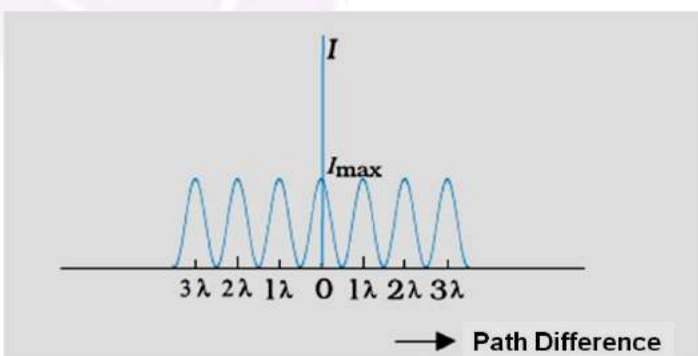
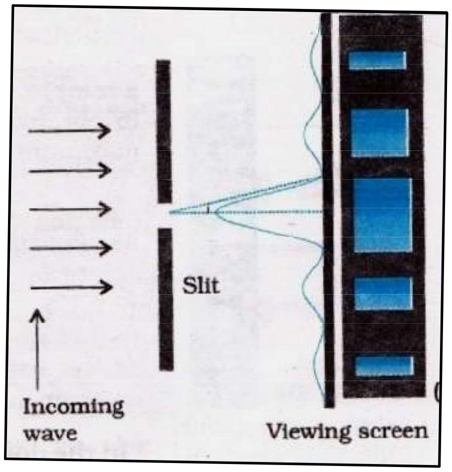
MARKING SCHEME

Q. No.	Expected Answer/ Value Points	Marks	Total Marks
	Section A		
Q1	i. Nichrome ii. $R_{Ni} > R_{Cu}$ (or $Resistivity_{Ni} > Resistivity_{Cu}$)	½ ½	1
Q2	Yes	1	1
Q3	i. Decreases ii. $n_{Violet} > n_{Red}$ (Also accept if the student writes $\lambda_V < \lambda_R$)	½ ½	1
Q4	Photoelectric Effect (/Raman Effect/ Compton Effect)	1	1
Q5	A is positive and B is negative (Also accept: A is negative and B is positive)	½ ½	1
	SECTION B		
Q6	Interference pattern ½ Diffraction pattern ½ Two Differences ½ + ½ 	½	



½

Differences

Interference	Diffraction
All maxima have equal intensity	Maxima have different (/rapidly decreasing) intensity
All fringes have equal width.	Different (/changing) width.
Superposition of two wavefronts	Superposition of wavelets from the same wavefront

(Any two)

½ + ½

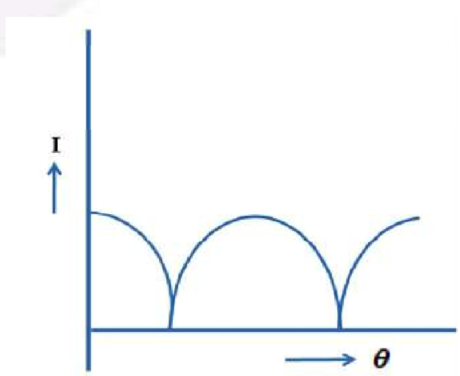
2

OR

Expression for intensity of polarized beam	1
Plot of intensity variation with angle	1

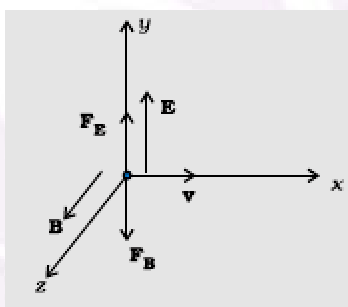
Intensity is $\frac{I_0}{2}\cos^2\theta$ (if I_0 is the intensity of unpolarised light.)
Intensity is $I\cos^2\theta$ (if I is the intensity of polarized light.)
(Award ½ mark if the student writes the expression as $I_0\cos^2\theta$)

1



1

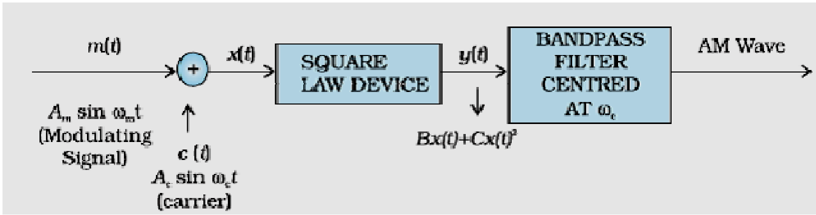
2

Q7	(a) Identification ½ + ½ (b) Uses ½ + ½ (a) X – rays Used for medical purposes. (Also accept UV rays and gamma rays and Any one use of the e.m. wave named) (b) Microwaves Used in radar systems (Also accept short radio waves and Any one use of the e.m. wave named)	 ½ ½ ½ ½	 **2**
Q8	Condition i. For directions of $\vec{E}, \vec{B}, \vec{v}$ 1 ii. For magnitudes of $\vec{E}, \vec{B}, \vec{v}$ 1 (i) The velocity $\vec{v}$, of the charged particles, and the $\vec{E}$ and $\vec{B}$ vectors, should be mutually perpendicular. Also the forces on q, due to $\vec{E}$ and $\vec{B}$, must be oppositely directed. (Also accept if the student draws a diagram to show the directions.)  (ii) $qE = qvB$ $or\ v = \frac{E}{B}$ **[**Alternatively**,** The student may write: Force due to electric field $= q\vec{E}$ Force due to magnetic field $= q\,(\vec{v} \times \vec{B})$ The required condition is $q\vec{E} = -q\,(\vec{v} \times \vec{B})$ $[or\ \vec{E} = -(\vec{v} \times \vec{B}) = (\vec{B} \times \vec{v})]$ (Note: Award 1 mark only if the student just writes: "The forces, on the charged particle, due to the electric and magnetic fields, must be equal and opposite to each other")**]**	 ½ ½ ½ ½ ½ ½ ½ ½	 **2**

Q9	i. Writing $E_n \propto \frac{1}{n^2}$ — ½ ii. Identifying the level to which the electron is emitted. — ½ iii. Calculating the wavelengths and identifying the series of atleast one of the three possible lines, that can be emitted. — ½ + ½ i. We have $E_n \propto \frac{1}{n^2}$ ii. ∴ The energy levels are $-13.6\text{ eV};\ -3.4\text{ eV}; -1.5\text{ eV}$ ∴ The 12.5 eV electron beam can excite the electron up to n=3 level only. iii. Energy values, of the emitted photons, of the three possible lines are $3 \rightarrow 1 : (-1.5 + 13.6)\text{eV} = 12.1\text{ eV}$ $2 \rightarrow 1 : (-3.4 + 13.6)\text{eV} = 10.2\text{ eV}$ $3 \rightarrow 2 : (-1.5 + 3.4)\text{eV} = 1.9\text{ eV}$ The corresponding wavelengths are: 102 nm, 122 nm and 653 nm $\left(\lambda = \frac{hc}{E}\right)$ (Award this 1 mark if the student draws the energy level diagram and shows (and names the series) the three lines that can be emitted) / (Award these (½ + ½) marks if the student calculates the energies of the three photons that can be emitted and names their series also.)	½ ½ ½ + ½	**2**
Q10	a) Two properties for making permanent magnet — ½ + ½ b) Two properties for making an electromagnet — ½ + ½		

	a) For making permanent magnet**:** (i) High retentivity (ii) High coercitivity (iii) High permeability (Any two) b) For making electromagnet: (i) High permeability (ii) Low retentivity (iii) Low coercivity (Any two)	½ + ½ ½ + ½	**2**
	SECTION C		
Q11	a) The factor by which the potential difference changes — 1 b) Voltmeter reading — 1 Ammeter Reading — 1 a) $H = \frac{V^2}{R}$ $\therefore V$ increases by a factor of $\sqrt{9} = 3$ b) Ammeter Reading $I = \frac{V}{R+r}$ $= \frac{12}{4+2} A = 2A$ Voltmeter Reading $V = E - Ir$ $= [12 - (2 \times 2)]\ V = 8V$ (Alternatively, $V = iR = 2 \times 4V = 8V$)	 ½ ½ ½ ½ ½ ½	**3**
Q12	a) Achieving amplitude Modulation — 1 b) Stating the formulae — ½ Calculation of v_c and v_m — ½ + ½ Calculation of bandwidth — ½ a) Amplitude modulation can be achieved by applying the message signal, and the carrier wave, to a non linear (square law device) followed by a band pass filter.		

(Alternatively, The student may just draw the block diagram.)



(Alternatively, Amplitude modulation is achieved by superposing a message signal on a carrier wave in a way that causes the amplitude of the carrier wave to change in accordance with the message signal.) — **1**

b) Frequencies of side bands are:

$(\upsilon_c + \upsilon_m)$ and $(\upsilon_c - \upsilon_m)$ — ½

$\therefore \upsilon_c + \upsilon_m = 660$ kHz

and $\upsilon_c - \upsilon_m = 640$ kHz

$\therefore \upsilon_c = 650$ kHz — ½

$\therefore \upsilon_m = 10$ kHz — ½

Bandwidth = (660 – 640) kHz = 20 kHz — ½

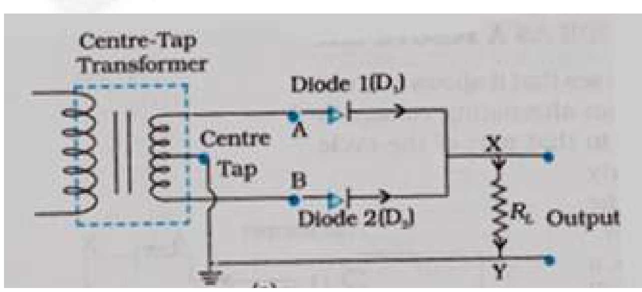
3

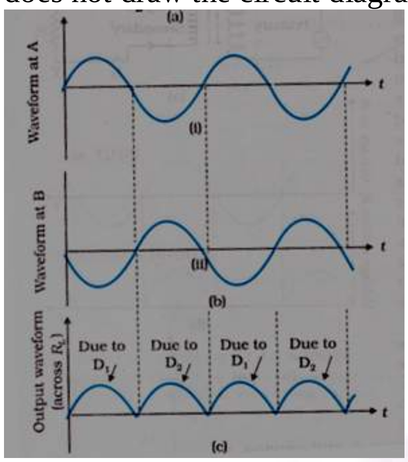
Q13

a)	The nature of biasing	1
b)	Diagram of full wave rectifier	1
	Working	1

a) Reverse Biased — **1**

b) Diagram of full wave rectifier — **1**



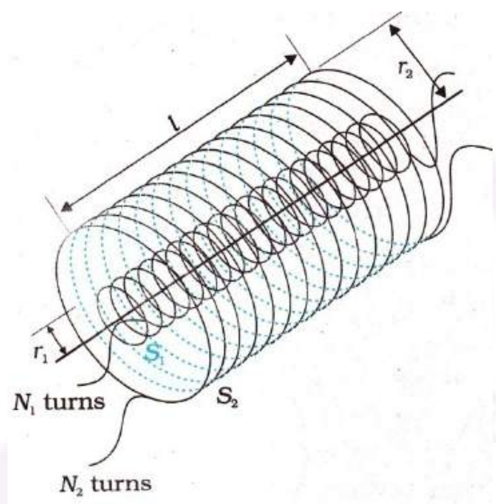
	<u>Working</u>: The diode D_1 is forward biased during one half cycle and current flows through the resistor, but diode D_2 is reverse biased and no current flows through it. During the other half of the signal, D_1 gets reverse biased and no current passes through it, D_2 gets forward biased and current flows through it. In both half cycles current, through the resistor, flows in the same direction. (Note: If the student just draws the following graphs (but does not draw the circuit diagram), award ½ mark only. )	1	3
Q14	Photon picture plus Einstein's photoelectric equation ½ + 1½ Two features ½ + ½ In the photon picture , energy of the light is assumed to be in the form of photons , each carrying an energy $h\upsilon$. Einstein assumed that photoelectric emission occurs because of a single collision of a photon with a free electron. The energy of the photon is used to (i) free the electrons from the metal. [For this, a minimum energy, called the work function (=W) is needed]. And (ii) provide kinetic energy to the emitted electrons.	½ ½ ½	

	Hence $(K.E.)_{max} = h\upsilon - W$ $/ \left(\frac{1}{2} m v_{max}^2 = h\upsilon - W\right)$ This is Einstein's photoelectric equation Two features (which cannot be explained by wave theory): i) 'Instantaneous' emission of photoelectrons ii) Existence of a threshold frequency iii) 'Maximum kinetic energy' of the emitted photoelectrons, is independent of the intensity of incident light (Any two)	½ ½ + ½	**3**
Q15	a. Calculation of wavelength, frequency and speed ½ + ½ + ½ b. Lens Maker's Formula ½ Calculation of R 1 a) $\lambda = \frac{589\text{ nm}}{1.33} = 442.8\text{nm}$ Frequency $\nu = \frac{3\times10^8\text{ ms}^{-1}}{589\text{ nm}} = 5.09 \times 10^{12}\text{Hz}$ Speed $v = \frac{3\times10^8}{1.33}\text{m/s} = 2.25 \times 10^8\text{m/s}$ b) $\frac{1}{f} = \left[\frac{\mu_2}{\mu_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ $\therefore \frac{1}{20} = \left[\frac{1.55}{1} - 1\right]\frac{2}{R}$ $\therefore R = (20 \times 1.10)\text{cm} = 22\text{ cm}$	½ ½ ½ ½ ½ ½	**3**
Q16	Definition of mutual inductance 1 Derivation of mutual inductance for two long solenoids 2		

(i) Mutual inductance is numerically equal to the induced emf in the secondary coil when the current in the primary coil changes by unity.

