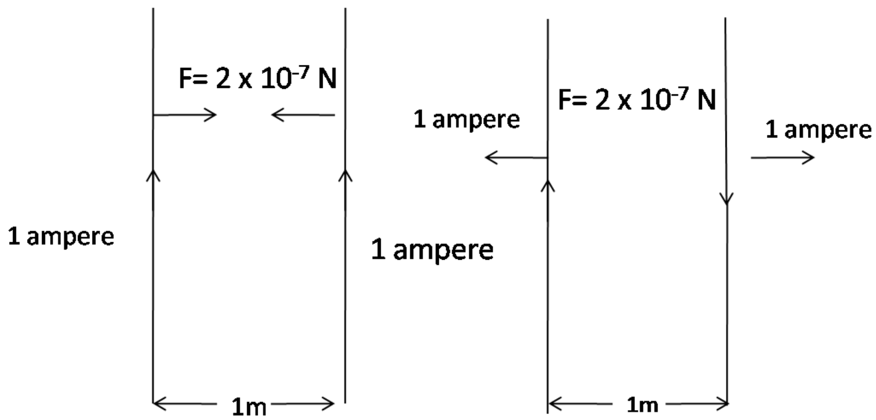
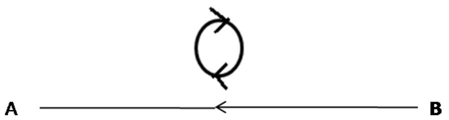
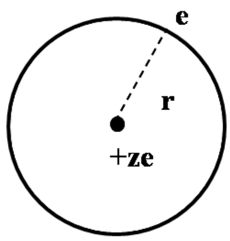
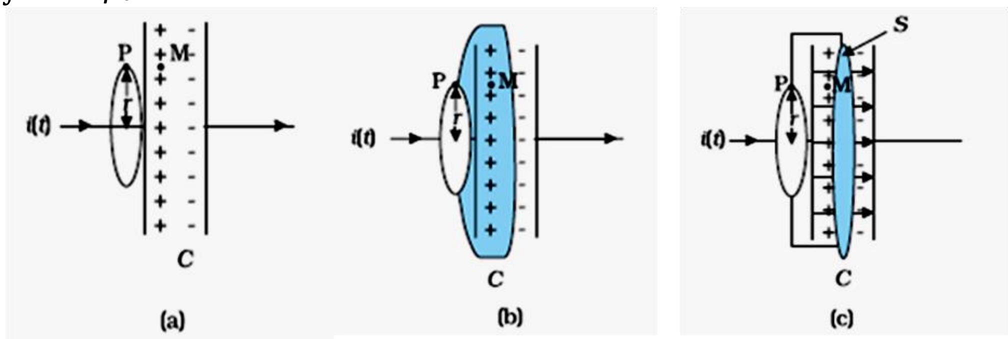
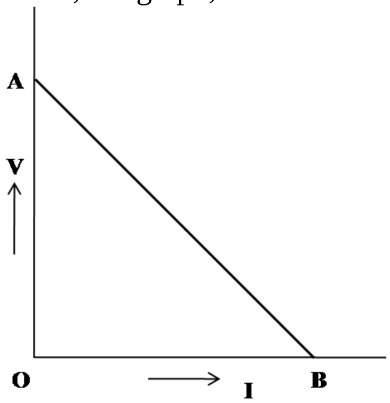
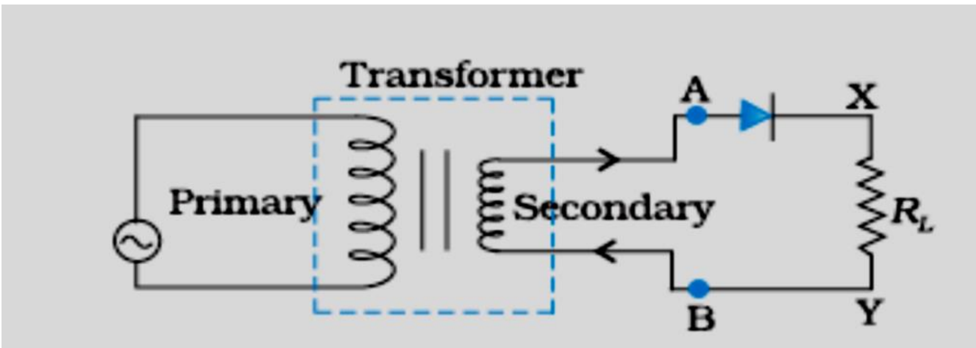
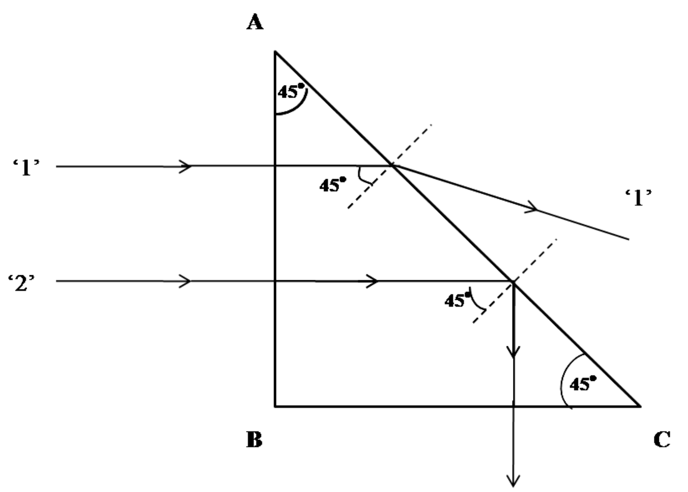
MARKING SCHEME
SET 55/1

Q. No	Expected Answer / Value Points	Marks	Total Marks
1.	**Definition :** One ampere is the value of steady current which when maintained in each of the two very long, straight, parallel conductors of negligible cross section and placed one metre apart in vaccum, would produce on each of these conductors a force equal of 2 x 10^{-7} N/m of its length. ***Alternatively*** If the student writes F = $\frac{\mu_o}{2\pi}\ \frac{I_1 I_2}{R}$L and says that when $I_1 = I_2 = 1\ ampere$ R= 1 meter and L = 1 meter, then F= 2 x 10^{-7} N ***Award full 1 mark*** ***Alternatively*** If the student draws **<u>any one</u>** of the two diagram, as shown ,  ***Award full 1 mark***	1	1
2.	$X-\ rays\ /\gamma-rays$	1	1
3.	Force decreases	1	1
4.	Intensity of radiation depends on the number of photons incident per unit area per unit time. [**Note**: Also accept the definition: 'number of quanta of radiation per unit area per unit time'. Also accept if the student writes: All photons, of a particular frequency, have the same kinetic energy and momentum, irrespective of the intensity of incident radiation. ***Alternatively*** The amount of light energy / Photon energy, incident per metre square per second is called intensity of radiation **SI Unit :** W/m^2 or J/(s- m^2)	½ ½	1
5.	Clockwise ***Alternatively***  	1	1

6.	Neutrinos are neutral (chargeless), (almost) massless particles that hardly interact with matter. ***Alternatively*** The neutrinos can penetrate large quantity of matter without any interaction **OR** Neutrinos are chargeless and (almost) massless particles.	1	1
7.	<u>**Any two**</u> of the following (or any other correct) reasons : i. AC can be transmitted with much lower energy losses as compared to DC ii. AC voltage can be adjusted (stepped up or stepped down) as per requirement. iii. AC current in a circuit can be controlled using (almost) wattless devices like the choke coil. iv. AC is easier to generate.	½ + ½	1
8.	As a diverging lens Light rays diverge on going from a rarer to a denser medium. [***Alternatively*** Also accept the reason given on the basis of lens marker's formula.]	½ ½	1
9.	Derivation of energy expression 1 ½ Significance of negative sign ½ As per Rutherford's model $\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_o}\frac{ze^2}{r^2}$ ⇨ $mv^2 = \frac{1}{4\pi\epsilon_o}\frac{ze^2}{r}$  Total energy = P.E +K.E. $= -\frac{1}{4\pi\epsilon_o}\frac{ze^2}{r} + \frac{1}{2}mv^2$ $= -\frac{1}{2}.\frac{1}{4\pi\epsilon_o}\frac{ze^2}{r} = = -\frac{1}{8\pi\epsilon_o}\frac{ze^2}{r}$ <u>Negative Sign</u> implies that Electron – nucleus form a bound system. ***Alternatively*** Electron – nucleus form an attractive system) **OR** Bohr's Postulate ½ Derivation of radius of nth orbit 1 Bohr's radius ½ For the electron, we have Bohr's Postulate ($mvr=\frac{nh}{2\pi}$)	½ ½ ½ ½ ½	2

	$\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_o}\frac{ze^2}{r^2}$ and $mvr = \frac{nh}{2\pi}$ $\therefore m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}$ and $mv^2r = \frac{1}{4\pi\epsilon_o}ze^2$ $\therefore$ r = $\frac{\epsilon_o n^2h^2}{\pi ze^2 m}$ Bohr's radius (for n = 1) = $\epsilon_o\ \ h^2/\pi ze^2 m$	½ ½ ½	2
10.	Formula for energy stored ½ New value of capacitance ½ Calculation of ratio 1 Energy stored in a capacitor = $\frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$ (any one) Capacitance of the (parallel) combination = C+C=2C Here, total charge, Q, remains the same $\therefore$ initial energy = $\frac{1}{2}\frac{Q^2}{C}$ And final energy = $\frac{1}{2}\frac{Q^2}{2C}$ $\therefore \frac{final\ energy}{initial\ energy} = \frac{1}{2}$ [**Note** : If the student does the correct calculations by assuming the voltage across the (i) Parallel or (ii) Series combination to remain constant (=V) and obtain the answers as (i) 2:1 or (ii) 1:2 , award full marks]	½ ½ ½ ½	2
11.	Statement of Ampere's circuital law ½ Showing inconsistency during the process of charging 1 Displacement Current ½ According to Ampere's circuital Law $\oint \vec{B}d\vec{l} = \mu_0 I$  Applying ampere's circuital law to fig (a) we see that, during charging, the right hand side in Ampere's circuital law equals $\mu_0 I$ However on applying it to the surfaces of the fig (b) or fig (c), the right hand side is zero.	½ ½ ½	

	Hence, there is a contradiction. We can remove the contradiction by assuming that there exists a current (associated with the changing electric field during charging), known as the displacement current. When this current ($= \frac{d\phi_E}{dt}$) is added on the right hand side, Ampere's circuital law, the inconsisitency disappears. It was, therefore necessary, to generalize the Ampere's circuital law, as $\oint \vec{B} d\vec{l} = \mu_0 I_c + \mu_0 \epsilon_o \frac{d\phi_E}{dt}$ [**Note** : If the student does the reasoning by using the (detailed) mathematics, relevant to displacement current, award full 2 marks]	½	2
12.	Relation between V and I ½ Graph ½ Determination of emf and internal resistance ½ + ½ The relation between V and I is V = E – Ir Hence, the graph, between V and I, has the form shown below.  For point A, I=0, Hence, V_A= E For point B, V=0, Hence, E=I_Br Therefore, $r = \frac{E}{I_B}$ <u>**Alternatively**</u>: emf (E) equals the intercept on the vertical axis. Internal resistance (r) equals the negative of the slope of the graph.	½ ½ ½ ½	2
13.	Circuit diagram 1 Working 1 	1	

	Working: During one half of the input AC, the diode is forward biased and a current flows through R_L. During the other half of the input AC, the diode is reverse biased and no current flows through the load R_L. Hence, the given AC input is rectified [**Note** : If the student just draws the waveforms, for the input AC voltage and output voltage (without giving any explanation) (award ½ mark only for "working")	½ ½	2
14.	Formula ½ Substitution and calculation ½ + 1 I = **neA V_d** $\mathbf{V_d} = \frac{I}{\mathbf{neA}} = \frac{1.5}{9\times10^{28}\times1.6\times10^{-19}\times1.0\times10^{-7}}$ m/s $= 1.048\times10^{-3}$m/s ($\approx$ 1mm/s)	½ ½ 1	2
15.	Tracing of Path of Ray 1 1 Tracing of Path of Ray 2 1  [**Note** : If the student just writes (without drawing any diagram) that angle of incidence for both rays '1' and '2' on face AC equals 45°, and says that it is less than critical angle for ray '1' (which therefore gets refracted) and more than critical angle for ray '2' (which undergoes total internal reflection), award only ½ + ½ marks.]	1 1	2
16.	Function of Transducer 1 Function of Repeater 1 **Transducer :** Any device that converts one form of energy to another. **Repeater :** A repeater accepts the signal from the transmitter, amplifies and retransmits it to the receiver.	1 1	2

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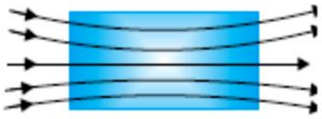
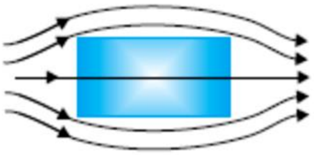
Diagrams	½ + ½
Explanations	½ + ½





A <u>paramagnetic</u> material tends to move from weaker to stronger regions of the magnetic field and hence increases the number of lines of magnetic field passing through it.
[***Alternatively:*** A <u>paramagnetic</u> material, dipole moments are induced in the direction of the field.]

A <u>diamagnetic</u> material tends to move from stronger to weaker regions of the magnetic field and hence, decreases the number of lines of magnetic field passing through it.
[***Alternatively:*** A <u>diamagnetic</u> material, dipole moments are induced in the opposite direction of the field.]
[**Note**: If the student just writes that a paramagnetic material has a small positive susceptibility ($0 < X < \varepsilon$) and a diamagnetic material has a negative susceptibility ($-1 \leq X < 0$), award the ½ mark for the second part of the question.]
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½

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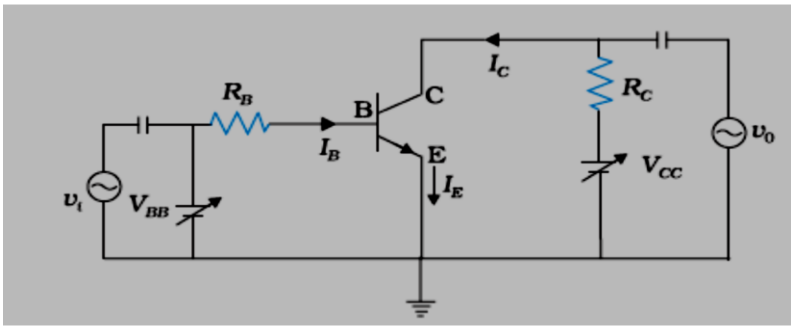
Circuit diagram	1 ½
Condition	½



