UNIT # 08
CURRENT ELECTRICITY

EXERCISE –I

1. $j \rightarrow$ Current density $\quad n \rightarrow$ Charge density

$j = -nev_d \qquad v_{d_1} = \dfrac{j}{n_1 e}$

$v_{d_2} = \dfrac{j}{n_2 e}, \ \dfrac{n_1}{n_2} = \dfrac{1}{4} \Rightarrow n_2 = 4n_1$

$\dfrac{v_{d_1}}{v_{d_2}} = \dfrac{n_2}{n_1} = \dfrac{4n_1}{n_1} = 4 : 1$

2. $j = \dfrac{I}{A} = nev_d$

$\dfrac{4I}{\pi d^2} = nev \ldots(i) \qquad \dfrac{16I}{\pi d^2} = nev' \ldots(ii)$

From equation (i) & (ii) $\dfrac{4I}{16I} = \dfrac{v}{v'} \Rightarrow v' = 4v$

3. $v_d = \dfrac{i}{Ane}$ As A ↑ so $v_d \downarrow \Rightarrow v_P > v_Q$

4. $i = nev_dA; \ I = \dfrac{2envA}{4} - (-nevA) = \dfrac{3}{2}nevA$

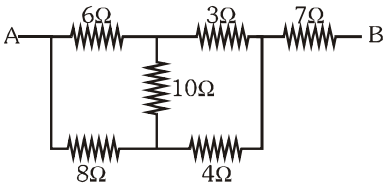
5. $R = \dfrac{\rho L}{A}\dfrac{L}{L} = \dfrac{\rho L^2}{AL} = \dfrac{\rho L^2}{V} = \dfrac{\rho L^2 d}{m}$

$d, \rho \rightarrow$ same for all as the material is same for all.

$\Rightarrow R_1 : R_2 : R_3 = \dfrac{25}{1} : \dfrac{9}{3} : \dfrac{1}{5} = 125 : 15 : 1$

6. $R = \dfrac{\rho L}{A}\dfrac{L}{L} = \dfrac{\rho L^2}{V} \Rightarrow R \propto L^2$

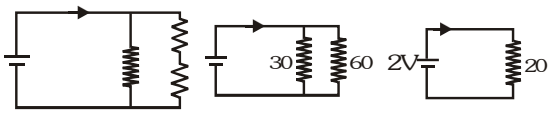
7.



Balanced Wheatstone Bridge

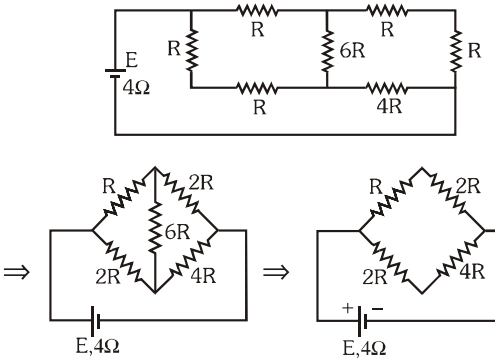
As $\dfrac{1}{9} + \dfrac{1}{12} = \dfrac{7}{36} = \dfrac{36}{7}$ So $R_{AB} = \dfrac{36}{7} + 7 = \dfrac{85\Omega}{7}$

8.



$V = IR \ \Rightarrow 2 = (I)(20) \Rightarrow I = \dfrac{1}{10}A$

9.



This is balanced wheat stone bridge
From maximum power transfer theorem
Internal resistance = External resistance
यह व्हीटस्टोन सेतु सन्तुलित है। अधिकतम शक्ति प्रदान करने से आन्तरिक प्रतिरोध = बाह्य प्रतिरोध

$\Rightarrow 4 = \dfrac{3R \times 6R}{3R + 6R} \Rightarrow 4 = 2R \Rightarrow R = 2 \ \Omega$

10. $P = \dfrac{V^2}{R}$ Initially, $I = \dfrac{V}{2R}$

Power across $P_X = P_Y = \left(\dfrac{\varepsilon^2}{4R}\right)R$

Finally, $I = \dfrac{2V}{3R}$, Power $P_X = \dfrac{4V^2}{9R}, P_y = P_z = \dfrac{2V^2}{9R}$

Hence P_x increases, P_y decreases.

Alternative method :

Brightness $\propto i^2R$ when S is closed current drawn from battery increases because R_{eq} decreases. i.e. current in X increases. So brightness of X increases and current in Y decreases. So brightness of Y decreases.

चमक $\propto i^2R$ जब S बंद है तो बैटरी से प्रवाहित धारा बढ़ती है क्योंकि R_{eq} घटता है अर्थात X में धारा बढ़ती है। इसलिये X की चमक बढ़ती है तथा Y में धारा घटती है। अत: Y की चमक घटती है।

11. $P = I^2R = \left(\dfrac{V}{R}\right)^2 R = \dfrac{\varepsilon^2}{(R + r)^2}R$

ε is constant and (R+ r) increases rapidly Then P↓
ε नियत है तथा (R+ r) लगातार बढ़ता है तो P↓

12. $P = i^2R \Rightarrow 10 = i^2 5 \Rightarrow i^2 = \dfrac{10}{5} = 2 \ \Rightarrow i = \sqrt{2}$

$i_4 = \dfrac{i_5}{2} \ \Rightarrow P_4 = \left(\dfrac{i}{2}\right)^2 4, \ P_5 = (i^2)5$

$\dfrac{P_4}{P_5} = \dfrac{1}{5} \Rightarrow P_4 = \dfrac{P_5}{5}, \ P_4 = \dfrac{10}{5} = 2$ cal/s

13. $R_1 = \frac{\rho\ell}{A_1}$, $R_2 = \frac{\rho\ell}{A_2}$ As $A_1 < A_2$ so $R_1 > R_2$

In series $H = I^2Rt$ $H \propto R$; $H_1 > H_2$

In parallel $H = \frac{V^2}{R}t$ $H \propto \frac{1}{R}$; $H_1 < H_2$

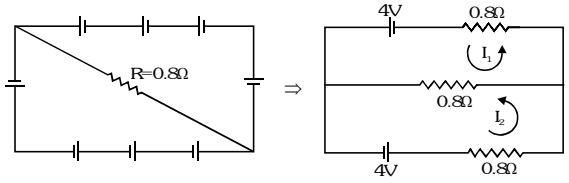
14. $V = \varepsilon + i(r) \Rightarrow 12.5 = \varepsilon + \frac{1}{2}(1) \Rightarrow \varepsilon = 12$ V

(As the battery is a storage battery it is getting charged)

(क्योंकि बैटरी एक संग्राहक बैटरी है जो आवेशित है।)

15. The correct answer is R = 0

16.



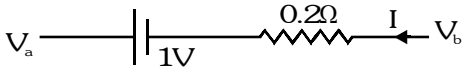
$1.6\ I_1 - 0.8\ I_2 = 4$ ...(i)

$1.6\ I_2 - 0.8\ I_1 = 4$ ...(ii)

from eq. (समीकरण से) $I_1 = I_2 = 5$

voltage difference across any of the battery.

(बैटरी के किसी सिरो पर विभवान्तर)



$V_a - 1 + 0.2 \quad 5 - V_b = 0$

$V_a - V_b = 0$ Volt

17. $V = IR \Rightarrow 0.2 = I\ (20)$

$I_g = 0.01$A (through the galvanometer)

$I_g G = (i - i_g)S \Rightarrow (0.01)\ (20) = (10 - 0.01)S$

$\Rightarrow S = 0.020\ \Omega$

18. $R_v = \frac{V}{i_g} - G \Rightarrow 910 = \frac{V}{10 \times 10^{-3}} - 90$

$\Rightarrow V = 10 \Rightarrow$ No. of divisions $= \frac{10}{0.1} = 100$

19. $20 + R = \frac{12}{0.1} \Rightarrow R = 100\Omega$

20. $I = \frac{12}{4 + 2 + \infty} = 0$. If i=0,

potential difference is equal of EMF of cell. = 12V

(विभवान्तर सेल के विद्युत वाहक बल के बराबर है)

21. $\frac{P}{S} = \frac{Q}{625} \Rightarrow \frac{P}{Q} = \frac{S}{625}$ ...(i)

$\frac{Q}{S} = \frac{P}{676} \Rightarrow \frac{P}{Q} = \frac{676}{S}$ ...(ii)

From (i) & (ii) $\frac{676}{S} = \frac{S}{625}$

$(676)\ (625) = S^2 \Rightarrow S = 650\Omega$

22. $E = \left(\frac{V}{\ell}\right) \times \frac{\ell}{3}$ & $E = \left(\frac{V}{3\ell/2}\right)(\ell') \Rightarrow \ell' = \frac{\ell}{2}$

23. Potential gradient (विभव प्रवणता) $x = \left(\frac{E}{10r}\right)\left(\frac{9r}{L}\right)$

According to question (प्रश्नानुसार)

$\frac{E}{2} = \left(\frac{E}{10r}\right)\left(\frac{9r}{L}\right)(\ell) \Rightarrow \ell = \frac{5L}{9}$

24. Potential gradient (विभव प्रवणता)

$x = \left(\frac{5}{0.5 + 4.5}\right)\left(\frac{4.5}{3}\right) = 1.5\ Vm^{-1}$

Here (x) (AC) =3 $\Rightarrow AC = \frac{3}{1.5} = 2$m

25. Potential gradient (विभव प्रवणता)

$x = \left(\frac{12}{8 + 16}\right) \times 4 = 2Vm^{-1}$

Effective emf of E_1 and E_2

(E_1 व E_2 का तुल्य विद्युत वाहक बल)

$E = \ E = \frac{\frac{E_2}{r_2} - \frac{E_2}{r_1}}{1/r_1 + 1/r_2} = \frac{1}{2}$volt

Balancing length AN $= \left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{1}{4}$m $= 25$cm

26. $P = \frac{V^2}{R} = \frac{V^2A}{\rho\ell} \propto \frac{r^2}{\ell}[V \rightarrow \text{same}]$

27. **(25W- 220V)**

$P_1 = \frac{V_1^2}{R_1}$, $R_1 = \frac{(220)^2}{25} = 1936\Omega$

(100W-220V)

$P_2 = \frac{V_2^2}{R_2}$, $R_2 = \frac{(220)^2}{100} = 484\ \Omega$

In Series (I same)

$H = I^2Rt$, $H \propto R$ so if $R_1 > R_2$ then $H_1 > H_2$

R_1 is likely to fuse

28. $P \Rightarrow \frac{V^2}{R} \Rightarrow \frac{V^2 A}{L\rho}$ ...(i)

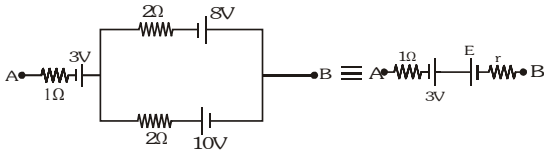
$$P' = \frac{V^2 A}{\left(L - \frac{L}{10}\right)\rho} \Rightarrow \frac{10V^2 A}{9L\rho} \quad ...(ii)$$

from eq. (i) & (ii) $P' = \frac{10}{9}P$

$$\frac{\Delta P}{P} \times 100 \Rightarrow \frac{\left(\frac{10}{9}P - P\right)}{P} \times 100 \Rightarrow \frac{1}{9} \times 100 \Rightarrow 11.11\%$$

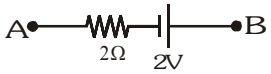
29. In parallel combination the equivalent resistance is less than the two individual resistance connected and in series combination equivalent resistance is more than the two individual components.
(समान्तर क्रम संयोजन में तुल्य प्रतिरोध का मान प्रत्येक प्रतिरोध के मान से कम तथा श्रेणीक्रम संयोजन में तुल्य प्रतिरोध का मान प्रत्येक प्रतिरोध के मान से अधिक होता है।)

30.



