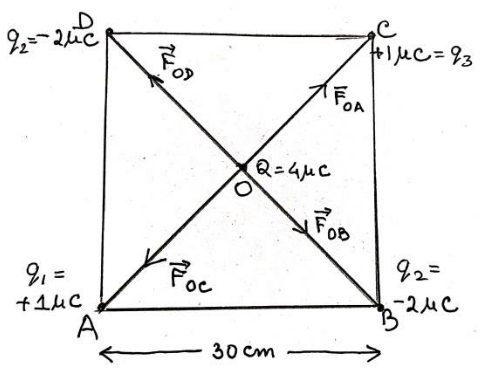
MARKING SCHEME : PHYSICS (042)

CODE : 55/5/3

Q.NO.	SECTION - A	MARKS	TOTAL MARKS
1.	(D) 2P	1	1
2.	(A) $\frac{\mu_0 I}{R}$	1	1
3.	(A) Aluminum	1	1
4.	(A) 0.1Ω	1	1
5.	(B) 5π	1	1
6.	(A) 0.8 fm	1	1
7.	(B) 1.5×10^{16}	1	1
8.	(C) $3.4\,e\text{V}, -6.8\,e\text{V}$	1	1
9.	(B) Ultraviolet rays	1	1
10	(A) A	1	1
11	(D) 125	1	1
12	(D) virtual, at a distance of 3.6 m from the surface.	1	1
13	(C) Assertion (A) is true but Reason (R) is false.	1	1
14	(D) Both Assertion (A) and Reason (R) are false.	1	1
15	(C) Assertion (A) is true but Reason (R) is false.	1	1
16	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).	1	1
	SECTION - B		
17	Deriving an expression for magnetic force 1½ Validity and Justification for zig-zag form conductor ½ Total number of mobile charge carriers in a conductor of length L, cross-sectional area A and number density of charge carriers n: $= nLA$ Force acting on the charge carriers in external magnetic field $\vec{B}$ $\vec{F} = (nAL)\, q\vec{v}_d \times \vec{B}$ ------(1) Where $\vec{v}_d$ is the drift velocity of the charge carriers Current flowing $I = v_d qnA$ $I\vec{L} = \vec{v}_d qnAL$ ------(2) On solving equation (1) and (2) $\vec{F} = I(\vec{L}\times\vec{B})$ Yes, because this force can be calculated by considering zig-zag conductor as a collection of linear strips $(d\vec{l})$ and summing them vectorically.	½ ½ ½ ½	2
18	(a) Diagram showing direction of forces 1 Finding net force 1		



(1)

OA = OB = OC = OD = r

Net force on charge $4\mu C$

$\vec{F} = \vec{F}_{OA} + \vec{F}_{OB} + \vec{F}_{OC} + \vec{F}_{OD}$ (½)

$\vec{F}_{OA} = -\vec{F}_{OC} \quad \Rightarrow \vec{F}_{OA} + \vec{F}_{OC} = 0$

$\vec{F}_{OB} = -\vec{F}_{OD} \quad \Rightarrow \vec{F}_{OB} + \vec{F}_{OD} = 0$

$\vec{F} = 0$ (½)

Alternatively

$$F_{OA} = F_{OC} = \frac{9\times10^{9}\times4\times10^{-6}\times1\times10^{-6}}{(15\sqrt{2}\times10^{-2})^{2}}$$

$= 0.8\,N$

$F_{OB} = F_{OD} = 1.6\ N$ (½)

$F_1 = F_{OA} - F_{OC} = 0$

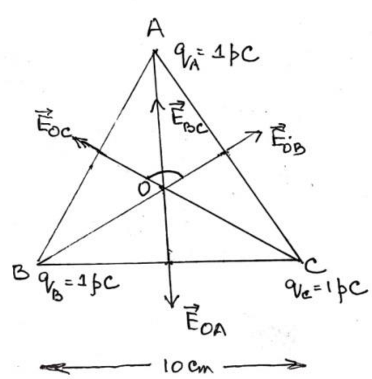
$F_2 = F_{OB} - F_{OD} = 0$

Net Force $F = 0$ (½)

