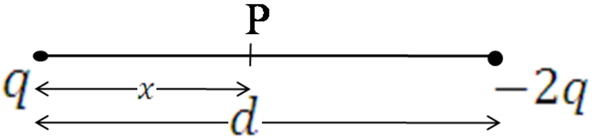
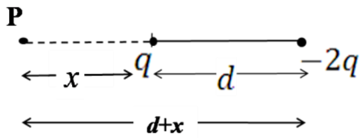
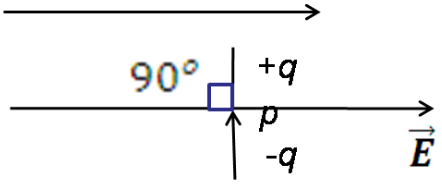
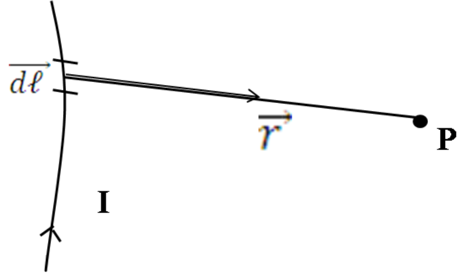
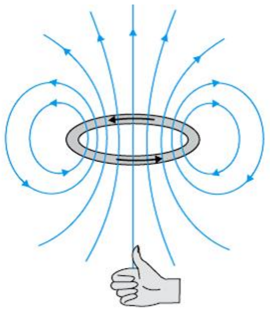
MARKING SCHEME
SET 55/1 (Compartment)

Q.No.	Expected Answer/Value Points	Marks	Total Marks
1.	$v_d = \frac{eV}{m\ell}\tau$	1	1
2.	With increase in temperature, the relaxation time (average time between successive collisions) decreases and hence resistivity increases. **Alternatively:** Resistivity $\rho \left(= \frac{m}{ne^2\tau}\right)$ increases as τ decreases with increase in temperature.	1	1
3.	Loss of strength of a signal while propagating through a medium.	1	1
4.	The locus of all points that are in the same phase / The surface of constant phase.	1	1
5.	A has positive polarity	1	1
6.	Telephone (**any other correct example)**	1	1
7.	$v = \frac{E}{B}$ where v is speed of electron **Alternatively:** $\left\|\overrightarrow{F_E}\right\| = \left\|\overrightarrow{F_B}\right\|$	1	1
8.	Line B Since slope (q/V) of B is lesser than that of A.	½ ½	1
9.	Formula ½ Substitution and simplification 1 Result ½  Let P be the required point at a distance x from charge q $\therefore \frac{1}{4\pi\epsilon_o}\frac{q}{x} + \frac{1}{4\pi\epsilon_o}\frac{(-2q)}{(d-x)} = 0$ $\frac{1}{x} = \frac{2}{d-x}$ $x = \frac{d}{3}$ required point is at a distance $\frac{d}{3}$ from charge q	½ ½ ½ ½	

	Alternatively:		
			
	$\frac{1}{4\pi\varepsilon_o}\frac{q}{x} = \frac{1}{4\pi\varepsilon_o}\frac{2q}{d+x}$	½	
	$2\,x = x + d$ or $x = d$	½	
	At distance d towards left of charge q	½	
	OR	½	2
	(i) Work Done 1 (ii) Orientation 1		
	(i) We have W = $\int_{\theta_1}^{\theta_2} \tau d\theta$ ∴ W = $\int_{o}^{\pi} pEsin\theta d\theta$ = $pE[-cos\theta]_o^{\pi}$ = -2 pE	½	
	(ii) ∵ $\tau = PE\ sin\theta$ for $\theta = \frac{\pi}{2}$, τ is maximum	½	
	Alternatively:	1	
			2
10.	(i) (a) Formula ½ (b) Result ½ (ii) (a) Formula ½ (b) Result ½		
	(i) $\omega_o = \frac{1}{\sqrt{LC}}$	½	
	$= \frac{1}{\sqrt{50\times10^{-3}\times80\times10^{-6}}}$ = 500 rad/s	½	
	[Also accept i.e. $\vartheta = \frac{500}{2\pi} = \frac{250}{\pi}Hz \simeq 80Hz)]$		
	(ii) $Q = \frac{\omega_o L}{R}$	½	
	$= \frac{500\times50\times10^{-3}}{40}$ = 0.625	½	2

11.	Formula 1 Substitution and Calculation ½ Result ½		
	$\lambda = \frac{h}{mv}$	1	
	$= \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.2 \times 10^{8}}$	½	
	$=3.31 \text{ x } 10^{-12}$m	½	2
12.	Flux through S_1 ½ Flux through S_2 ½ Ratio ½ Flux through S_1 with dielectric median ½		
	Flux through S_1 , $\Phi_1 = \frac{Q}{\epsilon_o}$	½	
	Flux through S_2 , $\Phi_2 = \frac{Q+2Q}{\epsilon_o} = \frac{3Q}{\epsilon_o}$	½	
	Ratio of flux = 1:3	½	
	No change in flux through S_1 with dielectric medium inside the sphere S_2	½	2
13.	(i) Statement of Biot Savart's law 1 (ii) Expression for magnetic field ½ (iii) Showing field lines ½		
	(i) According to Biot Savart's law, the magnetic field due to a current element $\overrightarrow{d\ell}$ carrying current I at a point with position *P* vector $\vec{r}$ is given by $d\vec{B} = \frac{\mu_o}{4\pi} I \left[\frac{\overrightarrow{d\ell} \times \vec{r}}{\lvert\vec{r}\rvert^3}\right]$	1	
			
	(ii) B = $\frac{\mu_o I}{2r}$	½	
	Field lines 	½	2

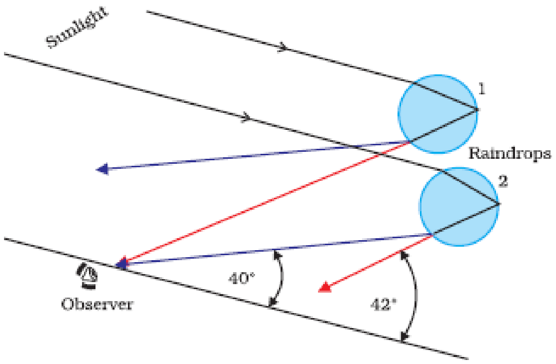
14.

(a) Conditions	½ + ½
(b) Formation of rainbow	
Diagram	½
Explanation	½

The condition for observing a rainbow are :

i. The sun comes out after a rainfall. ½

ii. The observer stands with the sun towards his/her back. (any one) ½



½

Formation of a rainbow:

- ➔ The rays of light reach the observer through a refraction, followed by a reflection, followed by a refraction.
- ➔ Figure shows red light, from drop 1 and violet light from drop 2, reaching the observers eye. ½ 2

15.

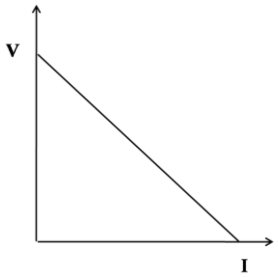
One difference between ε and V	½
VI Graph	½
Determination of 'r' and ε	1

Difference between emf(ε) and terminal voltage (v)

emf	terminal voltage
1) It is the potential difference between two terminals of the cells when no current is drawn from it. 2) It is the cause.	1) It is the potential difference between two terminals when current passes through it. 2) It is the effect.

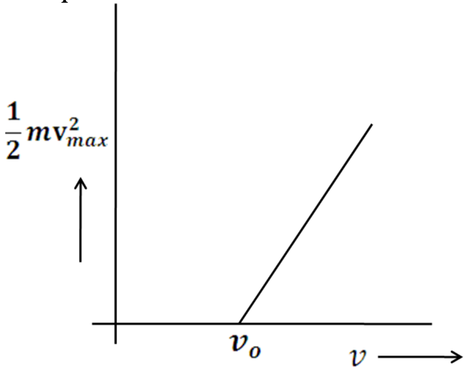
½

(**Any one)** or any other relevant difference



1

Negative of slope gives internal resistance. ½ 2

16.	(a) Difference between a permanent magnet and an electromagnet ½ + ½ (b) Any two properties of material ½ + ½		
	a) An electromagnet consists of a core made of a ferromagnetic material placed inside a solenoid. It behaves like a strong magnet when current flows through the solenoid and effectively loses its magnetism when the current is switched off.	½	
	(i) A permanent magnet is also made up of a ferromagnetic material but it retains its magnetism at room temperature for a long time after being magnetized once.	½	
	b) (i) High permeability (ii) Low retentivity (iii)Low coercivity <u>(Any two)</u>	½+ ½	
	[**Note:** Give ½ mark if the student just writes 'soft iron' is a suitable material for making electromagnets.]		2
17.	Three basic properties ½ + ½ + ½ Plot of KE $_{max}$ versus ν ½		
	Three basic properties of photons:		
	(i) Photons are quanta or discrete carriers of energy.	½	
	(ii) Energy of a photon is proportional to the frequency of light.	½	
	(iii)The photon gives all its energy to the electron with which it interacts.	½	
	Einstein's photoelectric equation $\frac{1}{2}mv^2_{max} = h\nu - w$		
	The plot is as shown  	½	2
18.	Naming the gate ½ Truth Table 1 Logic Symbol ½		
	NAND GATE	½	

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<td>
TRUTH TABLE

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<tr><th>A</th><th>B</th><th>Y</th></tr>
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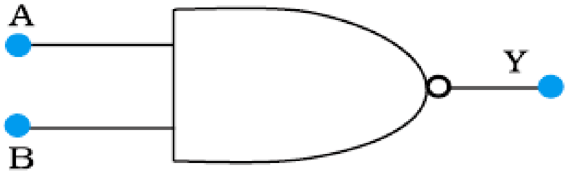
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
</table>

LOGIC SYMBOL

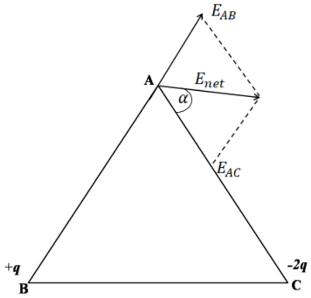


</td>
<td>1
½</td>
<td>2</td>
</tr>
<tr>
<td>19.</td>
<td>
<table>
<tr><td>Magnitude of resultant field</td><td>2</td></tr>
<tr><td>Direction of resultant field</td><td>1</td></tr>
</table>

(i) The magnitude

$$\left|\overrightarrow{E_{AB}}\right| = \frac{1}{4\pi\epsilon_o}\frac{q}{a^2} = E$$

$$\left|\overrightarrow{E_{AC}}\right| = \frac{1}{4\pi\epsilon_o}\frac{2q}{a^2} = 2E$$



$$E_{net} = \sqrt{(2E)^2 + E^2 + 2\times 2E\times E\times\left(-\frac{1}{2}\right)}$$

$$= \sqrt{4E^2 + E^2 - 2E^2}$$

$$= E\sqrt{3} = \frac{1}{4\pi\epsilon_o}\frac{q\sqrt{3}}{a^2}$$

(ii)Direction of resultant electric field at vertex A

$$\tan\propto = \frac{E_{AB}\sin 120^o}{E_{AC}+E_{AB}\cos 120^o}$$

$$= \frac{E\times\frac{\sqrt{3}}{2}}{2E+E\times\left(\frac{-1}{2}\right)} = \frac{1}{\sqrt{3}}$$

$\propto = 30^o$ (with side AC)
</td>
<td>½
½
½
½
½
½</td>
<td>3</td>
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</table>

20.

(a) Principle of potentiometer	½
Reason for Part (i), (ii) and (iii)	½ + ½ + ½
(b) Graph	1

a) Principle of potentiometer:

The potential drop across the length of a steady current carrying wire of uniform cross section is proportional to the length of the wire. ½

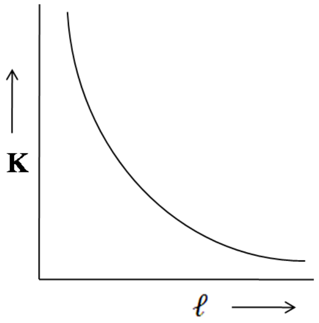
i. We use a long wire to have a lower value of potential gradient (i.e. a lower 'least count' or greater sensitivity of the potentiometer ½

ii. The area of cross section has to be uniform to get a 'uniform wire' as per the principle of the potentiometer ½
/ to ensure a constant value of resistance per unit length of the wire.

iii. The emf of the driving cell has to be greater than the emf of the primary cells as otherwise no balance point would be obtained. ½

b) Potential gradient $K = \frac{V}{L}$

∴ the required graph is as shown



1

3

21.

(i)	Formula	½
	Energy in the first excited state	½
	Energy required	½
(ii)	Kinetic energy	½
	Orbital radius (Formula and Result)	½ + ½

(i) For the hydrogen atom

a. $|E_n| \propto \frac{1}{n^2}$ ½

b. ∴ Energy of first excited state = $\frac{-13.6}{2^2}$ =-3.4eV ½

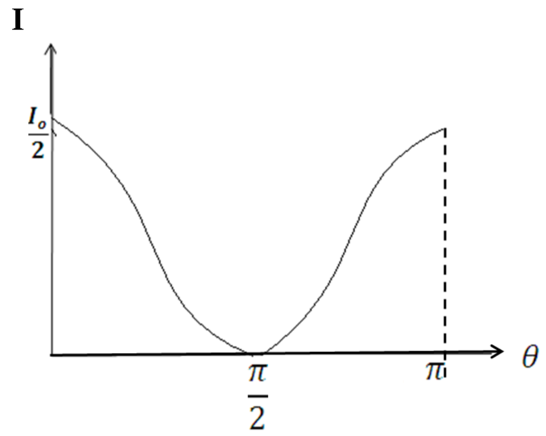
c. ∴ Energy required = [- 3.4 – (13.6)eV] = 10.2 eV ½

(ii)

a. Kinetic energy = $|energy\ of\ 1st\ excited\ state|$
= 3.4 eV ½

b. Orbital radius in nth state $\propto n^2$ ½
= 4 x 0.53$\dot{A}$
= 2.12 $\acute{A}$ ½

3

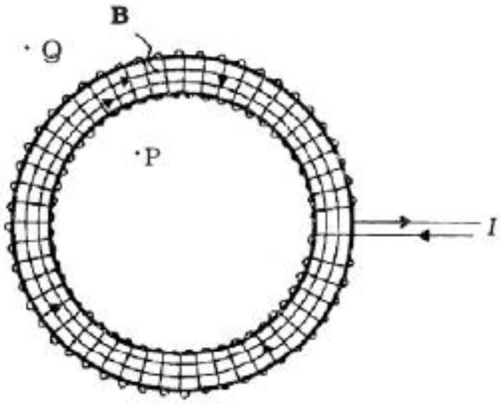
22.	(a) Graph showing variation of intensity with θ 1 (b) Determination of values of θ and β 1+1		
	(a) The required graph would have the form shown as:  	1	
	Using $I_2 = I_1\, cos^2\theta$ (b) I_1= Light transmitted by P_1 I_3= Light transmitted by $P_3 = I_1\, cos^2\beta$ I_2= Light transmitted by $P_2 = I_3\, cos^2(\theta - \beta)$	½	
	Alternatively , (Award mark to student who indicates correct value of I_1, I_2 and I_3 by making a diagram) $\therefore\ I_2 = I_3$ $I_1\, cos^2\beta . cos^2(\theta - \beta) = I_1 cos^2\beta$ $\theta = \beta$	½	
	Also $I_1 = I_2$ $I_{1=}\, I_1\, cos^2\beta . cos^2(\theta - \beta)$ or $cos^2\theta = 1$ $\therefore\ \theta = 0°$ or π	½	
	Therefore $\beta = 0°$ or π	½	3

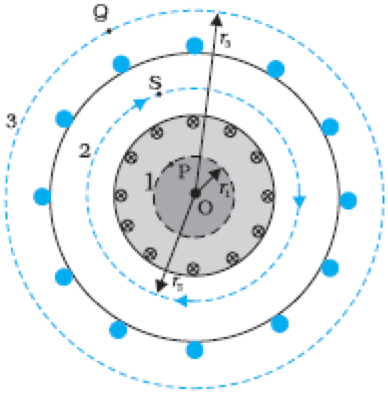
23.

