Marking Scheme

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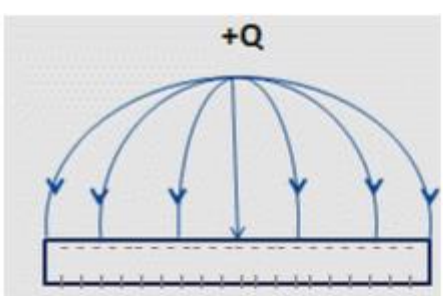
S.No	Value Points/Expected answers	Marks	Total Marks
1	When light is passed through a polaroid, its intensity is reduced to half and does not change an the rotation of the polaroid, the light is unpolarized, When the intensity of transmitted light changes on rotation of the polaroid, light is polaroid. Alternatively In Polarized/ unpolarized light, there is some restriction/no restriction on the vibrations of it electric (and magnetic) field vectors [Note: Award full marks to the student if he/she explains through the diagram only]	½+½ $\frac{1}{2}+\frac{1}{2}$	1
2.	Threshold frequency equals the minimum frequency of incident radiation (light) that can cause photoemission from a given photosensitive surface. (Alternatively) The frequency below which the incident radiations cannot cause the photoemission from photosensitive surface. OR Intensity of radiation is proportional to (/ equal to) the number of energy quanta (photons) per unit area per unit time.	1	1
3.	Decreases	1	1
4	The waves beyond 30 MHz frequency penetrate through the Ionosphere/ are not reflected back. OR Transmitted Power and Frequency	1 ½+½	1
5.	 Note: (i) Award this one mark even the student does not show the induced charges on the surface of the conducting plate (ii) Deduct $\frac{1}{2}$ mark if the arrows, on the field lines, are not shown.	1	1

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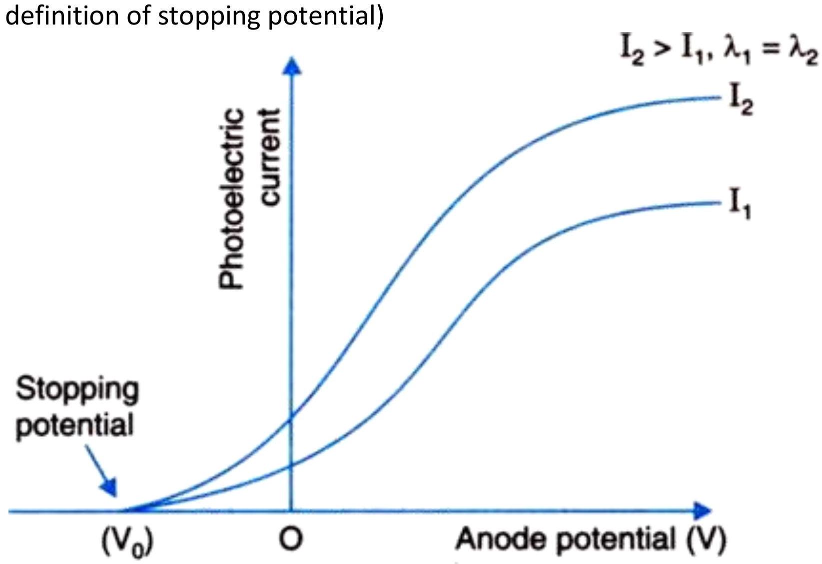
6.	(a) Definition of the terms (i) and (ii) $\frac{1}{2}+\frac{1}{2}$ (b) Graph of photocurrent versus anode potential 1		
	(a) (i) Threshold frequency equals the minimum frequency of incident radiation (light) that can cause photoemission from a given photosensitive surface.	½	
	(Alternatively) The frequency below which the incident radiations cannot cause the photoemission from photosensitive surface.	½	
	OR Intensity of radiation is proportional to (/ equal to) the number of energy quanta (photons) per unit area per unit time. (ii) Stopping potential : The minimum negative (retarding) potential, given to the anode (/collector plate) for which the photocurrent stops or becomes zero. (Note: Do not deduct the ½ mark here of the part (i), if a student writes incorrect definition or unable to write the definition of threshold frequency is as No.2 as well as here, In such a case, award him/her one full mark for the correct definition of stopping potential)		
		1	2
7.	Reason 1 Expression 1		

	Because of line of sight nature of propagation, direct waves get blocked at some point by the curvature of earth. [Alternatively : The transmitting antenna of height h, the distance to the horizon equals d= $\sqrt{2hR}$ (R = Radius of earth which is upto a certain distance from the TV tower.] The optimum separation between the receiving and transmitting antenna. d = $\sqrt{2h_TR} + \sqrt{2h_RR}$ [Where h_T = height of Transmitting antenna, h_R = Height of Receiving antenna)]	1 1	2
8.	Statement of Bohr's quantization condition ½ Calculation of shortest wavelength 1 Identification of part of electromagnetic spectrum ½ Electron revolve around the nucleus only in those orbits for which the angular momentum is some integral of h/2π. (where h is planck's constant) (Also give full credit it a student write mathematically mvr = $\frac{nh}{2\pi}$) $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ For Brackett Series, Shortest wavelength is for the transition of electrons from $n_i = \infty$ to $n_f = 4$ $\frac{1}{\lambda} = R\left(\frac{1}{4^2}\right) = \frac{R}{16}$ $\lambda = \frac{16}{R}$ m = 1458.5 nm on substitution the of value of R [Note: Don't deduct any mark for this part, when a student does not substitute the value of R, to calculate the numerical value of λ] Infrared region OR Statement of the Formula for r_n ½ Statement of the formula for v_n ½ Obtaining formula for T_n ½ Getting expression for T_2 (n = 2) ½	½ ½ ½ ½	

