

SOLUTIONS: PHYSICS(042)					
Code: 55/5/2					
Q.No.	VALUE POINTS/EXPECTED ANSWERS	Marks	Total Marks		
SECTION A					
1	(A) Infrared rays	1	1		
2	(D) $6 \mu\text{F}$	1	1		
3	(A) $\frac{\alpha}{r}$	1	1		
4	(B) 0 and $4a^2$	1	1		
5	(C) 0.196 Am^2	1	1		
6	(C) low ac voltage and large ac current to high ac voltage and small ac current	1	1		
7	(D) $\frac{4R}{3}$	1	1		
8	(A) X rays	1	1		
9	(C) $\frac{1}{4}$	1	1		
10	(A) 2 cm	1	1		
11	(B) $[M^0 L^2 T^{-2}]$	1	1		
12	(B) 5 cm	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	(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	(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is the not the correct explanation of the Assertion (A)	1	1		
SECTION - B					
17	<p>(a) <table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td style="padding: 5px;">Finding nature and position of the image</td> <td style="padding: 5px; text-align: right;">1 + 1</td> </tr> </table></p> <p>For refraction at convex surface</p> $\frac{n_1}{-u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$ $\frac{n}{v} = \frac{[n-1-3]}{R}$ $v = \frac{nR}{n-4}$ <p>For all values of $n < 4$, the value of v is negative and greater than R Therefore the nature of image is virtual and is formed in front of convex surface.</p> <p style="text-align: center;">OR</p>	Finding nature and position of the image	1 + 1	<p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>1</p>	
Finding nature and position of the image	1 + 1				

	<p>(b) Calculating intensity for the path difference $\lambda/3$ 2</p> $\phi = \frac{2\pi}{\lambda} \times \Delta x$ $= \frac{2\pi}{\lambda} \times \frac{\lambda}{3}$ $= \frac{2\pi}{3}$ $I' = 4I \cos^2 \frac{\phi}{2} \quad \text{Given } 4I = I_0$ $= I_0 \cos^2 \frac{2\pi}{6}$ $= \frac{I_0}{4}$ <p>Note: If a student attempt by using $I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \phi$, award full credit for correct answer.</p>	<p>1/2</p> <p>1/2</p> <p>1/2</p> <p>1/2</p>	<p style="text-align: center;">2</p>
<p>18</p>	<p>Finding value of X 2</p> $R = n^2 x$ $40 = (2)^2 x$ $x = 10 \Omega$ <p>Alternatively</p> <p>Volume of wire before and after stretch will remain same</p> $A_1 l_1 = A_2 l_2$ $A_2 = \frac{A l_1}{l_2}$ $= \frac{A}{2}$ $R = \rho \frac{l_2}{A_2}$ $40 = 4\rho \frac{2l_1}{A/2}$ $\therefore x = 10\Omega$	<p>1/2</p> <p>1/2</p> <p>1</p> <p>1/2</p> <p>1/2</p> <p>1/2</p>	<p style="text-align: center;">2</p>
<p>19</p>	<p>Finding magnitude and direction of magnetic field 2</p>		