(a) Difference between a solenoid and a toroid	1
(b) Derivation of the relation B=$\mu_0 nI$	1
(c) Magnetic field (i) inside and (ii) outside	½ + ½

(a) A toroid can be viewed as a solenoid which has been bent into a circular shape to close on itself — 1

(b)





½

For the magnetic field at a point S inside a toroid we have

$B(2\,\pi\,r) = \mu_\circ NI$

$B = \mu_\circ \frac{NI}{2\,\pi\,r} = \mu_\circ nI$ (n = no. of turns per unit length of solenoid) — ½

(c) For the loop 1, Ampere's circuital law gives — ½

$B_1 . 2\pi r_1 = \mu_0(0)$ i.e. $B_1 = 0$

Thus the magnetic field , in the open space inside the toroid is zero.

Also at point Q, we have $B_3(2\pi r_3) = \mu_0(I_{enclosed})$

But from the sectional cut, we see that the current coming out of the plane of the paper, is cancelled exactly by the current going into it.

Hence $I_{enclosed}$=0

$\therefore\ B_3 = 0$ — ½ — 3

	OR		
	Derivation of the expression for magnetic moment 2 ½ Direction of magnetic moment ½		
	We have $\mu = iA$	½	
	$= \frac{e\,.\text{v}}{2\pi r}.\pi r^2.$	½	
	$= \frac{e\text{v}r}{2}$	½	
	$\ell = m\text{v}r$		
	$\text{v}r = \frac{\ell}{m}$	½	
	$\vec{\mu} = \frac{-e\,\vec{l}}{2\,m}$	½	
	The direction of $\vec{\mu}$ is opposite to that of $\vec{l}$ because of the negative charge of the electron.	½	3
24.	(a) Derivation of the result $I = 4I_0 cos^2\frac{\phi}{2}$ 2 (b) Conditions for constructive and ½ destructive interference ½		
	(a) The resultant displacement is given by : $y = y_1 + y_2$		
	$= a\cos\omega t + a\cos(\omega t + \phi)$	½	
	$= a\cos\omega t\,(1+\cos\phi) - a\sin\omega t\sin\phi$ Put $R\cos\theta = a\,(1+\cos\phi)$		
	$R\sin\theta = a\sin\phi$	½	
	$\therefore\ R^2 = a^2(1 + cos^2\phi + 2\cos\phi) + a^2 sin^2\phi$ $= 2\,a^2\,(1+\cos\phi) = 4a^2cos^2\,\frac{\phi}{2}$	½	
	$\therefore I = R^2 = 4\,a^2cos^2\frac{\phi}{2} = 4\,I_0 cos^2\frac{\phi}{2}$	½	
	For constructive interference , $\cos\frac{\phi}{2} = \pm 1\ \ or\ \ \frac{\phi}{2} = n\,\pi\ \ or\ \phi = 2n\pi$	½	
	For destructive interference , $\cos\frac{\phi}{2} = 0\ \ or\ \ \frac{\phi}{2} = (2n+1)\,\frac{\pi}{2}\ or\ \phi = (2n+1)\pi$	½	3

25.

(a) Reason	1
(b) Any two values	½ +½
(c) Determination of sideband frequencies	½ + ½

(a) The ultra high frequency em radiations, continuously emitted by a mobile phone, may harm the system of the human body. 1

(b) Sister Anita shows
- (i) Concern about her brother ½
- (ii) Awareness about the likely effects of em radiations on human body ½
- (iii) Sense of responsibility **(<u>any two</u>)**

(c) The side bands are

$(\nu_e + \nu_m) and\ (\nu_e - \nu_m)$ ½

$or\ (1000 + 10) kHz\ and\ (1000 - 10) kHz$

$1010\ kHz\ and\ 990\ kHz$ ½ 3

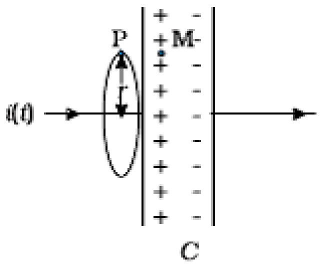
26.

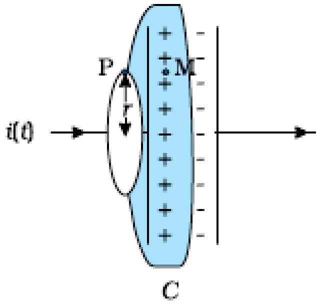
(a) Reason for momentary deflection	½
Deflection after the capacitor gets fully charged	½
(b) Explanation for modification in Ampere's circuital law	2

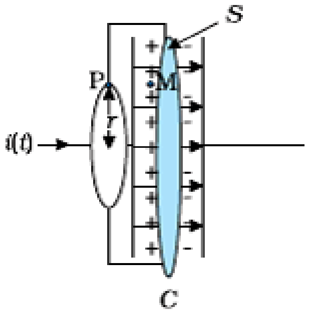
(a) The momentary deflection is due to the transient current flowing through the circuit when the capacitor is getting charged. ½

The deflection would be zero when the capacitor gets fully charged. ½

(b) We consider the charging of a capacitor when it is being charged by connecting it to a dc source.







In Ampere's circuital law, namely

$B\ (2\pi r) = \mu_0 i$

We have i as non zero for surface (a) but zero for surface (c)

Hence there is a contradiction in the value of B; calculated one way we have a magnetic field at P but calculated another way we have B=0 ½ ½

To remove this contradiction the concept of displacement current

$(i_d = \varepsilon_0 \frac{d\phi_E}{d\,t} = i)$ was introduced

and Ampere's circuital law was put in its generalized form namely ½

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 i_c + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$$ ½

This form gives consistent results for values of B irrespective of which surface is used to calculate it. 3

27.

(a) Definition of activity and its SI unit	½ + ½
(b) Calculation of the activity of the sample	2

a) The activity of a sample of radioactive nucleus equals its decay rate(or number of nuclei decaying per unit time) ½

Its SI unit is disintegration /s or Becquerel ½

b) R = λN ½

$$= \frac{log_{e^2} \times 25.3 \times 10^{20} \times 10}{4.5 \times 10^9}$$ ½

$$= \frac{0.6931 \times 25.3 \times 10^{21}}{4.5 \times 10^9 \times 365 \times 24 \times 60 \times 60}$$ ½

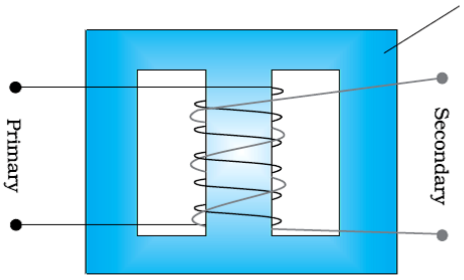
$= 1.24 \times 10^5\ dps$ ½

[Note: If a candidate gives the result in $(\text{year})^{-1}$, give full credit.] 3

28.

(a) Schematic arrangement	1
(b) Principle of a transformer	½
Obtaining expression	
(i) $\frac{V_1}{V_2} = \frac{N_1}{N_2}$	1
(ii) $\frac{V_1}{V_2} = \frac{I_2}{I_1}$	1
(c) Assumptions **(any one)**	½
(d) Two reasons for energy losses	½ + ½

a)



1

b) Principle of a transformer: when alternating current flows through the primary coil, an emf is induced in the neighbouring (secondary) coil ½

(i) Let $\frac{d\phi}{dt}$ be the tare of charge of flux through each turn of the primary and the secondary coil

$\frac{e_1}{e_2}$ = -$N_1\frac{d\phi}{dt}$/-$N_2\frac{d\phi}{dt}$ = $\frac{N_1}{N_2}$ ½

or

$\frac{V_1}{V_2}$= $\frac{N_1}{N_2}$ ------------------(1) ½

(ii) But for an ideal transformer $V_1 I_1$ = $V_2 I_2$

$\frac{V_1}{V_2}$= $\frac{I_2}{I_1}$ -----------------(2) ½

From equation (1) and (2

$\frac{V_1}{V_2}$= $\frac{N_1}{N_2} = \frac{I_2}{I_1}$ ½

c) Main assumptions

(i) The primary resistance and current are small

(ii) The flux linked with the primary and secondary coils is same / there is no leakage of flux from the core.

(iii)Secondary current is small ½

(Any one)

d) Reason due to which energy loses may occur

Flux leakage/resistance of the coils / eddy currents / Hysteresis (**Any two)** ½ +½ 5

OR

a) Derivation of the expressions for i. Induced emf ii. Induced current	2 ½
b) Expression for magnitude of force and its direction	1½
c) Expression for power	1

a) In one revolution

Change of area , dA = $\pi\ell^2$

∴ change of magnetic flux

dϕ = $\overrightarrow{B}.\overrightarrow{dA}$ = BdAcos0^o

= $B\ \pi\ell^2$ ½

Period of revolution T

(i) Induced emf $\varepsilon = B\pi\ell^2$/T = $B\pi\ell^2 v$ ½

(ii) Induced current in the rod, I = $\frac{\varepsilon}{R}$ = $\frac{\pi v B\ell^2}{R}$ 1

[**Note: Award 2 marks if the student derives the above relation using other method.]** ½

b) Force acting on the rod, F = $I\ell B$ ½

$= \frac{\pi v B^2\ell^3}{R}$ ½

The external force required to rotate the rod opposes the Lorentz force acting on the rod / external force acts in the direction opposite to the Lorentz force ½

c) Power required to rotate the rod

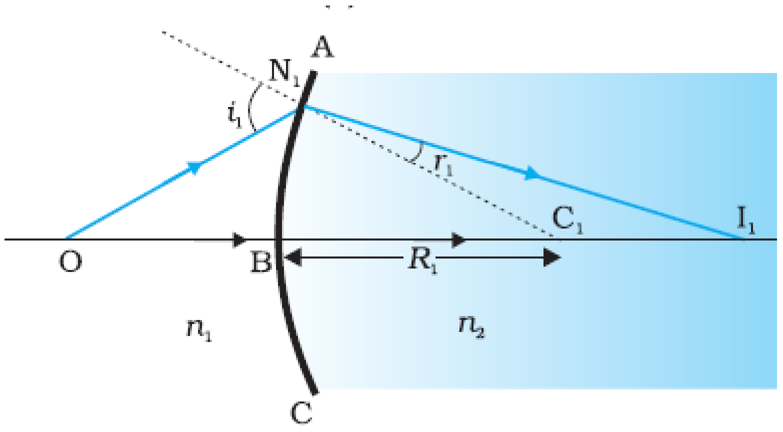
P = $F\vartheta$

$= \frac{\pi v B^2\ell^3 v}{R}$ ½

½ 5

29.

a)	Ray diagram	1
	Derivation of lens maker's formula	2 ½
b)	Calculation of radius of curvature	1 ½



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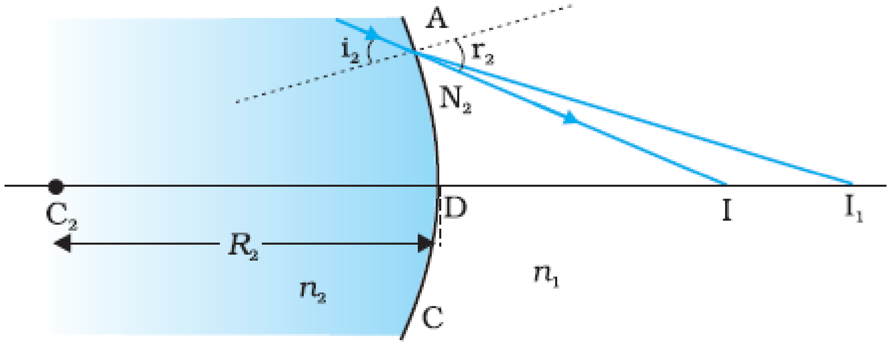

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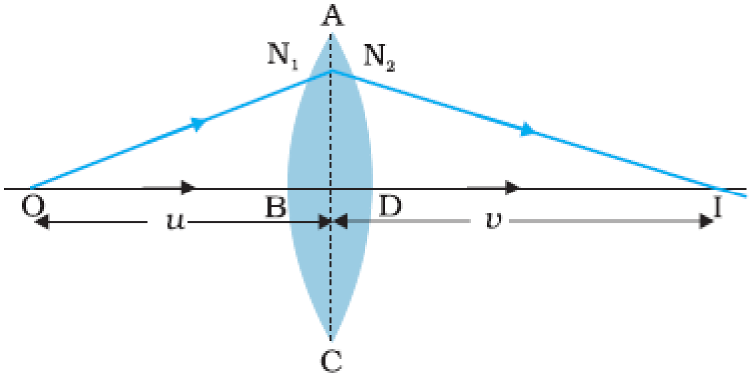


½

The first refracting surface ABC forms the image I_1 of the object O. The image I_1 acts as a virtual object for the second refracting surface ADC which forms the real image I as shown in the diagram

For refraction at ABC

$\frac{n_2}{v_1} - \frac{n_1}{u} = \frac{n_2-n_1}{R_1}$ ---------- (i) ½

For refraction at ADC

$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_1-n_2}{R_{12}}$ ---------- (ii) ½

Adding equation (i) and equation (ii)

$$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)(\frac{1}{R_1} - \frac{1}{R_2})$$ ½

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

We know If $u = \infty , v = f$

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

$$\frac{1}{f} = (n_2 - 1)(\frac{1}{R_1} - \frac{1}{R_2})$$ ½

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

$$\frac{1}{20} = (1.55 - 1)\left(\frac{1}{R} - \frac{1}{-R}\right)$$ ½

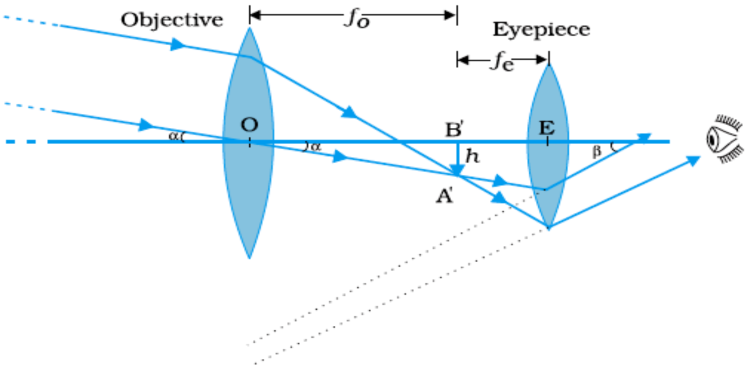
$$= 0.55 \times \frac{2}{R}$$

$$R = 0.55 \times 2 \times 20 = 22\ cm$$ 1 5

OR

(a)	Labelled ray diagram	1 ½
	Derivation of expression for magnifying power	1 ½
(b)	Determination of total magnification	2

a)