	Radius $r_n = \frac{h^2\epsilon_0}{\pi m e^2} n^2$ Velocity $v_n = \frac{2\pi e^2}{4\pi\varepsilon_0 h}\frac{1}{n}$ $T_n = \frac{2\pi r_n}{v_n} = \frac{4\varepsilon_0^2 h^3 n^3}{m e^4}$ For first excited state of hydrogen atom n=2 $T_2 = \frac{32\varepsilon_0^2\, h^3}{m e^4}$ On calculation we get $T_2 \approx 1.22\ X\ 10^{-15}\ s$. (However, do not deduct the last ½ mark if a student does not calculate the numerical value of T_2) <u>Alternatively</u> $r_n = (\ 0.53\ n^2\ )A^0 = 0.53\ X\ 10^{-10}\ n^2$ $v_n = (\frac{c}{137\ n})$ $T_n = \frac{2\pi(0.53)}{\left(\frac{c}{137\ n}\right)}\ X\ 10^{-10}\ n^2$ = $\frac{2\pi(0.53)}{c}\ X\ 10^{-10}\ n^3 \text{ x } 137\ \text{ s}$ $= \frac{2 \text{ x } 3.14 \text{ x } 0.53 \text{ x } 10^{-10} \text{ x } 8 \text{ x } 137}{3\ x\ 10^8}$ s = 1215.97 x 10^{-18} = (1.22 x 10^{-15}) s Alternatively If the student writes directly $T_n\ \alpha\ n^3$ T_2 = 8 times of orbital period of the electron in the ground state (award one mark only)	½ ½ ½ ½ ½ ½ ½ ½	2 2
9.	Reason for inability of e.m. theory 1 Resolution through photon picture 1		

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	The explanation based on e.m theory does not agree with the experimental observations (instantaneous nature , max K.E of emitted photoelectron is independent of intensity, existence of threshold frequency) on the photoelectric effect. **[Note: Do not deduct any mark if the student does not mention the relevant experimental observation or mentions any one or any two of these observation.]** The photon picture resolves this problem by saying that light, in interaction with matter behaves as if it is made of quanta or packets of energy, each of energy h ν . This picture enables us to get a correct explanation of all the observed experimental features of photoelectric effect. [NOTE: Award the first mark if the student just writes "As per E.M. theory the free electrons at the surface of the metal absorb the radiant energy continuously, this leads us to conclusions which do not match with the experimental observations"] Also award the second mark if the student just writes "The photon picture give us the Einstein photoelectric equation Kmax (= eVo) = h ν - ϕ_0 which provides a correct explanation of the observed features of the photoelectric effect.	1 1	2
10.	Calculation of Power dissipation in two combinations 1 +1 $R_1 = \frac{V^2}{P_1}$, $R_2 = \frac{V^2}{P_2}$, $P_s = \frac{V^2}{Rs} = \frac{P_1 P_2}{P_1+P_2}$ $\frac{1}{Ps} = \frac{1}{P_1} + \frac{1}{P_2}$ $\frac{1}{Rp} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{P_1+P_2}{V^2}$ $\therefore P_p = \frac{V^2}{R_P} = P_1 + P_2$	½ ½ ½ ½	2
11.	Obtaining the expression for the ratio of de Broglie wavelengths associated with electron orbiting in second & third excited state 1+1 $2\pi r = n\lambda$	½	

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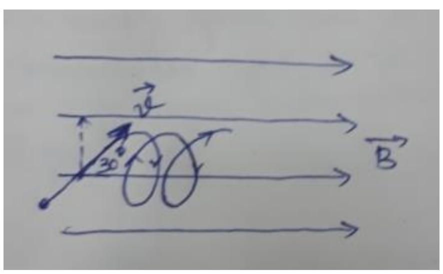
	For second excited state (n=3) $r = 0.529(n)^2$ A° $= 0.529(3)^2$ $\rightarrow$ $2\pi(0.529)(3)^2 = 3\lambda_2$ For third excited state n=4 $r= 0.529\ (4)^2$ $\rightarrow$ $2\pi(0.529)(4)^2 = 4\lambda_3$ $\rightarrow$ $\frac{3\lambda_2}{4\lambda_3} = \frac{(3)^2}{(4)^2}$ $\frac{\lambda_2}{\lambda_3} = 3:4$ Alternatively $2\pi\ (0.53\ n^2) = n\lambda$ $\rightarrow$ $\lambda \propto n$ $\rightarrow$ $\frac{\lambda_2}{\lambda_3} = \frac{(n) for\ second\ excited\ state}{(n) for\ third\ excited\ state}$ $\therefore \frac{\lambda\ second\ excited\ state}{\lambda\ third\ excited\ state} = \frac{3}{4}$	½ ½ ½ ½ ½ 1	2 2
12.	Drawing of trajectory 1 Explanation 1  Two components of velocity vector $\vec{v}$ are responsible for the helical motion. Force on the charged particle due to the component normal to the magnetic field, acts perpendicular to the velocity and the magnetic field. Hence makes the particle follow circular path. The component of velocity which is along the magnetic field, does not cause any force on the particle hence particle continues to move in a straight line path due to this component, hence resultant path will be helical.	1 1	2
13.	**SECTION C** (a) Explanation of information on the size of nucleus $1\frac{1}{2}$ (b) Showing the independence of density on mass number $1\frac{1}{2}$		

