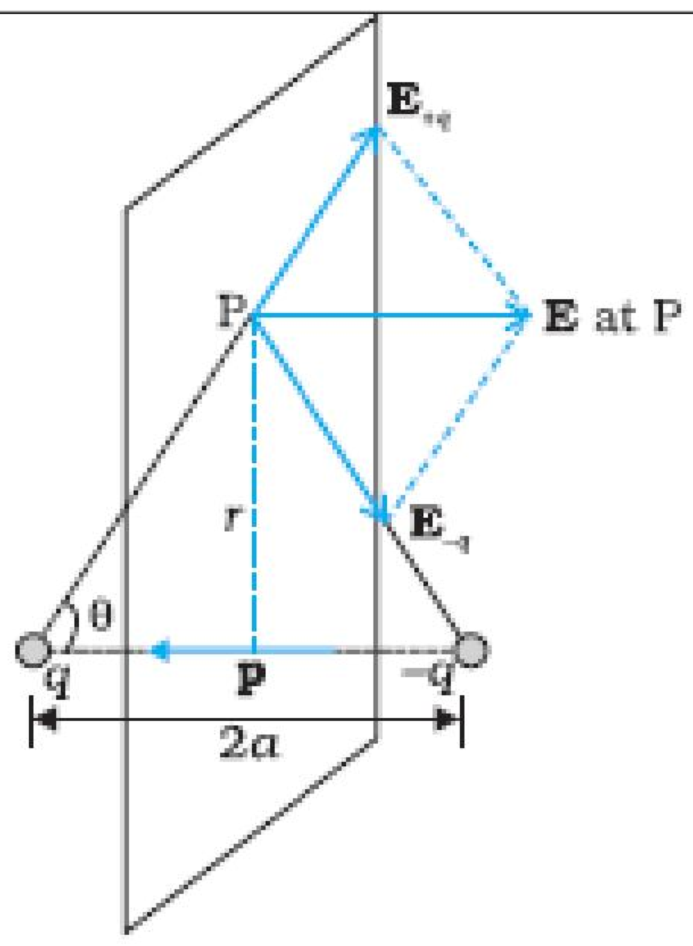
MARKING SCHEME (COMPARTMENT) 2019

SET: 55/1/2

Q. NO.	VALUE POINTS/ EXPECTED ANSWERS	MARKS	TOTAL MARKS
	SECTION - A		
1.	$H = B_E \cos\Theta$ [Alternatively $\Theta = \cos^{-1}(H/B_E)$] H= horizontal component of earth's magnetic field (=B_E) Θ= angle of dip. [Note: Award this 1 mark even if the student just writes the relation between H, B_E and Θ without explaining the meanings of the symbols]	1	1
2.	Heavy nuclei contain a large number of protons which exert strong repulsive forces on one another. [Alternatively : Because of strong repulsive forces between the large number of protons in them]	1	1
3.	Frequency range of the spectrum occupied by the signal. Alternatively Difference between the maximum and minimum frequencies considered essential for a given message signal Alternatively Band width= $\nu_{max} - \nu_{min}$	1	1
4.	Long Radio waves ; In communication systems **OR** X-rays ; nearly 10^{16} Hz to 10^{21} Hz	½ + ½ ½ + ½	1
5.	Frequency of photon $\nu = E/h$ $= \frac{2eV}{6.63 \times 10^{-34}\ Js}$ $= \frac{2 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}} Hz$ $= 4.8 \times 10^{14}$Hz [Award the last ½ mark even if the student just makes a correct substitution but does not calculate the value of ν] **OR** (i) Yes (ii) The photo electric current is dependent on the intensity of incident radiation Because the change of intensity changes the number of photons incident per second on the photosensitive surface.	½ ½ ½ ½	1 1
	SECTION - B		
6.	Diagram ½ Electric field due to point charges ½ Net electric field 1		



½

$$E_{+q} = \frac{1}{4\pi\epsilon_0}\frac{q}{(r^2 + a^2)}$$

$$E_{-q} = \frac{1}{4\pi\epsilon_0}\frac{q}{(r^2 + a^2)}$$

½

$$E = E_{+q}cos\theta + E_{-q}cos\theta$$

$$= 2E_{+q}cos\theta$$

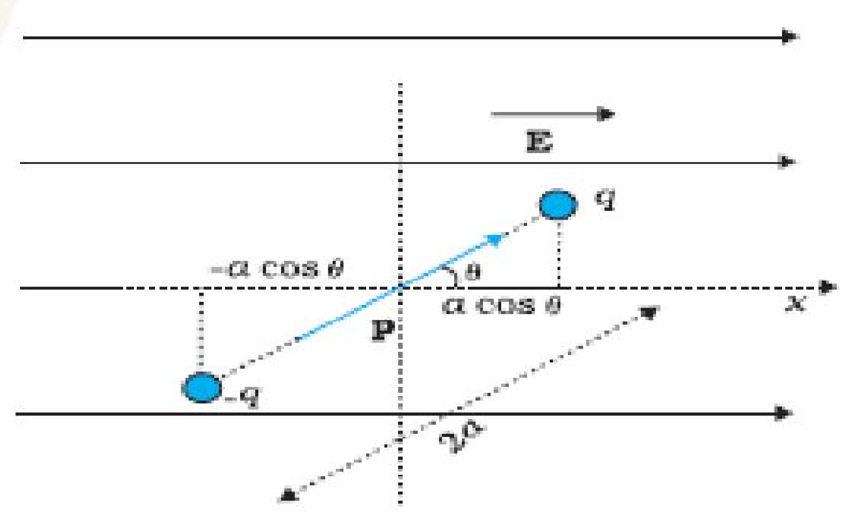
½

$$= \frac{2qa}{4\pi\epsilon_0(r^2 + a^2)^{3/2}}$$

½ 2

OR

Diagram	½
Expression for torque	½
Expression for P.E.	½
Minimum value of P.E.	½



½

Torque $\tau = pEsin\theta$

$$P.E. = W = \int_{\theta_0}^{\theta} pE\ sin\theta\ d\theta$$

½

$$= -pE\ (cos\theta - cos\theta_0)$$

½

$= -pE\ cos\theta$ (for θ_0=π/2)

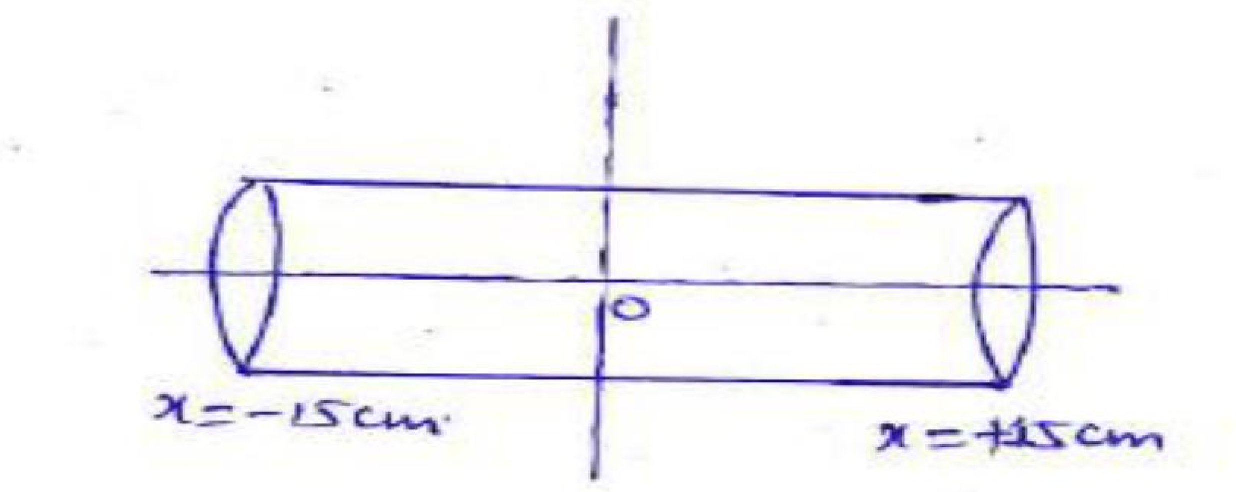
∴ Minimum value of P.E. = - p E

½ 2

[Note: Award the last ½ mark even if the student quotes zero (0) as the minimum value of P.E. which corresponds to the choice $\theta_0 = 0$ (or writes that this cannot be precisely specified as it depends on the choice of θ_0)]

7.

Diagram	½
Formula for flux	½
Calculation of Net outward flux	1



½

Flux $=\int \vec{E}.\overrightarrow{ds}$ ½

[Alternatively $\phi=\int Eds\ Cos\theta$]

Net outward flux

$=[200 \times \pi \times (\frac{5}{100})^2 + 200 \times \pi \times (\frac{5}{100})^2]$ ½

$=\pi\ Nm^2C^{-1}$ ($\cong$ 3.142 Nm^2C^{-1}) ½ — 2

[Note: Award full 2 marks even if the students does a direct (correct) calculation of the net outward flux without drawing the diagram or writing the formula for flux. In such a case, award 1 mark for correct substitutions and 1 mark for correct calculations. (Deduct ½ mark if the units for flux are not written)]

8.

Estimation of wavelength in terms of radius of orbit	1
Ratio of wavelengths in the two orbits	1

$2\pi r_n = n\lambda_n$ ½

and $r_n = a_0 n^2$ ½

$\therefore$ $\lambda_n = 2\pi a_0 n$ ½

and $\frac{\lambda_2}{\lambda_3} = \frac{2}{3}$ ½ — 2

9.

Explaining (any) two reasons	1 + 1

The message signal needs to be modulated (using a high frequency carrier wave) before transmission in a communication system because of the following reasons:

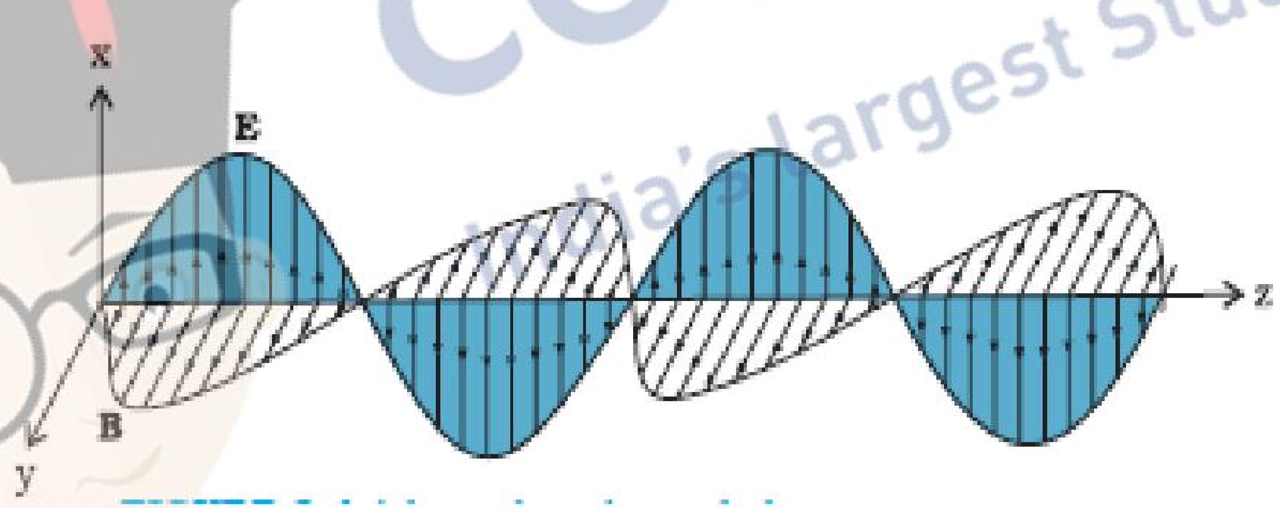
(i) We need an antenna of size of the order of $\lambda/4$; λ is very large for the usual low frequency message signals.

[Alternatively The size of the transmission antenna would be unmanageably large for the (usual) low frequency message signals]

(ii) The power radiated from a linear antenna of length *l* is proportional to $(^{l}/_{\lambda})^2$; it is therefore quite low for the (usual) large values of λ for message signals.