OR

(b)

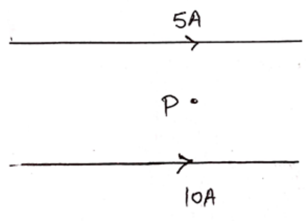
Finding net electric field at centroid	2

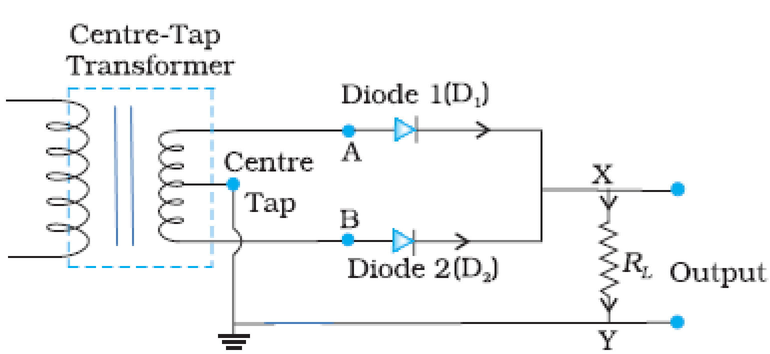


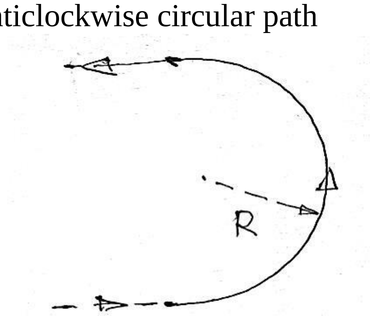
(1)

	$q_A = q_B = q_C = 1pC$ $AO = BO = CO = r$ $\lvert\vec{E}_{OA}\rvert = \lvert\vec{E}_{OB}\rvert = \lvert\vec{E}_{OC}\rvert$ $\vec{E}_{BC} = \vec{E}_{OB} + \vec{E}_{OC}$ $E_{BC} = \sqrt{E_{OB}^2 + E_{OC}^2 + 2E_{OB}E_{OC}\cos 120^0}$ $E_{BC} = E_{OB}$, $\vec{E}_{OA} = -\vec{E}_{BC}$ Net electric field $\vec{E}_O = \vec{E}_{OA} + \vec{E}_{BC}$ $\vec{E}_O = 0$ **Alternatively** $E_{OA} = E_{OB} = E_{OC} = 2.7\ NC^{-1}$ $E_{BC} = \sqrt{E_{OB}^2 + E_{OC}^2 + 2E_{OB}E_{OC}\cos 120^0}$ $= E_{OB}$ As $\vec{E}_{BC} = -\vec{E}_{OA}$ $\vec{E}_{BC} + \vec{E}_{OA} = 0$ Net electric field is zero. **Alternatively** $\lvert\vec{E}_{OA}\rvert = \lvert\vec{E}_{OB}\rvert = \lvert\vec{E}_{OC}\rvert$ Electric field vectors are making an angle of 120^0 with each other. They make a closed polygon. So vector sum of all electric field vectors will be zero. $\vec{E} = 0$	 ½ ½ ½ ½ 2	 2
19	Identifying behavior of combination 1 Justification 1 It will behave like a conversing lens. Power of converging lens is more than the power of diverging lens. Hence the combination will behave like a conversing lens. **Alternatively** $P = P_1 + P_2$ $= \frac{100}{10} + \frac{100}{-15}$ $P = \frac{10}{3}\text{D}$ **Alternatively**	 1 1	

