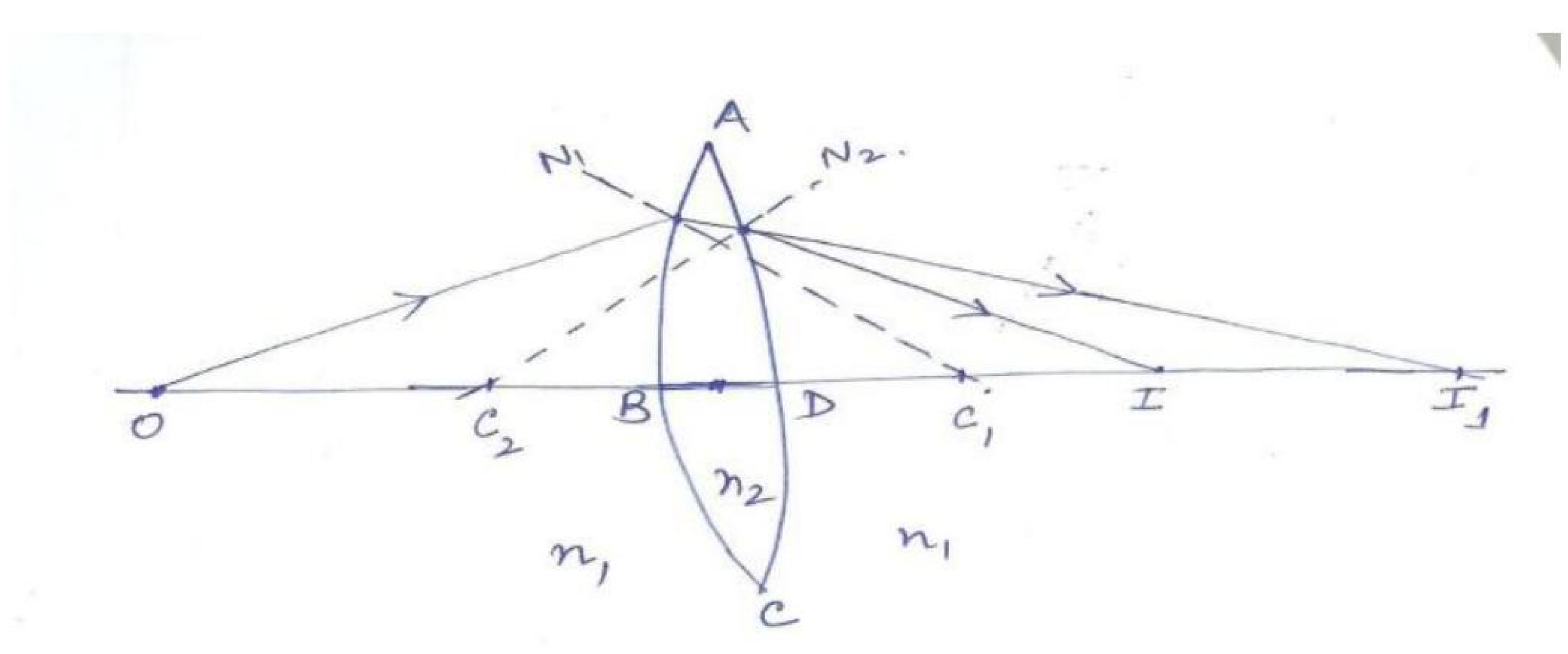
$\Rightarrow \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ ½

b)



½

(Alternatively accept this Ray diagram)



Similarly relation for the surface ADC.

$$\frac{-n_2}{DI_1} + \frac{n_1}{DI} = \frac{n_2 - n_1}{DC_2} \qquad \text{....(i)}$$ ½

Refraction at the first surface ABC of the lens.

$$\frac{n_1}{OB} + \frac{n_2}{BI_1} = \frac{n_2 - n_1}{BC_1} \qquad \text{....(ii)}$$

Adding (i) and (ii), and taking $BI_1 \simeq DI_1$, we get

$$\frac{n_1}{OB} + \frac{n_1}{DI} = (n_2 - n_1)\left(\frac{1}{BC_1} + \frac{1}{DC_2}\right)$$ ½

Here, $OB = -u$

$DI = +v$

$BC_1 = +R_1$

$DC_2 = -R_2$

$$\Rightarrow \frac{n_1}{-u} + \frac{n_1}{v} = (n_2 - n_1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

