Marking Scheme

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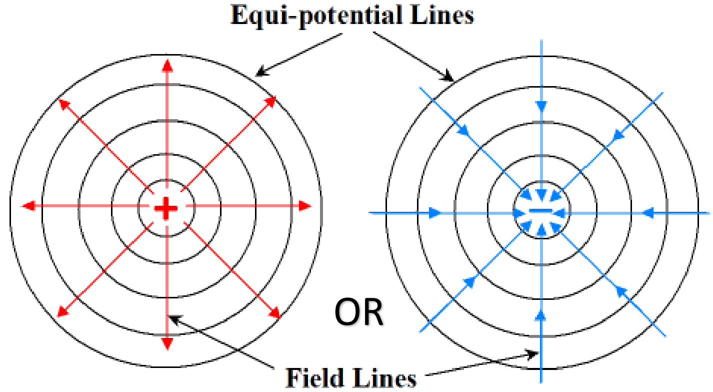
S.No.	**Value Points/Expected answers**	**Marks**	**Total Marks**
1.	Threshold frequency equals the minimum frequency of incident radiation (light) that can cause photoemission from a given photosensitive surface. (Alternatively) The frequency below which the incident radiations cannot cause the photoemission 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
2.	$\mu = \tan ip$ $ip = 60°$ $\mu = \tan 60 = \sqrt{3}$	½ ½	1
3.	The waves beyond 30 MHz frequency penetrate through the Ionosphere are not reflected back. OR Transmitted Power and Frequency	1 ½+½	1
4.	$v_d = \frac{eE}{m}\tau$ (Alternatively $v_d = \frac{ev}{ml}\tau$ Alternatively $= v_d \propto \tau$)	1	1
5.	 	1	1
6.	Einstein's equation ½ Naming two features ½ Explanation ½ + ½ $k.E_{max} = h\nu - w_o / ev_o = h\nu - h\nu_0 /$ (Or any other form)	½	

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	Two features 1. Maximum energy is independent of intensity 2. Maximum energy is directly proportional to frequency 3. Existence of threshold frequency 4. Instantaneous nature of photoelectric effect (any two) Explanation of two features 1. Energy of photon does not depend upon intensity 2. Energy of the photon is directly proportional to frequency 3. No photo electric emission possible If $h\nu < w_\circ$ 4. Complete photon energy is absorbed by a single electron (Any two, as per the two features named above)	½ $\frac{1}{2}+\frac{1}{2}$	2
7.	Formula 1 Calculation of the ratio of radii 1 R = $\frac{mv}{qB}$ R = $\frac{mv}{qB} = \frac{\text{þ}}{qB}$ Now, $\frac{q_d}{q_\alpha} = \frac{e}{2e} = \frac{1}{2}$ $\therefore \frac{r_d}{r_\alpha} = \frac{q_\alpha}{q_d} = \frac{2}{1}$	½ ½ ½ ½	2
8.	Calculation of Power dissipation in two combinations 1 +1		

	$R_1 = \frac{V^2}{P_1}$, $R_2 = \frac{V^2}{P_2}$, $P_s = \frac{V^2}{Rs} = \frac{P_1P_2}{P_1+P_2}$ $\frac{1}{Ps} = \frac{1}{P_1} + \frac{1}{P_2}$ $\frac{1}{Rp} = \frac{1}{R1} + \frac{1}{R2} = \frac{P_1+P_2}{V^2}$ $\therefore P_p = \frac{V^2}{R_P} = P_1 + P_2$	½ ½ ½ ½	2
9.	Calculation of focal length ½ Lens maker's formula ½ Calculation of radius of curvature 1 $f = \frac{1}{P} = \frac{1}{-5}\,m = -\frac{100}{5}\,cm = -20\,cm$ $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R1} - \frac{1}{R2}\right)$ $\mu_2 = 1.5$, $\mu_1 = 1.4$, $R_1 = -R$ $R_2 = R$ $\frac{1}{-20} = \left(\frac{1.5}{1.4} - 1\right)\left(-\frac{1}{R} - \frac{1}{R}\right)$ $\frac{1}{-20} = \left(\frac{0.1}{1.4}\right)\left(-\frac{2}{R}\right)$ $R = \frac{20}{7}$ cm (= 2.86 cm) OR Formula ½ Substitution and calculation 1½ $\mu = \frac{\sin\frac{(A + D_m)}{2}}{\sin A/2}$ $\mu = \frac{\mu_2}{\mu_1} = \frac{1.6}{\frac{4}{5}\sqrt{2}} = \frac{8}{4\sqrt{2}} = \sqrt{2}$ $\sqrt{2} = \frac{\sin(\frac{60+D_m}{2})}{Sin\ 60/2} = \frac{sin\frac{(60+D_m)}{2}}{Sin\ 30}$	½ ½ ½ ½ ½ ½	2