	$B = \frac{\mu_0 NI}{2r}$ $= \frac{4\pi \times 10^{-7} \times 200 \times 0.40}{2 \times 4 \times 10^{-2}}$ $= 1.256 \times 10^{-3} \text{ T}$ <p>Direction is perpendicularly inward into the horizontal plane.</p>	1/2 1/2 1/2 1/2	2				
20	<table border="1" style="width: 100%;"> <tbody> <tr> <td>(a) Reason for lesser mass of nucleus as compared to sum of masses of constituents</td> <td style="text-align: right;">1</td> </tr> <tr> <td>(b) Explanation</td> <td style="text-align: right;">1</td> </tr> </tbody> </table> <p>(a) Because of binding of nucleus some energy is released and hence mass decreases during formation of nucleus.</p> <p>(b) By very strong attraction due to nuclear forces</p>	(a) Reason for lesser mass of nucleus as compared to sum of masses of constituents	1	(b) Explanation	1	1 1	2
(a) Reason for lesser mass of nucleus as compared to sum of masses of constituents	1						
(b) Explanation	1						
21	<table border="1" style="width: 100%;"> <tbody> <tr> <td>Finding the cut-off potential</td> <td style="text-align: right;">2</td> </tr> </tbody> </table> $eV = h(\nu - \nu_0)$ $V = \frac{6.63 \times 10^{-34} \times (6.8 - 3.6) \times 10^{14}}{1.6 \times 10^{-19}}$ $= 1.33 \text{ V}$	Finding the cut-off potential	2	1/2 1 1/2	2		
Finding the cut-off potential	2						
SECTION - C							
22	<p>(a) <table border="1" style="width: 100%;"> <tbody> <tr> <td>Finding charge densities on A and B</td> <td style="text-align: right;">3</td> </tr> </tbody> </table></p> <p>For ball A</p> $q_1 = 2\sigma \times 4\pi R^2$ $= 8\pi R^2 \sigma$ <p>For ball B</p> $q_2 = 3\sigma \times 4\pi (2R)^2$ $= 48\pi R^2 \sigma$ <p>Total charge (Q) = $q_1 + q_2$</p> $= 56\pi R^2 \sigma$ <p>When balls A and B are connected by a wire, their potentials will be equal Let q be the charge on ball A and (Q - q) be the charge on the ball B after connecting wire.</p> $\frac{Kq}{R} = \frac{K(Q - q)}{2R}$	Finding charge densities on A and B	3	1/2 1/2 1/2			
Finding charge densities on A and B	3						

$$2q = Q - q$$

$$q = \frac{Q}{3}$$

$$= \frac{56\pi R^2 \sigma}{3}$$

$$Q - \frac{Q}{3} = \frac{112\pi R^2 \sigma}{3}$$

$$\sigma_A = \frac{\frac{56\pi R^2 \sigma}{3}}{4\pi R^2}$$

$$= \frac{14}{3} \sigma$$

$$\sigma_B = \frac{\frac{112\pi R^2 \sigma}{3}}{4\pi (2R)^2}$$

$$= \frac{7}{3} \sigma$$

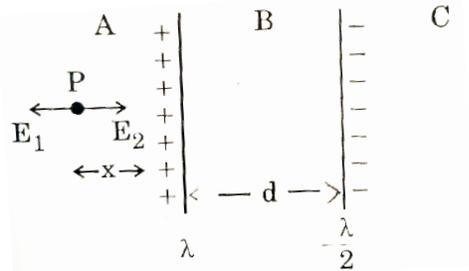
1/2

1/2

1/2

OR

(b)	Location of point at which net electric field is zero	2 1/2
	Identification of Region	1/2



1/2

Electric field due to wire 1 and wire 2 at point P

$$E_1 = \frac{\lambda}{2\pi\epsilon_0 x}$$

$$E_2 = \frac{\lambda/2}{2\pi\epsilon_0(x+d)}$$

1/2

At P, Net electric field is zero

$$E_1 = E_2$$

$$\frac{\lambda}{2\pi\epsilon_0 x} = \frac{\lambda}{2 \times 2\pi\epsilon_0 (x+d)}$$

$$x = -2d$$

1/2

1/2

1/2

Negative sign indicates that point lies in the region C.

At a distance 2d from wire 1 electric field is zero.

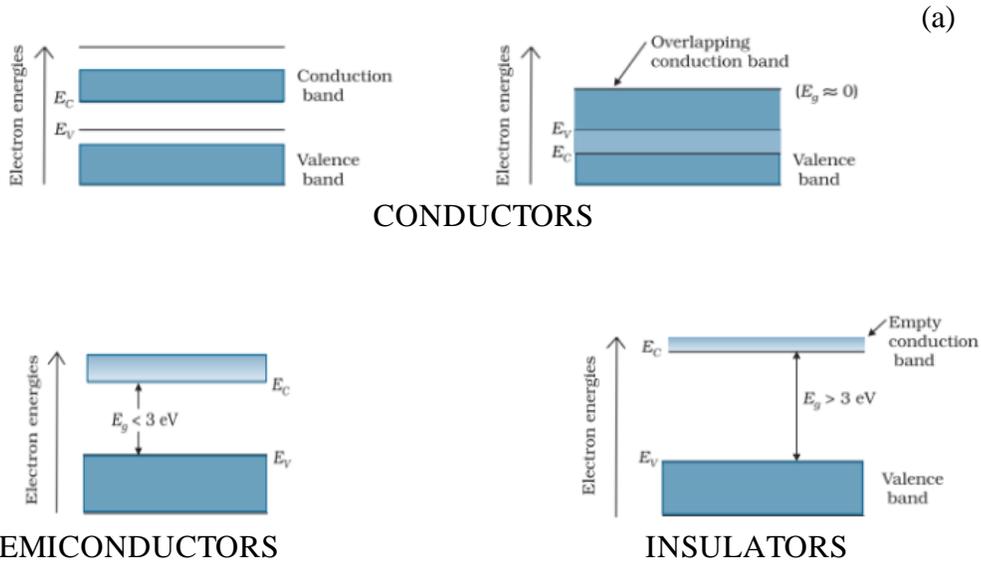
(Note : Award full credit if a student finds the position by taking point in region C directly)