	$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$ $\frac{1}{f}=\frac{1}{10}-\frac{1}{15}$ $\frac{1}{f}=\frac{1}{30}$ $f=30$ cm		2
20	Calculation of energy released 1 Calculation of time 1 (a) Number of atoms in 2g deuterium $=6.023\times10^{23}$ Energy released /atom $=\frac{3.27}{2}=1.635\,\text{MeV}$ $t=\frac{\text{Total energy released}}{\text{Power}}$ $t=\frac{6.023\times10^{23}\times1.635\times1.6\times10^{-13}}{200}$ $t=7.88\times10^{8}$ s	½ ½ ½ ½	2
21	Calculating frequency of light 2 $\nu=\frac{\text{v}}{2\pi r}$ $\nu=\frac{2.2\times10^{6}}{2\times\pi\times0.53\times10^{-10}}$ $\nu=6.6\times10^{15}\,\text{Hz}$	1 ½ ½	2
	SECTION - C		
22	(a) (i) Statement of Lenz's Law 1 Justification ½ (ii) Calculating emf induced 1½ (i) The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it. In a closed loop, when the polarity of induced emf is such that, the induced current favours the change in magnetic flux then the magnetic flux and consequently the current will go on increasing without any external source of energy. This violets law of conservation of energy.	1 ½	

	(ii) $\varepsilon = \frac{1}{2}Bl^2\omega$	½	
	$= \frac{1}{2}\times 2\times(2)^2\times(2\pi\times 60)$	½	
	$= 480\pi$ V		
	$= 1.51\times 10^3$ V	½	
	OR		
	(b)		
	(i) Statement and explanation of Ampere's circuital law — 1 (ii) Finding magnitude and direction of magnetic field — 2		
	Line integral of magnetic field over a closed loop in vacuum is equal to μ_0 times the total current passing through the loop.	1	
	Alternatively $\oint \vec{B}\cdot\vec{dl} = \mu_0 I$ The integral in this expression is over a closed loop coinciding with the boundary of the surface.		
	(ii) 		
	$B = \frac{\mu_0 I}{2\pi r}$	½	
	Net magnetic field B = $B_2 - B_1$		
	$B = \frac{\mu_0\times 10^2}{20\pi}[10-5]$		
	$B = \frac{4\pi\times 10^{-7}\times 10^2\times 5}{20\pi}$	½	
	$B = 10^{-5}T$	½	
	Along the direction of magnetic field produced by the conductor carrying current 10A.	½	3
23	(i) Calculation of work function — 1 (ii) Calculation of maximum speed — 2		
	(i) $\phi_0 = h\nu_0 = \frac{6.63\times 10^{-34}\times 3.0\times 10^{14}}{1.6\times 10^{-19}}$	½	
	$= 1.24$ eV	½	

	(ii) $$K_{max} = h\nu - h\nu_0$$ $$\frac{1}{2} mV_{\max}^2 = h(\nu - \nu_0)$$ $$V_{\max} = \left[\frac{2h(\nu-\nu_0)}{m}\right]^{\frac{1}{2}}$$ $$V_{\max} = \left[\frac{2\times 6.63\times 10^{-34}(9-3)\times 10^{14}}{9.1\times 10^{-31}}\right]^{\frac{1}{2}}$$ $$= 9.35\times 10^5 \ \ \text{m/s}$$	½ ½ ½ ½	 3
24	(a) Naming the parts of electromagnetic spectrum for (i) and (ii) ½ +½ (b) Writing one method of production and detection of each ½×4 (a) (i) Infrared waves (ii) Ultraviolet Rays (b) Method of production Infrared waves: Hot bodies / Vibration of atoms and molecules Ultraviolet Rays: Special UV lamps / Sun / Very hot bodies Method of detection Infrared waves: Thermopiles / IR photographic film / Bolometer Ultraviolet Rays: Photocells / photographic film	 ½ ½ ½ ½ ½ ½	 3
25	(a) Characteristics of p-n junction diode that makes it suitable for rectification 1 (b) Circuit diagram 1 Explanation of working of full wave rectifier 1 (a) p-n junction diode allows current to pass only when it is forward biased (b)  When input voltage to A, with respect to the centre tap at any instant is positive, at that instant voltage at B, being out of phase will be negative, diode D_1 gets forward biased and conducts while D_2 being reverse biased	 1 1	