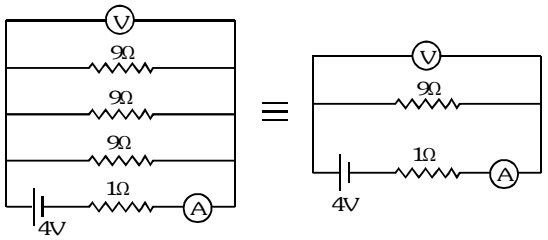
$$E = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{\frac{10}{2} + \frac{(-8)}{2}}{\frac{1}{2} + \frac{1}{2}} = 1 \text{ volt and}$$

$r = \frac{r_1 r_2}{r_1 + r_2} = 1\Omega$. Therefore



31. **Ans. (A)**

32. Given circuit can be reduced to
परिपथ का सरलीकृत रूप



Reading of ammeter (अमीटर का पाठ्यांक)

$$= \frac{4}{3+1} = 1A$$

Reading of voltmeter (वोल्टमीटर का पाठ्यांक)

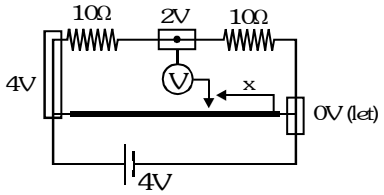
$= 3 \quad 1 = 3V$

33. $I_{wire} = \frac{4V}{0.4 \times 50\Omega} = 0.2$ A

Potential difference across voltmeter,
(वोल्टमीटर के सिरो पर विभवान्तर)

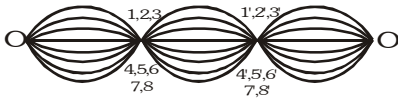
$V = Ir - 2$

$\Rightarrow 2 \sin\pi t = 0.2 \quad 50 \text{ x } -2 \Rightarrow 2\ \pi\cos\pi t = 10$ V



$\Rightarrow V = 20\ \pi\ (\cos\pi t)$ cm/s

34.



Points 1, 2, 3.....8 are of same potential and 1', 2', 3'.....8' are of same potential.
(बिन्दु 1, 2, 3.....8 का विभव समान है तथा बिन्दु 1', 2', 3'.....8' का विभव समान है।)

$R_{eq} = \frac{3R}{8}$

35. Total length of wire (तार की कुल लम्बाई)

$= 90 + 90 = 180$ m ;

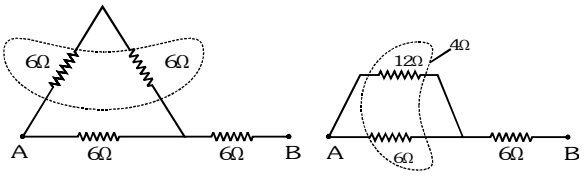
Total resistance of wire (तार का कुल प्रतिरोध)

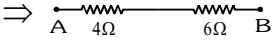
$= 180/5 = 12\ \Omega$.

As $I = \frac{nE}{R + nr} \Rightarrow 0.25 = \frac{n \times 1.4}{12 + 5 + n \times 2} \Rightarrow n = 4.7$

$\Rightarrow$ Total number of cells required = 5
(आवश्यक सेलों की कुल संख्या)

36.

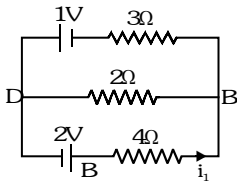


$\Rightarrow$  $\Rightarrow R_{eq} = 10\Omega$

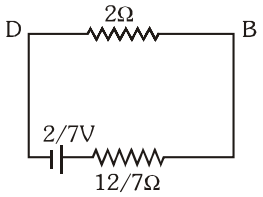
EXERCISE –II

1. Free–electron density and the total current passing through wire does not depend on 'n'.
(तार से प्रभावित मुक्त इलैक्ट्रॉन घनत्व तथा कुल धारा का मान n निर्भर नहीं करता है।)

2. $E_{eq} = \frac{E_1r_2 - E_2r_1}{r_1 + r_2} = \frac{2\times3 - 1\times4}{3+4} = \frac{2}{7}$



$r_{eq} = \frac{3\times4}{3+4} = \frac{12}{7}$; $i = \frac{2/7}{2+\frac{12}{7}} = \frac{1}{13}A$



$V_B > V_D = 2\left(\frac{1}{13}\right)$; $V_D - V_B = -\frac{2}{13}V$

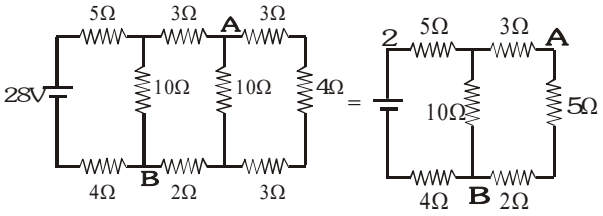
From Figure 1 :

$V_B + 4i_1 - 2 - V_D = 0$; $\frac{2}{13} - 2 + 4i = 0$

$i = \frac{6}{13}A$; $V_G = 3 - 3\ \ \frac{6}{13}$

$V_G = \frac{21}{13}V$, $V_H = 1+1\ \ \frac{6}{13} = V_H = \frac{19}{13}V$

3.



$R_{eq} = 14\Omega \Rightarrow I = 2A$; $V_{AB} = iR = 7$ volt

4. Both '4Ω' and '6Ω' resistors are short circuited therefore R_{eq} of the circuit in 2Ω is 10 A.
('4Ω' तथा '6Ω' प्रतिरोध दोनों लघुपथित है इसलिये 2Ω में परिपथ का R_{eq} = 10 A.)
Power (शक्ति) = VI = 200 watt
Potential difference across both 'A' and 'B' = 0
('A' तथा 'B' दोनों के सिरो पर विभवान्तर = 0)

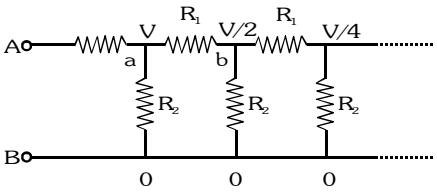
5. $I = \frac{dq}{dt} = 2 - 16t$
Power : $P = I^2R = (2 - 16t)^2R$

Heat produced $= \int Pdt = \int_0^{\frac{1}{8}} (4 - 256t^2 - 64t)Rdt$

$= \left[\left(4t - \frac{256t^3}{3} - \frac{64t^2}{2}\right)R\right]_0^{1/8} = \frac{R}{6}$ joules

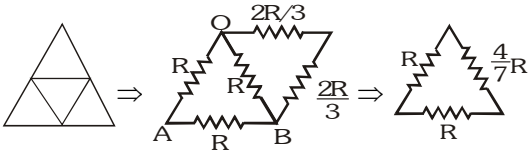
6. It is the concept of potentiometer.
(यह विभवमापी की अवधारणा पर आधारित है।)

7. By applying node analysis at point b



$\frac{\frac{V}{2} - V}{R_1} + \frac{\frac{V}{2} - \frac{V}{4}}{R_1} + \frac{\frac{V}{2}}{R_2} = 0 \Rightarrow \frac{R_1}{R_2} = \frac{1}{2}$

8.



$R_{AB} = \frac{11R}{18}$

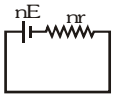
9. For wheat stone Bridge condition is $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
(व्हीट स्टोन सेतु प्रतिबंध के लिए $\frac{R_1}{R_2} = \frac{R_3}{R_4}$)
Therefore null point is independent of the battery voltage.
(अत: शून्य विक्षेप बिन्दु बैटरी की वोल्टता पर निर्भर नहीं करता है।)

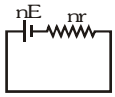
10. $V = E - ir \Rightarrow V = -ri + E$
Slope of graph 'V' and 'i' gives 'r' intercept of graph 'V' and 'i' gives $E \Rightarrow \tan\theta = \frac{y}{x} = r$.
('V' व 'i' के वक्र का ढाल 'r' है व 'V' व 'i' के वक्र का अंतखण्ड E है $\Rightarrow \tan\theta = \frac{y}{x} = r$.)

11. $\Delta V = E + ir$ and in charging current flows from positive terminal to negative terminal.
($\Delta V = E + ir$ तथा आवेशित धारा का प्रवाह धन सिरे से ऋण सिरे की ओर होता है।)

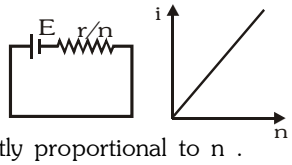
12. Slope of 'V' vs 'i' graph give internal resistance
$\therefore r = 5\ \Omega$
('V' व 'i' का ढाल आन्तरिक प्रतिरोध $r = 5\ \Omega$ द्वारा दिया जाता है।)
Intercept gives the value of e.m.f. E = 10 volt
(अन्तखण्ड विद्युत वाहक बल E के मान 10 volt द्वारा दिया जाता है।)

Maximum current is (अधिकतम धारा) $i_{max} = \frac{E}{r} \Rightarrow 2A$

13. If n batteries are in series than the circuit can be made as $i = \frac{nE}{nr} \Rightarrow \frac{E}{r}$  i.e. independent of n.

(यदि n बैटरियाँ श्रेणीक्रम में जुड़ी है तो परिपथ से $i = \frac{nE}{nr} \Rightarrow \frac{E}{r}$  अर्थात् n पर निर्भर नहीं।)

14. If n batteries are in parallel than the circuit can be made as $i = \frac{nE}{r}$ (यदि n बैटरियाँ समान्तर क्रम में हो तो परिपथ से $i = \frac{nE}{r}$)

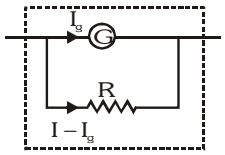


i is directly proportional to n .

15. In parallel combination current gets divided therefore parallel combination supports $i = i_1 + i_2$ is 20A in series current remain same therefore the series combination supports i = 10A.
(समान्तर क्रम संयोजन में धारा विभाजित होती है। अत: समान्तर क्रम संयोजन में धारा दो भागों $i = i_1 + i_2$ में विभक्त हो जाती है। जिसका मान 20A है। श्रेणीक्रम में धारा समान रहती है अत: श्रेणीक्रम में धारा i = 10A होगी।)

16. As power in 2Ω is maximum when the current in it is maximum. Current in it will maximum when the value of R_{eq} is minimum . $\therefore$ R = 0
(क्योंकि 2Ω में शक्ति अधिकतम होगी जब इसमें धारा अधिकतम हो। इसमें धारा अधिकतम होगी जब R_{eq} न्यूनतम हो। $\therefore$ R=0)
Heat $= i^2RT \Rightarrow (36)(2) = 72$ W

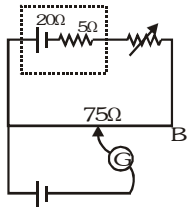
17. For Ammeter $I_g G = (I - I_g) R$



$50 \quad 10^{-6} \quad 100 = 5 \quad 10^{-3}$ (R) $\Rightarrow R \cong 1\Omega$
For voltmeter $I_g(R + G) = V$
$\Rightarrow 50\ \mu A\ (R + G) = 10V$
$\Rightarrow R + G = 200\ k\Omega$
$\Rightarrow R \cong 200 k\Omega$

18. $i_{min} = \frac{20}{R_{min}} = \frac{20}{200} = \frac{1}{10} A$

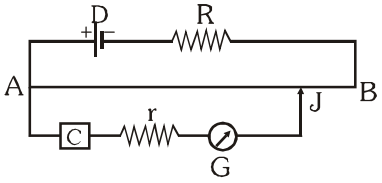
$i_{max} = \frac{20}{R_{max}} = \frac{20}{250} = \frac{2}{25}$ Amp

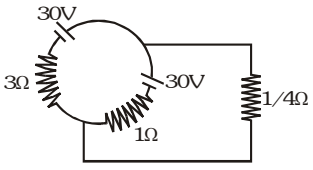


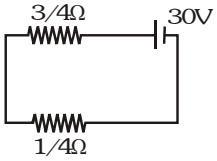
Potential $= i_{min} R_{PM} = \frac{1}{10} \times 75 = 7.5V$

Across potentiometer $V = i_{max} R_{PM} = \frac{2}{25} \times 75 = 6V$

19. If e.m.f of c is greater than the e.m.f. of the 'D' $I_r = 0$
So r does not play any role of zero deflection in galvanometer.
(यदि C का विद्युत वाहक बल 'D' के विद्युत वाहक बल की तुलना में अधिक होता है, तो $I_r = 0$
इसलिये गेल्वेनोमीटर के शून्य विक्षेप में r की कोई भूमिका नहीं होती है।)



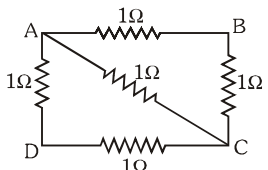
20. 