(iii) It is very difficult to avoid mixing up of signals from different transmitters if transmission is done at the (usual) low values of frequencies of ordinary message signals.

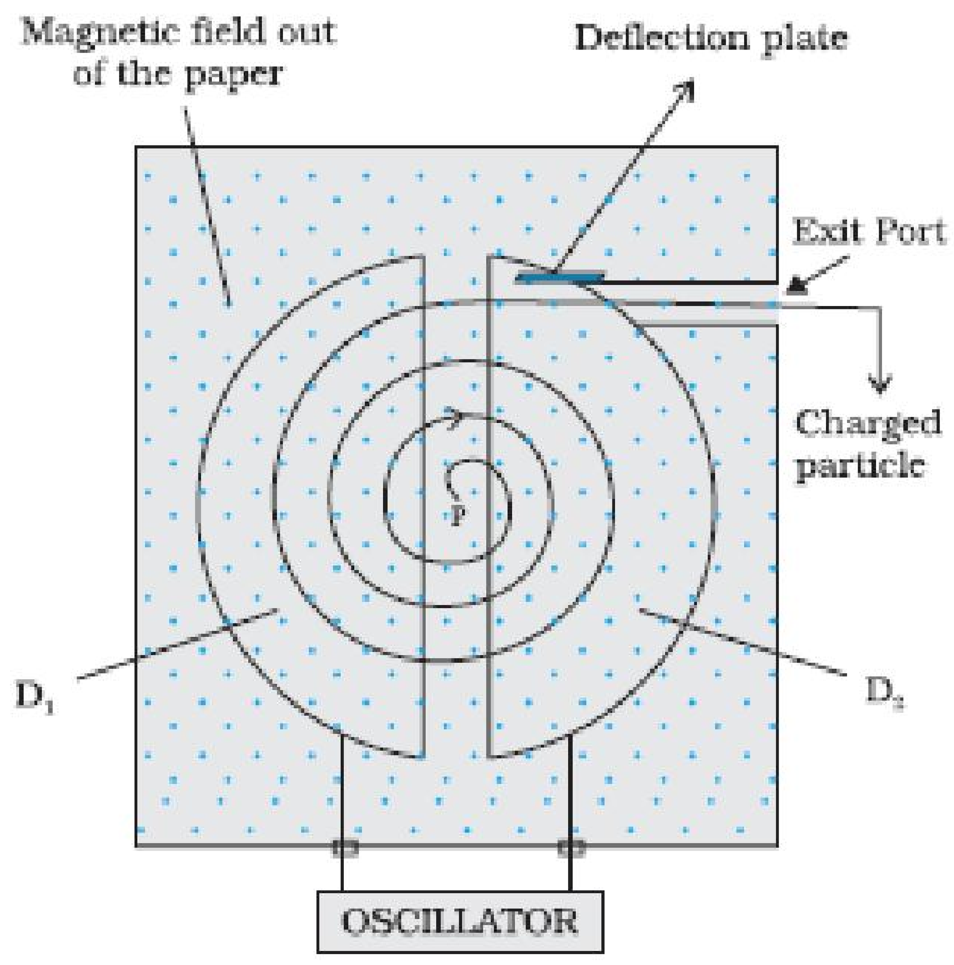
(Any two reasons) 1 + 1 — 2

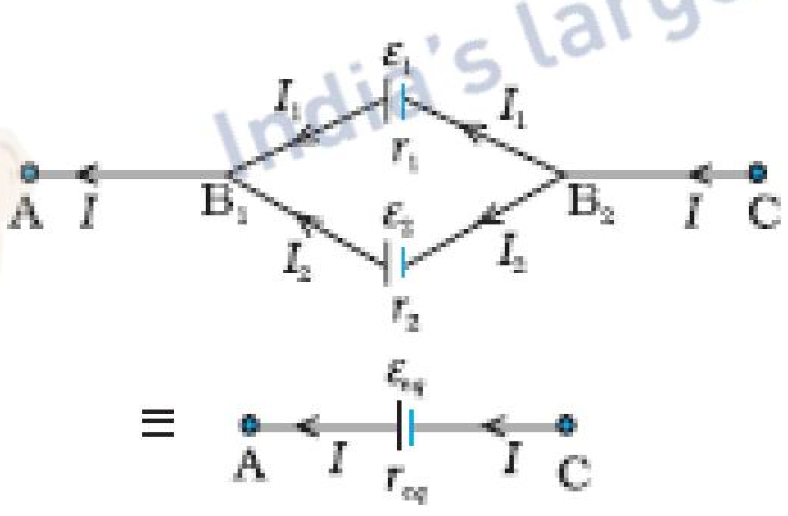
10.	(a) Effect + Reason ½ + ½ (b) Effect + Reason ½ + ½		
	(a) $I = \frac{V}{\sqrt{R^2+\omega^2 L^2}}$	½	
	When ω increases, I decreases, $\therefore$ brightness decreases	½	
	(b) $I = \frac{V}{\sqrt{R^2+\frac{1}{\omega^2 c^2}}}$	½	
	When ω increases, I increases, $\therefore$ brightness increases	½	
	<u>Alternatively:</u>		
	(a) Brightness decreases	½	
	Reason: The impedance of L increases with an increase in angular frequency ω	½	
	(b) Brightness increases	½	2
	Reason: The impedance of C decreases with an increase in angular frequency ω	½	
11.	(a) Graph of em wave 1 (b) (i) Relation between c, E_0 and B_0 ½ (ii) Expression for speed of em wave ½		
	(a) 	1	
	(b) (i) $c = \frac{E_0}{B_0}$	½	
	(ii) $c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$	½	2
12.	Formula for Induced Emf 1 Calculation of Induced Emf 1		
	$E = \frac{1}{2} B\omega r^2$	1	
	$= \left[\frac{1}{2} \times 8 \times 10^{-5} \times 4\pi \times (0.5)^2\right] V$	½	
	$= 12.56 \times 10^{-5} V$	½	2
	OR		

	Formula for Induced Emf 1 Calculation of Induced Emf 1		
	$\varepsilon = \frac{-d\phi}{dt}$	½	
	$= -A\frac{dB}{dt}$	½	
	$= -A\frac{dB}{dx} \times \frac{dx}{dt} = -Av\frac{dB}{dx}$	½	
	$= -[(0.1)^2 \times (-8 \times 10^{-3})]V$ $= 8 \times 10^{-5}V$	½	2

SECTION - C

13.	(a) Reason for circular motion 1 Expression for radius 1 (b) Path of the particle when $\Theta \neq 90^0$ 1		
	(a) $\vec{F} = q(\vec{v} \times \vec{B})$	½	
	Force $\vec{F}$ on a moving charged particle in a magnetic field acts perpendicular to the velocity vector at all instants. It therefore, changes only the direction of velocity without changing its magnitude. This results in a circular motion of the particle for which the force $\vec{F}$ provides the needed centripetal force $\left(= \frac{mv^2}{r}\right)$	½	
	Here F=qvB sin Θ = qvB (as Θ = π/2)		
	$\therefore \frac{mv^2}{r} = qvB$	½	
	$\therefore r = \frac{mv}{qB}$	½	
	(b) If $\Theta \neq 90^0$, then velocity will have a component along $\vec{B}$ also and the charged particle will move along $\vec{B}$ with this component of velocity while describing circular motion in a plane perpendicular to $\vec{B}$. Its motion is, therefore, helical.	1	3
	[Note: Award this 1 mark even if a student just writes that the charged particle will describe a helical path / motion.]		
	OR		
	Diagram 1 Working Principle 1 Two uses ½ + ½		

	 <u>Working Principle:</u> Cyclotron uses crossed electric and magnetic fields. Magnetic field makes the charged particle describe a circular path while electric field frequency is so adjusted as to accelerate the particle whenever it crosses the space between the dees. A relatively small electric field can then be used to accelerate particles to very high energy values. Uses: (i) To accelerate charged particles to very high energies (ii) To implant ions into solids to modify their properties. [or any other use]	1 1 ½ ½	3
14.	(a) Writing the colour band sequence — 1 (b) Reason for extensive use of carbon resistors in electric circuits — 1 (c) Two important precautions in a meter bridge experiment — ½ + ½ (a) The colour band sequence would be orange, blue, yellow, gold (Note: Award ½ mark if only two of the colours are correctly indicated as per the given sequence) (b) (i) Compact in size (ii) inexpensive (c) We need to (i) ensure that the jockey is not 'dragged' over the wire while locating the balance point. (ii) select the standard known resistance in such a way that the balance point is near the middle of the bridge wire. (iii) make all connections in a neat compact manner (iv) ensure that there is no excessive continuous current flow that may heat up the different resistance wires. (Any two; also accept any other suitable precaution)	1 ½ ½ ½ + ½	3
15.	(a) Drift Velocity and its significance — ½ + ½ Relaxation time and its significance — ½ + ½ (b) Change in drift velocity — 1 (a) <u>Drift Velocity:</u> It is the average velocity with which electrons move in a conductor when an external electric field (or potential difference) is applied across the	½	

	conductor.		
	Significance: The drift velocity controls the net current flowing across any cross section./ There is no net transport of charges across any area perpendicular to the applied field.	½	
	Relaxation time: It is the average time between successive collisions for the drifting electrons in the conductor.	½	
	Significance: It is a (very important) factor in determining the electrical conductivity of a conductor at different temperatures. (It is a factor which determines the drift velocity acquired by the electrons under a given applied external electric field)	½	
	(b) $v_d = \frac{eV}{mL}\tau$	½	
	$v_{d'} = \frac{eV}{m\times 5L}\tau$ $= \frac{v_d}{5}$	½	3
	OR		
	Diagram ½ Expression for equivalent emf and internal resistance 2 ½		
		½	
	$I = I_1 + I_2$		
	$= \left(\frac{E_1 - V}{r_1}\right) + \left(\frac{E_2 - V}{r_2}\right)$	½	
	$= \left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$	½	
	Hence $V = \left[\frac{E_1 r_2 + E_2 r_1}{r_1 r_2}\right] - I\left(\frac{r_1 r_2}{r_1 + r_2}\right)$	½	
	$\therefore E_{eff} = \frac{E_1 r_2 + E_2 r_1}{r_1 r_2}$	½	
	and $r_{eff} = \frac{r_1 r_2}{r_1 + r_2}$	½	3

16.

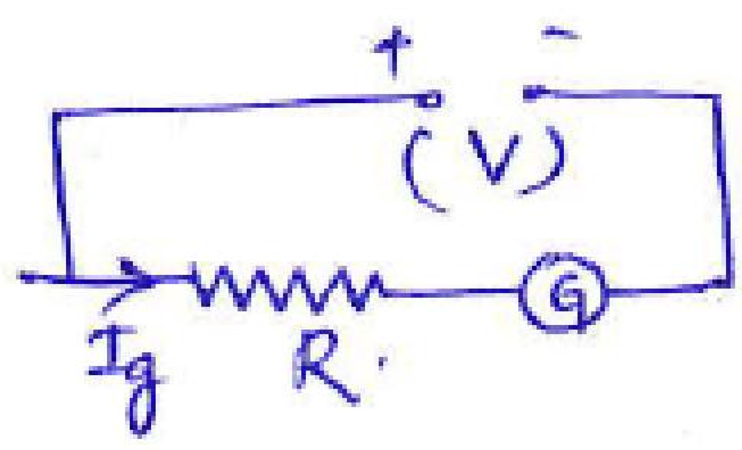
(a) Reason for needing a high resistance	1
(b) Formula	½
(c) Correct substitution	½
(d) Calculation	1

(a) We need high (series) resistance because ideal voltmeter should have an infinite resistance.

