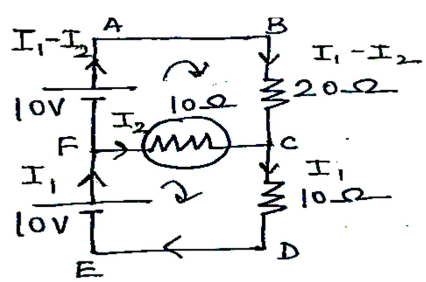
SOLUTIONS PHYSICS: Code: 55/4/3			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1.	**(A)** $\tan^{-1}\frac{4\pi\varepsilon_o E r^2}{Q}$	**1**	**1**
2.	**(A)** $R_A > R_B > R_C$	**1**	**1**
3.	**(D)** Negative Z axis	**1**	**1**
4.	**(C)** 60^0	**1**	**1**
5.	**(D)** Copper	**1**	**1**
6.	**(B)** 1.0 A	**1**	**1**
7.	**(C)** $1.8\times10^5 Vm^{-1}$	**1**	**1**
8.	**(C)** Concentric horizontal circles around the wire	**1**	**1**
9.	**(B)** Concave and real	**1**	**1**
10.	**(C)** Photons of light and electrons both exhibit dual nature	**1**	**1**
11.	**(B)** The red beam has more numbers of photons than the blue beam	**1**	**1**
12.	**(A)** Sn	**1**	**1**
13.	**(C)** Assertion is true, but Reason (R) is false.	**1**	**1**
14.	**(B)** Both Assertion (A) and Reason (R) are true but (R) is not the correct explanation of the Assertion (A)	**1**	**1**
15.	**(A)** Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	**1**	**1**
16.	**(A)** Both Assertion (A) and Reason (R) are true and (R) is the correct explanation of the Assertion (A)	**1**	**1**
	SECTION-B		
17.	(a) (i) Identifying the type of dopant ½ (ii) Identifying the type of extrinsic semiconductor ½ (b) Calculating the electron concentration 1		
	(a) (i) Trivalent (ii) p – type semi conductor	½ ½	
	(b) Electron concentration $n_e = \frac{n_i^2}{n_h}$	½	
	$n_e = \frac{(5\times10^8)^2}{8\times10^{12}}$ $n_e = 3.125\times10^4 m^{-3}$	½	**2**

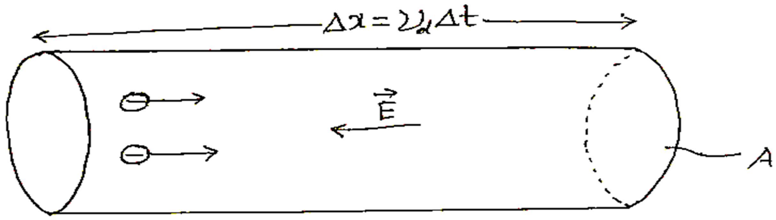
18.	Calculation of wavelength 2		
	$\beta_1 = \frac{D\lambda}{d}$	½	
	$\beta_2 = \frac{D_2\lambda}{d}$		
	$\beta_1 - \beta_2 = \frac{\lambda}{d}(D_1 - D_2)$	½	
	$= = \frac{\lambda}{d}\left[D - (D - 30\times10^{-2})\right]$		
	$\lambda = \frac{(\beta_1 - \beta_2)d}{30\times10^{-2}} = \frac{9\times10^{-5}\times2\times10^{-3}}{30\times10^{-2}}$	½	
	$\lambda = 6\times10^{-7}m$	½	**2**
19.	• Obtaining condition for focal length to be R 1 • Focal length of plano convex lens 1		
	$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$	½	
	For $f = R, R_1 = R, R_2 = -R$		
	$\frac{1}{R} = (n-1)\left(\frac{1}{R} + \frac{1}{R}\right)$		
	$n = \frac{3}{2}$	½	
	For convex lens		
	$\frac{1}{f} = (n-1)\left(\frac{2}{R}\right)$		
	For plano Convex lens $R_1 = R \quad R_2 = \infty$	½	
	$\frac{1}{f_p} = (n-1)\left(\frac{1}{R}\right)$		
	$f_p = 2f$	½	**2**
20.	Calculation of percentage change in radius 2		
	$r \alpha n^2$	½	
	$\frac{r_2}{r_3} = \frac{4}{9}$	½	
	Percentage change when electron makes transition from n=3 to n=2		

