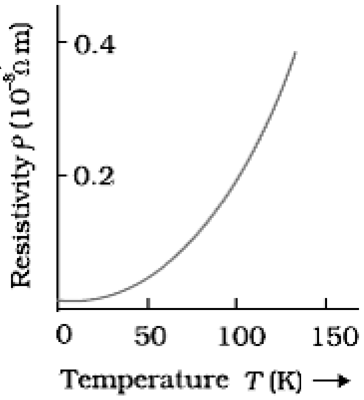
MARKING SCHEME
SET 55/2/1/F

Q. No.	Expected Answer / Value Points **SECTION - A**	Marks	Total Marks
Set1 Q1 Set2 Q5 Set3 Q2	$\vec{\tau} = \vec{p} \times \vec{E}$	1	1
Set1 Q2 Set2 Q4 Set3 Q5		1	1
Set1 Q3 Set2 Q2 Set3 Q4	$\frac{\pi}{3}$ [Note: Award ½ mark if the student just writes cosθ = 0.5]	1	1
Set1 Q4 Set2 Q3 Set3 Q1	No	1	1
Set1 Q5 Set2 Q1 Set3 Q3	Due to scattering of light. Alternatively, Red light gets scattered the least)	1	1
	SECTION - B		
Set1 Q6 Set2 Q7 Set3 Q10	Combination of resistors for part (i) 1 Combination of resistors for part (ii) 1 (i) Combining the resistors of 1Ω and 2Ω in parallel Net resistance = $\frac{2}{3}$ Ω Now connecting $\frac{2}{3}$ Ω and 3Ω in series $R = (\frac{2}{3} + 3)\Omega = \frac{11}{3}\ \Omega$ (ii) 2Ω and 3Ω are to be connected in parallel Net Resistance = $\frac{6}{5}$ Ω Now connecting $\frac{6}{5}$ Ω and 1Ω in series $R = \frac{6}{5} + 1 = \frac{11}{5}\ \Omega$	 ½ ½ ½ ½	 2

Set1 Q7 Set2 Q10 Set3 Q8	Formula ½ Determination of de –Brogic wavelength 1 ½ $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$ $= \frac{6.63 \text{ X } 10^{-34}}{\sqrt{2 \text{ X } 9.1 \text{ X } 10^{-31} \text{ X } 3.4 \text{ X } 1.6 \text{ X } 10^{-19}} m$ = 6.63 x $10^{-10} m$ Alternatively, For first excited state $n = 2$ $\therefore\ r_2 \cong 4 \text{ x } 0.53 A^0$ $= 2.12\ A^0$ As $2\pi\, r_n = n\lambda$ $\lambda = \frac{2 \times 3.14 \times 2.12 \times 10^{-10}}{2} m$ $\lambda \cong 6.6 \times 10^{-10}\ m$	½ 1 ½ ½ ½ ½ ½	2 2
Set1 Q8 Set2 Q6 Set3 Q9	a) β- decay of Tritium 1 b) Reason 1 a) $^{3}_{1}H \rightarrow {}^{3}_{2}He + {}^{0}_{-1}e + \bar{\vartheta} + Q$ Also accept: $^{A}_{Z}X \rightarrow {}^{A}_{ZH}Y + {}^{0}_{-1}e + \bar{\vartheta} + Q$ b) Due to their very weak interaction with matter.	1 1	2
Set1 Q9 Set2 Q8 Set3 Q7	Calculation of resistance of the diode at (i) I = 15 mA (ii) V= -10 V 1+1 (i) $R = \frac{\Delta V}{\Delta I} = \frac{(0.8-0.7)V}{(20-10)mA}$ $= \frac{0.1}{10} \times 10^3$	½	

