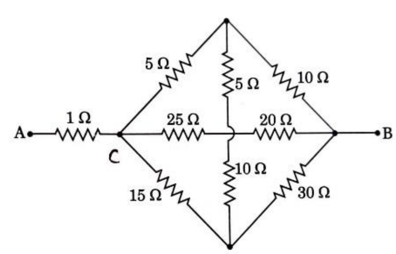
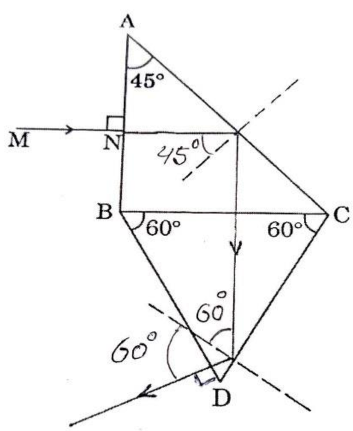
SOLUTIONS: PHYSICS(042)			
Code: 55/6/1			
Q.No.	**VALUE POINTS/EXPECTED ANSWERS**	**Marks**	**Total Marks**
	SECTION A		
1.	(D) $T_1 < T_2$	1	1
2.	(C) $\left[\frac{n^2-1}{n}\right]R$	1	1
3.	(C) $\frac{\mu_0 I}{4R}$	1	1
4.	(D) does not move at all	1	1
5.	(C) small resistance in parallel	1	1
6.	(B) $\frac{1}{2}$	1	1
7.	(C) g	1	1
8.	(A) 10 V	1	1
9.	(C) $2I_0$	1	1
10.	(A) Red Light	1	1
11.	(B) 1.326×10^{-27}	1	1
12.	(D) $F_{pp} = F_{pn} = F_{nn}$	1	1
13.	(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A)	1	1
14.	(C) Assertion (A) is true, But Reason (R) is false.	1	1
15.	(D) Both Assertion (A) and Reason (R) are false.	1	1
16.	(C) Assertion (A) is true, But Reason (R) is false.	1	1
	SECTION B		
17.	Finding equivalent resistance between points A and B 2 Resistance between points C and B $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $\frac{1}{R} = \frac{1}{15} + \frac{1}{45} + \frac{1}{45}$ R = 9 Ω Equivalent resistance between points A and B  	½ ½	

	$R_{eq} = R_1 + R_2$ $R_{eq} = 1 + 9$ $= 10\ \Omega$	½ ½	2
18.	(a) Finding the intensity for path difference of (i) $\frac{\lambda}{3}$ — 1 (ii) $\frac{\lambda}{2}$ — 1 (i) $\Delta\phi = \frac{2\pi}{\lambda}.\Delta x$ $\Delta\phi = \frac{2\pi}{\lambda}.\frac{\lambda}{3} = \frac{2\pi}{3}$ $I = 4I_0 \cos^2 \frac{\phi}{2}$ $I = 4I_0 \cos^2 \frac{\pi}{3}$ $I = I_0$ (ii) $\Delta\phi = \frac{2\pi}{\lambda}.\frac{\lambda}{2} = \pi$ $I = 4I_0 \cos^2 \frac{\pi}{2}$ $I = 0$ OR (b) Finding- The position of the image — 1½ The nature of the image — ½ $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ $\frac{1.5}{v} - \frac{1}{(-12)} = \frac{1.5-1}{30}$ v = -22.5 cm Image is virtual and erect.	½ ½ ½ ½ ½ ½ ½ ½	**2**

19.	**Finding-** (i) The energy of photon of the beam 1 (ii) The average number of photons emitted per second (N) 1 (i) E = hν $= 6.63\times10^{-34}\times3.0\times10^{14}$ $= 1.99\times10^{-19}$ J (ii) $N=\dfrac{P}{E}$ $=\dfrac{9\times10^{-3}}{1.99\times10^{-19}}$ $=4.5\times10^{16}$	½ ½ ½ ½	2
20.	**Tracing the path of ray MN** 2  Note: Please deduct ½ mark for not showing arrows with the rays.	1 1	2
21.	**Explanation for higher electron concentration in n-type semiconductor in comparison to hole concentration** 2 In a doped semiconductor the total number of conduction electrons is due to the electrons contributed by donors and those generated intrinsically, while the total number of holes is only due to the holes from the intrinsic sources.	2	2

<table>
<tr><td></td><td>SECTION - C</td><td></td><td></td></tr>
<tr><td>22.</td><td>

- Difference between emf and terminal voltage of a cell 1

Deriving expression for-

- Equivalent emf of combination of cells 1½
- Equivalent internal resistance of combination of cells ½

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(Any one difference)

1. Potential difference between the terminals of a cell in open circuit is emf and in closed circuit it is terminal voltage.
2. An emf does not depend on the external resistance, while terminal voltage depends on external resistance.
3. emf is the cause and terminal voltage is the effect.