[Alternatively The voltmeter needs to have a high resistance]

[Alternatively This ensures that the current through the galvanometer coil remains within its permissible limits even when it is connected across a voltage source of value equal to the limit of the converted voltmeter. 1

(b) ½



$$R = \left[\frac{V}{ig} - G\right]$$ ½

Here V=18V, G=12 Ω, i_g=3mA

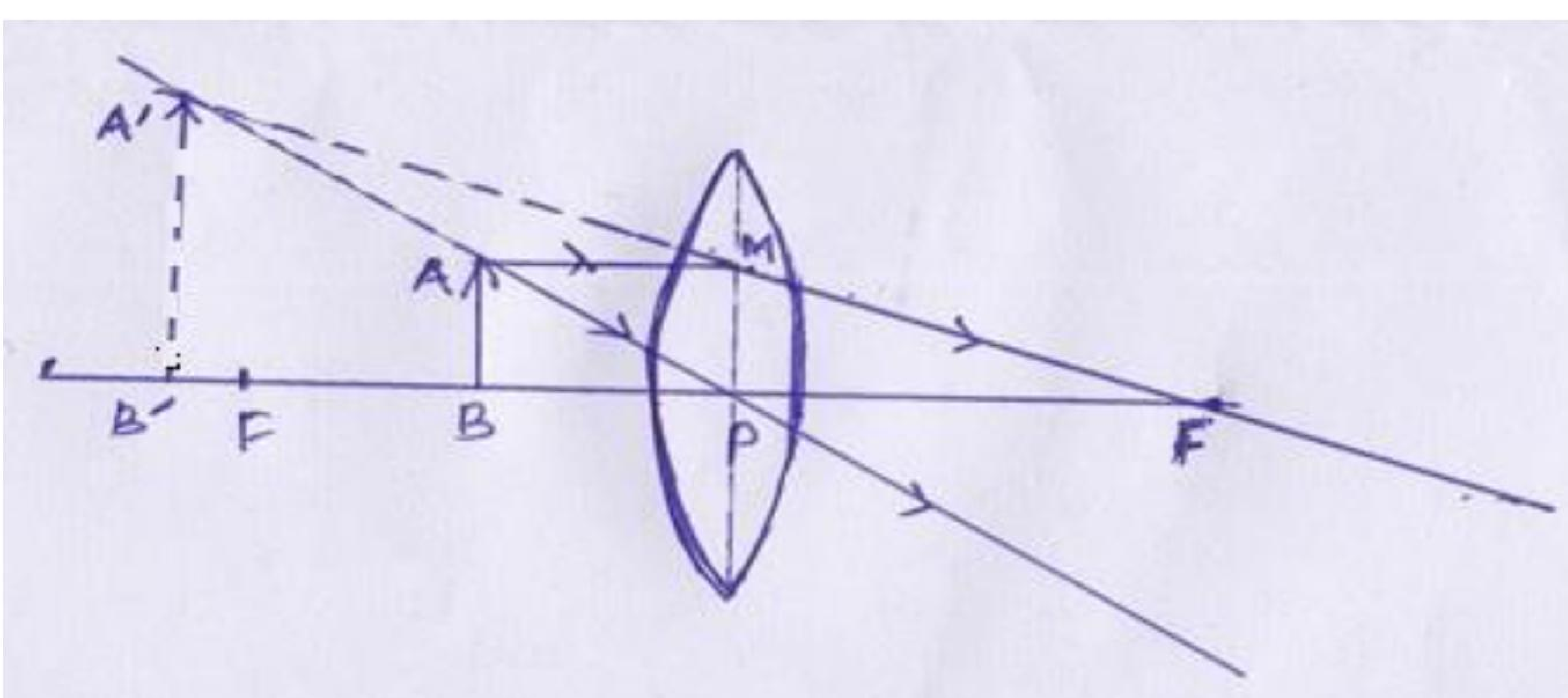
$$R = \left[\frac{18}{3\times10^{-3}} - 12\right]\Omega$$ ½

$$= [6000 - 12]\Omega \quad = \quad 5988\,\Omega$$ ½ 3

[Award full 2 marks even if diagram is not drawn but the formula and calculations are correct]

17.

Ray diagram	1
Derivation of lens formula	2



1

$\Delta A'B'P \sim \Delta ABP$

$\frac{A'B'}{AB} = \frac{B'P}{BP}$ --------------------------(i) ½

$\Delta A'B'F \sim \Delta MPF$

$\frac{A'B'}{MP} = \frac{B'F}{PF}$

or $\frac{A'B'}{AB} = \frac{B'F}{PF}$ --------------------------(ii) ½

From (i) and (ii)

$\frac{B'P}{BP} = \frac{B'F}{PF}$

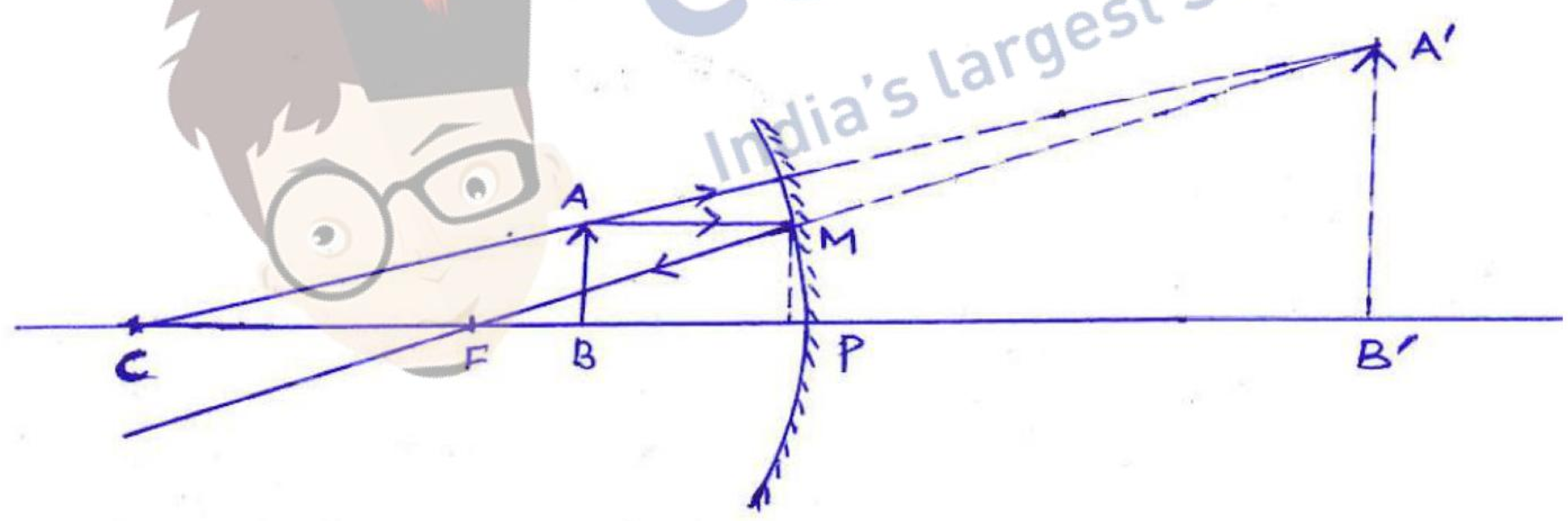
or $\frac{-v}{-u} = \frac{B'P+PF}{PF} = 1 + \frac{B'P}{PF}$

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

or $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ 1 3

OR

Ray diagram	1
Derivation of mirror formula	2



1

$A'B'F \sim \Delta MPF$

$\frac{A'B'}{MP} = \frac{B'F}{PF} = \frac{B'P+PF}{PF}$

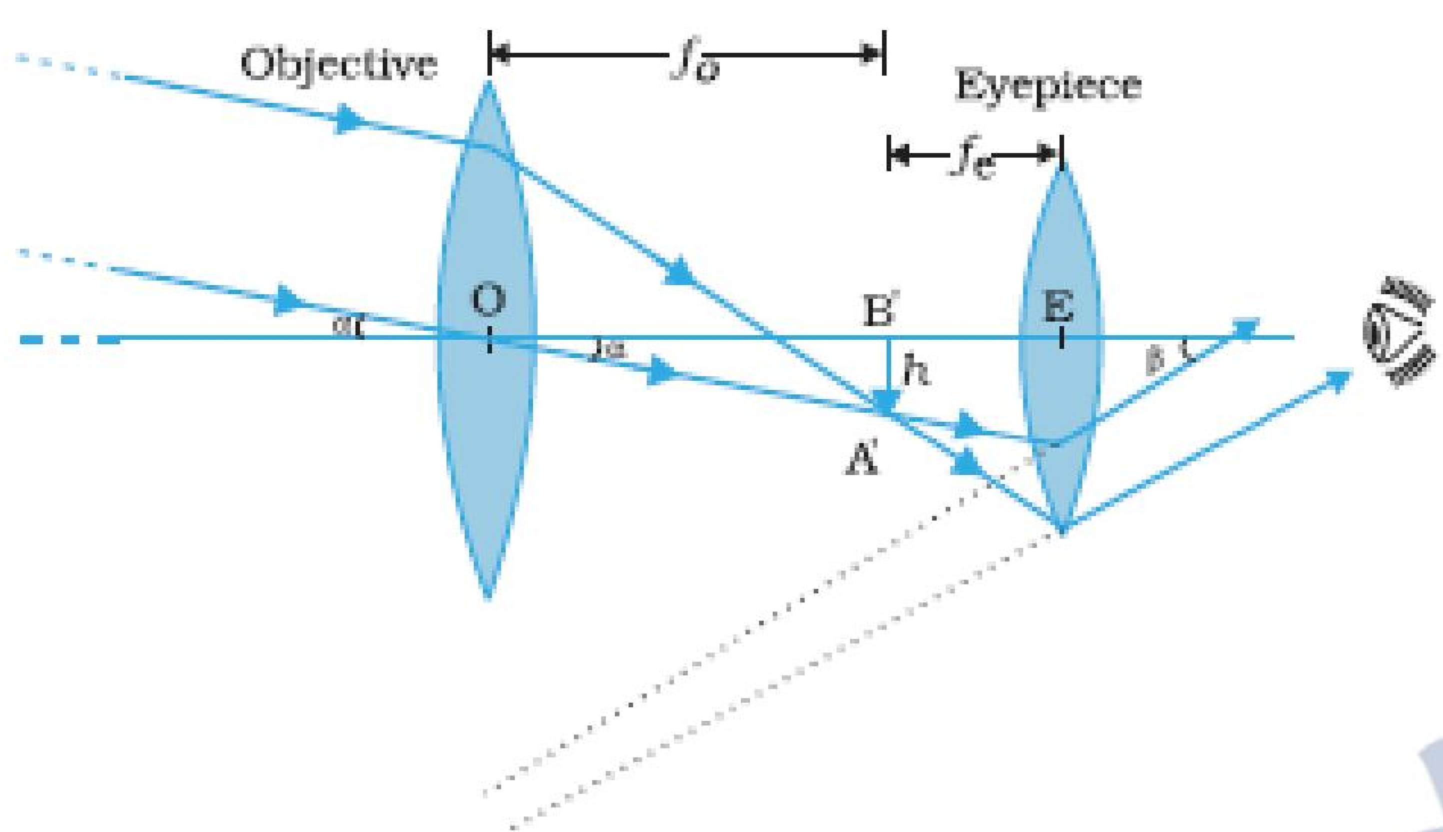
or $\frac{A'B'}{AB} = \frac{B'P+PF}{PF}$ --------------------------(i) ½