1/2

3

23

a) Drawing energy band diagrams	$\frac{1}{2} + \frac{1}{2} + \frac{1}{2}$
Formation of electron hole pair	$\frac{1}{2}$
b) Explanation	1



$\frac{1}{2}$

$\frac{1}{2} + \frac{1}{2}$

At room temperature, thermal energy is sufficient for electrons to make them free from the bonds and create a vacancy called hole. Hence electron hole pair is formed.

$\frac{1}{2}$

(b) The valence electron in carbon and silicon lie in the second and third orbit respectively. So, the energy required to take out an electron will be less for silicon as compared to carbon. Hence number of free electrons for conduction in silicon are significant but negligibly small for carbon.

1

3

24

Finding	
(i) Potential difference between the plates	1
(ii) Electric field between the plates	1
(iii) Workdone in pulling the plates apart	1

As battery is dis connected, charge remain same

$$C' = \frac{C}{2}$$

(i) $q = q'$

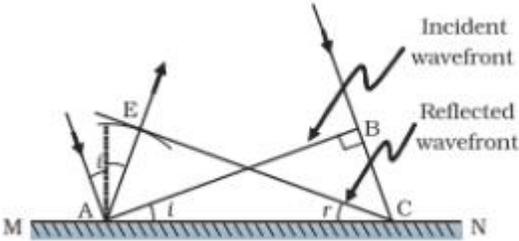
$$CV = C'V'$$

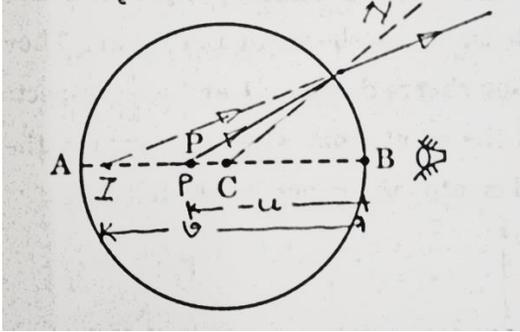
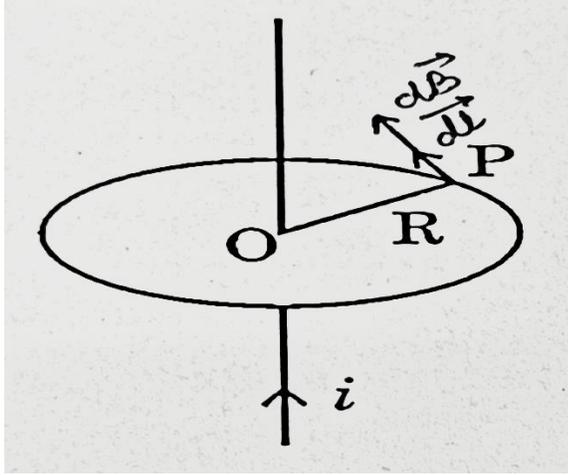
$$CV = \frac{C}{2} V'$$