Both 30V are in parallel

$30 - \frac{1}{4} i - \frac{3}{4} i = 0 \Rightarrow i = 30$ A

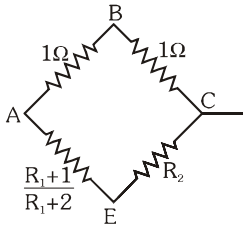
21. Assume DE $\Rightarrow R_1\Omega$
EC $\Rightarrow R_2\Omega$
$R_1 + R_2 = 1\Omega$
$V_B = V_E$



Means balance wheat stone bridge

$\frac{P}{Q} = \frac{R}{S}$; $\frac{1}{1} = \frac{\frac{R_1 + 1}{R_1 + 2}}{R_2}$

$R_2 = \frac{R_1 + 1}{R_1 + 2} = 1 - R_1$

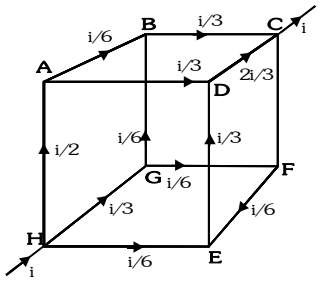


$R_1 + 1 = R_1 + 2 - R_1^2 - 2R_1$

$R_1^2 + 2R_1 - 1 = 0 \Rightarrow R_1 = -1 + \sqrt{2} \Rightarrow R_2 = 2 - \sqrt{2}$

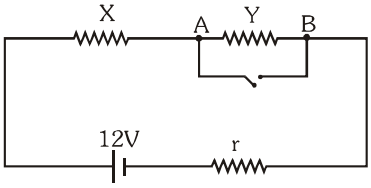
$\frac{CE}{ED} = \frac{R_2}{R_1} = \frac{2-\sqrt{2}}{\sqrt{2}-1} = \sqrt{2}$

22.



So current in FC=0

23.



$\frac{12}{X+Y+r} = 1A \Rightarrow V_x = 1 = 1 \quad X \Rightarrow X = 1\Omega$

When Y shorted $I = \frac{12}{1+r}$

$10 = 12 - Ir \Rightarrow 10 = 12 - \frac{12}{(1+r)}r$

$\Rightarrow 10 + 10r = 12 + 12 - 12r$

$\Rightarrow 10r = 2 \Rightarrow r = 0.2\ \Omega$

24. $\frac{E_1+E_2}{r_1+r_2+R} < \frac{E_1}{r_1+R}$; $(E_1 + E_2)(r_1 + R) < E_1(r_1 + r_2 + R)$

$E_1R + E_2R + E_1R < E_1r_2 + E_1R$; $R(E_1 + E_2) < E_1r_2$

On solving we get $E_1r_2 > E_2(R + r_1)$

25. If all were in series all of them would have being getting discharged. But since, 2 are in opposite polarity, they will be getting charged.

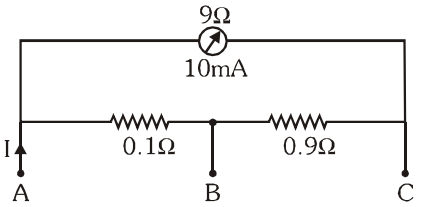
(यदि सभी श्रैणीक्रम में है तो इनका निरावेशन हो चुका है। लेकिन क्योंकि 2 की ध्रुवता विपरीत है इसलिये ये आवेशित हो जाते है।)

$V = E + iR$ getting charged $i = \frac{V}{R} = \frac{(nE-4)}{nR}$

as (nE–4) as 4 batteries will be cancelled out

$= E + \left(\frac{nE-4}{nR}\right)R$, $= E + \left(E - \frac{4}{n}\right) = 2\left(1 - \frac{2}{n}\right)E$

26.



Between A and B

$(9 + 0.9) \quad 10 \quad 10^{-3} = (I - 10mA) \quad 0.1$

$\Rightarrow$ 990 mA = I – 10mA $\Rightarrow$ I = 1000 mA = 1A

27. When S_2 open (जब S_2 खुला है।)

Assume resistance of AB = R

(माना AB का प्रतिरोध = R)

Resistance of wire per unit length.

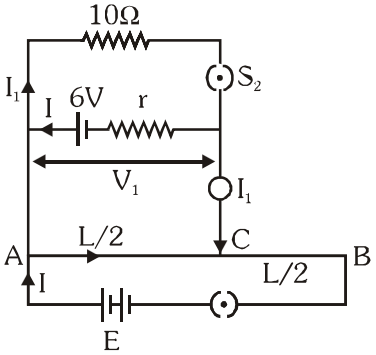
(तार की इकाई लम्बाई का प्रतिरोध)

$x = \frac{R}{L}$

$I = \frac{E}{R}$

Now in AC

$\frac{E}{R} \times \frac{R}{L} \times \frac{L}{2} = 6$



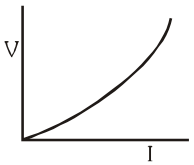
E = 12V

When S_2 closed

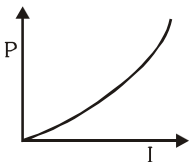
$V_1 = \frac{E}{R} \times \frac{R}{L} \times \frac{5L}{12} = \frac{5E}{12} = \frac{5 \times 12}{12} = 5V$

$\Rightarrow 6 - I_1r = 5 \Rightarrow 6 - \left(\frac{5}{10}\right)r = 5 \Rightarrow r = 2\ \Omega$

28.



$R = \frac{V}{I}$ = slope ↑



So R↑

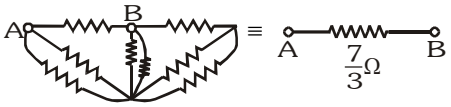
$P = I^2R$

R↑ P↑

$P \propto I^2$

29. Rearranged circuit between A & B is :

(A व B के मध्य परिपथ को पुन बनाने पर)



(due to symmetry)

Total resistance of circuit (परिपथ का कुल प्रतिरोध)

$= \frac{7}{3} + \frac{2}{3} = 3\ \Omega$. $i = \frac{9}{3} = 3$ A

Heat produced in cell (सैल में उत्पन्न उष्मा)

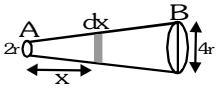
$= I^2 r = (3)^2 \left(\frac{2}{3}\right) = 6W$

Current in resistance connected directly between A & B $= \frac{7}{15} \times 3 = \frac{7}{5} = 1.4A$

(A व B के मध्य प्रतिरोध में धारा का मान

$= \frac{7}{15} \times 3 = \frac{7}{5} = 1.4A$)

30.



$r_x = r + rx = r(1 + x) \Rightarrow dR_x = \frac{\rho dx}{\pi r_x^2} = \frac{\rho dx}{\pi r^2 (1+x)^2}$

$R_1 = \int_0^{\ell} \frac{\rho dx}{\pi r_x^2 (1+x)^2} = \frac{\rho}{\pi r^2}\left[1 - \frac{1}{1+\ell}\right]$,

$R_2 = \int_{\ell}^{1} \frac{\rho dx}{\pi r^2 (1+x)^2} = \frac{\rho}{\pi r^2}\left[\frac{1}{1+\ell} - \frac{1}{1+1}\right]$

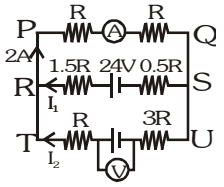
For null point

$\frac{R_1}{R_2} = \frac{10}{10} \Rightarrow R_1 = R_2$

$\Rightarrow 1 - \frac{1}{1+\ell} = \frac{1}{1+\ell} - \frac{1}{2} \Rightarrow \frac{3}{2} = \frac{2}{1+\ell}$

$\Rightarrow 3 + 3\ell = 4 \Rightarrow \ell = \frac{1}{3}$ m

31. $V_P - V_Q = 2(2R) \Rightarrow 4R = 24 - (2R)I_1$



$\Rightarrow I_1R = 12 - 2R$, $E - I_2(4R) = 4R$, $I_1 + I_2 = 2$

$\Rightarrow E = 20R - 48$

EXERCISE –III

Match the column

1. For potentiometer short circuit = x ℓ_1

(लघुपथित विभवमापी के लिये)

x Depends only on primary circuit

(x केवल प्राथमिक परिपथ पर निर्भर करता है।)

(A) $E_1\uparrow \Rightarrow x\uparrow \Rightarrow \ell_1\downarrow$ if secondary circuit remain same

(यदि द्वितीयक परिपथ समान है।)

(B) $R\uparrow \Rightarrow x\downarrow \Rightarrow \ell_1\uparrow$ if secondary circuit remain same

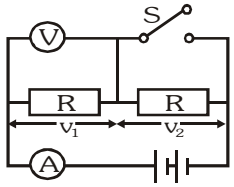
(यदि द्वितीयक परिपथ समान है।)

(C) S.C$\uparrow = \ell_1\uparrow$ if x remain same

(लघुपथित S.C$\uparrow = \ell_1\uparrow$ यदि x समान है।)

2. After closing the switch net resistance decreases therefore there will be increases in the current. After closing the switch V_2 becomes zero hence $V = V_1$.

(स्विच को बंद करने के बाद नेट प्रतिरोध घटता है। इसलिये यहाँ धारा का मान बढ़ता है। स्विच S_2 को बंद करने के बाद शून्य होग। अत: $V = V_1$)



After short circuiting current in the resistance becomes zero therefore power become zero.

(परिपथ को लघुपथित करने के बाद प्रतिरोध में धारा का मान शून्य होगा इसलिये शक्ति शून्य होगी।)

Comprehension–1

1. Power through fuse (फ्यूज से प्रवाहित शक्ति)

$P = I^2R = h \quad 2\pi r\ell$

h = heat energy lost per unit area per unit time

(प्रति इकाई समय पर प्रति इकाई क्षेत्रफल पर उष्मा उर्जा)

I = current.

$I^2 = \frac{h \times 2\pi r\ell}{\frac{\rho\ell}{\pi r^2}} \propto r^3 \Rightarrow I \propto r^{3/2}$

$\left(\frac{I_1}{I_2}\right) = \left(\frac{r_1}{r_2}\right)^{3/2} = \left(\frac{4}{1}\right)^{3/2} = \frac{8}{1}$

2. $P = VI \qquad 20kw \Rightarrow 2000 = \frac{V^2}{20}$

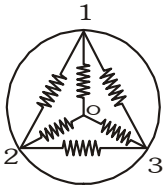
$\Rightarrow V = 200$ volt $\Rightarrow V < 200$ volt

3. At maximum power delivery R = r, so $\eta = 50\%$

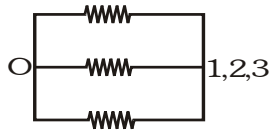
(प्रदान अधिकतम शक्ति पर)

Comprehension–2

1. As potential of 1, 2 and 3 are same potential difference across them 'zero'.
(क्योंकि 1, 2 व 3 का विभव समान है इनके सिरो पर विभवानतर शून्य है।)



2. As 1, 2 and 3 are having same potential therefore we can draw it.
(क्योंकि 1, 2 तथा 3 जिन पर विभव समान है अत:)



$R_{01} = R/3$; $R_{02} = R/3$; $R_{03} = R/3$

3. As point 1,2,3 are equipotential $\Delta V = I R_{12}$
(क्योंकि बिन्दु 1, 2 तथा 3 समविभव बिन्दु है।)
$\Rightarrow \Delta V = 0$ therefore $I = 0$ for R_{12}, R_{23},R_{31}

Comprehension–3

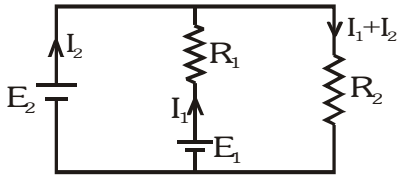
1. Current is maximum when resistance in the circuit is minimum. i.e. when S_1,S_3,S_5 are closed because then all resistances will be shortcircuited $I_{max} = \frac{V_0}{R}$.
(धारा का मान अधिक होगा जब परिपथ में प्रतिरोध न्यूनतम हो अर्थात् S_1, S_3, S_5 बंद है क्योंकि सभी प्रतिरोध लघुपथित है, $I_{max} = \frac{V_0}{R}$.