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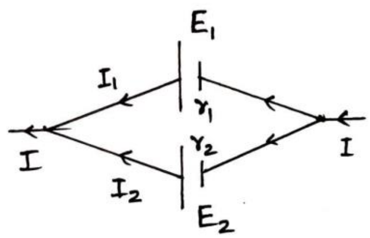
<tr><td></td><td>
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<tr><td></td><td>

$V = E_1 - I_1 r_1$

$V = E_2 - I_2 r_2$

$I = I_1 + I_2$

$I = \left(\frac{E_1 - V}{r_1}\right) + \left(\frac{E_2 - V}{r_2}\right)$

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On comparing above equation with $I = \frac{E_{eq} - V}{r_{eq}}$

$E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$

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$r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$

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<tr><td>23.</td><td>

Finding-

(i) The torque acting on the loop 1

(ii) The magnitude and direction of net force 2

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(i) $\tau = mB\sin\theta$

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As $\vec{m}$ and $\vec{B}$ are in same direction, $\theta = 0^0$

$\tau = 0$

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(ii) $F = \frac{\mu_0 I_1 I_2 l}{2\pi r}$

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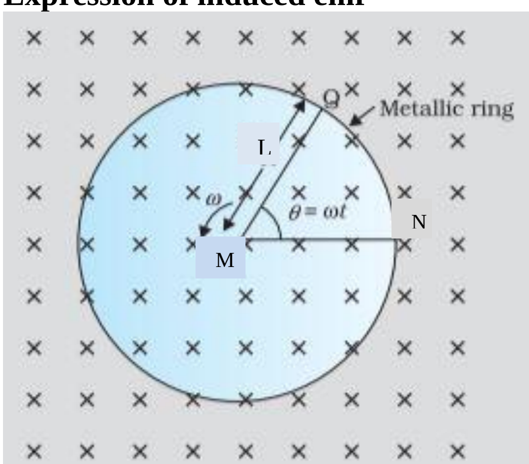
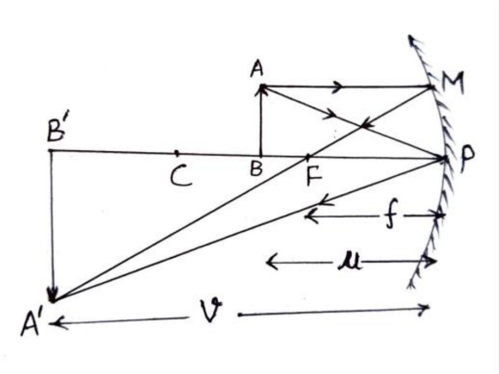
	$F_{net} = \frac{\mu_0 I_1 I_2 l}{2\pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$		
	$= \frac{4\pi \times 10^{-7} \times 2 \times 1 \times 5 \times 10^{-2}}{2\pi \times 10^{-2}}\left(1 - \frac{1}{2}\right)$	½	
	$F_{net} = 1 \times 10^{-6}$ N	½	
	Net force on the loop is towards the long straight wire.	½	3
24.	(a)		
	Stating Lenz's law — 1 Obtaining expression for induced emf — 2		
	Lenz's law The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it.	1	
	Expression of induced emf  		
	The magnitude of the emf generated across the length dr of the rod as it moves at right angles to the magnetic field is given by $d\varepsilon = Bv\,dr$	½	
	$\varepsilon = \int d\varepsilon$		
	$= \int_0^L Bv\,dr$	½	
	$\varepsilon = \int_0^L B\omega r\,dr$	½	
	$\varepsilon = \frac{1}{2} BL^2\omega$	½	
	Alternatively:		
	Area of the sector (QMN) = $\frac{1}{2}L^2\theta$	½	

