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

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

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

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

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

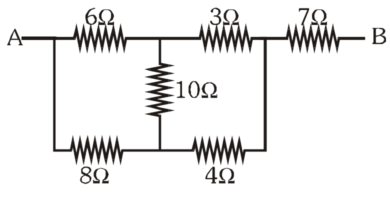
5. $R = \dfrac{\rho L}{A}\dfrac{L}{L} = \dfrac{\rho L^2}{AL} = \dfrac{\rho L^2}{V} = \dfrac{\rho L^2 d}{m}$

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

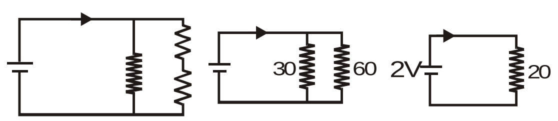
7.



Balanced Wheatstone Bridge

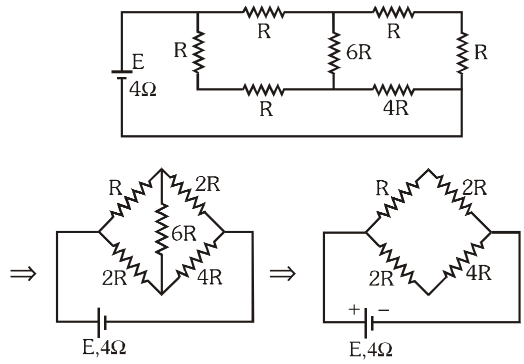
As $\dfrac{1}{9} + \dfrac{1}{12} = \dfrac{7}{36} = \dfrac{36}{7} \qquad$ So $R_{AB} = \dfrac{36}{7} + 7 = \dfrac{85\Omega}{7}$

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

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

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.

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 $P\downarrow$

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

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

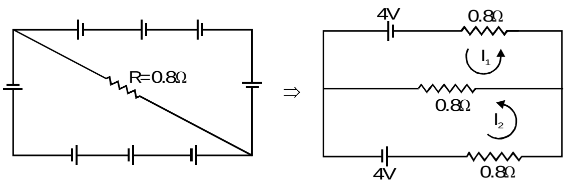
In parallel H= $\frac{V^2}{R}t \quad H \propto \frac{1}{R}$; $H_1 < H_2$

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

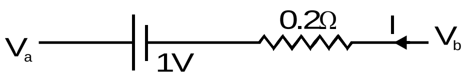
(As the battery is a storage battery it is getting charged)

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. $I_1 = I_2 = 5$
voltage difference across any of the battery.



$V_a - 1 + 0.2 \times 5 - V_b = 0$
$V_a - V_b = 0$ Volt

17. $V = IR \Rightarrow 0.2 = I\,(20)$
$I_g = 0.01A$ (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

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 $x = \left(\frac{E}{10r}\right)\left(\frac{9r}{L}\right)$

According to question

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

24. Potential gradient

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

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

25. Potential gradient

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

Effective emf of E_1 and E_2

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

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

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

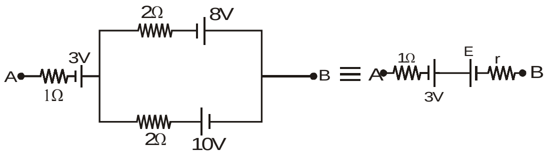
28. $P \Rightarrow \frac{V^2}{R} \Rightarrow \frac{V^2 A}{L\rho}$ ...(i)

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

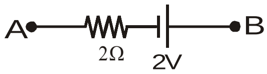
from eq. (i) & (ii) $P' = \frac{10}{9}P$

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

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.

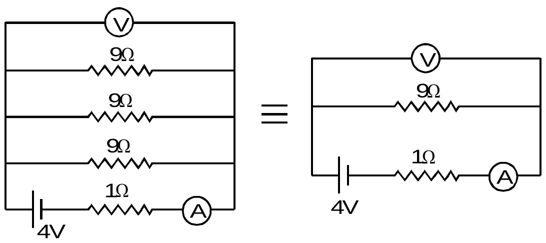
30. 

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

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

31. **Ans. (A)**

32. Given circuit can be reduced to



Reading of ammeter

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

Reading of voltmeter

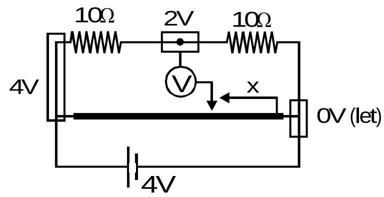
$$= 3 \times 1 = 3V$$

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

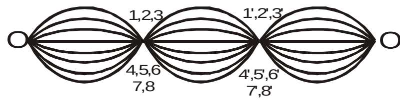
Potential difference across voltmeter,

$$V = Ir - 2$$

$\Rightarrow 2 \sin\pi t = 0.2 \times 50 \times -2 \Rightarrow 2\ \pi\cos\pi t = 10$ 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.

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

35. Total length of wire

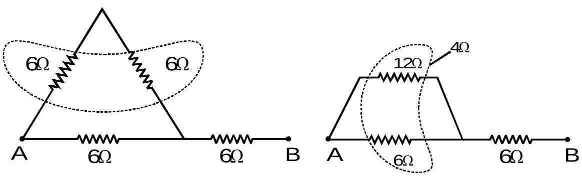
= 90 + 90 = 180 m ;

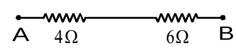
Total resistance of wire

= 180/5 = 12 Ω.

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

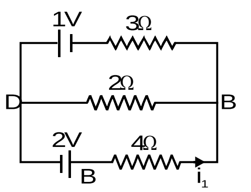
36. 

