Solutions to "In-chapter Excercises" Learning Chemistry

Questions based on 'concepts learned so far'

Solⁿ: 1 Number of free charge particles per unit volume

$$n = \frac{\text{total free charge particles}}{\text{total volume}}$$

$\because$ Total free electrons = total number of atoms

[$\because$ number of free electron per atom is one]

Total free electrons $= \frac{N_A}{M_W} \times M$

$$\text{so } n = \frac{\frac{N_A}{M_W} \times M}{V} = \frac{N_A}{M_W} \times d = \frac{6.023 \times 10^{23} \times 10^4}{100 \times 10^{-3}}$$

$$\boxed{n = 6.023 \times 10^{28} \ m^{-3}}$$

~~Solⁿ 2~~

~~time = displacement / drift velocity = S / V_d~~

~~$\therefore$ V_d = 1 mm/sec = 10^{-3} m/sec~~

~~S = 1 m~~

~~time = 1/10^{-3} = 10^3 sec~~

~~distance travelled = speed x time~~

~~$\therefore$ speed = 10^6 m/sec~~

~~so required distance = 10^6 x 10^3 m = 10^9 m~~

Solⁿ: 2 We know $R = \frac{\rho l}{A} = \frac{\text{Resistivity} \times \text{length}}{\text{Area of cross section}}$

$$\boxed{R_{AB} = \frac{\rho c}{ab}, \quad R_{CD} = \frac{\rho b}{ac}, \quad R_{EF} = \frac{\rho a}{bc}}$$

Solⁿ: 3 As we know that $R = \frac{\rho l}{A}$

In case $R' = \frac{\rho l'}{A'}$

$l' = 2l$

$A' l' = A l$ (Volume of wire remains constant)

$A' = A/2 \Rightarrow R' = \frac{\rho \times 2l}{A/2} = 4R$

$$\therefore \boxed{R' = 4R}$$

$\underline{Sol^n 4:}$ $R = \frac{\rho l}{A}$ and $\frac{R_1}{R_2} = \frac{l_1^2}{l_2^2}$ since volume is const.

~~$\frac{\Delta R}{R} = \Delta l$~~

hence $\frac{R_2 - R_1}{R_1} \times 100 = \left[\frac{\left(1 + \frac{x}{100}\right)^2 - 1}{1} \right] \times 100$

[for $x\%$ increment in length]

If x is small

$\frac{R_2 - R_1}{R_1} \times 100 \approx 2x\%$. [here $x = 1\%$]

hence $\boxed{\text{Ans} := 2\%}$

$\underline{Sol^n 5:}$

change in resistance is small

$\therefore R = R_0(1 + \alpha \Delta T)$

$\Rightarrow 1.2 = 1 \times (1 + 10^{-2} \Delta T)$

$0.2 = 10^{-2} \Delta T$

$\Rightarrow \Delta T = 20^\circ C \Rightarrow T_2 - T_1 = 20^\circ C \Rightarrow \boxed{T_2 = 40^\circ C}$

$\underline{Sol^n 6:}$ ~~$V_C - V_D$~~ $V_C - V_D = iR$

$\Rightarrow (10 - 4) = i(2)$

$\Rightarrow \boxed{i = 3A}$

$\underline{Sol^n 7:}$ All resistors are in series $R_{eq} = 6\Omega$

$i = \frac{V}{R_{eq}} = \frac{30}{6} = 5A$

$\boxed{i = 5A}$

$\underline{Sol^n 8:}$ ~~R_{eq}~~ $\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$ [since All resistors are in parallel]

$\frac{1}{R_{eq}} = \frac{3+2+1}{6} \Rightarrow R_{eq} = 1$

So current passing through battery $= \frac{V}{R_{eq}} = \frac{30}{1} = 30A$

potential diff across 2Ω Resistor $= 30V$

hence current through 2Ω resistor $= \frac{30}{2} = 15A$

" " 3Ω resistor $= \frac{30}{3} = 10A$

" " 6Ω resistor $= \frac{30}{6} = 5A$

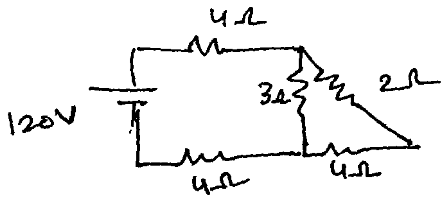
Sol^n 9: $R_{eq} = 1 + 1 = 2\Omega$

hence $i = \frac{30}{2} = 15A$ $\boxed{i = 15A}$

Sol^n 10:

2Ω, 1Ω in series $= 3\Omega$

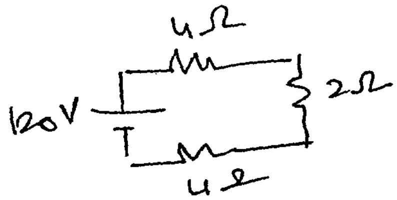
this 3Ω, 6Ω are in parallel $\Rightarrow \frac{3 \times 6}{3+6} = 2\Omega$



Now 2Ω, 4Ω in series $= 6\Omega$

6Ω in parallel with 3Ω

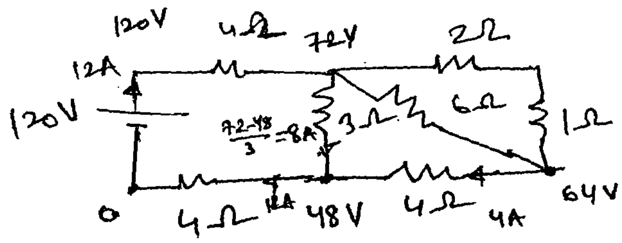
$= 2\Omega$



$\Rightarrow R_{eq} = 4 + 2 + 4 = 10\Omega$

$i = \frac{120}{10} = 12A$

~~Current~~ Assign potential to diff. points & use Kirchhoff's law



hence current through 6Ω

$= \frac{72-64}{6}$

$= \frac{8}{6} = 4/3$

So remaining current will pass through 2Ω hence current in 2Ω

$= 12 - (8 + 4/3)$

$= 4 - 4/3 = \underline{\underline{8/3\,A}}$ Ans.

$\boxed{\text{current in } 2\Omega = \frac{8}{3}A}$

Sol^n 11:

(i) $\frac{V^2}{R} = 100 \Rightarrow R = \frac{(220)^2}{100} = 484\,\Omega$ $\boxed{R = 484}$

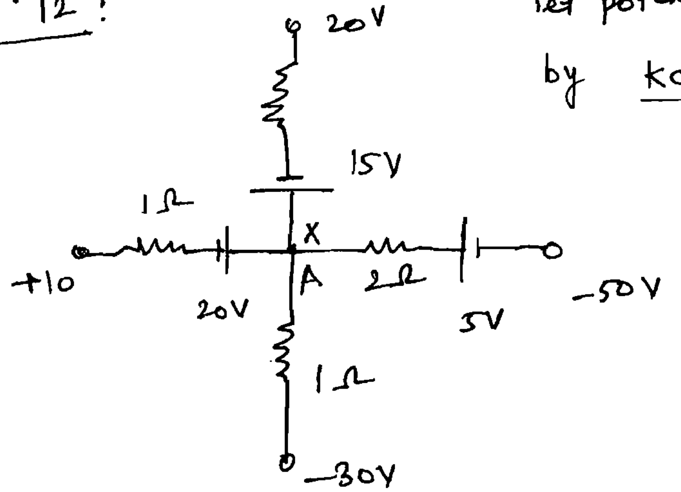
Since Resistance depends only on material hence it is consta for bulb.

(ii) $I = V/R = \frac{220}{484} = \frac{5}{11}$ Amp. $\boxed{i = \frac{5}{11}\text{ Amp}}$

(iii) Power consumed at 110 volt

$= \frac{(110)^2}{484} = 25W$ $\boxed{P = 25W}$

Sol^n 12:



let potential at $A = x$

by KCL at juction A

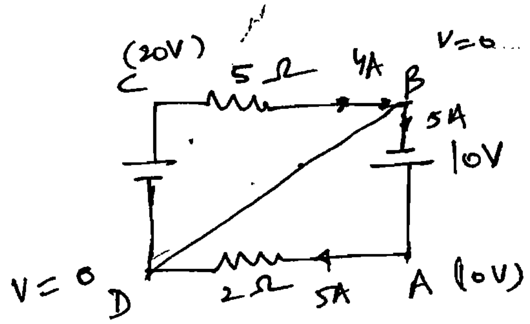
$$\frac{x-20-10}{1} + \frac{x-15-20}{2} + \frac{x+45}{2} + \frac{x+30}{1} = 0$$

$$\Rightarrow 6x + 10 = 0$$

$$\Rightarrow x = -5/3$$

$$\boxed{\text{Potential at } A = -\frac{5}{3}V}$$

Sol^n 13:



let at D potential = 0

hence current in CB

$$= \frac{20-0}{5} = 4 \text{ Amp.}$$

current in AD [same as BA]

$$= \frac{10-0}{2} = 5A.$$

hence at junction 'B' by KCL

Current in BD = 1 A from D to B.