1 ½

[**Note :** deduct ½ mark if not labelled]

Derivation

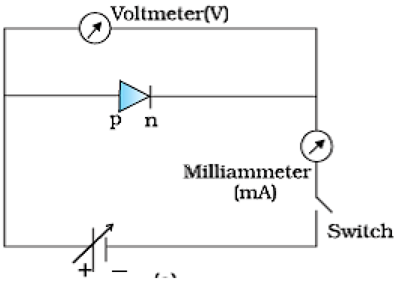
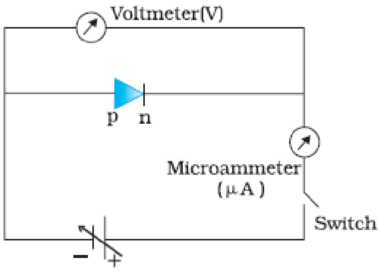
Magnifying Power

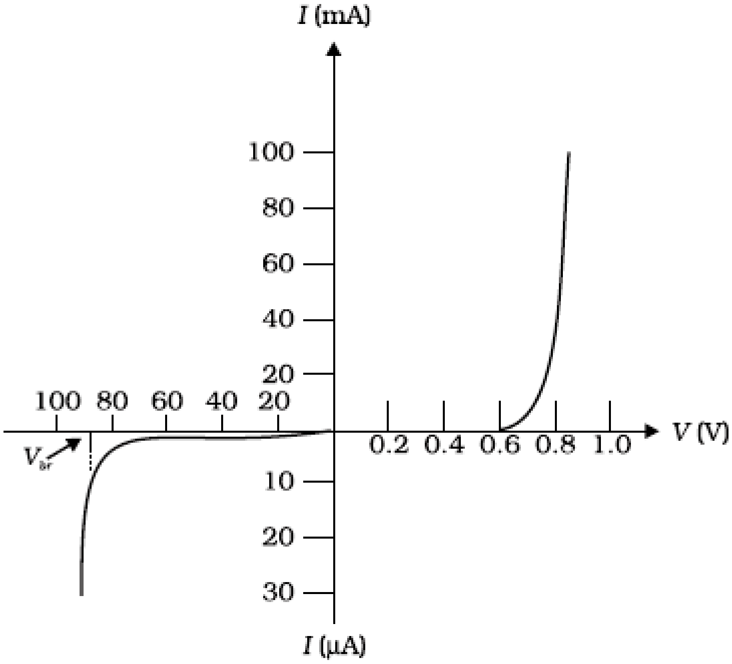
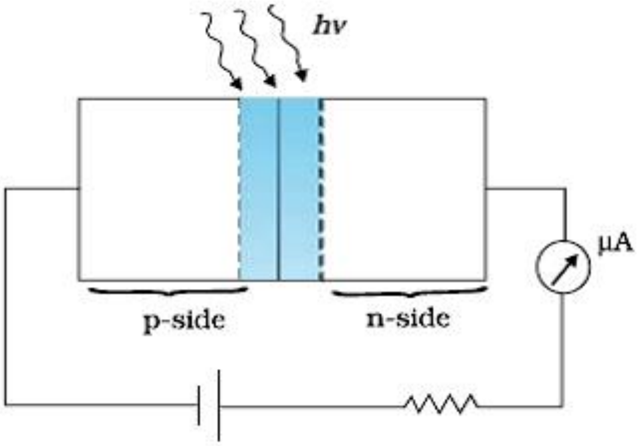
M= $\frac{\tan\beta}{\tan\propto} \cong \frac{\beta}{\propto}$ ½

Final image is formed at infinity when the image $A'B'$ is formed by the objective lens at the force of the eye piece

$$m = \frac{h}{f_e} \times \frac{f_0}{h}$$ ½

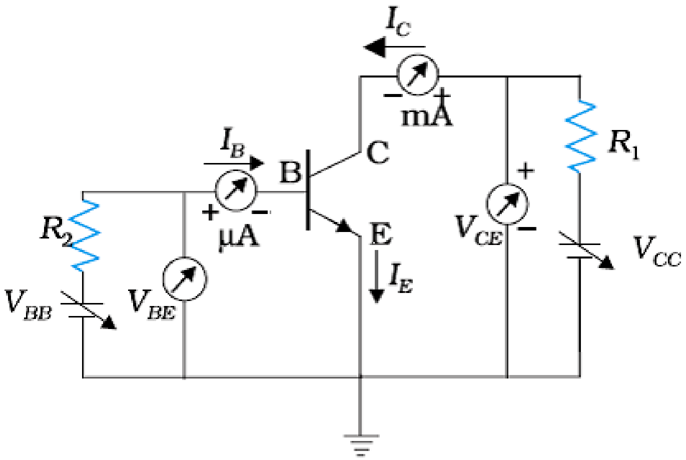
$$= \frac{f_0}{f_e}$$ ½

	b) Given $f_0 + f_e = 105 \quad , f_0 = 20\, f_e$ $20\, f_e + f_e = 105$ $f_e = \frac{105}{21} = 5\, cm$ $f_0 = 20 \times 5 = 100\, cm$ $\therefore Magnification\ m = \frac{f_0}{f_e} = \frac{100}{5} = 20$	½ ½ ½ ½	5
30.	(a) Circuit arrangement of p-n function in (i) Forward biasing ½ (ii) Reverse biasing ½ VI characteristics 1 Explanation ½ (b) Circuit diagram ½ Explanation 2 (a)  **Forward biasing**  **Reverse biasing** The VI characteristics are obtained by connecting the battery, to the diode, through a potentiometer (or rheostat). The applied voltage to the diode is changed. The values of current, for different values of voltage, are noted and a graph between V and I is plotted. The V-I characteristics ,of a diode, have the form shown here.	½ ½ 1	

	 	½+ ½	
	(b) The circuit diagram, for the photodiode, is shown here.		
	 	½	
	The photodiode is illuminated by optical signal, whose photon energy is greater than the energy gap of the semicoinductor used.	½	
	The electric field, at the junction, seperates the electrons and holes and thus gives rise to an emf.	½	
	When an external load is connected, a (photo) current flows through it. The magnitude of this current is proportional to the intensity of light incident on the photodiode.	½	5
	OR		

(a) Circuit diagram	1
Description of current formation	1
Deduction of $I_e = I_b + I_c$	½
(b) Circuit diagram	1
Working	1 ½

a) The circuit diagram is shown here



1

The emitter-base junction, being forward biased, the majority charge carriers (electrons), from the emitter, flow into the base region constituting the emitter current(I_E)

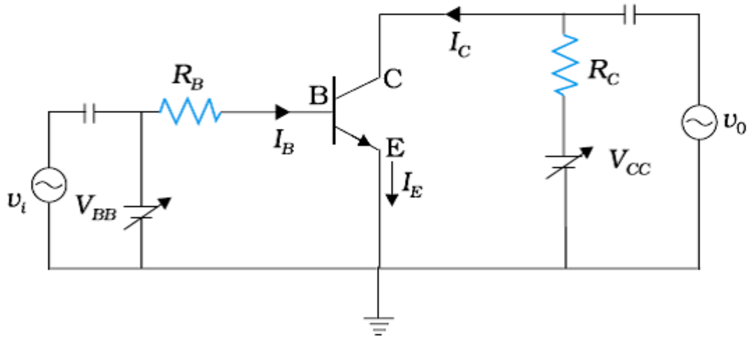
The base region, being very thin, only a (very) small fraction , of these charge carriers, swamps the holes present in the base region resulting in a (small) base current (I_B). 1

The majority of these charge carriers, are attracted by the (reverse biased) collector. These make up the collector current(I_C).

It is clear, therefore, that ½

$I_E = I_C + I_B$

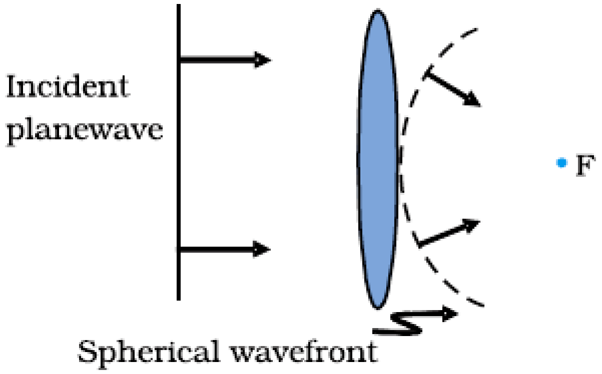
b) The circuit diagram, of a transistor, working as an amplifier, in its CE mode, is shown here.



1

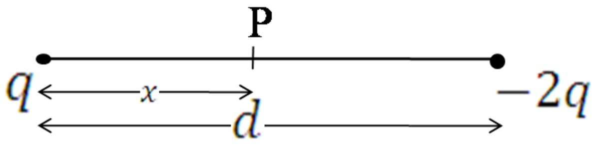
If a small sinusoidal voltage is superimposed on the dc base bias by connecting the source of this signal in series with V_{BB} supply. Then the base current will have sinusoidal variations superposed on the values I_B. As a consequence the collector current also will have sinusoidal variation superimposed on the value of I_C producing in turn corresponding change in the output voltage V_o. 1 ½ 5

MARKING SCHEME
SET 55/2 (Compartment)

Q.No.	Expected Answer/Value Points	Marks	Total Marks
1.	With increase in temperature, the relaxation time (average time between successive collisions) decreases and hence resistivity increases. **Alternatively:** Resistivity $\rho\left(=\frac{m}{ne^2\tau}\right)$ increases as τ decreases with increase in temperature.	1	1
2.	$v = \frac{E}{B}$ where v is speed of electron **Alternatively:** $\left\|\overrightarrow{F_E}\right\| = \left\|\overrightarrow{F_B}\right\|$	1	1
3.	Radio, Television **(Any one)**	1	1
4.		1	1
5.	Line B Since slope (*q/V*) of B is lesser than that of A.	½ ½	1
6.	$v_d = \frac{eV}{m\ell}\tau$	1	1
7.	A has positive polarity	1	1
8.	Modulation Index is defined as the ratio of amplitude of modulating signal to the amplitude of carrier wave i.e. $\mu = \frac{A_m}{A_c}$	1	1
9	Flux through S_1 ½ Flux through S_2 ½ Ratio ½ Flux through S_1 with dielectric median ½ Flux through S_1 , $\Phi_1 = \frac{Q}{\epsilon_o}$ Flux through S_2 , $\Phi_2 = \frac{Q+2Q}{\epsilon_o} = \frac{3Q}{\epsilon_o}$ Ratio of flux = 1:3 No change in flux through S_1 with dielectric medium inside the sphere S_2	½ ½ ½ ½	2

10.

Formula	½
Substitution and simplification	1
Result	½



½

Let P be the required point at a distance x from charge q

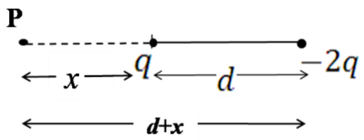
$$\therefore \frac{1}{4\pi\epsilon_o}\frac{q}{x}+\frac{1}{4\pi\epsilon_o}\frac{(-2q)}{(d-x)}=0$$ ½

$$\frac{1}{x}=\frac{2}{d-x}$$ ½

$$x=\frac{d}{3}$$

required point is at a distance $\frac{d}{3}$ from charge q ½

Alternatively:



½

$$\frac{1}{4\pi\varepsilon_o}\frac{q}{x}=\frac{1}{4\pi\varepsilon_o}\frac{2q}{d+x}$$ ½

$2\,x = x + d$ or $x = d$ ½

At distance d towards left of charge q ½ 2

OR

(i)	Work Done	1
(ii)	Orientation	1

(i) We have W = $\int_{\theta_1}^{\theta_2} \tau d\theta$

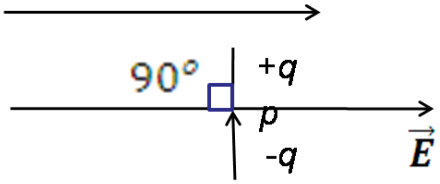
∴ W = $\int_o^{\pi} pEsin\theta d\theta$ ½

= $pE[-cos\theta]_o^{\pi}$

= -2 pE ½

(ii) $\because \tau = PE\ sin\theta$ for $\theta = \frac{\pi}{2}$, τ is maximum 1

Alternatively:



2

11.

a)	Difference between electromagnet and permanent magnet	1
b)	Properties of material (any two)	½ + ½

a) An electromagnet consists of a core made of a ferromagnetic material placed inside a solenoid. It behaves like a strong magnet when current flows through the solenoid and effectively loses its magnetism when the current is switched off. ½

A permanent magnet is also made up of a ferromagnetic material but it retains its magnetism at room temperature for a log time after being magnetized once. ½

b) Properties

i. High permeability

ii. Low retentivity ½ + ½

iii. Low coercivity (**Any two)** 2

12.

Formula	1
Substitution and Calculation	½
Result	½

$$\lambda = \frac{h}{mv}$$ 1

$$= \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.2 \times 10^{8}}$$ ½

$=3.31 \text{ x } 10^{-12}$m ½ 2

13.

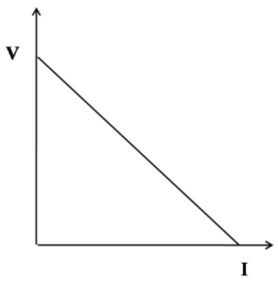
One difference between ε and V	½
VI Graph	½
Determination of ‘r’ and ε	1

Difference between emf(ε) and terminal voltage (v)

εmf	terminal voltage
1) It is the potential difference between two terminals of the cells when no current is drawn from it. 2) It is the cause.	1) It is the potential difference between two terminals when current passes through it. 2) It is the effect.