	$= 10\Omega$ (Also accept if a student calculates different value of the resistance like 30Ω using this method) (ii) $R = \frac{10\ V}{1\mu A}$ $= 10^7\Omega$	½ ½ ½	2
Set1 Q10 Set2 Q9 Set3 Q6	Dependence of refractive index on wavelength ½ Calculation of value of critical angle 1 ½ Refractive index of the transparent medium decreases with increase in wavelength of the incident light. Also accept: $\mu = A + \frac{B}{\lambda^2}$ $$\mu_{ga} = \frac{speed\ of\ light\ in\ air}{speed\ of\ light\ in\ glass}$$ $$= \frac{3\times10^8}{2\times10^8} = 1.5$$ Also $\mu_{ga} = \frac{1}{Sin\ I_c} \Rightarrow i_c = sin^{-1}\left(\frac{1}{\mu}\right)$ $$= sin^{-1}\left(\frac{2}{3}\right)$$ **OR** Relation of Power of each part with the focal length of original Lens 1 Finding the value of radius of curvature 1 Power of a lens = $\frac{1}{focal\ Length}$ After cutting the lens into two identical parts, the power of each part will be half of the power of original lens. i.e. focal length of each part will be $2f$ $\therefore P = \frac{1}{2f}$ $P = \frac{1}{f} \Longrightarrow f = \frac{1}{5}m = 0.2m = 20\ cm$ $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ (Since $R_1 = +R$, $R_2 = -R$	 ½ ½ ½ ½ ½ ½ ½	 2

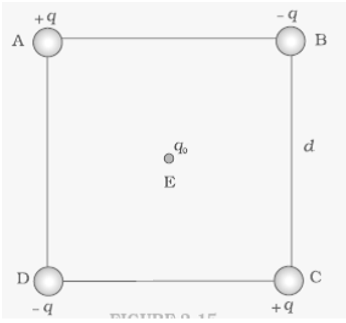
$$\Rightarrow \frac{1}{20} = (1.5-1)\left(\frac{2}{R}\right)$$

$R = 20\ cm$ ½ 2

SECTION - C

Set1 Q11
Set2 Q20
Set3 Q15

a) Finding the work done required to make the arrangement	2
b) Calculation of Extra work done	1



½

a) Work done

$$W = 0 + \left(\frac{-kq^2}{a}\right) + \left(-\frac{kq^2}{a} + \frac{kq^2}{a\sqrt{2}}\right) + \left(\frac{-kq^2}{a} + \frac{-kq^2}{a\sqrt{2}} + \frac{kq^2}{a\sqrt{2}}\right)$$ 1

$$= -\frac{4kq^2}{a} + 2\frac{kq^2}{a\sqrt{2}}$$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{a}\left[\sqrt{2}-4\right]$$ ½

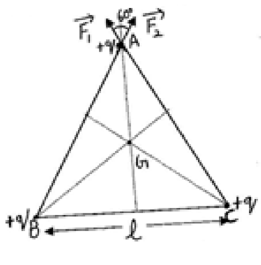
b) Potential at the centre of the square $V = 0$,
Hence extra work done ½

$$W = q_0 \times V$$ ½

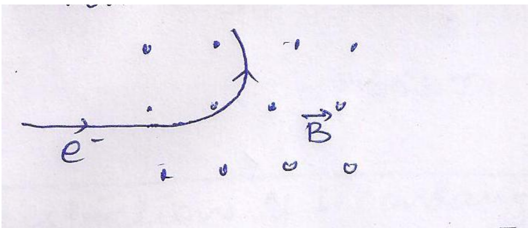
$$= q_0 \times 0 = 0$$ 3

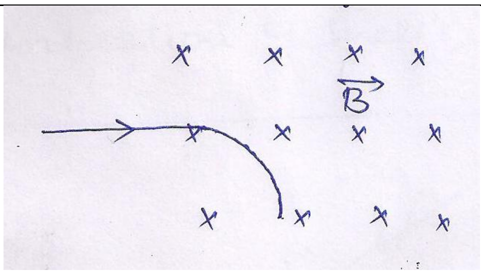
OR

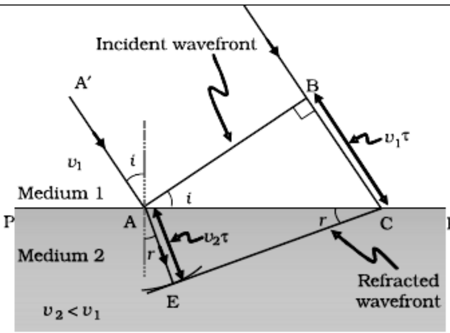
Condition for equilibrium	1
Finding magnitude and sign of the required charge	2