Condition : The transistor must be operated close to the centre of its active region.
Alternatively
The base- emitter junction of the transistor must be (suitably) forward biased and the collector – emitter junction must be (suitably) reverse biased.
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½</td>
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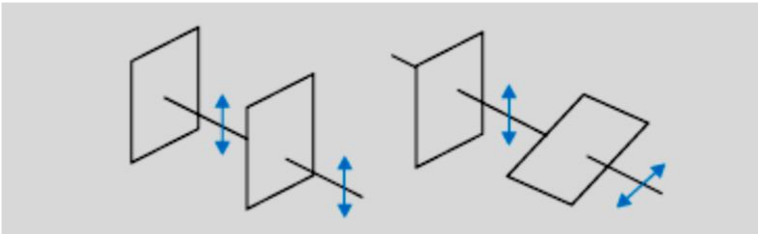
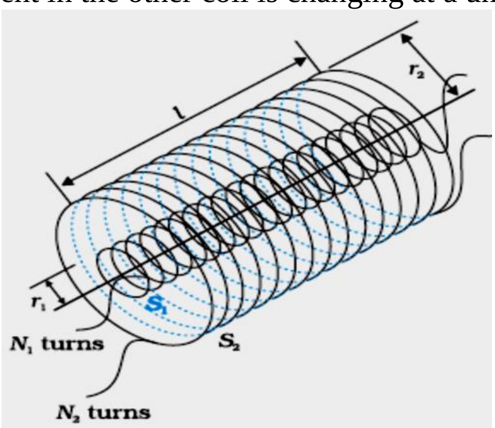
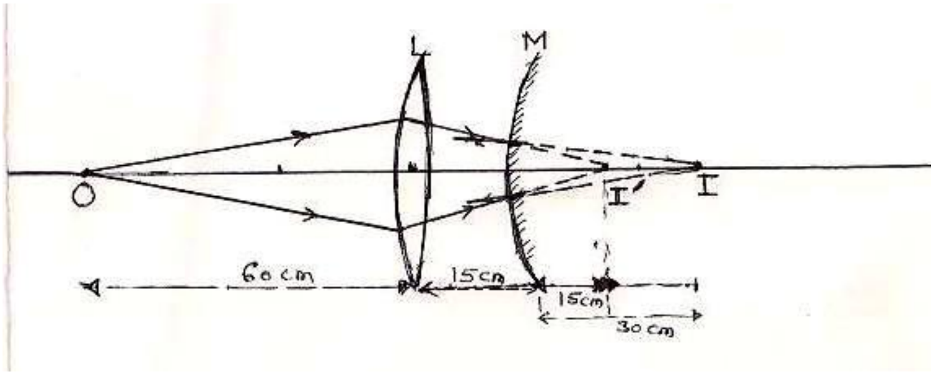
19.	a) Demonstration of transverse nature of light — 1 ½ b) Calculation of intensity through P_1 P_2 & P_3 — ½ + ½ + ½ a)  Light from the sodium lamp passing through the single Polaroid sheet (P_1) does not show any variation in intensity when this sheet is rotated. However, if the light, transmitted by P_1, is made to pass through another Polaroid sheet (P_2) the light intensity, coming out of P_2, varies from a maximum to zero, and again to maximum, when P_2 is rotated. These observations are consistent only with the transverse nature of light waves. b) Intensity of light transmitted through $P_1 = I_0 / 2$ Intensity of light transmitted through $P_3 = (I_0 / 2) \times \cos^2 30^0$ $= 3 I_0 / 8$ Intensity of light transmitted through $P_2 = \frac{3}{8} I_o \cos^2 60^o$ $= \frac{3}{32} I_o$ [**Note** : If the student takes the intensity of light transmitted through P_1 as I_o and calculates the intensity through P_3 and P_2 as $\frac{3}{4} I_o$ and $\frac{3}{16} I_o$ award ½ + ½ = 1 mark for part (b)]	1 ½ ½ ½ ½	3
20.	Definition of mutual induction — 1 Obtaining the expression — 2 Mutual inductance, between a pair of coils, equals the magnetic flux, linked with one of them, due to a unit current flowing in the other. ***Alternatively*** The mutual inductance, for a pair of coils, equals the emf induced, in one of them, when the current in the other coil is changing at a unit rate. 	1 ½	

	Let a current I_2 flow through the outer coil. The magnetic field due to this current $= \mu_o \frac{N_2}{l} \times I_2$ The resulting magnetic flux linked with the inner coil $= \emptyset_{12} = N_1.\left(\mu_o \frac{N_2}{l} \times I_2\right) \times \pi r_1^2$ $= \left(\mu_o \frac{N_1 N_2}{l} . \pi r_1^2\right) I_2$ $= M_{12} I_2$ $\therefore M_{12} = \mu_o \frac{N_1 N_2}{l} . \pi r_1^2$	½ ½ ½	3
21.	Answers to each of the three parts 1+1+1=3 a) This is to ensure that the connections do not contribute any extra, unknown, resistances in the circuit. b) This is done to minimize the percentage error in the value of the unknown resistance. [***Alternatively:*** This is done to have a better " balancing out" of the effects of any irregularity or non-uniformity in the metre bridge wire. **Or** This can help in increasing the senstivity of the metre bridge circuit.] c) Manganian / constantan /Nichrome This material has a low temperature **(any one)** of coefficient of resistance/ high reisistivity.	1 1 ½ + ½	3
	OR Calculation of total resistance of the circuit 1 Calculation of total current drawn from the voltage Source ½ Calculation of current through R 1 Calculation of potential drop across R ½ $R_{total} = \frac{R_O}{2} + \frac{\frac{R_O}{2}.R}{\frac{R_O}{2}+R}$ $= \frac{R(R_O + 4R)}{2(R_O + 2R)}$ $I_{(total)} = \frac{V}{R_{total}}$ Current through R = $I_2 = I_{total} \times \frac{\frac{R_O}{2}}{\frac{R_O}{2}+R}$ $= I_{total} \times \frac{R_O}{R_O+2R}$ $= \frac{V.2(R_O+2R)}{R(R_O+4R)} \times \frac{R_O}{R_O+2R}$ $= \frac{2VR_O}{R(R_O+4R)}$ Voltage across R = $I_2 R = \left(\frac{2VR_O}{R_O+4R}\right)$	½ ½ ½ ½ ½ ½	3

22.

Ray diagram	1
Nature of final image	½
Position of final image	1 ½



1

For the convex lens
u = -60 cm , f = +20 cm — ½
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ gives v = + 30 cm

For the convex mirror
u= + (30 – 15) cm = 15 cm , f = +$\frac{20}{2} cm$ = 10 cm — ½

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ gives v = +30 cm
Final image is formed at the distance of 30 cm from the convex mirror (or 45 cm from the convex lens) to the right of the convex mirror. — ½
The final image formed is a virtual image. — ½ — 3

23.

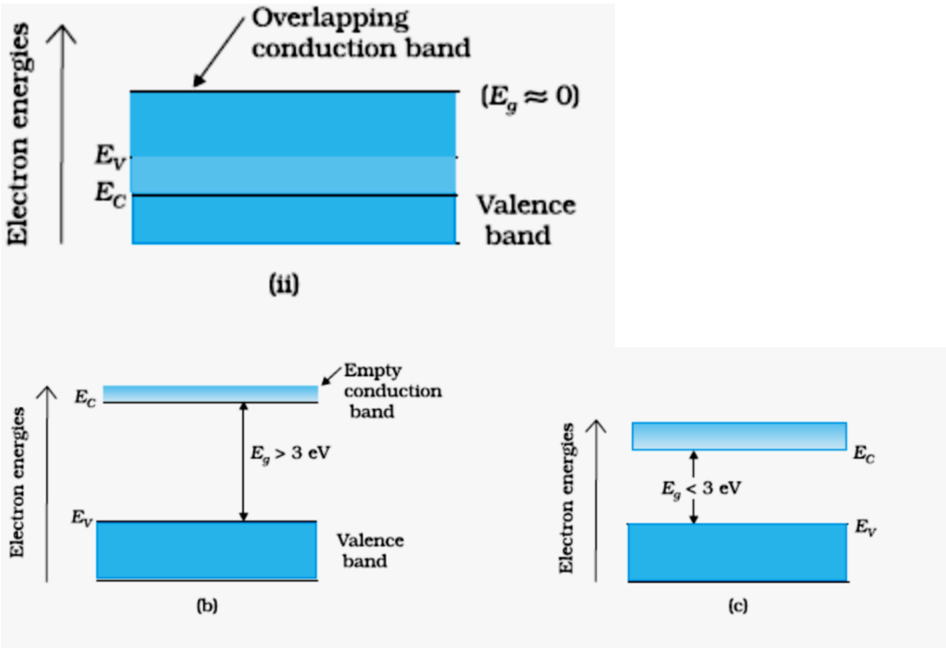
Deriving the expression for average power	2
Condition for no power dissipation	½
Condition for maximum power dissipation	½

Applied voltage = $V_0 \sin \omega t$ — ½
Current in the circuit =$I_o \sin (\omega t - \phi)$
where ϕ is the phase lag of the current with respect to the voltage applied ,
Hence instantaneous power dissipation

$$= V_0 \sin \omega t \times I_o \sin (\omega t - \phi)$$
$$= \frac{V_0 I_0}{2} [2 \sin \omega t . \sin (\omega t - \phi)]$$
$$= \frac{V_0 I_0}{2} [\cos \phi - \cos(2\omega t - \phi)]$$ — ½

Therefore, average power for one complete cycle
$$= \text{average of}[\frac{V_0 I_0}{2} [\cos \phi - \cos(2\omega t - \phi)]]$$ — ½

The average of the second term over a complete cycle is zero .
Hence , average power dissipated over one complete cycle = $\frac{V_0 I_0}{2} \cos \phi$ — ½
[**Note** : Please also accept alternative correct approach.]

	Conditions (i) No power is dissipated when R = 0 (or $\phi = 90^o$) [**Note:** Also accepts if the student writes 'This condition cannot be satisfied for a series LCR circuit".] (ii) Maximum power is dissipated when $X_L = X_C$ or $\omega L = \frac{1}{\omega C}$ (or $\phi = 0$)	½ ½	3
24.	Energy band diagrams 1 ½ Two distinguishing features 1 ½  **Two distinguishing features:** (i) In conductors, the valency band and conduction band tend to overlap (or nearly overlap) while in insulators they are seperated by a large energy gap and in semiconductors are separated by a small energy gap. (ii) The conduction band, of a conductor, has a large number of electrons available for electrical conduction. However the conduction band of insulators is almost empty while that of the semi- conductor has only a (very) small number of such electrons avilable for electrical conduction.	½ ½ + ½ 1 ½	3
25.	Values displayed 2 Diagnosis 1 (a) keen observer/ helpful/ concerned / responsible/ respectful towards elders. (**Any two**) (b) The doctor can trace and observe, the difference between the movement of an appropriate radio- isotope through a normal brain and a brain having tumor in it. [**Note** : Also accept any other appropriate explanation.]	1+1 1	3

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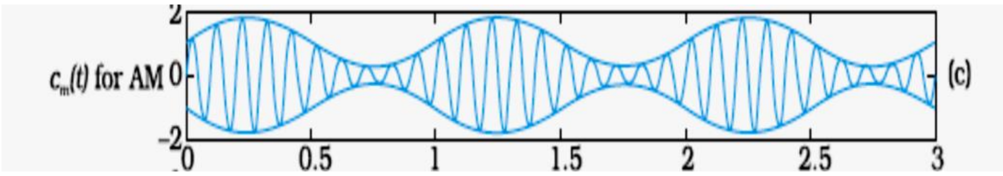
Two basic modes of communication ½ + ½
Process of Amplitude Modulation 1
Schematic Sketch 1

Two basic modes of communication are
i. Point – to –point
ii. Broadcast
In Amplitude modulation the amplitude of a carrier wave is made to vary, with time, in the same way as the modulating signal varies with time


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<td>27.</td>
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Formula ½
Calculation of debroglie wavelength 2
Comparison ½
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$ or $\lambda = \frac{12.27}{\sqrt{V}} A^o$

$\therefore \lambda = \frac{6.63 \times 10^{-34}}{\sqrt{(2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 50 \times 10^3)}}$
$\boldsymbol{\lambda}$= 5.33$\times$ 10^{-12}m
The resolving power of an electron microscope is much better than that of optical microscope.
[**Note** : If the student writes R.P $\alpha \frac{1}{\lambda}$, award this ½ mark]
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1

1
½</td>
<td>3</td>
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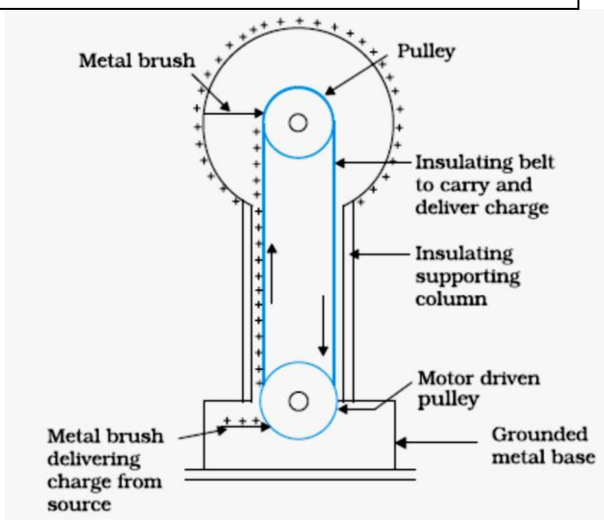
Diagram 2
Principle and working 2
Use and limitation ½ + ½


[**Note** : Award 1 mark only if the diagram is not labelled]
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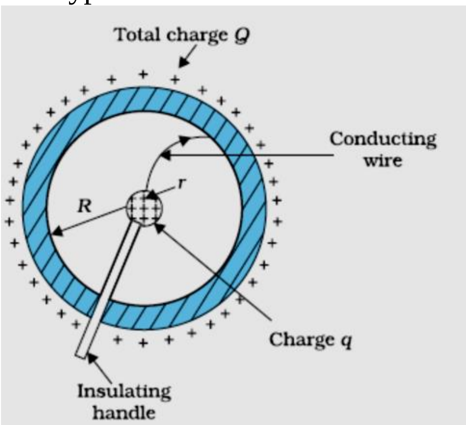
Principle & working

Consider a set up of the type shown here



i. Potential inside and on the surface, of the conducting sphere pf radius 'R':

$V'_R = \frac{1}{4\pi\epsilon_o} . \frac{Q}{R}$

ii. Potential due to small sphere of radius 'r' carrying a charge 'q':

At the surface of the smaller sphere : $V'_r = \frac{1}{4\pi\epsilon_o} . \frac{q}{r}$ ½

At the surface of the larger sphere : $V''_R = \frac{1}{4\pi\epsilon_o} . \frac{Q}{R}$

∴ The difference of potential between the smaller and the larger sphere:

$=\Delta V = \frac{1}{4\pi\epsilon_o} . \left[\left(\frac{Q}{R} + \frac{q}{r}\right) - \left(\frac{Q}{R} + \frac{q}{r}\right)\right]$ ½

$= \frac{q}{4\pi\epsilon_o}\left(\frac{1}{r} - \frac{1}{R}\right)$

When 'q' is positive, the inner sphere would always be at a higer potential with respect to outer sphere, irrespective of the amount of charges on the two. ½

∴ When both the spheres are connected, charge will flow from the smaller sphere to the larger sphere. Thus for a set up of the type shown, charge would keep on pilling up on the larger sphere. ½

Use : This machine is used to accelerate charged particles (electron, protons, ions) to high energies. ½

Limitation:It can build up potentials upto a few million volts only. ½ 5

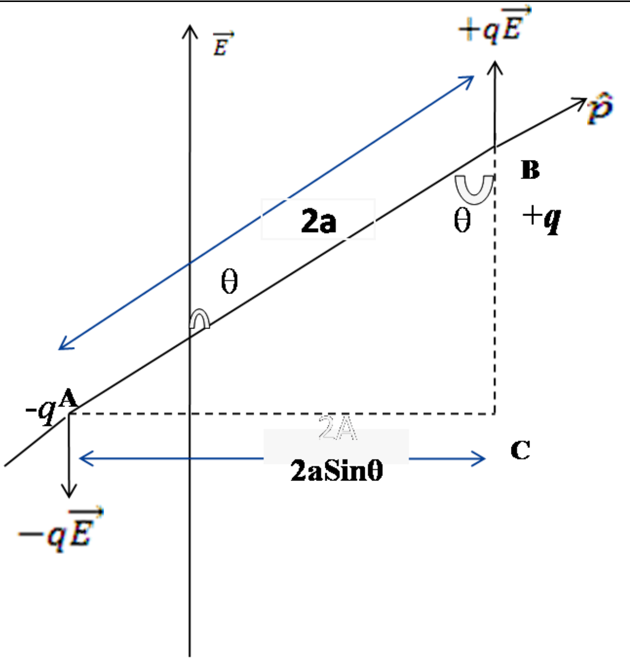
OR

(a)	Deducing the expression for torque	2
(b)	Finding the ratio of the flux through the two spheres	2
(c)	Finding the change in flux	1

(a)

The forces, acting on the two charges of the dipole, are

$+q\vec{E}$ and $-q\vec{E}$ ½



½

The net force on the dipole is zero.
The two forces are, however, equivalent to a torque having a magnitude

$\tau = (qE)AC$

$= qE.\ 2a \sin\theta$ ½

$= pE \sin\theta$

The direction of this torque is that of the cross product $(\vec{p} \times \vec{E})$. Hence, the torque acting on the dipole, is given by ½

$$\vec{\tau} = \vec{p} \times \vec{E}$$

(b) ½

As per Guass's Theorem

Electric Flux = $\oint_s \vec{E}.\vec{dS} = \frac{q_{enclosed}}{\epsilon_o}$ ½

∴ For sphere S$_1$, flux enclosed = $\phi_1 = \frac{2Q}{\epsilon_o}$ ½

For sphere S$_2$, flux enclosed = $\phi_2 = \frac{2Q+4Q}{\epsilon_o} = \frac{6Q}{\epsilon_o}$

½

∴ $\frac{\phi_1}{\phi_2} = \frac{1}{3}$ 1

When a medium of dielectric consistent ϵ_r is introduced in sphere S$_1$ the flux through S$_1$ would be $\phi_1' = \frac{2Q}{\epsilon_r}$

[Also award this mark if the student writes $\phi_1 = \frac{2Q}{\epsilon_o\epsilon_r}$]

[**Note** : If the student just writes that the flux through S$_1$ decreases, award ½ mark only.] 5

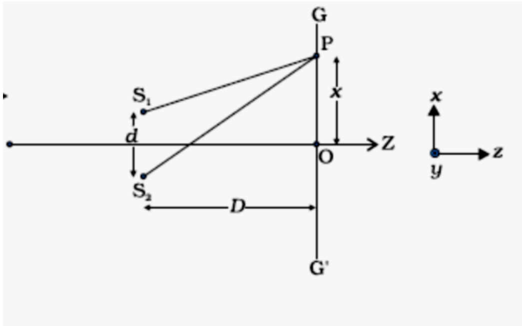
29.