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

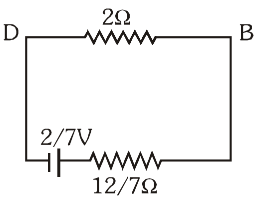
EXERCISE –II

1. Free–electron density and the total current passing through wire does not depend on 'n'.

2. $E_{eq} = \frac{E_1 r_2 - E_2 r_1}{r_1 + r_2} = \frac{2 \times 3 - 1 \times 4}{3 + 4} = \frac{2}{7}$



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



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

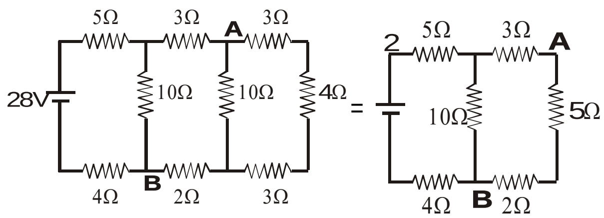
From Figure 1 :

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

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

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

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.

Power (5) = VI = 200 watt

Potential difference across both 'A' and 'B' = 0

5. $I = \frac{dq}{dt} = 2 - 16t$

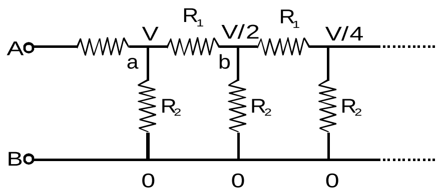
Power : $P = I^2R = (2 - 16t)^2R$

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

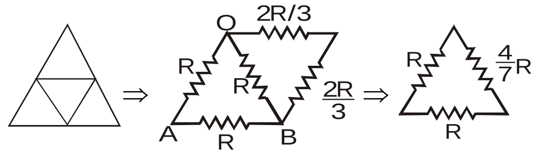
6. It is the concept of potentiometer.

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 $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

Therefore null point is independent of the battery voltage.

10. $V = E - ir \Rightarrow V = -ri + E$

Slope of graph 'V' and 'i' gives 'r' intercept of graph 'V' and 'i' gives $E \Rightarrow \tan\theta = \frac{y}{x} = r$.

11. $\Delta V = E + ir$ and in charging current flows from positive terminal to negative terminal.

12. Slope of 'V' vs 'i' graph give internal resistance

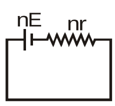
$\therefore r = 5\,\Omega$

Intercept gives the value of e.m.f. E = 10 volt

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

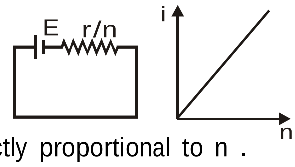
13. If n batteries are in series than the circuit can be made as

$i = \frac{nE}{nr} \Rightarrow \frac{E}{r}$



i.e. independent of n.

14. If n batteries are in parallel than the circuit can be made as $i = \frac{nE}{r}$



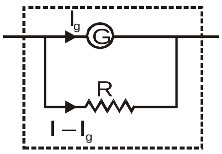
i is directly proportional to n .

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.

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

Heat $= i^2RT \Rightarrow (36)(2) = 72$ W

17. For Ammeter $I_gG = (I - I_g)\,R$



$50 \times 10^{-6} \times 100 = 5 \times 10^{-3} \times (R) \Rightarrow R \cong 1\Omega$

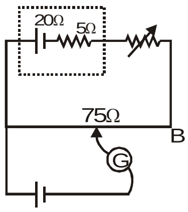
For voltmeter $I_g(R + G) = V$

$\Rightarrow 50\ \mu A\ (R + G) = 10V$

$\Rightarrow R + G = 200\ k\Omega$

$\Rightarrow R \cong 200 k\Omega$

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



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

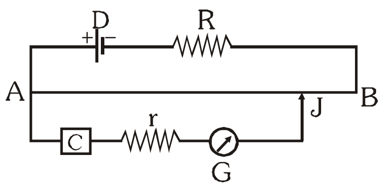
Potential $= i_{min}R_{PM} = \dfrac{1}{10} \times 75 = 7.5V$

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

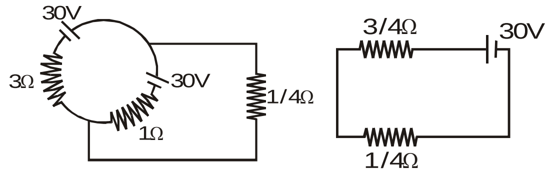
19. If e.m.f of c is greater than the e.m.f. of the 'D'

$I_r = 0$

So r does not play any role of zero deflection in galvanometer.



20.



Both 30V are in parallel

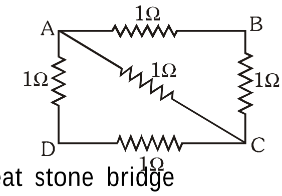
$30 - \dfrac{1}{4}i - \dfrac{3}{4}i = 0 \Rightarrow i = 30$ A

21. Assume DE $\Rightarrow R_1\Omega$

EC $\Rightarrow R_2\Omega$

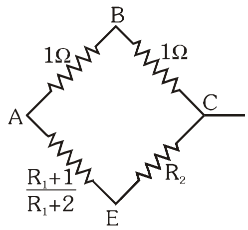
$R_1 + R_2 = 1\Omega$

$V_B = V_E$



Means balance wheat stone bridge

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



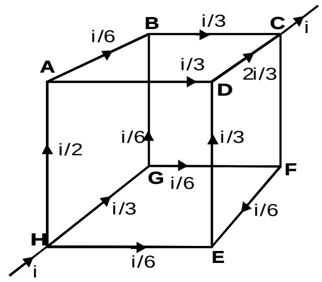
$R_2 = \dfrac{R_1+1}{R_1+2} = 1 - R_1$

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

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

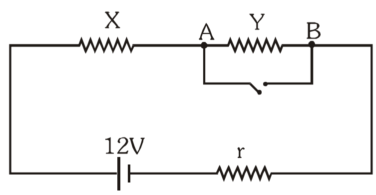
$\dfrac{CE}{ED} = \dfrac{R_2}{R_1} = \dfrac{2-\sqrt{2}}{\sqrt{2}-1} = \sqrt{2}$

22.