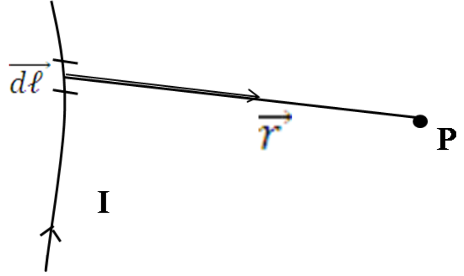
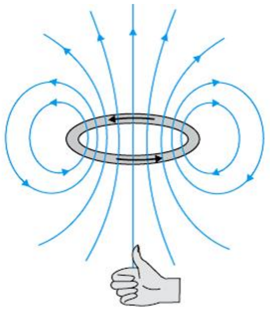
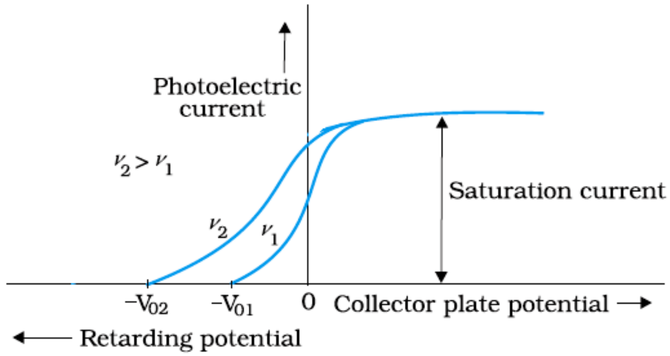
½

(**Any one)** or any other relevant difference



1

Negative of slope gives internal resistance. ½ 2

14.	(i) Statement of Biot Savart's law 1 (ii) Expression for magnetic field ½ (iii) Showing field lines ½ (i) According to Biot Savart's law, the magnetic field due to a current element $\vec{d\ell}$ carrying current I at a point with position *P* vector $\vec{r}$ is given by $d\vec{B} = \frac{\mu_o}{4\pi} I \left[\frac{\vec{d\ell}\times\vec{r}}{\lvert\vec{r}\rvert^3}\right]$  (ii) B = $\frac{\mu_o I}{2r}$ Field lines 	1 ½ ½	2
15.	a) Definition of stopping potential 1 b) Diagram / Plotting graph 1 a) The minimum negative potential, applied on the collector plate, that makes the photocurrent zero, is called the stopping potential. b) $\nu_2 > \nu_1$ 	1 1	2

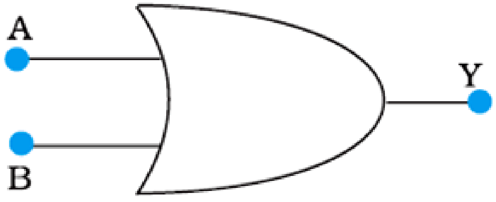
16.

a) Truth table for OR gate ½
Logic symbol for OR gate ½
b) Output waveform 1

a) Truth Table

Input		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

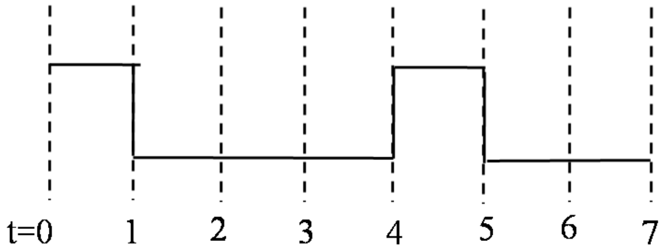
Logic symbol



½ + ½

b)

Output waveform



1

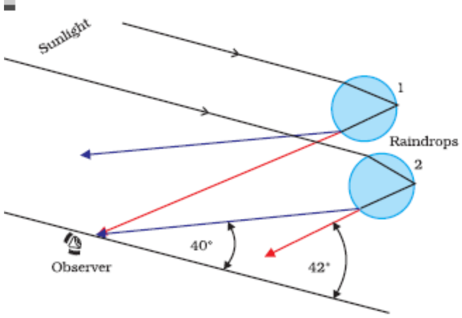
2

17.

(a) Conditions ½ + ½
(b) Formation of rainbow
Diagram ½
Explanation ½

The condition for observing a rainbow are :

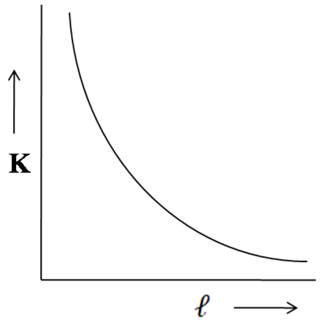
i. The sun comes out after a rainfall. ½
ii. The observer stands with the sun towards his/her back. (any one) ½



½

Formation of a rainbow:

- ➔ The rays of light reach the observer through a refraction, followed by a reflection, followed by a refraction.
- ➔ Figure shows red light, from drop 1 and violet light from drop 2, reaching the observers eye. ½ 2

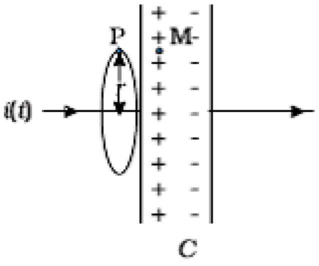
18.	(i) Formula of source frequency ½ Result of source frequency ½ (ii) Formula of quality factor ½ Result of quality factor ½		
	(i) $\omega = \frac{1}{\sqrt{L\,C}}$	½	
	$= \frac{1}{\sqrt{40 \times 10^{-3} \times 100 \times 10^{-6}}}$ = 500 rad/s Or $\nu = \frac{500}{2\pi}\ hz$	½	
	(ii) $Q = \frac{1}{R}\sqrt{\frac{L}{C}}\ or\ Q = \frac{\omega_0 L}{R}$	½	
	$= \frac{1}{50}\sqrt{\frac{40\ \times 10^{-3}}{100 \times 10^{-6}}}$ $= 0.4$	½	2
19.	(a) Principle of potentiometer ½ Reason for Part (i), (ii) and (iii) ½ + ½ + ½ (b) Graph 1		
	a) Principle of potentiometer: The potential drop across the length of a steady current carrying wire of uniform cross section is proportional to the length of the wire.	½	
	i. We use a long wire to have a lower value of potential gradient (i.e. a lower 'least count' or greater sensitivity of the potentiometer	½	
	ii. The area of cross section has to be uniform to get a 'uniform wire' as per the principle of the potentiometer / to ensure a constant value of resistance per unit length of the wire.	½	
	iii. The emf of the driving cell has to be greater than the emf of the primary cells as otherwise no balance point would be obtained.	½	
	b) Potential gradient K = $\frac{V}{L}$ ∴ the required graph is as shown  	1	3

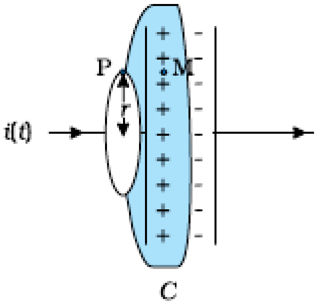
20.

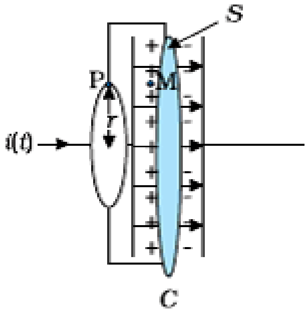
(a) Reason for momentary deflection ½
Deflection after the capacitor gets fully charged ½
(b) Explanation for modification in Ampere’s circuital law 2

(a) The momentary deflection is due to the transient current flowing through the circuit when the capacitor is getting charged. ½
The deflection would be zero when the capacitor gets fully charged. ½

(b) We consider the charging of a capacitor when it is being charged by connecting it to a dc source.



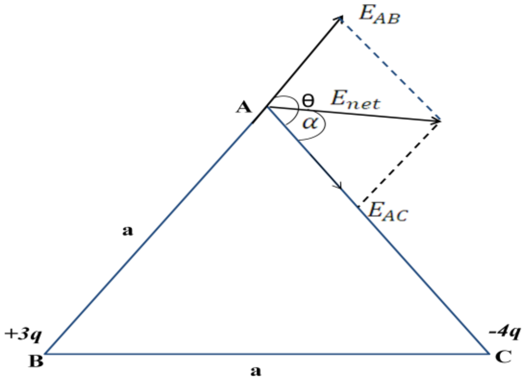


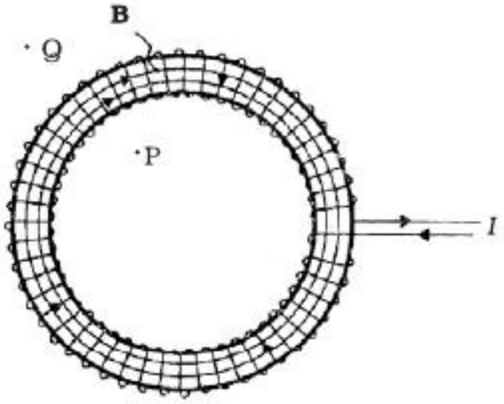
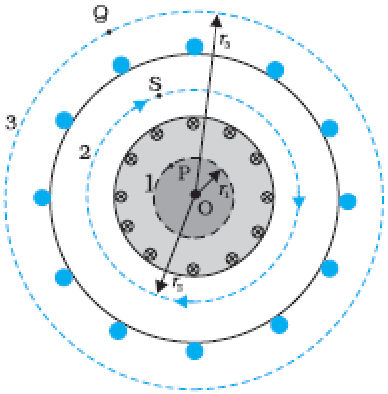


In Ampere’s circuital law, namely
$B\ (2\pi r) =\ \mu_0 i$
We have i as non zero for surface (a) but zero for surface (c)
Hence there is a contradiction in the value of B; calculated one way we have a magnetic field at P but calculated another way we have B=0 ½ ½
To remove this contradiction the concept of displacement current
$(i_d\ = \varepsilon_0 \frac{d\phi_E}{d\,t} = i)$ was introduced ½
and Ampere’s circuital law was put in its generalized form namely ½

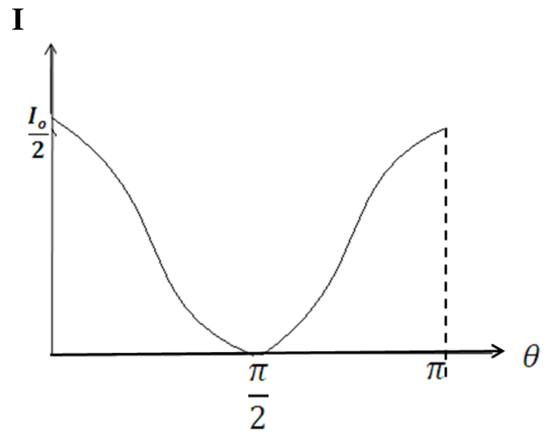
$$\oint \underset{B}{\rightarrow}.\ \underset{dl}{\rightarrow} = \mu_0 i_c +\ \mu_0\epsilon_0 \frac{d\phi_E}{dt}$$

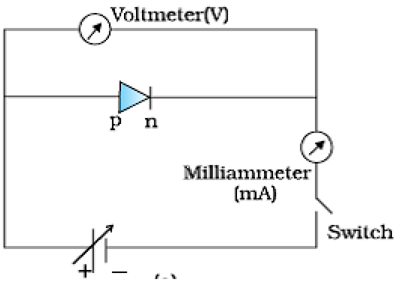
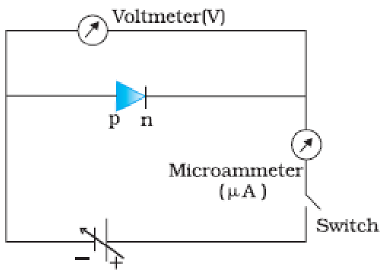
This form gives consistent results for values of B irrespective of which surface is used to calculate it. 3

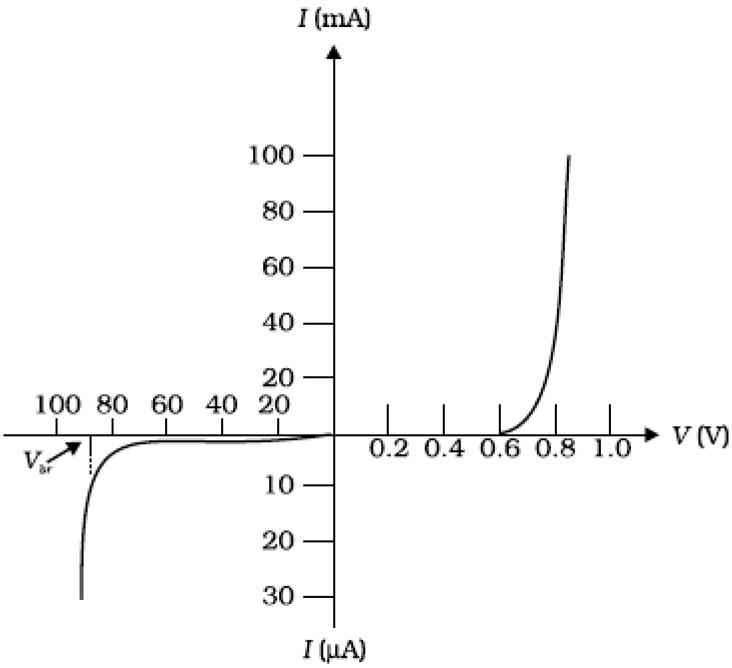
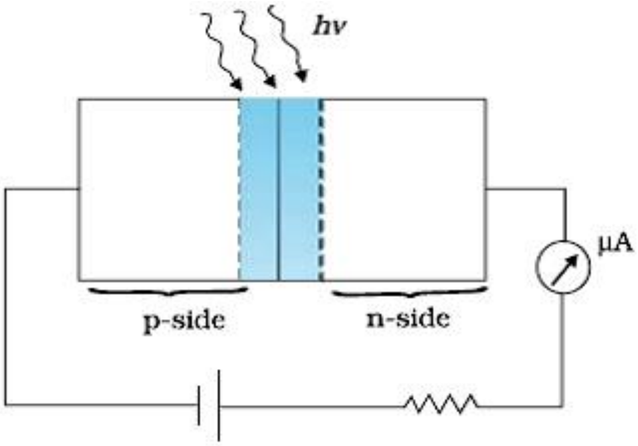
21.	(i) Magnitude of Resultant field 2 (ii) Direction of Resultant field 1		
	(i) Magnitude		
		½	
	$\left\lvert\overrightarrow{E_{AB}}\right\rvert = \frac{1}{4\pi\varepsilon_0}\,\frac{3q}{a^2} = 3E$, where E = $\frac{1}{4\pi\varepsilon_0}\,\frac{q}{a^2}$	½	
	$\left\lvert\overrightarrow{E_{AC}}\right\rvert = \frac{1}{4\pi\varepsilon_0}\,\frac{4q}{a^2} = 4E$	½	
	$E_{net} = \sqrt{(3E)^2 + (4E)^2 + 2\,(3E) \times (4E) \times \left(-\frac{1}{2}\right)}$		
	$= \sqrt{9\,E^2 + 16\,E^2 - 12E^2}$		
	$= E\,\sqrt{13} = \frac{1}{4\pi\varepsilon_0}\,\frac{q\sqrt{13}}{a^2}$	½	
	(ii) Direction		
	$\tan \propto = \frac{\lvert E_{AB}\rvert \sin 120^{\circ}}{\lvert E_{AC}\rvert + \lvert E_{AB}\rvert \cos 120^{\circ}}$	½	
	$= \frac{3E \times \sqrt{3}/2}{4E + 3E \times -\left(\frac{1}{2}\right)} = \frac{3E\sqrt{3} \times 2}{2 \times 5E}$		
	$\propto = tan^{-1}\left(\frac{3\sqrt{3}}{5}\right)$	½	3
22.	(a) Reason 1 (b) Any two values ½ +½ (c) Determination of sideband frequencies ½ + ½		
	(a) The ultra high frequency em radiations, continuously emitted by a mobile phone, may harm the system of the human body.	1	
	(b) Sister Anita shows		
	(i) Concern about her brother	½	
	(ii) Awareness about the likely effects of em radiations on human body	½	
	(iii) Sense of responsibility **(any two)**		