(a) Formation of bright and dark fringes	1
Obtaining the expression for fringe width	3
(b) Finding the ratio	1

(a) The light rays from the two (coherent) slits, reaching a point 'P' on the screen, have a path difference ($S_2P - S_1P$).The point 'P' would, therefore be a

i. Point of maxima(bright fringe), if $S_2P - S_1P = n\boldsymbol{\lambda}$. ½

ii. Point of minima (dark fringe), if $S_2P - S_1P = (2n+1)\frac{\lambda}{2}$ ½



(b)

½

We have

$(S_2P)^2 - (S_1P)^2 = \left\{D^2 - \left(x + \frac{d}{2}\right)^2\right\} - \left\{D^2 + \left(x - \frac{d}{2}\right)^2\right\}$

$= 2xd$

$S_2P - S_1P = \frac{2xd}{S_2P + S_1P} \approx \frac{2xd}{2D} = \frac{xd}{D}$ ½

∴ We have maxima at points, where ½

$$\frac{xd}{D} = n\lambda$$

and minima at points where

$$\frac{xd}{D} = \left(\frac{2n+1}{2}\right)\lambda$$ ½

Now, fringe width $\boldsymbol{\beta}$= separation between two successive maxima(or two successive minima) = $x_n - x_n - 1$ ½

$\therefore \boldsymbol{\beta} = \frac{\lambda D}{\boldsymbol{d}}$ ½

(b) We have ½

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{25}{9}$$

$$\therefore = \frac{a_1}{a_2} = \frac{4}{1}$$ ½

$$\therefore \frac{W_1}{W_2} = \frac{I_1}{I_2} = \frac{(a_1)^2}{(a_2)^2} = \frac{16}{1}$$

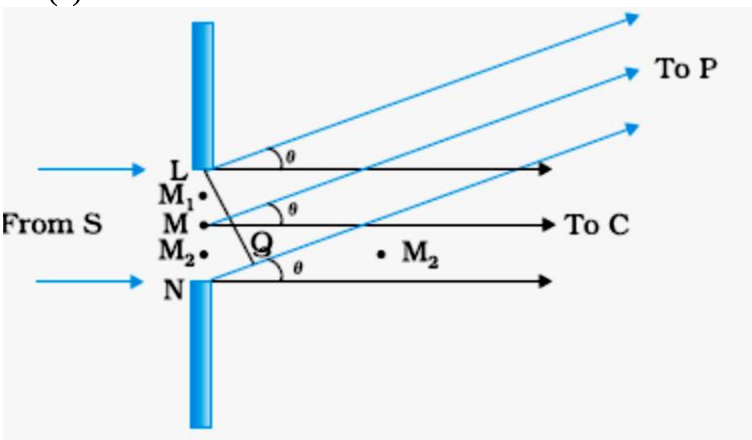
[**Note:** Give ½ mark if the student just writes Intensity ∝ width

5

OR

a) Obtaining the diffraction pattern	1 ½
Conditions for angular width	1 ½
b) Calculation of separation	2

(a)



½

The path difference (NP-LP) , between the two edges of the slit, is given by ½

NP-LP ≅ NQ = a sin$\theta \approx a\theta$

We, therefore, get maxima and minima, at different points of the screen, depending on the path difference between the contributions from the wavelets, emanating from different points of the slit. This results in a diffraction pattern on the screen. ½

The path difference between two points M_1 , M_2, in the slit plane, seperated by a distance 'y', is yθ. ½

At the central point, 'C', on the screen, 'θ' is zero.
All parts of the slit contribute in phase
Hence 'C' is a maximum.

At all points where '$\theta' \cong (n+\frac{1}{2})\frac{\lambda}{a}$, we get (secondary) maxima of varying intensity. This is because of the non-zero contribution of a (decreasing)part of the slit at these points. ½

At all points where $\theta \approx \frac{n\lambda}{a}$, we get minima. ½

This is because of a net (almost) zero contribution of the whole slit at these points.

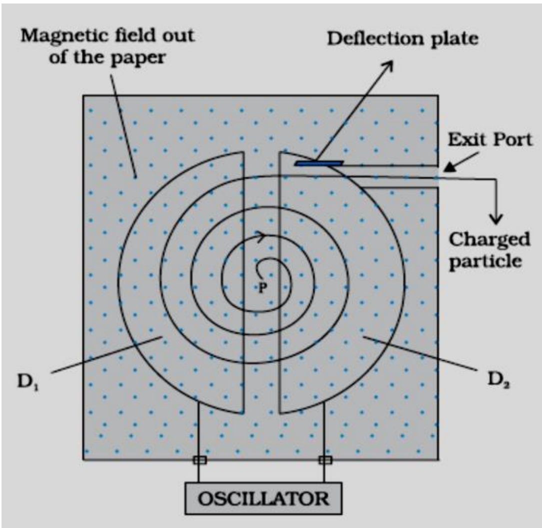
[**Note** : Please also accept alternative correct diagram with appopriate explanation.] ½

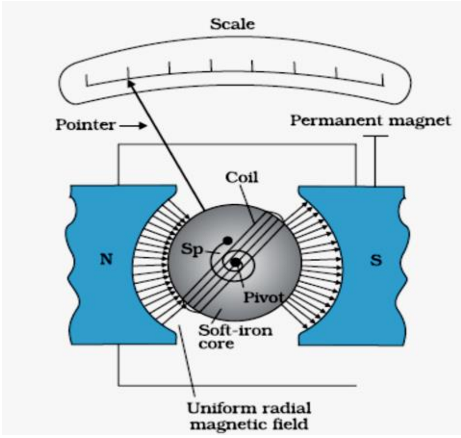
(b) Angular width of the secondary maxima $\approx 2(2n+1)\frac{\lambda}{a}$

∴ Linear width = $[(2n+1)\frac{\lambda}{a}]$ D ½

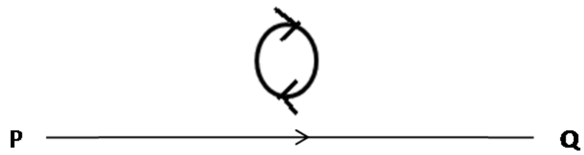
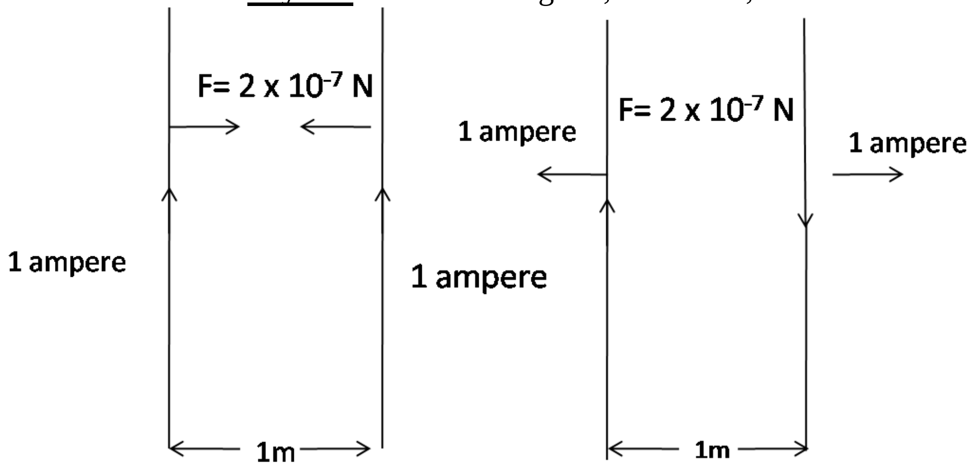
∴ Linear seperation, between the first maxima (n=1) of the two wavelengths, on the screen, is

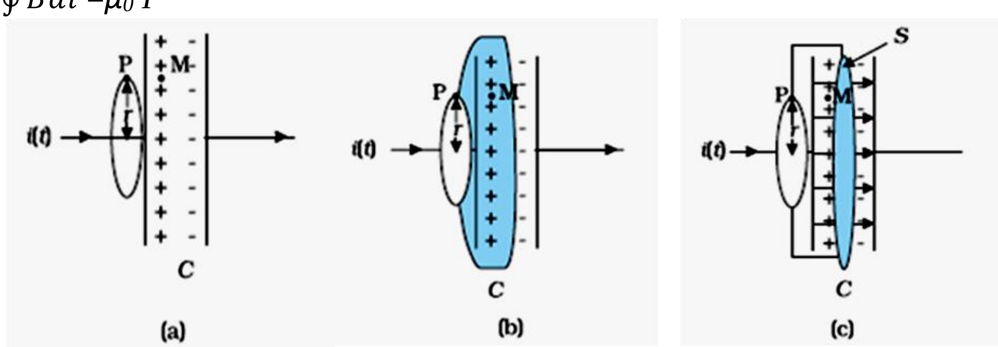
$$\frac{3(\lambda_2-\lambda_1)}{a}\times D$$

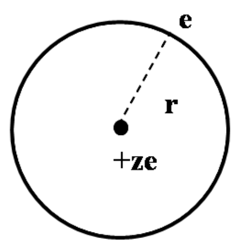
	∴ Seperation = $\frac{3(596-590)\times10^{-9}}{2\times10^{-6}} \times 1.5m$ = 13.5 x $\times 10^{-3}$m (= 13.5 mm)	1	5
30.	(a) Expression for frequency 1 ½ Frequency Independent of 'v' or energy ½ (b) Sketch of cyclotron 1 Construction 1 Working 1 (a) When a particle of mass 'm' and charge 'q' , moves with a velocity **v**, in a uniform magnetic field ***B*** , it experiences a force ***F*** where $\vec{F} = q\,(\vec{v} \times \vec{B})$ ∴ Centripetal force $\frac{mv^2}{r} = 2\ v\ B_\perp$ ∴ $r = \frac{mv}{qB_\perp}$ ∴ frequency = $\frac{v}{2\pi r} = \frac{qB_\perp}{2\pi m}$ ∴It is independent of the velocity or the energy of the particle.  **Construction**: The cyclotron is made up of two hollow semi-circular disc like metal containers, D_1 and D_2, called dees. It uses crossed electric and magnetic fields. The electric field is provided by an oscillator of adjustable frequency. [**Note**: Award this mark even if the student labels the diagram properly without writing the details of the construction.] **Working**: In a cyclotron, the frequency of the applied alternating field is adjusted to be equal to the frequency of revolution of the charged particles in the magnetic field. This ensures that the particles get accelerated every time	½ ½ ½ ½ 1 1	

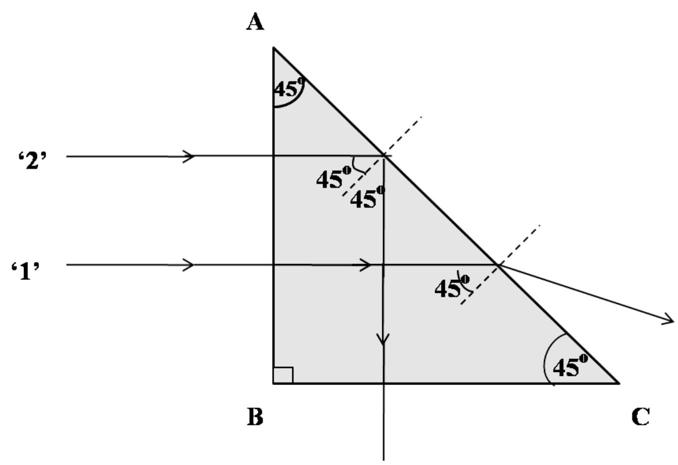
	they cross the space between the two dees. The radius of their path increases with increase in energy and they are finally made to leave the system via an exit slit.	1	5
	OR		
	(a) Labelled diagram 1 Principle and working 2 (b) i) Reason for cylindrical soft iron core 1 ii) Comparison of current sensitivity and voltage sensitivity 1		
		1	
	Principle and working : A current carrying coil, placed in a uniform magnetic field, (can) experience a torque Consider a rectangular coil for which no. of turns = N, Area of cross- section = l×b=A, Intensity of the uniform magnetic field=B, Current through the coil=I ∴ Deflecting torque = $BIL \times b = BIA$ $For\ N\ turns \quad \tau$ =NBIA	½	
	Restoring torque in the spring = kθ (k = restoring torque per unit twist) $\therefore NBIA = k\theta$	½	
	$\therefore I = \left(\frac{k}{NBA}\right)\theta$ $\therefore I \propto \theta$	½	
	The deflection of the coil, is, therefore, proportional to the current flowing through it.	½	
	(b) (i) The soft iron core not only makes the field radial but also increases the strength of the magnetic field. [**Note**:- Award this one mark even if the student writes just one of the two reasons given above) (ii) We have Current sensitivity = $\frac{\theta}{I}$ = NBA/k	1	
	Voltage sensitivity = $\frac{\theta}{V} = \frac{\theta}{IR} = \left(\frac{NBA}{k}\right) \cdot \frac{1}{R}$	½	
	It follows that an increase in current senstivity may not necessarily increase the voltage sensitivity.	½	5

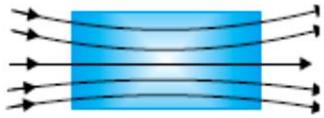
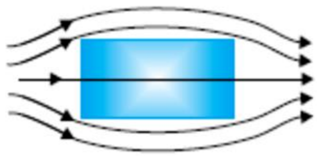
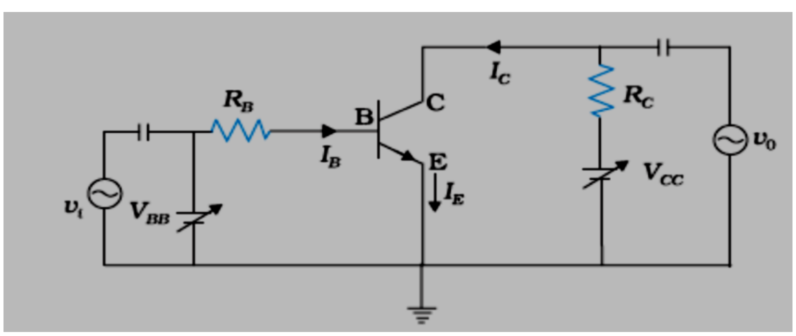
MARKING SCHEME
SET 55/2