<u>Alternatively:</u> Mutual inductance is numerically equal to the magnetic flux linked with one coil/secondary coil when unit current flows through the other coil /primary coil. **1**

(ii)



½

Let a current, i_2, flow in the secondary coil

$$\therefore B_2 = \frac{\mu_0 N_2 i_2}{l}$$ ½

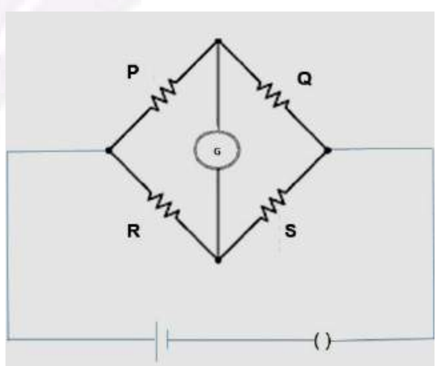
$\therefore$ Flux linked with the primary coil

$$= N_1 A_1 B_2 = \frac{\mu_0 N_2 N_1 A_1 i_2}{l} = M_{12} i_2$$ ½

Hence, $M_{12} = \frac{\mu_0 N_2 N_1 A_2}{l} = \mu_0 n_2 n_1 A_1 l \left(n_1 = \frac{N_1}{l}; n_2 = \frac{N_2}{l}\right)$ ½ **3**

OR

Definition of self inductance	1
Expression for energy stored	2

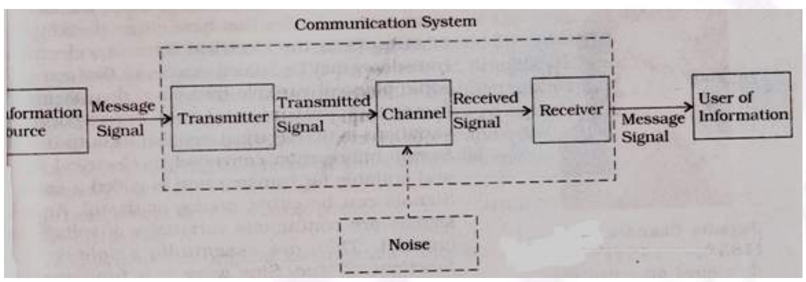
	(i) Self inductance, of a coil, is numerically equal to the emf induced in that coil when the current in it changes at a unit rate. (Alternatively: The self inductance of a coil equals the flux linked with it when a unit current flows through it.) (ii) The work done against back /induced emf is stored as magnetic potential energy. The rate of work done, when a current *i* is passing through the coil, is $\frac{dW}{dt} = \lvert\varepsilon\rvert i = \left(L\frac{di}{dt}\right)i$ $\therefore W = \int dW = \int_0^I Lidi$ $= \frac{1}{2}Li^2$	**1** ½ ½ ½ ½	**3**
Q17	a) Principle of meter bridge — 1 b) Relation between l_1,l_2, and S — 2 a) The principle of working of a meter bridge is same as that of a balanced Wheatstone bridge. (Alternatively:  When i_g=0, then $\frac{P}{Q} = \frac{R}{S}$)	**1**	

<table>
<tr><td></td><td>b) $\frac{R}{S} = \frac{l_1}{100-l_1}$

When X is connected in parallel:
$$\frac{R}{\left(\frac{XS}{X+S}\right)} = \frac{l_2}{100-l_2}$$
On solving, we get $X = \frac{l_1 S(100-l_2)}{100(l_2-l_1)}$</td><td>½

½

1</td><td>3</td></tr>
<tr><td>Q18</td><td>Diagram of generalized communication system 1½
Function of (a) transmitter (b) channel (c) receiver ½+ ½ + ½



[Also accept the following diagram

]
(a) Transmitter: A transmitter processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception.
(b) Channel: It carries the message signal from a transmitter to a receiver.
(c) Receiver: A receiver extracts the desired message signals from the received signals at the channel output.</td><td>1 ½

½

½

½</td><td>3</td></tr>
</table>

Q19

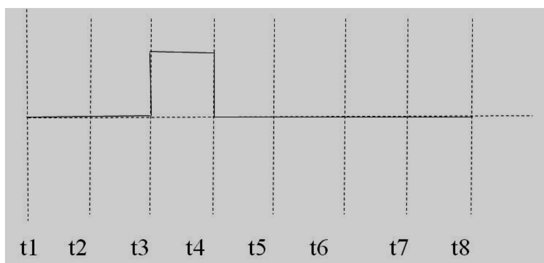
a) Function of each of the three segments	½ + ½ + ½
b) Diagram of output wave form	1
Truth table	½

a) Emitter: Supplies a large number of majority charge carriers. — ½

Base: Controls the flow of majority carriers from the emitter to the collector. — ½

Collector: It collects the majority carriers from the base / majority of those emitted by the emitter. — ½

b)



— 1

Truth Table

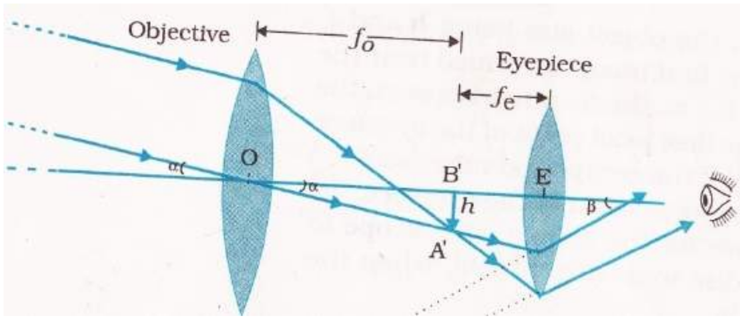
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

— ½

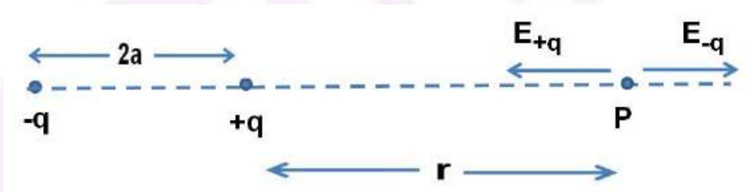
Total: **3**

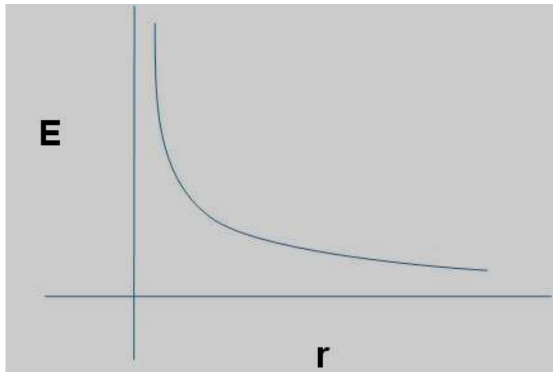
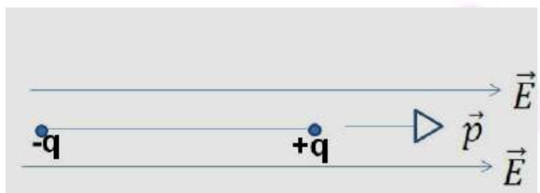
Q20

(a) Ray diagram for astronomical telescope in normal adjustment	1 ½
(b) Identification of lenses for objective and eyepiece	1
Reason	½

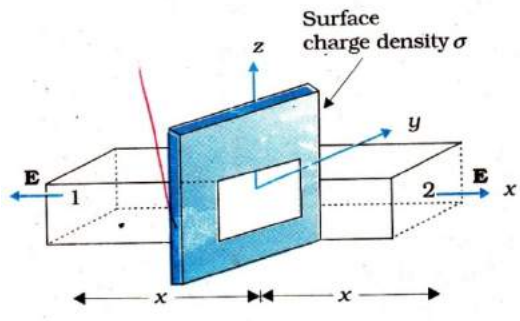
	(a) Ray diagram of astronomical telescope  (Note: Deduct ½ mark if the 'arrows' are not marked) (b) Objective Lens: Lens L_1 Eyepiece Lens: Lens L_2 Reason: The objective should have large aperture and large focal length while the eyepiece should have small aperture and small focal length.	1 ½ ½ ½ ½	3
Q21	(a) Statement of Biot Savart law — 1 Expression in vector form — ½ (b) Magnitude of magnetic field at centre — 1 Direction of magnetic field — ½ (a) It states that magnetic field strength, $d\vec{B}$, due to a current element, $Id\vec{l}$, at a point, having a position vector **r** relative to the current element, is found to depend (i) directly on the current element, (ii) inversely on the square of the distance |**r**| , (iii) directly on the sine of angle between the current element and the position vector **r**. In vector notation, $$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{l} \times \vec{r}}{\|\vec{r}\|^3}$$ **Alternatively**, $$\left(d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{l} \times \hat{r}}{\|\vec{r}\|^2}\right)$$	 1 ½	

	(b) $B_p = \frac{\mu_0 \times 1}{2R} = \frac{\mu_0}{2R}$ (along z – direction)	½	
	$B_Q = \frac{\mu_0 \times \sqrt{3}}{2R} = \frac{\mu_0 \sqrt{3}}{2R}$ (along x – direction)		
	$\therefore B = \sqrt{{B_p}^2 + {B_Q}^2} = \frac{\mu_0}{R}$	½	
	This net magnetic field **B**, is inclined to the field $\mathbf{B_p}$, at an angle Θ, where		
	$\tan\theta = \sqrt{3}$ $\left(/\theta = \tan^{-1}\sqrt{3} = 60^0\right)$	½	
	(in XZ plane)		**3**
Q22	Formula for energy stored ½ Energy stored before 1 Energy stored after 1 Ratio ½		
	Energy stored = $\frac{1}{2} CV^2 \left(= \frac{1}{2}\frac{Q^2}{C}\right)$	½	
	Net capacitance with switch S closed = $C + C = 2C$	½	
	$\therefore$ Energy stored = $\frac{1}{2} \times 2C \times V^2 = CV^2$	½	
	After the switch S is opened, capacitance of each capacitor= KC		
	$\therefore$ Energy stored in capacitor A = $\frac{1}{2}KCV^2$		
	For capacitor B,		
	Energy stored = $\frac{1}{2}\frac{Q^2}{KC} = \frac{1}{2}\frac{C^2V^2}{KC} = \frac{1}{2}\frac{CV^2}{K}$	½	
	$\therefore$ Total Energy stored = $\frac{1}{2}KCV^2 + \frac{1}{2}\frac{CV^2}{K} = \frac{1}{2}CV^2\left(K + \frac{1}{K}\right)$		
	$= \frac{1}{2}CV^2\left(\frac{K^2+1}{K}\right)$	½	

	$\therefore$ Required ratio $= \dfrac{2CV^2.K}{CV^2(K^2+1)} = \dfrac{2K}{(K^2+1)}$	½	3
SECTION D			
Q23	a) Name of the installation, the cause of disaster ½ + ½ b) Energy release process 1 c) Values shown by Asha and mother 1+1		
	a) (i) Nuclear Power Plant:/'Set-up' for releasing Nuclear Energy/Energy Plant (Also accept any other such term)	½	
	(ii)Leakage in the cooling unit/ Some defect in the set up.	½	
	b) Nuclear Fission/Nuclear Energy Break up (/ Fission) of Uranium nucleus into fragments	**1**	
	c) Asha: Helpful, Considerate, Keen to Learn, Modest	**1**	
	Mother: Curious, Sensitive, Eager to Learn, Has no airs (Any one such value in each case)	**1**	**4**
SECTION E			
Q24	(a) Derivation of E along the axial line of dipole 2 (b) Graph between E vs r 1 (c) (i) Diagrams for stable and unstable equilibrium of dipole ½ + ½ (ii) Torque on the dipole in the two cases ½ + ½		
	(a) 		
	Electric field at P due to charge $(+q)$ $= E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}$	½	
	Electric field at P due to charge $(-q)$ $= E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$	½	
	Net electric Field at P= $E_1 - E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2} - \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$	½	
	$= \dfrac{1}{4\pi\varepsilon_0}\dfrac{2pr}{(r^2-a^2)^2}$ $(p = q.2a)$		
	Its direction is parallel to $\vec{p}$.	½	

	(b)		
		1	
	(Note: Award ½ mark if the student just writes: For short Dipole = $\frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$ without drawing the graph)		
	(c)		
	Stable equilibrium	½	
	Unstable equilibrium	½	
	(Note: Award ½ mark only if the student does not draw the diagrams but just writes: (i) For stable Equilibrium: $\vec{p}$ is parallel to $\vec{E}$. (ii) For unstable equilibrium: $\vec{p}$ is antiparallel to $\vec{E}$)		
	Torque = 0 for (i) as well as case (ii). (Also accept, $\vec{\tau} = \vec{p} \times \vec{E}$ / $\tau = pE\sin\theta$)	½ + ½	5
	OR		
	a) Using Gauss's theorem to find E due to an infinite plane sheet of charge — 3 b) Expression for the work done to bring charge q from infinity to r — 2		

a)



½

$$\oint E.ds = \frac{q}{\varepsilon_0}$$

½

The electric field E points outwards normal to the sheet. The field lines are parallel to the Gaussian surface except for surfaces 1 and 2. Hence the net flux = $\oint E.ds = EA + EA$ where A is the area of each of the surface 1 and 2. **1**

$$\therefore \oint E.ds = \frac{q}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0} = 2EA;$$