2. After regular closing of switches, total resistance decreases gradually.
(स्विचों को बंद करने के बाद कुल प्रतिरोध धीरे–धीरे घटता है।)

3. $P_1 = \frac{V_0^2}{R}$, $P_2 = \frac{V_0^2}{\frac{37}{7}R}$ so $\frac{P_1}{P_2} = \frac{7}{37}$

Comprehension–4

1. $I_1 = \frac{E_1 - E_2}{R_1}$, $I_1 + I_2 = \frac{E_2}{R_2} \Rightarrow I_2 = \frac{E_2}{R_2} - \frac{E_1 - E_2}{R_1}$



$\Rightarrow$ $I_1 = \left(\frac{-1}{R_1}\right) E_2 + \frac{E_1}{R_1}$ & $I_2 = \left(\frac{1}{R_1} + \frac{1}{R_2}\right) E_2 - \frac{E_1}{R_1}$

$\Rightarrow \frac{1}{R_1} = \frac{0.3}{6} \Rightarrow R_1 = 20\Omega$

and $\frac{1}{R_1} + \frac{1}{R_2} = \frac{0.3}{4} \Rightarrow R_2 = 40\Omega$

Now as $\frac{E_1}{R_1} = 0.3 \Rightarrow E_1 = 0.3 \quad 20 = 6V$

Comprehension–5

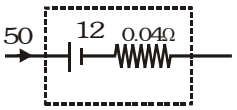
1. In balancing condition, current in the circuit should be zero which happens at ℓ=20 cm according to graph.
(संतुलन की स्थिति में, परिपथ में धारा शून्य होगी। जो ग्राफ के अनुसार ℓ = 20 cm पर है।)

2. At balance point $\varepsilon = \frac{\ell}{100} V = \frac{20}{100} \times 6 = 1.2V$
(संतुलन बिन्दु पर)

3. At $\ell = 0$, applying kirchhoff's 2nd law in the circuit containing cell, ε= IR
($\ell = 0$ पर सैल को रखने वाले परिपथ में किरचॉफ का द्वितीय लगाने पर, ε= IR)
where I is the current at $\ell = 0$, & ε is the emf of the cell. $\Rightarrow R = \frac{\varepsilon}{I} = \frac{1.2}{40 \times 10^{-3}} = 30\Omega$
(जहाँ $\ell = 0$ पर I धारा है तथा ε सैल का विद्युत वाहक बल है
$\Rightarrow R = \frac{\varepsilon}{I} = \frac{1.2}{40 \times 10^{-3}} = 30\Omega$)

Comprehension–6

1. V = E + ir
= 12 + (0.04) (50)
= 12 + 2 $\Rightarrow$ 14 V



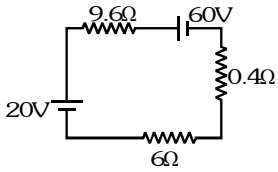
2. **Ans. (A)**
Loss in power (व्ययित शक्ति)
$= i^2r = (50)^2(.04) = 100$ W

3. **Ans. (C)**
Total input (कुल निवेशी शक्ति)
– Loss in power (व्ययित शक्ति)
= Useful power (कार्यकारी शक्ति),
Input power (निवेशी शक्ति) = 14 (50) = 700 w
Loss in power (व्ययित शक्ति) = 100 w,
Rate of conversion (परिवर्तन की दर) = 600 watt

EXERCISE –IV A

1. $I = \frac{40}{16} = \frac{10}{4} = 2.5\,A$

$I_1 = \left(\frac{R_2}{R_1 + R_2}\right) I$



$I_1 = \left(\frac{48}{60}\right) 2.5 = 2A \Rightarrow I_2 = 0.5$

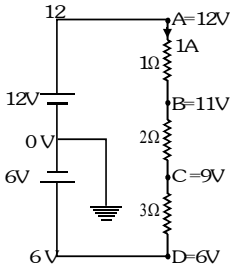
$\Rightarrow V = 0.5(7) = 3.5$ volt

2. $\Delta V = IR$

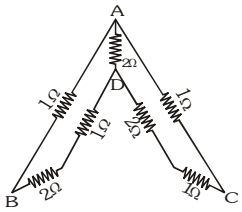
$\Delta V_{AB} = 1V$

$\Delta V_{BC} = 2V$

$\Delta V_{CD} = 3V$

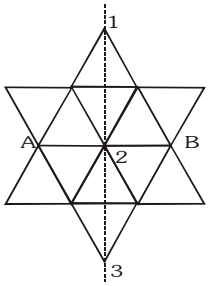


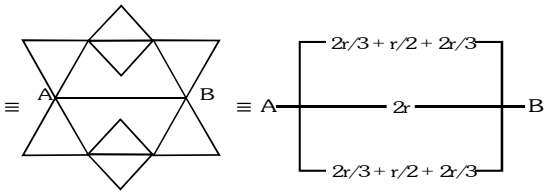
3. By symmetric path method Points E, F and B, C are Equipotential $\Rightarrow R_{AD} = 1\Omega$
(बिन्दु E, F तथा B, C सममिती पथ द्वारा समविभव)



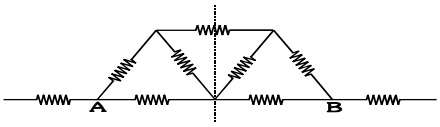
4. By perpendicular Axis symmetry all points 1, 2, 3 are at same potential therefore junction on this line can be redrawn as $R_{AB} = \frac{22}{35}R$.

(बिन्दु 1, 2, 3 पर लम्बवत् अक्ष सममिती से विभव का मान समान है अत: इस रेखा पर संधि $R_{AB} = \frac{22}{35}R$.)



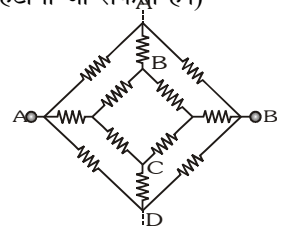


5. By applying perpendicular Axis– Symmetry
(लम्बवत् अक्ष सममिति से)

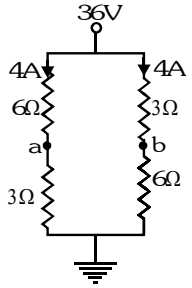


$R_{AB} = \frac{8}{7}R$

6. By applying perpendicular axis symmetry. Points lying on the line 'AD' have same potential therefore Resistance between AB and CD can be removed $R_{AB} = 9\Omega$.
(लम्बवत् अक्ष सममिति से रेखा 'AD' पर स्थित बिन्दुओं पर विभव समान होगा। इसलिये AB तथा CD के मध्य प्रतिरोध $R_{AB} = 9\Omega$ हटाया जा सकता है।)

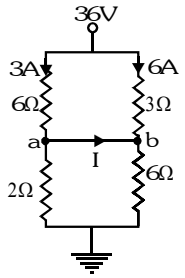


7. (i) When switch S is open
(जब स्विच S खुला है।)



$V_a - V_b = (36 - 6\ 4) - (36 - 3\ 4) = -12V$

(ii) Total current through circuit = $\frac{36V}{4\Omega} = 9A$
(परिपथ से होकर प्रवाहित कुल धारा)



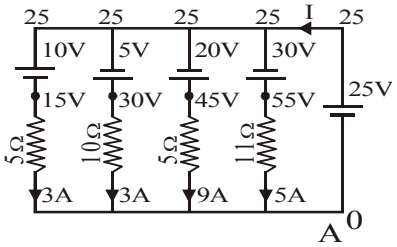
Therefore I = 3A

8. (i) Chemical energy consumed = 3 watt
(रासायनिक ऊर्जा क्षय)

(ii) Rate of energy dissipation = i^2R = 0.4 watt
(ऊर्जा क्षय की दर)

(iii) Rate of energy dissipation in resistor
(प्रतिरोधक में ऊर्जा की दर)
= (E – ir) = 2.6 watt

(iv) The output energy to the source = 2.6 watt
(स्त्रोत की निर्गत ऊर्जा)

9. 

Taking point 'A' as reference potential and its potential to be '0' : I = 20 A

(बिन्दु 'A' को निर्देश विभव मानने पर इसके विभव का मान शून्य होगा।)

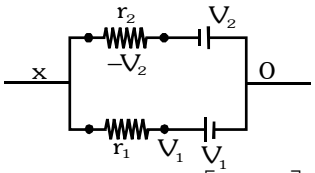
Power supplied by 20 V cell

(20 V सेल द्वारा दी गयी शक्ति)

$= -20 \quad 1 = -20$ W

10. By applying node Analysis

(नोड विश्लेषण विधि से)



$$\frac{x+V_2}{r_2}+\frac{x-V_1}{r_1}=0 \Rightarrow x\left[\frac{1}{r_2}+\frac{1}{r_1}\right]=\frac{V_2r_1-V_1r_2}{r_1r_2}$$

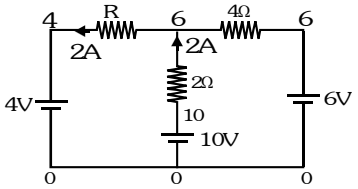
$$x=\frac{V_2r_1-V_1r_2}{r_1+r_2}\ ,\ \frac{1}{r_{eq}}=\frac{1}{r_1}+\frac{1}{r_2}$$

11. $P_1 = P_2 \Rightarrow \dfrac{\in^2 R_1}{(R_1+r)^2}=\dfrac{\in^2 R_2}{(R_2+r)^2}$

$$\frac{R_2+r}{R_1+r}=\sqrt{\frac{R_2}{R_1}}\ ,\ r=\sqrt{R_1R_2}$$

12. By taking 'O' as a reference potential as current through '4Ω' is zero there should be no potential drop across it

(बिन्दु 'O' को निर्देश विभव मानने पर '4Ω' में प्रवाहित धारा शून्य होगी। इसके सिरो पर कोई विभवपात नहीं होगा।)



Value of 'R' for this condition = 1Ω

(इस स्थिति में 'R' का मान)

13. '2R' and 'R_x' are in series therefore $R = 2R + R_x$ and it is in parallel with

$$'R' \Rightarrow R_{eq}=\frac{(2R+R_x)(R)}{(R+2R+R_x)}=R_x$$

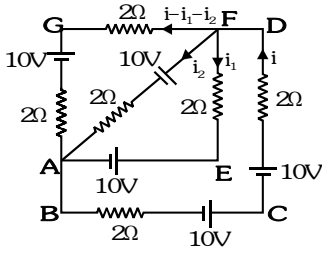
('2R' व 'R_x' श्रैणीक्रम में है अत: $R = 2R + R_x$ तथा

'R' इसके समान्तर क्रम में है $\Rightarrow R_{eq}=\dfrac{(2R+R_x)(R)}{(R+2R+R_x)}=R_x$)