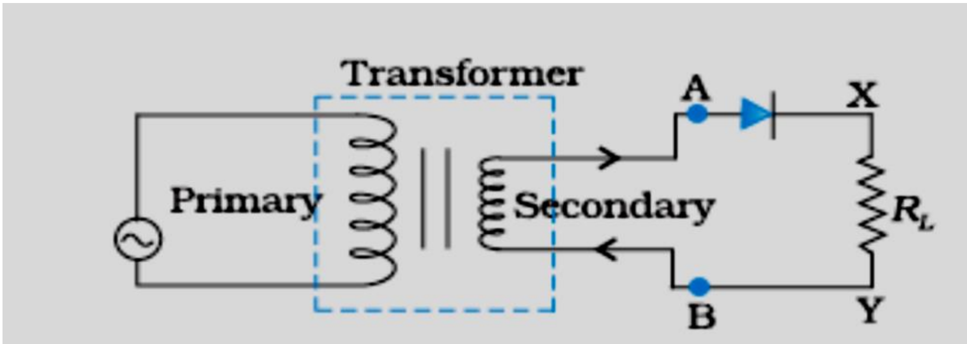
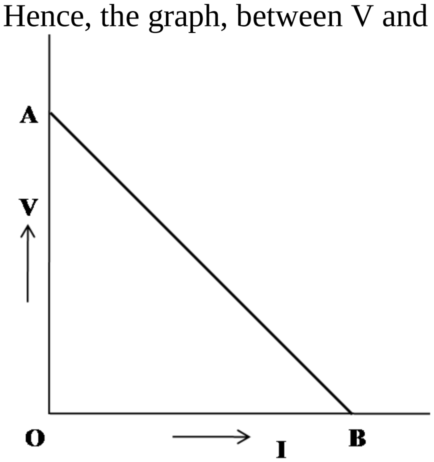
Q. No.	Expected Answer / Value Points	Marks	Total Marks
1.	Clockwise  	1	1
2.	**Definition :** One ampere is the value of steady current which when maintained in each of the two very long, straight, parallel conductors of negligible cross section and placed one metre apart in vaccum, would produce on each of these conductors a force equal of 2 x 10^{-7} N/m of its length. ***Alternatively*** If the student writes $F = \frac{\mu_o}{2\pi}\ \frac{I_1 I_2}{R} L$ and says that when $I_1 = I_2 = 1\ ampere$ R= 1 meter and L = 1 meter, then F= 2 x 10^{-7} N ***Award full 1 mark*** ***Alternatively*** If the student draws **<u>any one</u>** of the two diagram, as shown ,  ***Award full 1 mark***	1	1
3.	**<u>Any two</u>** of the following (or any other correct) reasons : i. AC can be transmitted with much lower energy losses as compared to DC ii. AC voltage can be adjusted (stepped up or stepped down) as per requirement. iii. AC current in a circuit can be controlled using (almost) wattless devices like the choke coil. iv. AC is easier to generate.	½ + ½	1

4.	They start from positive charges and end on negative charges [**Alternatively**: Electric field is conservative in nature.]	1	1
5.	Converging lens Light rays converge, on moving from denser to rarer medium. **Alternatively**: **Note:** If explained on the basis of lens makers formulae, award 1 mark.	½ ½	1
6.	Metal A ∵ work functions $W = h\nu$ and $\nu_o' > \nu_o$	½ ½	1
7.	Infrared radiation	1	1
8.	Neutrinos are neutral (chargeless), (almost) massless particles that hardly interact with matter. ***Alternatively*** The neutrinos can penetrate large quantity of matter without any interaction **OR** Neutrinos are chargeless and (almost) massless particles.	1	1
9.	Formula ½ Calculation of drift velocity 1 ½ I = AneV_d $\therefore V_d = \frac{1.8}{2.5\times10^{-7}\times9\times10^{28}\times1.6\times10^{-19}}$ = 5 X 10^{-4}m/s	 ½ ½ 1	2
10.	Statement of Ampere's circuital law ½ Showing inconsistency during the process of charging 1 Displacement Current ½ According to Ampere's circuital Law $\oint \vec{B} d\vec{l} = \mu_0 I$  Applying ampere's circuital law to fig (a) we see that, during charging, the right hand side in Ampere's circuital law equals $\mu_0 I$	 ½ ½	

	However on applying it to the surfaces of the fig (b) or fig (c), the right hand side is zero. Hence, there is a contradiction. We can remove the contradiction by assuming that there exists a current (associated with the changing electric field during charging), known as the displacement current. When this current (= $\frac{d\phi_E}{dt}$) is added on the right hand side, Ampere's circuital law, the inconsisitency disappears. It was, therefore necessary, to generalize the Ampere's circuital law, as $\oint \vec{B} d\vec{l} = \mu_0 I_c + \mu_0 \in_o \frac{d\phi_E}{dt}$ [**Note** : If the student does the reasoning by using the (detailed) mathematics, relevant to displacement current, award full 2 marks]	½ ½	2
11.	Derivation of energy expression 1 ½ Significance of negative sign ½ As per Rutherford's model  $\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_o} \frac{ze^2}{r^2}$ ⇨ $mv^2 = \frac{1}{4\pi\epsilon_o} \frac{ze^2}{r}$ Total energy = P.E +K.E. $= - \frac{1}{4\pi\epsilon_o} \frac{ze^2}{r} + \frac{1}{2} mv^2$ $= - \frac{1}{2} . \frac{1}{4\pi\epsilon_o} \frac{ze^2}{r} = = - \frac{1}{8\pi\epsilon_o} \frac{ze^2}{r}$ Negative Sign implies that Electron – nucleus form a bound system. ***Alternatively*** Electron – nucleus form an attractive system) **OR** Bohr's Postulate ½ Derivation of radius of nth orbit 1 Bohr's radius ½ For the electron, we have Bohr's Postulate ($mvr=\frac{nh}{2\pi}$) $\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_o} \frac{ze^2}{r^2}$ and $mvr= \frac{nh}{2\pi}$ $\therefore m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}$	½ ½ ½ ½ ½ ½	2

	and $mv^2r = \frac{1}{4\pi\epsilon_o} ze^2$ $\therefore r = \frac{\epsilon_o n^2 h^2}{\pi z e^2 m}$ Bohr's radius (for n = 1) = $\epsilon_o \; h^2/\pi z e^2 m$	½ ½	2
12.	Tracing the path of the two rays 1 + 1  [**Note** : If the student does not draw the diagram but just writes that the angle of incidence for both rays '2' and '1', on face AC = 45^o and says that it is less than critical angle for ray '1' which therefore gets refracted and more than critical angle for ray '2',which undergoes total internal reflection; ***Award ½ + ½ marks*****]**	1+1	2
13.	Function of transmitter 1 Function of modulator 1 **<u>Transmitter</u>**: A transmitter processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception. **<u>Modulator</u>**: It is a device in which the amplitude/ (frequency/phase) of a high frequency carrier wave is made to change in accordance with the message signal through (appropriate) superposition.	1 1	2

14.	Diagrams ½ + ½ Explanations ½ + ½   A <u>paramagnetic</u> material tends to move from weaker to stronger regions of the magnetic field and hence increases the number of lines of magnetic field passing through it. [***Alternatively:*** A <u>paramagnetic</u> material, dipole moments are induced in the direction of the field.] A <u>diamagnetic</u> material tends to move from stronger to weaker regions of the magnetic field and hence, decreases the number of lines of magnetic field passing through it. [***Alternatively:*** A <u>diamagnetic</u> material, dipole moments are induced in the opposite direction of the field.] [**Note**: If the student just writes that a paramagnetic material has a small positive susceptibility (0< X < ε) and a diamagnetic material has a negative susceptibility (-1≤ X < 0), award the ½ mark for the second part of the question.]	½ ½ ½ ½	2
15.	Circuit diagram 1 ½ Condition ½  **Condition :** The transistor must be operated close to the centre of its active region. ***Alternatively*** The base- emitter junction of the transistor must be (suitably) forward biased and the collector – emitter junction must be (suitably) reverse biased.	1 ½ ½	2

16.	Circuit diagram 1 Working 1		
		1	
	Working: During one half of the input AC, the diode is forward biased and a current flows through R_L.	½	
	During the other half of the input AC, the diode is reverse biased and no current flows through the load R_L.	½	
	Hence, the given AC input is rectified [**Note** : If the student just draws the waveforms, for the input AC voltage and output voltage (without giving any explanation) (award ½ mark only for "working")		2
17.	Relation between V and I ½ Graph ½ Determination of emf and internal resistance ½ + ½		
	The relation between V and I is $V = E - Ir$ Hence, the graph, between V and I, has the form shown below.	½	
		½	
	For point A, I=0, Hence, $V_A = E$ For point B, V=0, Hence, $E = I_B r$ Therefore, $r = \frac{E}{I_B}$	½	

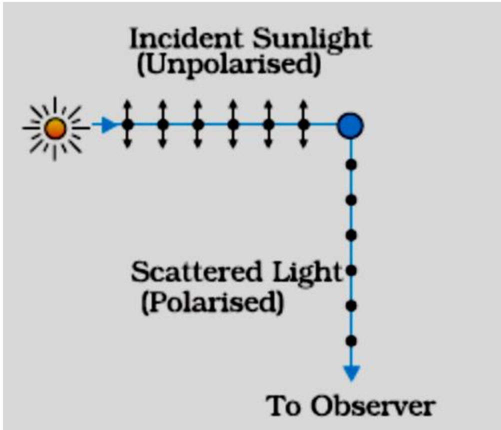
	Alternatively: emf (E) equals the intercept on the vertical axis. Internal resistance (r) equals the negative of the slope of the graph.	½	2
18.	Formula for energy stored ½ New value of capacitance ½ Calculation of ratio 1 Energy stored in a capacitor = $\frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$ (any one) Capacitance of the (parallel) combination = C+C=2C Here, total charge, Q, remains the same ∴ initial energy = $\frac{1}{2}\frac{Q^2}{C}$ And final energy = $\frac{1}{2}\frac{Q^2}{2C}$ ∴ $\frac{final\ energy}{initial\ energy} = \frac{1}{2}$ [**Note** : If the student does the correct calculations by assuming the voltage across the (i) Parallel or (ii) Series combination to remain constant (=V) and obtain the answers as (i) 2:1 or (ii) 1:2 , award full marks]	½ ½ ½ ½	2
19.	Deriving the expression for average power 2 Condition for no power dissipation ½ Condition for maximum power dissipation ½ Applied voltage = $V_0 \sin\omega t$ Current in the circuit =$I_o \sin(\omega t - \phi)$ where ϕ is the phase lag of the current with respect to the voltage applied , Hence instantaneous power dissipation $= V_0 \sin\omega t \times I_o \sin(\omega t - \phi)$ $=\frac{V_0 I_0}{2}[2\sin\omega t\,.\sin(\omega t - \phi]$ $=\frac{V_0 I_0}{2}[\cos\phi - \cos(2\omega t - \phi]$ Therefore, average power for one complete cycle = average of[$\frac{V_0 I_0}{2}[\cos\phi - \cos(2\omega t - \phi]]$ The average of the second term over a complete cycle is zero . Hence , average power dissipated over one complete cycle = $\frac{V_0 I_0}{2}\cos\phi$ [**Note** : Please also accept alternative correct approach.] Conditions (i) No power is dissipated when R = 0 (or $\phi = 90^o$) [**Note:** Also accepts if the student writes 'This condition cannot be satisfied for a series LCR circuit".] (ii) Maximum power is dissipated when $X_L = X_C$ or $\omega L = \frac{1}{\omega C}$ (or $\phi = 0$)	½ ½ ½ ½ ½ ½	3

20.	Answers to each of the three parts 1+1+1=3		
	a) This is to ensure that the connections do not contribute any extra, unknown, resistances in the circuit.	1	
	b) This is done to minimize the percentage error in the value of the unknown resistance. [***Alternatively:*** This is done to have a better " balancing out" of the effects of any irregularity or non-uniformity in the metre bridge wire. **Or** This can help in increasing the senstivity of the metre bridge circuit.]	1	
	c) Manganian / constantan /Nichrome This material has a low temperature **(any one)** of coefficient of resistance/ high reisistivity.	½ + ½	3
	OR		
	Calculation of total resistance of the circuit 1 Calculation of total current drawn from the voltage Source ½ Calculation of current through R 1 Calculation of potential drop across R ½		
	$R_{total} = \frac{R_o}{2} + \frac{\frac{R_o}{2}.R}{\frac{R_o}{2}+R}$	½	
	$= \frac{R(R_o + 4R)}{2(R_o + 2R)}$		
	$I_{(total)} = \frac{V}{R_{total}}$	½	
	Current through R = $I_2 = I_{total} \times \frac{\frac{R_o}{2}}{\frac{R_o}{2}+R}$	½	
	$= I_{total} \times \frac{R_o}{R_o+2R}$	½	
	$= \frac{V.2(R_o+2R)}{R(R_o+4R)} \times \frac{R_o}{R_o+2R}$		
	$= \frac{2VR_o}{R(R_o+4R)}$	½	
	Voltage across R = $I_2 R = (\frac{2VR_o}{R_o+4R})$	½	3

21.

a) Diagram	½
Explanation	1
b) Intensity through P_1, P_3, P_2	½ + ½ + ½

(a)



½

OR

The acceleration, of the charges, in the scattering molecules, due to the electric field of the incident radiation, can be in two mutually perpendicular directions. ½

The observer, however, receives the scattered light , corresponding to only one of these two sets of the accelerated charges.

This causes scattered light to get polarised. ½

Alternatively : The observer receives scattered light corresponding to only one of the two sets of accelerated charges i.e. electrons oscillating perpendicular to the direction of propagation.

(b)

Intensity of light through $P_1 = \frac{I_o}{2}$ ½

Intensity of light through $P_2 = \frac{I_o}{2}\cos^2 45$

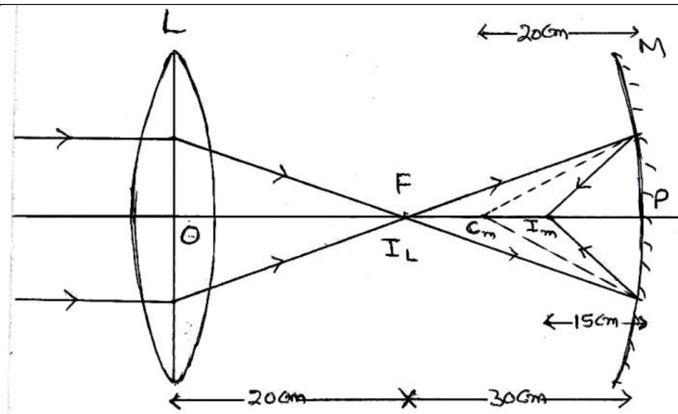
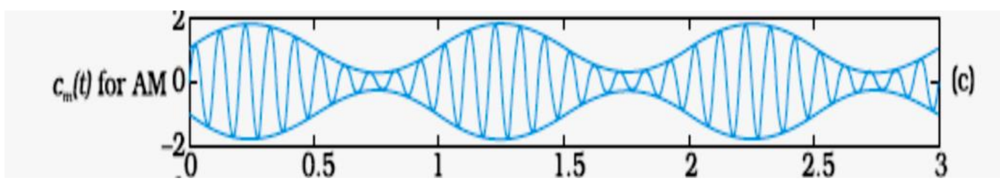
$= \frac{I_o}{2} \cdot \frac{1}{2} = \frac{I_o}{4}$ ½

Intensity of light through $P_3 = \frac{I_o}{4}\cos^2 45 = \frac{I_o}{4} \times \frac{1}{2} = \frac{I_o}{8}$ ½

[**Note**: If the students takes the intensity of light, transmitted through P_1, as I_o and calculates the intensities, transmitted by P_2 and P_3, as $\frac{I_o}{2}$ and $\frac{I_o}{4}$, respectively, award ½ + ½ = 1 mark only.]