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

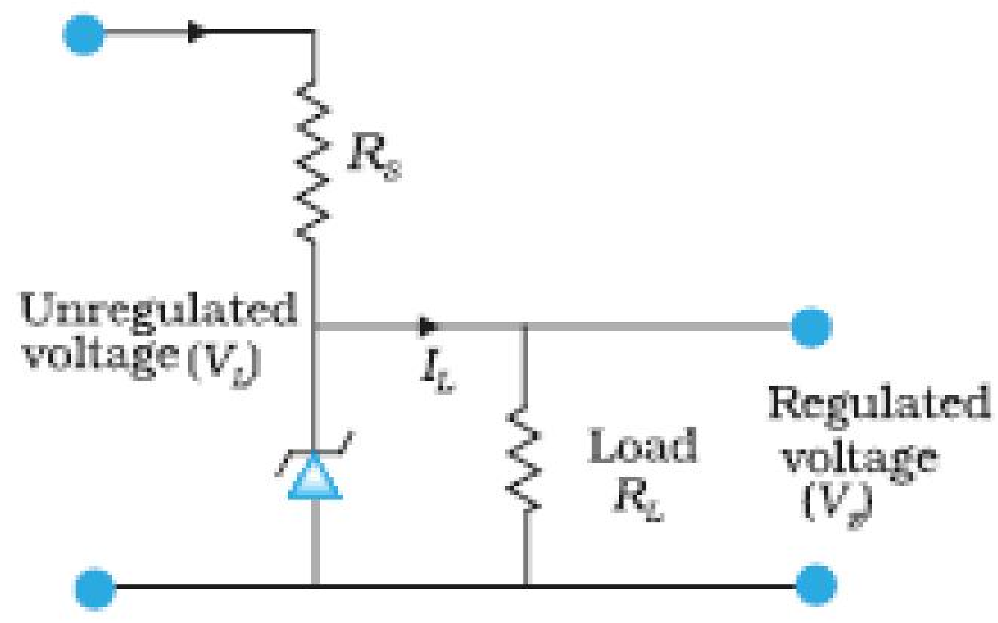
$\frac{A'B'}{AB} = \frac{B'C}{BC} = \frac{B'P+PC}{PC-PB}$ --------------------------(ii) ½

or $\frac{B'P+PF}{PF} = \frac{B'P+PC}{PC-PB}$

or $\frac{v-f}{-f} = \frac{v-2f}{-2f+u}$

	Cross multiply and divide by uvf : $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$	1	3
18.	Labeled Diagram 1 Working ½ Limitations ½ How the limitations are overcome in a reflecting telescope 1  <u>Working</u> The objective forms a real image of a distant object at its second focal point. The eyepiece magnifies this image producing a final inverted image. <u>Limitations</u> It needs large sized lenses which are expensive and very heavy, difficult to make and tend to have chromatic and spherical aberrations and distortions (Award this ½ mark if the student writes any one of these limitations) <u>Reflecting telescopes</u> Reflecting telescopes can overcome these limitations because the mirrors used in them (i) are free from chromatic aberration and can have very little spherical aberration. (ii) are less heavy and easier to support.	1 ½ ½ ½ + ½	3
19.	(a) Name and Principle of the device ½ + ½ (b) Circuit diagram 1 Working ½ (c) I- V characteristics ½ (a) Zener diode is used as a voltage regulator It works on the principle that after the breakdown voltage V_Z, a large change in the reverse current can be produced by an almost insignificant change in the reverse bias voltage <u>Alternatively:</u> The Zener Voltage remains constant, even when the current through the Zener diode varies over a wide range.	½ ½	

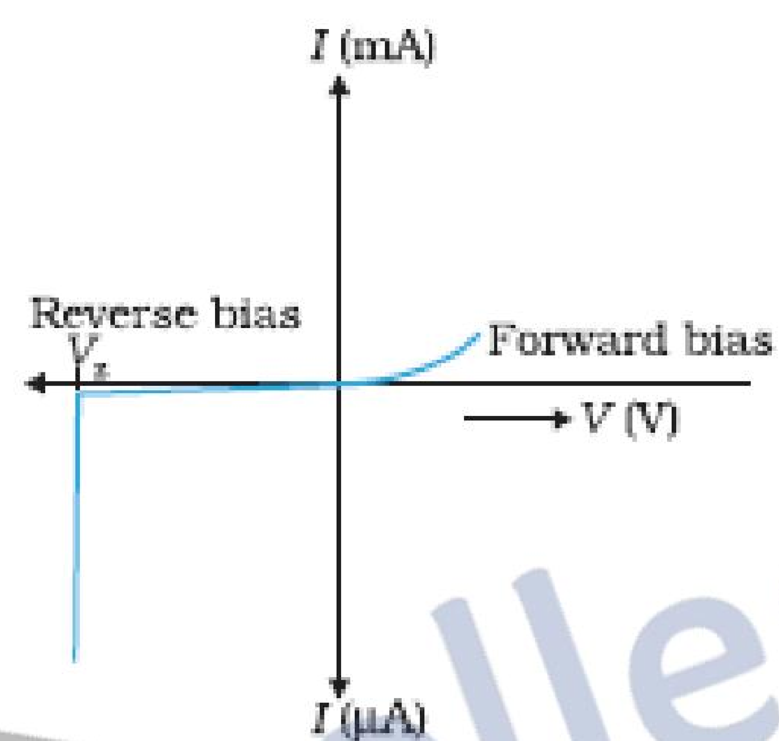
(b)



1

If the input voltage increases the current through R_S and Zener diode also increases. This increases the voltage drop across R_S without any change in the voltage across the Zener diode. If input voltage decreases, the current through R_S and Zener diode decreases. The voltage across R_S decreases without any change in voltage across the Zener diode. ½

(c)



½ 3

OR

(a) Truth tables of AND and NOT gates 1+ ½
(b) Obtaining OR gate from NAND gates 1 ½

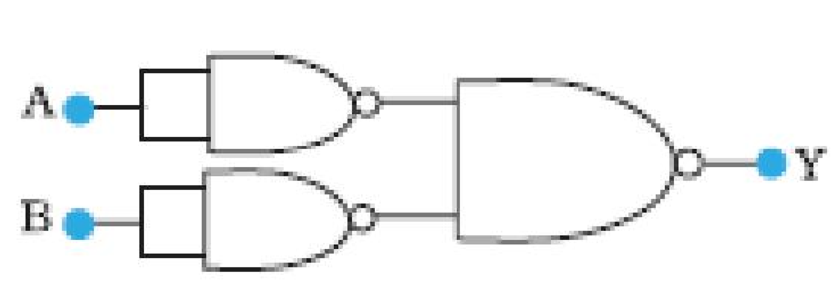
(a) AND gate 1

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

NOT gate ½

A	B
0	1
1	0

(b) 1 ½ 3



[Note: Award ½ mark if the student just writes the truth table of NAND gate without drawing any diagram]

20.

(a) Each of the two definitions	1 + 1
(b) Graph	1

(a) (i) The threshold frequency (for a given photosensitive surface), is the minimum frequency of the incident radiation that can cause photoemission (from that surface)

Alternatively

$$Threshold\ frequency = \frac{work\ function\ (for\ the\ given\ surface)}{h}$$

(for a given photosensitive surface)

Alternatively

The threshold frequency (for a given photosensitive surface) is that value of the frequency of incident radiation for which the photoelectrons just get emitted from the surface and have (practically) zero kinetic energy. — 1

(ii) Stopping Potential

It is the (least) value of the (negative) potential difference between the cathode and the plate that stops the most energetic photoelectrons (getting emitted in a given set up) from just reaching the plate.

Alternatively

Stopping Potential $V_0 = (h\nu - W)/e$

ν = frequency of incident radiation

W= work function of the given photosensitive surface

[Note: Award this 1 mark even if the student just writes the formula without explaining the symbols] — 1

Alternatively

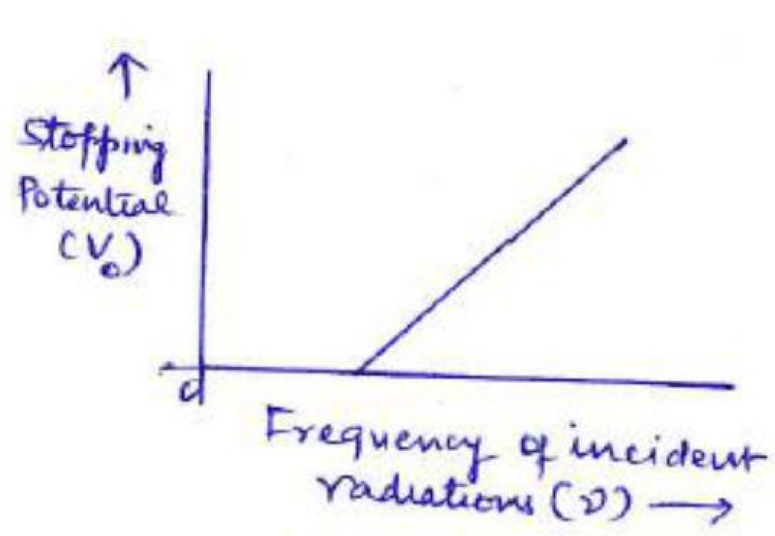
Stopping Potential $V_0 = \frac{h(\nu - \nu_0)}{e}$

where ν = frequency of incident radiation

ν_0= threshold frequency of the given photosensitive surface

[Note: Award this 1 mark even if the student just writes the formula without explaining the symbols]

(b) The required graph is shown below

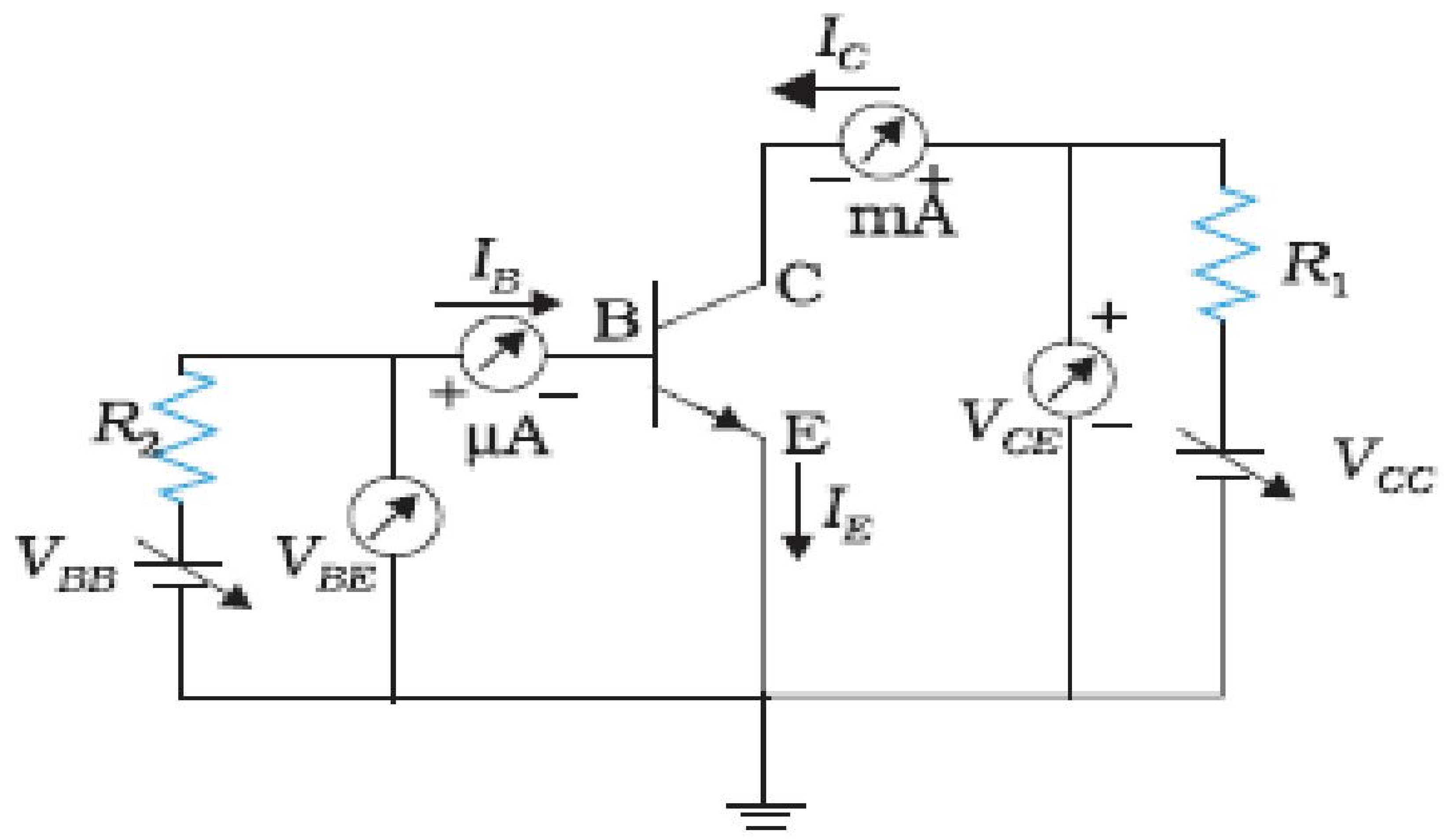


1 — 3

21.