	(a)Many of the ∝-particles pass through the foil. a few particles deflect by more than 90°. Rutherford argued that to deflect the ∝-particles backward, it must experience a large repulsive force. It shows that most of the part of the part of an atom is the empty space and its positive charge is concentrated tightly at its centre and its size is very small as compared to the size of atom. (nearly $\frac{1}{10,000}$ to $\frac{1}{10,000}$ times the size of atom) <u>Alternatively</u> In Rutherford experiment , the calculation of distance of closest approach provides information about the size of the nucleus. Let K be the initial kinetic energy of the alpha particle. At the distance of closest approach $\frac{1}{4\pi\epsilon_\circ}\frac{(Ze)(2e)}{a^2} = k$ $\therefore a = \frac{2ze^2}{4\pi\epsilon_\circ k}$ (a) Radius of the nucleus of mass number A, $R=R_\circ A^{1/3}$, Where $R_\circ$ is constant Volume of the nucleus $V = \frac{4}{3}\pi R^3$ $= \frac{4}{3}\pi(R_\circ A^{1/3})^3$ $= \frac{4}{3}\pi A R_\circ^3$ Density (p) $= \frac{mass}{volume} = \frac{mA}{(\frac{4}{3}\pi R_\circ^3 A)}$ $= \frac{3m}{4\pi R_\circ^3}$ i:e. independent of mass number A.	½ ½ ½ ½ ½ ½	3
14.	Underlying principle of cyclotron 1/2 Working 1 Schematic diagram 1/2 Obtaining the expression for the cyclotron frequency 1		

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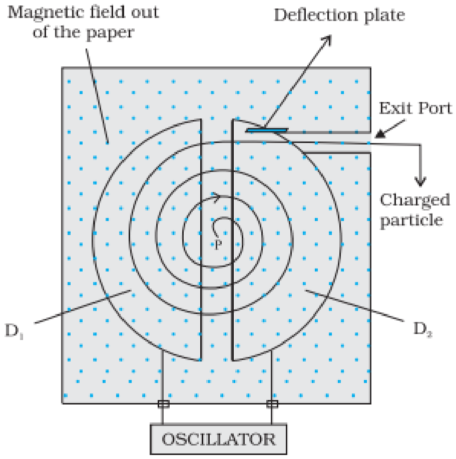
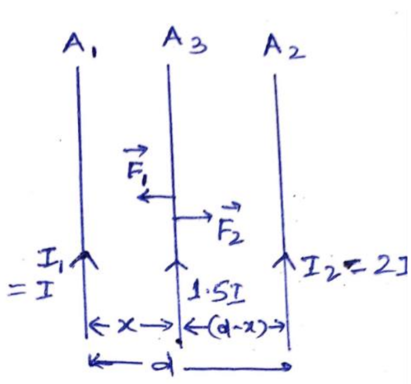
	Cyclotron works on the principle that kinetic energy of the charged particle is increased when they move in crossed oscillating electric and magnetic fields again and again.  When charged particle enter is inside the metal boxes, no electric field acts on them, the magnetic field however acts on the particle and makes it go round in a circular path inside the metal boxes,(dees), everytime when particle moves one dee to another it is acted upon by the electric field and the sign of electric field changes alternatively in turn with the circular motion of the particle, hence particle is accelerated, which in turn increases the kinetic energy of it. $\frac{mv^2}{r}$ = qvB r = $\frac{mv}{qB}$ frequency $\nu = \frac{v}{2\pi r} = \frac{v}{2\pi(\frac{mv}{qB})} = \frac{qB}{2\pi m}$	½ ½ ½ ½	2
15.	Finding the position of third wire $2\frac{1}{2}$ Reason 1/2 	½	

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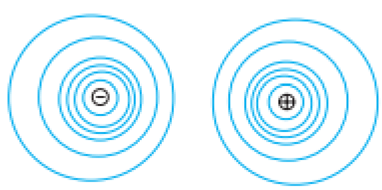
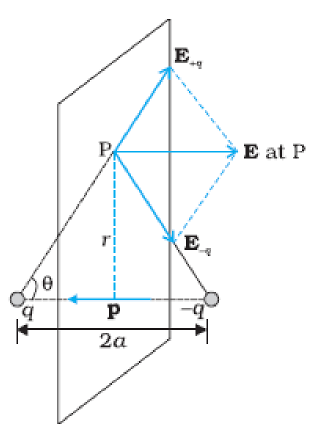
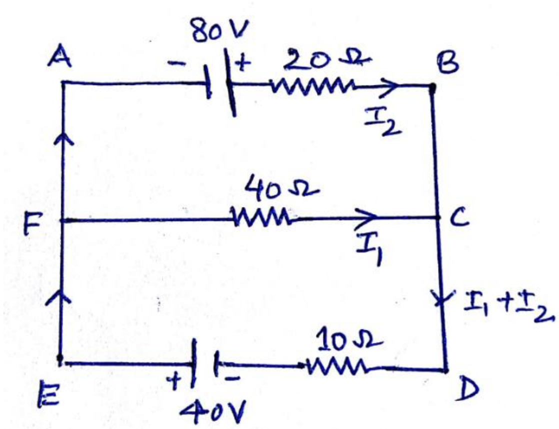
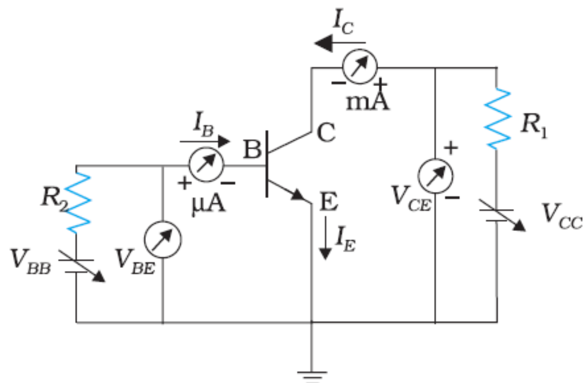
	$F_1 = \frac{\mu_\circ}{4\pi}\ \frac{IX1.5I}{x}$	½	
	$F_1 = \frac{\mu_\circ}{4\pi}\ \frac{2IX1.5I}{(d-x)}$	½	
	For no force on the conductor A_3 $\frac{\mu_\circ}{4\pi}\ \frac{IX1.5I}{X} = \frac{\mu_\circ}{4\pi}\ \frac{2IX1.5I}{(d-x)}$ $\frac{1}{x} = \frac{2}{(d-x)}$	½	
	$\rightarrow$ 3x = d x =d/3	½	
	No Also accept in general it will depend on the value of I_3	½	3
16.	(a) Drawing of equipotential surfaces due to an electric dipole 1 (b) Derivation of electric field on the perpendicular bisector 2		
	(a) 	½	
	(b) (a) Derivation for the expression of the electric field on the equatorial line 3 (b) Finding the position and nature of Q 1 + 1		
	(a)  	1	