So current in FC=0

23.



$\dfrac{12}{X+Y+r} = 1A \Rightarrow V_x = 1 = 1 \times X \Rightarrow X = 1\Omega$

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

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

$\Rightarrow$ 10+10 r = 12 + 12 – 12r

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

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 $E_1r_2 > E_2(R + r_1)$

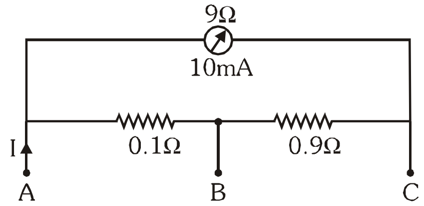
25. If all were in series all of them would have being getting discharged. But since, 2 are in opposite polarity, they will be getting charged.

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

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

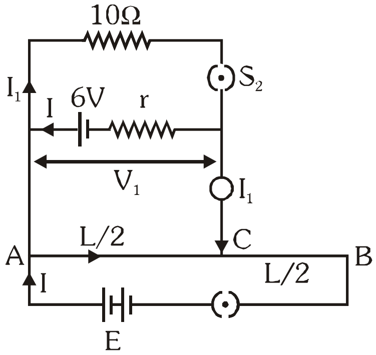
$\Rightarrow$ 990 mA = I – 10mA $\Rightarrow$ I = 1000 mA = 1A

27. When S_2 open (

Assume resistance of AB = R

Resistance of wire per unit length.

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



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

Now in AC

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

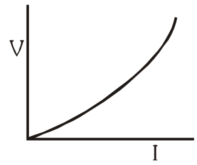
E = 12V

When S_2 closed

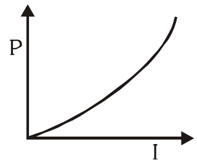
$V_1 = \frac{E}{R} \times \frac{R}{L} \times \frac{5L}{12} = \frac{5E}{12} = \frac{5 \times 12}{12} = 5V$

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

28.



$R = \frac{V}{I} = \text{slope} \uparrow$



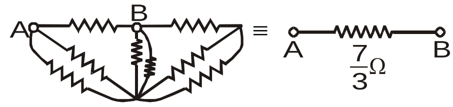
So R$\uparrow$

$P = I^2R$

R$\uparrow$ P$\uparrow$

$P \propto I^2$

29. Rearranged circuit between A & B is :



(due to symmetry)

Total resistance of circuit

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

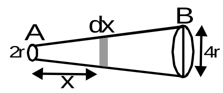
Heat produced in cell

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

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

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

30.



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

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

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

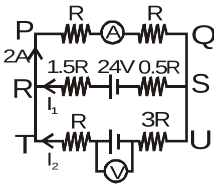
For null point

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

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

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

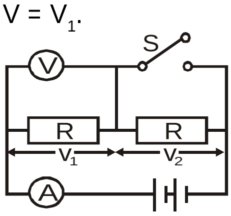
1. For potentiometer short circuit = x ℓ_1
x Depends only on primary circuit

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

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

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

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 $V = V_1$.



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

Comprehension–1

1. Power through fuse
$P = I^2R = h \times 2\pi r\ell$
h = heat energy lost per unit area per unit time

I = current.

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

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

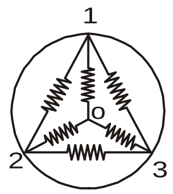
2. P = VI 20kw $\Rightarrow 2000 = \frac{V^2}{20}$

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

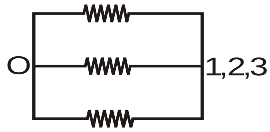
3. At maximum power delivery R = r, so η = 50%

Comprehension–2

1. As potential of 1, 2 and 3 are same potential difference across them 'zero'.



2. As 1, 2 and 3 are having same potential therefore we can draw it.



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

3. As point 1,2,3 are equipotential $\Delta V = I\,R_{12}$

$\Rightarrow \Delta V = 0$ therefore I = 0 for R_{12}, R_{23}, R_{31}

Comprehension–3

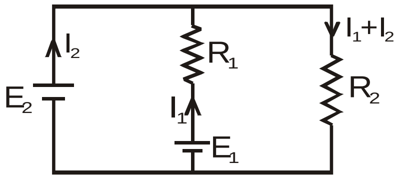
1. Current is maximum when resistance in the circuit is minimum. i.e. when S_1, S_3, S_5 are closed because then all resistances will be shortcircuited $I_{max} = \frac{V_0}{R}$.