1

$$E = \frac{\sigma}{2\varepsilon_0}$$

b)

$$W = q\int_{\infty}^{r} \vec{E}.d\vec{r}$$

½

$$= q\int_{\infty}^{r} (-Edr)$$

½

$$= -q\int_{\infty}^{r} \left(\frac{\sigma}{2\epsilon_0}\right) dr$$

½

$$= \frac{q\sigma}{2\in} |\infty - r|$$

$$\Rightarrow (\infty)$$

½

5

Q25

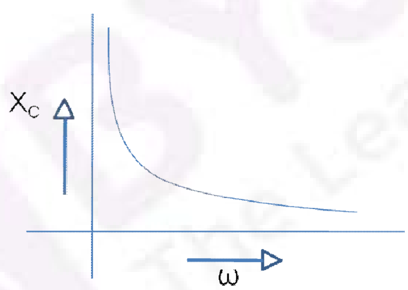
a)	Identification	½
b)	Identifying the curves	1
	Justification	½
c)	Variation of Impedance with frequency	½
	Graph	½
d)	Expression for current	1½
	Phase relation	½

a) The device X is a capacitor — ½

b) Curve B ⟶ voltage — ½
Curve C ⟶ current — ½
Curve A ⟶ power

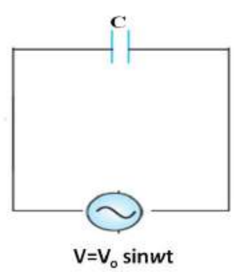
Reason: The current leads the voltage in phase, by $\pi/2$, for a capacitor. — ½

c) $X_c = \frac{1}{\omega C}$ $(/X_c \propto \frac{1}{\omega})$ — ½



— ½

d) $V = V_o \sin \omega t$



$Q = CV = CV_O \sin \omega t$ — ½

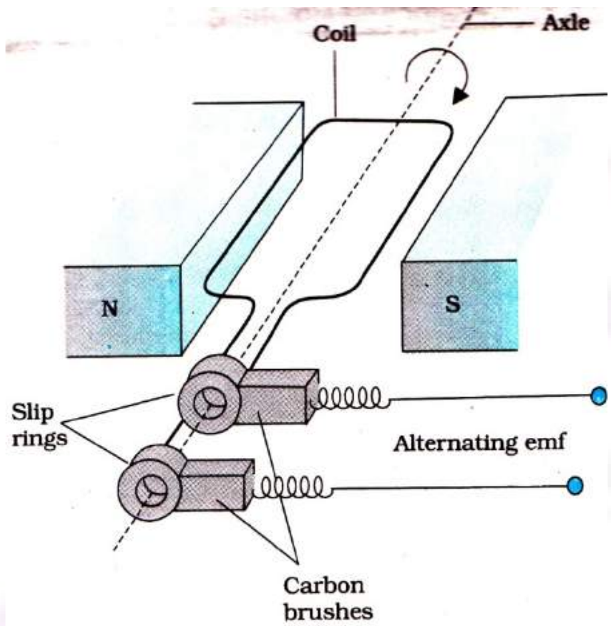
$I = \frac{dq}{dt} = \omega c V_o \cos \omega t$ — ½

$= I_O \sin(\omega t + \pi/2)$ — ½

Current leads the voltage, in phase , by $\pi/2$ — ½

(Note : If the student identifies the device X as an Inductor but writes correct answers to parts (c) and (d) (in terms of an inductor), the student be given full marks for (only) these two parts)

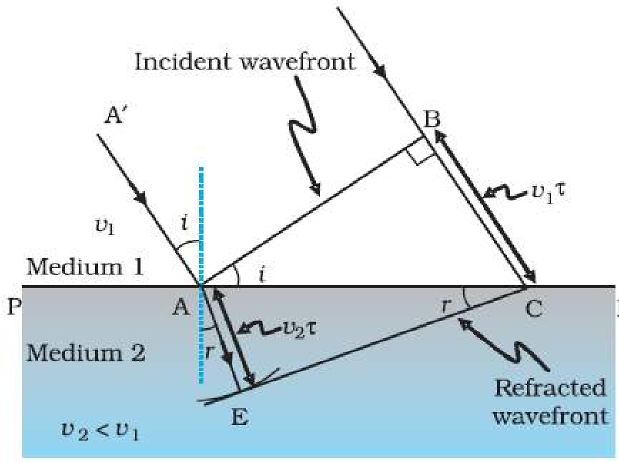
Total: 5

	OR		
	a) Labelled diagram of ac generator — 1 Expression for emf — 2 b) Formula for emf — ½ Substitution — ½ Calculation of emf — 1		
	a) 	**1**	
	Let ω be the angular speed of rotation of the coil. We then have		
	$\phi(t) = NBA\cos\omega t$	½	
	$\therefore\ E = -\frac{d\phi}{dt}$		
	$= NBA\omega\sin\omega t$	½	
	$= E_0\sin\omega t \qquad (E_0 = NBAw)$	**1**	
	b) Induced emf $= BlV$	½	
	$\therefore E = 0.3 \times 10^{-4} \times 10 \times 5$ volt	½	
	$E = 1.5 \times 10^{-3}\text{V}\ (= 1.5\text{mV})$	**1**	5

Q26

a) Definition of wavefront	½
Verifying laws of refraction by Huygen's principle	3
b) Polarisation by scattering	½
Calculation of Brewster's angle	1

a) The wavefront is the common locus of all points which are in phase(/surface of constant phase) — ½



1

Let a plane wavefront be incident on a surface separating two media as shown. Let v_1 and v_2 be the velocities of light in the rarer medium and denser medium respectively. From the diagram

$$BC = v_1 t \text{ and } AD = v_2 t$$ ½

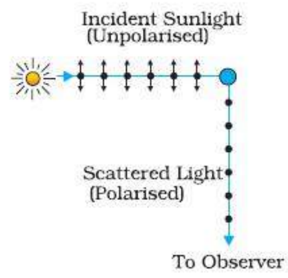
$$\sin i = \frac{BC}{AC} \text{ and } \sin r = \frac{AD}{AC}$$ ½

$$\therefore \frac{\sin i}{\sin r} = \frac{BC}{AD} = \frac{v_1 t}{v_2 t}$$ ½

$$= \frac{v_1}{v_2} = a\ constant$$ ½

This proves Snell's law of refraction.

b) When unpolarised light gets scattered by molecules, the scattered light has only one of its two components in it.
(Also accept diagrammatic representation



) ½

We have, $\mu = \tan i_B$ ½

$\therefore \tan i_B = 1.5$

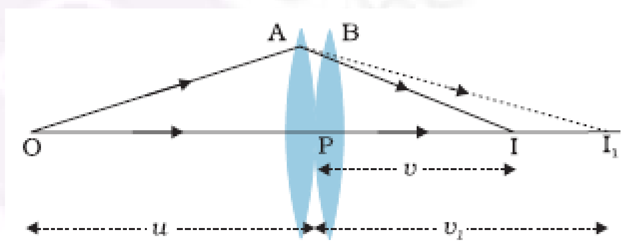
$\therefore i_B = \tan^{-1} 1.5$

$(/56.3^{o})$ ½ **5**

OR

a)	Ray diagram	1
	Expression for power	2
b)	Formula	½
	Calculation of speed of light	1 ½

a)



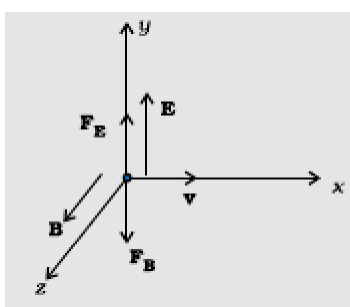
1

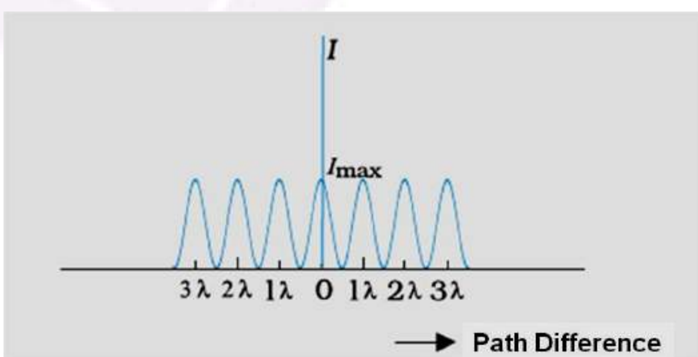
Two thin lenses, of focal length f_1 and f_2 are kept in contact. Let O be the position of object and let u be the object distance. The distance of the image (which is at I_1), for the first lens is v_1.

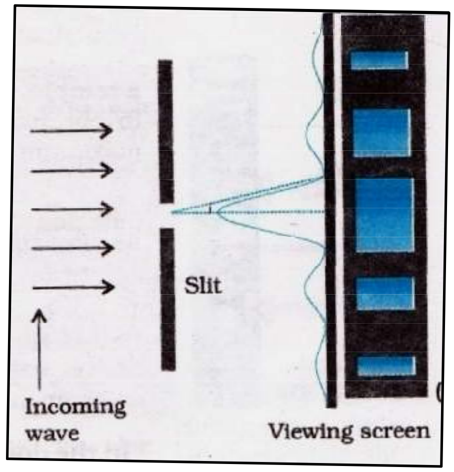
This image serves as object for the second lens. ½

	Let the final image be at I. We then have $$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$$ $$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$$ Adding , we get $$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$ $$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$ $$\therefore P = P_1 + P_2$$	½ ½ ½	
	b) At minimum deviation $$r = {}^{A}/_{2} = 30^0$$ We are given that $$i = \frac{3}{4}A = 45^0$$ $$\therefore \mu = \frac{\sin 45^0}{\sin 30^0} = \sqrt{2}$$ $\therefore$ Speed of light in the prism = $\frac{c}{\sqrt{2}}$ $$(\cong 2.1 \times 10^8\ \text{ms}^{-1})$$ [Award ½ mark if the student writes the formula: $$\mu = \frac{\sin(A + D_m)/2}{\sin({}^{A}/_{2})}$$ but does not do any calculations.]	½ ½ ½ ½	**5**

MARKING SCHEME

Q. No.	Expected Answer/ Value Points	Marks	Total Marks
Section A			
Q1	Q to P through ammeter and D to C through ammeter (**Alternatively:** Anticlockwise as seen from left in coil PQ clockwise as seen from left in coil CD)	½ ½	**1**
Q2	Speed of electromagnetic wave, $c = \frac{E_0}{B_0}$.	**1**	**1**
Q3	i. Nichrome ii. $R_{Ni} > R_{Cu}$ (or $\text{Resistivity}_{Ni} > \text{Resistivity}_{Cu}$)	½ ½	**1**
Q4	i. Decreases ii. $n_{Violet} > n_{Red}$ (Also accept if the student writes $\lambda_V < \lambda_R$)	½ ½	**1**
Q5	Photoelectric Effect (/Raman Effect/ Compton Effect)	**1**	**1**
SECTION B			
Q6	Condition i. For directions of $\vec{E}, \vec{B}, \vec{v}$ — 1 ii. For magnitudes of $\vec{E}, \vec{B}, \vec{v}$ — 1 i. The velocity $\vec{v}$, of the charged particles, and the $\vec{E}$ and $\vec{B}$ vectors, should be mutually perpendicular. Also the forces on q, due to $\vec{E}$ and $\vec{B}$, must be oppositely directed. (Also accept if the student draws a diagram to show the directions.) 	½ ½	

	ii. $qE = qvB$ $or\ v = \frac{E}{B}$ **[**Alternatively**,** The student may write: Force due to electric field $= q\vec{E}$ Force due to magnetic field $= q\,(\vec{v} \times \vec{B})$ The required condition is $q\vec{E} = -q\,(\vec{v} \times \vec{B})$ $\left[or\ \vec{E} = -(\vec{v} \times \vec{B}) = (\vec{B} \times \vec{v})\right]$ (Note: Award 1 mark only if the student just writes: "The forces, on the charged particle, due to the electric and magnetic fields, must be equal and opposite to each other")**]**	½ ½ ½ ½ ½ ½	 **2**
Q7	(a) Identification ½ + ½ (b) One use each ½ + ½ a) X-rays/ Gamma rays One use of the name given b) Infrared/Visible/Microwave One use of the name given **(Note**: Award ½ mark for each correct use (relevant to the name chosen) even if the names chosen are incorrect.**)**	 ½ ½ ½ ½	 **2**
Q8	Interference pattern ½ Diffraction pattern ½ Two Differences ½ + ½ 	 ½	



½

Differences

Interference	Diffraction
All maxima have equal intensity	Maxima have different (/rapidly decreasing) intensity
All fringes have equal width.	Different (/changing) width.
Superposition of two wavefronts	Superposition of wavelets from the same wavefront

½ + ½

(Any two)

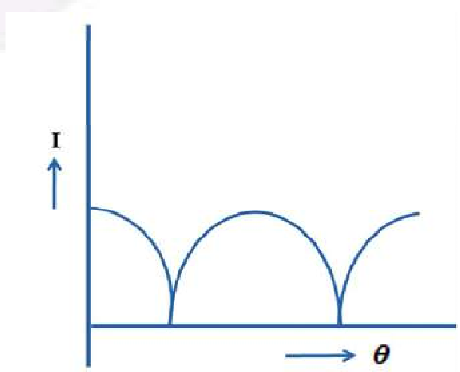
2

OR

Expression for intensity of polarized beam	1
Plot of intensity variation with angle	1

Intensity is $\frac{I_0}{2}\cos^2\theta$ (if I_0 is the intensity of unpolarised light.)
Intensity is $I\cos^2\theta$ (if I is the intensity of polarized light.)
(Award ½ mark if the student writes the expression as $I_0\cos^2\theta$)