	The magnitude of the electric fields due to the two charges +q and -q are $$E_{+q} = \frac{1}{4\pi \in_0} \frac{q}{\left(r^2 + a^2\right)}$$	½	
	$$E_{-q} = \frac{1}{4\pi \in_0} \frac{q}{\left(r^2 + a^2\right)}$$	½	5
	The components normal to the dipole axis cancel away and the components along the dipole axis add up Hence total Electric field = - ($E_{+q} + E_{-q}$)cosθ $\hat{p}$	½	
	$$E = -\frac{2qa}{4\pi\varepsilon_0 \left(r^2 + a^2\right)^{3/2}} \hat{p}$$	½	
17.	Writing two loop equations 1 + 1 Calculation of currents through 40 Ω and 20 Ω resistors 1  In loop ABCFA $+80 - 20 I_2 + 40 I_1 = 0$ $4 = I_2 - 2 I_1$	1	
	In loop FCDEA $-40 I_1 - 10(I_1 + I_2) + 40 = 0$		

	$-50\,I_1 - 10\,I_2 + 40 = 0$ $5\,I_1 + I_2 = 4$	1	
	Solving these two equations		
	$I_1 = 0A$	½	
	& $I_2 = 4A$	½	3
	OR		
	End error, overcoming ½ Formula for meter bridge ½ Calculation of value of S 2		
	The end error, in a meter bridge, is the error arising due to (i)Ends of the wire not coinciding with the 0 cm / 100 cm marks on the meter scale. (ii)Presence of contact resistance at the joints of the meter bridge wire with the metallic strips .		
	It can be reduced/overcome by finding balance length with two interchanged positions of R and S and taking the average value of 'S' from two readings.	½	
	(Note: Award this ½ make even if student just writes only the point (i) or point (ii) given above.)		
	For a meter bridge		
	$\frac{R}{S} = \frac{l}{100 - l}$	½	
	For the two given conditions		
	$\frac{5}{S} = \frac{l_1}{100 - l_1}$		
	$\frac{5}{S/2} = \frac{1.5l_1}{100 - 1.5l_1}$	½	

	Dividing the two $2 = \dfrac{1.5l_1}{100 - 1.5l_1} \times \dfrac{100 - l_1}{l_1}$ $200 - 3\,l_1 = 150 - 1.5\,l_1$ $l_1 = \dfrac{100}{3}$ cm Putting the value of l_1 in any one of the two given conditions. $S = 10\Omega$	½ ½ ½	3
18.	(a) Functions of the three segments $\frac{1}{2}+\frac{1}{2}+\frac{1}{2}$ (b) Circuit diagram for studying the output characteristics 1 obtaining output characteristics ½ (i) Emitter : supplies the large number of majority carriers for current flow through the transistor (ii) Base: Allows most of the majority charge carriers to go over to the collector Alternatively , It is the very thin lightly doped central segment of the transistor. Collector : collects a major portion of the majority charge carriers supplied by the emitter. (b) 	½ ½ ½ 1	

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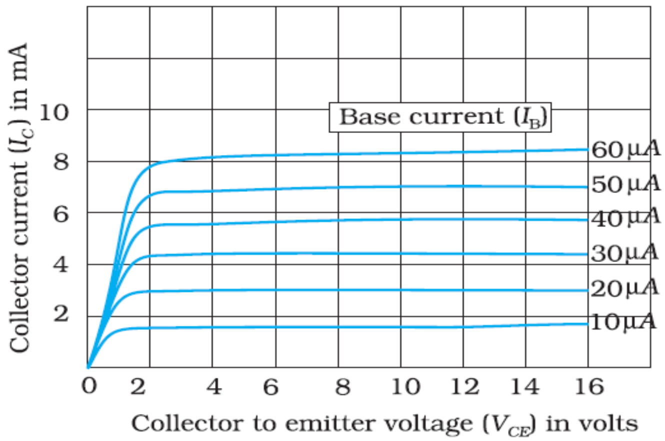
The output characteristics are obtained by observing the variation of I_c when V_{CE} is varied keeping I_B constant . ½

Note:Award the last ½ mark even if the student just draws the graph for output characteristics



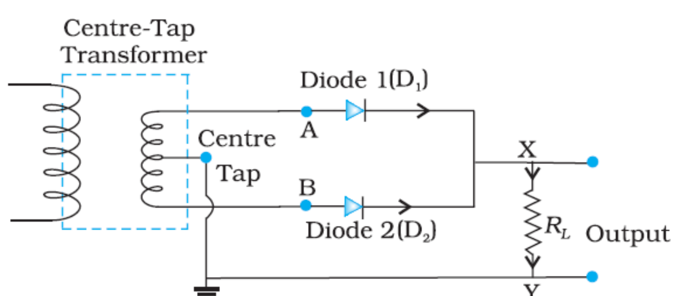
(b)

[Note: Do not deduct marks of this part, for not writing values on the axis]

OR

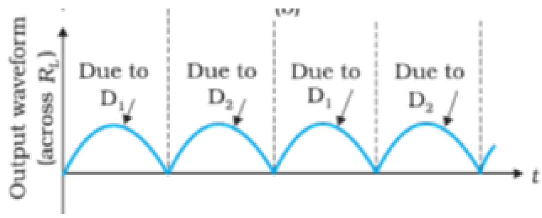
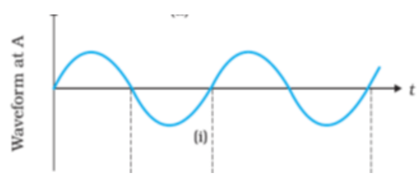
Circuit diagram of full wave rectifier	1
working	1
Input and output wave forms	$\frac{1}{2}+\frac{1}{2}$

The circuit diagram of a full wave rectifier is shown below.