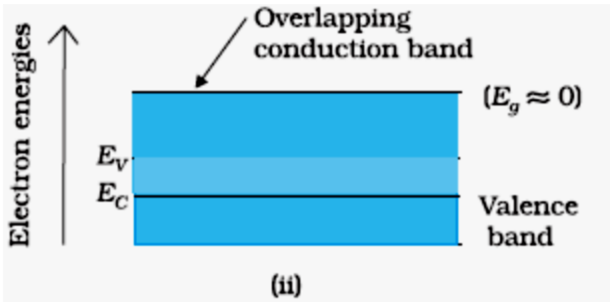
3

22.	**Definition 1** **Derivation 2** Self inductance : It is equal to the magnetic flux, linked with the solenoid, when a unit current passes through it. ***Alternatively*** It is equal to the induced emf in the solenoid when the current, through the solenoid itself , changes at a unit rate. Energy stored U = $\int_o^I Eidt$ Here $\lvert E \rvert = L\frac{di}{dt}$ U = ∴ $U = \int_o^I L\frac{di}{dt} \times idt = \int_o^I Lidi$ ∴ U = $\frac{1}{2}LI^2$	1 ½ 1 ½	3
23.	Values displayed 2 Diagnosis 1 (a) keen observer/ helpful/ concerned / responsible/ respectful towards elders. (**Any two**) (b) The doctor can trace and observe, the difference between the movement of an appropriate radio- isotope through a normal brain and a brain having tumor in it. [**Note** : Also accept any other appropriate explanation.]	1+1 1	3
24.	Position of final image formed by the lens mirror combination 2 Ray diagram 1 For the lens $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ As u is infinity, v = 20cm For the concave mirror, the image, formed by the lens, acts as the object. Hence, u = - (50 – 20)cm = -30cm Also, *f* = -10cm $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ $-\frac{1}{10} = \frac{1}{v} - \frac{1}{30}$ ∴ v = -15cm The final image is, therefore, at a distance of 15cm to the left of the concave mirror(or at a distance of 35cm to the right of the convex lens)	½ ½ ½ ½	

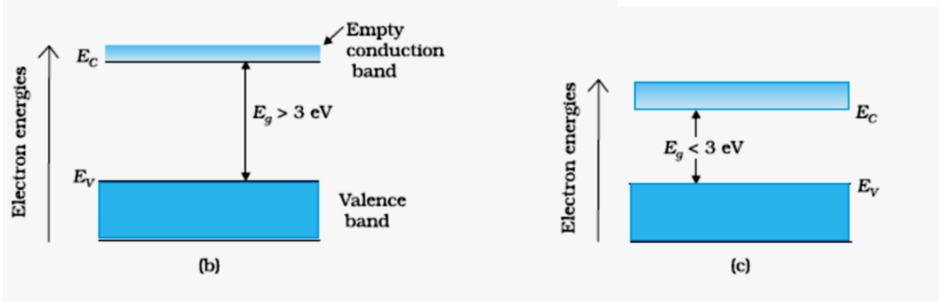
		1	3
25.	Two basic modes of communication ½ + ½ Process of Amplitude Modulation 1 Schematic Sketch 1 Two basic modes of communication are i. Point – to –point ii. Broadcast In Amplitude modulation the amplitude of a carrier wave is made to vary, with time, in the same way as the modulating signal varies with time 	 ½ ½ 1 1	3
26.	Formula ½ Calculation of debroglie wavelength 2 Comparison ½ $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$ or $\lambda = \frac{12.27}{\sqrt{V}} A^o$ $\therefore \lambda = \frac{6.63 \times 10^{-34}}{\sqrt{(2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 50 \times 10^{3})}}$ $\boldsymbol{\lambda}= 5.33\times 10^{-12}$m The resolving power of an electron microscope is much better than that of optical microscope. [**Note** : If the student writes R.P $\alpha \frac{1}{\lambda}$, award this ½ mark]	 ½ 1 1 ½	3

27.

Energy band diagrams	1 ½
Two distinguishing features	1 ½



½



½ + ½

Two distinguishing features:

(i) In conductors, the valency band and conduction band tend to overlap (or nearly overlap) while in insulators they are seperated by a large energy gap and in semiconductors are separated by a small energy gap. 1

(ii) The conduction band, of a conductor, has a large number of electrons available for electrical conduction. However the conduction band of insulators is almost empty while that of the semi- conductor has only a (very) small number of such electrons avilable for electrical conduction. ½ 3

28.

(a) Expression for frequency	1 ½
Frequency Independent of ‘v’ or energy	½
(b) Sketch of cyclotron	1
Construction	1
Working	1

(a) When a particle of mass ‘m’ and charge ‘q’ , moves with a velocity $\mathbf{v}$, in a uniform magnetic field $\boldsymbol{B}$, it experiences a force $\boldsymbol{F}$ where

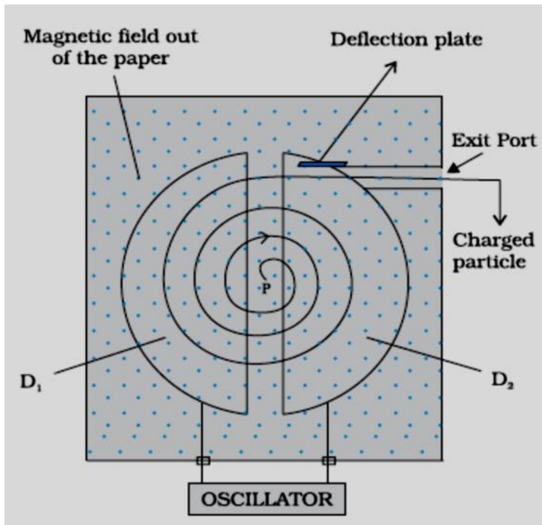
$$\vec{F} = q\,(\vec{v} \times \vec{B})$$ ½

$\therefore$ Centripetal force $\frac{mv^2}{r} = 2\ v\ B_\perp$

$\therefore r = \frac{mv}{qB_\perp}$ ½

$\therefore$ frequency = $\frac{v}{2\pi r} = \frac{qB_\perp}{2\pi m}$ ½

$\therefore$It is independent of the velocity or the energy of the particle. ½



1

<u>Construction</u>: The cyclotron is made up of two hollow semi-circular disc like metal containers, D_1 and D_2, called dees.
It uses crossed electric and magnetic fields. The electric field is provided by an oscillator of adjustable frequency.

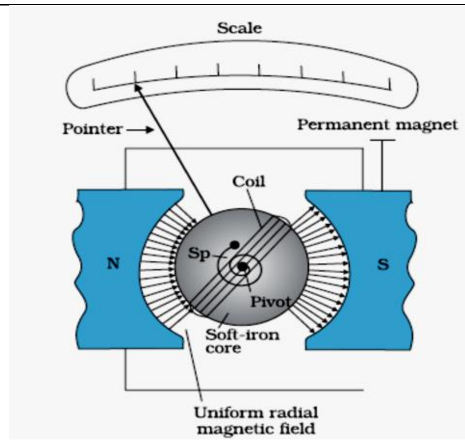
[**Note**: Award this mark even if the student labels the diagram properly without writing the details of the construction.] 1

<u>Working</u>: In a cyclotron, the frequency of the applied alternating field is adjusted to be equal to the frequency of revolution of the charged particles in the magnetic field. This ensures that the particles get accelerated every time they cross the space between the two dees. The radius of their path increases with increase in energy and they are finally made to leave the system via an exit slit. 1

5

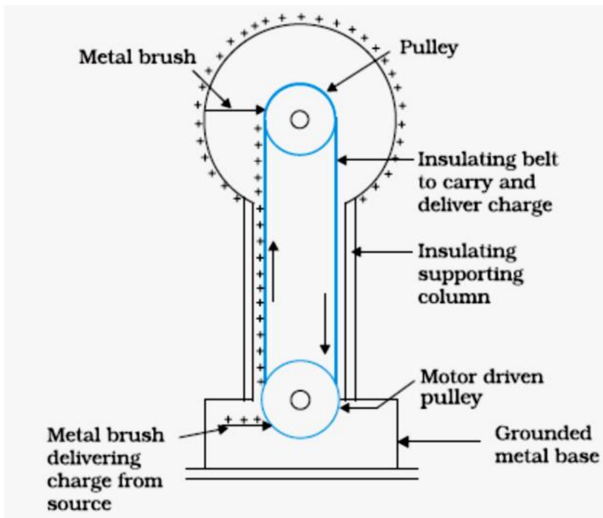
OR

(a)	Labelled diagram	1
	Principle and working	2
(b)	i) Reason for cylindrical soft iron core	1
	ii) Comparison of current sensitivity and voltage sensitivity	1

		1	
	Principle and working : A current carrying coil, placed in a uniform magnetic field, (can) experience a torque Consider a rectangular coil for which no. of turns = N, Area of cross- section = l×b=A, Intensity of the uniform magnetic field=B, Current through the coil=I ∴ Deflecting torque = $BIL \times b = BIA$ $For\ N\ turns$ τ =NBIA	½	
	Restoring torque in the spring = kθ (k=restoring torque per unit twist) $\therefore NBIA = k\theta$ $\therefore I = \left(\frac{k}{NBA}\right)\theta$	½	
	$\therefore I \propto \theta$	½	
	The deflection of the coil, is, therefore, proportional to the current flowing through it.	½	
	(b) (i) The soft iron core not only makes the field radial but also increases the strength of the magnetic field. [**Note**:- Award this one mark even if the student writes just one of the two reasons given above)	**1**	
	(ii) We have Current sensitivity = $\frac{\theta}{I}$ = NBA/k Voltage sensitivity = $\frac{\theta}{V} = \frac{\theta}{IR} = \left(\frac{NBA}{k}\right) . \frac{1}{R}$	½	
	It follows that an increase in current senstivity may not necessarily increase the voltage sensitivity.	½	5

29.

Diagram	2
Principle and working	2
Use and limitation	½ + ½

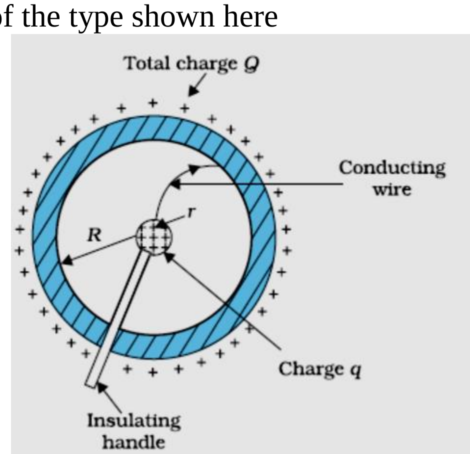


2

[**Note** : Award 1 mark only if the diagram is not labelled]

Principle & working

Consider a set up of the type shown here



i. Potential inside and on the surface, of the conducting sphere pf radius 'R':

$V_R' = \frac{1}{4\pi\epsilon_o}.\frac{Q}{R}$

ii. Potential due to small sphere of radius 'r' carrying a charge 'q':

At the surface of the smaller sphere : $V_r' = \frac{1}{4\pi\epsilon_o}.\frac{q}{r}$ ½

At the surface of the larger sphere : $V_R'' = \frac{1}{4\pi\epsilon_o}.\frac{Q}{R}$

∴ The difference of potential between the smaller and the larger sphere:

$=\Delta V = \frac{1}{4\pi\epsilon_o}.\left[\left(\frac{Q}{R}+\frac{q}{r}\right)-\left(\frac{Q}{R}+\frac{q}{r}\right)\right]$ ½

$= \frac{q}{4\pi\epsilon_o}\left(\frac{1}{r} - \frac{1}{R}\right)$

When 'q' is positive, the inner sphere would always be at a higer potential with respect to outer sphere, irrespective of the amount of charges on the two. ½

∴ When both the spheres are connected, charge will flow from the smaller sphere to the larger sphere. Thus for a set up of the type shown, charge would keep on pilling up on the larger sphere. ½

Use : This machine is used to accelerate charged particles (electron, protons, ions) to high energies. ½

Limitation:It can build up potentials upto a few million volts only. ½ — 5

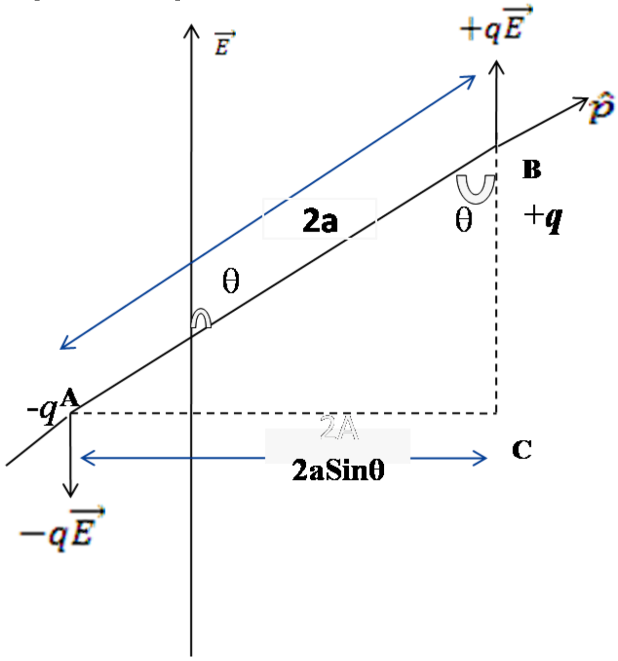
OR

(a)	Deducing the expression for torque	2
(b)	Finding the ratio of the flux through the two spheres	2
(c)	Finding the change in flux	1

(a)

The forces, acting on the two charges of the dipole, are ½

$+q\vec{E}$ and $-q\vec{E}$



½

The net force on the dipole is zero.

The two forces, however, equivalent to a torque having a magnitude

$\tau = (qE)AC$

$= qE.\ 2a \sin\theta$

$= pE \sin\theta$ ½

The direction of this torque is that of the cross product $(\vec{p} \times \vec{E})$. Hence, the torque acting on the dipole, is given by

$$\vec{\tau} = \vec{p} \times \vec{E}$$ ½

(b)

As per Guass's Theorem

Electric Flux = $\oint_S \vec{E}.\vec{dS} = \frac{q_{enclosed}}{\epsilon_o}$ ½

∴ For sphere S_1, flux enclosed = $\phi_1 = \frac{2Q}{\epsilon_o}$ ½

For sphere S_2, flux enclosed = $\phi_2 = \frac{2Q+4Q}{\epsilon_o} = \frac{6Q}{\epsilon_o}$ ½

∴ $\frac{\phi_1}{\phi_2} = \frac{1}{3}$ ½

When a medium of dielectric consistent ϵ_r is introduced in sphere S_1 the flux through S_1 would be $\phi_1' = \frac{2Q}{\epsilon_r}$ 1

[Also award this mark if the student writes $\phi_1 = \frac{2Q}{\epsilon_o \epsilon_r}$]

[**Note** : If the student just writes that the flux through S_1 decreases, award ½ mark only.] 5

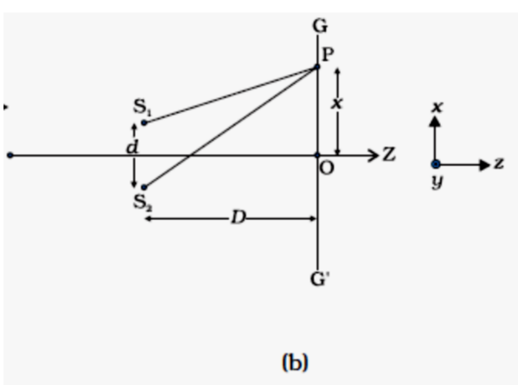
30.