	$\therefore\ \sin(\frac{60+D_m}{2}) = \sqrt{2}\,.\,\frac{1}{2} = \frac{1}{\sqrt{2}}$ = Sin 45^0 $\therefore \frac{60+D_m}{2} = 45^o$ $\therefore$ $D_m = 30^0$	½ ½	 2
10.	Statement of Bohr's quantization condition ½ Calculation of shortest wavelength 1 Identification of part of electromagnetic spectrum ½ Electron revolves 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 $n_f = 4$ $\frac{1}{\lambda} = R\,(\frac{1}{4^2}) = \frac{R}{16}$ $\lambda = \frac{16}{R}$ 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 $$Radius\ r_n = \frac{h^2\epsilon_0}{\pi m e^2}n^2$$	 ½ ½ ½ ½ ½	

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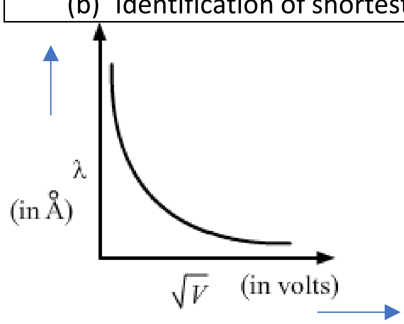
	$$velocity \;\; v_n = \frac{2\pi e^2}{4\pi\varepsilon_0 h}\,\frac{1}{n}$$	½	
	$$Time\ period \;\; T_n = \frac{2\pi r_n}{v_n} = \frac{4\varepsilon_0^2 h^3 n^3}{me^4}$$		
	For first excited state of hydrogen atom n=2	½	
	$$T_2 = \frac{32\varepsilon_0^2\, h^3}{me^4}$$	½	
	On calculation we get $T_2 \approx 1.22\, X\, 10^{-15}\, s.$ (However, do not deduct the last ½ mark if a student does not calculate the numerical value of T_2)		
	<u>Alternatively</u>		2
	$r_n = (\,0.53\, n^2\,)A^0 \;= 0.53\, X\, 10^{-10}\, n^2$	½	
	$v_n = (\frac{c}{137\, n})$	½	
	$T_n = \frac{2\pi(0.53)}{\left(\frac{c}{137\, n}\right)}\, X\, 10^{-10}\, n^2$		
	= $\frac{2\pi(0.53)}{c}\, X\, 10^{-10}\, n^3$ x 137 s		
	= $\frac{2 \times 3.14 \times 0.53 \times 10^{-10} \times 8 \times 137}{3\, x\, 10^8}$ s	½	
	= 1215.97 x 10^{-18} = (1.22 x 10^{-15}) s	½	
	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)		2
11.	(a) Graph 1 (b) Identification of shortest wavelength 1		
(a)		1	

(b)	(give ½ mark, if the student just writes the formula $\lambda = \frac{h}{\sqrt{2mqV}}$ but does not draw the graph) $\lambda = \frac{h}{\sqrt{2mE}}$ ∴ For same E, $\lambda \propto \frac{1}{\sqrt{m}}$ ∴ α Particle has shortest wavelength as mass of alpha particle is maximum (Give this 1 mark, even if the student directly writes that the alpha particle has the shortest wavelength)	½ ½	2
12.	<table><tr><td>Reason</td><td>1</td></tr><tr><td>Expression</td><td>1</td></tr></table> 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. $D = \sqrt{2h_T R} + \sqrt{2h_R R}$ [Where h_T = height of Transmitting antenna (h_R = Height of Receiving antenna)]	1 1	2
13.	<table><tr><td>(a) Principle</td><td>1</td></tr><tr><td>(b) Two reasons</td><td>(½+ ½)</td></tr><tr><td>(c) Definitions of voltage sensitivity and current sensitivity</td><td>(½+ ½)</td></tr></table> (a) ' A current carrying coil can experience a torque in a magnetic field.'	1	