(a)

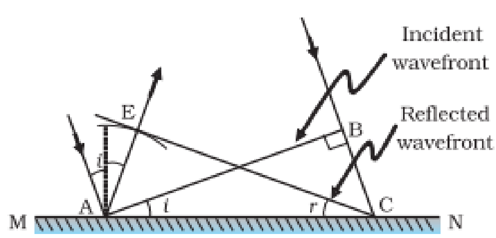
1

<table>
<tr>
<td></td>
<td>Because of the center tap in the secondary of the transformer, diodes 1 and 2 get forward biased in successive halves of the input ac cycle. However the current through the load flows in the same direction in both the halves of he input ac cycle. We therefore, get a unidirectional (rectified) current through the load for the full cycle of the input ac.
The input and output wave forms are as shown below.

</td>
<td>1

½

½</td>
<td>3</td>
</tr>
<tr>
<td>19.</td>
<td>

Definition of the wavefront	1
Verification of the law of Reflection	2

The wave front is defined as a surface of constant phase
Alternatively: The wave front is a locus of points which oscillate in phase
Consider a plane wave AB incident at an angle 'I' on a reflecting surface MN
</td>
<td>1

1</td>
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</table>

	let t = time taken by the wave front to advance from B to C. ∴ BC = vt Let CE represent the tangent plane drawn from the point C to the sphere of radius 'vt' having A as its center. then AE= BC= vt it follows that Δ EAC $\cong$ ΔBAC Hence $\angle i = \angle r$ ∴ Angle of incidence = angle of reflection OR Definition of the refractive index 1 Verification of laws of refraction 2 The refractive index of medium 2, w.r.t medium 1 equals the ratio of the sine of angle of incidence (in medium 1) to the sine of angle of refraction (in medium 2) Alternatively: Refractive index of radium 2 w.r.t medium 1 $n_{21} = \frac{\sin i}{\sin r}$ Alternatively : Refractive index of medium 2 w.r.t medium 1 $n_{21} = \frac{\text{Velcoity of light in medium 1}}{\text{Velocity of light in medium 2}}$	½ ½ 1	3

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	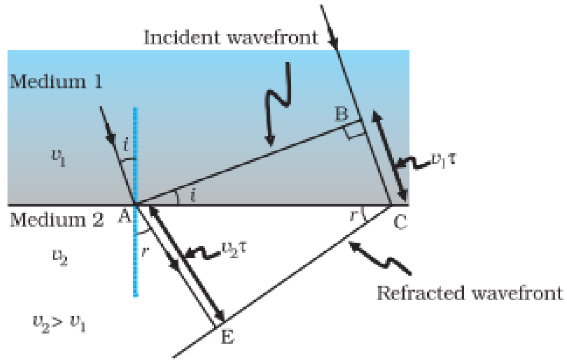 The figure drawn here shows the refracted wave front corresponding to the given incident wave front. It is seen that $\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$ $\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$ $\therefore \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \mu_{21}$ This is Snell's law of refraction.	1 ½ ½	3
20.	(a) Identification ½ + ½ Frequency Range ½ + ½ (b) Proof 1 Microwaves: Frequency range ($\sim$ 10^{10} to 10^{12} hz) Ultraviolet rays: Frequency range ($\sim$ 10^{15} to 10^{17} hz) Note: Award $(\frac{1}{2}+\frac{1}{2})$ marks for frequency ranges even if the student just writes the correct order of magnitude for them) (b) Average energy density of the electric field = ½ $\in_0 E^2$	½ + ½ ½ + ½ ½	

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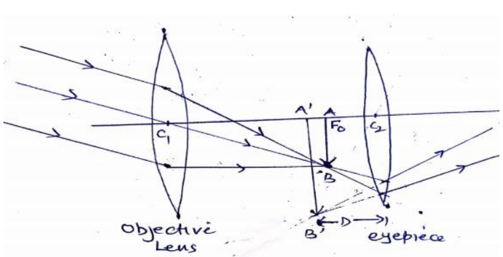
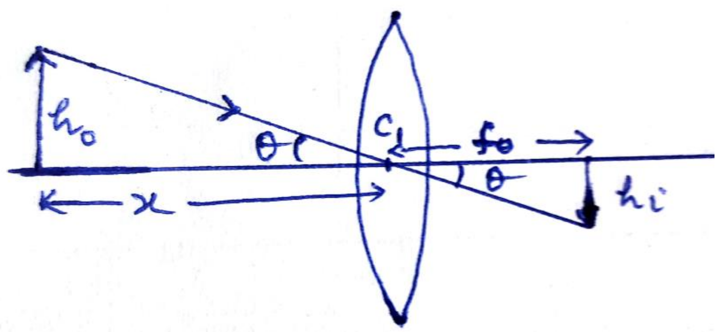
	$= \frac{1}{2} \in_0 (cB)^2$		
	$= \frac{1}{2} \in_0 \frac{1}{\mu_0 \in_0} B^2$		
	$= \frac{1}{2} \frac{B^2}{\mu_0}$	½	
	= Average energy density of the magnetic field.		
	[Note: Award 1 mark for this part if the student just writes the expressions for the average energy density of the electric and magnetic fields.]		3
21.	Labelled ray diagram of an astronomical telescope — 1 ½ Calculation of the diameter of the image of the moon. — 1½		
		1½	
	[Note: (i) Deduct ½ mark If arrows are not shown. (ii) Award one mark of this part if a student draws the ray diagram for normal Adjustment / relaxed eye.]		
	Angular magnification of the telescope = $\frac{f_o}{f_e} = \frac{15}{0.01} = 1500$	½	3
	For objective lens, $\tan\alpha = \frac{3.48 X 10^6}{3.8 X 10^8}$		
	For eyepiece $\tan\beta = \frac{h_i}{f_e} = \frac{h_i}{10^{-2}}$	½	
	$\therefore$ Magnifying power $= \frac{\beta}{\alpha} = \frac{\frac{h_i}{10^{-2}}}{\frac{3.48 X 10^6}{3.8 X 10^8}}$		