By solving above equation $R_x = \left(\sqrt{3}-1\right)R$

14. In loop ABCDEA $20-4i-2i_1-10=0$

$\Rightarrow -2i-i_1=-5 \Rightarrow i_1=-2i+5$



In loop ABCDFA $20-4i-10-2i_2=0 \Rightarrow i_2=-2i+5$

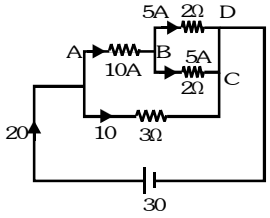
In loop ABCDFGA $20-4i-10-4(i-i_1-i_2) = 0$

Put the values of i_1 & i_2

$\Rightarrow 10-4i-4\ (1+2i-5+2i-5) =0$

$\Rightarrow 10-4i-20i+40=0 \Rightarrow i = \dfrac{25}{12}$A

15. Circuit can be redrawn as



$R_{eq} = \dfrac{3}{2}\Omega$; $I = \dfrac{V}{R_{eq}} = 20$ A

Current In $I_{CD} = I_{AC} + I_B$; $I_{CD} = 15$ A

16. (i) $i=\dfrac{-i_0}{T_0}t+i_0\ ;\ \int dq=\int -\dfrac{i_0t}{T_0}dt+\int i_0dt$

$$Q=-\frac{i_0T_0}{2}+i_0T_0=\frac{i_0T_0}{2}$$

(ii) $i=i_0\left(1-\dfrac{t}{T_0}\right)$

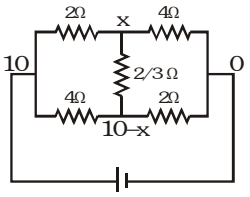
(iii) Heat $= i^2Rdt$ $\left[\because i=i_0\left(\dfrac{1-t}{T_0}\right)\right]$

$$=\int\frac{i_0^2}{T_0^2}t^2+\int i_0^2dt-\int_0^{T_0}\frac{2i_0^2}{T_0}tdt$$

$$=\frac{i_0^2}{T_0^2}\frac{T_0^3}{3}+i_0^2T_0-i_0^2T_0$$

$$\text{Heat}=\frac{i_0^2T_0}{3}$$

17. Submission of current at the Node 'X' is
(Node 'X' पर धाराओं का योग)

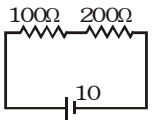


$$\frac{x-10}{2}+\frac{x-0}{4}+3\left(\frac{2x-10}{2}\right)=0$$

$$\Rightarrow 15x - 20 - 60 = 0 \Rightarrow x=\frac{80}{15}$$

$$\text{Current} = \frac{\Delta V}{R}=\left[\frac{10}{15}\times\frac{3}{2}\right]= 1\ A$$

18. Potential difference across voltmeter is same as that of 200Ω
(वोल्टमीटर के सिरो पर विभवान्तर का मान प्रतिरोध 200 Ω के सिरो के समान है।)



$$V_1=\left(\frac{200}{300}\right)10=\frac{20}{3}V$$

19. $5 - ir = 4 \Rightarrow i = 1A$
$1\quad R = 4\ V \Rightarrow R = 4\ \Omega$

20. $\frac{R_1}{R_2}=\frac{40}{60}=\frac{4}{6}$ ...(i); $\frac{R_1(R_2+10)}{R_2\times 10}=1$

$R_1R_2 + 10R_1 = R_2\quad 10$...(ii)

By solving (i) and (ii) $R_1=\frac{10}{3}\Omega$; $R_2 = 5\Omega$

21. (i) Current due to primary circuit
(प्राथमिक परिपथ के कारण धारा)

$$i=\frac{1E_p}{R_{pm}+r}=\frac{10}{10}=1\ \text{Amp}$$

$\Delta V = 1R_{PM} \Rightarrow \Delta V = 9$volt

Potential gradient (विभव प्रवणता) = $\frac{9}{12}$

$\left(\frac{9}{12}\right)(\ell_1) = 4.5 \Rightarrow \ell_1 = 6$m

(ii) $i=\frac{E_p}{R_{PM}+r+R_{ext}}=\frac{10}{9+1+10}=\frac{1}{2}A$

$\Delta V = iR_{PM} = \frac{1}{2}\quad 9R = 4.5$ volt

Potential gradient $x=\frac{\Delta V}{L}=\frac{4.5}{12}$

$S.C = x\ell_1 = \left(\frac{4.5}{12}\right)\times 8 = 3V$

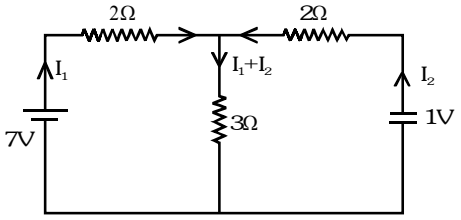
$V = E - ir,\ iR = 3 \Rightarrow i=\frac{3}{2}$

$= 4.5 - \left(\frac{3}{2}\right)r = 3 \Rightarrow r = 1\ \Omega$

22. Power developed in it is maximum when external resistance = internal resistance.
(इसमें उत्पन्न शक्ति अधिकतम होगी जब बाह्य प्रतिरोध = आन्तरिक प्रतिरोध)

$$\frac{nr}{324/n}=R \Rightarrow \frac{9n^2}{324}=4 \Rightarrow n=12$$

23. Applying KVL



$7 = 2I_1 + 3\ (I_1 + I_2),\ 1 = 2I_2 + 3\ (I_1 + I_2)$

$\Rightarrow I_1 = 2A,\ I_2 = -1A$

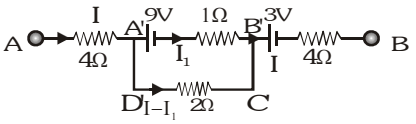
Power supplied by E_1 = a = E_1I_1 = 14W

Power supplied by E_2 = b = E_2I_2 = –1W

Therefore a + b = 14–1 = 13W

24. Heat developed will be maximum for the resistor '4' because (P.D.) will be maximum for the branch containing '5Ω' and '4Ω'
('4' प्रतिरोध के लिए उत्पन्न शक्ति अधिकतम होगी क्योंकि '5Ω' व '4Ω' प्रतिरोध की शाखाओं के लिये विभवान्तर अधिकतम होगा।)

25.



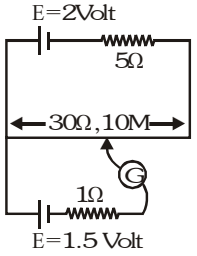
By applying K.V.L
$V_A - 4I - 9 - I_1 - 3 - 4I = V_B$
$16 = +8I + I_1 + 12$
$8I + I_1 = 4V$ ....(i)
By applying K.V.L. in loop A'B'C'D'A'
$-9 - I_1 + 2(I - I_1) = 0$
$-3I_1 + 2I = 9$ ...(ii)
By solving (i) and (ii) Current in 2Ω resistance is 3.5A.

26.(i) $I=\int \vec{J}.\vec{d}_A = J_0\int_0^R\left(1-\frac{r}{R}\right)2\pi r dr = J_0 2\pi\left[\int_0^R r dr - \int_0^R \frac{r^2}{R}dr\right]$

$$= J_0 2\pi\left[\frac{R^2}{2}-\frac{R^2}{3}\right] = J_0\left(\frac{2\pi R^2}{6}\right)=\frac{J_0 A}{3}$$

(ii) $J=\int_0^R J_0\left(\frac{r}{R}\right)2\pi r dr = \frac{J_0 2\pi}{R}\int_0^R r^2 dr = \frac{J_0 2\pi R^2}{3}=\frac{2J_0 A}{3}$

27. Potential gradient = x = 0.2



$E_2 = x\ell_1$

$1.5 = (0.2)\ell_1$

$\ell_1 = 7.5m$

(a) $i = \frac{2}{35}$, $V = ir \Rightarrow x = \frac{12}{70}$

$x\ell_1$=S.C.

$\Rightarrow \quad \frac{12}{70}\ell_1 = \frac{15}{10} \Rightarrow \ell_1 = \frac{15\times 7}{12} = 8.75m$

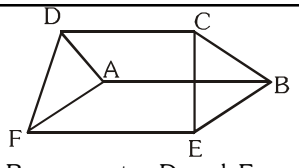
(b) $S.C. = \left(\frac{E}{R+r_1}\right)R = \left(\frac{1.5}{6}\right)5 = 1.25$

S.C. = $x\ell_2$

$1.25 = 0.2\ (\ell_2) \Rightarrow \ell_2 = 6.25m$

EXERCISE –IV B

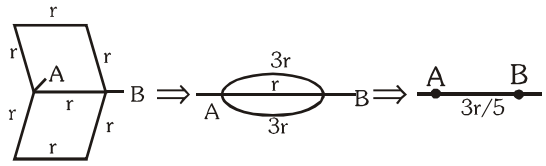
1.



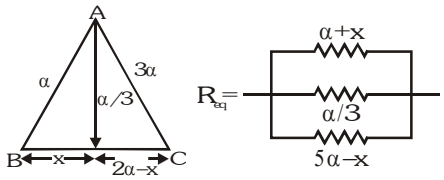
By symmetry D and F are at same potential and C and E .

And by symmetry C and E are at same potential. So we can removed DF and CE

(सममिति से D व F पर विभव C व E पर विभव के समान है। तथा सममिति से C व E पर भी विभव समान होगा। इसलिये हम DF व CE को हटा सकते है।)



2.



$\Rightarrow \frac{1}{R_{eq}} = \frac{1}{(\alpha+x)} + \frac{3}{\alpha} + \frac{1}{(5\alpha - x)}$

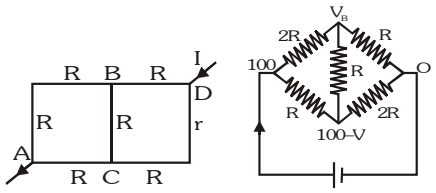
$= \frac{\alpha(5\alpha - x) + 3(\alpha+x)(5\alpha - x) - 2(\alpha+x)}{\alpha(\alpha+x)(5\alpha - x)}$

$\frac{1}{R_{eq}} = \frac{5\alpha^2 - \alpha x + \alpha^2 + \alpha x + 15\alpha^2 - 3x^2 + 12\alpha x}{\alpha(\alpha+x)(5\alpha - x)}$

$R_{eq} = \frac{\alpha(\alpha+x)(5\alpha - x)}{21\alpha^2 + 12\alpha x - 3x^2} \Rightarrow \frac{dR_{eq}}{dx} = 0$

$R_{eq}\ (max) = \frac{3}{11}\alpha$

3. By applying nodal analysis at note 'B' and 'C'.
(नोड 'B' व 'C' पर नोड विश्लेषण विधि से।)



$\frac{V-100}{2R} + \frac{2V-100}{R} + \frac{V-0}{R} = 0$

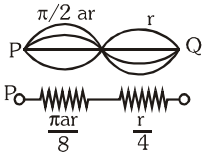
$\Rightarrow 7V - 300 = 0 \Rightarrow V_B = \frac{300}{7}$ and $V_C = \frac{400}{7}$

$I_{BC} = \frac{V_B - V_C}{R} = \frac{100}{7R}$

$I = \frac{200}{7R} + \frac{300}{7R} = \frac{500}{7R} = \frac{5}{7}\left(\frac{100}{R}\right)$

i.e. times the length of any side.