	$= \frac{\lvert r_2 - r_3 \rvert}{r_3} \times 100$ $= \left(\frac{\lvert 4-9 \rvert}{9}\right) \times 100$ $=55.55\%$	½ ½	 2
21.	(a) (i) Comparison of brightness of bulbs P and Q with bulb S ½ Justification ½ (ii) Comparison of brightness of bulb S with Q ½ Justification ½ (i) Brightness of the bulb ‘S’ will be more than bulbs ‘P’ and ‘Q’ The current flowing through the bulb ‘S’ is twice of the current in bulbs ‘P’ and ‘Q’. (ii) Brightness of the bulb ‘S’ and ‘Q’will be same The current flowing through both bulbs is same. **Alternatively-** (i) Brightness of the bulb ‘S’ will be more than bulbs ‘P’ and ‘Q’ The potential difference across ‘S’ is twice than the potential difference across bulbs ‘P’ and ‘Q’ (ii) Brightness of both bulbs ‘S’ and ‘Q’ is same. The potential difference across ‘S’ and ‘Q’ will be same. **OR** (b) Finding the current through the bulb ‘B’ 2  By applying Kirchhoff’s loop rule to closed loops ABCFA and FCDEF $2I_1-3I_2=1$----(1) $I_1+I_2=1$-----(2) On solving,	 ½ ½ ½ ½ ½ ½ ½	

	Current through the bulb, $I_2 = \frac{1}{5} A$	½	**2**
	SECTION-C		
22.	(a) Majority and minority charge carriers in p-type and n-type semiconductor 2 (b) Brief explanation for formation of diffusion current and drift current 1 **(a)** In p-type semiconductor Majority charge carriers - holes Minority charge carriers - electrons In n-type semiconductors Majority charge carriers - electrons Minority charge carriers – holes **(b)** Diffusion current – during the formation of p n junction , and due to the concentration gradient across p and n – sides , holes diffuse from p side to n side ($p \rightarrow n$) and electrons diffuse from n – side to p – side ($n \rightarrow p$). This motion of charge carriers gives rise to diffusion current across the junction. Drift current –Due to electric field at junction, an electron on p – side of the junction moves to n- side and a hole on n – side of the junction moves to p-side. This motion of charge carriers due to electric field gives drift current.	½ ½ ½ ½ ½ ½	**3**
23.	(a) Conditions for, no force experienced by charged particle in magnetic field 1 (b) Obtaining the magnitude of magnetic force exerted by wire on the loop 2 (a) • If charged particle is at rest v = 0 • If B is parallel or antiparallel to v **(b)** Magnitude of force acting between two current carrying conductor $F = \frac{\mu_0}{4\pi} \frac{2I_1I_2}{r} L$ Force on segment MN of loop $F_{MN} = \frac{\mu_0}{4\pi} \frac{2I_1I_2}{l} \times l$ (Towards the wire) Force on segment KP of loop	 ½ ½ ½ ½	

	$F_{KP} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{2l} \times l$ (Away from the wire) No force due to segment MK and NP Net force on the loop $F = F_{MN} - F_{KP}$ $F = \frac{\mu_0}{4\pi} I_1 I_2$	½ ½	 3
24.	(a) For obtaining expression of self inductance 2 (b) Identification of self inductance of coils from graph with reason 1 Magnetic field due to a current I flowing in the solenoid $B = \mu_0 nI$ Total flux linked with solenoid is $N\phi_B = (nl)(\mu_0 nI)A$ $= \mu_0 n^2 AlI$ $L = \frac{N\phi_B}{I}$ $L = \mu_0 n^2 Al$ (b) Coil 1 Slope of line 1, $\frac{\lvert\varepsilon\rvert}{dI/dt} = L$ is more for coil 1 than coil 2	 ½ ½ ½ ½ 1	 3
25.	Explanation of (a) Photoelectric emission 1 (b) Dependency of maximum kinetic energy on frequency only 1 (c) Explanation of slope of cut off voltage versus frequency graph 1 (a) Einstein Photo electric equation $h\nu = h\nu_o + K_{max}$ $K_{max} = h(\nu - \nu_o)$ For $\nu < \nu_o$, K_{max} will be negative Hence, Photoelectric emission is not possible. (b) According to Einstein Photoelectric equation $K_{max} = h(\nu - \nu_o)$ Hence $K_{max} \propto \nu$ It shows K_{max} depends upon frequency only and not depends upon intensity. (c) $eV_o = h\nu - h\nu_o$	 ½ ½ ½ ½	