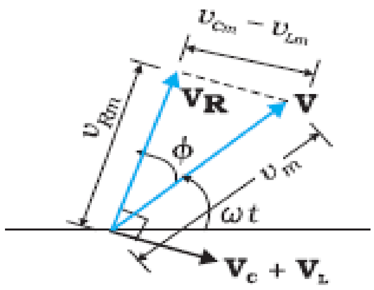
	does not conduct. Hence during this half cycle an output current and output voltage across R_L is obtained. During second half of the cycle when voltage at A becomes negative with respect to centre tap, the voltage at B would be positive. Hence D_1 would not conduct but D_2 would be giving an output current and output voltage. Thus output voltage is obtained during both halves of the cycle.	1	3
26	Explanation of (a), (b) and(c) 1+1+1 (a) Charge of additional charge carriers is just equal and opposite to that of the ionised cores in the lattice. (b) Under equilibrium, the diffusion current is equal to the drift current. (c) Reverse current is limited due to concentration of minority charge carriers on either side of the junction.	 1 1 1	 3
27	(a) Calculation for magnetic force and radius 2 (b) Tracing the path 1 (a) $\vec{F}_B = q(\vec{v}\times\vec{B})$ $= -1.6\times10^{-19}\left[(3\times10^{6}\,\hat{i})\times(91\times10^{-3}\,\hat{k})\right]$ $=1.6\times10^{-19}\left[3\times10^{6}\times91\times10^{-3}\right]\hat{j}$ $=4.368\times10^{-14}\,\hat{j}$ N $r=\dfrac{mv}{qB}$ $r=\dfrac{9.1\times10^{-31}\times3\times10^{6}}{1.6\times10^{-19}\times91\times10^{-3}}$ m $r=1.875\times10^{-4}$ m (b) Anticlockwise circular path 	½ ½ ½ ½ 1	 3
28	(a) Calculating the drift speed $1\frac{1}{2}$ (b) Calculation of Relaxation time $1\frac{1}{2}$		

	(i) $v_d = \frac{I}{enA}$ $= \frac{4.25}{1.6\times10^{-19}\times8.5\times10^{28}\times10^{-6}}$ m/s $= 3.125\times10^{-4}$ m/s (ii) $\tau = \frac{v_d ml}{eV}$ $= \frac{3.12\times10^{-4}\times9.1\times10^{-31}\times5}{1.6\times10^{-19}\times1}$ m/s $= 88.72\times10^{-16}$ s $= 8.872\times10^{-15}$ s	½ ½ ½ ½ ½ ½	 3
	SECTION - D		
29	(i) (C) greater than θ_2 (ii) (C) λ decreases but ν is unchanged (iii) (a) (D) violet colour OR (iii) (b) (C) $r_R < r_Y < r_V$ (iv) (D) undergo total internal reflection	1 1 1 1	 4
30	(i) (D) HCl (ii) (B) The net dipole moment of induced dipoles is along the direction of the applied electric field. (iii) (B) decreases and the electric field also decreases. (iv) (a) (C) $\left[\frac{5K}{4K+1}\right]C_0$ **OR** (iv) (b) (D) $\frac{3}{16}$	1 1 1 1	 4
	SECTION - E		
31	(a) (i) To identify the circuit element X, Y & Z — 1½ (ii) To establish relation for impedance — 2 Showing variation in current with frequency — ½ (iii) To obtain condition for- (i) Minimum impedance — ½ (ii) Wattless current — ½ (i) X : Resistor Y : real inductor (such that its reactance is equal to its resistance) /	 ½	

Inductor ½

Z : real capacitor (such that its reactance is equal to its resistance)/ Capacitor ½

(ii)