	Induced emf is $\varepsilon = B \times \frac{d}{dt}\left(\frac{1}{2}L^2\theta\right)$ $\varepsilon = \frac{1}{2}BL^2\frac{d\theta}{dt}$ $\varepsilon = \frac{1}{2}BL^2\omega$ OR (b) Definition of self inductance 1 Deriving expression for self inductance for a long solenoid 2 Self inductance of a coil is the ratio of the flux linkage to the current flowing in the coil. **Alternatively:** Self inductance of a coil is defined as the flux linked with the coil when unit current flows through it. **Alternatively**: Self inductance of a coil may be defined as the magnitude of emf induced in the coil when current changes at the rate of 1 A/s in the coil. **Expression for self inductance of a long solenoid:** The magnetic field due to current flowing in the solenoid, B = $\mu_0 nI$ Total flux linked with the given solenoid $N\phi_B = (nl)(\mu_0 nI)\,\mathrm{A}$ $N\phi_B = \mu_0 n^2\,\mathrm{A}\,lI$ Self inductance $L = \frac{N\phi_B}{I}$ $L = \mu_0 n^2\,\mathrm{A}\,l$	½ ½ ½ 1 ½ ½ ½ ½	 3
25.	Naming the electromagnetic waves 1½ Writing wavelength range 1½ The electromagnetic waves used are (i) Microwaves (ii) Ultraviolet / Infrared (iii) X-Rays Wavelength range of electromagnetic waves used (i) 0.1 m to 1 mm (ii) 400 nm to 1 nm / 1mm to 700 nm (iii) 1 nm to 10^{-3} nm	 ½ ½ ½ ½ ½ ½	 3

26.	Drawing the ray diagram 1 Obtaining the mirror formula 2  **Note:** Please deduct ½ mark of this diagram if not showing arrows with the rays. In similar triangles $\Delta A'B'F$ *and* ΔMPF $\frac{A'B'}{MP}=\frac{B'F}{FP}$ or $\frac{A'B'}{AB}=\frac{B'F}{FP}$ $(\because MP=AB)$ ---------(1) In similar triangles $\Delta A'B'P$ *and* ΔABP $\frac{A'B'}{AB}=\frac{PB'}{PB}$ -------(2) from equation (1) and (2) $\frac{B'F}{FP}=\frac{PB'}{PB}$ $\frac{PB'-PF}{FP}=\frac{PB'}{PB}$ $\frac{(-v)-(-f)}{(-f)}=\frac{(-v)}{(-u)}$ on solving we get $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$	1 ½ ½ ½ ½	3
27.	• To state the necessary force for revolving electron around the nucleus ½ • Deriving the expression for total energy of electron in hydrogen atom 2 • Significance of negative sign ½ The electrostatic force of attraction between the electrons and the nucleus provides the necessary centripetal force required to an electron to revolve in the orbit.	½	

	$\frac{mv^2}{r}=\frac{e^2}{4\pi\varepsilon_0 r^2}$ -------(1) (Z = 1 for hydrogen atom) Kinetic energy of the electron $K=\frac{1}{2}mv^2$ $K=\frac{e^2}{8\pi\varepsilon_0 r}$ (from eq (1)) Potential energy of the electron $U=\frac{-e^2}{4\pi\varepsilon_0 r}$ $\left(\because U=\frac{q_1 q_2}{4\pi\varepsilon_0 r}\right)$ Total energy of the electron E = K + U $E=\frac{-e^2}{8\pi\varepsilon_0 r}$ Note: Full credit of this part should be given if a student shows this derivation using alternative method Negative sign signifies that electron is bound to the nucleus OR force is attractive.	½ ½ ½ ½ ½	3
28.	Finding the amount of energy released 2 Showing the nuclear density is independent of mass number 1 $\Delta m=\left[m({}_1^2H)+m({}_1^3H)\right]-\left[m({}_2^4He)+m({}_0^1\text{n})\right]$ = (2.014102 + 3.016049) – (4.002603 + 1.008665) = 0.018883u Q = $\Delta m\times 931$ = 0.018883 × 931 MeV Q = 17.58 MeV Nuclear density = $\frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$ $\rho=\frac{mA}{\frac{4}{3}\pi R^3}$ $R=R_0 A^{1/3}$ $\rho=\frac{3m}{4\pi R_0^3}$ Independent of mass number (A)	½ ½ ½ ½ ½ ½	3