$$V' = 2V$$

$\frac{1}{2}$

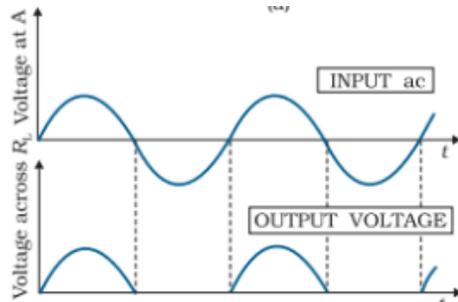
$\frac{1}{2}$

	<p>(ii) $E' = \frac{V'}{d}$$= \frac{2V}{2d}$$= \frac{V}{d} = E$</p> <p>(iii) $W = U' - U$$= \frac{1}{2} \times \frac{C}{2} \times (2V)^2 - \frac{1}{2} CV^2$$= \frac{1}{2} CV^2$</p>	<p>1/2</p> <p>1/2</p> <p>1/2</p>	<p>3</p>
<p>25</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>Describing reflection of plane wavefront using Huygen's principle 2</p> <p>Proving law of reflection 1</p> </div> <div style="text-align: center;">  </div> <p>Consider a plane wave AB incident at an angle i on a reflecting surface MN. v represents speed of the wave in the medium and τ represents the time taken by wavefront to advance from point B to C.</p> <p>$BC = v\tau$</p> <p>To construct the reflected wavefront, a sphere of radius $v\tau$ from point A is drawn.</p> <p>$AE = BC = v\tau$</p> <p>Also $\Delta EAC \cong \Delta BAC$</p> <p>$\therefore i = r$</p>	<p>1</p> <p>1</p> <p>1</p>	<p>3</p>
<p>26</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>Finding nature and position of image 2</p> <p>Drawing ray diagram 1</p> </div> <p>For light going from denser to rarer medium</p> $\frac{n_2}{-u} + \frac{n_1}{v} = \frac{n_1 - n_2}{R}$ $\frac{1.5}{8.75} + \frac{1}{v} = \frac{(1-1.5)}{-7}$ $\frac{1}{v} = \frac{0.5}{7} - \frac{1.5}{8.75}$ $= \frac{-1}{10}$	<p>1/2</p> <p>1/2</p> <p>1/2</p>	

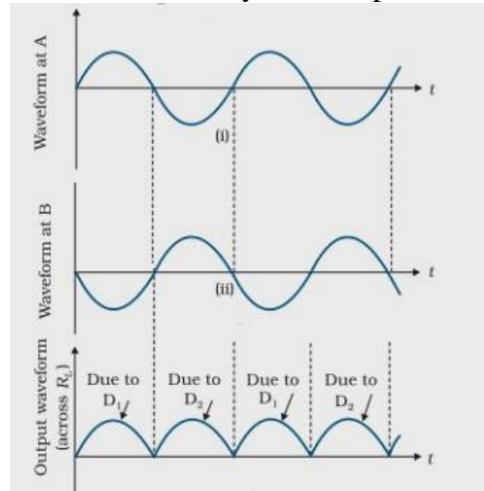
	<p>$v = -10 \text{ cm}$ Nature of image is virtual</p> 	1/2	
27	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>(a) Deriving expression of magnetic field for long straight wire 2 (b) Explanation 1</p> </div> <p>(a)</p>  <p>Consider an amperian loop of radius R around the wire carrying current I.</p> $\oint \vec{B} \cdot d\vec{l} = \mu_0 i$ $B \times 2\pi r = \mu_0 i$ $B = \frac{\mu_0 i}{2\pi r}$ <p>(b) The expression for magnetic field due to a long straight current carrying infinite wire can be obtained easily using Ampere's circuital law whereas Biot- Savart's law requires lengthy calculation.</p>	1/2 1/2 1/2	3
28	<div style="border: 1px solid black; padding: 5px;"> <p>Difference between half wave and full wave rectification 1 Working of full wave rectifier 2</p> </div>		

In half wave rectification there is output in one half of input cycle, whereas in full wave rectification, output is obtained for both half cycles of input (positive and negative)

Alternatively

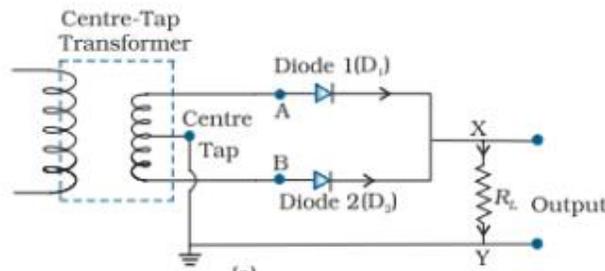


Half wave Rectification



Full wave Rectification

Working of full wave rectifier:

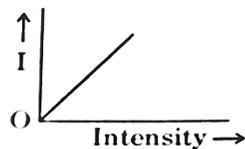


Suppose the input voltage to A with respect to the centre-tap at any instant is positive. At that instant, voltage at B being out of phase will be negative. So, diode D_1 gets forward biased and conducts (while D_2 being reverse biased is not conducting). Hence, during this positive half cycle we get an output current (and output voltage across the load resistor R_L). In the course of ac cycle when the voltage at A becomes negative with respect to centre tap, the voltage at B would be positive. In this part of the cycle diode D_1 would not conduct but diode D_2 would, giving an output current and output voltage (across R_L) during the negative half cycle of the input ac.