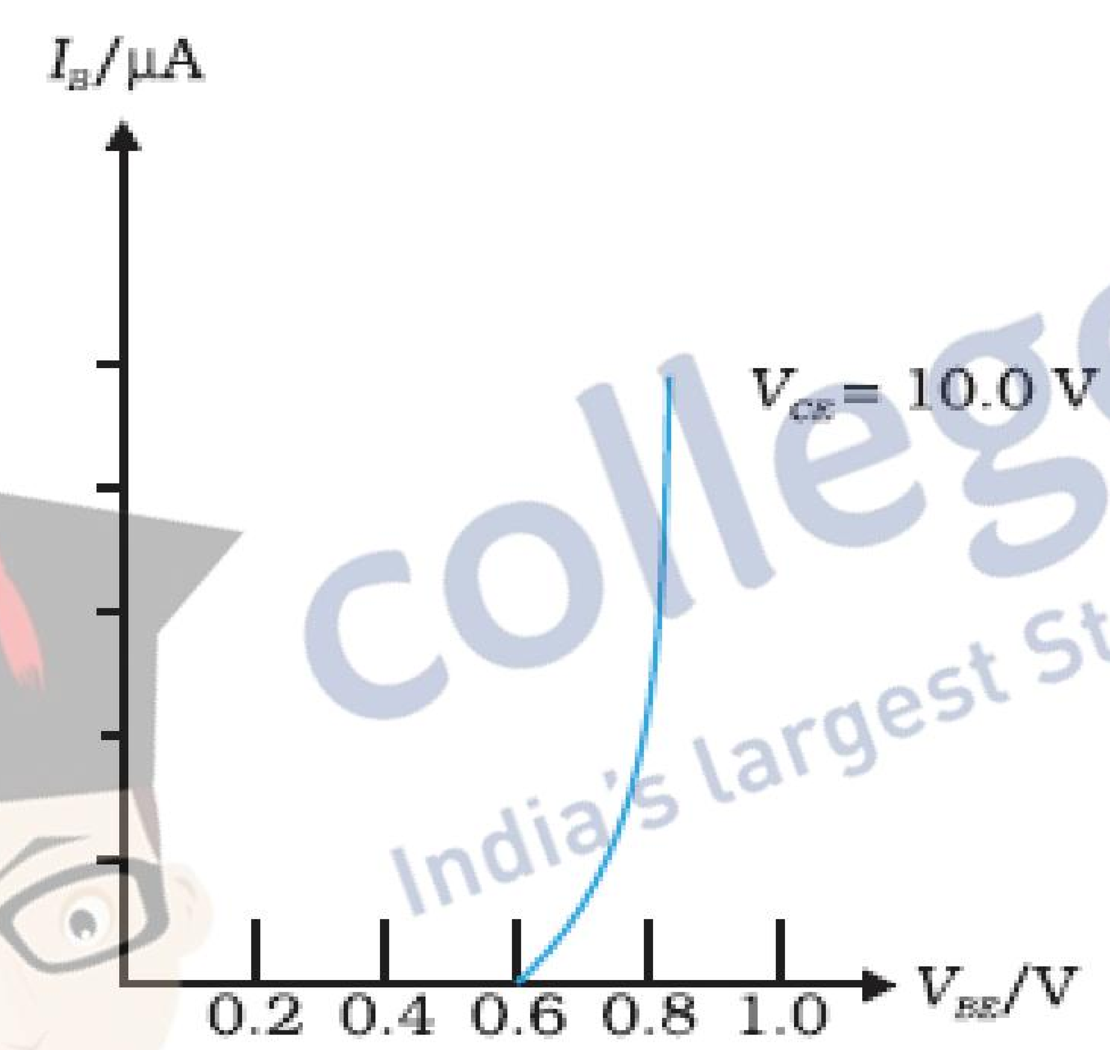
(a) Circuit diagram for studying the characteristics of an npn transistor 1
(b) Finding the input resistance and current gain 1+1

(a)



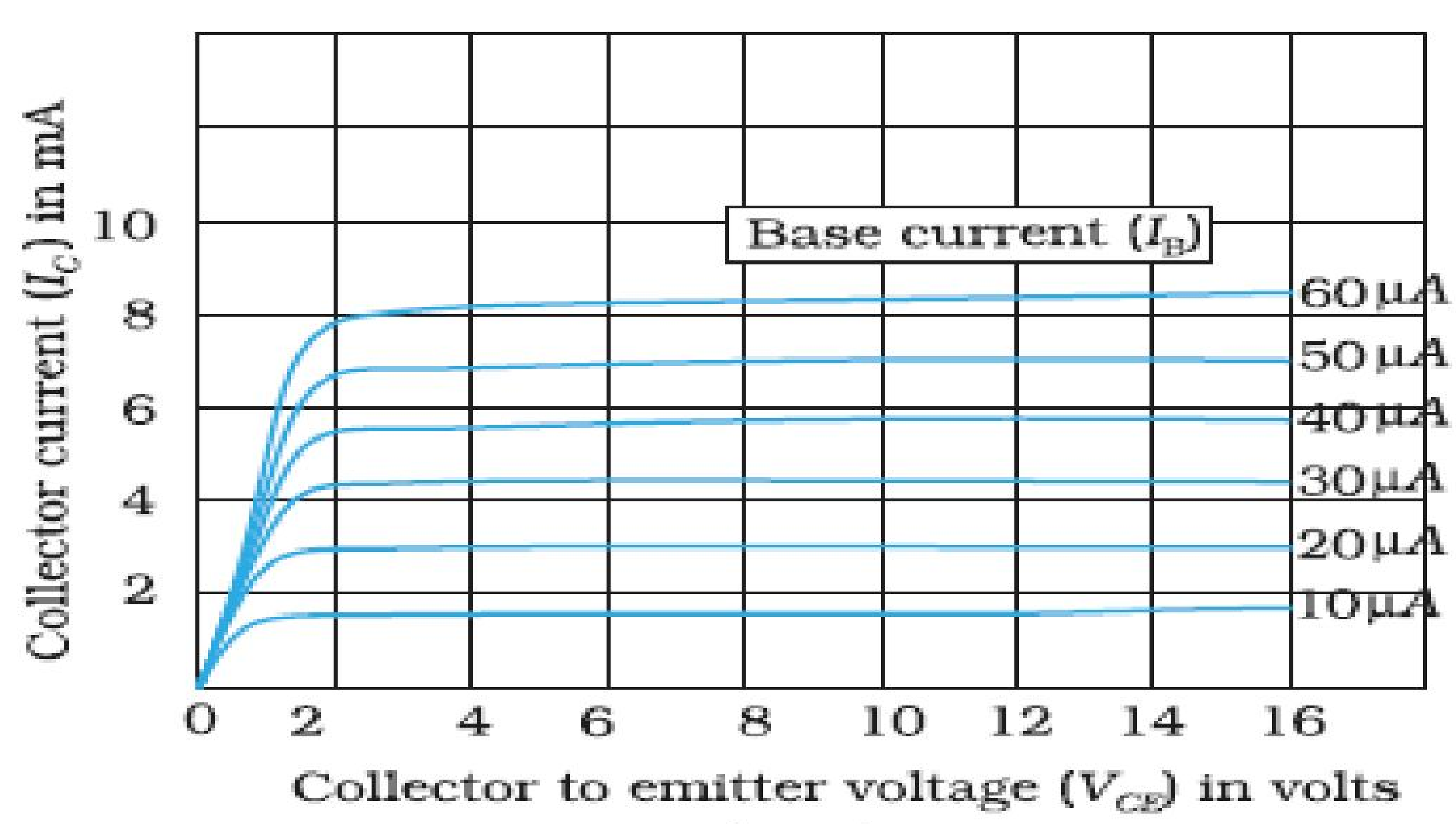
1

(b)