	$V_o = \frac{h}{e}\nu - \frac{h}{e}\nu_o$ This equation represents the equation of straight line (y = mx + c) with the slope $\frac{h}{e}$.	½ ½	3
26.	(a) • Conditions for interference of two waves (i) Constructively (ii) Destructively ½ + ½ • Interference conditions for two lights originating from two sodium lamps ½ • Reason ½ (b) Justification of effect on fringe width of interference pattern 1 (a) (i) Conditions for constructive interference $\Delta = n\lambda$ (ii) Conditions for destructive interference $\Delta = (n+\frac{1}{2})\lambda$ n = 0,1,2……… • No Two independent monochromatic source of light can not be coherent (b) Fringe width $\beta = \frac{\lambda D}{d}$ $\lambda_{red} > \lambda_{green}$ $\beta_{red} > \beta_{green}$	½ ½ ½ ½ ½ ½	3
27.	**(a)** (i) Deriving the expression for resistivity of a conductor 2 (ii) Comparison of charges Q_1 and Q_2 1		



Total charge transported along E is

$$I\Delta t = \frac{e^2 A}{m}\tau\, n\Delta t E$$ ½

$$\frac{I}{A} = \frac{ne^2}{m}\tau E$$ ½

$$J = \frac{1}{\rho}E$$ ½

$$\rho = \frac{m}{ne^2\tau}$$ ½

Alternatively-

Current in the conductor- ½

$$I = neAv_d$$

$$\frac{I}{A} = ne\frac{eE}{m}\tau$$ ½

$$J = \frac{ne^2\tau}{m}E$$ ½

$$J = \frac{1}{\rho}E$$ ½

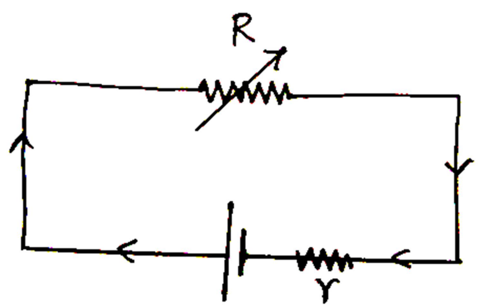
$$\rho = \frac{m}{ne^2\tau}$$

(ii) From given graph

$$\frac{Q_1}{Q_2} = \frac{A_1\,(\text{Area of rectangle})}{A_2\,(\text{Area of triangle})}$$ ½