(a) Formation of bright and dark fringes	1
Obtaining the expression for fringe width	3
(b) Finding the ratio	1

(a) The light rays from the two (coherent) slits, reaching a point 'P' on the screen, have a path difference ($S_2P - S_1P$).The point 'P' would, therefore be a

i. Point of maxima(bright fringe), if $S_2P - S_1P = n\lambda$. ½

ii. Point of minima (dark fringe), if $S_2P - S_1P = (2n+1)\frac{\lambda}{2}$ ½



½

We have

$(S_2P)^2 - (S_1P)^2 = \left\{D^2 - \left(x+\frac{d}{2}\right)^2\right\} - \left\{D^2 + \left(x-\frac{d}{2}\right)^2\right\}$

= 2xd

$S_2P - S_1P = \frac{2xd}{S_2P + S_1P} \approx \frac{2xd}{2D} = \frac{xd}{D}$ ½

∴ We have maxima at points, where

$$\frac{xd}{D} = n\lambda$$ ½

and minima at points where

$$\frac{xd}{D} = \left(\frac{2n+1}{2}\right)\lambda$$ ½

Now, fringe width $\boldsymbol{\beta}$= separation between two successive maxima(or two successive minima) = $x_n - x_n - 1$ ½

$$\therefore \boldsymbol{\beta} = \frac{\lambda D}{\boldsymbol{d}}$$ ½

(b) We have

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{25}{9}$$ ½

$$\therefore = \frac{a_1}{a_2} = \frac{4}{1}$$

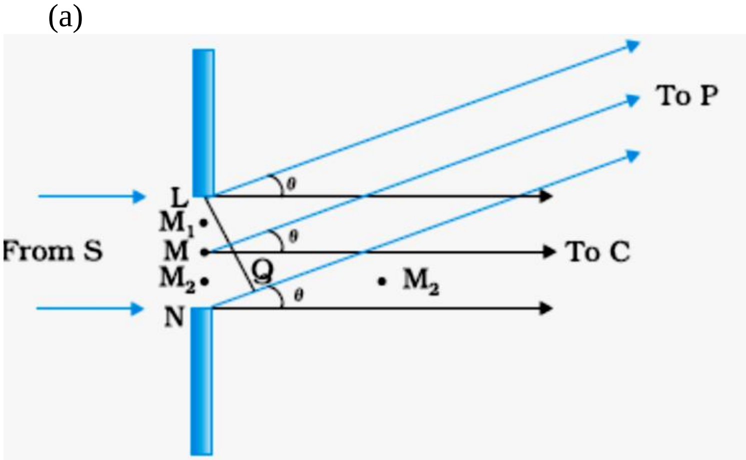
$$\therefore \frac{W_1}{W_2} = \frac{I_1}{I_2} = \frac{(a_1)^2}{(a_2)^2} = \frac{16}{1}$$ ½

[**Note:** Give ½ mark if the student just writes Intensity ∝ width 5

OR

a)	Obtaining the diffraction pattern	1 ½
	Conditions for angular width	1 ½
b)	Calculation of separation	2

(a)



½

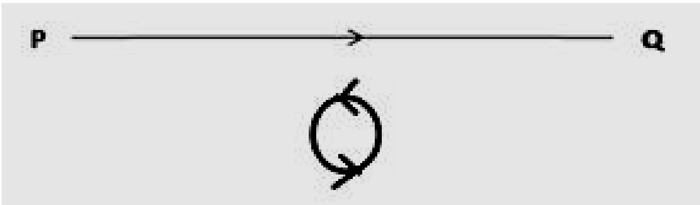
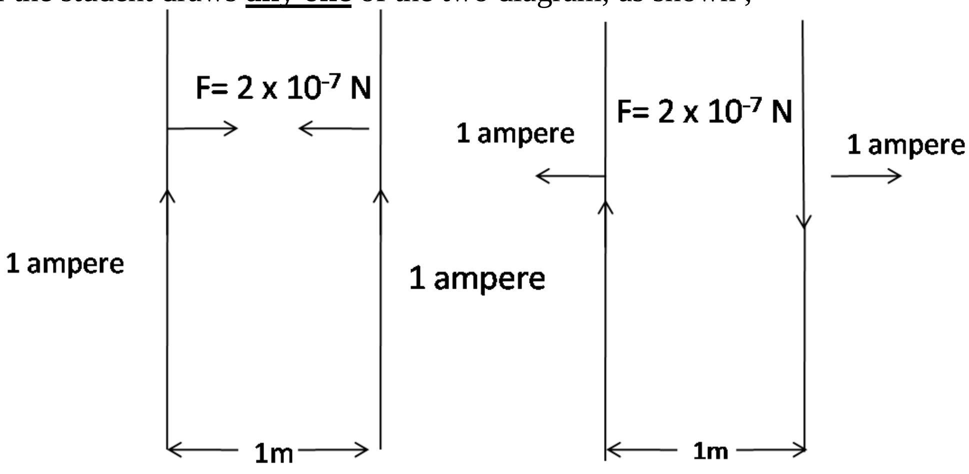
The path difference (NP-LP) , between the two edges of the slit, is given by

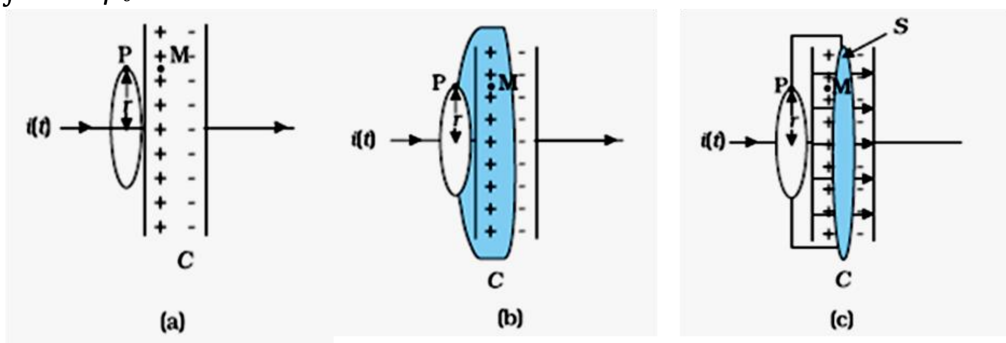
NP-LP ≅ NQ = a sinθ ≈ $a\theta$ ½

We, therefore, get maxima and minima, at different points of the screen, depending on the path difference between the contributions from the wavelets, emanating from different points of the slit. This results in a ½

	diffraction pattern on the screen. The path difference between two points M_1 , M_2, in the slit plane, seperated by a distance 'y', is yθ. At the central point, 'C', on the screen, 'θ' is zero. All parts of the slit contribute in phase Hence 'C' is a maximum. At all points where '$\theta' \cong (n+\frac{1}{2})\frac{\lambda}{a}$, we get (secondary) maxima of varying intensity. This is because of the non-zero contribution of a (decreasing)part of the slit at these points. At all points where $\theta \approx \frac{n\lambda}{a}$, we get minima. This is because of a net (almost) zero contribution of the whole slit at these points. [**Note** : Please also accept alternative correct diagram with appopriate explanation.] (b) Angular width of the secondary maxima $\approx 2(2n+1)\frac{\lambda}{a}$ ∴ Linear width = $[(2n+1)\frac{\lambda}{a}]$ D ∴ Linear seperation, between the first maxima (n=1) of the two wavelengths, on the screen, is $\frac{3(\lambda_2-\lambda_1)}{a} \times D$ ∴ Seperation = $\frac{3(596-590)\times10^{-9}}{2\times10^{-6}} \times 1.5m$ = 13.5 x $\times 10^{-3}$m (= 13.5 mm)	½ ½ ½ ½ ½ 1	5

MARKING SCHEME
SET 55/3

Q. No.	Expected Answer / Value Points	Marks	Total Marks
1.	Anticlockwise 	1	1
2.	Metal A The minimum frequency, at which photoemission starts, is more for metal A **Alternatively:** Work function of A is more.	½ ½	1
3.	**Definition :** One ampere is the value of steady current which when maintained in each of the two very long, straight, parallel conductors of negligible cross section and placed one metre apart in vaccum, would produce on each of these conductors a force equal of 2 x 10^{-7} N/m of its length. ***Alternatively*** If the student writes F = $\frac{\mu_o}{2\pi}\ \frac{I_1 I_2}{R}$L and says that when $I_1 = I_2 = 1\ ampere$ R= 1 meter and L = 1 meter, then F= 2 x 10^{-7} N ***Award full 1 mark*** ***Alternatively*** If the student draws **<u>any one</u>** of the two diagram, as shown ,  ***Award full 1 mark***	1	1
4.	As a diverging lens Light rays diverge on going from a rarer to a denser medium. [***Alternatively*** Also accept the reason given on the basis of lens marker's formula.]	½ ½	1
5.	At the point of intersection of the two field lines, there will be two directions for the electric field. This is not acceptable.	1	1
6.	Short radio waves (or) microwaves	1	1

7.	Neutrinos are neutral (chargeless), (almost) massless particles that hardly interact with matter. ***Alternatively*** The neutrinos can penetrate large quantity of matter without any interaction **OR** Neutrinos are chargeless and (almost) massless particles.	1	1
8.	<u>**Any two**</u> of the following (or any other correct) reasons : i. AC can be transmitted with much lower energy losses as compared to DC ii. AC voltage can be adjusted (stepped up or stepped down) as per requirement. iii. AC current in a circuit can be controlled using (almost) wattless devices like the choke coil. iv. AC is easier to generate.	½ + ½	1
9.	Statement of Ampere's circuital law ½ Showing inconsistency during the process of charging 1 Displacement Current ½ According to Ampere's circuital Law $\oint \vec{B} d\vec{l} = \mu_0 I$	½	
		½	
	Applying ampere's circuital law to fig (a) we see that, during charging, the right hand side in Ampere's circuital law equals $\mu_0 I$ However on applying it to the surfaces of the fig (b) or fig (c), the right hand side is zero. Hence, there is a contradiction.	½	
	We can remove the contradiction by assuming that there exists a current (associated with the changing electric field during charging), known as the displacement current.	½	
	When this current ($= \frac{d\phi_E}{dt}$) is added on the right hand side, Ampere's circuital law, the inconsisitency disappears. It was, therefore necessary, to generalize the Ampere's circuital law, as $\oint \vec{B} d\vec{l} = \mu_0 I_c + \mu_0 \in_o \frac{d\phi_E}{dt}$ [**Note** : If the student does the reasoning by using the (detailed) mathematics, relevant to displacement current, award full 2 marks]		2

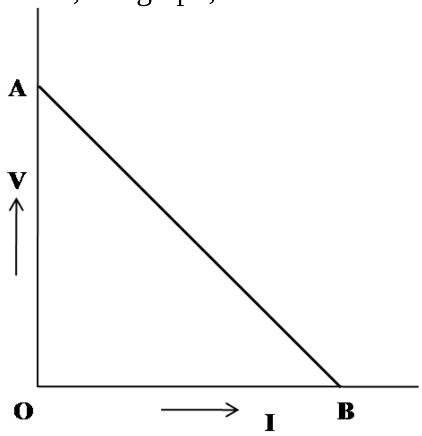
<table>
<tr><td>10.</td><td>Formula ½
Calculation of drift velocity 1 ½

$I = AneV_d$

$V_d = \frac{2.7}{2.5\times10^{-7}\times1.6\times10^{-19}\times9\times10^{28}}$

$= 7.5 \times 10^{-4}$ m/s</td><td>½

½
1</td><td>2</td></tr>
<tr><td>11.</td><td>Relation between V and I ½
Graph ½
Determination of emf and internal resistance ½ + ½

The relation between V and I is
V = E – Ir
Hence, the graph, between V and I, has the form shown below.


For point A, I=0, Hence, $V_A= E$
For point B, V=0, Hence, $E=I_Br$
Therefore, $r = \frac{E}{I_B}$
<u>Alternatively</u>: emf (E) equals the intercept on the vertical axis. Internal resistance (r) equals the negative of the slope of the graph.</td><td>½

½

½

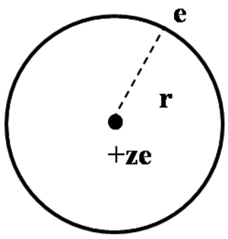
½</td><td>2</td></tr>
<tr><td>12.</td><td>Formula for energy stored ½
New value of capacitance ½
Calculation of ratio 1

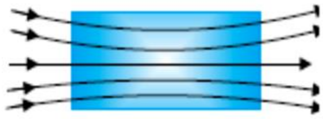
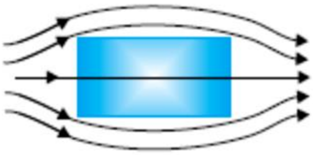
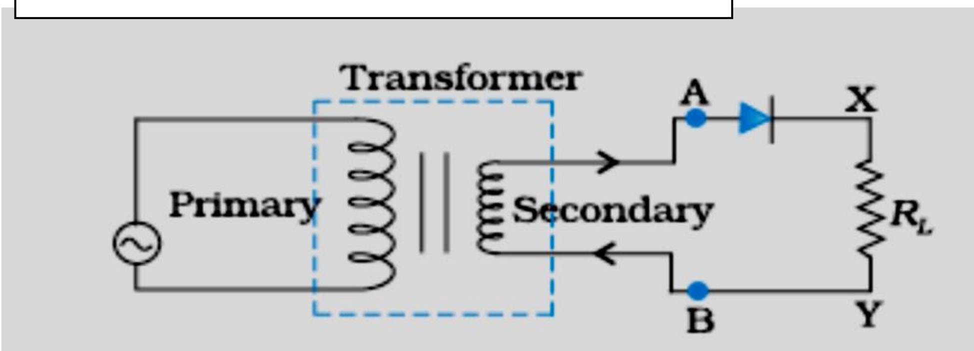
Energy stored in a capacitor = $\frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$ (any one)
Capacitance of the (parallel) combination = C+C=2C
Here, total charge, Q, remains the same
∴ initial energy = $\frac{1}{2}\frac{Q^2}{C}$
And final energy = $\frac{1}{2}\frac{Q^2}{2C}$
∴ $\frac{final\ energy}{initial\ energy} = \frac{1}{2}$
[Note : If the student does the correct calculations by assuming the voltage across the</td><td>½

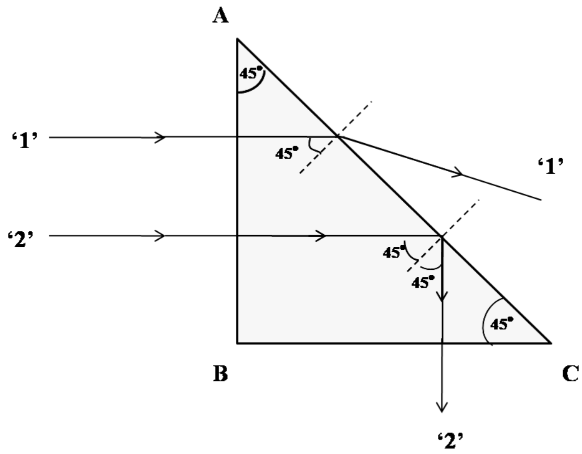
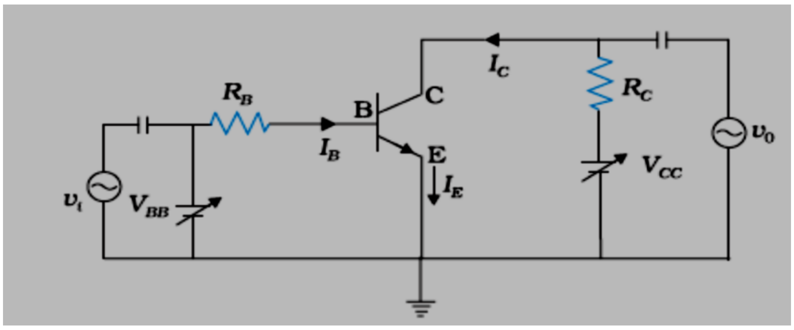
½