SECTION D

29

(i) (C)



(ii) (D) Remains the same

(iii) (C) cut-off potential versus frequency of incident light

(iv) (a) (C) $K_B > K_Y > K_R$

OR

(b) (A) Caesium

1

1

1

3

1

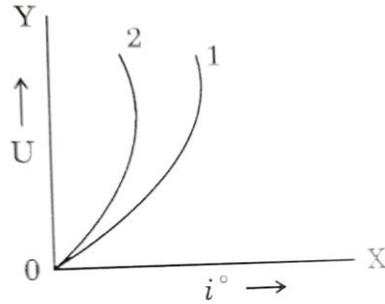
1

1

1

4

(II) $U = \frac{1}{2}LI^2$ Parabolic graph obtained.



(1 indicates 10mH) & (2 indicates 20mH)

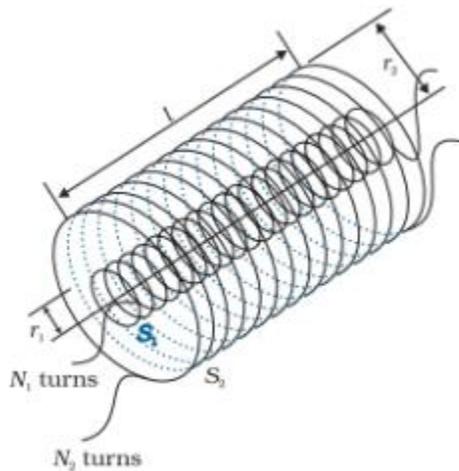
OR

(a)	(i) Defining mutual inductance	1
	Deducing expression for mutual inductance	2
	(ii) Finding flux linked with the inductor	2

(i) Mutual inductance is defined as the induced emf in primary coil when the current in secondary coil changes at the unit rate.

Alternatively

Mutual inductance is defined as the magnetic flux linked with the primary coil when the current in secondary coil is unity.



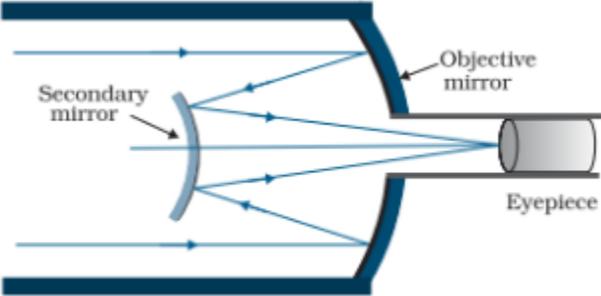
Consider two long co-axial solenoids each of length l . Radius of inner solenoid S_1 is r_1 and number of turns per unit length is n_1 .

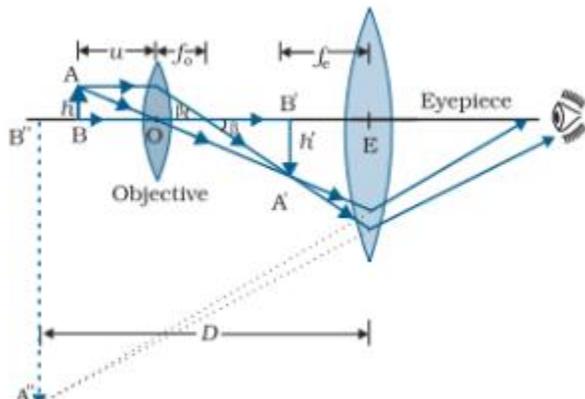
The corresponding quantities for outer solenoid S_2 are r_2 and n_2 respectively. Let N_1 and N_2 be the total number of turns of coils S_1 and S_2 respectively.