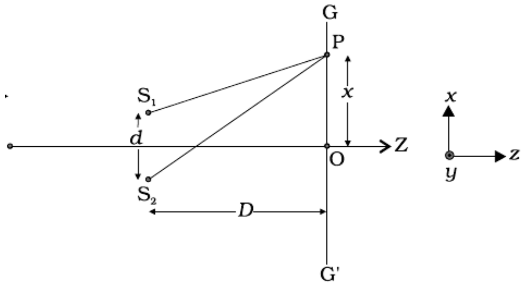
½

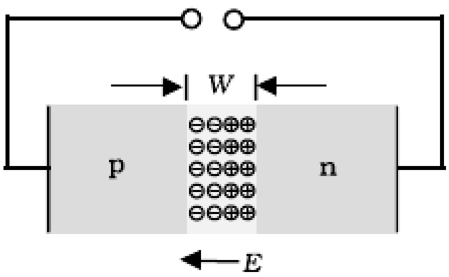
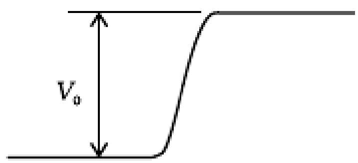
	The charge, at any one vertex will remain in equilibrium, if the net electric force there, due to the other three charges, is zero.	1	
	Let Q be the required charge $\vec{F}_1$ = Force at A due to the charge at B $= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{l^2}$ along $\overrightarrow{BA}$ $\vec{F}_2$ = Force at A due to the charge at C $= \frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{l^2}$ along $\overrightarrow{CA}$	½	
	$\vec{F}_1 + \vec{F}_2 = \sqrt{3}.\frac{1}{4\pi\epsilon_0} \cdot \frac{q^2}{l^2}$ along GA	½	
	Force at A due to charge at G $=\frac{1}{4\pi\epsilon_0} \cdot \frac{Qq(3)}{l^2}$ $3Qq = -\sqrt{3}q^2$	½	
	$Q = -\frac{q}{\sqrt{3}}$		3
Set1 Q12 Set2 Q21 Set3 Q16	a) Depiction of Trajectory and finding the Time 1+1 b) Calculation of magnitude of magnetic field 1 a) When field is taken vertically upward  Alternatively, When Magnetic field is taken vertically inward		

	 [Note: Either of the above two figures, should be accepted] Radius of the path: $\frac{mv^2}{r} = qvB$ $\therefore r = \frac{mv}{qB} = \frac{9.1\times10^{-31}\times4\times10^{4}}{1.6\times10^{-19}\times10^{-5}}$ m $= \frac{9.1\times4}{1.6} \times 10^{-3}$m $= 22.3 \times 10^{-3} m$ = 2.23 x 10^{-2}m $= 2.23\ cm$ $T = \frac{\pi r}{v} = \frac{\pi\times2.25\times10^{-3}}{4\times10^{4}} \approx 1.8\times10^{-7}\ s$ [Note: Full credit may be given if a student calculates (i) r and (ii) time taken directly without calculating r] b) $ILB = mg$ $2 \times 1.5 \times B = 200 \times 10^{-3} \times 9.8$ $B = \frac{200\times9.8\times10^{-3}}{3}$ T $=$ 0.653T	1 ½ ½ ½ ½	3
Set1 Q13 Set2 Q22 Set3 Q17	Constructions of Secondary wavelets of refracted wavefront 1 ½ Verification of Snell's Law 1 ½		