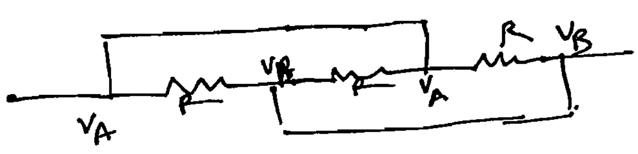
Sol^n 14: $R_1 = \frac{(200)^2}{50}$ $R_2 = \frac{(200)^2}{100}$ $R_3 = \frac{(200)^2}{25}$

hence $i = \frac{200}{R_1+R_2+R_3} = \frac{100}{200\times7} = \frac{1}{14}$ A

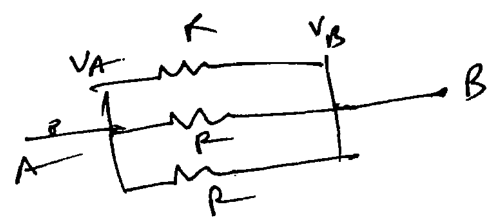
Since higher resistance, will glow more ($\because$ I same)

B_3 will glow more.

Sol^n 15:



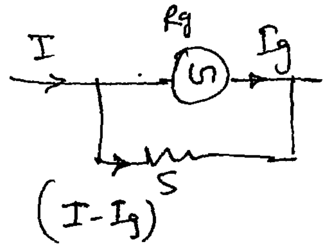
So we can have modified circuit as



So $\boxed{R_{eq} = \frac{R}{3}}$

Ex-II Questions based on concepts learned so far

1.

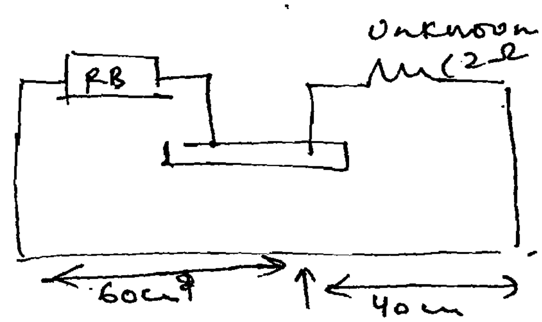


$R_g I_g = (I - I_g) S$

$\Rightarrow 99 \times \frac{I}{10} = \left(I - \frac{I}{10} \right) S$

$\Rightarrow \boxed{S = 11\,\Omega}$

2.



$\frac{R}{60} = \frac{2}{40} \Rightarrow \boxed{R = 3\,\Omega}$

3.

$i_g R_g = (i - i_g) S$

$\Rightarrow S = \frac{i_g R_g}{i - i_g} = \frac{1 \times 10^{-3} \times 20}{49 \times 10^{-3}} = \frac{20}{49}\,\Omega$

4. (B)

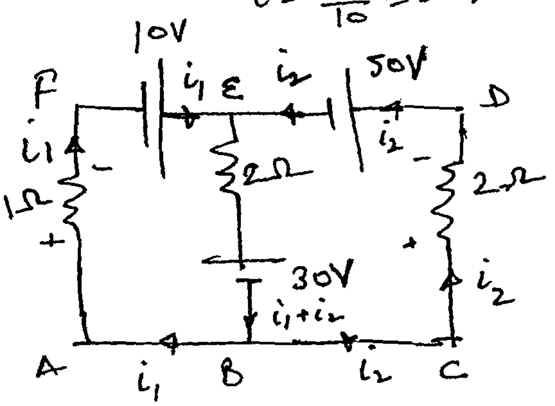
5. (A)

6. All elements are in series same current

$\varepsilon_{eq} = 25\text{ V} \qquad R_{eq} = 4+3+2+1 = 10$

$i = \frac{25}{10} = 2.5\text{A}$

7.



KVL in ABEFA

$i_1 \cdot 10 + 2(i_1 + i_2) + 30 = 0$

$\boxed{3i_1 + 2i_2 + 20 = 0}$ — (1)

KVL in BEDCB

$30 + 2i_2 + 50 + 2(i_1 + i_2) = 0$

$\Rightarrow 4i_2 + 2i_1 + 80 = 0$

$\Rightarrow \boxed{2i_2 + i_1 + 40 = 0}$ — (2)

Solving (1) and (2)