4. By path symmetry potential of points A,B,C,D is same.
(बिंदु A,B,C,D पर सममिति पथ विधि से विभव समान होगा।)



$R_{eq} = \frac{ra}{4}\left(\frac{\pi}{2}+1\right) \Rightarrow R_{eq} = \frac{ra}{8}(\pi+2)$

5. $I = I_0 \sin\left(\frac{2\pi t}{T}\right)$

As $\frac{dq}{dt} = I$ so $Q = 2\int_0^{T/2} I_0 \sin\left(\frac{2\pi t}{T}\right)dt = \frac{2I_0T}{\pi}$

Total heat generated

$= \int_0^T I^2 R dt = \int_0^T I_0^2 R \sin^2\left(\frac{2\pi t}{T}\right)dt$

$= \frac{I_0^2R}{2}\int_0^T \left(1 - \cos\frac{4\pi t}{T}\right)dt = \frac{I_0^2R}{2}(T)$

$= \left(\frac{Q\pi}{2T}\right)^2\left(\frac{RT}{2}\right) = \frac{Q^2\pi^2R}{8T}$

6. $R = \rho\frac{\ell}{A}$

$\int_0^R dR = \int_0^L \frac{\rho_0 e^{-x/L}x dx}{A}$

$R = \frac{\rho_0 L}{A}\left(1 - \frac{1}{e}\right) = \frac{\rho_0 L(e-1)}{Ae}$

$I = \frac{V}{R} = \frac{V_0 A}{\rho_0 L}\left(\frac{e}{e-1}\right)$

7. Current with both switches opened is -
(दोनों स्विचों को खोलने पर धारा)

$$\frac{V}{R_{eq}} = \frac{1.5}{450} = \frac{1}{300} = i$$

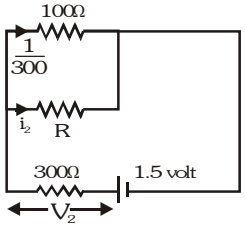
After closing the switch (स्विच बंद करने के बाद),

$V_1 + V_2 = V$

$$\frac{1}{3} + V_2 = \frac{3}{2}$$

$$V_2 = \frac{9-2}{6} = \frac{7}{6}$$

$$i = \frac{7}{1800}$$

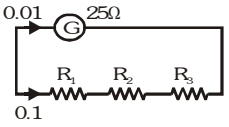


By kirchoffs first law (किरचॉफ के प्रथम नियम से)

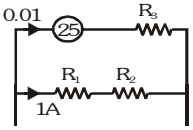
$$i_2 = \frac{7}{1800} - \frac{1}{300} = \frac{1}{1800}; \quad i_2R = i_1R_1$$

$$R = 1800\left(\frac{1}{3}\right) = 600\Omega$$

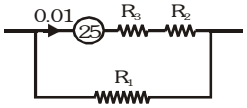
8. $(0.01)\ G = 0.1(R_1 + R_2 + R_3)$
$G = 10\ (R_1 + R_2 + R_3)$...(i)



$(0.01)G = 1(R_1 + R_2)$...(ii)

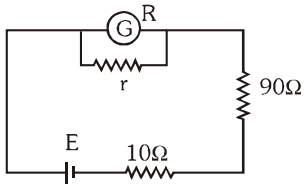


$(0.01)G = 10R_1$...(iii)



By solving Equation (i), (ii) and (iii)
$R_1 = 0.0278\Omega$; $R_2 = 0.25\Omega$; $R_3 = 2.5\Omega$

9.



Assume 1 division have x ampere When r=10Ω

$$\frac{E}{90 + 10 + 10R/(10+R)} = 9x \ldots \text{(i) When } r=50\Omega$$

$$\frac{E}{90 + 10 + 50R/(50+R)} = 30x \ldots \text{(ii)}$$

(i) divided by (ii)

$$\frac{(10+R)}{100(10+R)+10R} \times \frac{100(50+R)+50R}{(50+R)} = \frac{9}{30}$$

$$\frac{(10+R)(500+15R)}{(100+11R)(50+R)} = \frac{9}{30}$$

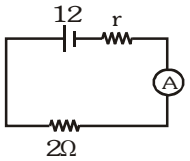
After solving R = 233.3 Ω

10. $R_A = \frac{S \times G}{S+G}$; $R_A = \frac{99 \times 1}{100} = 0.99\Omega$

$3(2 + r + 0.99) = 12$

$\Rightarrow 2 + r + 0.99 = 4$

$\Rightarrow r = 1.01\ \Omega$



$I_g(R+G) = V$; $I_gS = (I-I_g)G$; $I_g(S+G) = 4IG$

By solving the above equation we get the answers.

EXERCISE –V-A

1. In order to convert an ammeter into a voltmeter, one has to connect a high resistance in series with it.

अमीटर को वोल्टमीटर में परिवर्तित करने के लिये अमीटर में श्रेणीक्रम में उच्च प्रतिरोध लगाना चाहिये।

3. The emf of the standard cell $E \propto 100$

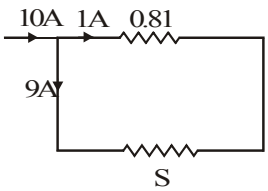
मानक सेल का विद्युत वाहक बल $E \propto 100$

The emf of the secondary cell $e \propto 30$

द्वितीयक सेल का विद्युत वाहक बल $e \propto 30$

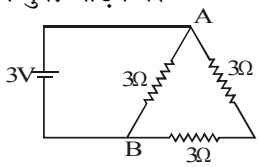
$$\frac{E}{e} = \frac{100}{30} \Rightarrow e = \frac{30E}{100}$$

4. I_g=1A; G=0.81Ω; I=10A

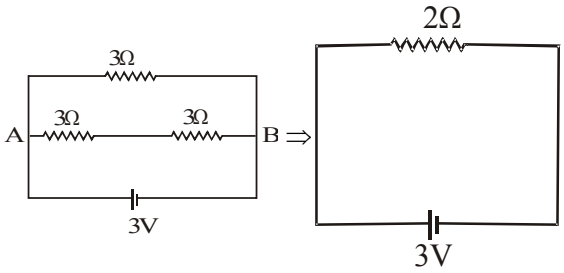


$$S = \left(\frac{I_g}{I - I_g}\right)G; \quad S = \frac{1}{9} \times 0.81 = 0.09\Omega$$

5. On redrawing the circuit between A and B we get
A व B के मध्य परिपथ को पुन: जोड़ने पर



$I = \frac{3V}{2\Omega} = 1.5A$



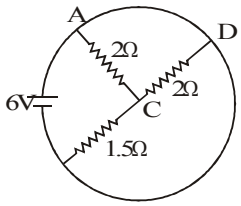
6. For a given volume, the resistance of the wire is expressed as
दिये गये आयतन के लिये, तार का प्रतिरोध

$$R = \frac{\rho \ell^2}{\text{Volume}} \Rightarrow R \propto \ell^2$$

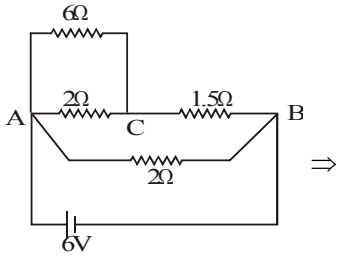
$$\frac{R_2}{R_1} = \left(\frac{2\ell}{\ell}\right)^2 = 4 \Rightarrow \frac{R_2 - R_1}{R_1} = 3$$

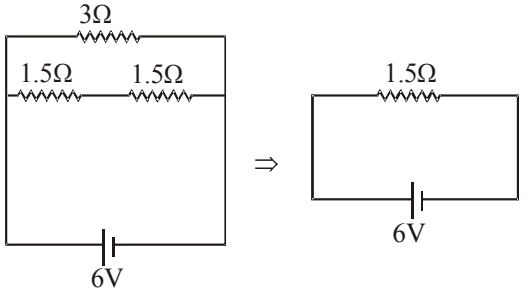
So, the change in resistance of wire will be 300%
अत: तार के प्रतिरोध में परिवर्तन 300% होगा।

7.



On redrawing the diagram, we get $I = \frac{6}{1.5} = 4A$





8. Let resistances be R_1 and R_2
माना R_1 व R_2 प्रतिरोध है

then $S = R_1 + R_2$ and $P = \frac{R_1 R_2}{R_1 + R_2}$

$$n = \frac{S}{P} = \frac{(R_1 + R_2)^2}{R_1 R_2} = \frac{R_1}{R_2} + \frac{R_1}{R_2} + 2$$

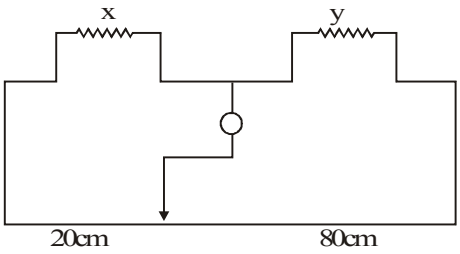
$$= \left(\sqrt{\frac{R_1}{R_1}} - \sqrt{\frac{R_2}{R_1}}\right)^2 + 4 \Rightarrow n_{min} = 4$$

9. Given that $\frac{\ell_1}{\ell_2} = \frac{4}{3}$ & $\frac{r_1}{r_2} = \frac{2}{3} \Rightarrow \frac{A_1}{A_2} = \frac{r_1^2}{r_2^2} = \frac{4}{9}$

In parallel : $I_1R_2 = I_2R_2$

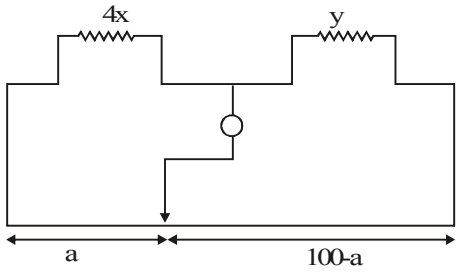
hence $\frac{I_1}{I_2} = \frac{R_2}{R_1} = \frac{\ell_2}{A_2} \times \frac{A_1}{l_1} = \frac{3}{4} \times \frac{4}{9} = \frac{1}{3}$

10.



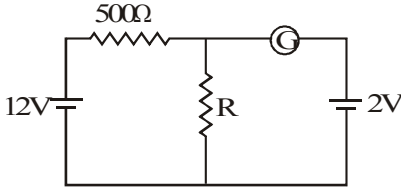
$$\frac{x}{20} = \frac{y}{80} \Rightarrow \frac{x}{y} = \frac{1}{4}$$

Now



$$\frac{4x}{a} = \frac{y}{100 - a} \Rightarrow a = 50 \text{ cm}$$

12 Voltage across R=2V
R के सिरो पर वोल्टता = 2V
Hence, voltage across 500Ω=10V
अत: 500Ω प्रतिरोध के सिरो पर वोल्टता = 10V



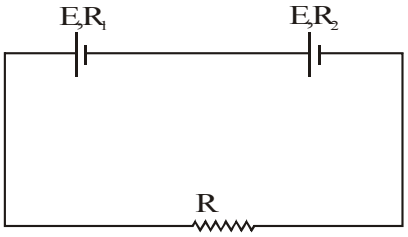
Current through $500\Omega = \frac{10}{500} = \frac{1}{50} A$

500Ω प्रतिरोध से होकर गुजरने वाली धारा $=\frac{10}{500}=\frac{1}{50}$A

As 500Ω and RΩ are in series value of
क्योंकि 500Ω तथा RΩ श्रेणीक्रम में है

$$R=\frac{V_R}{I_R}=\frac{2}{1/50}=100\Omega$$

13.