2. After regular closing of switches, total resistance decreases gradually.

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



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

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

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

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

Comprehension–5

1. In balancing condition, current in the circuit should be zero which happens at ℓ=20 cm according to graph.

2. At balance point $\varepsilon = \frac{\ell}{100} V = \frac{20}{100} \times 6 = 1.2V$

3. At ℓ = 0, applying kirchhoff's 2nd law in the circuit containing cell, ε= IR

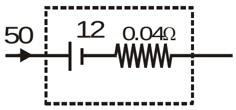
where I is the current at ℓ = 0, & ε is the emf of the cell. $\Rightarrow R = \frac{\varepsilon}{I} = \frac{1.2}{40 \times 10^{-3}} = 30\Omega$

Comprehension–6

1. V = E + ir

= 12 + (0.04) (50)

= 12 + 2 $\Rightarrow$ 14 V



2. **Ans. (A)**

Loss in power

= $i^2r = (50)^2(.04) = 100$ W

3. **Ans. (C)**

Total input

– Loss in power (

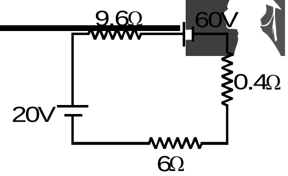
= Useful power (

Input power = 14 (50) = 700 w

Loss in power = 100 w, Rate of conversion = 600 watt

EXERCISE –IV A

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



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

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

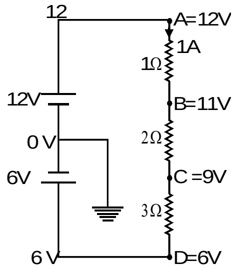
$\Rightarrow$ V = 0.5(7) = 3.5 volt

2. $\Delta V = IR$

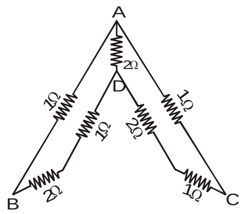
$\Delta V_{AB} = 1V$

$\Delta V_{BC} = 2V$

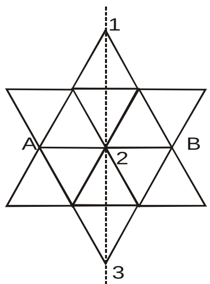
$\Delta V_{CD} = 3V$

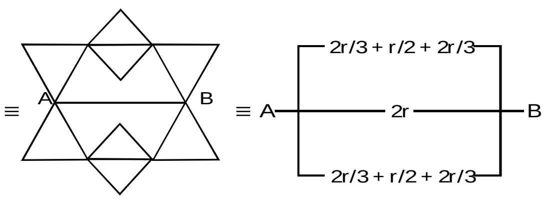


3. By symmetric path method Points E, F and B, C are Equipotential $\Rightarrow R_{AD} = 1\Omega$

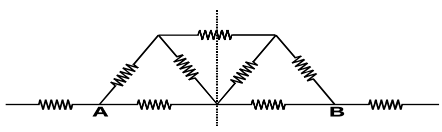


4. By perpendicular Axis symmetry all points 1, 2, 3 are at same potential therefore junction on this line can be redrawn as $R_{AB} = \frac{22}{35} R$.



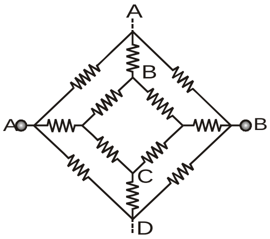


5. By applying perpendicular Axis– Symmetry

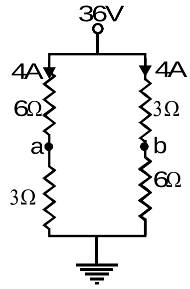


$R_{AB} = \frac{8}{7} R$

6. By applying perpendicular axis symmetry. Points lying on the line 'AD' have same potential therefore Resistance between AB and CD can be removed $R_{AB} = 9\Omega$.

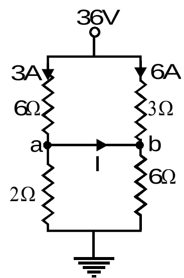


7. (i) When switch S is open



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

(ii) Total current through circuit = $\dfrac{36V}{4\Omega} = 9A$



Therefore I = 3A

8. (i) Chemical energy consumed = 3 watt

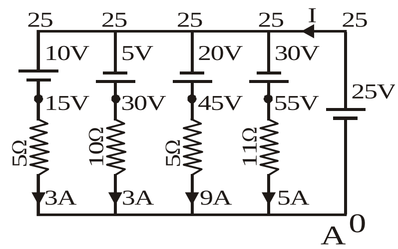
(ii) Rate of energy dissipation = i^2R = 0.4 watt

(iii) Rate of energy dissipation in resistor

= (E – ir) = 2.6 watt

(iv) The output energy to the source = 2.6 watt

9.

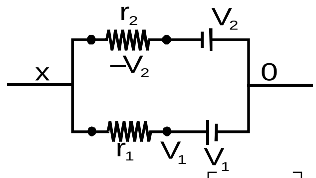


Taking point 'A' as reference potential and its potential to be '0' : I = 20 A

Power supplied by 20 V cell

$= -20 \times 1 = -20$ W

10. By applying node Analysis



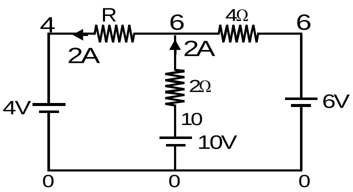
$$\frac{x+V_2}{r_2} + \frac{x-V_1}{r_1} = 0 \Rightarrow x\left[\frac{1}{r_2}+\frac{1}{r_1}\right] = \frac{V_2 r_1 - V_1 r_2}{r_1 r_2}$$

$$x = \frac{V_2 r_1 - V_1 r_2}{r_1 + r_2}, \ \frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$

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

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

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



Value of 'R' for this condition = 1Ω

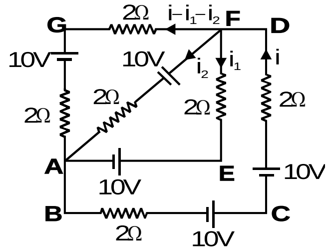
13. '2R' and 'R_x' are in series therefore R = 2R + R_x and it is in parallel with