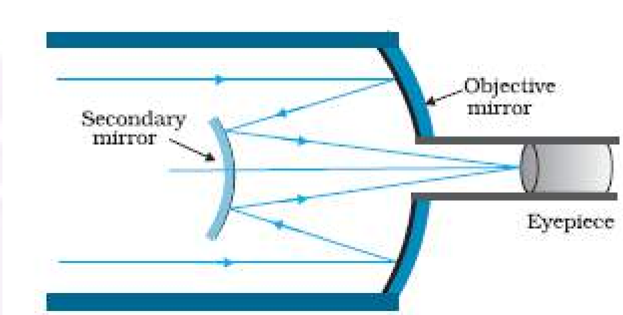
1

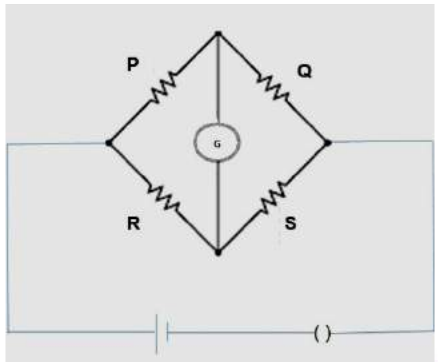


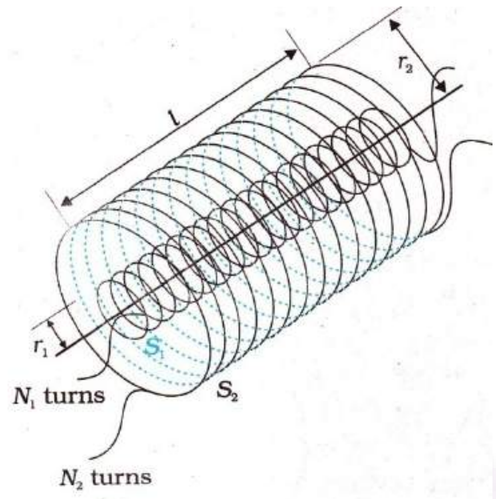
1

2

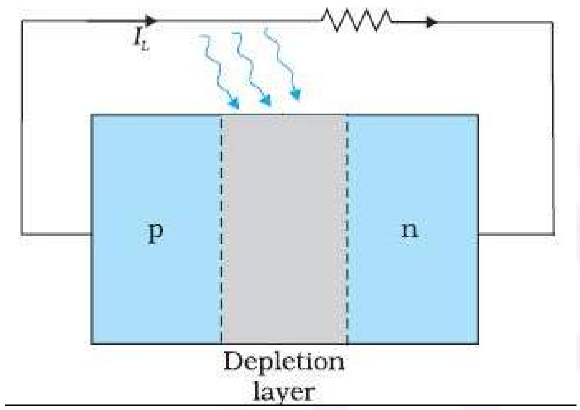
Q9	Formula ½ Calculation 1½		
	$$\frac{1}{\lambda} = R\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)$$	½	
	∴ For Balmer Series: $(\lambda_B)_{short} = {}^{4}/_{R}$	½	
	and For Lyman Series: $(\lambda_L)_{short} = {}^{1}/_{R}$	½	
	$\therefore \lambda_B = 913.4 \times 4\ A^0 = 3653.6\ A^0$	½	**2**
Q10	a) Two properties for making permanent magnet ½ + ½ b) Two properties for making an electromagnet ½ + ½		
	a) For making permanent magnet**:** (i) High retentivity (ii) High coercitivity (iii) High permeability (Any two)	½ + ½	
	b) For making electromagnet: (i) High permeability (ii) Low retentivity (iii) Low coercivity (Any two)	½ + ½	**2**
	SECTION C		
Q11	a. Calculation of wavelength, frequency and speed ½ + ½ + ½ b. Lens Maker's Formula ½ Calculation of *R* 1		

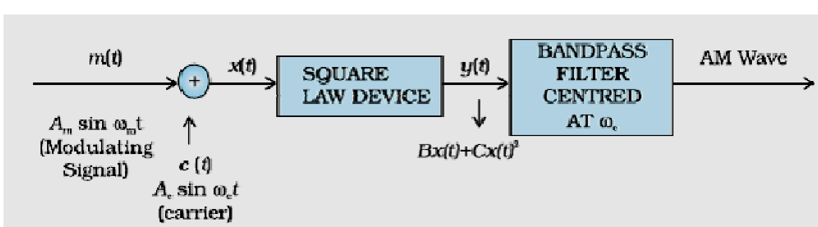
	a) $\lambda = \frac{589 \text{ nm}}{1.33} = 442.8\text{nm}$ Frequency $\nu = \frac{3\times10^8 \text{ ms}^{-1}}{589 \text{ nm}} = 5.09 \times 10^{12}\text{Hz}$ Speed $v = \frac{3\times10^8}{1.33}\text{m/s} = 2.25 \times 10^8\text{m/s}$ b) $\frac{1}{f} = \left[\frac{\mu_2}{\mu_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ $\therefore \frac{1}{20} = \left[\frac{1.55}{1} - 1\right]\frac{2}{R}$ $\therefore R = (20 \times 1.10)\text{cm} = 22 \text{ cm}$	½ ½ ½ ½ ½ ½	3
Q12	(a) Ray Diagram for reflecting Telescope — 2 (b) Two advantages of it over refracting type of telescope — ½ + ½ (a) Ray Diagram Arrow marking Labelling  (b) **Advantages** (i) Spherical aberration is absent (ii) Chromatic aberration is absent (iii) Mounting is easier (iv) Polishing is done on only one side (v) Light gathering power is more **(Any two)**	 **1** ½ ½ ½ + ½	3

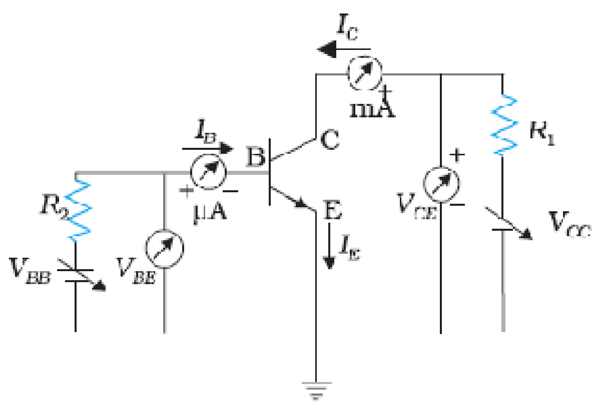
Q13	a) Principle of meter bridge 1 b) Relation between l_1,l_2, and S 2 a) The principle of working of a meter bridge is same as that of a balanced Wheatstone bridge. (Alternatively:  When i_g=0, then $\frac{P}{Q} = \frac{R}{S}$) b) $\frac{R}{S} = \frac{l_1}{100-l_1}$ When X is connected in parallel: $\frac{R}{\left(\frac{XS}{X+S}\right)} = \frac{l_2}{100-l_2}$ On solving, we get $X = \frac{l_1 S(100-l_2)}{100(l_2-l_1)}$	1 ½ ½ 1	3
Q14	Definition of mutual inductance 1 Derivation of mutual inductance for two long solenoids 2 (i) Mutual inductance is numerically equal to the induced emf in the secondary coil when the current in the primary coil changes by unity. <u>Alternatively:</u> Mutual inductance is numerically equal to the magnetic flux linked with one coil/secondary coil		

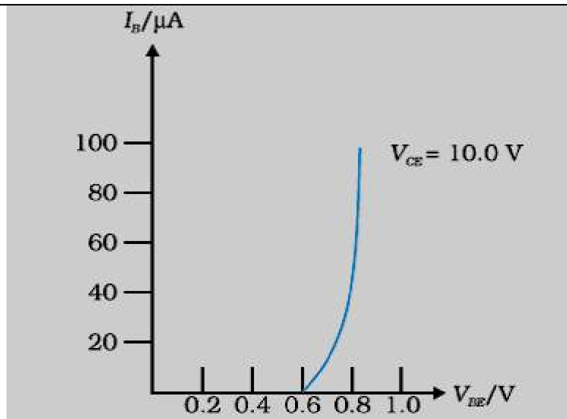
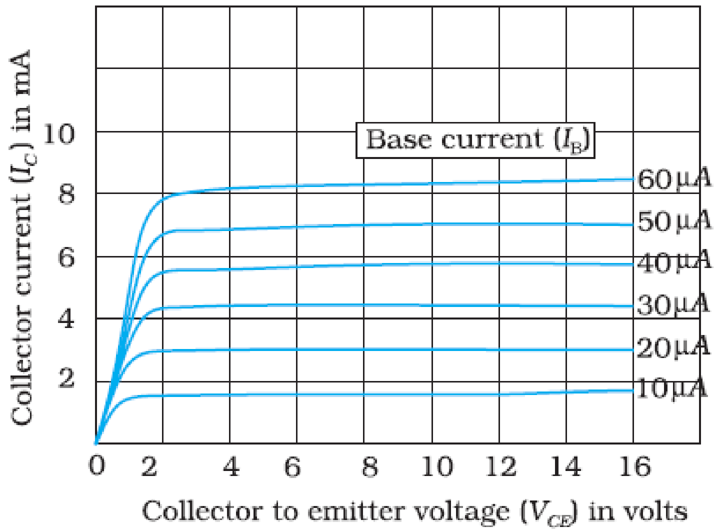
<table>
<tr><td></td><td>when unit current flows through the other coil /primary coil.</td><td>**1**</td><td></td></tr>
<tr><td></td><td>(ii)

</td><td>½</td><td></td></tr>
<tr><td></td><td>Let a current, i_2, flow in the secondary coil
$$\therefore B_2 = \frac{\mu_0 N_2 i_2}{l}$$</td><td>½</td><td></td></tr>
<tr><td></td><td>∴ Flux linked with the primary coil
$$= N_1 A_1 B_2 = \frac{\mu_0 N_2 N_1 A_1 i_2}{l} = M_{12} i_2$$</td><td>½</td><td></td></tr>
<tr><td></td><td>Hence, $M_{12} = \frac{\mu_0 N_2 N_1 A_2}{l} = \mu_0 n_2 n_1 A_1 l \left(n_1 = \frac{N_1}{l}; n_2 = \frac{N_2}{l}\right)$</td><td>½</td><td>**3**</td></tr>
<tr><td></td><td>**OR**
Definition of self inductance 1
Expression for energy stored 2</td><td></td><td></td></tr>
<tr><td></td><td>(i) Self inductance, of a coil, is numerically equal to the emf induced in that coil when the current in it changes at a unit rate.
(Alternatively: The self inductance of a coil equals the flux linked with it when a unit current flows through it.)</td><td>**1**</td><td></td></tr>
</table>

	(ii) The work done against back /induced emf is stored as magnetic potential energy. The rate of work done, when a current i is passing through the coil, is $\frac{dW}{dt} = \|\varepsilon\|i = \left(L\frac{di}{dt}\right)i$ $\therefore W = \int dW = \int_0^I Lidi$ $= \frac{1}{2}Li^2$	½ ½ ½ ½	3
Q15	(a) Variation of photocurrent with intensity of radiation — 1 (b) Stopping potential versus frequency for different materials — 1 (c) Independence of maximum kinetic energy of the emitted photoelectrons — 1 (a) The collision of a photon can cause emission of a photoelectron(above the threshold frequency). As intensity increases, number of photons increases. Hence the current increases. (b) We have, $eV_s = h(v - v_0)$ $\therefore v_s = \frac{h}{e}(v) + \left(-\frac{hv_0}{e}\right)$ $\therefore$ Graph of v_s with v is a straight line and slope $\left(= {}^{h}/_{e}\right)$ is a constant. (c) Maximum for different surfaces $\text{K.E} = h(v - v_0)$ Hence, it depends on the frequency and not on the intensity of the incident radiation.	1 ½ ½ ½ ½	3

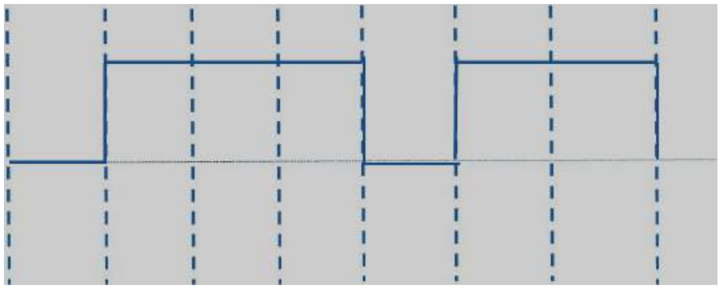
Q16	(a) Identification of the bulb and reason — ½ + ½ (b) Diagram of solar cell — ½ (c) Names of the processes — ½ + ½ + ½		
	(a) Bulb B_1 glows	½	
	Diode D_1 is forward biased.	½	
	(b) Diagram  	½	
	(c) Generation: Incident light generates electron-hole pairs.	½	
	Separation: Electric field of the depletion layer separates the electrons and holes.	½	
	Collection: Electrons and holes are collected at the n and p side contacts.	½	**3**
Q17	Formula for energy stored — ½ Energy stored before — 1 Energy stored after — 1 Ratio — ½		

	Energy stored = $\frac{1}{2}CV^2$ $\left(=\frac{1}{2}\frac{Q^2}{C}\right)$ Net capacitance with switch S closed = $C + C = 2C$ $\therefore$ Energy stored = $\frac{1}{2} \times 2C \times V^2 = CV^2$ After the switch S is opened, capacitance of each capacitor= KC $\therefore$ Energy stored in capacitor A = $\frac{1}{2}KCV^2$ For capacitor B, Energy stored = $\frac{1}{2}\frac{Q^2}{KC} = \frac{1}{2}\frac{C^2V^2}{KC} = \frac{1}{2}\frac{CV^2}{K}$ $\therefore$ Total Energy stored = $\frac{1}{2}KCV^2 + \frac{1}{2}\frac{CV^2}{K} = \frac{1}{2}CV^2\left(K + \frac{1}{K}\right)$ $= \frac{1}{2}CV^2\left(\frac{K^2+1}{K}\right)$ $\therefore$ Required ratio = $\frac{2CV^2.K}{CV^2(K^2+1)} = \frac{2K}{(K^2+1)}$	½ ½ ½ ½ ½ ½	3
Q18	a) Achieving amplitude Modulation — 1 b) Stating the formulae — ½ Calculation of v_c and v_m — ½ + ½ Calculation of bandwidth — ½ a) Amplitude modulation can be achieved by applying the message signal, and the carrier wave, to a non linear (square law device) followed by a band pass filter. (Alternatively, The student may just draw the block diagram.) 		