Current in the circuit (परिपथ में धारा) $=\frac{2E}{R_1+R_2+R}$

potential difference across cell with R_2 resistance
प्रतिरोध R_2 के साथ सेल के सिरों पर विभवान्तर

$$=E-IR_2=E-\frac{2E}{R_1+R_2+R}\times R_2$$

But potential difference = 0

$$\Rightarrow E=\frac{2E}{R_1+R_2+R}\times R_2\Rightarrow R=R_2-R_1$$

14. Current supplied by the source to the external resistance
बाह्य प्रतिरोध के स्त्रोत के द्वारा दी गई धारा

$$I=\frac{E}{R+r}$$

If (यदि) r>>R; $I=\frac{E}{r}$

which will be constant(जो कि नियत है।)

15. The internal resistance of a cell
सेल का आन्तरिक प्रतिरोध

$$r=\left(\frac{e}{v_T}-1\right)R=\left(\frac{l_1}{l_2}-1\right)R=\left(\frac{240}{120}-1\right)2=2\Omega$$

16. Kirchoff's first law is based on law of conservation of charge.Kirchoff's second law is based on law of conservation of energy.
किरचॉफ का प्रथम नियम आवेश संरक्षण पर आधारित है और किरचॉफ का द्वितीय नियम ऊर्जा संरक्षण पर आधारित होता है।

17. Specific resistance (ρ_B)=2ρ_A ; diameter d_B=2d_A
विशिष्ट प्रतिरोध (ρ_B)=2ρ_A ; व्यास d_B=2d_A

$$\frac{\ell_B}{\ell_A}=?\ \text{ for }\ \frac{(\text{Resistance})_B}{(\text{Resistance})_A}=1$$

$$\frac{\rho_B\ell_B}{A_B}=\frac{\rho_A\ell_A}{A_A}\qquad \frac{\ell_B}{\ell_A}=\frac{\rho_A}{\rho_B}\frac{A_B}{A_A}$$

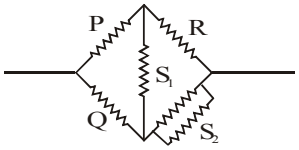
$$\frac{\ell_B}{\ell_A}=\frac{\rho_A}{\rho_B}\frac{(dia_B)^2}{(dia_A)^2}=\frac{1}{2}\times 2^2=2$$

18. Given that
$R_{100\,C}$ = 100Ω
$R_{T\,C}$ = 200Ω
T=?
$R_{100}=R_0[1+\alpha(100)]$ ...(i)
$R_T=R_0[1+\alpha T]$...(iii)
On dividing eq. (2) by eq. (1), we get

$$\frac{R_T}{R_{100}}=\frac{1+\alpha T}{1+100\alpha}$$

On solving, we get T=400 C

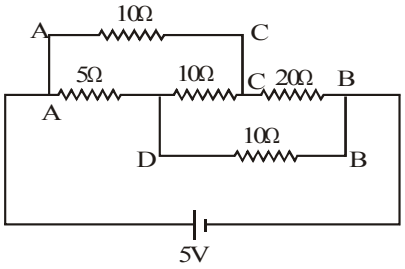
19.



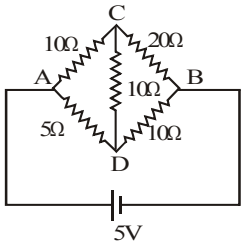
Under balanced condition
(सन्तुलित अवस्था में)

$$\frac{P}{Q}=\frac{R}{\frac{S_1S_2}{S_1+S_2}}\Rightarrow\frac{P}{Q}=\frac{R(S_1+S_2)}{S_1S_2}$$

20.

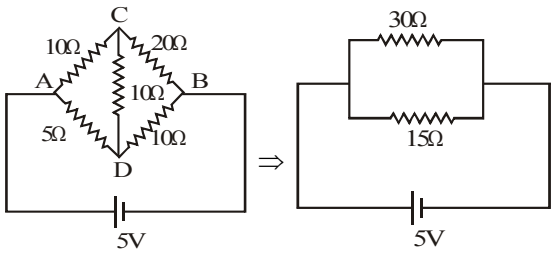


On redrawing the circuit, we get (परिपथ से)



It is a balanced Whetstone bridge having R_{eff} as
यह व्हीटस्टोन सेतु से सन्तुलित है जिसका

$$R_{eff}=\frac{30\times 15}{45}=10\Omega$$



The current delivered by the source is
स्त्रोत से निकलने वाली धारा

$$I = \frac{V}{R} = \frac{5}{10} = 0.5A$$

21. Let the resistance of the wire at 0 C is R_0 also let the temperature coefficient of resistance is α.
माना 0 C पर तार का प्रतिरोध R_0 है तथा माना प्रतिरोध का तापीय गुणांक α है।

$R_{50}=R_0[1+\alpha(50-0)]$....(i)

Similarly $R_{100}=R_0[1+\alpha(100-0)]$ ...(ii)

On dividing equation (ii) by equation (i), we get

$$\frac{R_{100}}{R_{50}} = \frac{1+100\alpha}{1+50\alpha} \; ; \; \frac{6}{5} = \frac{1+100\alpha}{1+50\alpha}$$

$$\Rightarrow 6+300\alpha = 5+500\alpha \Rightarrow 1 = 200\alpha$$

$$\alpha = \frac{1}{200} / °C$$

On replacing $\alpha = \frac{1}{200} / °C$ in equation (i), we get

$$5=R_0\left[1+\frac{1}{200}50\right] \Rightarrow 5 = R_0\left[1+\frac{1}{4}\right]$$

$$\Rightarrow 5 = R_0\left[\frac{5}{4}\right] \Rightarrow R_0 = 4\Omega$$

22. $\frac{55}{20} = \frac{R}{80} \Rightarrow R = \frac{55\times 8}{2} = 220\Omega$

24. Choosing A as origin,(A को मूल बिन्दु मानने पर)

$$E = \rho j = \rho\frac{I}{2\pi r^2}$$

25. $$V_C - V_B = -\frac{\rho I}{2\pi}\int_a^{(a+b)}\frac{1}{r^2}dr = \frac{\rho I}{2\pi}\left[\frac{1}{(a+b)}-\frac{1}{a}\right]$$

$$V_B - V_C = -\frac{\rho I}{2\pi}\left[\frac{1}{a}-\frac{1}{(a+b)}\right]$$

27. For series combination (श्रेणीक्रम संयोजन के लिये)

$$\alpha_S = \frac{\alpha_1 R_{01} + \alpha_2 R_{02}}{R_{01}+R_{02}}$$

$R_{01} = R_{02} = R_0$ (given)

$$\alpha_S = \frac{\alpha_1+\alpha_2}{2}$$

For parallel combination (समान्तर क्रम संयोजन के लिये)

$$\frac{1}{R} = \frac{1}{R_1}+\frac{1}{R_2}$$

$$\Rightarrow \frac{1}{R_{eq}} = \frac{1}{R_0(1+\alpha_1 t)}+\frac{1}{R_0(1+\alpha_2 t)}$$

$$\frac{1}{\frac{R_0}{2}(1+\alpha_p t)} = \frac{1}{R_0(1+\alpha_1 t)}+\frac{1}{R_0(1+\alpha_2 t)}$$

$2\,(1+\alpha_p t)^{-1} = (1+\alpha_1 t)^{-1} + (1+\alpha_2 t)^{-1}$

using binomial expansion (द्विपद प्रसार से)

$$2 - 2\alpha_p t = 1 - \alpha_1 t + 1 - \alpha_2 t \Rightarrow \alpha_p = \frac{\alpha_1+\alpha_2}{2}$$

28. $R = \rho\frac{\ell}{A} \Rightarrow R \;\alpha\; \ell^2$

$$\frac{\Delta R}{R} = \frac{\Delta R}{R} = \frac{2\Delta\ell}{\ell} = 2[0.1] = 0.2\% \text{ increase.}$$

29. $R = R_1 + R_2 + R_3 + R_4 \Rightarrow \Delta R = \frac{5}{100}\times 100 = 5\Omega$

$\Delta R = \Delta R_1 + \Delta R_2 + \Delta R_3 + \Delta R_4 = 20$

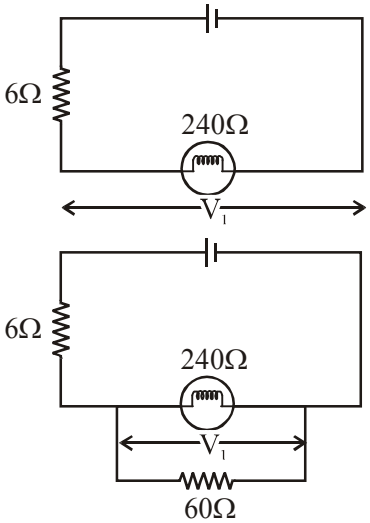
For combination $\frac{\Delta R}{R}\times 100 = \frac{20}{400}\times 100 = 5\%$

30. i = 0.2 A, $\rho = 4 \quad 10^{-7}$ Ω-m, $A = 8 \quad 10^{-7}$ m^2

$$x = \frac{i\rho}{A} = \frac{0.02\times 4\times 10^{-7}}{8\times 10^{-7}} = 0.1 \text{ V/m}$$

31. Due to greater heating as $H = I^2R$
25W get fused.
अधिक ऊष्मा के कारण चूंकि $H = I^2R$
अत: 25W बल्ब फ्यूज हो जायेगा।

32.



$$R_{bulb} = \frac{(120)^2}{60} = 240\Omega$$

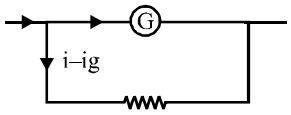
$$V_1 = \frac{120}{246}\times 240 = 117.07$$

$$R_{heater} = \frac{(120)^2}{240} = 60\Omega$$

$$V_2 = \frac{120}{54} \times 48 = 106.6$$

So change in voltage = $V_1 - V_2 \approx 10.4$ Volt

33. To increase the range of ammeter, resistance should be decreased (So additional shunt connected in parallel) so total resistance to ammeter decreases.
अमीटर की रेन्ज में वृद्धि करने के लिये प्रतिरोध घटाना होगा (अत: समान्तर क्रम में अतिरिक्त शंट जोड़ते है) इसलिये अमीटर का कुल प्रतिरोध घटता है।



EXERCISE –V-B

Single Choice

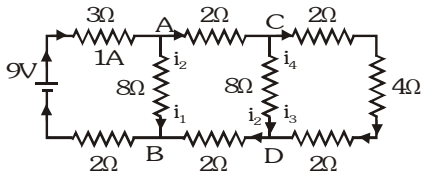
1. Net resistance of the circuit is 9Ω.

$\therefore$ current drawn from the battery,

परिपथ का नेट प्रतिरोध 9Ω है

$\therefore$ बैटरी से प्रवाहित वैद्युत धारा

$i = \frac{9}{9} = 1A$ = current through 3Ω resistor



Potential difference between A and B is

A व B के मध्य विभवान्तर

$V_A - V_B = 9-(3+2) = 4V = 8i_1$

$\therefore i_1 = 0.5$ A $\quad \therefore i_2 = 1 - i_1 = 0.5$ A

Similarly, potential difference between C and D

इसीप्रकार C व D के मध्य विभवान्तर

$V_C - V_D = (V_A - V_B) - i_2(2+2) = 4 - 4i_2 = 4 - 4(0.5) = 2V = 8i_3 \quad \therefore i_3 = 0.25$ A

Therefore, $i_4 = i_2 - i_3 = 0.5 - 0.25 \Rightarrow i_4 = 0.25$ A

2. As there is no change in the reading of galvanometer with switch S open or closed. It implies that bridge is balanced. Current through S is zero and

स्विच S के खुले या बंद होने की स्थिति में गेल्वेनोमीटर का पाठ्यांक समान रहता है। यह दर्शाता है कि सेतु सन्तुलित है। S से प्रवाहित धारा शून्य होगी तथा

$I_R = I_G$, $I_P = I_Q$.