	(b) (i) Galvanometer is a very sensitive device, if gives a full scale deflection for a current of the order of a few μA (ii) Resistance of galvanometer is not very small, hence it will change the value of current in the circuit branch when connected (in series in that branch) (c) current sensitivity is defined as the deflection per unit current (Alternatively current sensitivity $= \frac{\emptyset}{I}$) Voltage sensitivity is defined as the deflection per unit potential difference applied. (Alternatively Voltage sensitivity $= \frac{\emptyset}{V}$)	½ ½ ½ ½	3
14.	(a) Definition of mutual inductance and S.I unit 1+½ (b) Obtaining the expression for resultant force on the loop 1½ (a) Mutual inductance equals the magnetic flux associated with a coil when unit current flows in its neighbouring coil. Alternatively: Mutual inductance equals the induced emf in a coil when the rate of change of current in its neighbouring coil is one ampere/ second. S.I unit : henry (H) or weber/ampere (or any other correct SI unit) (b) Force per unit length between two parallel straight conductors $F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}$ Force on the part of the loop which is parallel to 7nfinite straight wire and at a distance x from it.	1 ½ ½	

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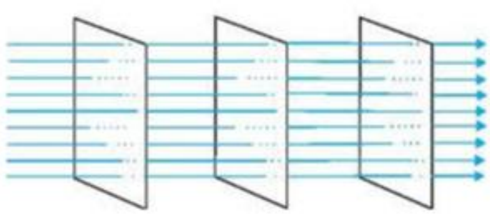
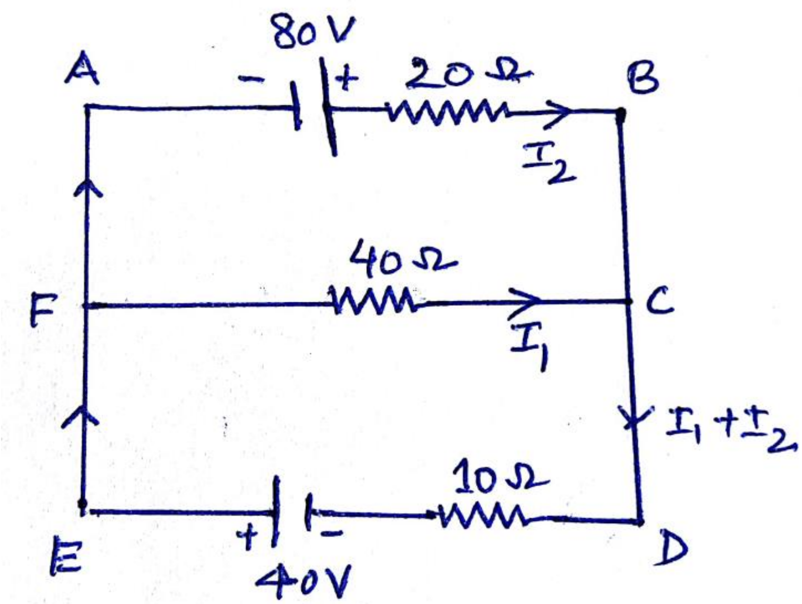
	$F_1 = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a}{x}$ (away from the 8nfinite straight wire) Force on the part of the loop which is at a distance (x + a) from it $F_2 = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a}{(x + a)}$ (towards the 8nfinite straight wire) Net force $F = F_1 - F_2$ $F = \frac{\mu_0}{2\pi} I_1 I_2\ a \left[\frac{1}{x} - \frac{1}{x+a}\right]$ $F = \frac{\mu_0}{2\pi}\frac{I_1 I_2\ a^2}{x(x + a)}$ (away from the 8nfinite straight wire)	½ ½	3
15.	(a) Drawing the equipotential surfaces 1 (b) Electric potential at (o,o,$\pm$z) 1 Electric potential at (x,y,o) 1 (a)  z-direction (b)Electric potential at (o,o,$\pm$ z): $V=\frac{1}{4\pi\varepsilon_\circ}\frac{p}{z^2-a^2}$ / $V = \frac{1}{4\pi\varepsilon_\circ}\frac{(q \times 2a)}{z^2 - a^2}$ Electric potential at (x,y,o) , V=0	1 1 1	3
16.	Writing two the loop equation 1 + 1 Calculation of currents 40Ω and 20 Ω resistance 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	½	
	$I_1 = 0A$	½	
	& $I_2 = 4A$		
	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. (Note: Award this ½ make even if student just writes only the point (i) or point (ii) given above.) For a meter bridge $\frac{R}{S} = \frac{l}{100 - l}$ For the two given conditions $\frac{5}{S} = \frac{l_1}{100 - l_1}$ $\frac{5}{S/2} = \frac{1.5l_1}{100 - 1.5l_1}$ Dividing the two $2 = \frac{1.5l_1}{(100 - 1.5l_1)} \times \frac{(100 - l_1)}{l_1}$ $200 - 3\ l_1 = 150 - 1.5\,l_1$ $l_1 = \frac{100}{3}$ cm Putting the value of l_1 in any one of the two given conditions. S = 10 Ω	½ ½ ½ ½ ½ ½ ½	