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

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

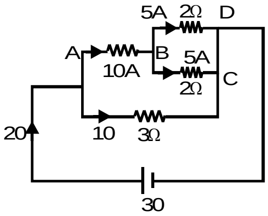
In loop ABCDFGA $20 - 4i - 10 - 4(i - i_1 - i_2) = 0$

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 = $\frac{25}{12}$ A

15. Circuit can be redrawn as



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

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

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

$Q = -\frac{i_0 T_0}{2} + i_0 T_0 = \frac{i_0 T_0}{2}$

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

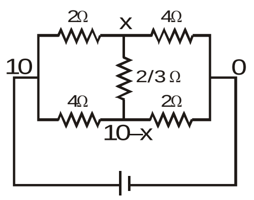
(iii) Heat = i^2Rdt [$\because$ $i = i_0\left(\frac{1-t}{T_0}\right)$]

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

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

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

17. Submission of current at the Node 'X' is

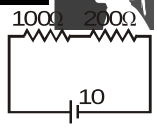


$\frac{x-10}{2} + \frac{x-0}{4} + 3\left(\frac{2x-10}{2}\right) = 0$

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

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



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

19. 5 – ir = 4 $\Rightarrow$ i = 1A

1 x R = 4 V $\Rightarrow$ R = 4 Ω

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_2x 10...(ii)

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

21. (i) Current due to primary circuit

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

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

Potential gradient = $\frac{9}{12}$

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

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

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

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

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

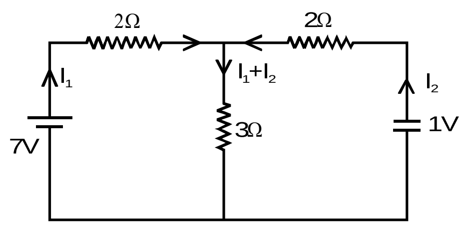
V = E – ir, iR = 3 $\Rightarrow i = \frac{3}{2}$

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

22. Power developed in it is maximum when external resistance = internal resistance.

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

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

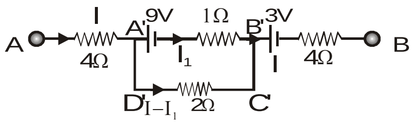
Power supplied by E_1 = a = E_1I_1 = 14W

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'

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)

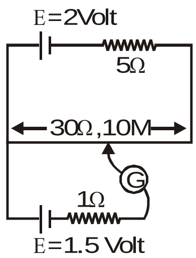
By solving (i) and (ii) Current in 2Ω resistance is 3.5A.

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) $J = \int_0^R J_0\left(\frac{r}{R}\right)2\pi r dr = \frac{J_0 2\pi}{R}\int_0^R r^2 dr = \frac{J_0 2\pi R^2}{3} = \frac{2J_0A}{3}$

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.

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

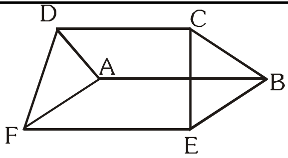
(b) S.C.$=\left(\frac{E}{R+r_1}\right)R = \left(\frac{1.5}{6}\right)5 = 1.25$

S.C. $= x\ell_2$

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

EXERCISE –IV B

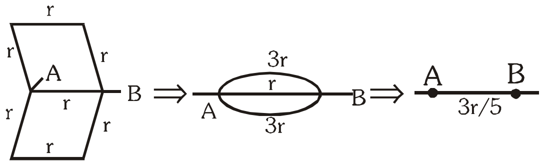
1.



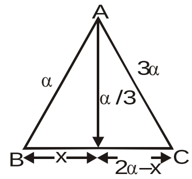
By symmetry D and F are at same potential and C and E .

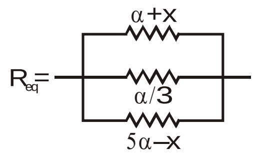
And by symmetry C and E are at same potential.

So we can removed DF and CE



2.





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

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

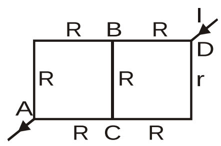
$$\frac{1}{R_{eq}} = \frac{5\alpha^2 - \alpha x + \alpha^2 + \alpha x + 15\alpha^2 - 3x^2 + 12\alpha x}{\alpha(\alpha+x)(5\alpha-x)}$$

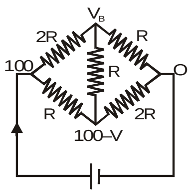
$$R_{eq} = \frac{\alpha(\alpha+x)(5\alpha-x)}{21\alpha^2+12\alpha x - 3x^2} \Rightarrow \frac{dR_{eq}}{dx} = 0$$

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

3. By applying nodal analysis at note 'B' and 'C'.

(:8'B'7'C'4 :8 7<9557 5 9)





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

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

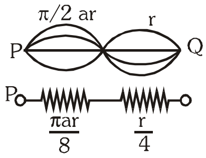
$I_{BC} = \frac{V_B - V_C}{R} = \frac{100}{7R}$

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

i.e. times the length of any side.

4. By path symmetry potential of points A,B,C,D is same.

)



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

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

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

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

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

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 -

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

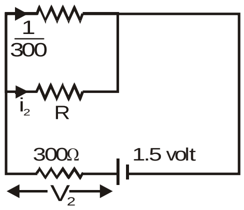
After closing the switch

$V_1 + V_2 = V$

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

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

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



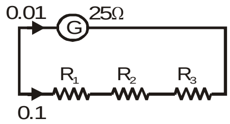
By kirchoffs first law

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

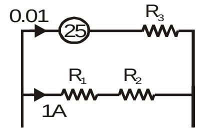
$R = 1800\left(\frac{1}{3}\right) = 600\Omega$

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

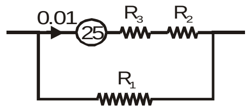
$G = 10\,(R_1 + R_2 + R_3)$...(i)



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



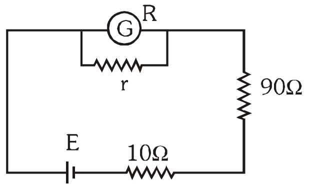
$(0.01)G = 10R_1$...(iii)



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

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

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

(i) divided by (ii)

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

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

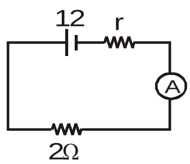
After solving R = 233.3 Ω

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 Ω



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

By solving the above equation we get the answers.