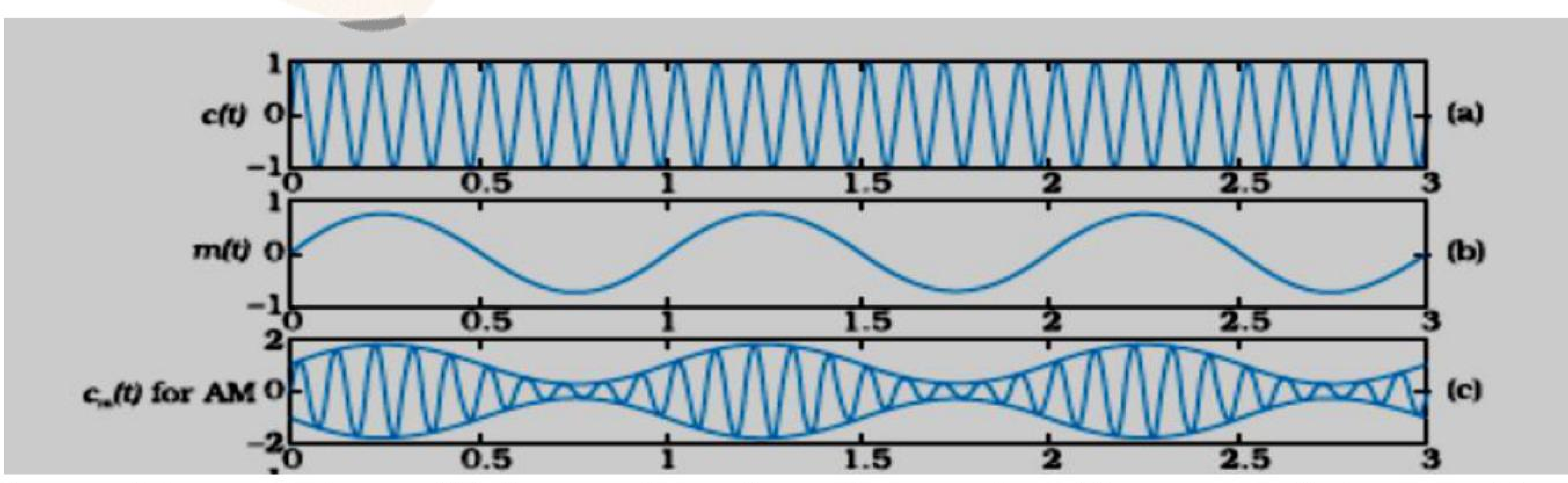
½

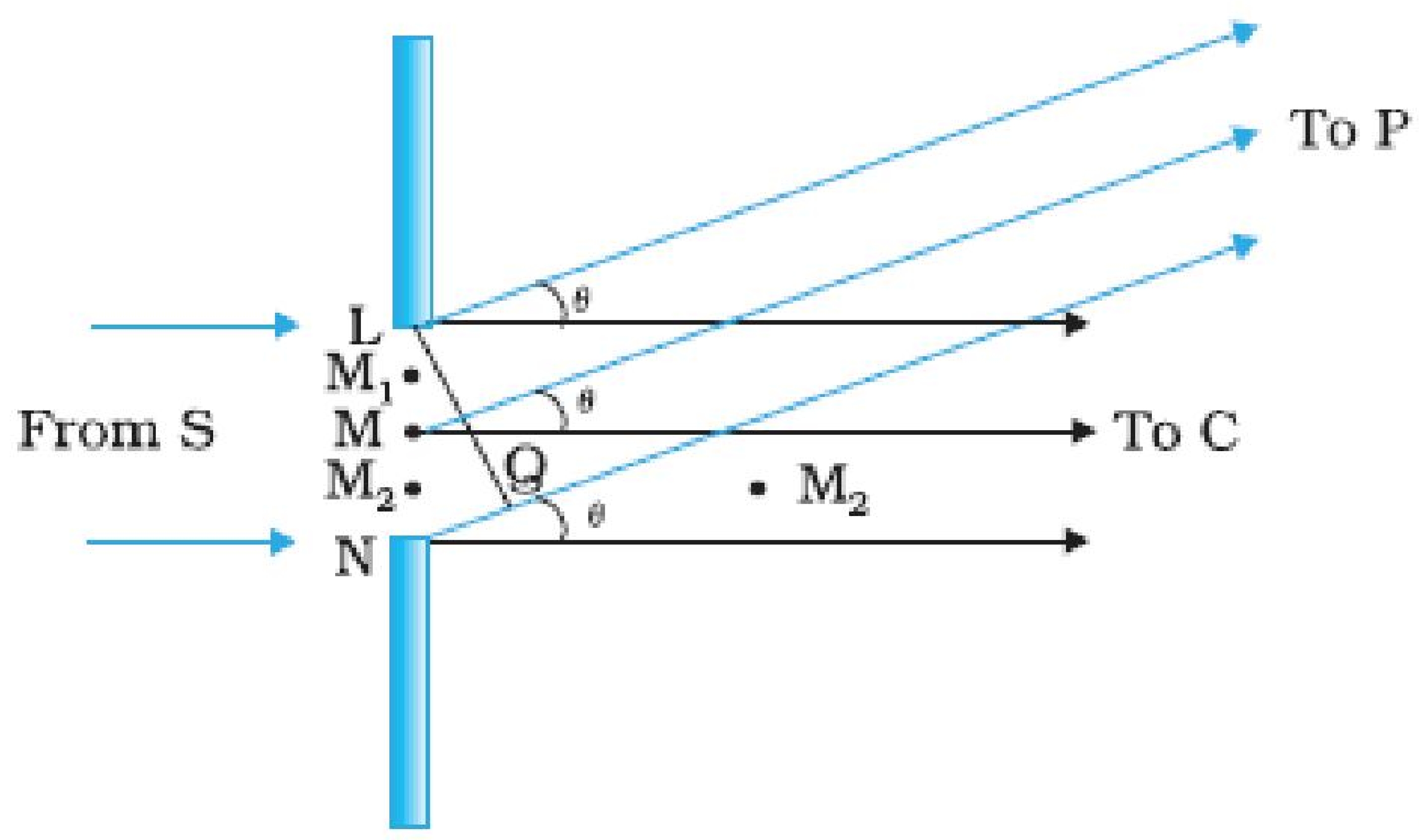
Input Resistance $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$ ½



½

$$\beta_{ac} = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$$ ½ 3

22.	(a) Highest energy level to which atom will be excited 1 (b) Calculation of longest Lyman wavelength 1 (c) Calculation of longest Balmer wavelength 1		
	(a) Maximum Energy that the excited hydrogen atom can have is E=-13.6eV + 12.5eV=-1.1 eV Now $E_3 = \frac{-13.6}{3^2} eV = -1.5eV \quad (< (-1.1eV))$	½	
	$E_4 = \frac{-13.6}{4^2} eV = -0.85eV \quad (> (-1.1eV))$ It follows that the electron can only be excited up to the n=3 state.	½	
	(b) Longest wavelength of Lyman series: $\frac{1}{\lambda_L} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = R.\frac{3}{4}$	½	
	$\therefore \lambda_L = \frac{4}{3} \times \frac{1}{R}$ $= \frac{4}{3 \times 1.1 \times 10^7} m \cong 1218\ A^0$	½	
	Longest wavelength of Balmer series: $\frac{1}{\lambda_B} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$	½	
	$= \frac{5R}{36}$ $\lambda_B = \left(\frac{36}{5 \times 1.1 \times 10^7}\right) m \approx 6560 A^0$	½	3
23.	(a) Explanation of amplitude modulation 1 ½ (b) Calculation of modulation index 1 ½		
		½ ½ ½	
	[Note: Award 1 mark here if the student just draws the diagram of the amplitude, modulated wave without drawing the 'carrier wave' and the 'message signal' diagrams]		
	(b) $a_m + a_c = 20\ V$ $a_c - a_m = 5\ V$ => $a_c = 12.5\ V$ $a_m = 12.5\ V$	½	

	Modulation index $\mu = \frac{a_m}{a_c}$ $= \frac{7.5}{12.5} = 0.6$	½ ½	3
24.	(a) Explanation for formation of diffraction pattern 2 (b) Calculation of separation 1 (a)  Path difference, NP-LP=NQ =a sinθ $\approx a\theta$ At C on the screen, $\theta = 0^0$. All path differences are zero and hence all wavelets meet in phase and produce a maxima at C. At points P on the screen for which path difference is λ, 2λ, 3λ, ……nλ; the wavelets will cancel each other in pairs and produce minima. $\therefore a\theta = n\lambda$ --------- condition for minima (n=1,2,………) At points P on the screen for which path difference is $\frac{\lambda}{2}$, $3\frac{\lambda}{2}$, ………...., $(2n+1)\frac{\lambda}{2}$, The wavelets produce a maxima due to one uncancelled part of the wavefront. $\therefore a\theta = (2n+1)\frac{\lambda}{2}$--------- condition for maxima (n=1,2,………) (b) separation between 1st secondary maxima of the two wavelengths $=\frac{3D}{2d}(\lambda_2 - \lambda_1)$ $=\frac{3\times1.5}{2\times2\times10^{-4}} \times 60 \times 10^{-10}$ m =67.5 X10^{-6} m =67.5 μm	½ ½ ½ ½ ½ ½	3

SECTION - D			
25.	(a) Derivation of the expression for the average power 3 (b) Definition of terms (i) watt less current (ii) Quality factor 1 + 1		
	(a) Power at any instant 't' $$P=Vi$$ $$= (V_m sin\, wt)(i_m \sin(wt+\varphi))$$	½	
	$$= \frac{V_m i_m}{2}\ (2\sin wt \sin(wt+\varphi))$$	½	
	$$= \frac{V_m i_m}{2}\ [cos\,\varphi - \cos(2wt+\varphi)]$$	½	
	The term $\cos(2wt+\varphi)$ is time dependent and its average over a cycle is zero. Therefore average power	½	
	$$\bar{P} = \frac{V_m i_m}{2} cos\varphi$$	½	
	$$\bar{P} = \frac{V_m i_m}{\sqrt{2}\sqrt{2}} cos\varphi$$		
	$$\bar{P} = V_{rms} i_{rms} cos\varphi$$	½	
	(b) (i) When no power is dissipated even through a current is flowing in the circuit, the current is then called a wattles current. Alternatively The net power dissipation in a circuit containing an ideal inductor or a capacitor is zero. Therefore, the associated current is wattless current.	1	
	(ii) Q factor of LCR circuit is defined as the ratio of its resonant angular frequency (ω_0) to the band width ($2\Delta\omega$) of the circuit. Alternatively $$Q = \frac{\omega_0}{2\Delta\omega}$$ Alternatively $$Q = \frac{\omega_0 L}{R}$$ Alternatively Quantity factor is the ratio of rms voltage drop across inductor or the capacitor, in resonance condition, to the rms voltage applied to the circuit. $$Q = \frac{(V_{rms})_L\ [/(V_{rms})_C]}{(V_{rms})_R}$$ Alternatively Quantity factor is measure of the sharpness of the resonance in LCR circuit.		

Alternatively

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$ 1 5

OR

(a) Statement of Faraday's Laws	1
(b) Derivation of the expression for the emf induced across the ends of a straight conductor	2
(c) Derivation of Magnetic energy stored	2

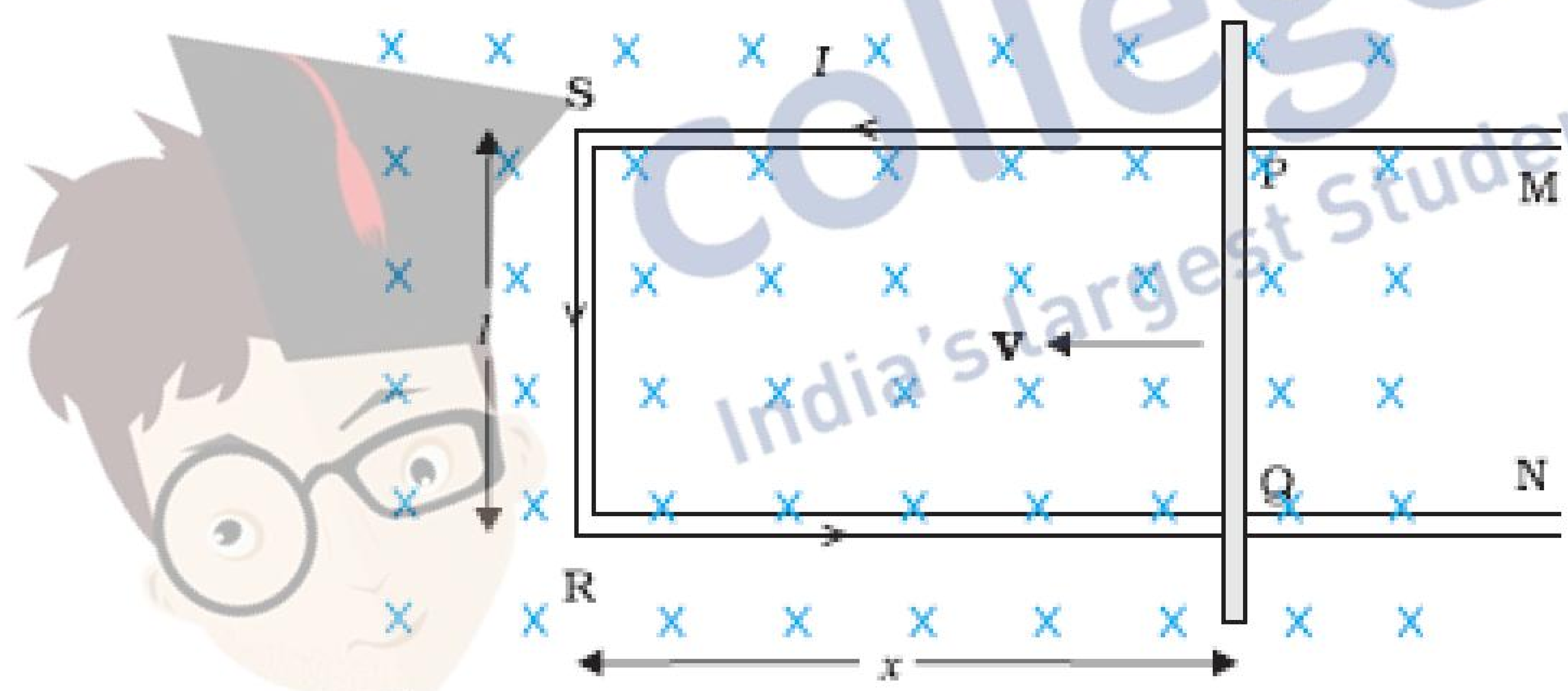
(a) (i) Whenever there is a change in magnetic flux linked with a coil, an emf is induced in the coil, however it lasts so long as magnetic flux keeps on changing.

(ii) The magnitude of the induced emf is equal to the rate of change of magnetic flux through the circuit

Alternatively

$$\varepsilon = \frac{-d\phi}{dt}$$ 1

(b)



½

Straight conductor PQ of length 'l' is moving with velocity 'v' in uniform magnetic field B, which is perpendicular to the plane of the system.

Length RQ=x, RS=PQ=l

Instantaneous flux= (normal) field × area

The magnetic flux (ϕ_B) enclosed by the loop PQRS, ½

$$\therefore \phi_B = Blx$$

Since 'x' is changing with time, there is a change of magnetic flux. The rate of change of this magnetic flux determines the induced emf

$$\therefore e = \frac{-d\phi}{dt} = \frac{-d}{dt}(Blx)$$

$$= -Bl\frac{dx}{dt}$$ ½

$$e = Blv$$ ½

as $\frac{dx}{dt} = -v$

(c) Work done (that gets stored as the magnetic potential energy) when current 'I' flows in the solenoid.

$$dW = (e)(I\text{dt})$$

$$\therefore dW = \left(L\frac{dI}{dt}\right).(Idt)$$ ½

$$\therefore dW = LIdI$$

Total work done $W = \int dW = \int LI\, dI$

$$W = \frac{1}{2}L\,I^2$$ ½

For the solenoid, we have $L = \mu_0 n^2 Al$

and $B = \mu_0 nI$ ½

$$\therefore\ W = \frac{1}{2}(\mu_0 n^2 Al)\left[\frac{B}{\mu_0 n}\right]^2$$

$$= \frac{B^2 Al}{2\mu_0}$$ ½ — 5

26.