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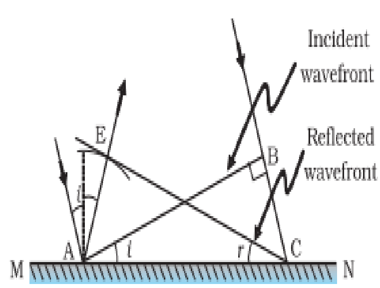
17.	(a) Relation between Average life and half life 1 (b) Finding the required time 2	1	
	(a) $T = \frac{1}{\lambda}$ Alternatively $= \left(\frac{T_{1/2}}{\ln_e 2}\right) / \left(\frac{T_{1/2}}{0.6931}\right) / 1.44\ T_{1/2}$	½	
	We have $N = N_o \bar{e}^{\lambda t}$		
	(b) Here $\frac{No_1}{No_2} = \frac{1}{2}$, $\frac{N_1}{N_2} = \frac{2}{1}$		
	$\therefore \frac{N1}{N2} = \frac{No_1}{No_2} \exp(-(\lambda_1 - \lambda_2)t$	½	
	$\therefore\ 2 = \frac{1}{2} \exp(-(\lambda_1 - \lambda_2)t$	½	
	$\Rightarrow \exp(-(\lambda_1 - \lambda_2)t = 4$		
	$\Rightarrow -(\lambda_1 - \lambda_2)t = 2 \ln_e 2$	½	
	$\Rightarrow -\ln_e 2 \left(\frac{1}{60} - \frac{1}{30}\right) t = 2$		
	$\Rightarrow \frac{t}{60} = 2$		3
	$\Rightarrow t = 120$ years (Also accept if the student gets the answer just through reasoning without using this formula based approach)		
18.	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	1	
	Consider a plane wave AB incident at an angle 'I' on a reflecting surface MN		
	 	1	

let t = time taken by the wave front to advance from B to C.

$\therefore$ 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 ½

it follows that

$\Delta\,EAC \cong \Delta BAC$

Hence $\angle i = \angle r$ ½

$\therefore$ 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)

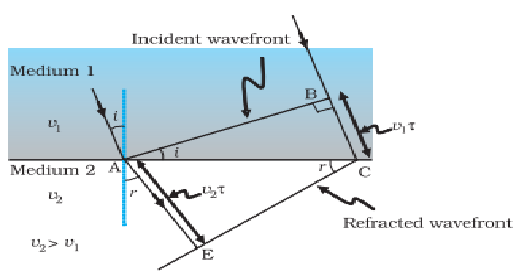
Alternatively:

Refractive index of radium 2 w.r.t medium 1

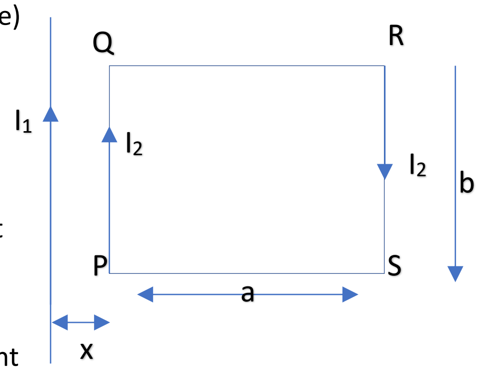
$$n_{21} = \frac{\sin i}{\sin r}$$

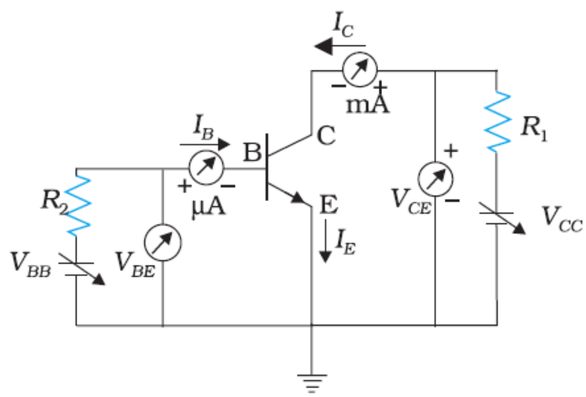
Alternatively : Refractive index of medium 2 w.r.t medium 1 1

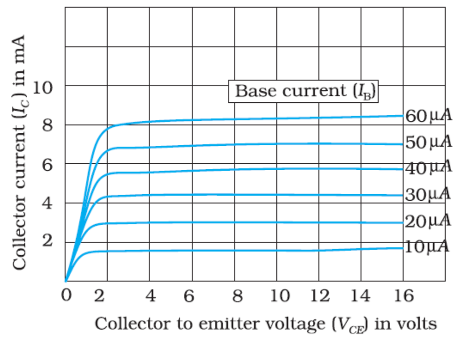
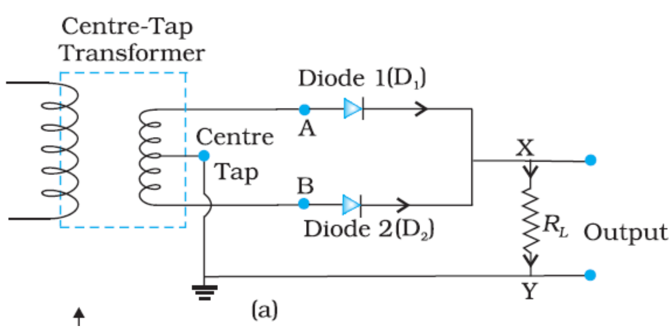
$$n_{21} = \frac{\text{Velcoity of light in medium 1}}{\text{Velocity of light in medium 2}}$$

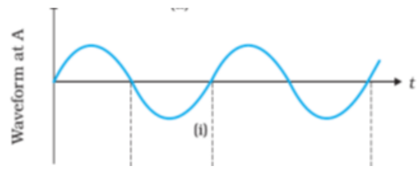


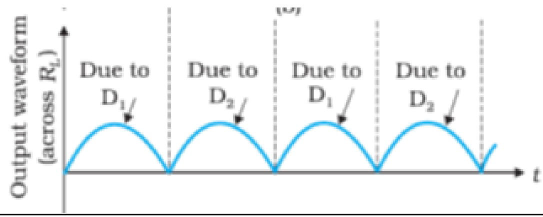
1

	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.	½ ½	3
19.	(a) Definition of self inductance 1 S.I unit ½ (b) resultant force ½ (c) It is defined as the magnetic flux linked with a coil, when a unit current is passed through it [Alternatively $L = \frac{\phi}{I}$] Alternatively It is defined as the induced e.m.f. developed in a coil, when the rate of change of current through the coil is unity. (Alternatively $L = \left\lvert \frac{e}{di/dt} \right\rvert$) S.I. unit : henry/ (weber/ampere)  (d) We have F= $\frac{\mu_0 I_1 I_2}{2\pi d}$ L force on side PQ = $\frac{\mu_0 I_1 I_2}{2\pi x}$ b This is directed towards left Force on side RS = $\frac{\mu_0 I_1 I_2}{2\pi(x+a)}$b This is directed towards right ∴ Net force on the loop	1 ½ ½ ½	