	(c) The side bands are $(\nu_e + \nu_m) and (\nu_e - \nu_m)$ $or\ (1000 + 10) kHz\ and\ (1000 - 10) kHz$ $1010\ kHz\ and\ 990\ kHz$	½ ½	3
23.	(a) Difference between a solenoid and a toroid 1 (b) Derivation of the relation B=$\mu_0 nI$ 1 (c) Magnetic field (i) inside and (ii) outside ½ + ½		
	(a) A toroid can be viewed as a solenoid which has been bent into a circular shape to close on itself	1	
	(b)   	½	
	For the magnetic field at a point S inside a toroid we have $B(2\,\pi\,r) = \ \mu_\circ NI$ $B = \mu_\circ \frac{NI}{2\,\pi\,r} = \mu_\circ nI$ (n = no. of turns per unit length of solenoid)	½	
	(c) For the loop 1, Ampere's circuital law gives $B_1 . 2\pi r_1 = \mu_0(0)$ i.e. $B_1 = 0$ Thus the magnetic field , in the open space inside the toroid is zero.	½	

	Also at point Q, we have $B_3(2\pi r_3) = \mu_0(I_{enclosed})$ But from the sectional cut, we see that the current coming out of the plane of the paper, is cancelled exactly by the current going into it. Hence $I_{enclosed}$=0 $\therefore\ B_3 = 0$ **OR** Derivation of the expression for magnetic moment 2 ½ Direction of magnetic moment ½ We have $\mu = iA$ $= \frac{e.\text{v}}{2\pi r}.\pi r^2.$ $= \frac{e\text{v}r}{2}$ $\ell = m\text{v}r$ $\text{v}r = \frac{\ell}{m}$ $\vec{\mu} = \frac{-e\vec{l}}{2\,m}$ The direction of $\vec{\mu}$ is opposite to that of $\vec{l}$ because of the negative charge of the electron.	½ ½ ½ ½ ½ ½ ½	3 3
24.	(i) Relation between average life and half life 1 (ii) Calculation for activity 2 (i) Average Life $\tau = \frac{T_{1/2}}{0.693}$ (ii) Activity $= \lambda N$ $= \frac{0.6931}{28} \times 15 \times 10^{-3} \times 75 \times 10^{20}\ year^{-1}$ $= \frac{1125 \times 0.6931}{28} \times 10^{17}\ year^{-1}$ $= 2.81\ \times 10^{18} yr^{-1}\ or = 8.81 \times 10^{10} s^{-1}$ [**Note: There is a misprint in this part of question. Award last 1 mark of the second part even if the candidate attempts.]**	1 ½ ½ 1	3
25.	(a) Derivation of the result $I = 4I_0 cos^2\frac{\phi}{2}$ 2 (b) Conditions for constructive and ½ destructive interference ½ (a) The resultant displacement is given by : $y = y_1 + y_2$ $= a\cos\omega t + a\cos(\omega t + \phi)$ $= a\cos\omega t\ (1 + \cos\phi) - a\sin\omega t\sin\phi$ Put $R\cos\theta = a\ (1 + \cos\phi)$ $R\sin\theta = a\sin\phi$	½ ½	

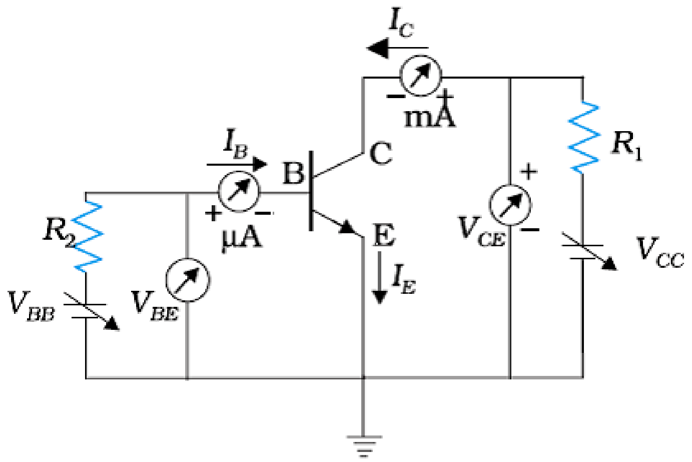
	$\therefore\ R^2 = a^2(1+cos^2\phi + 2\cos\phi) + a^2sin^2\phi$ $= 2\,a^2\,(1+\cos\phi) = 4a^2cos^2\,\frac{\phi}{2}$ $\therefore I = R^2 = 4\,a^2cos^2\frac{\phi}{2} = 4\,I_0cos^2\frac{\phi}{2}$ For constructive interference , $\cos\frac{\phi}{2} = \pm 1 \ \ or \ \ \frac{\phi}{2} = n\,\pi \ \ or\ \phi = 2n\pi$ For destructive interference , $\cos\frac{\phi}{2} = 0 \ \ or \ \ \frac{\phi}{2} = (2n+1)\ \frac{\pi}{2}\ or\ \phi = (2n+1)\pi$	½ ½ ½ ½	3
26.	(i) Formula ½ Energy in the first excited state ½ Energy required ½ (ii) Kinetic energy ½ Orbital radius (Formula and Result) ½ + ½ (i) For the hydrogen atom a. $\lvert E_n\rvert \propto \frac{1}{n^2}$ b. ∴ Energy of first excited state = $\frac{-13.6}{2^2}$ =-3.4eV c. ∴ Energy required = [- 3.4 – (13.6)eV] = 10.2 eV (ii) a. Kinetic energy = |energy of 1st excited state| = 3.4 eV b. Orbital radius in nth state $\propto n^2$ = 4 x 0.53$\dot{A}$ = 2.12 $\acute{A}$	½ ½ ½ ½ ½ ½	3
27.	(a) Graph showing variation of intensity with θ 1 (b) Determination of values of θ and β 1+1 (a) The required graph would have the form shown as:  Using $I_2 = I_1\,cos^2\theta$	1	

	(b) I_1= Light transmitted by P_1 I_3= Light transmitted by $P_3 = I_1 \cos^2\beta$ I_2= Light transmitted by $P_2 = I_3 \cos^2(\theta-\beta)$	½	
	Alternatively , (Award mark to student who indicates correct value of I_1, I_2 and I_3 by making a diagram) $\therefore\ I_2 = I_3$ $I_1 \cos^2\beta . \cos^2(\theta-\beta) = I_1 \cos^2\beta$ $\theta = \beta$	½	
	Also $I_1 = I_2$ $I_{1=} I_1 \cos^2\beta . \cos^2(\theta-\beta)$ or $\cos^2\theta = 1$ $\therefore\ \theta = 0^\circ$ or π	½	
	Therefore $\beta = 0^\circ$ or π	½	3
28.	(a) Circuit arrangement of p-n function in (i) Forward biasing ½ (ii) Reverse biasing ½ VI characteristics 1 Explanation ½ (b) Circuit diagram ½ Explanation 2		
	(a)  **Forward biasing**	½	
	 **Reverse biasing**	½	
	The VI characteristics are obtained by connecting the battery, to the diode, through a potentiometer (or rheostat). The applied voltage to the diode is changed. The values of current, for different values of voltage, are noted and a graph between V and I is plotted.	1	

	The V-I characteristics ,of a diode, have the form shown here.  	½+ ½	
	(b) The circuit diagram, for the photodiode, is shown here.  	½	
	The photodiode is illuminated by optical signal, whose photon energy is greater than the energy gap of the semicoinductor used.	½	
	The electric field, at the junction, seperates the electrons and holes and thus gives rise to an emf.	½	
	When an external load is connected, a (photo) current flows through it. The magnitude of this current is proportional to the intensity of light incident on the photodiode.	½	5
	OR		

(a)	Circuit diagram	1
	Description of current formation	1
	Deduction of $I_e = I_b + I_c$	½
(b)	Circuit diagram	1
	Working	1 ½

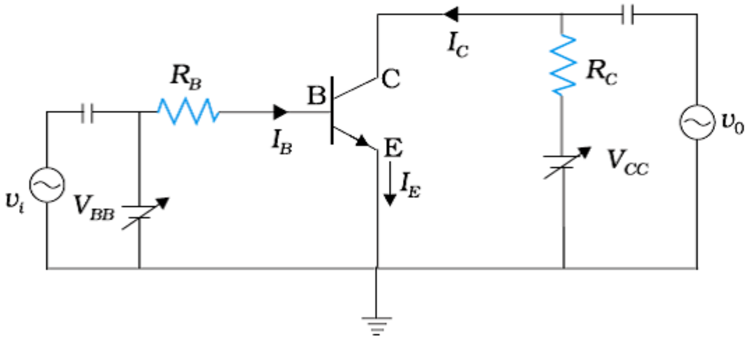
a) The circuit diagram is shown here



1

The emitter-base junction, being forward biased, the majority charge carriers (electrons), from the emitter, flow into the base region constituting the emitter current(I_E)
The base region, being very thin, only a (very) small fraction , of these charge carriers, swamps the holes present in the base region resulting in a (small) base current (I_B).
The majority of these charge carriers, are attracted by the (reverse biased) collector. These make up the collector current(I_C). 1
It is clear, therefore, that
$I_E = I_C + I_B$ ½

b) The circuit diagram, of a transistor, working as an amplifier, in its CE mode, is shown here.



1

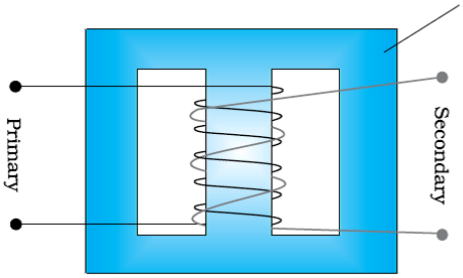
If a small sinusoidal voltage is superimposed on the dc base bias by connecting the source of this signal in series with V_{BB} supply. Then the base current will have sinusoidal variations superposed on the values I_B. As a consequence the collector current also will have sinusoidal variation superimposed on the value of I_C producing in turn corresponding change in the output voltage V_o. 1 ½

5

29.

(a)	Schematic arrangement	1
(b)	Principle of a transformer	½
	Obtaining expression	
	(i) $\frac{V_1}{V_2} = \frac{N_1}{N_2}$	1
	(ii) $\frac{V_1}{V_2} = \frac{I_2}{I_1}$	1
(c)	Assumptions **(any one)**	½
(d)	Two reasons for energy losses	½ + ½

a)



1

b) Principle of a transformer: when alternating current flows through the primary coil, an emf is induced in the neighbouring (secondary) coil ½

(i) Let $\frac{d\phi}{dt}$ be the tare of charge of flux through each turn of the primary and the secondary coil

$$\frac{e_1}{e_2} = -N_1\frac{d\phi}{dt} / -N_2\frac{d\phi}{dt} = \frac{N_1}{N_2}$$ ½

or

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \text{ ------------------(1)}$$ ½

(ii) But for an ideal transformer $V_1 I_1 = V_2 I_2$

$$\frac{V_1}{V_2} = \frac{I_2}{I_1} \text{ -----------------(2)}$$ ½

From equation (1) and (2

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$ ½

c) Main assumptions

(i) The primary resistance and current are small

(ii) The flux linked with the primary and secondary coils is same / there is no leakage of flux from the core.

(iii)Secondary current is small

(**Any one)** ½

d) Reason due to which energy loses may occur

Flux leakage/resistance of the coils / eddy currents / Hysteresis (**Any two)** ½ +½ 5

OR

a) Derivation of the expressions for	2 ½
i. Induced emf	
ii. Induced current	
b) Expression for magnitude of force and its direction	1½
c) Expression for power	1

a) In one revolution

Change of area , dA = $\pi\ell^2$

∴ change of magnetic flux

$d\phi = \overrightarrow{B}.\overrightarrow{dA} = \mathrm{BdAcos}0^o$ ½

$= B\,\pi\ell^2$ ½

Period of revolution T

(i) Induced emf $\varepsilon = B\pi\ell^2/\mathrm{T} = B\pi\ell^2 v$ 1

(ii) Induced current in the rod, I = $\frac{\varepsilon}{R} = \frac{\pi v B\ell^2}{R}$ ½

[Note: Award 2 marks if the student derives the above relation using other method.]

b) Force acting on the rod, F = $I\ell B$ ½

$= \frac{\pi v B^2\ell^3}{R}$ ½

The external force required to rotate the rod opposes the Lorentz force acting on the rod / external force acts in the direction opposite to the Lorentz force ½

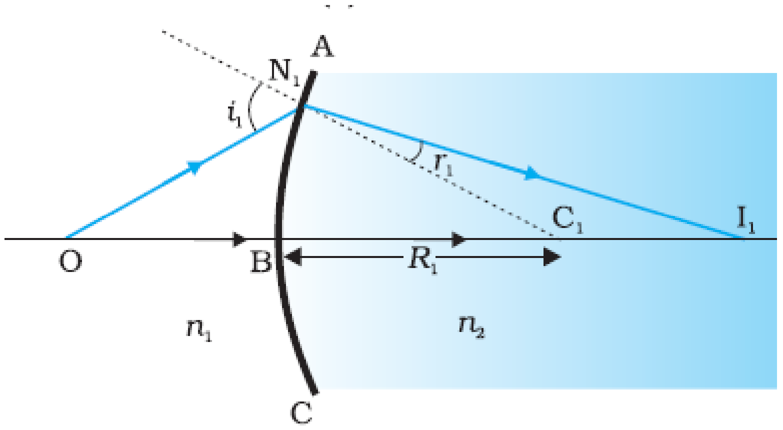
c) Power required to rotate the rod

P = $F\vartheta$ ½

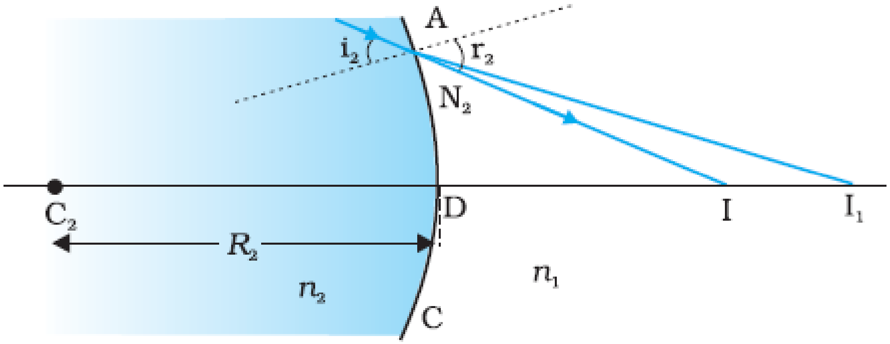
$= \frac{\pi v B^2\ell^3 v}{R}$ ½ 5

30.