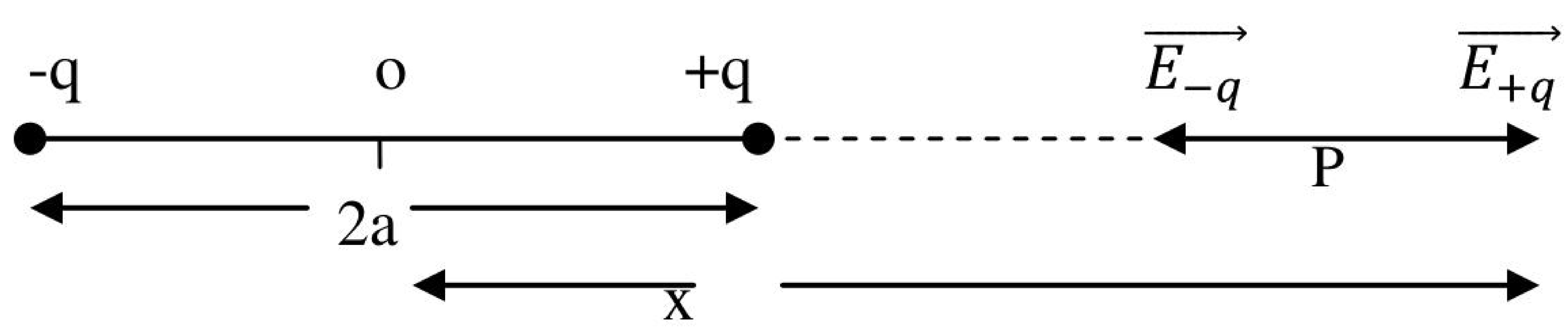
$$\Rightarrow n_1\left(\frac{1}{v} + \frac{1}{u}\right) = (n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ ½ 5

Set1 Q26
Set2 Q25
Set3 Q24

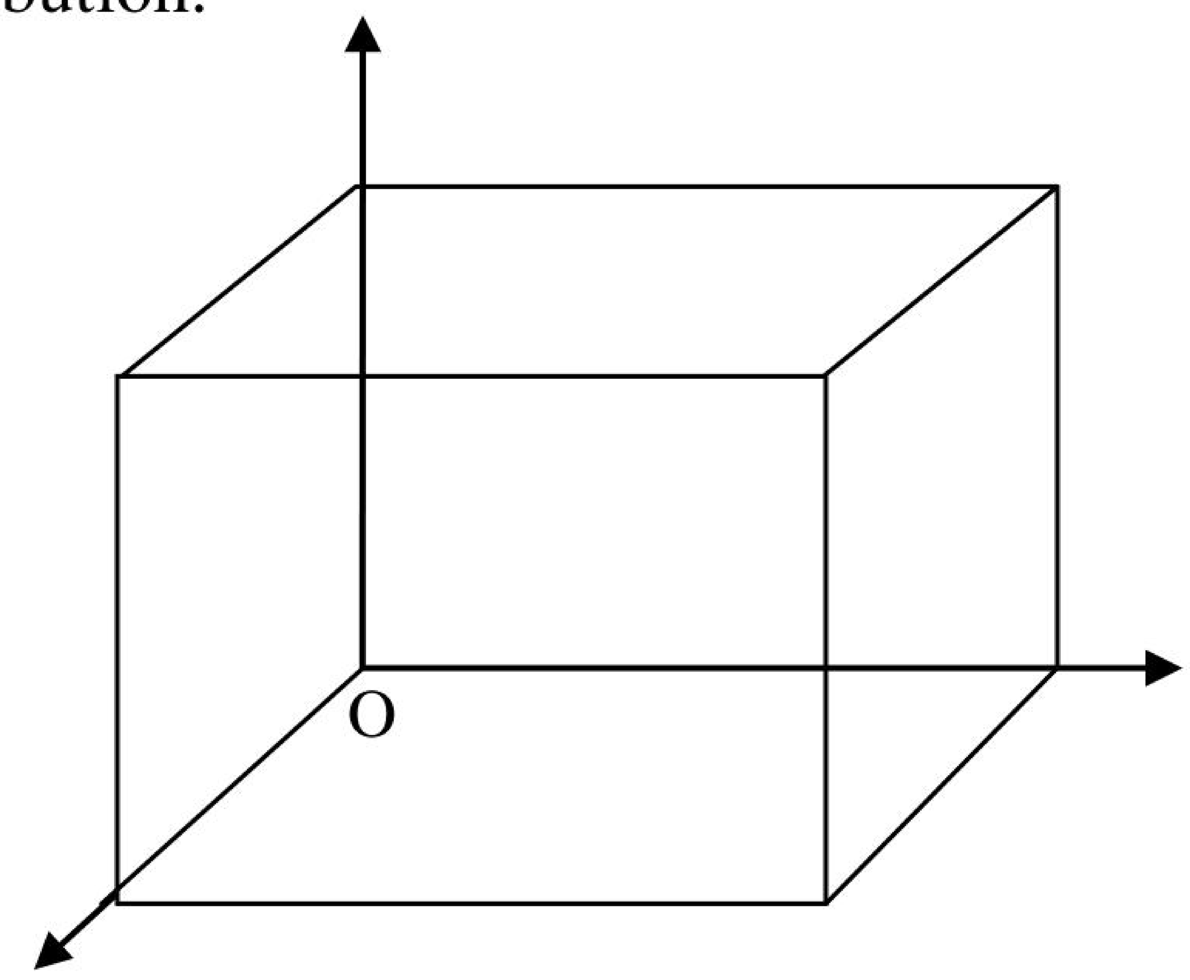
a) Derivation of the expression for the Electric field E and its limiting value	3
b) Finding the net electric flux	2