	 In ΔABC $Sin\ i = \frac{BC}{AC} = \frac{V_1\tau}{AC}$ In ΔAEC $Sin\ r = \frac{AE}{AC} = \frac{V_2\tau}{AC}$ $\Rightarrow \frac{Sin\ i}{Sin\ r} = \frac{v_1}{v_2} = \mu_{21}$	1½ ½ ½ ½	3
Set1 Q14 Set2 Q16 Set3 Q18	Calculation of Magnitude of emf 2 Calculation of current induced 1 Intial flux through the coil $(\phi_B)_{initial} = NBA\cos\theta$ $= 500 \times (3.0 \times 10^{-5} \times \pi \times 10^{-2} \cos 0^0) Wb$ $= 1.5\,\pi \times 10^{-4} Wb$ Final flux after rotation $(\phi_B)_{final} = 500 \times (3.0 \times 10^{-5} \times \pi \times 10^{-2} \cos 180^0)\ Wb$ $= -1.5\pi \times 10^{-4}\ Wb$ Induced emf $e = -\frac{d\varphi}{dt}$ $= \frac{3\pi \times 10^{-4}}{0.25} V \simeq 3.8 \times 10^{-3} V$ =3.8mV Induced current $= \frac{e}{R}$	½ ½ ½ ½ ½	

	$= \frac{3.8 \times 10^{-3}}{200}$ A $= 1.9 \times 10^{-5} A$ (=19Aμ)	½	3
Set1 Q15 Set2 Q17 Set3 Q11	Calculation of Longest wavelengths 1+1 Region in which these transitions lie ½ +½ Rydberg's formula $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ Transistions corresponding to Longest wavelength in Lyman series $n_i = 2, n_f = 1$ $\frac{1}{\lambda} = R\left(1 - \frac{1}{4}\right) = \frac{3}{4} R$ $\lambda = \frac{4}{3R} = \frac{4}{3 \times 1.1 \times 10^7}$ m $= 1.21 \times 10^{-7} = 121\ nm$ Transistion corresponding to Longest wavelength in Balmer Series. $n_i = 3, n_f = 2$ $\frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{9}\right)$ $= \frac{5}{36} R = 6.545 \times 10^{-7} m \simeq 655\ nm$ First transistion lies in ultraviolet region Second transistion lies in Visible region	 ½ ½ ½ ½ ½ ½	 3
Set1 Q16 Set2 Q18 Set3 Q12	Reason for not obtaining sustained interference pattern ½ Derivation of fringe width 2 ½ Two independent sources do not maintain constant phase difference, therefore the interference pattern will also change, with time.	 ½	

	 Consider a point P on the screen and let there be the maximum intensity $S_2P - S_1P = n\lambda \quad (n = 0,1,2, \ldots \ldots \ldots ..) \quad \ldots\ldots(i)$ $(S_2P)^2 - (S_1P)^2 = \left[D^2 + \left(x + \frac{d}{2}\right)^2\right] - \left[D^2 + \left(x - \frac{d}{2}\right)^2\right]$ $= 2xd$ Where, $SS_1 = d\ , OP = x,$ $\therefore \quad S_2P - S_1P = \frac{2xd}{S_2P + S_1P}$ If $x, d \ll D,\ then$ $S_2P - S_1P = \frac{2xd}{2D} = \frac{xd}{D}$ …………………(ii) From (i) & (ii) $\frac{xd}{D} = n\lambda$ $\Rightarrow x = \frac{n\lambda D}{d}$ for n^{th} maximum Similarly for (n+1)th maximum $x' = \frac{(n+1)\lambda D}{d}$ ∴Fringe width $\beta = x' - x = \frac{\lambda D}{d}$	½ ½ ½ ½ ½	3
Set1 Q17 Set2 Q19 Set3 Q13	Answer of (a), (b) and (c) 1+1+1 (a) Defined as the frequency range over which a given equipment operates . [Alternatively: The 'frequency spread' of a given signal] Importance : To design the equipments used in communication system for distinguishing different message signals . (b) Digital signals are those which take only discrete stepwise values and analogue signals are continuous variations of voltage /current .	½ ½ ½ + ½ ½	