EXERCISE –V-A

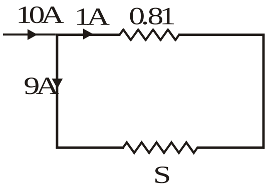
1. In order to convert an ammeter into a voltmeter, one has to connect a high resistance in series with it.

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

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

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

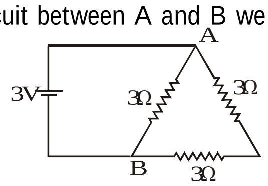
4. I_g=1A; G=0.81Ω; I=10A

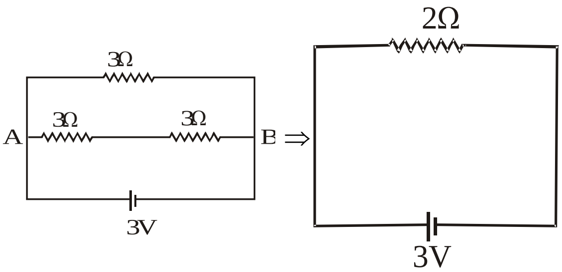


$$S = \left(\frac{I_g}{I - I_g}\right)G \; ; \; S = \frac{1}{9} \times 0.81 = 0.09\Omega$$

5. On redrawing the circuit between A and B we get

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





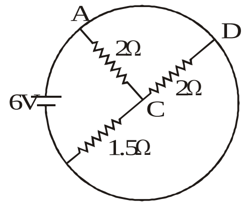
6. For a given volume, the resistance of the wire is expressed as

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

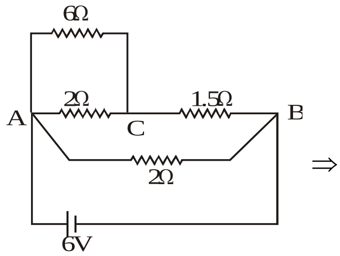
$$\frac{R_2}{R_1} = \left(\frac{2\ell}{\ell}\right)^2 = 4 \Rightarrow \frac{R_2 - R_1}{R_1} = 3$$

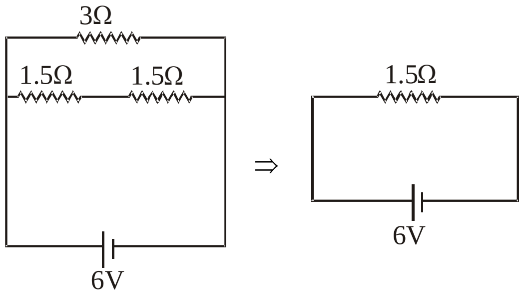
So, the change in resistance of wire will be 300%

7.



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





8. Let resistances be R_1 and R_2

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

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

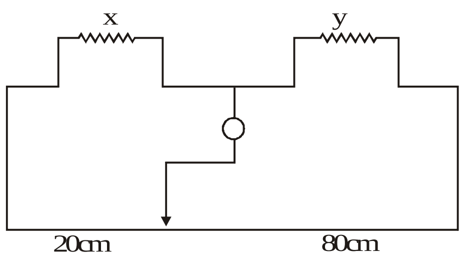
$$= \left(\sqrt{\frac{R_1}{R_1}} - \sqrt{\frac{R_2}{R_1}}\right)^2 + 4 \Rightarrow n_{min} = 4$$

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 : $I_1R_2 = I_2R_2$

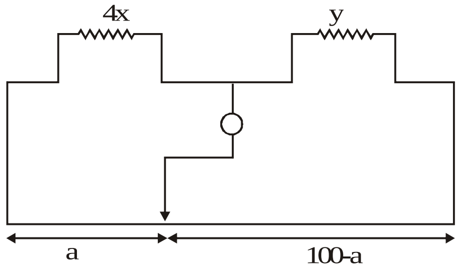
hence $\frac{I_1}{I_2} = \frac{R_2}{R_1} = \frac{\ell_2}{A_2} \times \frac{A_1}{I_1} = \frac{3}{4} \times \frac{4}{9} = \frac{1}{3}$

10.



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

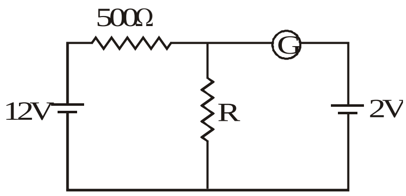
Now



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

12 Voltage across R=2V

Hence, voltage across 500Ω=10V

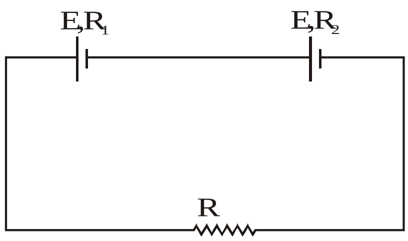


Current through 500Ω=$\frac{10}{500}=\frac{1}{50}$A

As 500Ω and RΩ are in series value of

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

13.



Current in the circuit $=\frac{2E}{R_1+R_2+R}$

potential difference across cell with R_2 resistance

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

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

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

If (   ) r>>R; I=$\frac{E}{r}$

which will be constant

15. The internal resistance of a cell

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

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.