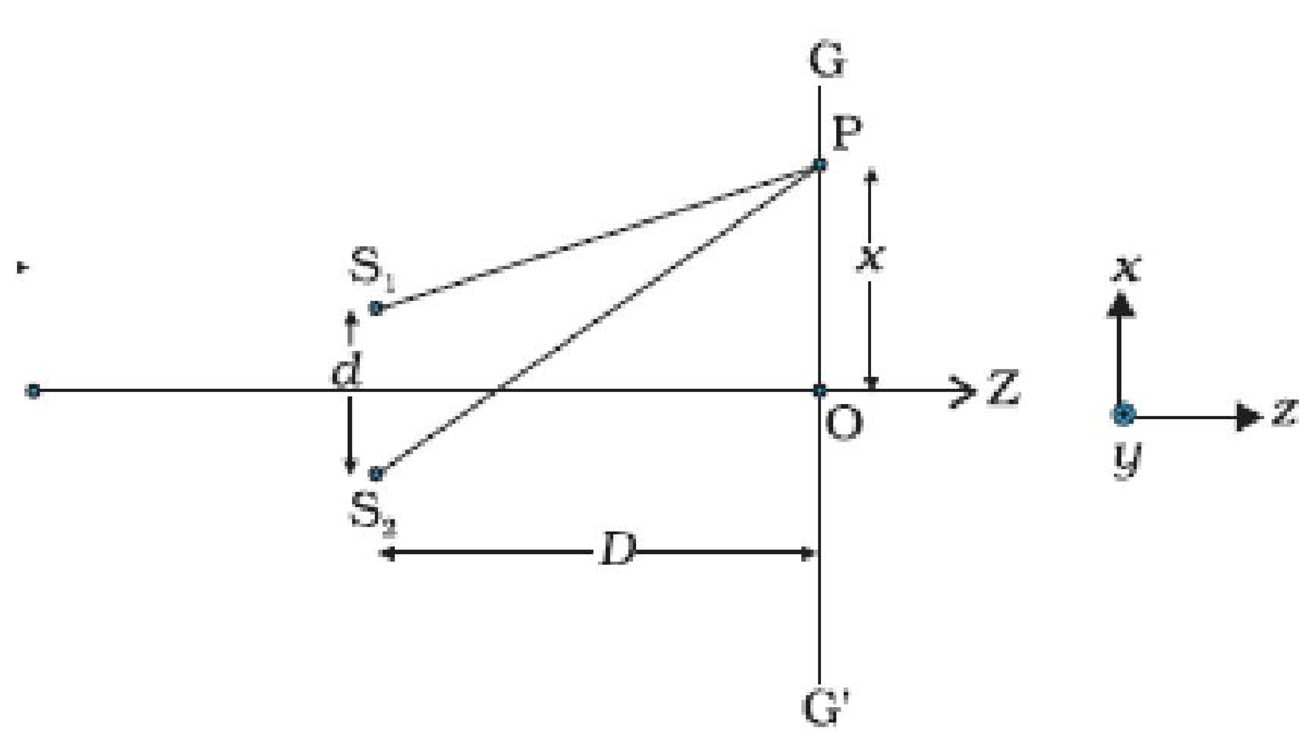
(a) Answer and justification	½ + ½
(b) Explanation of the formation of interference fringes and derivation of expression of fringe width	1 + 2
(c) Finding the intensity of light	1

(a) No, ½

Because to obtain the steady interference pattern, the phase difference between the waves should remain constant with time, two independent monochromatic light sources cannot produce such light waves. ½

(b)

When light waves from two coherent sources, in Young's double slit experiment, superpose at a point on the screen, they produce constructive/ destructive interference, depending on the path difference between the two waves. 1



½

Path difference between the waves reaching at point P from two sources S_1 and S_2

$$S_2P - S_1P \approx \frac{xd}{D}$$ ½

For constructive interference (i.e for nth bright fringe on the screen)

$$\frac{xd}{D} = n\lambda \qquad \text{where n= } 0, \pm 1, \pm 2, \ldots \ldots \ldots$$

$$\therefore x_n = \frac{n\lambda D}{d}$$ ½

Similarly for (n+1)th bright fringe

$$x_{n+1} = \frac{(n+1)\lambda D}{d}$$

Fringe width $\beta = x_{n+1} - x_n$

$$= \frac{\lambda D}{d}$$ ½

[<u>Alternatively</u>

Path difference for nth dark fringe on the screen

$$\frac{xd}{D} = (n + \frac{1}{2})\lambda$$

$$x_n = \frac{(n + \frac{1}{2})\lambda D}{d}$$

For (n+1)th dark fringe

$$x_{n+1} = \frac{(n + \frac{3}{2})\lambda D}{d}$$

Fringe width $\beta = x_{n+1} - x_n$

$$= \frac{\lambda D}{d}]$$

(c) The intensity at a point on the screen where waves meet with a phase difference (ϕ), is given by

$$I = 4I_0 cos^2 \phi/_2$$ ½

Phase difference (φ) when path difference is 'x'

$$\phi = \frac{2\pi}{\lambda}.x$$

$\therefore$ for x=λ , we have

$$\phi = 2\pi$$

$$\therefore \text{Intensity } I = 4I_0 cos^2 \pi = K$$

$$\therefore \; 4I_0 = K$$

$$\therefore \; I_0 = K/_4$$

Phase difference, when path difference is λ/4, is

$$\phi' = \frac{2\pi}{\lambda}.\lambda/_4 = \pi/2$$

$$\therefore I' = 4I_0 cos^2 \pi/_4$$

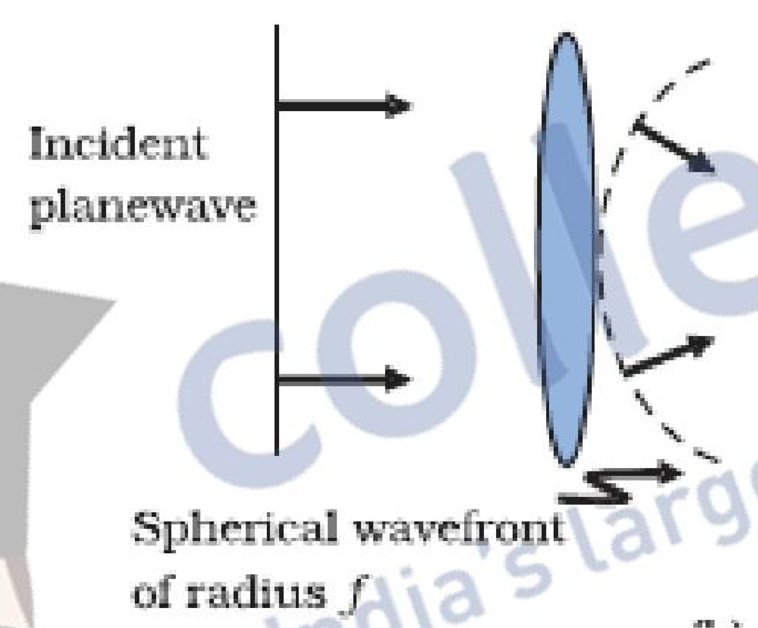
$$=2I_0$$ [½]

$$= 2\frac{K}{4} = K/_2$$ [5]

OR

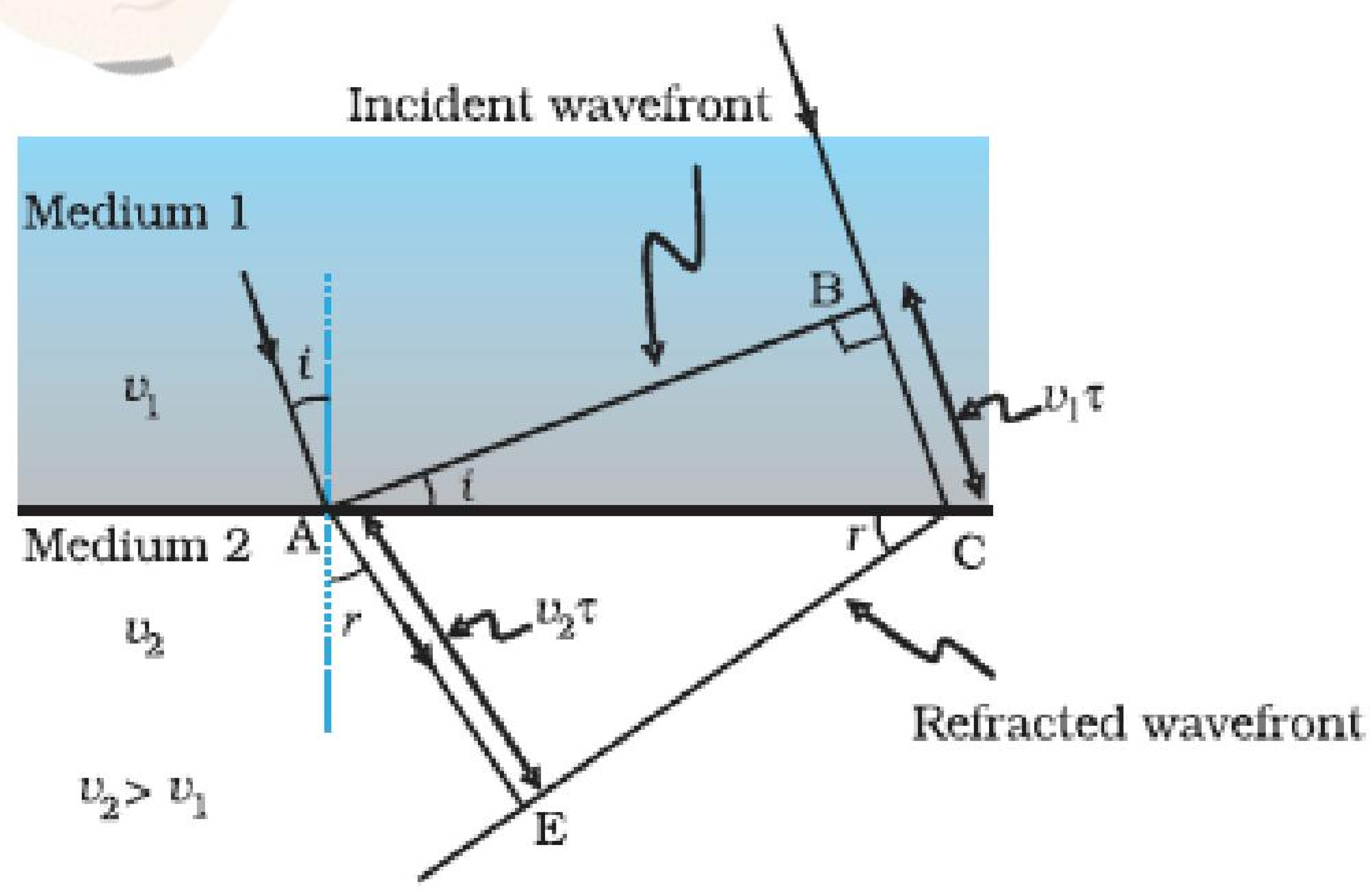
(a) Sketch of the refracted wave front	1
(b) Verification of laws of refraction	2
(c) Estimation of speed and wavelength	1+1

(a)



[1]

(b)



[½]

In right triangle ABC

$$\sin i = \frac{BC}{AC}$$ [½]

In ΔAEC

$$\sin r = \frac{AE}{AC}$$ [½]

[½]

$$\frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{v_1\tau}{v_2\tau} = \frac{v_1}{v_2} = \mu$$