a)



½

Electric field intensity at point p due to charge –q

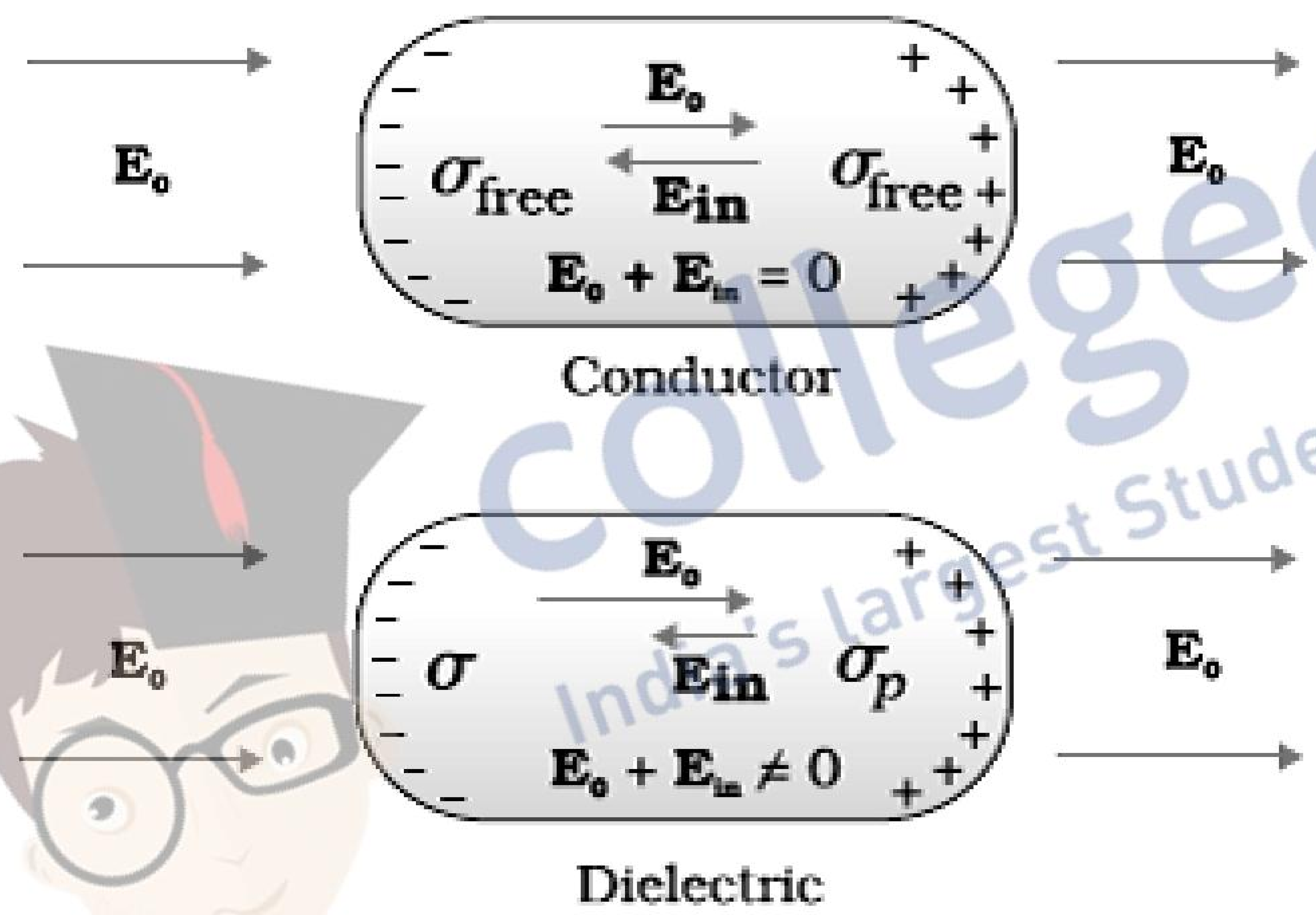
	$\overrightarrow{E_{-q}} = \frac{1}{4\pi\varepsilon_o} \cdot \frac{q}{(x+a)^2} \ (\hat{x})$ Due to charge +q $\overrightarrow{E_{+q}} = \frac{1}{4\pi\varepsilon_o} \cdot \frac{q}{(x-a)^2} \ (\hat{x})$	½	
	Net Electric field at point p $\vec{E} = \overrightarrow{E_{-q}} + \overrightarrow{E_{+q}}$ $= \frac{q}{4\pi\varepsilon_o} \text{ x } \left[\frac{1}{(x-a)^2} - \frac{1}{(x+a)^2}\right] (\hat{x})$	½	
	$= \frac{q}{4\pi\varepsilon_o} \left[\frac{4aqx}{(x^2-a^2)^2}\right] (\hat{x})$	½	
	$= \frac{1}{4\pi\varepsilon_o} \frac{(q\times 2a)2x}{(x^2-a^2)^2} (\hat{x})$ $\vec{E} = \frac{1}{4\pi\varepsilon_o} \cdot \frac{2px}{(x^2-a^2)^2} \hat{x}$	½	
	For x>> a $(x^2 - a^2)^2 \simeq x^4$ $\vec{E} = \frac{1}{4\pi\varepsilon_o} \cdot \frac{2p}{x^3} \hat{x}$	½	
	b) Only the faces perpendicular to the direction of x-axis, contribute to the Electric flux. The remaining faces of the cube give zero contribution.	½	
	 Total flux $\phi = \phi_I + \phi_{II}$ $= \oint_I \vec{E}.\overrightarrow{ds} + \oint_{II} \vec{E}.\overrightarrow{ds}$	½	

$= 0 + 2(a)\,.\,a^2$ ½

$\therefore \phi = 2a^3$ ½ 5

OR