	(Alternatively, Amplitude modulation is achieved by superposing a message signal on a carrier wave in a way that causes the amplitude of the carrier wave to change in accordance with the message signal.) b) Frequencies of side bands are: $(\upsilon_c + \upsilon_m)$ and $(\upsilon_c - \upsilon_m)$ $\therefore \upsilon_c + \upsilon_m = 660$ kHz and $\upsilon_c - \upsilon_m = 640$ kHz $\therefore \upsilon_c = 650$ kHz $\therefore \upsilon_m = 10$ kHz Bandwidth = (660 – 640) kHz = 20 kHz	1 ½ ½ ½ ½	3
Q19	a) Circuit diagram 1 Input characteristics ½ Output characteristics ½ b) Output pulse wave form ½ Truth table/Logic symbol ½  	1	

		½	
		½	
	(The Student can show only one curve) **[Alternatively,** The student may just write: Input characteristics: (I_B) vs (V_{BE}) graph keeping V_{CE} = constant Output characteristics: (I_C) vs (V_{CE}) graph keeping I_B = constant]		

<u>Output waveform</u>:

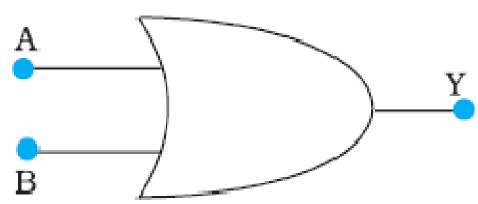


½

Truth Table:

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

and/or
Logic symbol:



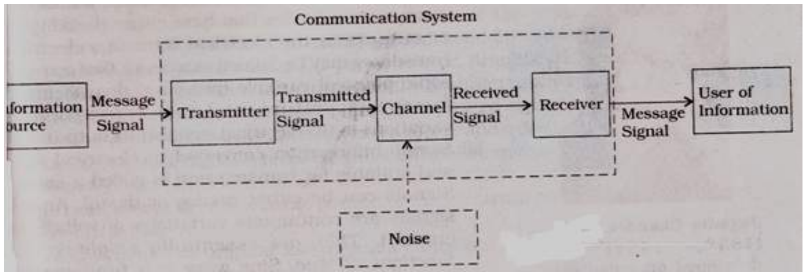
½

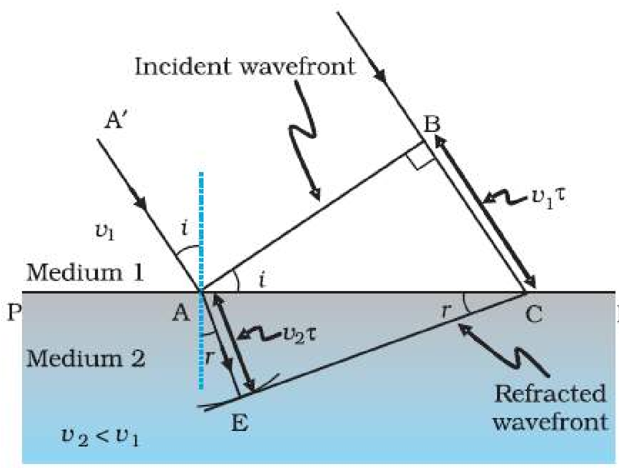
3

Q20

Formula	½
Field due to each coil	½ + ½
Magnitude of resultant field	1
Direction of resultant field	½

	Field at the centre of a circular coil $= \frac{\mu_0 I}{2R}$ Field due to coil $P = \frac{\mu_0 \times 3}{2\times5\times10^{-2}}$ tesla $= 12\pi \times 10^{-6}$ tesla Field due to coil Q $= \frac{\mu_0 \times 4}{2\times5\times10^{-2}}$ tesla $= 16\pi \times 10^{-6}$ tesla $\therefore$ Resultant Field $= (\pi\sqrt{12^2 + 16^2})\mu$T $= (20\,\pi)\mu$T Let the field make an angle θ with the vertical $\tan\theta = \frac{12\pi \times 10^{-6}}{16\pi \times 10^{-6}} = \frac{3}{4}$ $\theta = \tan^{-1}\frac{3}{4}$ (Alternatively: $\theta' = \tan^{-1}\frac{4}{3}, \theta' =$ angle with the horizontal) [Note1: Award 2 marks if the student directly calculates B without calculating B_P and B_Q separately.] [Note 2: Some students may calculate the field B_Q and state that it also represents the resultant magnetic field (as coil P has been shown 'broken' and , therefore, cannot produce a magnetic field); They may be given 2 ½ marks for their (correct) calculation of B_Q]	½ ½ ½ 1 ½	3
Q21	Diagram of generalized communication system 1½ Function of (a) transmitter (b) channel (c) receiver ½+ ½ + ½		

	 [Also accept the following diagram ] (a) Transmitter: A transmitter processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception. (b) Channel: It carries the message signal from a transmitter to a receiver. (c) Receiver: A receiver extracts the desired message signals from the received signals at the channel output.	**1 ½** ½ ½ ½	 **3**
Q22	a) The factor by which the potential difference changes 1 b) Voltmeter reading 1 Ammeter Reading 1 a) $H = \frac{V^2}{R}$ $\therefore V$ increases by a factor of $\sqrt{9} = 3$ b) Ammeter Reading $I = \frac{V}{R+r}$ $= \frac{12}{4+2} A = 2A$ Voltmeter Reading $V = E - Ir$ $= [12 - (2 \times 2)]\ V = 8V$ (Alternatively, $V = iR = 2 \times 4V = 8V$)	½ ½ ½ ½ ½ ½	 **3**

	SECTION D		
Q23	a) Name of the installation, the cause of disaster ½ + ½ b) Energy release process 1 c) Values shown by Asha and mother 1+1		
	a) (i) Nuclear Power Plant:/'Set-up' for releasing Nuclear Energy/Energy Plant (Also accept any other such term) (ii)Leakage in the cooling unit/ Some defect in the set up. b) Nuclear Fission/Nuclear Energy Break up (/ Fission) of Uranium nucleus into fragments c) Asha: Helpful, Considerate, Keen to Learn, Modest Mother: Curious, Sensitive, Eager to Learn, Has no airs (Any one such value in each case)	½ ½ **1** **1** **1**	**4**
	SECTION E		
Q24	a) Definition of wavefront ½ Verifying laws of refraction by Huygen's principle 3 b) Polarisation by scattering ½ Calculation of Brewster's angle 1		
	a) The wavefront is the common locus of all points which are in phase(/surface of constant phase)	½	
		**1**	
	Let a plane wavefront be incident on a surface separating two media as shown. Let v_1 and v_2 be the velocities of light in the rarer medium and denser medium respectively. From the diagram $BC = v_1 t$ and $AD = v_2 t$	½	

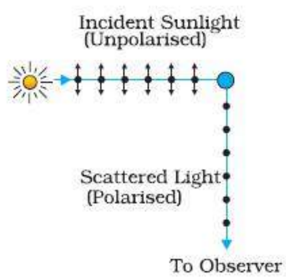
$$\sin i = \frac{BC}{AC} \text{ and } \sin r = \frac{AD}{AC}$$ ½

$$\therefore \frac{\sin i}{\sin r} = \frac{BC}{AD} = \frac{v_1 t}{v_2 t}$$ ½

$$= \frac{v_1}{v_2} = a\ constant$$ ½

This proves Snell's law of refraction.

b) When unpolarised light gets scattered by molecules, the scattered light has only one of its two components in it. (Also accept diagrammatic representation



) ½

We have, $\mu = \tan i_B$ ½

$\therefore \tan i_B = 1.5$

$\therefore i_B = \tan^{-1} 1.5$

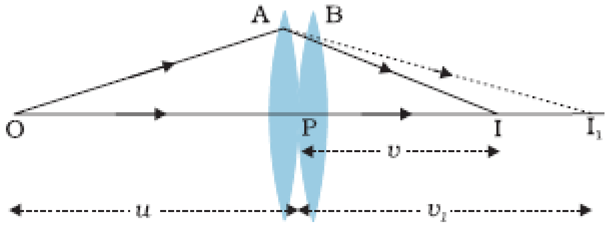
$(/56.3^{o})$ ½

5

OR

a)	Ray diagram	1
	Expression for power	2
b)	Formula	½
	Calculation of speed of light	1 ½

a)



1

Two thin lenses, of focal length f_1 and f_2 are kept in contact. Let O be the position of object and let u be the object distance. The distance of the image (which is at I_1), for the first lens is v_1.

This image serves as object for the second lens. ½

Let the final image be at I. We then have

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$$ ½

$$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$$

Adding , we get

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$ ½

$$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\therefore P = P_1 + P_2$$ ½

b) At minimum deviation

$$r = {}^{A}/_{2} = 30^0$$ ½

We are given that

$$i = \frac{3}{4}A = 45^0$$ ½

$$\therefore \mu = \frac{\sin 45^0}{\sin 30^0} = \sqrt{2}$$ ½

$\therefore$ Speed of light in the prism $= \frac{c}{\sqrt{2}}$

$$(\cong 2.1 \times 10^8\ \text{ms}^{-1})$$ ½

[Award ½ mark if the student writes the formula:

$$\mu = \frac{\sin(A + D_m)/2}{\sin({}^{A}/_{2})}$$

but does not do any calculations.]

5

Q25

(a) Derivation of E along the axial line of dipole	2
(b) Graph between E vs r	1
(c) (i) Diagrams for stable and unstable equilibrium of dipole	½ + ½
(ii) Torque on the dipole in the two cases	½ + ½

(a)

Electric field at P due to charge $(+q)$ = $E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}$ — ½

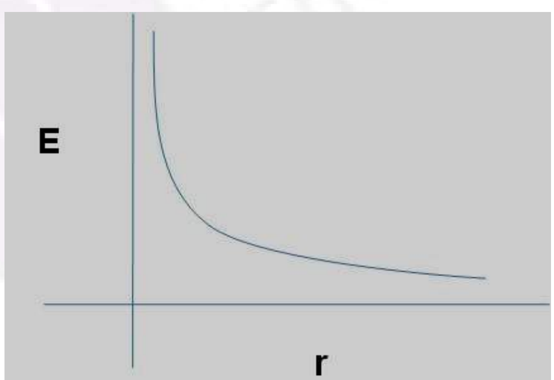
Electric field at P due to charge $(-q)$ = $E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$ — ½

Net electric Field at P= $E_1 - E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2} - \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$ — ½

$$= \frac{1}{4\pi\varepsilon_0}\frac{2pr}{(r^2-a^2)^2} \qquad (p = q.2a)$$

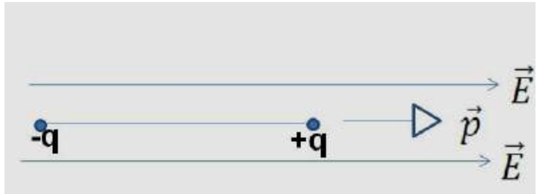
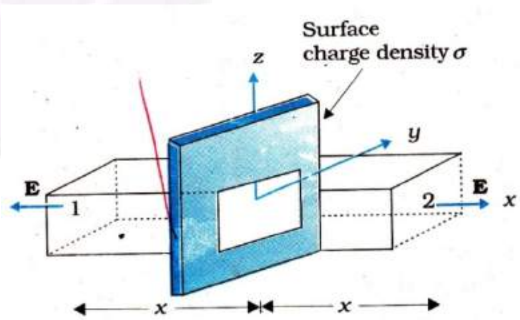
Its direction is parallel to $\vec{p}$. — ½

(b)

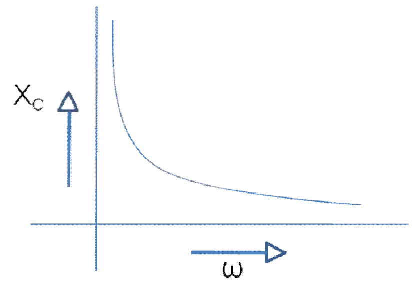
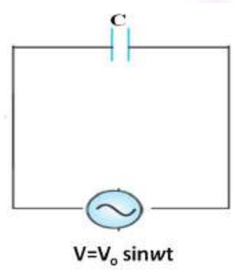


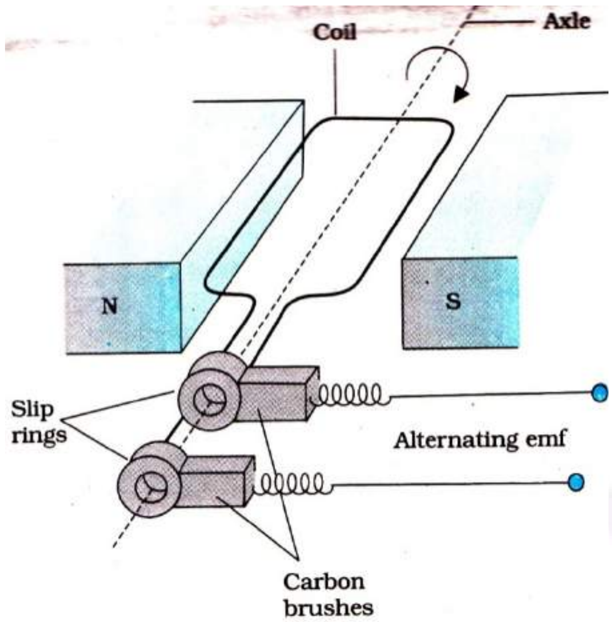
1

(Note: Award ½ mark if the student just writes: For short Dipole = $\frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$ without drawing the graph)