17. Specific resistance $(\rho_B)=2\rho_A$; diameter $d_B=2d_A$

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

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

$$\frac{\ell_B}{\ell_A}=\frac{\rho_A}{\rho_B}\frac{(dia_B)^2}{(dia_A)^2}=\frac{1}{2}\times2^2=2$$

18. Given that

$R_{100^\circ C}=100\Omega$

$R_{T^\circ C}=200\Omega$

T=?

$R_{100}=R_0[1+\alpha(100)]$ ...(i)

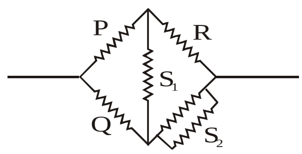
$R_T=R_0[1+\alpha T]$...(iii)

On dividing eq. (2) by eq. (1), we get

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

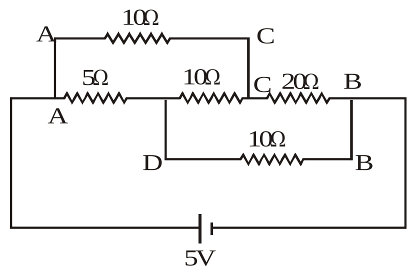
On solving, we get T=400°C

19.

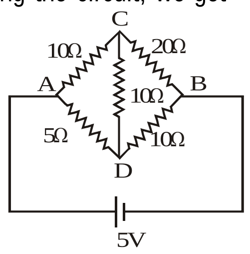


Under balanced condition

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

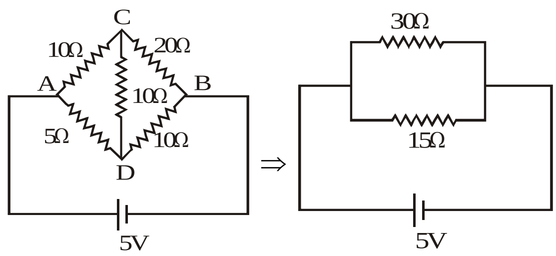
20. 

On redrawing the circuit, we get



It is a balanced Whetstone bridge having R_{eff} as

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



The current delivered by the source is

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

21. Let the resistance of the wire at 0°C is R_0 also let the temperature coefficient of resistance is α.

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

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

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

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

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

$$\alpha = \frac{1}{200}\ /\ ^\circ C$$

On replacing $\alpha = \frac{1}{200}\ /\ ^\circ C$ 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,

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

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

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

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

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

For parallel combination

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

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

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

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

using binomial expansion

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

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

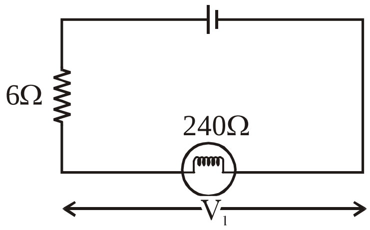
30. $i = 0.2$ A, $\rho = 4 \times 10^{-7}\ \Omega$-m, $A = 8 \times 10^{-7}\ m^2$

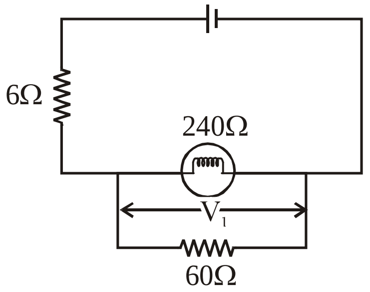
$$x = \frac{i\rho}{A} = \frac{0.02 \times 4 \times 10^{-7}}{8 \times 10^{-7}} = 0.1\ V/m$$

31. Due to greater heating as $H = I^2R$

25W get fused.

32.





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

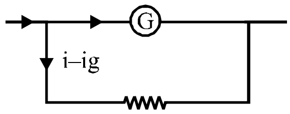
$$V_1 = \frac{120}{246} \times 240 = 117.07$$

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

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

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.



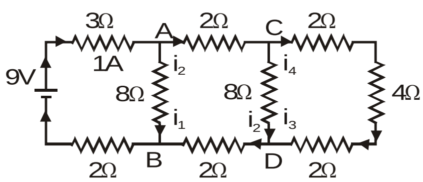
EXERCISE –V-B

Single Choice

1. Net resistance of the circuit is 9Ω.

$\therefore$ current drawn from the battery,

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



Potential difference between A and B is

$V_A - V_B = 9–(3+2) = 4V = 8i_1$

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

Similarly, potential difference between C and D

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

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

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

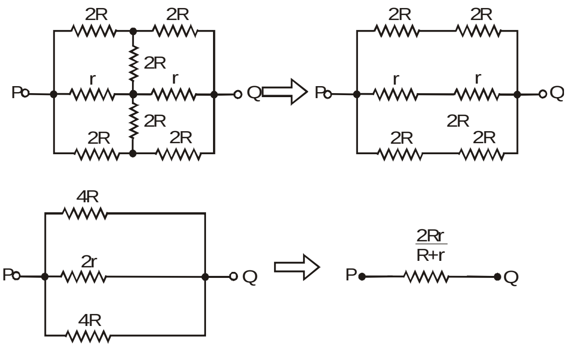
4. In the first case $\frac{(3E)^2}{R}$ t = msΔT..(i) $\left[H = \frac{V^2}{R}t\right]$

When length of the wire is doubled, resistance and mass both are doubled. Therefore, in the second case .t = (2m)sΔT ..(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, $R=\frac{V^2}{P}$ $\therefore R_1 = \frac{V^2}{100}$ & $R_2=R_3 = \frac{V^2}{60}$

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.