a) Explanation of difference in behavior of (i) conductor (ii) dielectric	1+1
Definition of polarization and its relation with susceptibility	½ + ½
b) (i) Finding the force on the charge at centre and the charge at point A	½ +½
(ii) Finding Electric flux through the shell	1



½

½

In the presence of Electric field, the free charge carriers, in a conductor, move the charge distribution in the conductor readjusts itself so that the net Electric field within the conductor becomes zero. ½

In a dielectric, the external Electric field induces a net dipole moment, by stretching /reorienting the molecules. The Electric field, due to this induced dipole moment,opposes ,but does not exactly cancel, the external Electric field. ½

Polarisation: Induced Dipole moment, per unit volume, is called the polarization.For Linear isotropic dielectrics having a susceptibility x_c,we have ½

	$P = X_e E$ B (i) Net Force on the charge $\frac{Q}{2}$,placed at the centre of the shell, Is zero. Force on charge '2Q' kept at point A $F = E \times 2Q = \frac{1\left(\frac{3Q}{2}\right)2Q}{4\pi\varepsilon_0 r^2} = \frac{(K\ )3Q^2}{r^2}$ Electric flux through the shell $\phi = \frac{Q}{2\varepsilon_0}$	½ ½ ½ 1	 5

These answers are meant to be used by evaluators