½

½</td><td></td></tr>
</table>

	(i) Parallel or (ii) Series combination to remain constant (=V) and obtain the answers as (i) 2:1 or (ii) 1:2 , award full marks]		2
13.	Derivation of energy expression 1 ½ Significance of negative sign ½		
	As per Rutherford's model $\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_o}\ \frac{ze^2}{r^2}$		
	 		
	⇨ $mv^2 = \frac{1}{4\pi\epsilon_o}\ \frac{ze^2}{r}$	½	
	Total energy = P.E +K.E. $= -\frac{1}{4\pi\epsilon_o}\ \frac{ze^2}{r} + \frac{1}{2}\ mv^2$	½	
	$= -\frac{1}{2}.\frac{1}{4\pi\epsilon_o}\ \frac{ze^2}{r} = = -\frac{1}{8\pi\epsilon_o}\ \frac{ze^2}{r}$	½	
	Negative Sign implies that Electron – nucleus form a bound system. ***Alternatively*** Electron – nucleus form an attractive system)	½	2
	OR		
	Bohr's Postulate ½ Derivation of radius of nth orbit 1 Bohr's radius ½		
	For the electron, we have Bohr's Postulate ($mvr = \frac{nh}{2\pi}$)	½	
	$\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_o}\ \frac{ze^2}{r^2}$ and $mvr = \frac{nh}{2\pi}$ $\therefore m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}$	½	
	and $mv^2r = \frac{1}{4\pi\epsilon_o} ze^2$	½	
	$\therefore$ r = $\frac{\epsilon_o n^2h^2}{\pi ze^2 m}$	½	
	Bohr's radius (for n = 1) = $\epsilon_o\ \ h^2/\pi ze^2m$		2

14.	Diagrams ½ + ½ Explanations ½ + ½   A <u>paramagnetic</u> material tends to move from weaker to stronger regions of the magnetic field and hence increases the number of lines of magnetic field passing through it. [***Alternatively:*** A <u>paramagnetic</u> material, dipole moments are induced in the direction of the field.] A <u>diamagnetic</u> material tends to move from stronger to weaker regions of the magnetic field and hence, decreases the number of lines of magnetic field passing through it. [***Alternatively:*** A <u>diamagnetic</u> material, dipole moments are induced in the opposite direction of the field.] [**Note**: If the student just writes that a paramagnetic material has a small positive susceptibility $(0 < X < \varepsilon)$ and a diamagnetic material has a negative susceptibility $(-1 \leq X < 0)$, award the ½ mark for the second part of the question.]	½ ½ ½ ½	2
15.	Circuit diagram 1 Working 1  **<u>Working</u>:** During one half of the input AC, the diode is forward biased and a current flows through R_L. During the other half of the input AC, the diode is reverse biased and no current flows through the load R_L. Hence, the given AC input is rectified [**Note** : If the student just draws the waveforms, for the input AC voltage and output voltage (without giving any explanation) (award ½ mark only for "working")	1 ½ ½	2

16.	Tracing the path of the two rays 1 + 1  [**Note** : If the student just writes that angle of incidence for both rays '1' and '2' on face AC = 45^o and says that it is less than critical angle for ray '1' (which therefore gets refracted) and more than critical angle for ray '2' (which undergoes total internal reflection) ***Award ½ + ½ marks***	1 1	2
17.	Circuit diagram 1 ½ Condition ½  **Condition :** The transistor must be operated close to the centre of its active region. ***Alternatively*** The base- emitter junction of the transistor must be (suitably) forward biased and the collector – emitter junction must be (suitably) reverse biased.	1 ½ ½	2
18.	Function of receiver 1 Function of Demodulator 1 <u>Receiver:</u> It extracts the desired message signals from the received signals at the channel output. <u>Demodulator:</u> It is a device to retrieve information (or) the message signal from the carrier wave at the receiver.	1 1	2

<table>
<tr><td>19.</td><td>

Position of the final image (formed by the lens-mirror combination)	2
Ray diagram	1

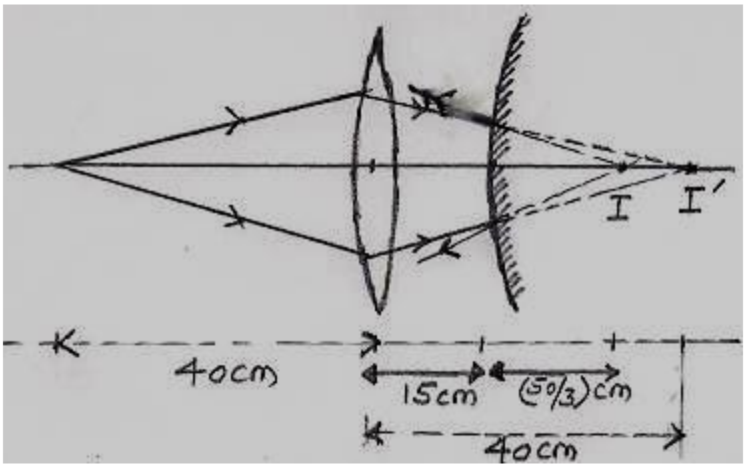
For the lens:

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

U= - 40 cm, f= +20 cm This gives v= + 40cm
This image acts as a (virtual) object for the convex mirror
$\therefore u = (+40 - 15)cm = 25cm$
Also f= + $\frac{20}{2} cm = +10\ cm$
From
$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$
We get

$$v = \frac{50}{3} cm \simeq 16.67cm$$

The final image is, therefore formed at a distance of 16.67 cm($\frac{50}{3} cm$) to the right of the convex mirror.
(at a distance of 31.67 cm (=$\frac{95}{3} cm$) to the right of the convex lens.



</td><td>½

½

½

½

1</td><td>3</td></tr>
<tr><td>20.</td><td>

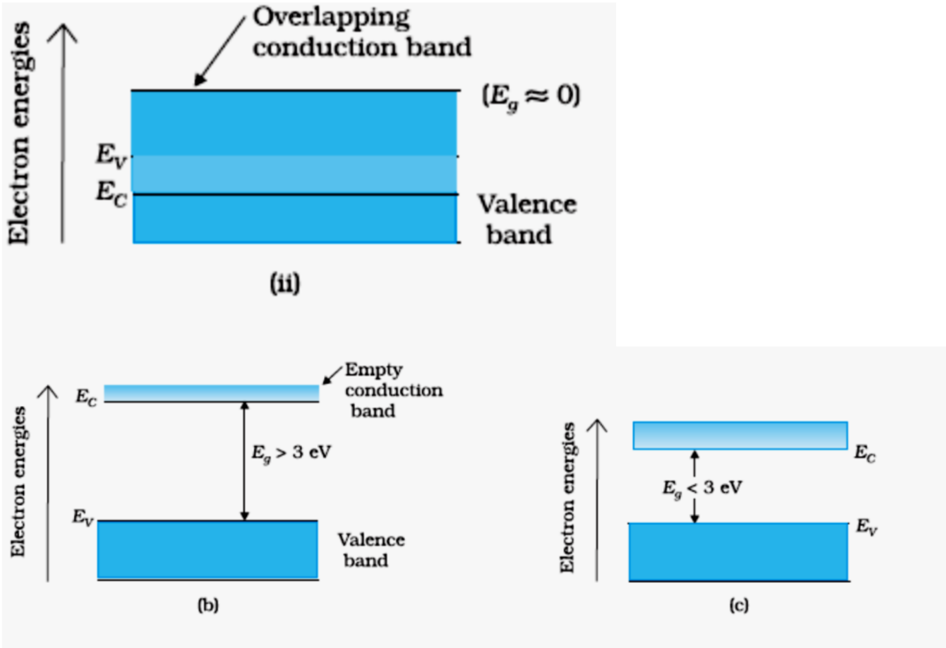
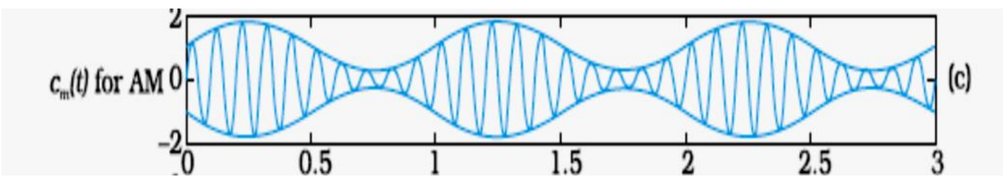
Formula	½
Calculation of debroglie wavelength	2
Comparison	½

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$ or $\lambda = \frac{12.27}{\sqrt{V}} A^o$

$\therefore \lambda = \frac{6.63 \times 10^{-34}}{\sqrt{(2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 50 \times 10^3)}}$

$\boldsymbol{\lambda}$= 5.33× 10^{-12}m
The resolving power of an electron microscope is much better than that of optical microscope.
[**Note** : If the student writes R.P $\alpha \frac{1}{\lambda}$, award this ½ mark]

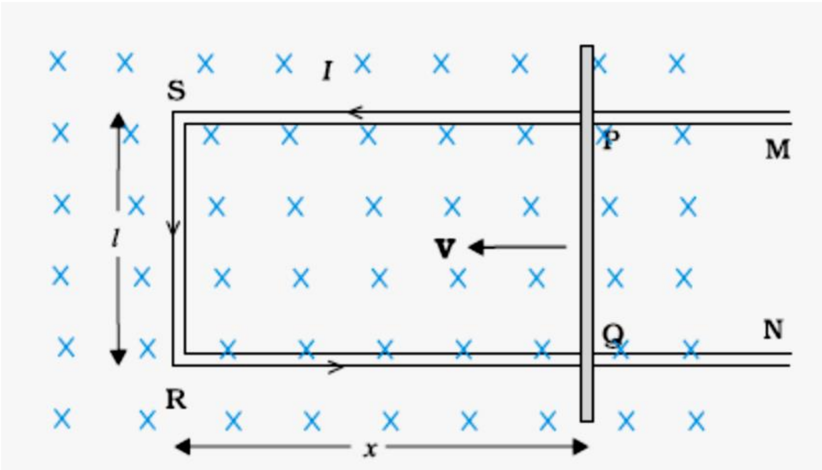
</td><td>½
1
1
½</td><td>3</td></tr>
</table>

21.	Energy band diagrams 1 ½ Two distinguishing features 1 ½  **Two distinguishing features:** (i) In conductors, the valency band and conduction band tend to overlap (or nearly overlap) while in insulators they are seperated by a large energy gap and in semiconductors are separated by a small energy gap. (ii) The conduction band, of a conductor, has a large number of electrons available for electrical conduction. However the conduction band of insulators is almost empty while that of the semi- conductor has only a (very) small number of such electrons avilable for electrical conduction.	½ ½ + ½ 1 ½	3
22.	Two basic modes of communication ½ + ½ Process of Amplitude Modulation 1 Schematic Sketch 1 Two basic modes of communication are i. Point – to –point ii. Broadcast In Amplitude modulation the amplitude of a carrier wave is made to vary, with time, in the same way as the modulating signal varies with time 	½ ½ 1 1	3

23.	Answers to each of the three parts 1+1+1=3		
	a) This is to ensure that the connections do not contribute any extra, unknown, resistances in the circuit.	1	
	b) This is done to minimize the percentage error in the value of the unknown resistance. [***Alternatively:*** This is done to have a better " balancing out" of the effects of any irregularity or non-uniformity in the metre bridge wire. **Or** This can help in increasing the senstivity of the metre bridge circuit.]	1	
	c) Manganian / constantan /Nichrome This material has a low temperature **(any one)** of coefficient of resistance/ high reisistivity.	½ + ½	3
	OR		
	Calculation of total resistance of the circuit 1 Calculation of total current drawn from the voltage Source ½ Calculation of current through R 1 Calculation of potential drop across R ½		
	$R_{total} = \frac{R_o}{2} + \frac{\frac{R_o}{2}.R}{\frac{R_o}{2}+R}$	½	
	$= \frac{R(R_o + 4R)}{2(R_o + 2R)}$		
	$I_{(total)} = \frac{V}{R_{total}}$	½	
	Current through R = $I_2 = I_{total} \times \frac{\frac{R_o}{2}}{\frac{R_o}{2}+R}$	½	
	$= I_{total} \times \frac{R_o}{R_o+2R}$	½	
	$= \frac{V.2(R_o+2R)}{R(R_o+4R)} \times \frac{R_o}{R_o+2R}$		
	$= \frac{2VR_o}{R(R_o+4R)}$	½	
	Voltage across R = $I_2 R = (\frac{2VR_o}{R_o+4R})$	½	3
24.	Values displayed 2 Diagnosis 1		
	(a) keen observer/ helpful/ concerned / responsible/ respectful towards elders. (**Any two**)	1+1	
	(b) The doctor can trace and observe, the difference between the movement of an appropriate radio- isotope through a normal brain and a brain having tumor in it. [**Note** : Also accept any other appropriate explanation.]	1	3

25.

(a) Deriving the expression for the induced emf	2
(b) Understanding motional emf in terms of Lorentz force	1



½

(a) Imagine the rod PQ to be moving with a velocity **v** from its initial (varying) position towards some position SR.
The magnetic flux, enclosed by the loop PQRS , at the instant shown,is

$\varphi = Blx$ ½

$\therefore e = -\frac{d\varphi}{dt} = -Bl\frac{dx}{dt}$ ½

$= Blv \quad (\because v = -\frac{dx}{dt})$ ½

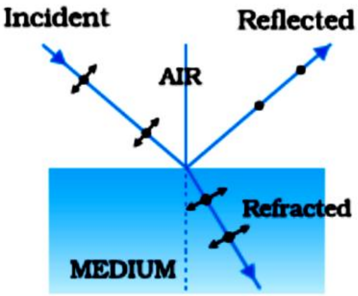
(b) Lorentz force, on a charge q, moving with a speed v, in a (normal) uniform magnetic field B, is Bqv
All charges experience the same force. Work done to move the charge from P to Q, is W = Bqv× l ½

$$\therefore e = \frac{W}{q} = \frac{Bqvl}{q} = Blv$$ ½ **3**

26.

a) Polarization by reflection	1 ½
b) Intensity of light passing through P_1, P_2, P_3	½ + ½ + ½

(a) When unpolarised light is incident on the boundary between two transparent media, the reflected light gets plane polarized with its electric vector perpendicular to the plane of incidence. ½

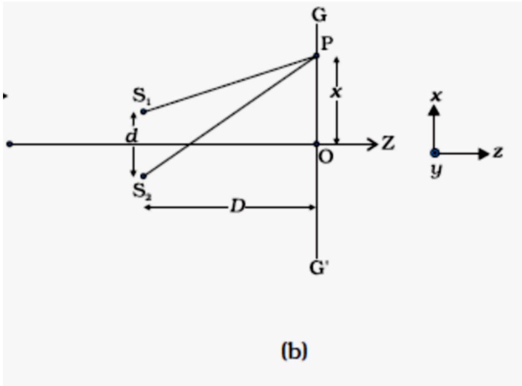


½

	The polarization is complete when the reflected and refracted rays are at right angles to each other. This condition occurs for an angle of incidence, i_p, where $\tan i_p = \mu$ [**Note** : Award this 1 mark even if the student writes about Brewster's law and says that the reflected light is totally polarised when the angle of incidence, i_p equals $\tan^{-1}\mu$ (b) Intensity of light through $P_1 = \frac{I_o}{2}$ Intensity of light through $P_2 = \frac{I_o}{2}\cos^2 60$ $= \frac{I_o}{2} \cdot \left(\frac{1}{2}\right)^2 = \frac{I_o}{8}$ Intensity of light through $P_3 = \frac{I_o}{8}\cos^2 30 = \frac{I_o}{8} \times \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3I_o}{32}$ [**Note**: If the students takes the intensity of light, transmitted through P_1, as I_o, and calculates the intensity of light, transmitted by P_2 and P_3, as $\frac{I_o}{4}$ and $\frac{3I_o}{16}$, award ½ + ½ = 1 mark only.]	½ ½ ½ ½	 3
27.	Deriving the expression for average power 2 Condition for no power dissipation ½ Condition for maximum power dissipation ½ Applied voltage = $V_0 \sin\omega t$ Current in the circuit $= I_o \sin(\omega t - \phi)$ where ϕ is the phase lag of the current with respect to the voltage applied , Hence instantaneous power dissipation $= V_0 \sin\omega t \times I_o \sin(\omega t - \phi)$ $= \frac{V_0 I_0}{2}[2\sin\omega t . \sin(\omega t - \phi]$ $= \frac{V_0 I_0}{2}[\cos\phi - \cos(2\omega t - \phi]$ Therefore, average power for one complete cycle = average of[$\frac{V_0 I_0}{2}[\cos\phi - \cos(2\omega t - \phi]]$ The average of the second term over a complete cycle is zero . Hence , average power dissipated over one complete cycle = $\frac{V_0 I_0}{2}\cos\phi$ [**Note** : Please also accept alternative correct approach.] Conditions (i) No power is dissipated when R = 0 (or $\phi = 90^o$) [**Note:** Also accepts if the student writes 'This condition cannot be satisfied for a series LCR circuit".] (ii) Maximum power is dissipated when $X_L = X_C$ or $\omega L = \frac{1}{\omega C}$ (or $\phi = 0$)	 ½ ½ ½ ½ ½ ½	 3
28.	(a) Formation of bright and dark fringes 1 Obtaining the expression for fringe width 3 (b) Finding the ratio 1 (a) The light rays from the two (coherent) slits, reaching a point 'P' on the screen, have a path difference ($S_2P - S_1P$).The point 'P' would, therefore be a		

i. Point of maxima(bright fringe), if $S_2P - S_1P = n\lambda$. ½

ii. Point of minima (dark fringe), if $S_2P - S_1P = (2n+1)\frac{\lambda}{2}$ ½



(b)