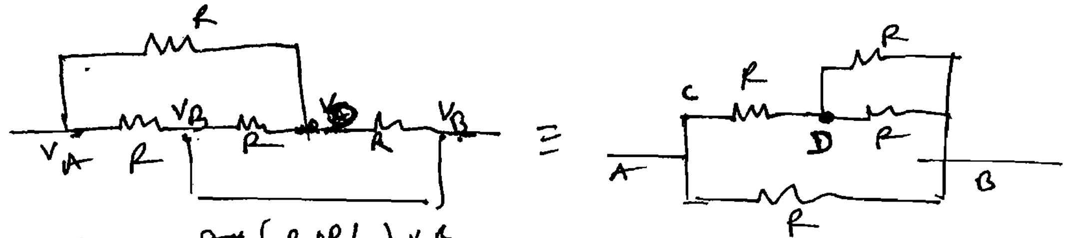
$i_1 = 10\text{A}\,,\; i_2 = -25\text{A}$

current in wire AF = 10A from A to F

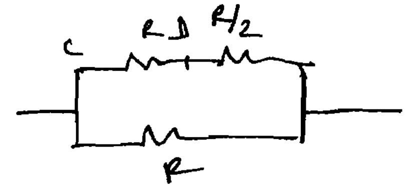
— " — EB = 15A from B to E

— " — DE = 25A from E to D

Sol^n 8



$$R_{eq} = \frac{\left(R+R/2\right)\times R}{\frac{3R}{2}+R} = \frac{3R}{5}$$



$$i = \frac{\mathcal{E}(5)}{3R} = \frac{5E}{3R}$$

current in CD

(inverse ratio of resistance) $= i\,\dfrac{R}{(3R/2)+R}$

$$= \frac{\cancel{5}E}{3}\times\frac{2}{\cancel{5}R}$$

$$= \frac{2E}{3R}$$

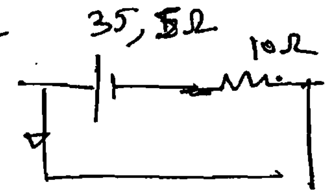
Ans!

Sol^n 9 :

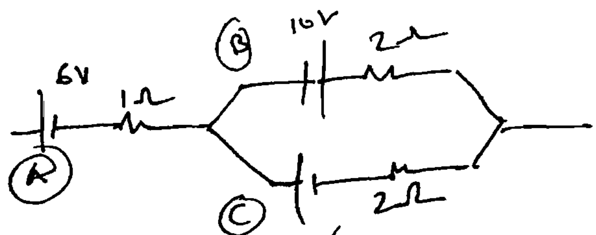
$\mathcal{E}_{eq} = 35\,V$

$R_{eq} = 4+1+8+1+1+2+2+1 = 15\,\Omega$

$i = \frac{35}{15} = \frac{7}{3}\,A$ Ans:



Sol^n 10 :

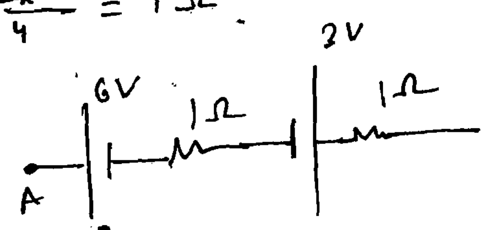


(B) & (C) are in parallel with opposite polarity. So

$$\mathcal{E}_{eq} = \frac{\mathcal{E}_1 r_2 - \mathcal{E}_2 r_1}{r_2+r_1} = \frac{10-4}{2} = 3\,V$$

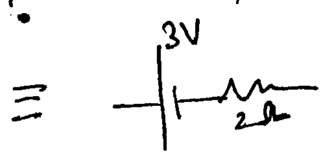
$$r_{eq} = \frac{2\times 2}{4} = 1\,\Omega$$

hence



$\mathcal{E}_{eq} = 3V$

$r_{eq} = 2\,\Omega$



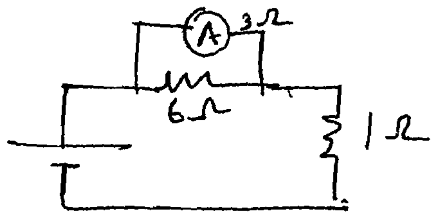
Sol^n (11)

full scale current $= i_g = V/G$

to change its range

$$V_1 = (G+R_s)\,I_g \Rightarrow nV = (G+R_s)\,V/G$$

(12)