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

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 $\frac{3r}{2}$

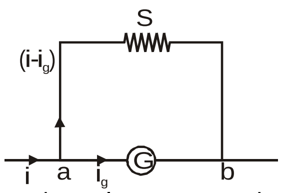
$R_{III} < R_{II} < R_{IV} < R_1 \therefore P_{III} < P_{II} < P_{IV} < P_1$

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.

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

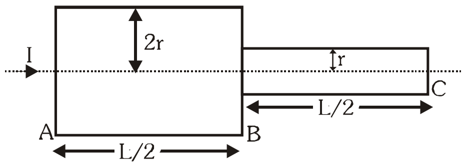


Substituting the values, we get i=100.1 mA

13. W=0. Therefore, from first law of thermodynamics, $\Delta U = \Delta Q = i^2Rt = (1)^2 (100) (5 \times 60)$ 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.

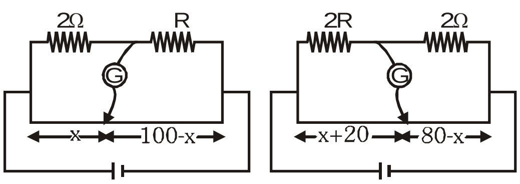
15. $H = I^2Rt \qquad I \rightarrow$ same



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.



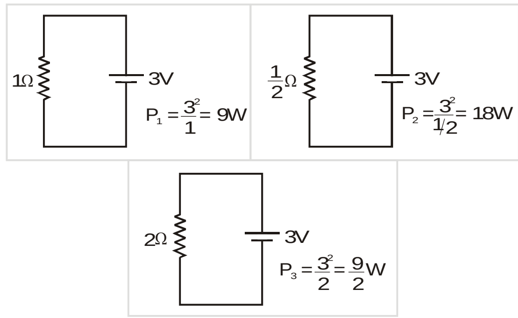
$R > 2\Omega \quad \therefore 100 - x > x$

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

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

Solving eq. (i) and (ii) we get R=3Ω

17. Given circuits can be reduced to



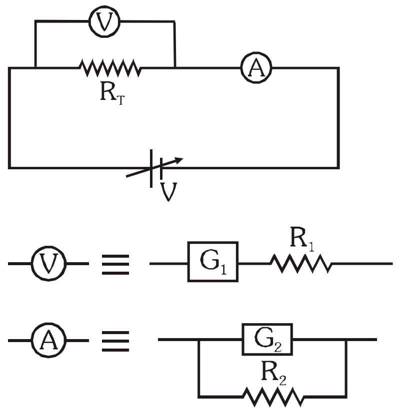
18. $P = \frac{V^2}{R}$ and 100W > 60W >

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

[**Note :** Although 100 = 60 +40 so at room tempeature

$\frac{V^2}{R_{100}} = \frac{V^2}{R_{60}} + \frac{V^2}{R_{40}} \Rightarrow \frac{1}{R_{100}} = \frac{1}{R_{60}} + \frac{1}{R_{40}}$ (Applicable Only at room temperature)

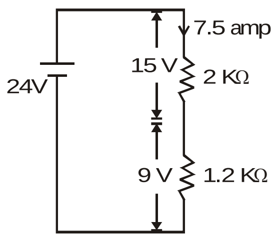
19.



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

Multiple Choice

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



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

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

(A) Current I is 7.5 mA

(B) Voltage drop across R_L is 9 volt

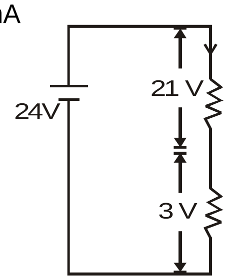
(C) $\dfrac{P_1}{P_2} = \dfrac{V_1^2}{R_1} \times \dfrac{R_2}{v_2^2} = \dfrac{225 \times 1.2}{2 \times 81} \Rightarrow 1.6$

(D) After interchanging the two resistor R_1 and R_2

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

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

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



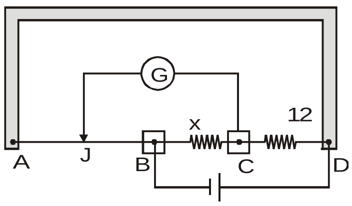
Assertion - Reason

1. Ans. D

Subjective Problems

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

(ii)

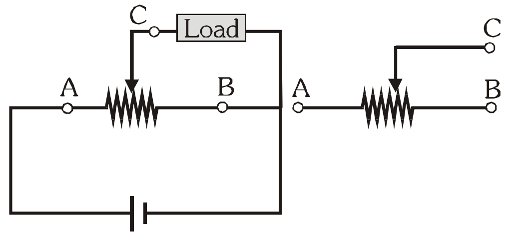


(iii) AJ = 60 cm $\quad \therefore$ BJ = 40 cm

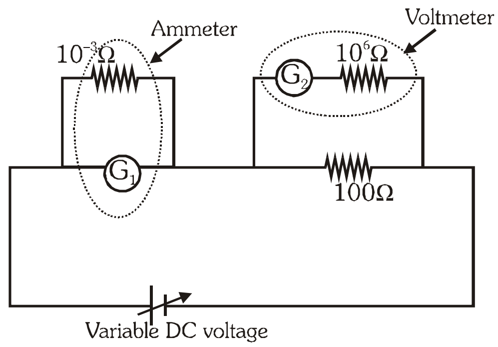
If no deflection is taking place. Then, the Wheatstone's bridge is said to be balanced,

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

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

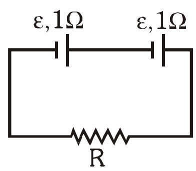


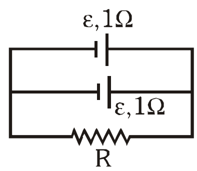
3.



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.

5.





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

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