½

We have

$(S_2P)^2 - (S_1P)^2 = \left\{D^2 - \left(x + \frac{d}{2}\right)^2\right\} - \left\{D^2 + \left(x - \frac{d}{2}\right)^2\right\}$

= 2xd

$S_2P - S_1P = \frac{2xd}{S_2P + S_1P} \approx \frac{2xd}{2D} = \frac{xd}{D}$ ½

∴ We have maxima at points, where ½

$$\frac{xd}{D} = n\lambda$$

and minima at points where

$\frac{xd}{D} = \left(\frac{2n+1}{2}\right)\lambda$ ½

Now, fringe width $\boldsymbol{\beta}$= separation between two successive maxima(or two successive minima) = $x_n - x_n - 1$ ½

∴ $\boldsymbol{\beta} = \frac{\lambda D}{\boldsymbol{d}}$ ½

(b) We have

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{25}{9}$$ ½

$$\therefore = \frac{a_1}{a_2} = \frac{4}{1}$$

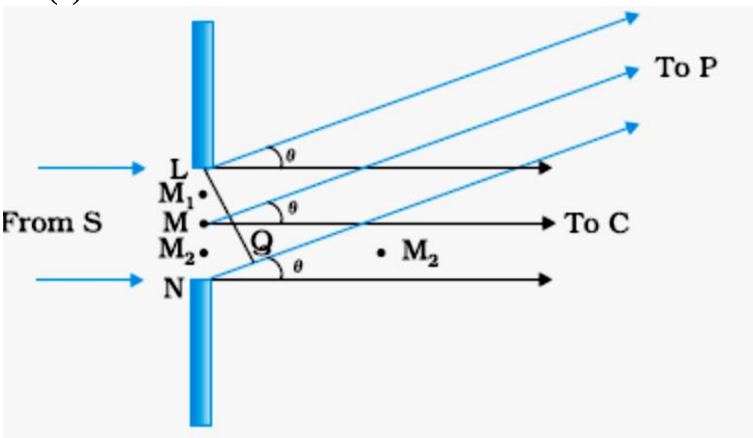
$$\therefore \frac{W_1}{W_2} = \frac{I_1}{I_2} = \frac{(a_1)^2}{(a_2)^2} = \frac{16}{1}$$ ½

[**Note:** Give ½ mark if the student just writes Intensity ∝ width 5

OR

a) Obtaining the diffraction pattern	1 ½
Conditions for angular width	1 ½
b) Calculation of separation	2

(a)



½

The path difference (NP-LP) , between the two edges of the slit, is given by ½

NP-LP ≅ NQ = a sin$\theta \approx a\theta$ ½

We, therefore, get maxima and minima, at different points of the screen, depending on the path difference between the contributions from the wavelets, emanating from different points of the slit. This results in a diffraction pattern on the screen. ½

The path difference between two points M_1 , M_2, in the slit plane, seperated by a distance 'y', is yθ.

At the central point, 'C', on the screen, 'θ' is zero.

All parts of the slit contribute in phase ½

Hence 'C' is a maximum.

At all points where '$\theta' \cong (n + \frac{1}{2})\frac{\lambda}{a}$, we get (secondary) maxima of varying intensity. This is because of the non-zero contribution of a (decreasing)part of the slit at these points. ½

At all points where $\theta \approx \frac{n\lambda}{a}$, we get minima.

This is because of a net (almost) zero contribution of the whole slit at these points. ½

[**Note** : Please also accept alternative correct diagram with appopriate explanation.]

(b) Angular width of the secondary maxima $\approx 2(2n+1)\frac{\lambda}{a}$ ½

∴ Linear width = $[(2n+1)\frac{\lambda}{a}]$ D

∴ Linear seperation, between the first maxima (n=1) of the two wavelengths, on the screen, is

$$\frac{3(\lambda_2 - \lambda_1)}{a} \times D$$

∴ Seperation = $\frac{3(596-590)\times 10^{-9}}{2\times 10^{-6}} \times 1.5m$ 1

= 13.5 x $\times 10^{-3}$m (= 13.5 mm)

5

29.

(a) Expression for frequency	1 ½
Frequency Independent of 'v' or energy	½
(b) Sketch of cyclotron	1
Construction	1
Working	1

(a) When a particle of mass 'm' and charge 'q' , moves with a velocity **v**, in a uniform magnetic field ***B*** , it experiences a force ***F*** where

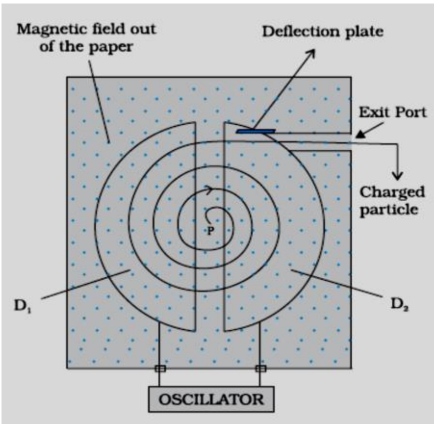
$$\vec{F} = q\,(\vec{v} \times \vec{B})$$ ½

∴ Centripetal force $\frac{mv^2}{r} = 2\, v\, B_{\perp}$ ½

∴ $r = \frac{mv}{qB_{\perp}}$

∴ frequency = $\frac{v}{2\pi r} = \frac{qB_{\perp}}{2\pi m}$ ½

∴It is independent of the velocity or the energy of the particle. ½



1

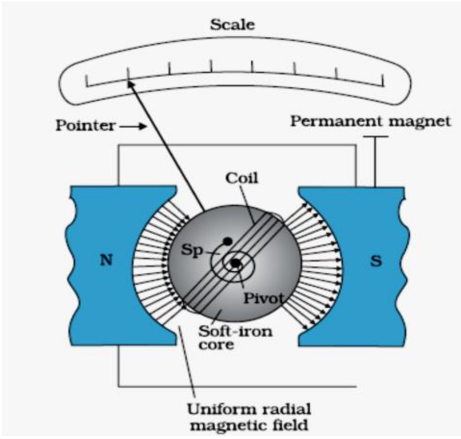
Construction: The cyclotron is made up of two hollow semi-circular disc like metal containers, D_1 and D_2, called dees.
It uses crossed electric and magnetic fields. The electric field is provided by an oscillator of adjustable frequency. 1

[**Note**: Award this mark even if the student labels the diagram properly without writing the details of the construction.]

Working: In a cyclotron, the frequency of the applied alternating field is adjusted to be equal to the frequency of revolution of the charged particles in the magnetic field. This ensures that the particles get accelerated every time they cross the space between the two dees. The radius of their path increases with increase in energy and they are finally made to leave the system via an exit slit. 1 5

OR

(a) Labelled diagram	1
Principle and working	2
(b) i) Reason for cylindrical soft iron core	1
ii) Comparison of current sensitivity and voltage sensitivity	1



1

Principle and working : A current carrying coil, placed in a uniform magnetic field, (can) experience a torque ½

Consider a rectangular coil for which no. of turns = N,
Area of cross- section = l×b=A,
Intensity of the uniform magnetic field=B,
Current through the coil=I

∴ Deflecting torque = $BIL \times b = BIA$

$For\ N\ turns \quad \tau$ =NBIA

Restoring torque in the spring = kθ ½

(k=restoring torque per unit twist)

$$\therefore NBIA = k\theta$$

$$\therefore I = \left(\frac{k}{NBA}\right)\theta$$ ½

$$\therefore I \propto \theta$$

The deflection of the coil, is, therefore, proportional to the current flowing through it. ½

(b) (i) The soft iron core not only makes the field radial but also increases the strength of the magnetic field. **1**

[**Note**:- Award this one mark even if the student writes just one of the two reasons given above)

(ii) We have

Current sensitivity = $\frac{\theta}{I}$ = NBA/k ½

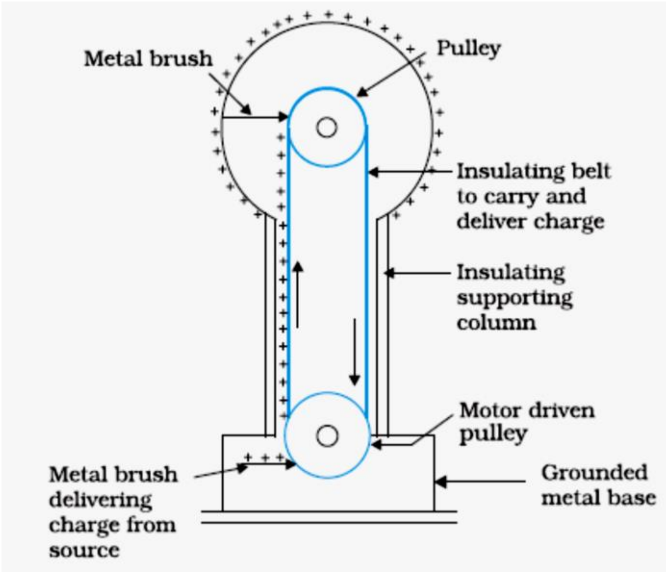
Voltage sensitivity = $\frac{\theta}{V} = \frac{\theta}{IR} = \left(\frac{NBA}{k}\right).\frac{1}{R}$ ½

It follows that an increase in current senstivity may not necessarily increase the voltage sensitivity.

5

30.

Diagram	2
Principle and working	2
Use and limitation	½ + ½

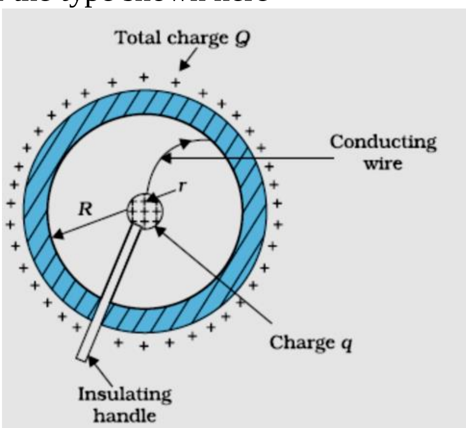


2

[**Note** : Award 1 mark only if the diagram is not labelled]

Principle & working

Consider a set up of the type shown here



i. Potential inside and on the surface, of the conducting sphere pf radius 'R':

$V_R' = \frac{1}{4\pi\epsilon_o} . \frac{Q}{R}$

½

ii. Potential due to small sphere of radius 'r' carrying a charge 'q':

At the surface of the smaller sphere : $V_r' = \frac{1}{4\pi\epsilon_o} . \frac{q}{r}$

At the surface of the larger sphere : $V_R'' = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R}$

∴ The difference of potential between the smaller and the larger sphere:

$=\Delta V = \frac{1}{4\pi\epsilon_0} \cdot \left[\left(\frac{Q}{R} + \frac{q}{r}\right) - \left(\frac{Q}{R} + \frac{q}{R}\right)\right]$ ½

$= \frac{q}{4\pi\epsilon_0}\left(\frac{1}{r} - \frac{1}{R}\right)$

When 'q' is positive, the inner sphere would always be at a higer potential with respect to outer sphere, irrespective of the amount of charges on the two. ½

∴ When both the spheres are connected, charge will flow from the smaller sphere to the larger sphere. Thus for a set up of the type shown, charge would keep on pilling up on the larger sphere. ½

Use : This machine is used to accelerate charged particles (electron, protons, ions) to high energies. ½

Limitation:It can build up potentials upto a few million volts only. ½ 5

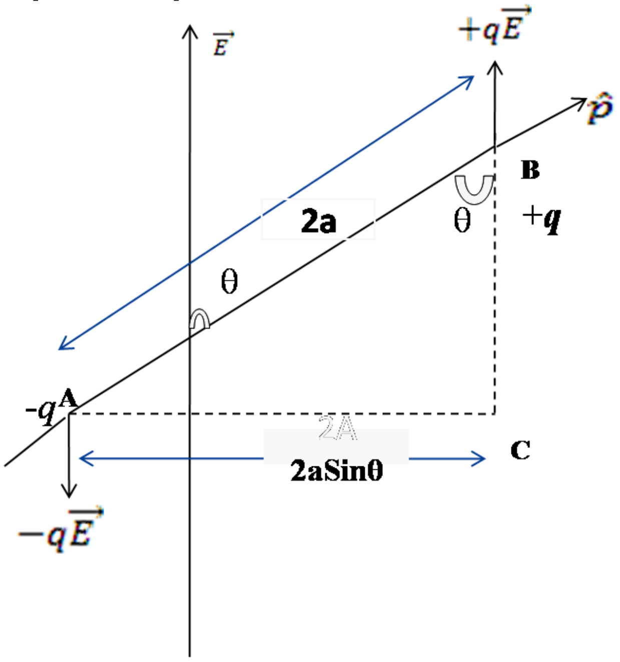
OR

(a)	Deducing the expression for torque	2
(b)	Finding the ratio of the flux through the two spheres	2
(c)	Finding the change in flux	1

(a)

The forces, acting on the two charges of the dipole, are ½

$+q\vec{E}$ and $-q\vec{E}$



½

The net force on the dipole is zero.

The two forces, however, equivalent to a torque having a magnitude

$\tau = (qE)AC$

$= qE.\ 2a \sin\theta$

$= pE \sin\theta$ ½

	The direction of this torque is that of the cross product $(\vec{p} \times \vec{E})$. Hence, the torque acting on the dipole, is given by $\vec{\tau} = \vec{p} \times \vec{E}$ (b) As per Guass's Theorem Electric Flux = $\oint_s \vec{E}.\vec{dS} = \frac{q_{enclosed}}{\epsilon_o}$ ∴ For sphere S_1, flux enclosed = $\phi_1 = \frac{2Q}{\epsilon_o}$ For sphere S_2, flux enclosed = $\phi_2 = \frac{2Q+4Q}{\epsilon_o} = \frac{6Q}{\epsilon_o}$ ∴ $\frac{\phi_1}{\phi_2} = \frac{1}{3}$ When a medium of dielectric consistent ϵ_r is introduced in sphere S_1 the flux through S_1 would be $\phi_1' = \frac{2Q}{\epsilon_r}$ [Also award this mark if the student writes $\phi_1 = \frac{2Q}{\epsilon_o \epsilon_r}$] [**Note** : If the student just writes that the flux through S_1 decreases, award ½ mark only.]	½ ½ ½ ½ ½ 1	5