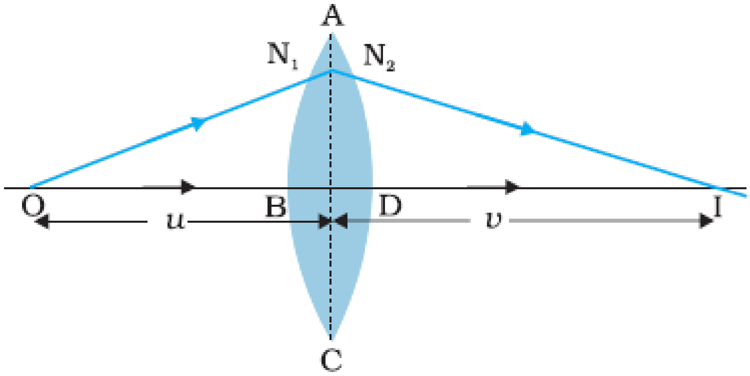
a) Ray diagram	1
Derivation of lens maker's formula	2 ½
b) Calculation of radius of curvature	1 ½



½



½



½

The first refracting surface ABC forms the image I_1 of the object O. The image I_1 acts as a virtual object for the second refracting surface ADC which forms the real image I as shown in the diagram

For refraction at ABC

$\frac{n_2}{v_1}$ - $\frac{n_1}{u}$ = $\frac{n_2-n_1}{R_1}$ ---------- (i) ½

For refraction at ADC

$\frac{n_2}{v}$ - $\frac{n_1}{u}$ = $\frac{n_1-n_2}{R_{12}}$ ---------- (ii) ½

Adding equation (i) and equation (ii)

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

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ ½

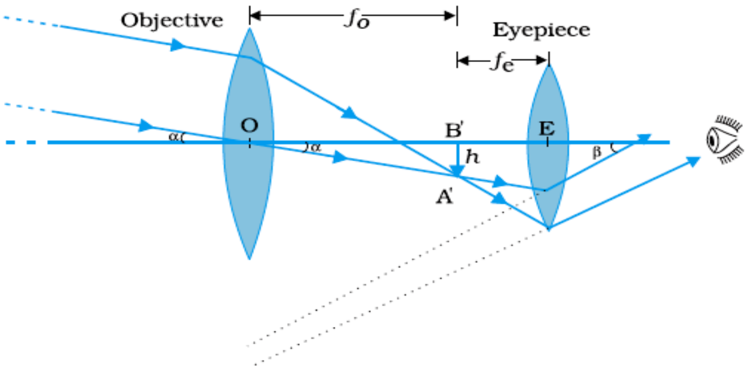
We know If $u = \infty$, $v = f$

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

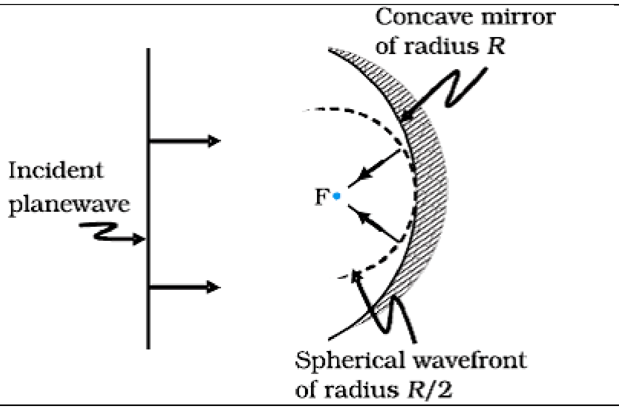
$$\frac{1}{f} = (n_2 - 1)(\frac{1}{R_1} - \frac{1}{R_2})$$ ½

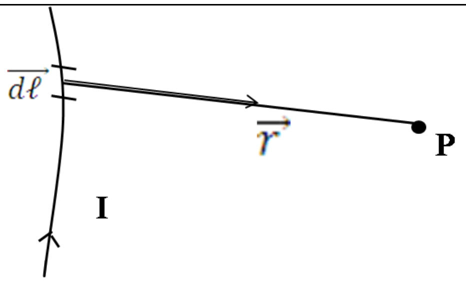
(b) $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$$\frac{1}{20} = (1.55 - 1)\left(\frac{1}{R} - \frac{1}{-R}\right)$$

	$= 0.55 \times \frac{2}{R}$	½	
	$R = 0.55 \times 2 \times 20 = 22\ cm$	1	5
	OR		
	(a) Labelled ray diagram 1 ½ Derivation of expression for magnifying power 1 ½ (b) Determination of total magnification 2		
	a) 	1 ½	
	[**Note :** deduct ½ mark if not labelled] Derivation Magnifying Power $M = \frac{\tan\beta}{\tan\propto} \cong \frac{\beta}{\propto}$	½	
	Final image is formed at infinity when the image $A'B'$ is formed by the objective lens at the force of the eye piece $m = \frac{h}{f_e} \times \frac{f_0}{h}$	½	
	$= \frac{f_0}{f_e}$	½	
	b) Given $f_0 + f_e = 105 \quad , f_0 = 20\ f_e$	½	
	$20\ f_e + f_e = 105$ $f_e = \frac{105}{21} = 5\ cm$	½	
	$f_0 = 20 \times 5 = 100\ cm$	½	
	$\therefore Magnification\ m = \frac{f_0}{f_e} = \frac{100}{5} = 20$	½	5

MARKING SCHEME
SET 55/3 (Compartment)

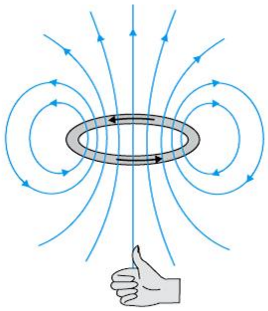
Q.No.	Expected Answer/Value Points	Marks	Total Marks
1.	Line B Since slope (*q/V*) of B is lesser than that of A.	½ ½	1
2.	Demodulation is the process of retrieval of information from the carrier wave at the receiver end.	1	1
3.		1	1
4.	A has positive polarity	1	1
5.	$v_d = \frac{eV}{m\ell}\tau$	1	1
6.	$v = \frac{E}{B}$ where v is speed of electron **Alternatively:** $\left\lvert\vec{F_E}\right\rvert = \left\lvert\vec{F_B}\right\rvert$	1	1
7.	In point to point communication, communication takes place over a single link between a transmitter and a receiver. In the broadcast mode, there are a large number of receivers corresponding to a single transmitter.	½ ½	1
8.	With increase in temperature, the relaxation time (average time between successive collisions) decreases and hence resistivity increases. **Alternatively:** Resistivity $\rho\left(=\frac{m}{ne^2\tau}\right)$ increases as τ decreases with increase in temperature.	1	1
9	(i) Statement of Biot Savart's law 1 (ii) Expression for magnetic field ½ (iii) Showing field lines ½ (i) According to Biot Savart's law, the magnetic field due to a current element $\vec{d\ell}$ carrying current I at a point with position P vector $\vec{r}$ is given by $d\vec{B} = \frac{\mu_o}{4\pi} I \left[\frac{\vec{d\ell}\times\vec{r}}{\lvert\vec{r}\rvert^3}\right]$	1	



½

(ii) B = $\frac{\mu_o I}{2r}$

Field lines



½

2

10.

(a) Difference between a permanent magnet and an electromagnet ½ + ½
(b) Any two properties of material ½ + ½

a) An electromagnet consists of a core made of a ferromagnetic material placed inside a solenoid. It behaves like a strong magnet when current flows through the solenoid and effectively loses its magnetism when the current is switched off. ½

(i) A permanent magnet is also made up of a ferromagnetic material but it retains its magnetism at room temperature for a long time after being magnetized once. ½

b)

(i) High permeability
(ii) Low retentivity
(iii)Low coercivity ½+ ½

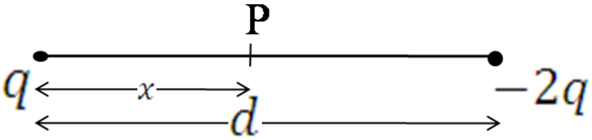
(Any two)

[**Note:** Give ½ mark if the student just writes ‘soft iron’ is a suitable material for making electromagnets.]

2

11.

Formula	½
Substitution and simplification	1
Result	½



½

Let P be the required point at a distance x from charge q

$$\therefore \frac{1}{4\pi\epsilon_o}\frac{q}{x} + \frac{1}{4\pi\epsilon_o}\frac{(-2q)}{(d-x)} = 0$$

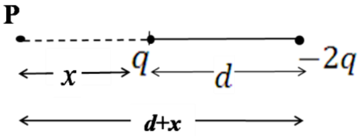
½

$$\frac{1}{x} = \frac{2}{d-x}$$ ½

$$x = \frac{d}{3}$$

required point is at a distance $\frac{d}{3}$ from charge q ½

Alternatively:



½

$$\frac{1}{4\pi\varepsilon_o}\frac{q}{x} = \frac{1}{4\pi\varepsilon_o}\frac{2q}{d+x}$$ ½

$2\,x = x + d$ or $x = d$ ½

At distance d towards left of charge q ½ 2

OR

(i)	Work Done	1
(ii)	Orientation	1

(i) We have W = $\int_{\theta_1}^{\theta_2} \tau d\theta$

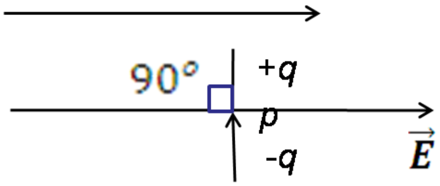
∴ W = $\int_{o}^{\pi} pE\sin\theta d\theta$ ½

= $pE[-\cos\theta]_o^\pi$

= -2 pE ½

(ii) ∵ $\tau = PE\ \sin\theta$ for $\theta = \frac{\pi}{2}$, τ is maximum 1

Alternatively:



2

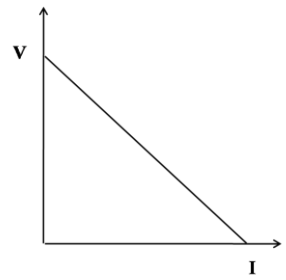
12.

One difference between ε and V	½
VI Graph	½
Determination of ‘r’ and ε	1

Difference between emf(ε) and terminal voltage (v) ½

εmf	terminal voltage
1) It is the potential difference between two terminals of the cells when no current is drawn from it. 2) It is the cause.	1) It is the potential difference between two terminals when current passes through it. 2) It is the effect.

(**Any one)** or any other relevant difference 1



Negative of slope gives internal resistance. ½ 2

13.

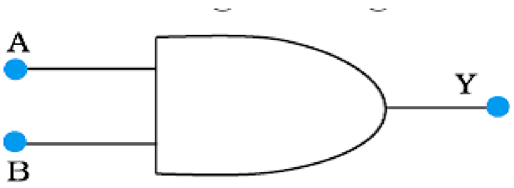
(i) AND gate Truth Table ½
Logic symbol ½
(ii) Output waveform 1

(i) For the AND gate:

Truth Table

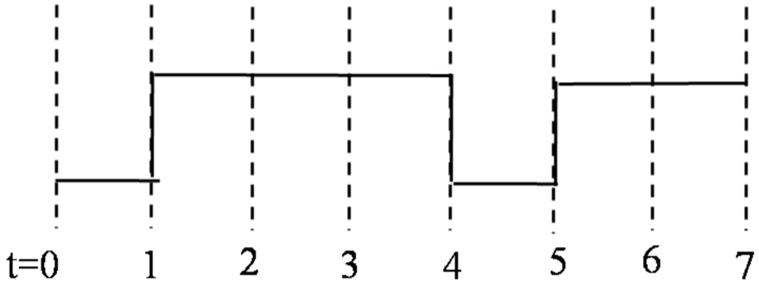
Input		Output
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Logic Symbol



½ +½

(ii) Output Waveform:



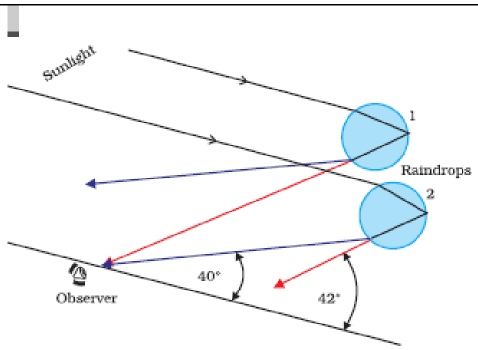
1 2

14.

(a) Conditions ½ + ½
(b) Formation of rainbow
Diagram ½
Explanation ½

The condition for observing a rainbow are :

i. The sun comes out after a rainfall. ½
ii. The observer stands with the sun towards his/her back. (any one) ½

<table>
<tr>
<td></td>
<td>
Formation of a rainbow:
➔ The rays of light reach the observer through a refraction, followed by a reflection, followed by a refraction.
➔ Figure shows red light, from drop 1 and violet light from drop 2, reaching the observers eye.</td>
<td>½
½</td>
<td>2</td>
</tr>
<tr>
<td>15.</td>
<td>(i) Source frequency – Formula ½
Calculation and Result ½
(ii) Quality Factor –Formula ½
-Calculation and Result ½

(i) $W_0 = \frac{1}{\sqrt{LC}}$
$= \frac{1}{\sqrt{80 \times 10^{-3} \times 50 \times 10^{-6}}} s^{-1} = 500\ rad/s$
$or\ \nu_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{500}{2\pi} Hz \approx 80\ Hz$
(ii)
$Q = \frac{\omega_0 L}{R} = \frac{500 \times 80 \times 10^{-3}}{60} = \frac{4}{6} = \frac{2}{3} \cong 0.67$</td>
<td>½
½
½ + ½</td>
<td>2</td>
</tr>
<tr>
<td>16.</td>
<td>De Broglie wavelength ½
Calculation and Result 1½

$\lambda = \frac{h}{mv}$
$= \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.5 \times 10^{8}} = \frac{66.3}{9.1 \times 2.5} \times 10^{-12}\ m$
$= 2.9 \times 10^{-12} m = 2.9\ pm$</td>
<td>½
½
1</td>
<td>2</td>
</tr>
<tr>
<td>17.</td>
<td>Flux through S_1 ½
Flux through S_2 ½
Ratio ½
Flux through S_1 with dielectric median ½

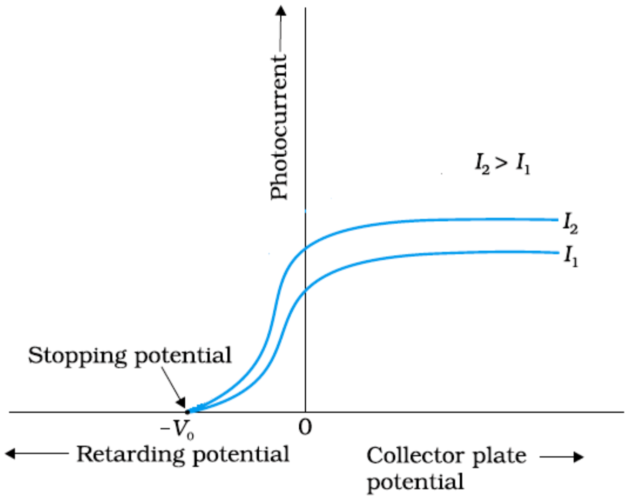
Flux through S_1 , $\Phi_1 = \frac{Q}{\epsilon_o}$
Flux through S_2 , $\Phi_2 = \frac{Q+2Q}{\epsilon_o} = \frac{3Q}{\epsilon_o}$
Ratio of flux = 1:3
No change in flux through S_1 with dielectric medium inside the sphere S_2</td>
<td>½
½
½
½</td>
<td>2</td>
</tr>
</table>

18.