$$\frac{Q_1}{Q_2} = \frac{2}{3/2}$$

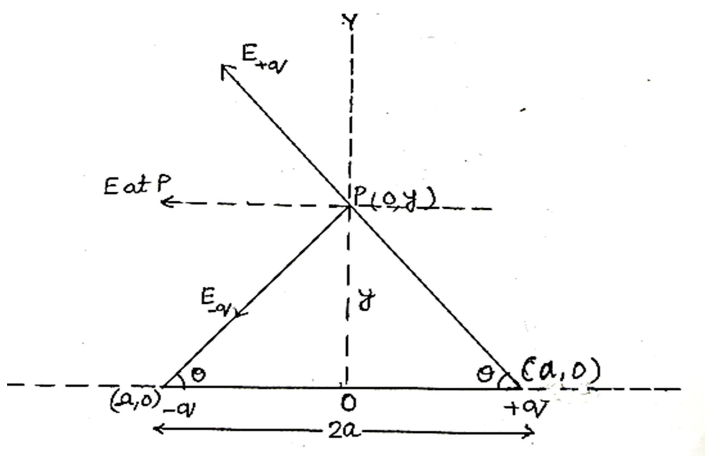
$$Q_1 > Q_2$$ ½

	OR (b) (i) (I) • Obtaining the expression for current ½ • Finding value of maximum current ½ (II) Obtaining terminal voltage V and its maximum possible value 1 (ii) Obtaining the internal resistance of the battery 1  • $V = E - Ir$ $IR = E - Ir$ $I = \frac{E}{R+r}$ For maximum value of current R=0 $I_{max} = \frac{E}{r}$ (II) V= $V_+ + V_-$ -Ir $V = E - Ir$ $V_{max} = E$, when I=0 (ii) $I_1R_1 + I_1r = I_2R_2 + I_2r$ $r = \frac{I_2R_2 - I_1R_1}{I_1 - I_2}$	½ ½ ½ ½ ½ ½	3
28.	(a) Three characteristics of electro- magnetic wave 1½ (b) Explanation of displacement current, • how 1 • Where it exists ½ (a) (Any three) • Electromagnetic wave carries energy.	½	

	• Electromagnetic wave carries momentum. • Electromagnetic wave moves with velocity of light in vacuum. • In electromagnetic wave, electric field vector, magnetic field vector and direction of propagation, all are mutually perpendicular. • Electromagnetic waves are transverse in nature. • Electromagnetic waves do not require a physical medium to propagate and can travel through a vacuum. • Electromagnetic waves consist of oscillating electric and magnetic fields. (b) • During charging of capacitor, time varying electric field / electric flux between the plates of capacitor induces the displacement current. • Displacement current exists between the plates of capacitor.	½ ½ 1 ½	 3
	SECTION-D		
29.	(i) (C) $\sqrt{\frac{Ke^2}{mr}}$ (ii) (B) $\frac{-Ke^2}{2r}$ (iii) (C) $-2.48, 2.48$ (iv) (a) (D) $\frac{1}{n^3}$ OR (b) (C) $1.59\,\mathring{A}$	1 1 1 1	 4
30.	(i) (C) $\frac{2\varepsilon_o KL^2}{d}$ (ii) (B) $\frac{\varepsilon_o VKL^2}{d}$ (iii) (A) $\frac{V}{d}$ (iv) (a) (C) $\frac{d}{2K}$ OR (b) (D) Zero	1 1 1 1	 4

31.	**(a)** (i) Calculation of focal length of concave lens 3 (ii) Calculation of • Angle of minimum deviation 1 • Angle of incidence 1		
	For real image form by Convex lens $\frac{1}{f_1}=\frac{1}{v_1}-\frac{1}{u_1}$ $\frac{1}{10}=\frac{1}{v_1}-\frac{1}{(-30)}$ $v_1=15\,cm$	½ ½	
	For Combination of lenses, let the focal length of combination of lens is f_3 $\frac{1}{f_3}=\frac{1}{v_3}-\frac{1}{u_3}$ $\frac{1}{f_3}=\frac{1}{(15+45)}+\frac{1}{30}$ $f_3=20cm$	 ½ ½	
	Let the focal length of concave lens is f_2 $\frac{1}{f_3}=\frac{1}{f_1}+\frac{1}{f_2}$ $\frac{1}{f_2}=\frac{1}{20}-\frac{1}{10}$ $f_2=-20cm$	 ½ ½	
	(ii) Angle of minimum deviation $\mu=\frac{\text{Sin}\frac{(A+\delta_m)}{2}}{\text{Sin}\frac{A}{2}}$ $\sqrt{3}=\frac{\text{Sin}\frac{(60^\circ+\delta_m)}{2}}{\text{Sin }30}$ $\frac{\sqrt{3}}{2}=Sin\frac{(A+\delta_m)}{2}$	 ½	