3. Current I can be independent of R_6 only when R_1, R_2, R_3, R_4 and R_6 form a balanced wheatstone's bridge. Therefore, $\frac{R_1}{R_2} = \frac{R_3}{R_4} \Rightarrow R_1R_4 = R_2R_3$

जब R_1, R_2, R_3, R_4 व R_6 व्हीटस्टोन सेतु से सन्तुलित है तो धारा I केवल प्रतिरोध R_6 पर निर्भर नहीं करती है।

अत: $\frac{R_1}{R_2} = \frac{R_3}{R_4} \Rightarrow R_1R_4 = R_2R_3$

4. In the first case (प्रथम स्थिति में) $\frac{(3E)^2}{R} t = ms\Delta T$..(i)

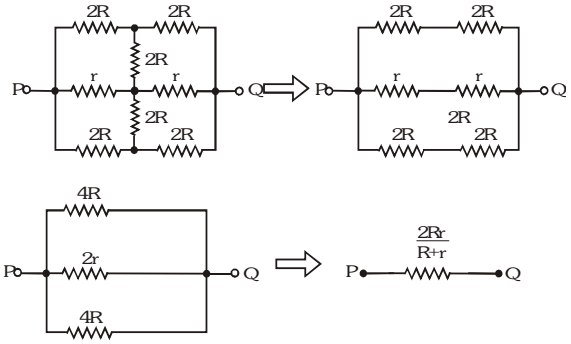
$\left[H = \frac{V^2}{R}t\right]$

When length of the wire is doubled, resistance and mass both are doubled. Therefore, in the second case (जब तार की लम्बाई दुगनी है तो प्रतिरोध व द्रव्यमान दोनो दुगने होंगे। अत:) $\frac{(NE)^2}{2R}.t = (2m)s\Delta T$ ..(ii)

Dividing eq. (ii) by (i), we get

$$\frac{N^2}{18} = 2 \Rightarrow N^2 = 36 \Rightarrow N = 6$$

5. The circuit can be redrawn as follows



6. $P = \frac{V^2}{R}$ so, $R = \frac{V^2}{P} \quad \therefore R_1 = \frac{V^2}{100}$ & $R_2 = R_3 = \frac{V^2}{60}$

Now, $W_1 = \frac{(250)^2}{(R_1+R_2)^2} \cdot R_1$ and

$W_2 = \frac{(250)^2}{(R_1+R_2)^2} \cdot R_2$ and $W_3 = \frac{(250)^2}{R_3}$

$W_1 : W_2 : W_3 = 15 : 25 : 64 \Rightarrow W_1 < W_2 < W_3$

7. Ammeter is always connected in series and voltmeter in parallel. (अमीटर को हमेशा श्रेणीक्रम में तथा वोल्टमीटर समान्तर क्रम में लगाते है)

8. The ratio $\frac{AC}{CB}$ will remain unchanged.

$\frac{AC}{CB}$ का अनुपात समान होता है।

9. $P=i^2R$ Current is same, so $P \propto R$.

In the first case it is 3r, in second case it is (2/3)r, in III case it is $\frac{r}{3}$ & in IV case the net resistance is $\frac{3r}{2}$

$P=i^2R$ धारा समान है अत: $P \propto R$.

प्रथम स्थिति में यह 3r, द्वितीय स्थिति में (2/3)r, तृतीय स्थिति में यह $\frac{r}{3}$ व IV स्थिति में नेट प्रतिरोध $\frac{3r}{2}$ होता है।

$R_{III} < R_{II} < R_{IV} < R_1 \therefore P_{III} < P_{II} < P_{IV} < P_1$

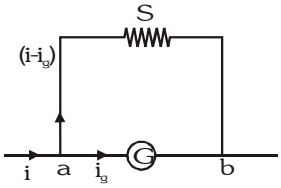
10. $R_{PQ} = \frac{5}{11}r$, $R_{QR} = \frac{4}{11}r$ and $R_{PR} = \frac{3}{11}r$

$\therefore R_{PQ}$ is maximum

11. BC, CD and BA are known resistance. The unknown resistance is connected between A and D.

BC, CD व BA ज्ञात प्रतिरोध है। A व D के मध्य अज्ञात प्रतिरोध जोड़ते है।

12. $V_{ab} = i_g.G=(i-i_g)S \quad \therefore i = \left(1+\frac{G}{S}\right)i_g$



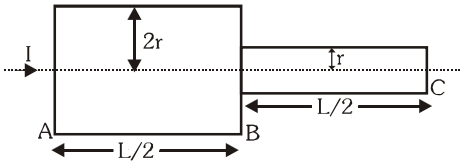
Substituting the values, we get i=100.1 mA

13. W=0. Therefore, from first law of thermodynamics, W=0. अत: ऊष्मागतिकी के प्रथम नियम से

$\Delta U = \Delta Q = i^2Rt = (1)^2 (100) (5 \quad 60)$ J = 30 kJ

14. Current in the respective loop will remain confined in the loop itself. Therefore, current through 2Ω resistance = 0. Current always flow in closed path. प्रत्येक लूप में बहने वाली धारा अपने ही लूप तक सीमित रहेगी। अत: 2Ω प्रतिरोध में धारा का मान शून्य होगा।

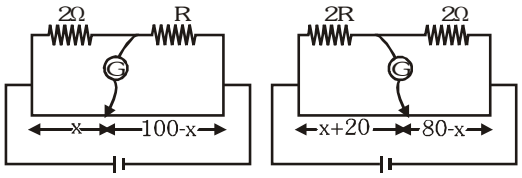
15. $H = I^2Rt \qquad I \rightarrow$ same



So $H \propto R \qquad R = \frac{\rho\ell}{\pi r^2} \qquad \rho, \ell$ same.

So $H \propto R \propto \frac{1}{r^2} \qquad H_{BC} = 4H_{AB}$

16.



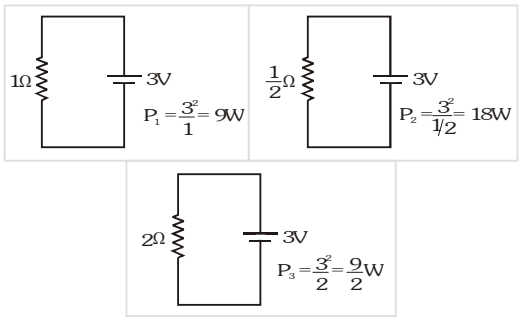
$R > 2\Omega \quad \therefore 100 - x > x$

Applying $\frac{P}{Q} = \frac{R}{S}$

We have $\frac{2}{R} = \frac{x}{100-x}$ ..(i) $\qquad \frac{R}{2} = \frac{x+20}{80-x}$ ...(ii)

Solving eq. (i) and (ii) we get $R=3\Omega$

17. Given circuits can be reduced to



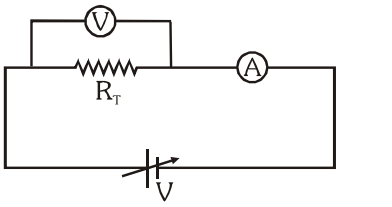
18. $P = \frac{V^2}{R}$ and 100W > 60W >

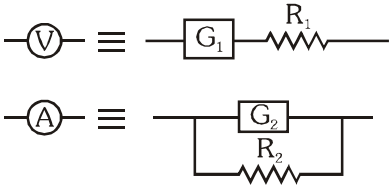
$40W \Rightarrow \frac{V^2}{R_{100}} > \frac{V^2}{R_{60}} > \frac{V^2}{R_{40}} \Rightarrow \frac{1}{R_{100}} > \frac{1}{R_{60}} > \frac{1}{R_{40}}$

[**Note** : Although (यद्यपि) 100 = 60 +40 so at room tempeature (अत: कमरे के ताप पर)

$\frac{V^2}{R_{100}} = \frac{V^2}{R_{60}} + \frac{V^2}{R_{40}} \Rightarrow \frac{1}{R_{100}} = \frac{1}{R_{60}} + \frac{1}{R_{40}}$ (Applicable Only at room temperature)
(केवल कमरे के ताप पर मान्य है)]

19.

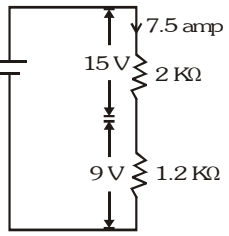




20. $R = \frac{\rho L}{A} = \frac{\rho L}{Lt} = \frac{\rho}{t} \Rightarrow$ independent of L

Multiple Choice

1. $I = \frac{V}{R_{eq}}$ 24V



$\left[R_p = \frac{1.5 \times 6}{7.5}\right]$

$I = \frac{240}{32} \Rightarrow \frac{60}{8} = 7.5$ mA

(A) Current (धारा) I is 7.5 mA

(B) Voltage drop across R_L is 9 volt

R_L के सिरो पर वोल्टता = 9 volt

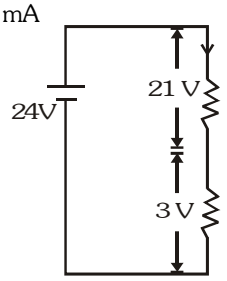
(C) $\frac{P_1}{P_2} = \frac{V_1^2}{R_1}$ $\frac{R_2}{v_2^2} = \frac{225 \times 1.2}{2 \times 81} \Rightarrow 1.6$

(D) After interchanging the two resistor R_1 and R_2 दो प्रतिरोध R_1 व R_2 बदल दिये जाने के बाद

$I = \frac{V}{R_{eq}} = \frac{2.4}{(48)} \times 7 = 3.5$ mA

$\frac{P_1}{P_2} = \frac{V_1^2}{R_1}\frac{R_L}{(v_2)^2} \Rightarrow \left(\frac{v_1}{v_2}\right)^2$

$\Rightarrow \left[\frac{9}{3}\right]^2 = 9$



Assertion - Reason

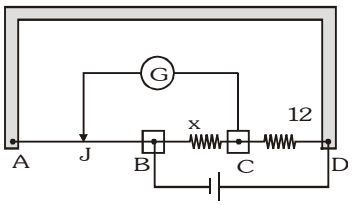
1. Ans. D

Subjective Problems

1. (i) There are no positive and negative terminals on the galvanometer because only zero deflection is needed.

यहा गेल्वेनोमीटर पर धनात्मक व ऋणात्मक टर्मिनल नहीं होते है क्योंकि केवल शून्य विक्षेप आवश्यक होता है।

(ii)



(iii) AJ = 60 cm ∴ BJ = 40 cm

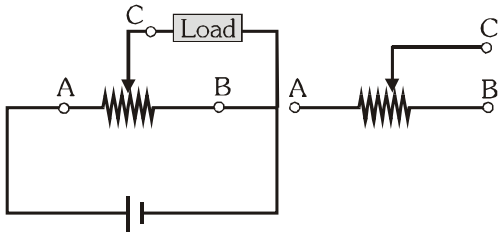
If no deflection is taking place. Then, the Wheatstone's bridge is said to be balanced,

इस स्थान पर कोई विक्षेप नहीं देता है तो हम कहेंगे कि व्हीटस्टोन सेतु सन्तुलित है। अत:

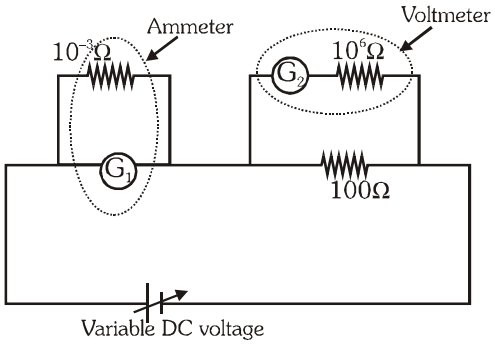
Hence, $\frac{X}{12} = \frac{R_{BJ}}{R_{AJ}} \Rightarrow \frac{X}{12} = \frac{40}{60} = \frac{2}{3} \Rightarrow x = 8\Omega$

2. The rheostat is as shown in figure. Battery should be connected between A and B and the load between C and B

धारा नियंत्रक चित्रानुसार है। बैटरी को A व B के मध्य जोड़ते है तथा लोड को C व B के मध्य



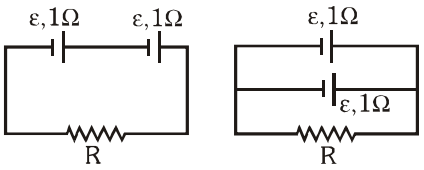
3.



4. Slide wire bridge is most sensitive when the resistance of all the four arms of bridge is same. Hence, B is the most accurate answer.

सेतु का स्लाईड तार बहुत संवेदनशील होता है जब सेतु की चारो भुजाओं पर प्रतिरोध समान हो। अत: B अधिक यथार्थ उत्तर होगा।

5.



$J_1 = \left(\frac{2\varepsilon}{R+2}\right)^2 R$ and $J_2 = \left(\frac{\varepsilon}{R+1/2}\right)^2 R$ as $\frac{J_1}{J_2} = 2.25$

so $\frac{4\varepsilon^2}{(R+2)} = 2.25\frac{4\varepsilon^2}{(1+2R)^2} \Rightarrow R = 4\Omega$