	(c) Transducer : converts one form of energy into another Repeater : Enhances the range of communication.	½	3
Set1 Q18 Set2 Q11 Set3 Q14	Basic Processes during Formation of p-n junction diode 2 Explanation of barrier potential 1 Two important processes involved during the formation of p-n jumction are (i) Diffusion (ii) Drift Due to the different concentration gradient of the charge carriers on two sides of the junction, electrons from n-side start moving towards p-side and holes start moving from p-side to n-side . This process is called Diffusion. Due to diffusion, positive space change region is created on the n-side of the junction and negative space change region is created on the p-side of the junction. Hence, an electric field called Junction field is set up from n-side to p-side which forces the holes of n-side to move towards p-side and electrons of p-side to move towards n-side . This process is called Drift. [Also accept : Diffusion : Movement of majority charge carriers across the junction. Drift : Movement of minority charge carriers across the junction]  Alternatively :  The loss of electron from n region and gain of electron by p region causes a difference of potential across the junction called barrier potential whose polarity is such that it opposes further flow of charges.	1 1 ½ ½	3
Set1 Q19 Set2 Q12 Set3 Q21	Answers of part (a), (b) and (c) 1+1+1 a) No Electrons at different depths, need different energies to come out. b) No	½ ½ ½	

	The K.E. depends on the energy of each photon and not on the number of photons (intensity of light). c) Number of photoelectrons emitted depends on the intensity of incident light .	½ 1	 3

Set1 Q20
Set2 Q13
Set3 Q22

Identification of equivalent gate	1
Truth Table	2

Equivalent gate is OR gate
[Note: If a student identifies (i) NOR gate (ii) NAND gate separately, award this one mark] — 1

Truth Table

A	B	X	Y
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

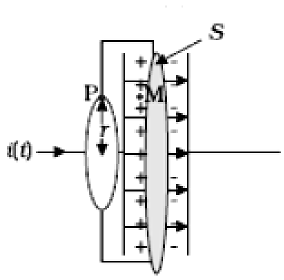
1 x 2= 2 — 3

Set1 Q21
Set2 Q14
Set3 Q19

Explanation of deflection in galvanometer	1
Modification of Ampere's circuital Law	1
Generalized Expression	1

During charging / discharging of the capacitor, displacement current between the plates is set up. Hence, circuit becomes complete and galvanometer shows momentary deflection. — 1

(Alternatively , There is a momentary flow of current during charging / discharging.)



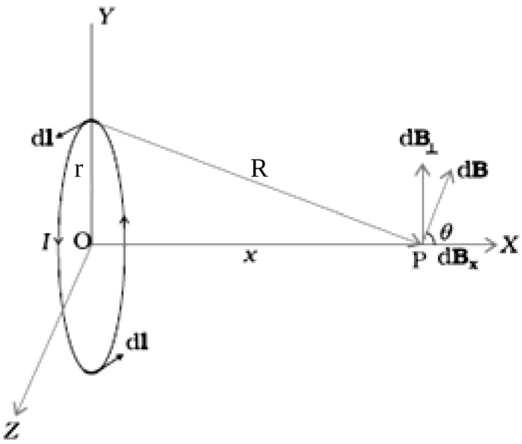
½

According to Ampere's circuital Law

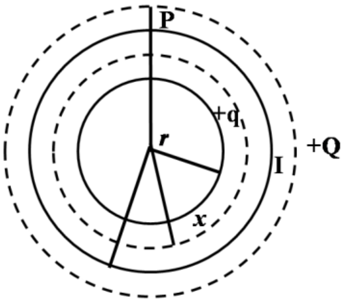
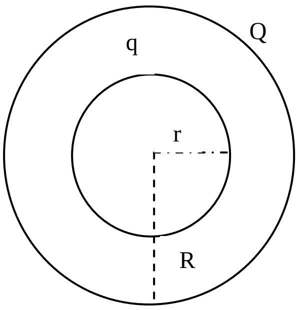
$\oint \vec{B}.\vec{dl} = \mu_o I$ — ½