	(c)  Stable equilibrium	½	
	 Unstable equilibrium	½	
	(Note: Award ½ mark only if the student does not draw the diagrams but just writes: (i) For stable Equilibrium: $\vec{p}$ is parallel to $\vec{E}$. (ii) For unstable equilibrium: $\vec{p}$ is antiparallel to $\vec{E}$)		
	Torque = 0 for (i) as well as case (ii). (Also accept, $\vec{\tau} = \vec{p} \times \vec{E}$ / $\tau = pE \sin\theta$)	½ + ½	**5**
	OR a) Using Gauss's theorem to find E due to an infinite plane sheet of charge — 3 b) Expression for the work done to bring charge q from infinity to r — 2		
	a) 	½	
	$$\oint E.ds = \frac{q}{\varepsilon_0}$$	½	

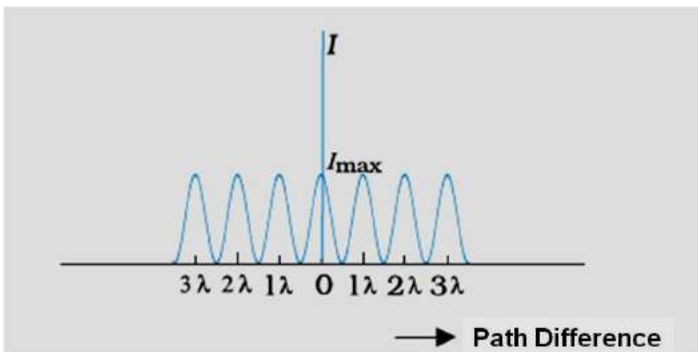
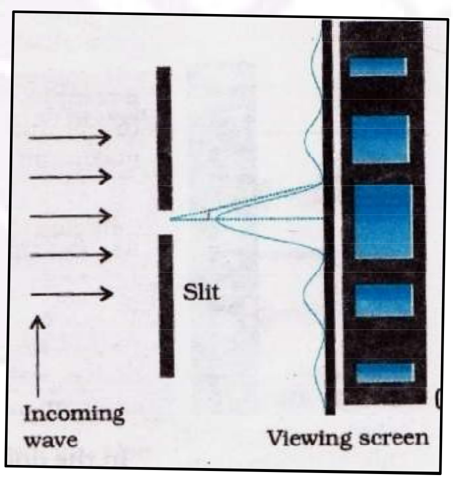
	The electric field E points outwards normal to the sheet. The field lines are parallel to the Gaussian surface except for surfaces 1 and 2. Hence the net flux = $\oint E.ds = EA + EA$ where A is the area of each of the surface 1 and 2. $\therefore \oint E.ds = \frac{q}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0} = 2EA;$ $E = \frac{\sigma}{2\varepsilon_0}$ b) $W = q\int_{\infty}^{r} \vec{E}.d\vec{r}$ $= q\int_{\infty}^{r}(-Edr)$ $= -q\int_{\infty}^{r}\left(\frac{\sigma}{2\epsilon_0}\right)dr$ $= \frac{q\sigma}{2 \in}\lvert\infty - r\rvert$ $\Rightarrow (\infty)$	**1** **1** ½ ½ ½ ½	**5**
Q26	a) Identification ½ b) Identifying the curves 1 Justification ½ c) Variation of Impedance with frequency ½ Graph ½ d) Expression for current 1½ Phase relation ½ a) The device X is a capacitor b) Curve B → voltage Curve C → current Curve A → power	½ ½ ½	

	Reason: The current leads the voltage in phase, by $\pi/2$, for a capacitor.	½	
	c) $X_c = \frac{1}{\omega C}$ $(/X_c \propto \frac{1}{\omega})$	½	
		½	
	d) $V = V_o \sin \omega t$ 		
	$Q = CV = CV_0 \sin \omega t$	½	
	$I = \frac{dq}{dt} = \omega c V_o \cos \omega t$	½	
	$= I_0 \sin(\omega t + \pi/2)$	½	
	Current leads the voltage, in phase , by $\pi/2$	½	
	(Note : If the student identifies the device X as an Inductor but writes correct answers to parts (c) and (d) (in terms of an inductor), the student be given full marks for (only) these two parts)		5
	OR		
	a) Labelled diagram of ac generator — 1 Expression for emf — 2 b) Formula for emf — ½ Substitution — ½ Calculation of emf — 1		

	a) 	1	
	Let ω be the angular speed of rotation of the coil. We then have		
	$\phi(t) = NBA\cos\omega t$	½	
	$\therefore\ E = -\dfrac{d\phi}{dt}$		
	$= NBA\omega\sin\omega t$	½	
	$= E_0\sin\omega t \qquad (E_0 = NBAw)$	1	
	b) Induced emf $= BlV$	½	
	$\therefore E = 0.3 \times 10^{-4} \times 10 \times 5$ volt	½	
	$E = 1.5 \times 10^{-3}\text{V}\ (= 1.5\text{mV})$	1	
			5

MARKING SCHEME

Q. No.	Expected Answer/ Value Points	Marks	Total Marks
	Section A		
Q1	i. Decreases ii. $n_{\text{Violet}} > n_{\text{Red}}$ (Also accept if the student writes $\lambda_V < \lambda_R$)	½ ½	**1**
Q2	Photoelectric Effect (/Raman Effect/ Compton Effect)	**1**	**1**
Q3	Clockwise in loop 1 Anticlockwise in loop 2	½ ½	**1**
Q4	$\vec{E}$ along y- axis and $\vec{B}$ along z-axis (**Alternatively :** $\vec{E}$ along z-axis and $\vec{B}$ along y-axis**)**	½ + ½	**1**
Q5	i. Nichrome ii. $R_{Ni} > R_{Cu}$ (or $\text{Resistivity}_{Ni} > \text{Resistivity}_{Cu}$)	½ ½	**1**
	SECTION B		
Q6	a) Two properties for making permanent magnet ½ + ½ b) Two properties for making an electromagnet ½ + ½ a) For making permanent magnet**:** (i) High retentivity (ii) High coercitivity (iii) High permeability (Any two)	½ + ½	

	b) For making electromagnet: (i) High permeability (ii) Low retentivity (iii) Low coercivity (Any two)	½ + ½	**2**
Q7	Interference pattern ½ Diffraction pattern ½ Two Differences ½ + ½		
		½	
		½	

Differences

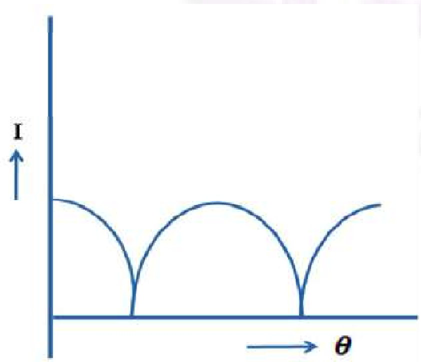
Interference	Diffraction
All maxima have equal intensity	Maxima have different (/rapidly decreasing) intensity
All fringes have equal width.	Different (/changing) width.
Superposition of two wavefronts	Superposition of wavelets from the same wavefront

(Any two) ½ + ½ — 2

OR

Expression for intensity of polarized beam	1
Plot of intensity variation with angle	1

Intensity is $\frac{I_0}{2}\cos^2\theta$ (if I_0 is the intensity of unpolarised light.)
Intensity is $I\cos^2\theta$ (if I is the intensity of polarized light.)
(Award ½ mark if the student writes the expression as $I_0\cos^2\theta$) — 1



1 — 2

Q8

a)	Reason for no flow of current	1
b)	Reason for momentary current	1

In the steady state, the displacement current and hence the conduction current, is zero as $|\vec{E}|$, between the plates , is constant . — 1

During charging / discharging, the displacement current and hence the conduction current is non zero as $|\vec{E}|$, between the plates , is changing with time. — 1

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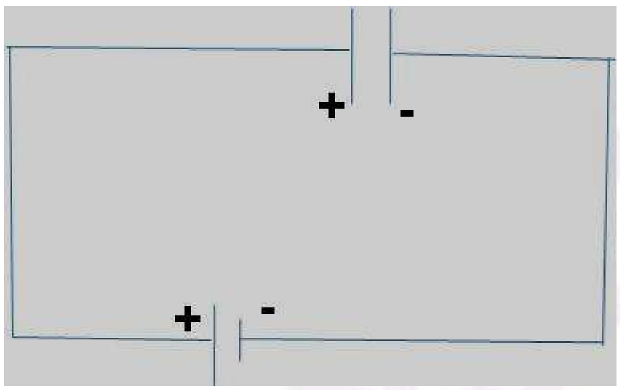
<u>Alternatively</u>

i) In the steady state no current flows because, we have two sources (battery and fully charged capacitor) of ‘equal potential’ connected in opposition.

ii) During charging /discharging there is a momentary flow of current as the ‘potentials’ of the two ‘sources’ are not equal to each other.



<u>Alternatively,</u>
Capacitative impedence $= \frac{1}{\omega C}$

iii) During steady state: $\omega = 0$
$\therefore X_c \to \infty$
Hence current is zero.

iv) During charging /discharging : $\omega \neq 0$
$\therefore X_c$ is finite.
Hence current can flow.
</td>
<td>
1

1

½
½

½
½
</td>
<td>2</td>
</tr>
<tr>
<td>Q9</td>
<td>
a) Calculation of energy difference ½
b) Formula ½
c) Calculation of wavelength ½
d) Name of the series of spectral lines ½
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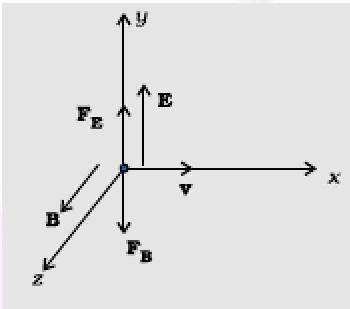
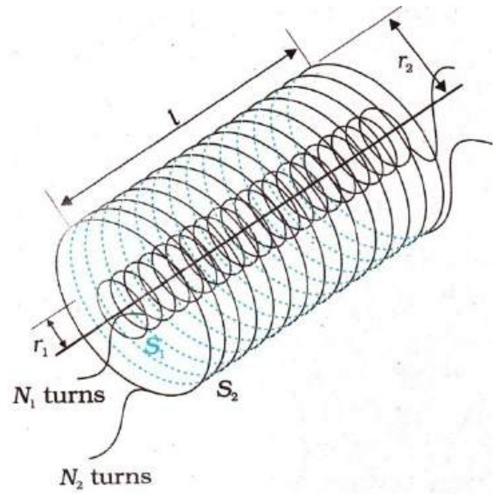
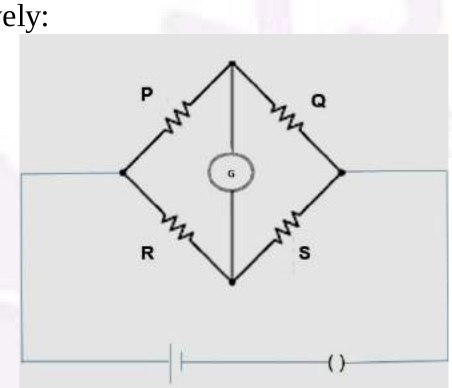
</table>

	Energy difference = 3.4 eV – 1.51 eV = 1.89 eV= 3.024×10^{-19} J Energy = $\frac{hc}{\lambda}$ =3.024×10^{-19} J Wavelength = $6.57\text{x}10^{-7}$m Series is Balmer series	½ ½ ½ ½	**2**
Q10	Condition i. For directions of $\vec{E}, \vec{B}, \vec{v}$ 1 ii. For magnitudes of $\vec{E}, \vec{B}, \vec{v}$ 1 (i) The velocity $\vec{v}$, of the charged particles, and the $\vec{E}$ and $\vec{B}$ vectors, should be mutually perpendicular. Also the forces on q, due to $\vec{E}$ and $\vec{B}$, must be oppositely directed. (Also accept if the student draws a diagram to show the directions.)  (ii) $qE = qvB$ $or\ v = \frac{E}{B}$ **[**Alternatively**,** The student may write: Force due to electric field = $q\vec{E}$ Force due to magnetic field = $q\ (\vec{v} \times \vec{B})$ The required condition is $q\vec{E} = -q\ (\vec{v} \times \vec{B})$ $[or\ \vec{E} = -(\vec{v} \times \vec{B}) = (\vec{B} \times \vec{v})]$ (Note: Award 1 mark only if the student just writes: "The forces, on the charged particle, due to the electric and magnetic fields, must be equal and opposite to each other")**]**	 ½ ½ ½ ½ ½ ½ ½ ½	**2**

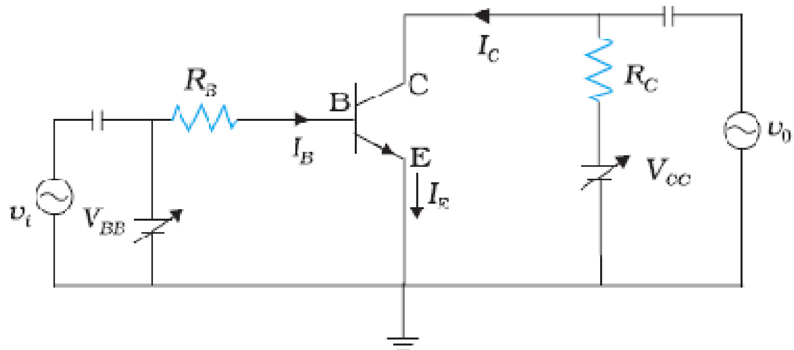
	SECTION C		
Q11	a. Calculation of wavelength, frequency and speed ½ + ½ + ½ b. Lens Maker's Formula ½ Calculation of R 1		
	a) $\lambda = \frac{589\text{ nm}}{1.33} = 442.8\text{nm}$	½	
	Frequency $\nu = \frac{3\times10^{8}\text{ ms}^{-1}}{589\text{ nm}} = 5.09 \times 10^{12}\text{Hz}$	½	
	Speed $v = \frac{3\times10^{8}}{1.33}\text{m/s} = 2.25 \times 10^{8}\text{m/s}$	½	
	b) $\frac{1}{f} = \left[\frac{\mu_2}{\mu_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$	½	
	$\therefore \frac{1}{20} = \left[\frac{1.55}{1} - 1\right]\frac{2}{R}$	½	
	$\therefore R = (20 \times 1.10)\text{cm} = 22\text{ cm}$	½	**3**
Q12	Definition of mutual inductance 1 Derivation of mutual inductance for two long solenoids 2		
	(i) Mutual inductance is numerically equal to the induced emf in the secondary coil when the current in the primary coil changes by unity. <u>Alternatively:</u> Mutual inductance is numerically equal to the magnetic flux linked with one coil/secondary coil when unit current flows through the other coil /primary coil.	**1**	