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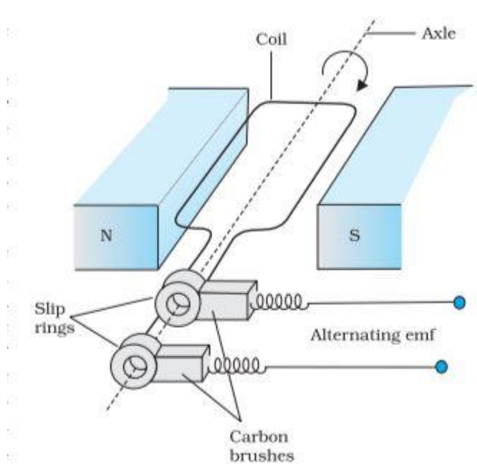
<tr><td></td><td>SECTION - D</td><td></td><td></td></tr>
<tr><td>29.</td><td>(i) (A) $\left(\frac{C}{4}\right)$
(ii) (B) $\frac{\sigma}{\sigma-\sigma_p}$
(iii) (C) $\frac{1}{2}\varepsilon_0 E^2 V$
(iv) (a) (D) 6
OR
(b) (B) $\frac{2K}{K+1}$</td><td>1
1
1
1</td><td>4</td></tr>
<tr><td>30.</td><td>(i) (B) Antimony
(ii) (C) 0.05 eV
(iii) (B) A layer of positive charge on n side and a layer of negative charge on p side appear
(iv) (a) (B) The applied voltage mostly drops across the depletion region
OR
(b) (C) 100 Hz</td><td>1
1
1
1</td><td>4</td></tr>
<tr><td></td><td>SECTION - E</td><td></td><td></td></tr>
<tr><td>31.</td><td>(a)
(i) Writing principle of ac generator 1
Labelled diagram of ac generator 1
Working of ac generator 1
(ii) Finding rms voltages across three circuit elements 1½
Explanation of the algebraic sum of rms voltages across three circuit elements is more than the rms voltage source ½

(i) Principle: It works on the principle of electromagnetic induction.

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1</td><td></td></tr>
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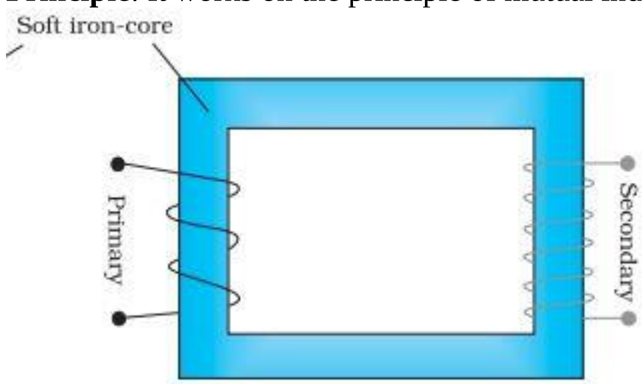
	Working: The coil is mechanically rotated in the uniform magnetic field. The rotation of the coil causes the magnetic flux through it to change, so an emf is induced in the coil.	1	
	(i) $Z=\sqrt{R^2+\left(\omega L-\frac{1}{\omega C}\right)^2}$ $=\sqrt{(400)^2+\left(100\pi\times\frac{5}{\pi}-\frac{1}{100\,\pi\times\frac{50}{\pi}\times10^{-6}}\right)^2}$ $=500\,\Omega$ $I_{rms}=\frac{V_{rms}}{Z}$ $I_{rms}=\frac{140}{\sqrt{2}\times500}=\frac{0.28}{\sqrt{2}}$ A $\left(V_{rms}\right)_R=I_{rms}\ R$ $=\frac{0.28}{\sqrt{2}}\times400$ $=\frac{112}{\sqrt{2}}=56\sqrt{2}$ V	½	
	$\left(V_{rms}\right)_L=I_{rms}\,\omega$L $=\frac{0.28}{\sqrt{2}}\times500$ $=\frac{140}{\sqrt{2}}=70\sqrt{2}$ V	½	
	$\left(V_{rms}\right)_C=I_{rms}\frac{1}{\omega C}$ $=\frac{0.28}{\sqrt{2}}\times200$ $=\frac{56}{\sqrt{2}}=28\sqrt{2}$ V	½	
	The algebraic sum of voltages is more than the rms voltage of source because voltages across R, L and C are not in phase. **OR**	½	

(b)

(i)	Writing principle of transformer	1
	Labelled diagram of step-up transformer	1
	Working of step-up transformer	1
(ii)	Finding-	
	• rms value of input current	1
	• expression for instantaneous output voltage	½
	• expression for instantaneous output current	½