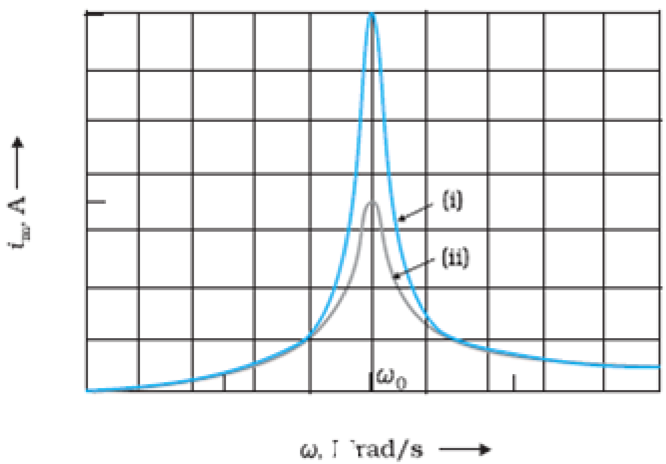
½

From the fig.

$V_m^2 = V_{Rm}^2 + (V_{Cm} - V_{Lm})^2$ ½

$V_m^2 = (i_m \mathrm{R})^2 + (i_m X_C - i_m X_L)^2$ ½

Impedance (Z) $= \dfrac{V_m}{I_m} = \sqrt{R^2 + (X_C - X_L)^2}$ ½



½

(iii) $Z = \sqrt{R^2 + (X_C - X_L)^2}$

For the minimum value of impedance

(i) $X_C = X_L$ ½

(ii) Average power consumed in A.C. circuit over a cycle

P = VI cos φ

For wattless current P = 0

Since V ≠ 0 , I ≠ 0

cos φ = 0

i.e. $\varphi = \frac{\pi}{2}$ ½

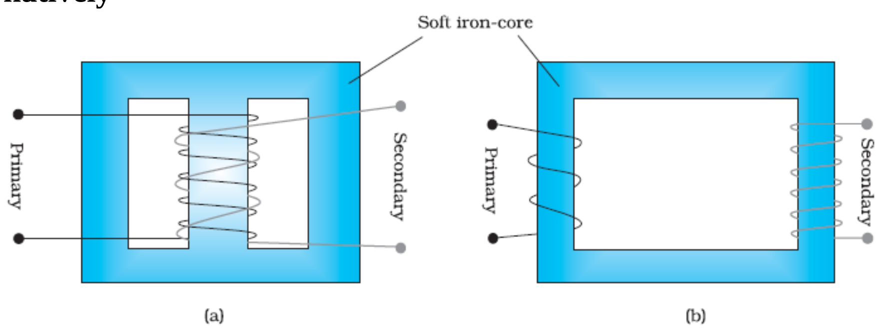
OR

(b)

(i) Description of Construction and working	1+1
Obtaining relation ($\frac{V_S}{V_P}$)	1
(ii) Causes of energy losses	2

(i) **Construction:** A transformer consists of two sets of coils, insulated from each other. They are wound on a soft- iron core, either one on top of other or on separate limbs of the core.

Alternatively



1

Working: When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links with the secondary and induces an e.m.f. in it. 1

For an ideal transformer the induced e.m.f. (ε_p) in primary coil for applied alternating voltage (V_P)

$$\varepsilon_p = V_P = -N_P \frac{d\phi}{dt} \quad \text{------------------(1)}$$

½

e.m.f. induced ε_S in the secondary coil

$$\varepsilon_S = V_S = -N_S \frac{d\phi}{dt} \quad \text{------------------(2)}$$

From eq. (1) and (2)