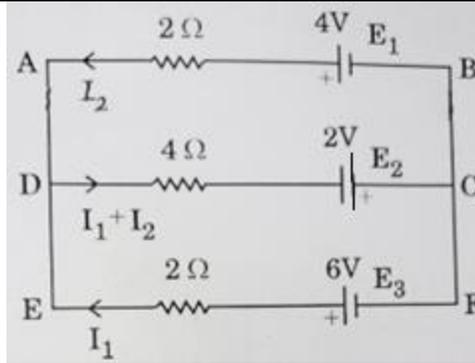
When a current I_2 is set up through S_2 , it sets up magnetic flux through S_1 .

$$\begin{aligned} N_1\phi_1 &= M_{12}I_2 \\ &= (n_1l) \times (\pi r_1^2) \times (\mu_0 n_2 I_2) \\ &= \mu_0 n_1 n_2 \pi r_1^2 l I_2 \end{aligned}$$

$$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l = M_{21}$$

	<p>(ii)</p> $ e = L \frac{dI}{dt}$ $L = \frac{e}{dI/dt}$ $= \frac{5 \times 10^{-3}}{2/40}$ $= 0.1H$ $\phi = LI$ $= 0.1 \times \frac{2}{40} \times 10$ $= 0.05 \text{ Wb}$	<p>1/2</p> <p>1/2</p> <p>1/2</p> <p>1/2</p>	<p>5</p>								
<p>32</p>	<table border="1" data-bbox="310 779 1299 961"> <tbody> <tr> <td>(a) Drawing ray diagram of reflecting telescope</td> <td>1</td> </tr> <tr> <td>Explanation of formation of image</td> <td>1</td> </tr> <tr> <td>Advantages</td> <td>1/2 + 1/2</td> </tr> <tr> <td>(b) Finding focal lengths of the two lenses</td> <td>2</td> </tr> </tbody> </table> <p>(i)</p>  <p>The parallel rays from a distant object are reflected by a large concave mirror. These rays are then reflected by a convex mirror placed just before the focus of concave mirror and are converged to a point outside the hole. The final image is viewed through eye piece.</p> <p>Advantages (any two)</p> <ol style="list-style-type: none"> 1) No chromatic aberration. 2) Less spherical aberration 3) Less mechanical support required 4) Brighter Image 5) High resolving power. 6) High magnifying power <p>(ii) For image at infinity</p> $ f_o + f_e = L$	(a) Drawing ray diagram of reflecting telescope	1	Explanation of formation of image	1	Advantages	1/2 + 1/2	(b) Finding focal lengths of the two lenses	2	<p>1</p> <p>1</p> <p>1/2 + 1/2</p> <p>1/2</p>	
(a) Drawing ray diagram of reflecting telescope	1										
Explanation of formation of image	1										
Advantages	1/2 + 1/2										
(b) Finding focal lengths of the two lenses	2										

	<p>According to question</p> $f_o = 50 \times f_e$ $f_e + 50f_e = 102$ $f_e = 2 \text{ cm}$ $f_o = 100 \text{ cm}$ <p style="text-align: center;">OR</p> <p>(b)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="padding: 5px;">(i) Two advantages of a compound microscope over simple microscope</td> <td style="text-align: right; padding: 5px;">$\frac{1}{2} + \frac{1}{2}$</td> </tr> <tr> <td style="padding: 5px;">Drawing ray diagram and Explanation</td> <td style="text-align: right; padding: 5px;">1 + 1</td> </tr> <tr> <td style="padding: 5px;">(ii) Obtaining power of combined lens</td> <td style="text-align: right; padding: 5px;">2</td> </tr> </tbody> </table> <p>(i) Advantages (any two)</p> <ol style="list-style-type: none"> 1) Larger magnification 2) Brighter image <p>Any other valid advantage</p> <div style="text-align: center;">  </div> <p>(deduct $\frac{1}{2}$ mark for not showing arrow for ray diagram)</p> <p>The lens nearest the object, called the objective, forms a real, inverted, magnified image of the object. This serves as the object for the second lens, the eye piece, functions like a simple microscope and produces final image which is enlarged and virtual.</p> <p>(ii) Power of plano concave lens = $P_1 = \frac{-(n_1-1)}{R}$</p> <p>Power of convex lens = $P_2 = (n_2-1) \left(\frac{2}{R} \right)$</p> $P = P_1 + P_2$ $= \frac{(2n_2 - n_1 - 1)}{R}$	(i) Two advantages of a compound microscope over simple microscope	$\frac{1}{2} + \frac{1}{2}$	Drawing ray diagram and Explanation	1 + 1	(ii) Obtaining power of combined lens	2	<p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2} + \frac{1}{2}$</p> <p>1</p> <p>1</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>$\frac{1}{2}$</p> <p>5</p>	
(i) Two advantages of a compound microscope over simple microscope	$\frac{1}{2} + \frac{1}{2}$								
Drawing ray diagram and Explanation	1 + 1								
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33	<p>(a)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="padding: 5px;">(i) Finding current through batteries E₁, E₂ and E₃</td> <td style="text-align: right; padding: 5px;">3</td> </tr> <tr> <td style="padding: 5px;">(ii) Finding effective resistance</td> <td style="text-align: right; padding: 5px;">2</td> </tr> </tbody> </table>	(i) Finding current through batteries E ₁ , E ₂ and E ₃	3	(ii) Finding effective resistance	2				
(i) Finding current through batteries E ₁ , E ₂ and E ₃	3								
(ii) Finding effective resistance	2								