(i) **Principle**: It works on the principle of mutual induction. 1



1

Working: When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it. Since the no. of turns are more in secondary windings an emf induced is proportional to the no. of turns. Therefore more emf is developed across the secondary windings. 1

(ii) $P_i = V_p I_p$ ½

$200 = \frac{20}{\sqrt{2}} I_p$

$I_p = 10\sqrt{2}\text{A}$ ½

$\frac{V_o}{V_i} = \frac{250}{50}$

$5 = \frac{V_o}{V_i}$

$V_o \ = 100\sin(100\pi)\,\text{t V}$ ½

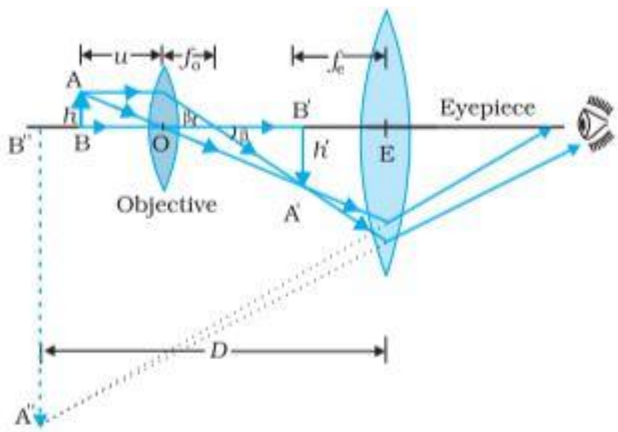
$\text{P}_o \ = (V_o)_{rms}\,(I_o)_{rms}$

$200 = \frac{100}{\sqrt{2}}(I_o)_{rms}$

$(I_o)_{rms} = 2\sqrt{2}\text{A}$

<table>
<tr><td></td><td>$\therefore I_o = \left(2\sqrt{2}\right)\sqrt{2}\sin(100\pi)\,t$
$I_o = 4\sin(100\pi)\,t\,A$</td><td>½</td><td>**5**</td></tr>
<tr><td>32.</td><td>(a)

(i) Drawing ray diagram of compound microscope — 1½
Obtaining an expression for total magnification — 1½
(ii) Calculating distance between the objective and the eye-piece — 2

(i)


Note: Deduct ½ mark for not showing arrows with the rays.
Magnification produced by objective
$m_0 = \frac{h'}{h} = \frac{L}{f_o}$
Magnification produced by eye-piece
$m_e = 1 + \frac{D}{f_e}$
If the final image is formed at infinity
$m_e = \frac{D}{f_e}$
Total magnification
$m = m_0 \times m_e$
$= \left(\frac{L}{f_o}\right)\left(\frac{D}{f_e}\right)$

(ii) $\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_0}$
$\frac{1}{v_o} - \frac{1}{(-1.5)} = \frac{1}{1.25}$
$v_o = 7.5\,\text{cm}$</td><td>1½

½

½

½

½

½</td><td></td></tr>
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$L = |v_o| + |f_e|$ as final image is formed at infinity ($v_e = \infty, u_e = f_e$) ½

$L = 7.5 + 5$

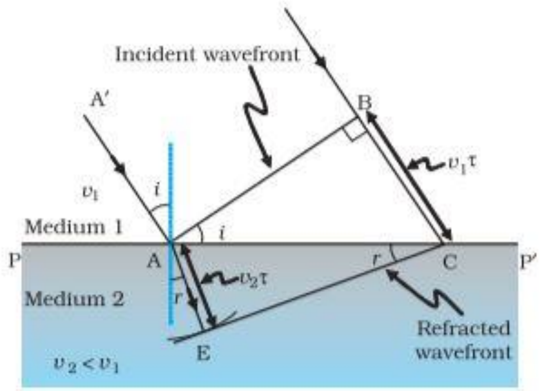
$L = 12.5$ cm ½

OR

(b)

(i) Explaining the refraction of a plane wavefront	1
Verification of Snell's law	2
(ii) Deducing that a convex mirror always produces a virtual image of an object	2

(i)