(c) Speed of yellow light inside the glass slab ½

$$v = \frac{c}{\mu}$$

$$= \frac{3 \times 10^8}{1.5} m/s$$ ½

$$= 2 \times 10^8\ m/s$$

Wavelength of yellow light inside the glass slab ½

$$\lambda' = \frac{\lambda}{\mu}$$

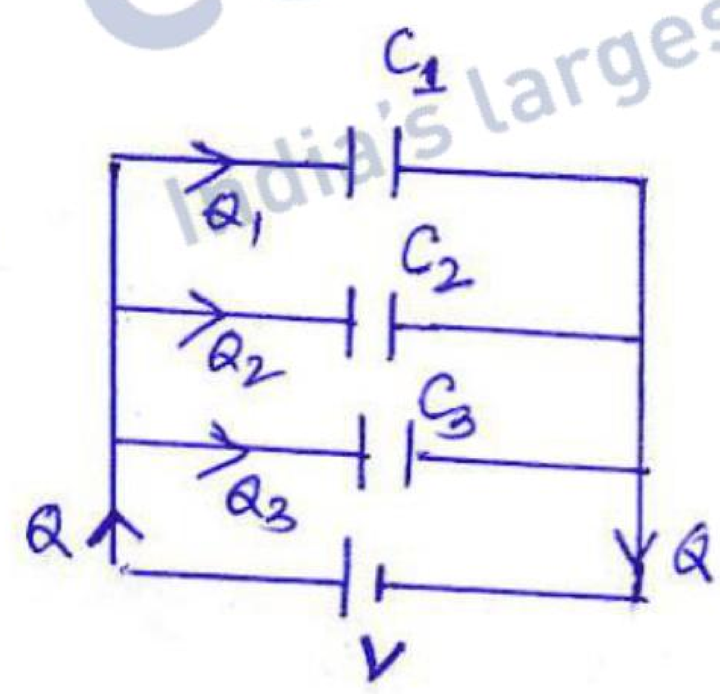
$$= \frac{590}{1.5} nm$$ ½ 5

$$=393.33 nm$$

27.

(a) Derivation of expression for the resultant capacitance in (i) parallel (ii) series 1 ½ + 1 ½
(b) Calculation of energy stored in the 12µf capacitor 2

(a) (i) Parallel



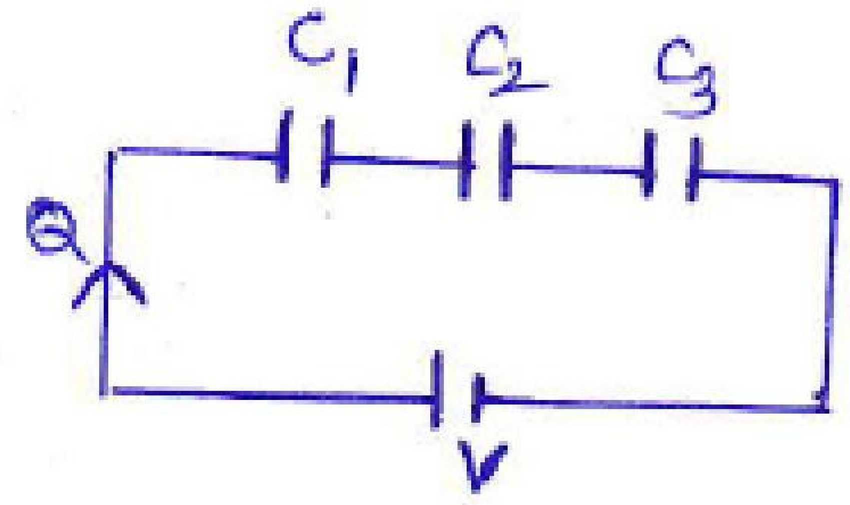
½

$Q_1 = C_1V$,
$Q_2 = C_2V$,
$Q_3 = C_3V$, ½

But $Q = Q_1 + Q_2 + Q_3$
$\therefore\ Q = C_1V + C_2V + C_3V$
$\therefore\ CV = C_1V + C_2V + C_3V$ ½
$C = C_1 + C_2 + C_3$

(ii) Series

½



Potential difference across the plates of the three capacitors are:

$$V_1 = \frac{Q}{C_1}$$

$$V_2 = \frac{Q}{C_2}$$ ½

$$V_3 = \frac{Q}{C_3}$$

But $V = V_1 + V_2 + V_3$ ½

$$V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$\therefore \frac{Q}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\therefore \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$ ½

(b) Potential difference across the capacitor of 4µf capacitance ½

$$V = \frac{Q}{C} = \frac{16\mu C}{4\mu F}$$

=4V

Potential across 12µf capacitor

=12 V- 4V ½

=8V

Energy stored on this capacitor

$$U = \frac{1}{2}CV^2$$ ½ | 5

$$= \frac{1}{2}(12 \times 10^{-6})8^2 \text{ joule}$$

$=6 \text{ X } 64 \times 10^{-6}$ joule

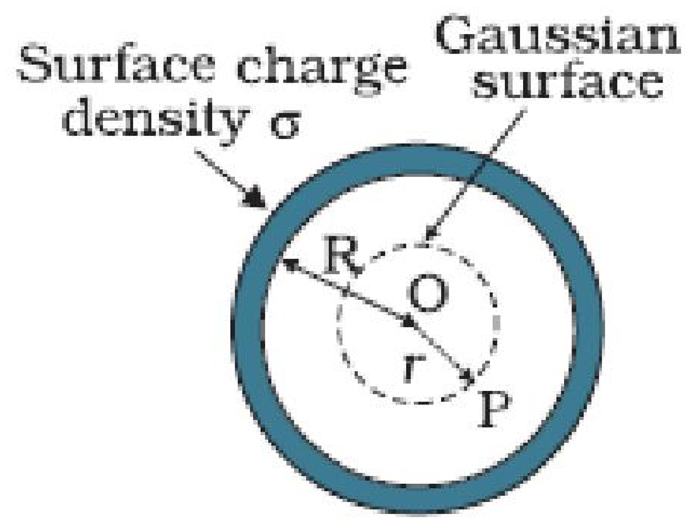
$=384 \times 10^{-6}$ J

=384 µJ

OR

(a) Derivation of expression for the Electric field	
(i) inside (ii) outside	1 + 2
(b) Graphical variation of the Electric field	1
(c) Calculation of Electric flux	1

(a) (i) <u>Inside</u>



The point P is inside the spherical shell. The Gaussian surface is a sphere through P centered at ‘O’ ½

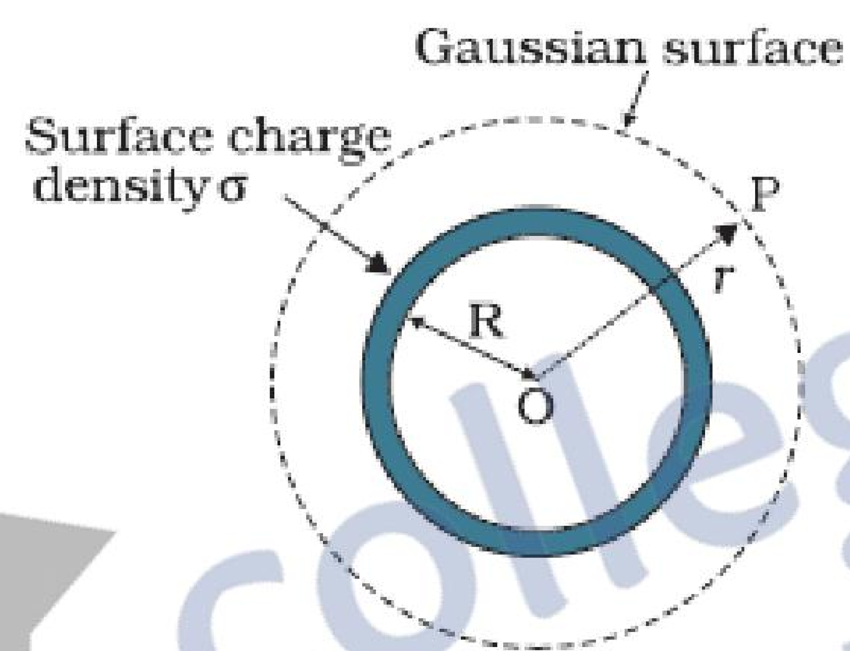
Flux through this surface= $E \times 4\pi r^2$ ½

However there is no charge enclosed by this Gaussian surface. Hence using Gauss’s Law

$$E \times 4\pi r^2 = 0$$
$$\Rightarrow E = 0$$

½

<u>Outside</u>



(a)

½

½

To calculate Electric Field $\vec{E}$ at the outside point P, we take the Gaussian surface to be a sphere of radius ‘r’ and with center O, passing through P.

Electric Flux through the Gaussian surface

$\varphi = E \times 4\pi r^2$

Charge enclosed by this the Gaussian surface = $\sigma \times 4\pi R^2$

By Gauss’s Law

$$E \times 4\pi r^2 = \frac{\sigma \times 4\pi R^2}{\epsilon_0} = q/\epsilon_0$$

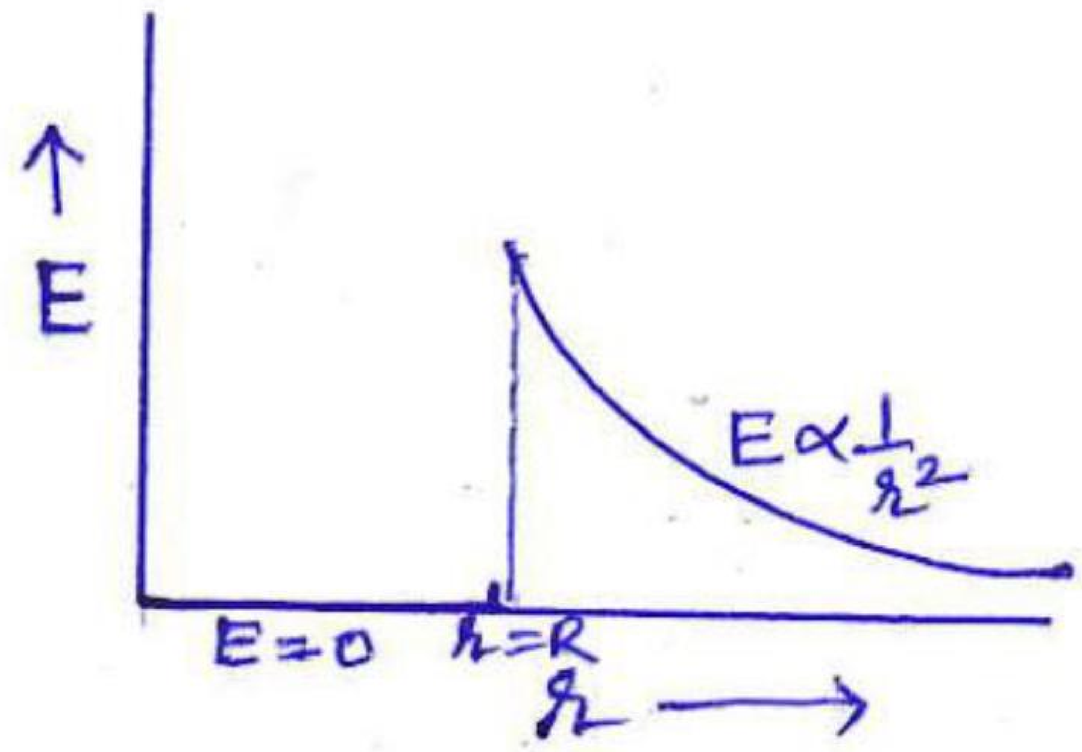
Where q= total charge on the spherical shell. ½

$$\therefore E = \frac{q}{4\pi\epsilon_0 r^2}$$

$$\vec{E} = \frac{1}{4\pi\epsilon_0'}\frac{q}{r^2}\hat{r}$$

1 | 5

(b)

	 (c) Electric flux passing through the square sheet $\phi = \int \vec{E}.\vec{ds}$ $=EA\cos\Theta$ $=200 \times 0.01 \times \cos 60^0$ $=1.0\ Nm^2/C$ [Note: The student may do the calculation by taking $\Theta=30^0$ and get $\sqrt{3}Nm^2/C$ as the answer. In that case award ½ mark only for part (c)]	½ ½	