	$60^\circ = \frac{(A+\delta_m)}{2}$ $\delta_m = 60^o$	½	
	Angle of incidence $i + e = A + \delta$ $2i = A + \delta_m$ $i = \frac{A+\delta_m}{2}$ $i = 60^\circ$	½ ½	
	OR (b)		
	(i) (I) Finding the slit separation 1½ (II) Calculation of distance between central maximum and first minimum 1½ (ii) Calculation of distance between first order minima on both sides of central maxima 2		
	(i) (I) Slit separation $\beta = \frac{D\lambda}{d}$ $d = \frac{D\lambda}{\beta}$ $= \frac{633 \times 10^{-9} \times 5}{5 \times 10^{-3}}$ $= 633 \times 10^{-6} m$ $=633 \mu m$	½ ½ ½	
	(II) Distance of first minimum from central maximum $x_n = \frac{(2n-1)\lambda D}{2d}$ n =1 $x = \frac{633 \times 10^{-9} \times 5}{2 \times 5 \times 10^{-3}}$	½ ½	

	$x = 316.5\times10^{-6}$ m $x = 316.5\mu$m (ii) Distance between first order minima on both the side $W=\dfrac{2D\lambda}{d}$ $=\dfrac{2\times650\times10^{-9}}{0.6\times10^{-3}}\times60\times10^{-2}$ $=1.3\times10^{-3}$m	½ ½ 1 ½	5
32.	**(a)** (i) Finding electric field at a far off point (y>>a) 3 (ii) Calculation of work done in shifting the charges 2  Magnitude of electric field due to the two charges +q and -q are given by $E_{+q}=\dfrac{q}{4\pi\varepsilon_o}\dfrac{1}{y^2+a^2}$ $E_{-q}=\dfrac{q}{4\pi\varepsilon_o}\dfrac{1}{y^2+a^2}$ Components normal to the dipole axis cancel out. The components along the dipole axis add up.	 ½ ½ ½	

The total electric field is opposite to the dipole moment will be given by-

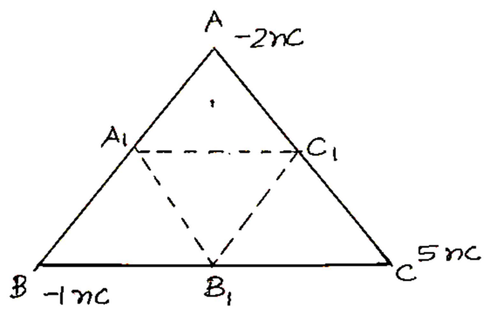
$\vec{E} = -(E_{+q} + E_{-q}) \cos\theta \, \hat{p}$ ½

$= -\dfrac{2qa}{4\pi\varepsilon_o (y^2 + a^2)^{3/2}} \hat{p}$ ($\hat{p}$ is a unit vector along dipole moment) ½

At large distance (y>>a)

$\vec{E} = \dfrac{-2qa}{4\pi\varepsilon_o y^3} \hat{p}$ ½

(ii)



Initial electrostatic potential energy of the system

$U_1 = \dfrac{1}{4\pi\varepsilon_o}\left(\dfrac{q_A q_B}{AB} + \dfrac{q_C q_A}{AC} + \dfrac{q_C q_B}{BC}\right)$

$= \dfrac{9\times10^9}{0.2}\left[(-2\times-1) + (-2\times5) + (-1\times5)\right]\times10^{-18}$ ½

$U_1 = -5.85\times10^{-7} J$

$U_2 = \dfrac{1}{4\pi\varepsilon_o}\left(\dfrac{q_{A_1} q_{B_1}}{A_1B_1} + \dfrac{q_{C_1} q_{A_1}}{A_1C_1} + \dfrac{q_{c_1} q_{B_1}}{B_1C_1}\right)$ ½

$U_2 = -11.7\times10^{-7} J$

$W = U_2 - U_1 = -5.85\times10^{-7} J$ ½

OR

(b) ½

(i)

- Showing consistency of Gauss's theorem with Coulomb's law 1
- Derivation for electric field due to uniformly charged thin spherical shell at (I) y > r (II) y < r 2

(ii) Finding type and magnitude of charge. 2

(i)

- Gauss's theorem is based on the inverse square dependence on distance contained in the coulomb's law.