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

½

(ii) Any four energy losses

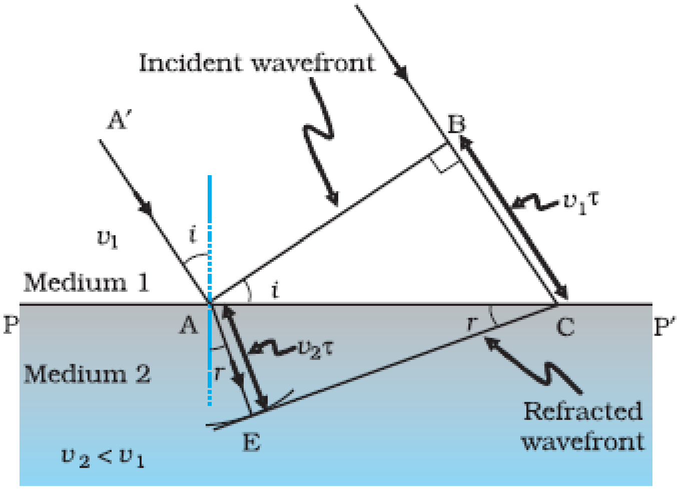
1. Flux leakage.
2. Resistance of windings/ copper loss.
3. Eddy currents/iron loss.
4. Hysteresis.
5. Magnetostriction.

$\frac{1}{2} \times 4$ 5

32 (a)

(i) Drawing refracted wavefront and Verification of Snell's law	3
(ii) Calculation of distance	2

(i)



1

Considering triangles ABC and AEC

$\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$ and ------(1) ½

$\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$ ------(2)

From equation (1) and equation (2)

$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$ ------(3) ½

If c represents the speed of light in vacuum, then

$n_1 = \frac{c}{v_1}$ and $n_2 = \frac{c}{v_2}$ ½

In terms of refractive indices

$n_1 \sin i = n_2 \sin r$ ½

which is Snell's law of refraction.

(ii)

$$X_4 = \frac{(2n-1)\lambda D}{2d}$$ ½

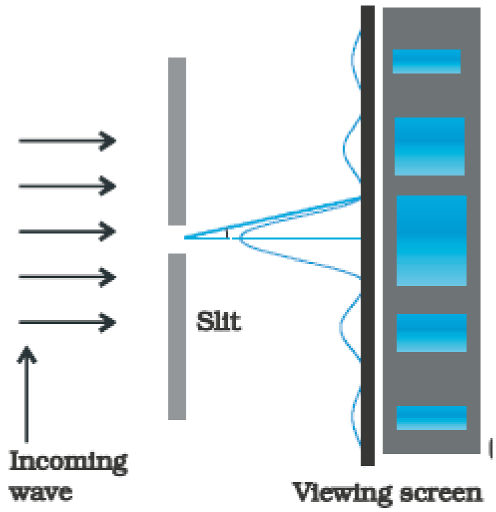
$$X_4 = \frac{(2\times4-1)\times600\times10^{-9}\times1.5}{2\times0.3\times10^{-3}}$$ 1

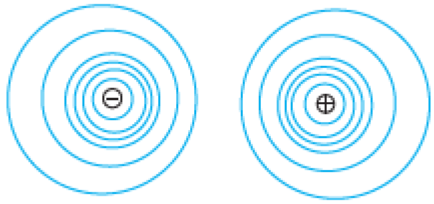
$$=1.05\times10^{-2}\ m$$ ½

OR

(b)

(i) Brief discussion of Diffraction of light and drawing the shape of diffraction pattern	2+1
(ii) Proof using mirror formula	2

	(i) A beam of light falls normally on a single slit and bends around its corners. This phenomenon is called diffraction. When a beam of light falls normally on a narrow single slit, then diffracted light goes on to meet a screen. It is observed that at the center of the screen intensity is maximum and goes on decreasing as one move away from the center on either side of screen.  (ii) $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$ $v=\frac{uf}{u-f}$ Following new cartesian sign conversion $v=\frac{(-u)(-f)}{-u-(-f)}$ $v=\frac{uf}{f-u}$ as $f>u$ v is +ve, So image is virtual. $m=-\frac{v}{u}=\frac{f}{f-u}>1$ i.e. Enlarged image	1 1 1 1 1	 5
33	(a) (i) Drawing equipotential surfaces 1 (ii) Obtaining an expression for potential energy 2 (iii) Finding the change in potential energy 2 (i)		