	$= \frac{\mu_0 I_1 I_2 b}{2\pi}\left[\frac{1}{x}-\frac{1}{x+a}\right]$ $= \frac{\mu_0 I_1 I_2}{2\pi}\frac{ba}{x+a}$ [Note: This question (part(b)) is (almost) the same as Q.No.14 (b). If the student has not been able to solve Q.No.14 (b) as well as Q.no.17(b), she/he would lose marks in only one of these parts; she/he would then be awarded the $1\frac{1}{2}$ marks of this part in one of these two questions if it has not been answered correctly at both the places]	½	3
20.	(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	

	The output characteristics are obtained by observing the variation of I_c when V_{CE} is varied keeping I_B constant . 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 ½ + ½ The circuit diagram of a full wave rectifier is shown below.  (a) 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 the input ac cycle. We therefore, get a unidirectional (rectified) current through the load for the full cycle of the input ac.	½ 1 1	

<table>
<tr><td></td><td>The input and output wave forms are as shown below.



</td><td>½

½</td><td>3</td></tr>
<tr><td>21.</td><td>

(a)Obtaining the expression for modulation index in terms of and B	1 ½
(b) calculation of μ	1
reason	½

We are given that
$A = A_c + A_m$
and $B = A_c - A_m$

$A_c = (A + B)/2$
$A_m = (A - B)/2$

$\therefore \quad \mu = \dfrac{A_m}{A_c}$
$= \dfrac{A-B}{A+B}$

(e) We have

$\mu = \dfrac{A_m}{A_c}$
$= \dfrac{10}{15} = 2/3$

μ is kept less than one to avoid distortion</td><td>½
½
½
½
½
½</td><td>3</td></tr>
</table>

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22.

(a) statement of Gauss's law in magnetism	1/2
Its significance	1/2
(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. ½

Alternatively

$$= \oint_S \vec{B}.\vec{d}.s = 0$$ ½

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 ½

(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

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

(g) Magnetic field lines do not intersect.

OR

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

	Diamagnetic	Paramagnetic	Ferromagnetic	
1	$-1 \le \chi \langle 0$	$-0 \langle \chi \langle \varepsilon$	$\chi \rangle\rangle 1$	½
2	$0 \le \mu_r \langle 1$	$1 \le \mu_r \langle 1+\varepsilon)$	$\mu_r \rangle\rangle 1$	½
3	$\mu \langle \mu_0$	$\mu \rangle \mu_0$	$\mu \rangle\rangle \mu_0$	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) ½ 3

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

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23.	(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) (h) Average energy density of the electric field = ½ $\in_0$ E^2 = ½ $\in_0$ $(Cb)^2$ $= \frac{1}{2} \in_0 \frac{1}{\mu_0 \in_0} B^2$ $= \frac{1}{2} \frac{B^2}{\mu_0}$ = 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.]	½+½ ½+½ ½ ½	3
24.	(a) Calculation of energy of a photon of light 1½ Identification of photodiode ½ (b)Why photodiode are operated in reverse bias 1 We have $E = h\nu = \frac{hc}{\lambda}$		

	$= \dfrac{6.63\times10^{-34}\times3\times10^{8}}{600\times10^{-9}}$ J $= \dfrac{19.89\times10^{-26}}{6\times10^{-7}\times1.6\times10^{-19}}$ eV $= \dfrac{19.89}{9.6}$ 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] (i) 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 ½ ½	3
25.	SECTION D (a) Two characteristic features of distinction 2 Derivation of the expression for the intensity $1\frac{1}{2}$ (b) Calculation of separation between the first order minima and third order maxima $1\frac{1}{2}$ (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.	1	