Applying it to surface P, $\oint \vec{B}.\vec{dl} = \mu_o I_c$
Applying it to surface S, $\oint \vec{B}.\vec{dl} = 0$

	$$\therefore \oint_p \vec{B}.\vec{dl} \neq \oint_s \vec{B}.\vec{dl}$$ This is in contradiction to Ampere's circutial law. Hence the law needs modification. Alternatively: this observations shows that during charging/ discharging, the circuit is (momentarily) complete and there is a 'current flow' between the capacitor plates also. There is, therefore, a need to include this current ' flowing' across the 'gap'.] Modified form of Ampere's circuital law $\oint \vec{B}.\vec{dl} = \mu_o \left[i_c + \epsilon_o \frac{d}{dt}\phi_e\right]$	½ ½	3
Set1 Q22 Set2 Q15 Set3 Q20	Expression for (a) potential drop 1 ½ (b) charge ½ (c) energy stored 1 a) Net e.m.f = $2V - V = V$ Net resistance = $2R + R = 3R$ So current in the circuit I = $\frac{V}{3R}$ Potential difference across $BE = 2V - I \times 2R$ $= 2V - \frac{V}{3R} \times 2R = \frac{4}{3}V$ So potential differnce across C= $\frac{4}{3}V - V = \frac{V}{3}$ (i) Charge $Q = C \times \frac{V}{3} = \frac{CV}{3}$ (ii) Energy stored = $\frac{1}{2}CV^2$ $= \frac{1}{2}C\left(\frac{V}{3}\right)^2 = \frac{CV^2}{18}$	½ ½ ½ ½ ½ ½	3
	SECTION - D		
Set1 Q23 Set2 Q23 Set3 Q23	Values displayed 2 Measures to avoid wastage of energy 1 Calculation of wastage of energy 1 (a) Any two values – Knowledgeable , concern for conservation of resources,	2	

	convincing , thoughtful etc. (b) (i) High power devices should be used only when required. (ii)All electrical devices should be switched off when not in use . (c) Energy = $P \times t = \frac{2}{1000} \times 20\ kWh\ =\ .04\ kWh$ Or, $E = 2 \times 20 \times 3600\ J = 144000$ J	1 1	 4
	SECTION - E		
Set1 Q24 Set2 Q26 Set3 Q25	Point of similarities and differences between coulomb's law and Biot Savart's Law 1+1 Derivation of magnetic field at the centre of a circular coil 3 Similarities i) Both are long range, since both depend inversely on the square of distance to the point of interest. ii) Principle of super position is applicable in both cases. Differences i) Electrostatic field is produced by a scalar source (electric charge). The magnetic field is produced by a vector source Id$\vec{l}$ ii) Electrostatic field is along the displacement vector joining the source and field point. The magnetic field is perpendicular to the plane containing the current element (Id$\vec{l}$).  By Biot-Savart's Law dB = $\frac{\mu_0 I dl}{4\pi r^2)} = \frac{\mu_0 I dl}{4\pi x^2 + r^2)}$ When the perpendicular components are summed over, they cancel out and. The contribution is only from the x component which can be obtained by integrating $dB_X = dB\cos\theta$	 ½ ½ ½ ½ ½ ½ ½	