	$= \frac{h_i X 3.8 X 10^8}{3.48 X 10^6 X 10^{-2}}$ =1500		
	h_i = 13.73 cm	½	
	Also accept angular magnification of the telescope $= \frac{f_o}{f_e}\left(1+\frac{f_e}{d}\right) = \frac{15}{0.01}\left(1+\frac{0.01}{0.25}\right) = 1560$ So, h_i = 14.29 cm		
	Alternatively 	½	
	From figure: $\frac{h_0}{x} = \frac{h_i}{f_0}$ [Where h_o and h_i are the diameter of the moon and diameter of the image of the moon respectively.]	½	
	$h_i = \frac{h_0 f_o}{x}$	½	
	$= \frac{3.48 \times 10^6}{3.8 \times 10^8} \times 15$ = 13.73cm	½	3
22.	(a)Obtaining the expression for modulation index in terms of A and B 1 ½ (b) calculation of μ 1 Reason ½		
	We are given that $A = A_c + A_m$ and $B = A_c - A_m$ $A_c = (A + B) /2$	½	

	$A_m = (A - B)/2$ $\therefore \quad \mu = \dfrac{A_m}{A_c}$ $= \dfrac{A-B}{A+B}$ (b) We have $\mu = \dfrac{A_m}{A_c}$ $= \dfrac{10}{15} = \dfrac{2}{3}$ μ is kept less than one to avoid distortion	½ ½ ½ ½ ½	 3
23.	(a)statement of Gauss's law in magnetism ½ Its significance ½ (b)Four Important properties ½ x4 (a) Gauss's law for magnetism states that "The total flux of the magnetic field, through any closed surface, is always zero. Alternatively $= \oint_S \vec{B}.\vec{d}.s = 0$ This law implies that magnetic monopoles do not exist" / magnetic field lines form closed loops **[Note: Award this I mark if the student just attempts it]** (b) Four properties of magnetic field lines (i) Magnetic field lines always form continuous closed loops. (ii) The tangent to the magnetic field line at a given point represents the direction of the net magnetic field at that point.	 ½ ½ ½ ½	

(iii) The larger the number of field lines crossing per unit area, the stronger is the magnitude of the magnetic field. ½

(iv) Magnetic field lines do not intersect. ½

OR

Three points of difference	3 x ½
One example of each	1½

	Diamagnetic	Paramagnetic	Ferromagnetic	
1	$-1 \le \chi < 0$	$-0 < \chi < \varepsilon$	$\chi \gg 1$	½
2	$0 \le \mu_r < 1$	$1 \le \mu_r < 1+\varepsilon)$	$\mu_r \gg 1$	½
3	$\mu < \mu_0$	$\mu > \mu_0$	$\mu \gg \mu_0$	½

Where ε is any positive constant.

[Note: Give full credit of this part if student write any other three correct difference]

Examples (Any one example of each type)

Diamagnetic materials: Bi,Cu, Pb,Si, water, NaCl, Nitrogen (at STP) ½

Paramagnetic materials: Al,Na,Ca, Oxygen(at STP), Copper chloride ½

Ferromagnetic materials: Fe,Ni,Co,AlniCo ½ 3

24.

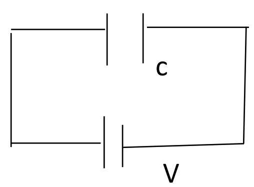
(a) Calculation of energy of a photon of light	1½
(b) Identification of photodiode	1½
Why photodiode are operated in reverse bias	1

We have

$$E = h\nu = \frac{hc}{\lambda}$$ ½

$$= \frac{6.63\times10^{-34}\times3\times10^{8}}{600\times10^{-9}} \text{ J}$$ ½

$$= \frac{19.89\times10^{-26}}{6\times10^{-7}\times1.6\times10^{-19}} \text{ eV}$$

	$= \frac{19.89}{9.6}$ eV = 2.08eV The band gap energy of diode D_2 (= 2eV) is less than the energy of the photon. Hence diode D_2 will not be able to detect light of wavelength 600 nm. [Note: Some student may take the energy of the photon as 2eV and say that all the three diodes will be able is detect this right , Award them the ½ mark for the last part of identification] (b) A photodiode when operated in reverse bias, can measure the fractional change in minority carrier dominated reverse bias current with greater ease Alternatively: It is easier is observe the change in current with change in light intensity , if a reverse bias is applied	½ ½ 1	3
25.	a) Description of the process of transferring the charge. $\frac{1}{2}$ Derivation of the expression of the energy stored $2\frac{1}{2}$ b) Calculation of the ratio of energy stored 2 (a)  The electrons are transferred to the positive terminal of the battery from the metallic plate connected to the positive terminal, leaving behind positive charge on it. Similarly, the electrons move on to the second plate from negative terminal, hence it gets negatively charged. Process continuous till the potential difference between two plates equals the potential of the battery. [Note: award this $\frac{1}{2}$ mark, If the student writes, there will be no transfer of charge between the plates] Let 'dw' be the work done by the battery in increasing the charge on the capacitor from q to (q+ dq). $dW = V\ dq$	½ ½	