1

$\sin i = \frac{BC}{AC} = \frac{v_1\tau}{AC}$ ½

$\sin r = \frac{AE}{AC} = \frac{v_2\tau}{AC}$ ½

$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$

$\frac{\sin i}{\sin r} = \frac{c/n_1}{c/n_2}$ ½

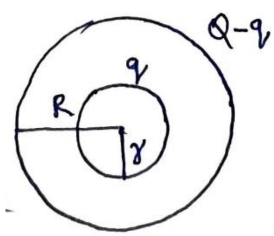
$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$ or $n_1 \sin i = n_2 \sin r$ ½

(ii) $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ ½

$u < 0$, $f > 0$

$\frac{1}{v} + \frac{1}{(-u)} = \frac{1}{f}$ ½

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

	$\frac{1}{v}$ is positive		
	$\therefore$ v is positive $\Rightarrow$ virtual image	½	5
33.	(i) Finding the amount of work done 2		
	(ii) Finding		
	(I) The electric field at their common centre 1		
	(II) The potential at their common centre 2		
	(a)		
	(i) $V = -\int \vec{E} \cdot \overrightarrow{dr}$		
	$= -\int 40\,x\,dx$		
	$= -20\,x^2$	½	
	Potential at A (0, 3m), $V_A = 0$		
	Potential at B (5m, 0), V_B = -500 V	½	
	Work done in taking a unit positive charge from a point (0, 3m) to the point (5m, 0)		
	$W = q(V_B - V_A)$	½	
	$= 1(-500 - 0)$		
	$W = -500\,J$	½	
	(ii) (I) Electric field at the common centre will be zero as the charge enclosed by the inner sphere is zero.	1	
			
	Alternatively: $q_{en} = 0$	½	
	$\phi_E = 0$		
	$\oint \vec{E}.\overrightarrow{ds} = 0$		
	$E = 0$	½	
	(II) $\because$ Surface charge densities are equal		
	$\frac{q}{4\pi r^2} = \frac{Q-q}{4\pi R^2}$	½	

$$q = \frac{Qr^2}{R^2 + r^2}$$ ½

Potential at common centre

$$V = \frac{kq}{r} + \frac{k(Q-q)}{R}$$ ½

$$V = \frac{k}{r}\frac{Qr^2}{(R^2+r^2)} + \frac{k}{R}\left[Q - \frac{Qr^2}{(R^2+r^2)}\right]$$

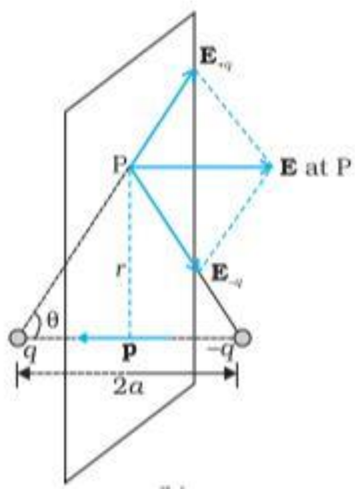
$$V = \frac{kQ(R+r)}{R^2+r^2}$$ ½

OR

(b)

(i)	Obtaining expression for electric field due to a dipole on its equatorial plane	2
	Finding electric field:	
	(I) At centre of the dipole	½
	(II) At a point r >> a	½
(ii)	Calculating net electric flux through cube	2

(i)



½

The magnitudes of the electric field due to two charges +q and -q are

$$E_{+q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{(r^2+a^2)}$$

$$E_{-q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{(r^2+a^2)}$$ ½

The total electric field

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

	$\vec{E} = -\dfrac{\vec{p}}{4\pi\varepsilon_0\left(r^2+a^2\right)^{3/2}}$	½	
	Direction of electric field is opposite to dipole moment ($\vec{p}$)	½	
	(I) At centre of dipole, r = 0		
	$\vec{E} = -\dfrac{-\vec{p}}{4\pi\varepsilon_0 a^3}$	½	
	(II) At a point r>>a		
	$\vec{E} = -\dfrac{-\vec{p}}{4\pi\varepsilon_0 r^3}$	½	
	(ii) $\vec{E} = (10x+5)\hat{i}$ N/C		
	$\phi_L = \int \vec{E}.\vec{ds}$		
	$= -E_L(L^2)$		
	$= -5L^2$	½	
	$\phi_R = E_R(L^2)$		
	$= (10L+5)L^2$	½	
	$\phi_{net} = \phi_L + \phi_R$		
	$= -5L^2 + (10L+5)L^2$	½	
	$= 10L^3 \;\; \text{Nm}^2/\text{C}$	½	5