  Alternatively- 1

  According to Gauss's theorem

$$\oint \vec{E}.d\vec{s} = \frac{q}{\varepsilon_o}$$

½

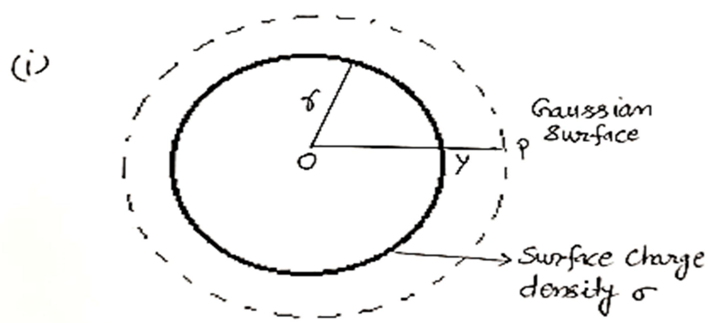
$$E = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}$$

According to Coulomb's law, force on charge q_o in this field

$$F = \frac{1}{4\pi\varepsilon_o}\frac{qq_o}{r^2}$$

Therefore, Gauss's law is consistent with Coulomb's law ½

- (I) For y > r



Electric flux through Gaussian surface $E \times 4\pi y^2$

The charge enclosed by the surface $\sigma \times 4\pi r^2$

Using Gauss theorem

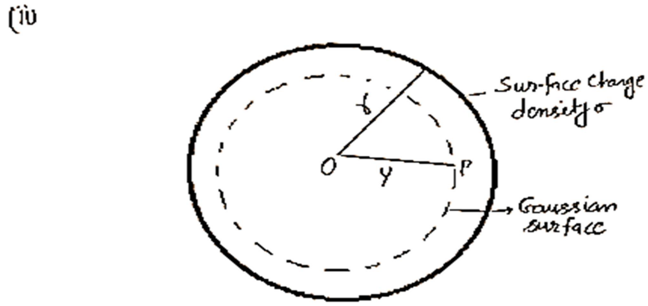
$$E(4\pi y^2) = \frac{\sigma 4\pi r^2}{\varepsilon_o}$$

½

$$\vec{E} = \frac{q}{4\pi\varepsilon_0 y^2}\hat{r}$$

½

(II) For y < r



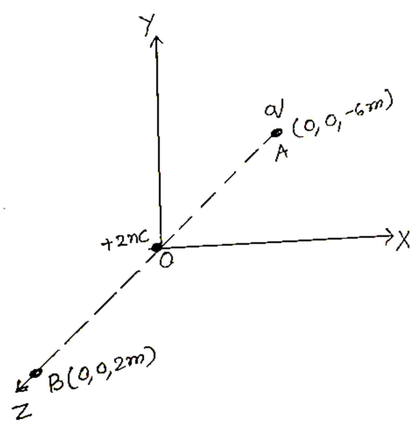
The charge enclosed by Gaussian surface = 0

Using Gauss theorem

Electric flux $= E(4\pi y^2) = 0$ ½

i.e. $E = 0 \quad (y < r)$ ½

(ii)



Let the charge is kept at A be q

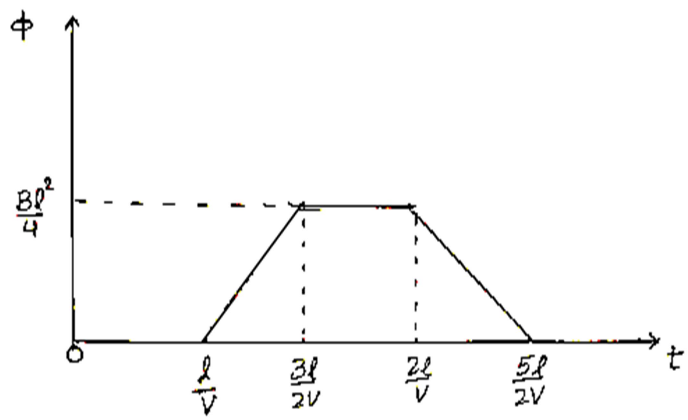
Potential at point B due to charge at the origin O and charge (q) at A