	Where $V = \frac{q}{c}$	½	
	$\therefore dW = \frac{q}{c}dq$	½	
	Total work done in changing up the capacitor		
	$W = \int dw = \int_0^Q \frac{q}{c}dq$	½	
	$\therefore W = \frac{Q^2}{2C}$		
	Hence energy stored = $W = \frac{Q^2}{2C}\ (= \frac{1}{2}CV^2\ = \frac{1}{2}QV)$	½	
	(b) Charge stored on the capacitor q=CV When it is connected to the uncharged capacitor of same capacitance, sharing of charge takes place between the two capacitor till the potential of both the capacitor becomes $\frac{V}{2}$	½	
	Energy stored on the combination $(u_2) = \frac{1}{2}C\left(\frac{V}{2}\right)^2 + \frac{1}{2}C\left(\frac{V}{2}\right)^2 = \frac{CV^2}{4}$	½	
	Energy stored on single capacitor before connecting	½	
	$U_1 = \frac{1}{2}CV^2$		
	Ratio of energy stored in the combination to that in the single capacitor		
	$\frac{U_2}{U_1} = \frac{CV^2/4}{CV^2/2} = 1:2$	½	
	OR		
	(c) Derivation for the expression of the electric field on the equatorial line — 3 (d) Finding the position and nature of Q — 1 + 1		

Marking Scheme

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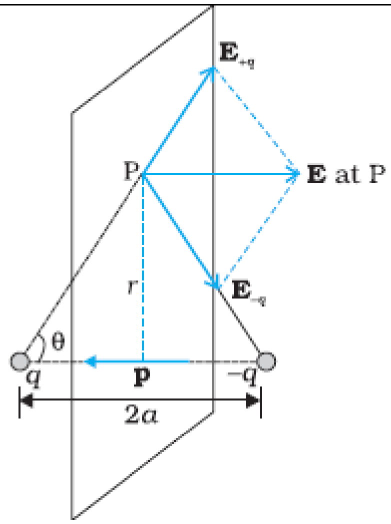
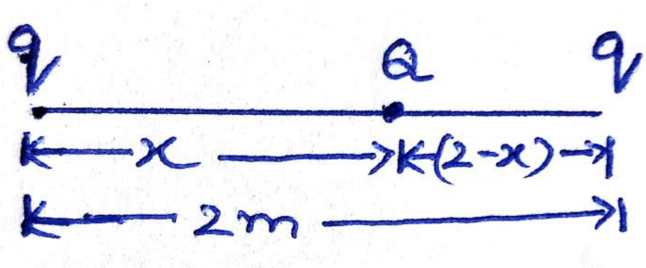
(a)		1	
	The magnitude of the electric fields due to the two charges +q and -q are		
	$E_{+q} = \dfrac{1}{4\pi \in_0} \dfrac{q}{\left(r^2 + a^2\right)}$	½	
	$E_{-q} = \dfrac{1}{4\pi \in_0} \dfrac{q}{\left(r^2 + a^2\right)}$	½	
	The components normal to the dipole axis cancel away and the components along the dipole axis add up		5
	Hence total Electric field = - ($E_{+q} + E_{-q}$)cosθ $\widehat{p}$	½	
	$E = -\dfrac{2qa}{4\pi\varepsilon_0 \left(r^2 + a^2\right)^{3/2}} \widehat{p}$	½	
	(b) 	½	
	System is in equilibrium therefore net force on each charge of system will be zero.		

For the total force on 'Q' to be zero

$$\frac{1}{4\pi \in_0}\frac{qQ}{x^2}=\frac{1}{4\pi \in_0}\frac{qQ}{(2-x)^2}$$ ½

x = 2 – x

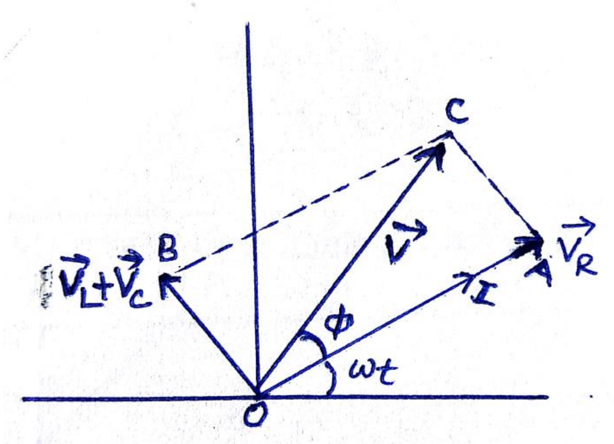
2x = 2 ½
x = 1 m

(Give full credit of this part, if a students writes directly 1m by observing the given condition)

For the equilibrium of charge "q" the nature of charge Q must be opposite to the nature of charge q. ½ 5

26.

(a) Derivation of the expression for impedance	2
plot of impedance with frequency	½
b) Phase difference between voltage across inductor and capacitor	½
(c) Reason and calculation of self induction	$\frac{1}{2}+1\frac{1}{2}$



1

$|\vec{V}|=V_m$

$|V_R| = V_{Rm}$

$|V_L| = V_{Lm}$

From the figure, the pythagorean theorem gives

$V_m^2 = V_{Rm}^2 + (V_{Lm} - V_{cm})^2$

$V_{Rm} = i_m R$, $V_{Lm} = i_m X_L$, $V_{cm} = i_m Xc$,

$V_m = i_m Z$ ½

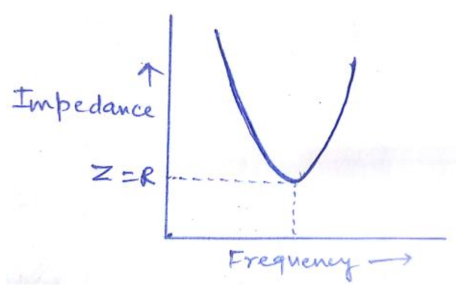
$= (i_m Z)^2 = (I_m R)^2 + (i_m X_L - i_m X_c,)$