	$= \frac{\mu_o}{4\pi} \frac{Idl}{(x^2 + r^2)} \cdot \frac{r}{(x^2 + r^2)^{1/2}}$	½	
	$= \frac{\mu_o Idl}{4\pi(x^2 + r^2)^{3/2}}$		
	$\boldsymbol{B} = B_x \hat{\imath} = \frac{\mu_o Ir}{4\pi(x^2+r^2)^{3/2}} .2\pi r \hat{\imath}$	½	
	$= \frac{\mu_0 Ir^2}{2(x^2+r^2)^{3/2}} \hat{\imath}$	½	5
	At the centre x=0, $\vec{B}_0 = \frac{\mu_0 I}{2r} \hat{\imath}$ [Note: Any alternative method should also be accepted]		
	OR		
	Definition of eddy current — 1 Production of eddy currents — 1 Application of eddy currents — ½ + ½ + ½ Description — ½ + ½ + ½		
	The induced circulating current produced in the bulk piece of a conductor, when it is subjected to changing magnetic flux are known as 'eddy currents'/ Eddy currents are produced when a bulk conductor is present in a changing magnetic field.	1	
	Application of Eddy Current	½	
	i) Magnetic braking in trains Strong electromagnets are situated above the rails in some electrically powered trains. When the electromagnet are activated, the eddy currents induced in the rails oppose, the motion of the train. As there are no mechanical linkage, the breaking effect is strong.	½ ½	
	ii) Electronmagnetic damping Certain galvanometers have fixed core made of non magnet metallic material. When the coil oscillates, the eddy current generated in the core oppose the motion and bring the coil to rest quickly.	½ ½	
	iii) Electric power meters The shiny metal disc in the electric power meter rotates due to eddy currents. Electric currents are induced in the disc by magnetic fields produced by sinusoidally varying current in a coil. [Note: Any alternative application should be accepted]	½	5

Set1 Q25 Set2 Q24 Set3 Q26	a) Derivation of (i) Electric field between sphere and shell — 1 ½ (ii) outside the spherical shell — 1 ½ (b) Explanation, for flow of charge — 2		
	(a)  	½	
	(i) According to Gauss's law $\oint \vec{E}\,.\overrightarrow{ds} = \frac{q}{\epsilon_0}$	½	
	Applying Gauss's law to surface I $E.4\pi x^2 = \frac{q}{\epsilon_0}$	½	
	$E = \frac{q}{4\pi\epsilon_0 x^2}$	½	
	(ii) Using Gauss law for the Gaussian surface II		
	$E.4\pi x^2 = \frac{Q+q}{\epsilon_0}$	½	
	$E = \frac{q+Q}{4\pi\epsilon_0 x^2}$	½	
	(b)  	½	
	$V_r = \frac{1}{4\pi\epsilon_o}(\frac{q}{r} + \frac{Q}{R})$	½	
	$V_R = \frac{1}{4\pi\epsilon_o}(\frac{q}{r} + \frac{Q}{R})$	½	

$V_r > V_R$ ½

Hence charge will always flow from the smaller sphere to the larger sphere. 5

OR

a) Derivation of the expression for net electric field 2
b) Finding resultant electric field due to an electric dipole 3

By super position principle ½

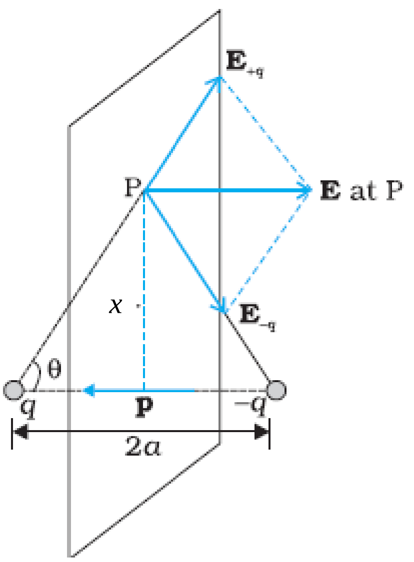
$$\mathbf{E}(\mathbf{r}) = \mathbf{E}_1(\mathbf{r}) + \mathbf{E}_2(\mathbf{r}) + \ldots$$

$$= \frac{1}{4\pi\epsilon_o}\left[\frac{q_1}{r_{1p}^2}\hat{r}_{1P} + \frac{q_2}{r_{2p}^2}\hat{r}_{2P} + \ldots..\right]$$ 1

Where, $\vec{r}_{ip} = \vec{r}_p - \vec{r}_i$

½

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_{iP}^2}\hat{\mathbf{r}}_{iP}$$