	(ii) 	½	
	Let a current, i_2, flow in the secondary coil $\therefore B_2 = \frac{\mu_0 N_2 i_2}{l}$	½	
	$\therefore$ Flux linked with the primary coil $= N_1 A_1 B_2 = \frac{\mu_0 N_2 N_1 A_1 i_2}{l} = M_{12} i_2$	½	
	Hence, $M_{12} = \frac{\mu_0 N_2 N_1 A_2}{l} = \mu_0 n_2 n_1 A_1 l \left(n_1 = \frac{N_1}{l}; n_2 = \frac{N_2}{l}\right)$	½	3
	OR Definition of self inductance — 1 Expression for energy stored — 2		
	(i) Self inductance, of a coil, is numerically equal to the emf induced in that coil when the current in it changes at a unit rate. (Alternatively: The self inductance of a coil equals the flux linked with it when a unit current flows through it.)	**1**	

	(ii) The work done against back /induced emf is stored as magnetic potential energy. The rate of work done, when a current i is passing through the coil, is $\frac{dW}{dt} = \lvert\varepsilon\rvert i = \left(L\frac{di}{dt}\right)i$ $\therefore W = \int dW = \int_0^I Lidi$ $= \frac{1}{2}Li^2$	½ ½ ½ ½	3
Q13	a) Principle of meter bridge — 1 b) Relation between l_1,l_2, and S — 2 a) The principle of working of a meter bridge is same as that of a balanced Wheatstone bridge. (Alternatively:  When i_g=0, then $\frac{P}{Q} = \frac{R}{S}$) b) $\frac{R}{S} = \frac{l_1}{100-l_1}$ When X is connected in parallel: $\frac{R}{\left(\frac{XS}{X+S}\right)} = \frac{l_2}{100-l_2}$ On solving, we get $X = \frac{l_1 S(100-l_2)}{100(l_2-l_1)}$	1 ½ ½ 1	3

Q14

Transistor amplifier circuit diagram	1
Derivation of voltage gain	1 ½
Explanation of phase reversal	½



1

Change in the input voltage: $\Delta V_{BE} = I_B r_i$ ½

Change in the output voltage: $\Delta V_{CE} = I_C R_C$ ½

Voltage gain= Output voltage/Input voltage $A_V = -\frac{\beta R_C}{r_i}$ ½

Negative sign indicates, phase difference is 180° ½

(Alternatively, There is a phase reversal)

3

Q15

a) The factor by which the potential difference changes	1
b) Voltmeter reading	1
Ammeter Reading	1

a) $H = \frac{V^2}{R}$ ½

$\therefore V$ increases by a factor of $\sqrt{9} = 3$ ½

b) Ammeter Reading $I = \frac{V}{R+r}$ ½

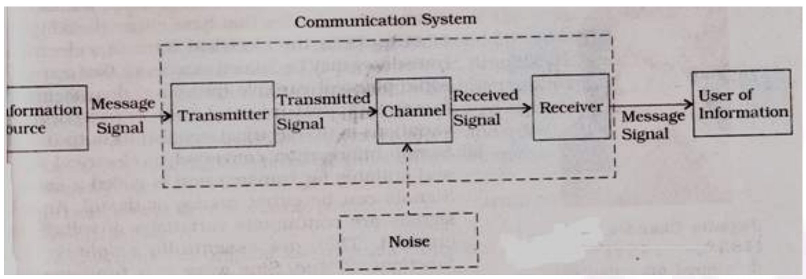
$= \frac{12}{4+2}\text{A} = 2\text{A}$ ½

<table>
<tr><td></td><td>Voltmeter Reading $V = E - Ir$

$= [12 - (2 \times 2)]\ V = 8V$
(Alternatively, $V = iR = 2 \times 4V = 8V$)</td><td>½

½</td><td>3</td></tr>
<tr><td>Q16</td><td>

Diagram of generalized communication system	1½
Function of (a) transmitter (b) channel (c) receiver	½+ ½ + ½



[Also accept the following diagram

]

(a) Transmitter: A transmitter processes the incoming message signal so as to make it suitable for transmission through a channel and subsequent reception.

(b) Channel: It carries the message signal from a transmitter to a receiver.

(c) Receiver: A receiver extracts the desired message signals from the received signals at the channel output.
</td><td>1 ½

½

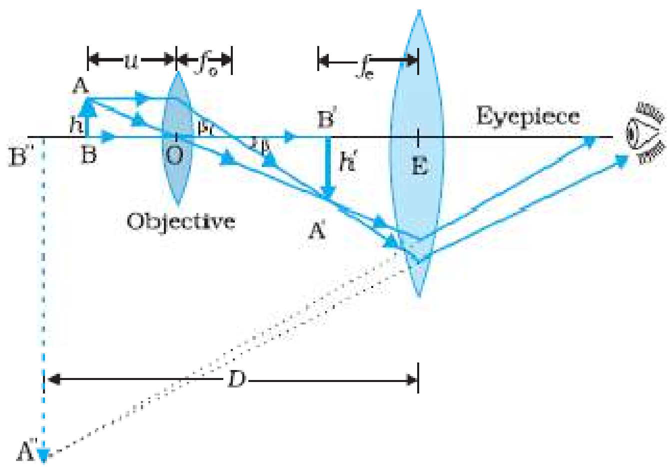
½

½</td><td>3</td></tr>
</table>

Q17

a) Ray diagram for compound microscope	1
b) Identification of objective and eye piece	1
c) Resolving power of microscope	½
d) One factor affecting the resolving power	½

a) Ray Diagram for compound microscope



1

b) Objective: Lens L_3 — ½

Eye Piece: Lens L_2 — ½

c) $R_p = \dfrac{2\mu \sin\beta}{1.22\lambda}$ — ½

d) Any one factor — ½

1. It depends on the wavelength of the light used.
2. Semi angle of cone of incident light.
3. Aperture of the objective
4. Refractive index of the medium.

3

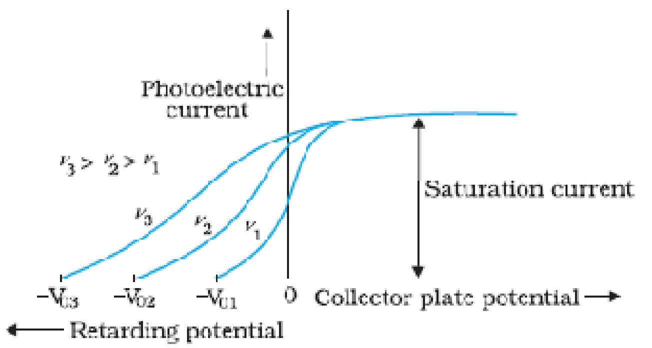
Q18

(a) Identification of X	½
(b) Identification of point A	½
(c) Graph for three different frequencies	1
(d) Graph for three different intensities.	1

a) X is collector plate potential. ½

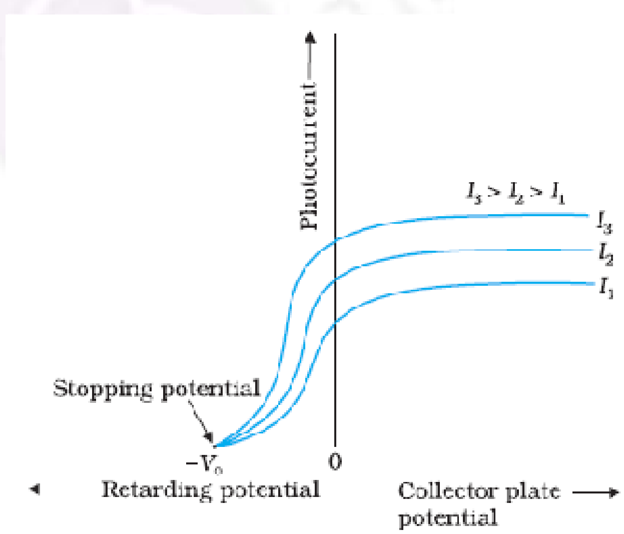
b) A is stopping potential. ½

c) Graph for different frequencies



1

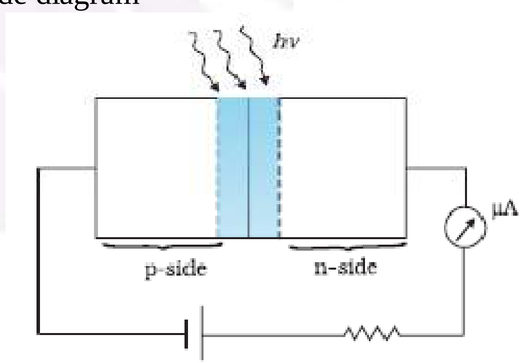
d) Graph for three different Intensities

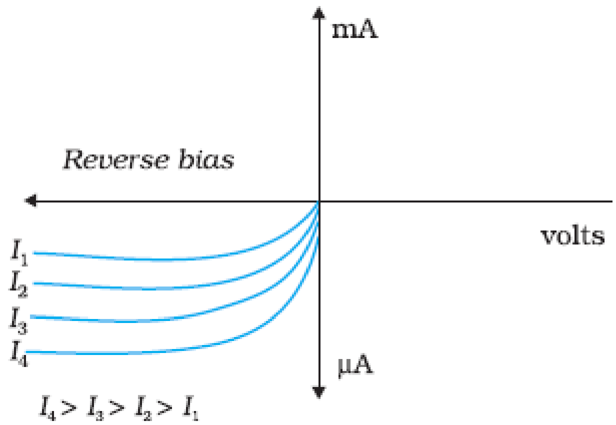


1

3

Q19	Formula for energy stored ½ Energy stored before 1 Energy stored after 1 Ratio ½		
	Energy stored = $\frac{1}{2}CV^2 \left(= \frac{1}{2}\frac{Q^2}{C}\right)$	½	
	Net capacitance with switch S closed $= C + C = 2C$	½	
	$\therefore$ Energy stored $= \frac{1}{2} \times 2C \times V^2 = CV^2$	½	
	After the switch S is opened, capacitance of each capacitor$= KC$		
	$\therefore$ Energy stored in capacitor A $= \frac{1}{2}KCV^2$		
	For capacitor B,	½	
	Energy stored $= \frac{1}{2}\frac{Q^2}{KC} = \frac{1}{2}\frac{C^2V^2}{KC} = \frac{1}{2}\frac{CV^2}{K}$		
	$\therefore$ Total Energy stored $= \frac{1}{2}KCV^2 + \frac{1}{2}\frac{CV^2}{K} = \frac{1}{2}CV^2\left(K + \frac{1}{K}\right)$ $= \frac{1}{2}CV^2\left(\frac{K^2+1}{K}\right)$	½	
	$\therefore$ Required ratio $= \frac{2CV^2.K}{CV^2(K^2+1)} = \frac{2K}{(K^2+1)}$	½	3
Q20	Formula for energy stored ½ Energy stored before 1 Energy stored after 1 Ratio ½		
	Energy stored = $\frac{1}{2}CV^2 \left(= \frac{1}{2}\frac{Q^2}{C}\right)$	½	
	Net capacitance with switch S closed $= C + C = 2C$	½	
	$\therefore$ Energy stored $= \frac{1}{2} \times 2C \times V^2 = CV^2$	½	
	After the switch S is opened, capacitance of each capacitor$= KC$		

	∴ Energy stored in capacitor A = $\frac{1}{2}KCV^2$		
	For capacitor B,		
	Energy stored $= \frac{1}{2}\frac{Q^2}{KC} = \frac{1}{2}\frac{C^2V^2}{KC} = \frac{1}{2}\frac{CV^2}{K}$	½	
	∴ Total Energy stored $= \frac{1}{2}KCV^2 + \frac{1}{2}\frac{CV^2}{K} = \frac{1}{2}CV^2\left(K + \frac{1}{K}\right)$		
	$= \frac{1}{2}CV^2\left(\frac{K^2+1}{K}\right)$	½	
	∴ Required ratio $= \frac{2CV^2.K}{CV^2(K^2+1)} = \frac{2K}{(K^2+1)}$	½	
			3
Q21	a) Correct Choice of *R* ½ Reason ½ b) Circuit Diagram **1** Working ½ *I-V* characteristics ½		
	a) R would be increased.	½	
	Resistance of S (a semi conductor) decreases on heating.	½	
	b) Photodiode diagram 	**1**	
	When the photodiode is illuminated with light (photons) (with energy $(h\nu)$ greater than the energy gap (E_g) of the semiconductor), then electron-hole pairs are generated due to the		