$z^2 = R^2 + ((X_L - X_c)^2$

$\therefore z = \sqrt{R^2 + (X_L - X_c)^2}$

[note: award these two marks, If a student does it correctly for the other case i.e ½

$(V_c > V_L)$]



½

(b) Phase difference between voltage across inductor and the capacitor at resonance is 180° ½

(c) Inductor will offer an additional impedance to ac due to its self inductance. ½

$R = \frac{V_{rm}}{I_{rms}} = \frac{200}{1} = 200\ \Omega$

Impedance of the inductor

$Z = \frac{V_{rms}}{I_{rms}} = \frac{200}{0.5} = 400\ \Omega$ ½

Since Z= $\sqrt{R^2 + (X_L)^2}$
$\therefore$ $(400)^2$- $(200)^2$ = $(X_L)^2$

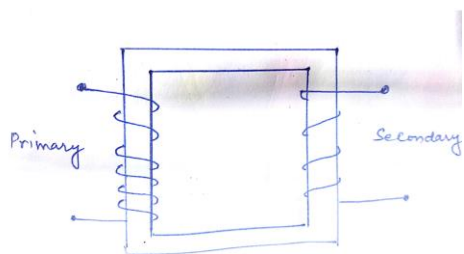
$X_L = \sqrt{600X200}$ = 346.4 Ω ½

Inductance (L) = $\frac{X_L}{w}$ =$\frac{364.4}{2X3.14X\ 50}$ = 1.1H ½

OR

(a) Diagram of the device	1
working Principle	½
Four sources of energy loss	$\frac{1}{2}+\frac{1}{2}+\frac{1}{2}+\frac{1}{2}$
(b) Estimation of Line power loss	1½

(a)



1

Working Principle : When the alternating voltage is applied to the primary , the resulting current produces an alternating magnetic flux in secondary and induces an emf in it./It works on the mutual induction. ½

Four sources of energy loss
(i) Flux leakage between primary and secondary windings ½
(ii) Resistance of the windings ½
(iii)Production of eddy currents in the iron core. ½
(iv)Magnetization of the core. ½

(b) Total resistance of the line = length X resistance per unit length
= 40 km x 0.5 Ω/km
= 20 Ω ½

Marking Scheme

55/1/3

	Current flowing in the line I = $P/_V$ I= $\frac{1200\ X\ 10^3}{4000}$ = 300A $\therefore$ *Line power loss in the form of heat* P=I^2 R =$((300)^2$ x 20 = 1800 kW	½ ½	5
27.	(a) ~~Two characteristic~~Two characteristic features of distinction ____2 ~~Dervation~~Derivation of the expression for the intensity $1\frac{1}{2}$ (b) Calculation of separation between the first order (a) (Any two of the following) (i) Interference pattern has number of equally spaced bright and dark bands while diffraction pattern has central bright maximum which is twice as wide as the other maxima. (ii) Interference is obtained by the superposing two waves originating from two narrow slits. The diffraction pattern is the superposition of the continuous family of waves originating from each point on a single slit. (iii) In interference pattern, the intensity of all bright fringes is same, while in diffraction pattern intensity of bright fringes go on decreasing with the increasing order of the maxima (iv)In interference pattern , the first maximum falls at an angle of $\frac{\lambda}{a}$. where a is the separation between two narrow slits, while in diffraction pattern, at the same angle first minimum occurs. (where 'a' is the width of single slit.) Displacement produced by source s_1 Y_1 = a cos wt Displacement produced by the other source 's_2' Y_2= a cos (wt + Ø) Resultant displacement Y = Y_1 + Y_2 = a [cos wt + cos (wt + Ø)	½+½ ½+½ ½	

	Content	Marks	Total
	$= 2a\cos(\varnothing/2)\cos(wt + \varnothing/2)$	½	
	Amplitude of resultant wave A= $2a\cos(\varnothing/2)$ Intensity $I \,\alpha\, A^2$ I= KA^2= K 4 $a^2 cos^2 (\frac{\varnothing}{2})$	½	
	(a) Distance of First order minima from centre of the central maxima = $x_{D1}=\frac{\lambda D}{a}$ Distance of third order maxima from centre of the central maxima $X_{B3}=\frac{7D\lambda}{2a}$	½	
	∴ Distance between first order minima and third order maxima= $x_{B3} - x_{d1}$ $= \frac{7D\lambda}{2a} - \frac{\lambda D}{a}$	½	
	$= \frac{5D\lambda}{2a}$ $= \frac{5 X 620 X 10^{-9} X 1.5}{2X3X10^{-3}}$		
	$=775 X 10^{-6}$m $=7.75 X 10^{-4}$m	½	
	OR		
	(a) Two conditions of total internal reflection 1 +1 (b) Obtaining the relation 1 (c) Calculating of the position of the final image 2		
	(a) (i) Light travels from denser to rarer medium.	1	
	(ii) Angle of incidence is more than the critical angle	1	
	For the Grazing incidence		
	μ sin i_c = 1 sin 90°	½	
	μ = $\frac{1}{sin i_c}$	½	
	(b) For convex lens of focal Length 10 cm		

	$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$	½	
	$\frac{1}{10} = \frac{1}{v_1} - \frac{1}{-30}$ => v_1 = 15 cm	½	
	Object distance for concave lens u_2= 15-5 =10 cm $\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$ $\frac{1}{-10} = \frac{1}{v_2} - \frac{1}{10}$ $v_2 = \infty$	½	
	For third lens $\frac{1}{f_3} = \frac{1}{v_3} - \frac{1}{u_3}$ $\frac{1}{30} = \frac{1}{v_3} - \frac{1}{\infty}$ => $v_3 = 30\ cm$	½	5

Marking Scheme

55/1/3