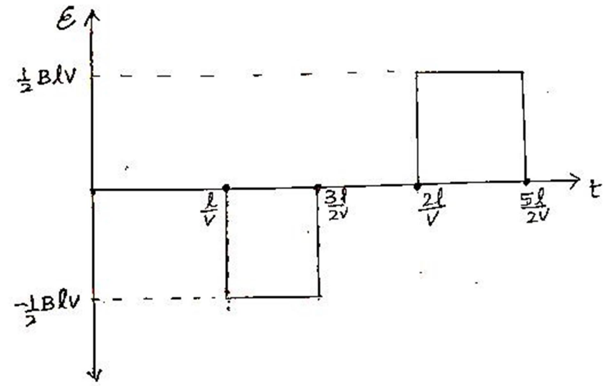
$V = V_1 + V_2$

$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{2\times10^{-9}}{2} + \frac{q}{6+2}\right]$ ½

$\frac{1}{4\pi\varepsilon_0}\left[10^{-9} + \frac{q}{8}\right] = 0$ ½ ½

$q = -8\times10^{-9}C$ ½ 5

33.	**(a)** (i) • Statement of Lenz's law ½ • Explaining, how this law is a consequence of law of conservation of energy ½ (ii) (I) Direction of induced current when loop enters and loop leaves ½+½ (II) Plots showing variation of magnetic flux (ϕ) with time (t), 1 induced emf (E) with time (t) and 1 relevant values E, (ϕ) and t on the graph 1		
	Lenz's law – Polarity of the induced emf is such that it tends to produce a current, which opposes the change in magnetic flux that produces it.	½	
	When magnet is moved closer/ away from the loop, same/ opposite pole is developed on the approaching face of the loop. So mechanical work is required to move a magnet which gets converted into electrical energy which is consistent with the law of conservation of energy.	½	
	(ii) (I) Anticlockwise Clockwise	½ ½	
	(II) 	1½	



1½

OR

(b)

(i)	
Difference between Peak value and rms value of ac	1
Relation	½
(ii) (I) Identification of elements X and Y by phasor diagram	1
(II) Obtaining	
• Resonance condition	1
• Expression for resonant frequency	1
• Impedance value	½

(i)

Peak value - It is the maximum value of Alternating current**.** 1

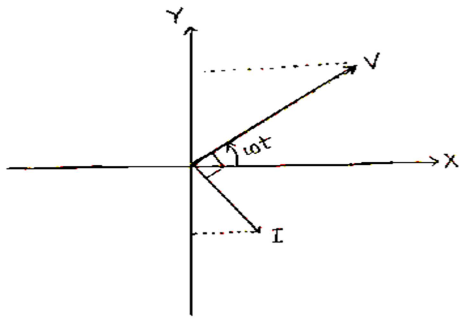
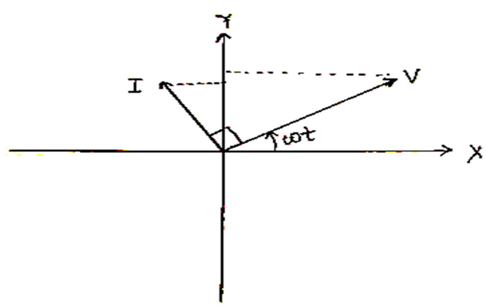
rms value - It is the equivalent dc current that would produce the same average power loss as alternating current.

Alternatively-

Peak value - It is the maximum value of Alternating current**.**

rms value- It is the effective value of an ac representing the equivalent dc, that would produce the same heating effect in same resistor in same time period.

Relation $I_{rms} = \frac{I_o}{\sqrt{2}}$ ½

	(ii) (I) X- Inductor (L)  	½	
	Y- Capacitor (C)  	½	
	(II) Impedance of the circuit $Z = (X_L - X_C)$	½	
	At resonance $Z = 0$ $X_L = X_C$	½	
	$\omega L = \frac{1}{\omega C}$	½	
	$\omega^2 = \frac{1}{LC}$, $\omega = \frac{1}{\sqrt{LC}}$	½	
	$\nu = \frac{1}{2\pi\sqrt{LC}}$ Impedance at resonance Z=0	½	**5**