½

The magnitudes of electric field at point P due to charges +q and -q

$$E_{+q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{x^2 + a^2}$$ ½

$$E_{-q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{x^2 + a^2}$$ ½

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The direction of $\overrightarrow{E_{+q}}$ and $\overrightarrow{E_{-q}}$ are shown in the figure. Clearly, the components normal to the dipole axis cancel away and along dipole axis add up. The total Electric field is opposite to $\hat{p}$

$$\mathbf{E} = -(E_{+q} + E_{-q})\cos\theta\ \hat{\mathbf{P}}$$

$$= -\frac{2qa}{4\pi\varepsilon_o(x^2+a^2)^{3/2}}\hat{\mathbf{P}}$$

where $\vec{p}$ = q x $\overrightarrow{2a}$

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½

½</td>
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<td>Set1 Q26
Set2 Q25
Set3 Q24</td>
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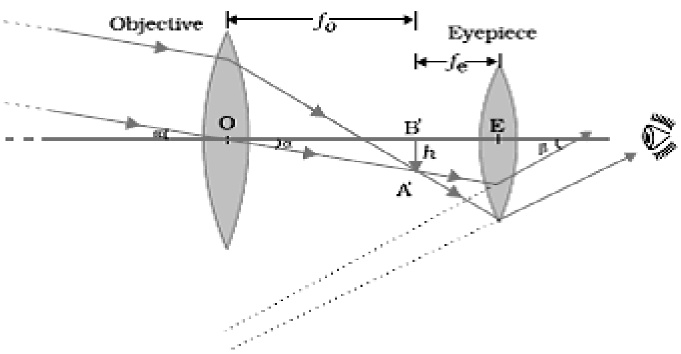
Ray diagram	1
Definition of magnifying Power	1
Two factors for increasing magnifying power	½ + ½
Two limitations and their minimization in Reflecting telescope	½ x 4



Magnifying power is the ratio of angle subtended at the eye by the final image to the angle which the object subtends at the eye .

$$m = \frac{f_0}{f_e}$$

Factors:

1. Increasing focal length of objective
2. Decreasing focal length of eye piece

Limitations (Any two):

1. Suffers from chromatic abberration
2. Suffers from spherical aberration
3. Small magnifying power
4. Small resolving power

Advantages of reflecting telescope (Any two):

1. No chromatic aberration, because mirror is used.
2. Spherical aberration can be removed by using a parabolic mirror .
3. Image is bright because no loss of energy due to reflection.

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½

½ + ½

½ + ½</td>
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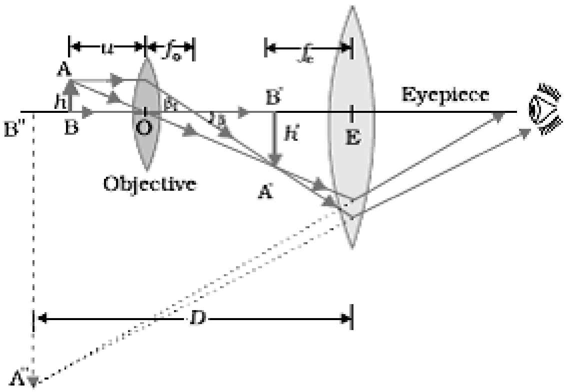
	4. Large mirror can be provided easier mechanical support .		
	OR		
	a) Ray Diagram — 1 Limit of resolution — ½ Factors on which resolution depends — ½ + ½ Relation with resolving power — ½ b) Two ways of increasing resolving power of microscope — ½ + ½ c) Justification of the statement — 1		
	a)  	1 ½	
	Definition of limit of resolution The minimum linear or angular separation between two point objects at which they can be just separately seen or resolved by an optical instrument.	½ +½ ½	
	It depends on i) Wavelength of light used ii) Medium between object and objective lens		
	Resolving power of microscope is the reciprocal of its limit of resolution	½ +½	
	b) Resolving power of compound microscope can be increased by i) Decreasing wavelength ii) Increasing refractive index of the medium between object and objective of the microscope.	½+½	
	c) A telescope produces an (angularly) magnified image of the far object and therby enables us to resolve them. A microscope magnifies small objects which are near to our eye.		5