(i)	Definition of threshold frequency	1
(ii)	Plotting of graph	1

(i) The threshold frequency for a given photosensitive surface is the minimum value of frequency of incident light that can cause photoemission from it. 1

(ii) The required plot is as shown here:



1

2

19.

(i)	Definition of Mass Defect	1
	Relation of mass effect and binding energy	½
(ii)	Total mass of Reactants and Products	½
	Mass defect	½
	Q value	½

(i) The mass defect of a nucleus equals the difference between the total mass of its constituents and the mass of the nucleus itself. 1

(Also accept $\Delta m = \left[Zm_p + (A-Z)m_n\right] - M$)

Binding energy $= (Mass\ defect) \times c^2$

(ii) Total Mass of Products $= 2 \times 2.0141024$

$= 4.0282048\ u$

Total mass of reactants = (1.00783 + 3.0160449) u

= 4.023879 u

$\therefore Mass\ Defect = (-0.004325\ u)$ ½

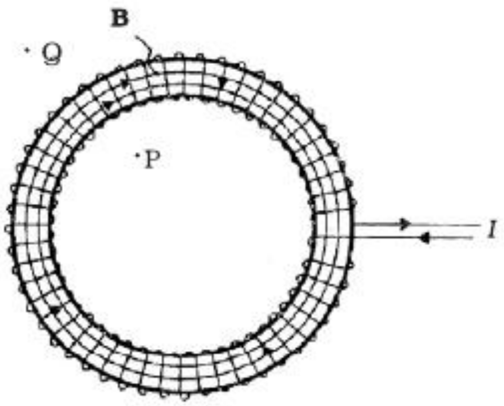
$\therefore Q\ value = -\ 04325\ \times 931.5\ MeV$ ½

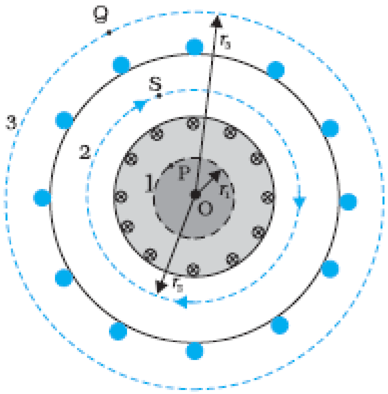
= 0.004325

$\approx -4.03\ MeV$ ½ 3

20.	(a) Reason 1 (b) Any two values ½ +½ (c) Determination of sideband frequencies ½ + ½		
	(a) The ultra high frequency em radiations, continuously emitted by a mobile phone, may harm the system of the human body.	1	
	(b) Sister Anita shows		
	(i) Concern about her brother	½	
	(ii) Awareness about the likely effects of em radiations on human body	½	
	(iii) Sense of responsibility **(any two)**		
	(c) The side bands are		
	$(\nu_e + \nu_m) and\ (\nu_e - \nu_m)$	½	
	$or\ (1000 + 10)kHz\ and\ (1000 - 10)kHz$		
	$1010\ kHz\ and\ 990\ kHz$	½	3
21.	(i) Finding wavelength of photon 2 (ii) Finding radius in n=4 orbit 1		
	(i) Energy of the ground state= $-13.6\ eV$		
	Energy of n =4 excited state = $\frac{-13.6}{16}\ eV$	½	
	$\therefore$ Energy of the photon absorbed = $\left(\frac{-13.6}{16} + 13.6\right)\ eV$		
	$= \frac{15}{16} \times 13.6\ eV = 12.75\ eV$	½	
	$= 1.275 \times 1.6 \times 10^{-19}\ J$		
	$\therefore \frac{hc}{\lambda} = 12.75 \times 1.6 \times 10^{-19}$	½	
	$\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{12.75 \times 1.6 \times 10^{-19}} m$	½	
	$= \frac{19.89}{20.400} \times 10^{-7} m$		
	$= 0.97 \times 10^{-7} m = 970 \dot{A}$ or 97nm	½	
	(ii) Radius of n =4 orbit $= (4)^2 \times 5.3 \times 10^{-11}\ m$	½	
	$= 8.48\ \dot{A}$	½	3
22.	(a) Difference between a solenoid and a toroid 1 (b) Derivation of the relation B=$\mu_0 nI$ 1 (c) Magnetic field (i) inside and (ii) outside ½ + ½		
	(a) A toroid can be viewed as a solenoid which has been bent into a circular shape to close on itself	1	

(b)





½

For the magnetic field at a point S inside a toroid we have

$$B(2\,\pi\,r) = \mu_\circ NI$$

$B = \mu_\circ \frac{NI}{2\,\pi\,r} = \mu_\circ nI$ (n = no. of turns per unit length of solenoid) ½

(c) For the loop 1, Ampere's circuital law gives

$B_1.2\pi r_1 = \mu_0(0)$ i.e. $B_1 = 0$ ½

Thus the magnetic field , in the open space inside the toroid is zero.

Also at point Q, we have $B_3(2\pi r_3) = \mu_0(I_{enclosed})$

But from the sectional cut, we see that the current coming out of the plane of the paper, is cancelled exactly by the current going into it.

Hence $I_{enclosed}$=0

$\therefore\ B_3 = 0$ ½ 3

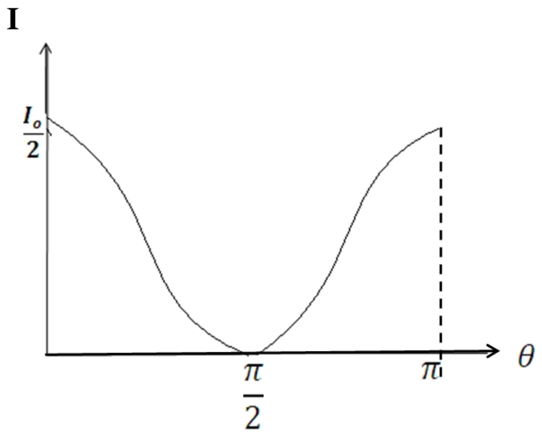
OR

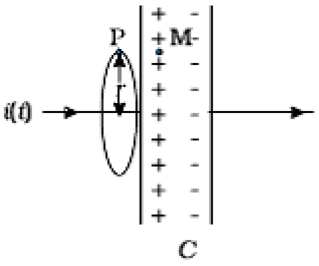
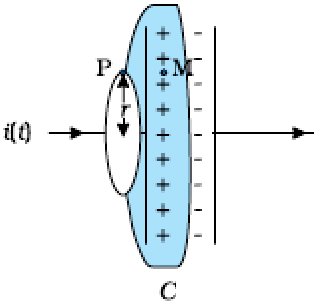
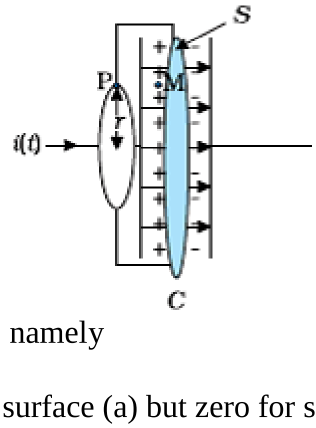
Derivation of the expression for magnetic moment	2 ½
Direction of magnetic moment	½

We have $\mu = iA$ ½

$= \frac{e\,.\mathrm{v}}{2\pi r}.\pi r^2.$ ½

$= \frac{evr}{2}$ ½

	$\ell = mvr$ $vr = \frac{\ell}{m}$ $\vec{\mu} = \frac{-e\,\vec{l}}{2\,m}$ The direction of $\vec{\mu}$ is opposite to that of $\vec{l}$ because of the negative charge of the electron.	½ ½ ½	3
23.	(a) Graph showing variation of intensity with θ — 1 (b) Determination of values of θ and β — 1+1 (a) The required graph would have the form shown as:  Using $I_2 = I_1\, cos^2\theta$ (b) I_1= Light transmitted by P_1 I_3= Light transmitted by $P_3 = I_1\, cos^2\beta$ I_2= Light transmitted by $P_2 = I_3\, cos^2(\theta - \beta)$ **Alternatively** , (Award mark to student who indicates correct value of I_1, I_2 and I_3 by making a diagram) $\therefore\ I_2 = I_3$ $I_1\, cos^2\beta . cos^2(\theta - \beta) = I_1 cos^2\beta$ $\theta = \beta$ Also $I_1 = I_2$ $I_{1=}\, I_1\, cos^2\beta . cos^2(\theta - \beta)$ or $cos^2\theta = 1$ $\therefore\ \theta = 0°$ or π Therefore $\beta = 0°$ or π	1 ½ ½ ½ ½	3
24.	(a) Derivation of the result $I = 4I_0 cos^2\frac{\phi}{2}$ — 2 (b) Conditions for constructive and — ½ destructive interference — ½ (a) The resultant displacement is given by : $y = y_1 + y_2$		

	$= a\cos\omega t + a\cos(\omega t + \phi)$ $= a\cos\omega t\,(1+\cos\phi) - a\sin\omega t\sin\phi$ Put $R\cos\theta = a\,(1+\cos\phi)$ $R\sin\theta = a\sin\phi$ $\therefore\ R^2 = a^2(1+cos^2\phi+2\cos\phi) + a^2sin^2\phi$ $= 2\,a^2\,(1+\cos\phi) = 4a^2cos^2\,\frac{\phi}{2}$ $\therefore I = R^2 = 4\,a^2cos^2\frac{\phi}{2} = 4\,I_0cos^2\frac{\phi}{2}$ For constructive interference , $\cos\frac{\phi}{2} = \pm 1$ *or* $\frac{\phi}{2} = n\,\pi$ *or* $\phi = 2n\pi$ For destructive interference , $\cos\frac{\phi}{2} = 0$ *or* $\frac{\phi}{2} = (2n+1)\,\frac{\pi}{2}$ *or* $\phi = (2n+1)\pi$	½ ½ ½ ½ ½ ½	3
25.	(a) Reason for momentary deflection ½ Deflection after the capacitor gets fully charged ½ (b) Explanation for modification in Ampere's circuital law 2 (a) The momentary deflection is due to the transient current flowing through the circuit when the capacitor is getting charged. The deflection would be zero when the capacitor gets fully charged. (b) We consider the charging of a capacitor when it is being charged by connecting it to a dc source.    In Ampere's circuital law, namely $B\,(2\pi r) = \mu_0 i$ We have i as non zero for surface (a) but zero for surface (c) Hence there is a contradiction in the value of B; calculated one way we have a magnetic field at P but calculated another way we have B=0 To remove this contradiction the concept of displacement current $(i_d = \varepsilon_0\frac{d\phi_E}{d\,t} = i)$ was introduced	½ ½ ½ ½ ½	

and Ampere's circuital law was put in its generalized form namely ½

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 i_c + \mu_0 \epsilon_0 \frac{d\phi_E}{dt}$$

This form gives consistent results for values of B irrespective of which surface is used to calculate it. 3

26.

(a)	Principle of potentiometer	½
	Reason for Part (i), (ii) and (iii)	½ + ½ + ½
(b)	Graph	1

a) Principle of potentiometer:

The potential drop across the length of a steady current carrying wire of uniform cross section is proportional to the length of the wire. ½

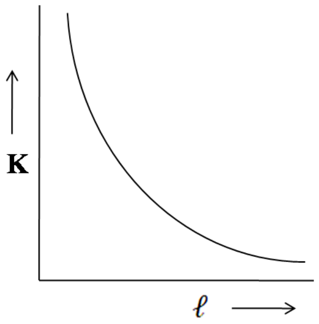
i. We use a long wire to have a lower value of potential gradient (i.e. a lower 'least count' or greater sensitivity of the potentiometer ½

ii. The area of cross section has to be uniform to get a 'uniform wire' as per the principle of the potentiometer ½
/ to ensure a constant value of resistance per unit length of the wire.

iii. The emf of the driving cell has to be greater than the emf of the primary cells as otherwise no balance point would be obtained. ½

b) Potential gradient K = $\frac{V}{L}$

∴ the required graph is as shown



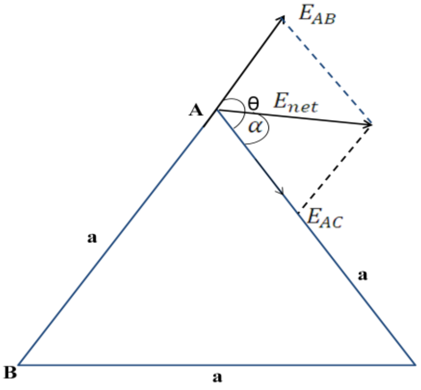
1

3

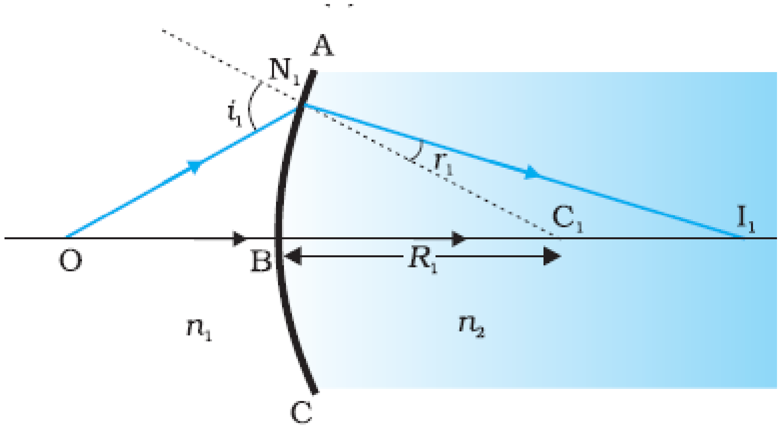
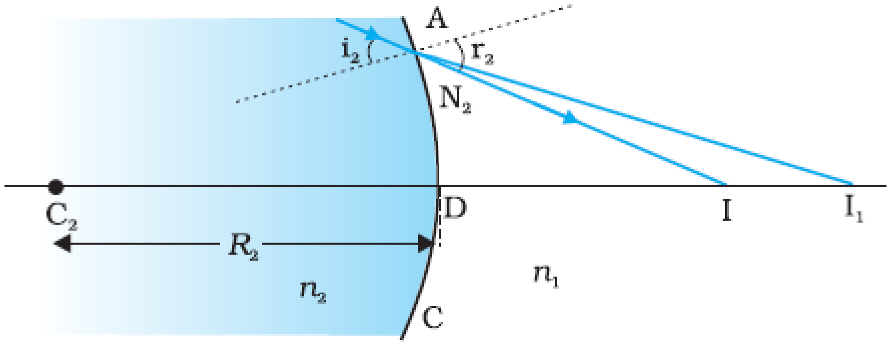
27.