	(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 $\frac{\lambda}{\alpha}$. 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) = 2a cos ($^{Ø}/_{2}$) cos (wt + $^{Ø}/_{2}$) Amplitude of resultant wave A= 2a cos ($^{Ø}/_{2}$) Intensity I α A^2 I= KA^2= K 4 $a^2 cos^2$ ($\frac{Ø}{2}$) (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}=$\frac{7D\lambda}{2a}$ ∴ Distance between first order minima and third order maxima= $x_{B3} - x_{d1}$ = $\frac{7D\lambda}{2a}$ - $\frac{\lambda D}{a}$ = $\frac{5D\lambda}{2a}$ = $\frac{5 X 620 X 10^{-9} X 1.5}{2X3X10^{-3}}$ =775 X 10^{-6}m =7.75 X 10^{-4}m	½ + ½ ½ + ½ ½ ½ ½ ½ 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

½

(a) (i) Light travels from denser to rarer medium.
(ii) Angle of incidence is more than the critical angle

For the Grazing incidence
μ sin i_c = 1 sin 90°

μ = $\frac{1}{sin i_c}$

(b) For convex lens of focal Length 10 cm — 1

1

$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$

$\frac{1}{10} = \frac{1}{v_1} - \frac{1}{-30}$ => v_1 = 15 cm — ½

½

Object distance for concave lens u_2= 15-5 =10 cm

$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$

½

$\frac{1}{-10} = \frac{1}{v_2} - \frac{1}{10}$ — ½

$v_2 = \infty$

For third lens

$\frac{1}{f_3} = \frac{1}{v_3} - \frac{1}{u_3}$

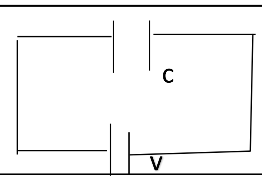
$\frac{1}{3_\circ} = \frac{1}{v_3} - \frac{1}{\infty}$ => $v_3 = 30\ cm$

5

26.

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)



½

	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]	½	
	Let 'dw' be the work done by the battery in increasing the charge on the capacitor from q to (q+ dq). $$dW = V\ dq$$ Where V = $\frac{q}{c}$ $\therefore$ 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= $\frac{Q^2}{2C}$	½	
	Hence energy stored = W= $\frac{Q^2}{2C}$ (=$\frac{1}{2}CV^2$ = $\frac{1}{2}$QV)		
	(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 $\left(\frac{V}{2}\right)^2$ = $\frac{CV^2}{4}$		
	Energy stored on single capacitor before connecting $U_1 = \frac{1}{2}CV^2$	½	
	Ratio of energy stored in the combination to that in the single capacitor	½	

$$\frac{U_2}{U_1} = \frac{CV^2/4}{CV^2/2} = 1:2$$

OR

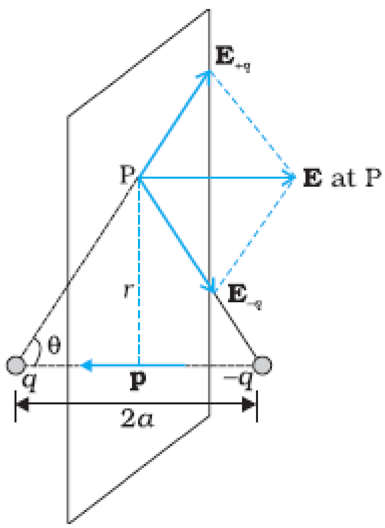
½

½

(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)

½



The magnitude of the electric fields due to the two charges +q and -q are

1

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

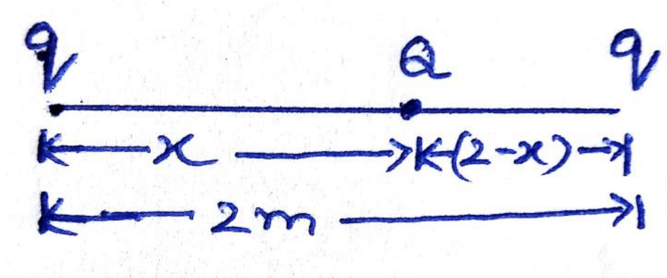
$$E_{-q} = \frac{1}{4\pi \epsilon_0} \frac{q}{\left(r^2 + a^2\right)}$$