i)

In closed loop ABCD, using Kirchoff's loop law

$$4I_1 + 6I_2 = 6 \dots\dots\dots(1)$$

Similarly In closed loop CDFE

$$6I_1 + 4I_2 = 8 \dots\dots\dots(2)$$

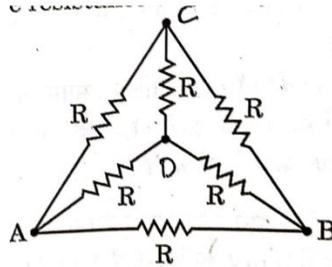
Solving eqn. (1) and (2)

$$I_2 = \frac{1}{5} A$$

$$I_1 = \frac{6}{5} A$$

$$I_1 + I_2 = \frac{7}{5} A$$

ii)



Resistances R_{AC} , R_{CB} , R_{AD} , and R_{DB} form a balanced Wheatstone bridge
Hence current through R_{CD} is zero and will not contribute to equivalent resistance.

The equivalent resistance of bridge is R , is in parallel with R_{AB}

Series combinations of R_{AC} & R_{CB} and R_{AD} & R_{DB} is in parallel with R_{AB}

$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R}$$

$$R_{eq} = \frac{R}{2}$$

Given $R = 10\Omega$, Therefore $R_{eq} = 5\Omega$

OR

1/2

1/2

1/2

1/2

1/2

1/2

1/2

1/2

1/2

1/2

(b)	(i) Calculating	
	(I) ratio of electric fields at points A & B	1 ½
	(II) drift velocity of free electrons at point B	1 ½
	(ii) Finding net electric field at point \vec{r}	2

(i) (I) $\vec{j} = \sigma \vec{E}$

$$\frac{j_A}{j_B} = \frac{E_A}{E_B}$$

$$= \frac{I/A_A}{I/A_B}$$

$$= \frac{A_B}{A_A}$$

$$= \frac{2}{1}$$

(II) $v_d = \frac{I}{neA}$

$$= \frac{1}{8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 2 \times 10^{-7}}$$

$$= 3.6 \times 10^{-4} \text{ m/s}$$

(ii)

$$\vec{E} = \frac{Kq}{r^2} \hat{r}$$

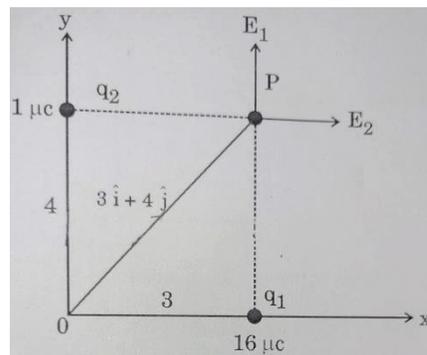
$$\vec{E}_1 = \frac{9 \times 10^9 \times 16 \times 10^{-6}}{(4)^2} \hat{j}$$

$$= 9 \times 10^3 \hat{j}$$

$$\vec{E}_2 = \frac{9 \times 10^9 \times 1 \times 10^{-6}}{(3)^2} \hat{i}$$

$$= 10^3 \hat{i}$$

$$\vec{E}_{net} = (\hat{i} + 9\hat{j}) 10^3 \text{ N/C}$$



NOTE: Award full credit of this part if a student finds magnitude and direction separately.

½

½

½

½

½

½

½

½

½

½

5