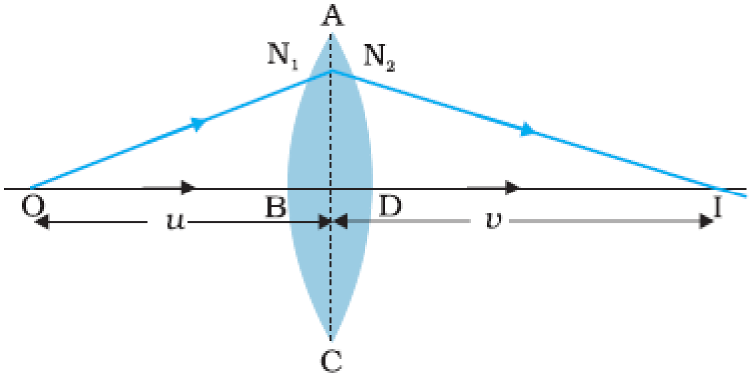
(i)	Magnitude of resultant field	2
(ii)	Direction of Resultant field	1

(i) Magnitude



½

	$|E_{AB}| = \frac{1}{4\pi\varepsilon_0}\frac{6q}{a^2} = 6E$ where E = $\frac{1}{4\pi\varepsilon_0}\frac{q}{a^2}$	½	
	$|E_{AC}| = \frac{1}{4\pi\varepsilon_0}\frac{8q}{a^2} = 8E$	½	
	$E_{net} = \sqrt{(6E)^2 + (8E)^2 + 2\,(6E)\times(8E)\times\left(-\frac{1}{2}\right)}$	½	
	$= E\sqrt{52} = \frac{1}{4\pi\varepsilon_0}\frac{q\sqrt{52}}{a^2}$		
	(ii) Direction		
	$\tan\propto = \frac{E_{AB}\sin 120^\circ}{E_{AC} + E_{AB}\cos 120^\circ}$	½	
	$= \frac{6E \times \sqrt{3}/2}{8E + 6E\left(-\frac{1}{2}\right)}$		
	$\propto = tan^{-1}\left(\frac{6\sqrt{3}}{10}\right)$	½	3
28.	a) Ray diagram 1 Derivation of lens maker's formula 2 ½ b) Calculation of radius of curvature 1 ½		
		½	
		½	



½

The first refracting surface ABC forms the image I_1 of the object O. The image I_1 acts as a virtual object for the second refracting surface ADC which forms the real image I as shown in the diagram

For refraction at ABC

$$\frac{n_2}{v_1} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} \text{ ---------- (i)}$$ ½

For refraction at ADC

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_1 - n_2}{R_{12}} \text{ ---------- (ii)}$$ ½

Adding equation (i) and equation (ii)

$$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)(\frac{1}{R_1} - \frac{1}{R_2})$$ ½

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

We know If $u = \infty , v = f$

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

$$\frac{1}{f} = (n_2 - 1)(\frac{1}{R_1} - \frac{1}{R_2})$$ ½

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

$$\frac{1}{20} = (1.55 - 1)\left(\frac{1}{R} - \frac{1}{-R}\right)$$

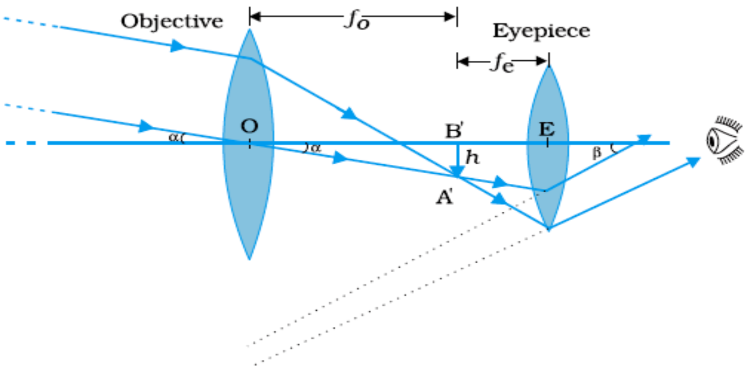
$$= 0.55 \times \frac{2}{R}$$ ½

$$R = 0.55 \times 2 \times 20 = 22\ cm$$ 1 5

OR

(a) Labelled ray diagram 1 ½
Derivation of expression for magnifying power 1 ½
(b) Determination of total magnification 2

a)



1 ½

[**Note :** deduct ½ mark if not labelled]

Derivation

Magnifying Power

M= $\frac{\tan\beta}{\tan\propto} \cong \frac{\beta}{\propto}$ ½

Final image is formed at infinity when the image $A'B'$ is formed by the objective lens at the force of the eye piece

$$m = \frac{h}{f_e} \times \frac{f_0}{h}$$ ½

$$= \frac{f_0}{f_e}$$ ½

b) Given

$f_0 + f_e = 105 \quad , f_0 = 20\, f_e$

$20\, f_e + f_e = 105$ ½

$f_e = \frac{105}{21} = 5\ cm$ ½

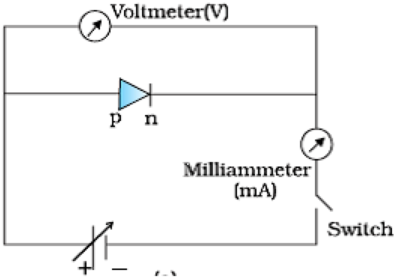
$f_0 = 20 \times 5 = 100\ cm$ ½

$\therefore Magnification\ m = \frac{f_0}{f_e} = \frac{100}{5} = 20$ ½ 5

29.

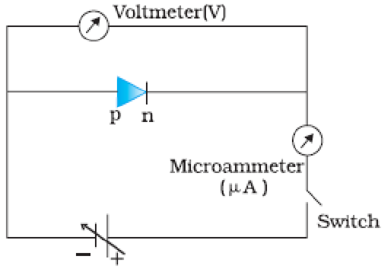
(a) Circuit arrangement of p-n function in
(i) Forward biasing ½
(ii) Reverse biasing ½
VI characteristics 1
Explanation ½
(b) Circuit diagram ½
Explanation 2

(a)



½

Forward biasing



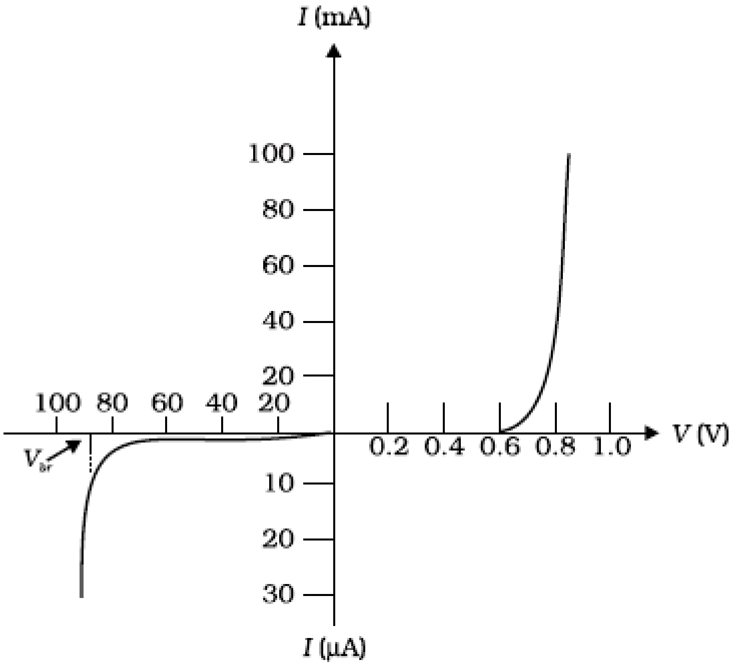
½

Reverse biasing

The VI characteristics are obtained by connecting the battery, to the diode, through a potentiometer (or rheostat). The applied voltage to the diode is changed. The values of current, for different values of voltage, are noted and a graph between V and I is plotted.

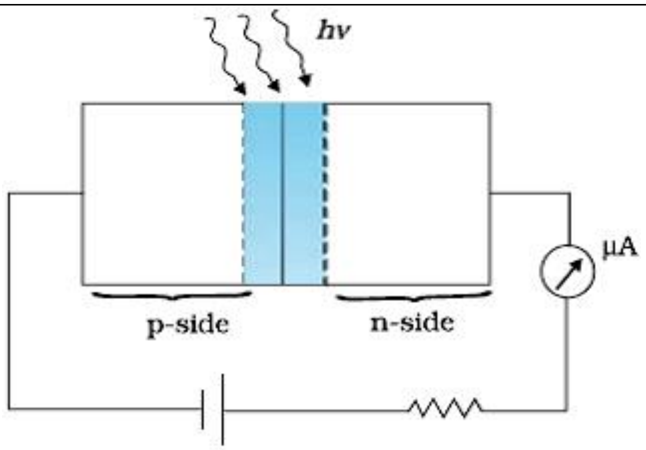
1

The V-I characteristics ,of a diode, have the form shown here.



½+ ½

(b) The circuit diagram, for the photodiode, is shown here.



½

The photodiode is illuminated by optical signal, whose photon energy is greater than the energy gap of the semicoinductor used. ½

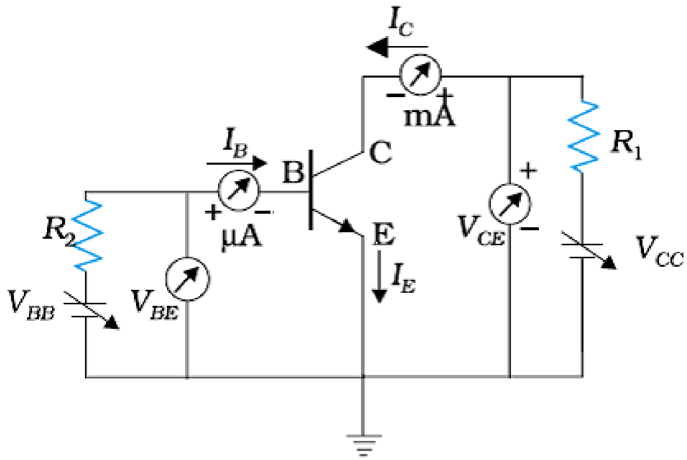
The electric field, at the junction, seperates the electrons and holes and thus gives rise to an emf. ½

When an external load is connected, a (photo) current flows through it. The magnitude of this current is proportional to the intensity of light incident on the photodiode. ½ 5

OR

(a)	Circuit diagram	1
	Description of current formation	1
	Deduction of $I_e = I_b + I_c$	½
(b)	Circuit diagram	1
	Working	1 ½

a) The circuit diagram is shown here



1

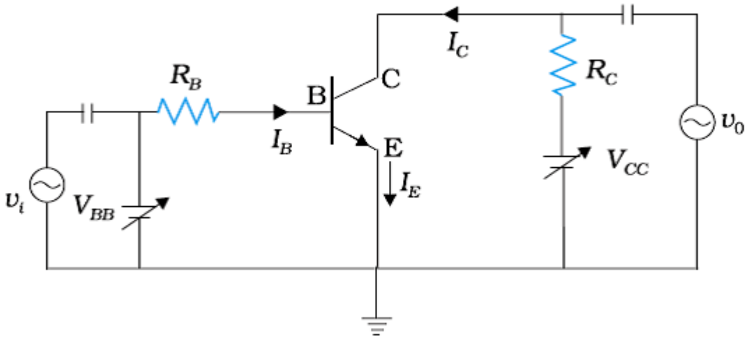
The emitter-base junction, being forward biased, the majority charge carriers (electrons), from the emitter, flow into the base region constituting the emitter current(I_E)

The base region, being very thin, only a (very) small fraction , of these charge carriers, swamps the holes present in the base region resulting in a (small) base current (I_B). 1

The majority of these charge carriers, are attracted by the (reverse biased) collector. These make up the collector current(I_C).

It is clear, therefore, that
$I_E = I_C + I_B$ ½

b) The circuit diagram, of a transistor, working as an amplifier, in its CE mode, is shown here.



1

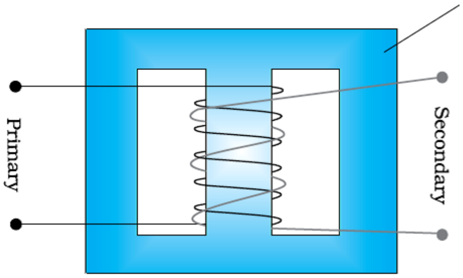
If a small sinusoidal voltage is superimposed on the dc base bias by connecting the source of this signal in series with V_{BB} supply. Then the base current will have sinusoidal variations superposed on the values I_B. As a consequence the collector current also will have sinusoidal variation superimposed on the value of I_C producing in turn corresponding change in the output voltage V_o. 1 ½

5

30.

(a) Schematic arrangement	1
(b) Principle of a transformer	½
Obtaining expression	
(i) $\frac{V_1}{V_2} = \frac{N_1}{N_2}$	1
(ii) $\frac{V_1}{V_2} = \frac{I_2}{I_1}$	1
(c) Assumptions **(any one)**	½
(d) Two reasons for energy losses	½ + ½

a)



1

b) Principle of a transformer: when alternating current flows through the primary coil, an emf is induced in the neighbouring (secondary) coil ½

(i) Let $\frac{d\phi}{dt}$ be the tare of charge of flux through each turn of the primary and the secondary coil

$$\frac{e_1}{e_2} = -N_1\frac{d\phi}{dt} / -N_2\frac{d\phi}{dt} = \frac{N_1}{N_2}$$ ½

or

$\frac{V_1}{V_2} = \frac{N_1}{N_2}$ -------------------(1)

	(ii) But for an ideal transformer $V_1 I_1 = V_2 I_2$	½	
	$\frac{V_1}{V_2} = \frac{I_2}{I_1}$ ------------------(2)	½	
	From equation (1) and (2 $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$	½	
	c) Main assumptions (i) The primary resistance and current are small (ii) The flux linked with the primary and secondary coils is same / there is no leakage of flux from the core. (iii)Secondary current is small **(Any one)**	½	
	d) Reason due to which energy loses may occur Flux leakage/resistance of the coils / eddy currents / Hysteresis (**Any two)**	½ +½	5
	OR		
	a) Derivation of the expressions for 2 ½ i. Induced emf ii. Induced current b) Expression for magnitude of force and its direction 1½ c) Expression for power 1		
	a) In one revolution Change of area , dA = $\pi\ell^2$ ∴ change of magnetic flux dϕ = $\vec{B}.\overrightarrow{dA}$ = BdAcos0^o	½	
	$= B\ \pi\ell^2$	½	
	Period of revolution T (i) Induced emf $\varepsilon = B\pi\ell^2/$T $= B\pi\ell^2 v$	1	
	(ii) Induced current in the rod, I = $\frac{\varepsilon}{R} = \frac{\pi v B\ell^2}{R}$	½	
	[**Note: Award 2 marks if the student derives the above relation using other method.]**		
	b) Force acting on the rod, F = $I\ell B$	½	
	$= \frac{\pi v B^2 \ell^3}{R}$	½	
	The external force required to rotate the rod opposes the Lorentz force acting on the rod / external force acts in the direction opposite to the Lorentz force	½	
	c) Power required to rotate the rod P = $F\vartheta$	½	
	$= \frac{\pi v B^2 \ell^3 v}{R}$	½	5