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 $\hat{p}$

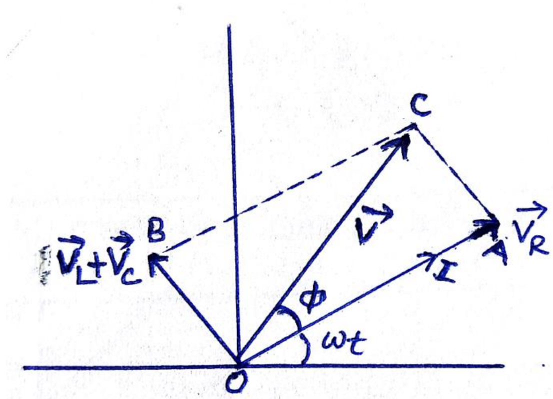
$$E = -\frac{2qa}{4\pi\varepsilon_0 \left(r^2 + a^2\right)^{3/2}} \hat{p}$$

½

(b)	 System is in equilibrium therefore net force on each charge of system will be zero. For the total force on 'Q' to be zero $\frac{1}{4\pi\in_0}\frac{qQ}{x^2}=\frac{1}{4\pi\in_0}\frac{qQ}{(2-x)^2}$ x = 2 – x 2x = 2 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 ½ ½ ½ ½	5
27.	(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 $\frac{1}{2}+1\frac{1}{2}$		

Marking Scheme

55/1/2

<table>
<tr><td></td><td>
</td><td>1</td><td></td></tr>
<tr><td></td><td>$\left|\vec{V}\right| = V_m$

$\left|V_R\right| = V_{Rm}$

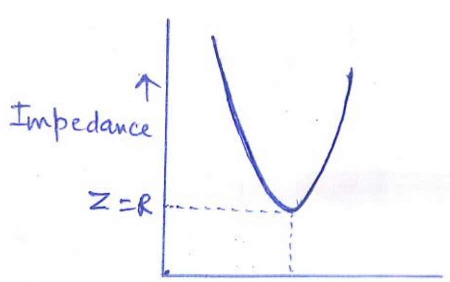
$\left|V_L\right| = V_{Lm}$
From the figure, the pythagorean theorem gives

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

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

$V_m = i_m Z$

$= (i_m Z)^2 = (I_m R)^2 + (i_m X_L - i_m X_c,)$</td><td>½</td><td></td></tr>
<tr><td></td><td>$z^2 = R^2 + ((X_L - X_c)^2$

$\therefore z = \sqrt{R^2 + (X_L - X_c)^2}$
[note: award these two marks, If a student does it correctly for other cases i.e
($V_c > V_L$)]</td><td>½</td><td></td></tr>
<tr><td></td><td>
</td><td>½</td><td></td></tr>
</table>

(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 Ω

Impedance of the inductor

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

Since Z= $\sqrt{R^2 + (X_L)^2}$

$\therefore$ $(400)^2$- $(200)^2$ = $(X_L)^2$

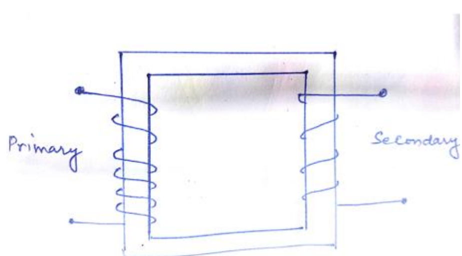
$X_L = \sqrt{600X200}$ = 346.4 Ω ½

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 (ii) Resistance of the windings (iii)Production of eddy currents in the iron core. (iv)Magnetization of the core.	 ½ ½ ½ ½	
	(b) Total resistance of the line = length X resistance per unit length = 40 km x 0.5 Ω/km = 20 Ω	½	
	Current flowing in the line I = P/V I= $\frac{1200\ X\ 10^3}{4000}$ = 300A	 ½	
	$\therefore Line\ power\ loss\ in\ the\ form\ of\ heat$ P=I^2 R =($(300)^2$ x 20 = 1800 kW	 ½	5

Marking Scheme

55/1/2

		½	

			5
		1	

		½ ½ ½ ½ ½ ½ ½ ½	5

Marking Scheme

55/1/2

		1 ½ ½ ½ ½ ½ ½ ½ ½	