 1

(ii) Work done in bringing a charge q_1 from infinity to $\vec{r}_1$:

$W_1 = q_1 V(\vec{r}_1)$ -------------(1) ½

Work done in bringing a charge q_2 from infinity to $\vec{r}_2$ against the external field :

$W_2 = q_2 V(\vec{r}_2)$ -------------(2) ½

Work done on q_2 against the field due to q_1:

$W_{12} = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$ -----------------(3) ½

Potential energy of the system = Total work done

$= q_1 V(\vec{r}_1) + q_2 V(\vec{r}_2) + \dfrac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$ ½

(iii) Change in Potential energy = Work done

$W = pE\,[\cos\theta_0 - \cos\theta_1]$ 1

$W = 10^{-30} \times 10^{5}\,[\cos 0^0 - \cos 60^0]$ ½

$W = 5.0 \times 10^{-26}$ J ½

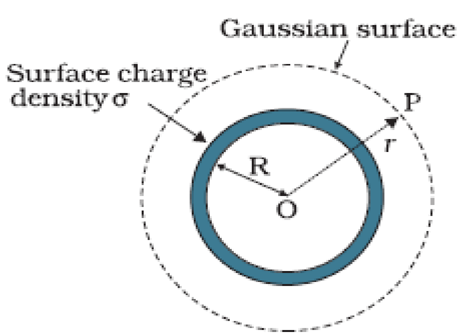
OR

(b)

(i) Deduction of an expression for electric field for (i) and (ii)	3
(ii) Finding magnitude and direction of the net electric field	2

(i)

(i) **<u>Electric Field outside the shell</u>**



½

Electric flux through Gaussian surface

$\Phi = E \times 4\pi r^2$

Charge enclosed by the Gaussian surface

$Q = \sigma \times 4\pi R^2$

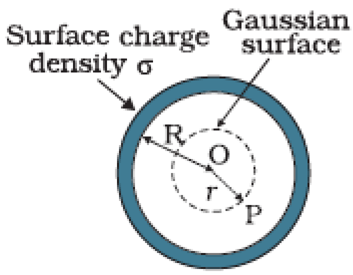
Using Gauss' law: $\int \vec{E}.\vec{ds} = \frac{Q}{\varepsilon_0}$ ½

$$E \times 4\pi r^2 = \frac{(\sigma 4\pi R^2)}{\varepsilon_0}$$

$$\therefore E = \frac{\sigma R^2}{\varepsilon_0 r^2}$$ ½

$$\vec{E} = \frac{\sigma R^2}{\varepsilon_0 r^2}\hat{r}$$

(ii) **<u>Field inside the shell</u>**



½

Electric flux through Gaussian surface

$\Phi = E \times 4\pi r^2$ $(\because r < R)$

Charge enclosed by the Gaussian surface

Q = 0

By Gauss' Law

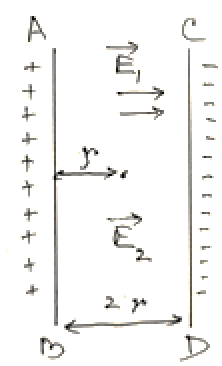
$E \times 4\pi r^2 = 0$ ½

i.e. E = 0 ½

(Note: Award full credit of this part if a student writes directly E=0, mentioning as there is no charge enclosed by Gaussian surface)

(ii) Electric field due to a long straight charged wire of linear charged density λ

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$ ½



Net electric field at the mid-point

$E_{net} = E_1 + E_2$

	$= \frac{\lambda_1}{2\pi\varepsilon_0 r} + \frac{\lambda_2}{2\pi\varepsilon_0 r}$ $E_{net} = \frac{1}{2\pi\varepsilon_0 r}[\lambda_1 + \lambda_2]$ $= \frac{2\times 9\times 10^9}{0.5}[10+20]\times 10^{-6}$ $= 1.08 \times 10^6$ NC^{-1} $\vec{E}_{net}$ is directed towards CD.	½ ½ ½	5