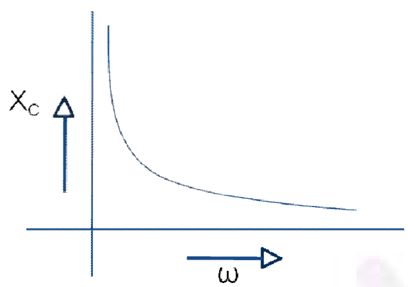
	absorption of photons. Due to junction field, electrons and holes are separated before they recombine. Electrons are collected on n-side and holes are collected on p-side giving rise to an emf. When an external load is connected, current flows. *V-I* Characteristics of the diode  	½ ½	**3**
Q22	(a) Statement of Biot Savart law — 1 Expression in vector form — ½ (b) Magnitude of magnetic field at centre — 1 Direction of magnetic field — ½ (a) It states that magnetic field strength, $d\vec{\boldsymbol{B}}$, due to a current element, $Id\vec{\boldsymbol{l}}$, at a point, having a position vector **r** relative to the current element, is found to depend (i) directly on the current element, (ii) inversely on the square of the distance |**r**| , (iii) directly on the sine of angle between the current element and the position vector **r**. In vector notation, $d\vec{\boldsymbol{B}} = \frac{\mu_0}{4\pi}\frac{Id\vec{\boldsymbol{l}} \times \vec{\boldsymbol{r}}}{\lvert\vec{\boldsymbol{r}}\rvert^3}$ **Alternatively**, $\left(d\vec{\boldsymbol{B}} = \frac{\mu_0}{4\pi}\frac{Id\vec{\boldsymbol{l}} \times \hat{r}}{\lvert\vec{r}\rvert^2}\right)$	**1** ½	

	(b) $B_p = \frac{\mu_0 \times 1}{2R} = \frac{\mu_0}{2R}$ (along z – direction) $B_Q = \frac{\mu_0 \times \sqrt{3}}{2R} = \frac{\mu_0\sqrt{3}}{2R}$ (along x – direction) $\therefore B = \sqrt{{B_p}^2 + {B_Q}^2} = \frac{\mu_0}{R}$ This net magnetic field **B**, is inclined to the field $\mathbf{B_p}$, at an angle ϴ, where $\tan\theta = \sqrt{3}$ $(/\theta = \tan^{-1}\sqrt{3} = 60^0)$ (in XZ plane)	½ ½ ½	**3**
	SECTION D		
Q23	a) Name of the installation, the cause of disaster ½ + ½ b) Energy release process 1 c) Values shown by Asha and mother 1+1 a) (i) Nuclear Power Plant:/'Set-up' for releasing Nuclear Energy/Energy Plant (Also accept any other such term) (ii)Leakage in the cooling unit/ Some defect in the set up. b) Nuclear Fission/Nuclear Energy Break up (/ Fission) of Uranium nucleus into fragments c) Asha: Helpful, Considerate, Keen to Learn, Modest Mother: Curious, Sensitive, Eager to Learn, Has no airs (Any one such value in each case)	½ ½ **1** **1** **1**	**4**
	SECTION E		
Q24	a) Identification ½ b) Identifying the curves 1 Justification ½ c) Variation of Impedance with frequency ½ Graph ½ d) Expression for current 1½ Phase relation ½ a) The device X is a capacitor	½	

b) Curve B ⟶ voltage ½
Curve C ⟶ current ½
Curve A ⟶ power

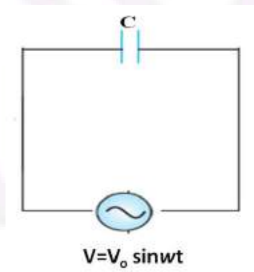
Reason: The current leads the voltage in phase, by $\pi/2$, for a capacitor. ½

c) $X_c = \frac{1}{\omega C}$ $(/X_c \propto \frac{1}{\omega})$ ½



½

d) $V = V_0 \sin\omega t$ ½



$Q = CV = CV_0 \sin\omega t$ ½

$I = \frac{dq}{dt} = \omega c V_0 \cos\omega t$ ½

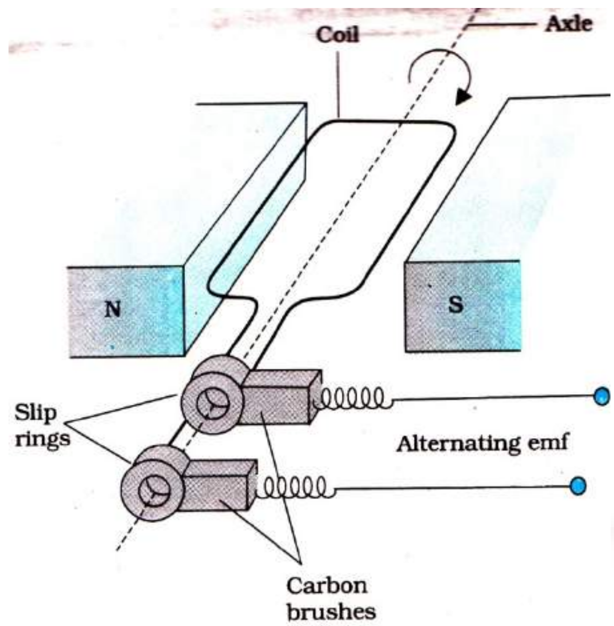
$= I_0 \sin(\omega t + \pi/2)$ ½

Current leads the voltage, in phase , by $\pi/2$

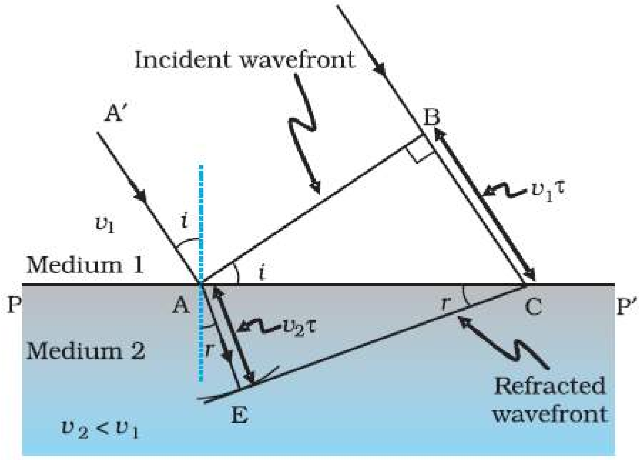
(Note : If the student identifies the device X as an Inductor but writes correct answers to parts (c) and (d) (in terms of an inductor), the student be given full marks for (only) these two parts) **5**

OR

a)	Labelled diagram of ac generator	1
	Expression for emf	2
b)	Formula for emf	½
	Substitution	½
	Calculation of emf	1

	a) 	1	
	Let ω be the angular speed of rotation of the coil. We then have		
	$\phi(t) = NBA\cos\omega t$	½	
	$\therefore\ E = -\frac{d\phi}{dt}$		
	$= NBA\omega\sin\omega t$	½	
	$= E_0\sin\omega t \qquad (E_0 = NBAw)$	1	
	b) Induced emf $= BlV$	½	
	$\therefore E = 0.3\times10^{-4}\times10\times5$ volt	½	
	$E = 1.5\times10^{-3}\text{V}\ (= 1.5\text{mV})$	1	
			5
Q25	a) Definition of wavefront — ½ Verifying laws of refraction by Huygen's principle — 3 b) Polarisation by scattering — ½ Calculation of Brewster's angle — 1		

a) The wavefront is the common locus of all points which are in phase(/surface of constant phase) ½



1

Let a plane wavefront be incident on a surface separating two media as shown. Let v_1 and v_2 be the velocities of light in the rarer medium and denser medium respectively. From the diagram

$$BC = v_1 t \text{ and } AD = v_2 t$$ ½

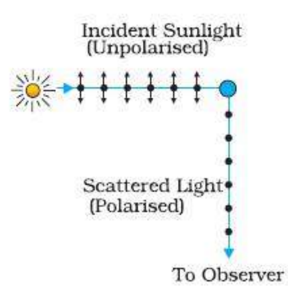
$$\sin i = \frac{BC}{AC} \text{ and } \sin r = \frac{AD}{AC}$$ ½

$$\therefore \frac{\sin i}{\sin r} = \frac{BC}{AD} = \frac{v_1 t}{v_2 t}$$ ½

$$= \frac{v_1}{v_2} = a\ constant$$ ½

This proves Snell's law of refraction.

b) When unpolarised light gets scattered by molecules, the scattered light has only one of its two components in it. (Also accept diagrammatic representation



) ½

We have, $\mu = \tan i_B$ ½

$\therefore \tan i_B = 1.5$

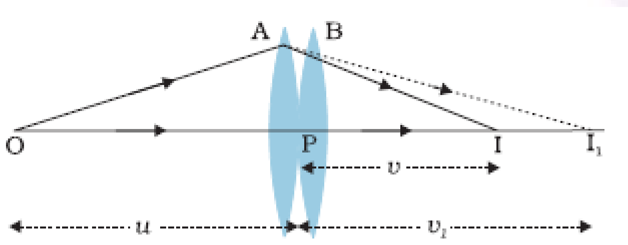
$\therefore i_B = \tan^{-1} 1.5$

$(/56.3^{o})$ ½

OR **5**

a)	Ray diagram	1
	Expression for power	2
b)	Formula	½
	Calculation of speed of light	1 ½

a)



1

Two thin lenses, of focal length f_1 and f_2 are kept in contact. Let O be the position of object and let u be the object distance. The distance of the image (which is at I_1), for the first lens is v_1.

This image serves as object for the second lens. ½

Let the final image be at I. We then have

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u}$$ ½

$$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$$

Adding , we get

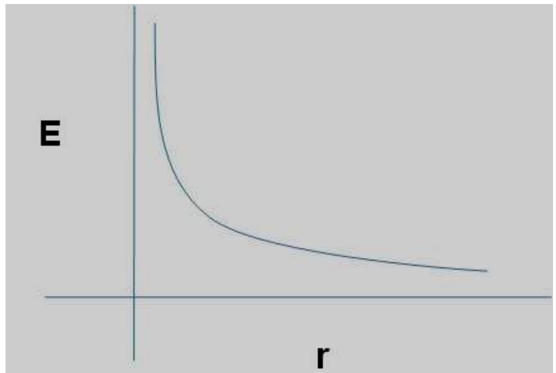
$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$ ½

$$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\therefore P = P_1 + P_2$$ ½

	b) At minimum deviation $r = {}^{A}/_{2} = 30^0$ We are given that $i = \frac{3}{4}A = 45^0$ $\therefore \mu = \frac{\sin 45^0}{\sin 30^0} = \sqrt{2}$ $\therefore$ Speed of light in the prism = $\frac{c}{\sqrt{2}}$ $(\cong 2.1 \times 10^8\ ms^{-1})$ [Award ½ mark if the student writes the formula: $\mu = \frac{\sin(A + D_m)/2}{\sin({}^{A}/_{2})}$ but does not do any calculations.]	½ ½ ½ ½	5
Q26	(a) Derivation of *E* along the axial line of dipole — 2 (b) Graph between *E* vs *r* — 1 (c) (i) Diagrams for stable and unstable equilibrium of dipole — ½ + ½ (ii) Torque on the dipole in the two cases — ½ + ½ (a)  Electric field at P due to charge $(+q) = E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}$ Electric field at P due to charge $(-q) = E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$ Net electric Field at P= $E_1 - E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2} - \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$ $= \frac{1}{4\pi\varepsilon_0}\frac{2pr}{(r^2 - a^2)^2}$ $(p = q.2a)$ Its direction is parallel to $\vec{p}$.	 ½ ½ ½ ½	

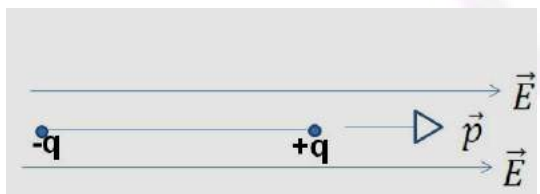
(b)



1

(Note: Award ½ mark if the student just writes: For short Dipole = $\frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$ without drawing the graph)

(c)



Stable equilibrium ½

Unstable equilibrium ½

(Note: Award ½ mark only if the student does not draw the diagrams but just writes:

(i) For stable Equilibrium: $\vec{p}$ is parallel to $\vec{E}$.

(ii) For unstable equilibrium: $\vec{p}$ is antiparallel to $\vec{E}$)

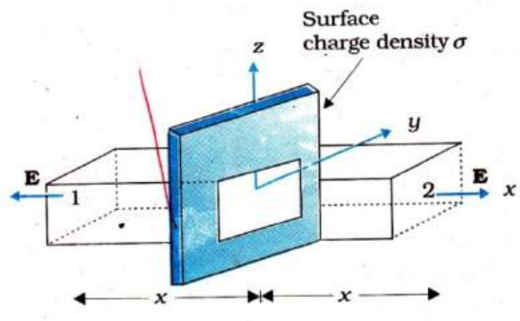
Torque = 0 for (i) as well as case (ii).

(Also accept, $\vec{\tau} = \vec{p} \times \vec{E}$ / $\tau = pE\sin\theta$) ½ + ½

OR 5

a)	Using Gauss's theorem to find E due to an infinite plane sheet of charge	3
b)	Expression for the work done to bring charge q from infinity to r	2

a)



½

$$\oint E.ds = \frac{q}{\varepsilon_0}$$ ½

The electric field E points outwards normal to the sheet. The field lines are parallel to the Gaussian surface except for surfaces 1 and 2. Hence the net flux = $\oint E.ds = EA + EA$ where A is the area of each of the surface 1 and 2. **1**

$$\therefore \oint E.ds = \frac{q}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0} = 2EA;$$ **1**

$$E = \frac{\sigma}{2\varepsilon_0}$$

b)

$$W = q\int_{\infty}^{r} \vec{E}.d\vec{r}$$ ½

$$= q\int_{\infty}^{r} (-Edr)$$ ½

$$= -q\int_{\infty}^{r} \left(\frac{\sigma}{2\epsilon_0}\right) dr$$ ½

$$= \frac{q\sigma}{2\in}|\infty - r|$$

$$\Rightarrow (\infty)$$ ½

5