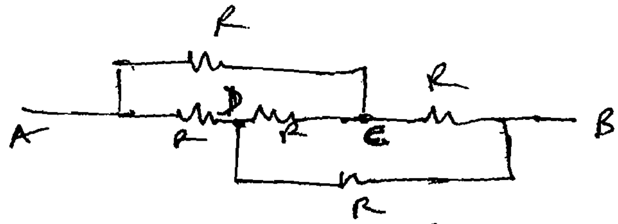
$R_{eq} = \left(\frac{3\times 6}{3+6}\right)+1 = 3\,\Omega$

current from battery $= \frac{18}{3} = 6\,A$

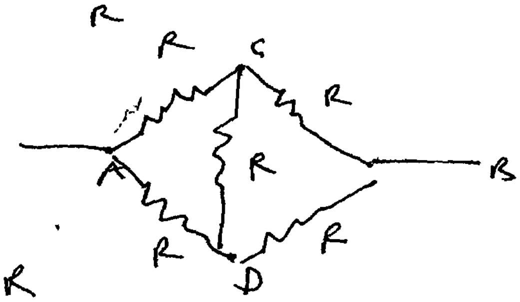
$\therefore$ current from Ammeter $= 6 \times \frac{6}{9} = 4\,A$

No, Its not the current through the 6 Ω resistor.
[$\because$ Ammeter is not in series with 6 Ω]

(13)



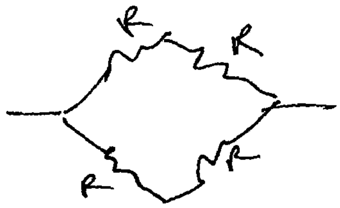
this can be Modified



this is balanced Wheatstone bridge

hence

$\equiv$



$\boxed{R_{eq} = R}$

(14) balanced wheatstone bridge hence can remove 20 Ω resistor.

$R_{eq} = \frac{16\times 8}{16+8} = \frac{16}{3}\,\Omega$

(15) by symmetry C, O and D will have same potential hence
~~Con Res~~ CO & OD will have zero current.
so we can remove and can find Req easily.

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

1| In series current will remain same

hence $n_1 \cancel{e} \cancel{A} V_{d_1} = n_2 \cancel{e} \cancel{A} V_{d_2}$ ($\because$ Area same)

$\Rightarrow \frac{V_{d_1}}{V_{d_2}} = \frac{n_2}{n_1}$ hence Ans (c) 4 : 1

2| $I = neAV_d$ —(1)

$I' = neA'V_d'$ —(2) [$\because$ same material hence n will remain same]

by (1) and (2)

$\Rightarrow I' = \left(\frac{A'}{A}\right)\left(\frac{V_d'}{V_d}\right) I$

$= \left(\frac{\pi (r/2)^2}{\pi r^2}\right)\left(\frac{2V}{V}\right) I = I/2$ Ans: (c) $I/2$

3| By convention current moves in the direction of positive charge flow. due to potential difference positive ions and negative ions will move in opposite direction. Hence both current will add up to give net current.

Due to +ive ion flow $I_1 = n(2e)A(V/4)$

— " — -ive ion flow $I_2 = neAV$

$I = I_1 + I_2 = neA\frac{V}{2} + neAV = \frac{3neAV}{2}$

4| $\sigma = \frac{1}{\rho}$ (Relation b/w resistivity and conductivity)

Ratio (z) of resistivity to conductivity $= \frac{\rho}{\sigma}$

$\Rightarrow z = \rho^2$ as $T\uparrow$, $\rho\uparrow$ hence $z\uparrow$

5| n & I both same

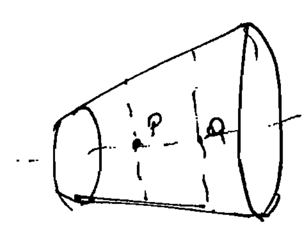
$ne\left(\frac{\pi d^2}{4}\right)V = ne\left(\pi (d/4)^2\right)V'$ $\Rightarrow \boxed{V' = 4V}$ Ans:

$\Rightarrow V' = \frac{16}{4}V = 4V$

6| Current is same through conductor. n is same Also.

Hence $I = neAV_d$

as $A\downarrow$ $V\uparrow$



$\therefore V_P > V_Q$ [Cross-section Area at P < cross section Area at Q]

7| $n = p$ (given), $A = S$, $e = v$

$I = neAV_d$

$I = pqSV_d$

$$\boxed{V_d = i/pqs}$$

8| free electrons move with a very high speed in comparison with metal ions (only vibrates)

hence $\boxed{K_1 > K_2}$. [K.E. of conduction electrons is more]

9| $I_{av} = \frac{\Delta Q}{\Delta t}$

$$\Rightarrow I = \frac{Q}{(2\pi/\omega)} \Rightarrow \boxed{I = \frac{Q\omega}{2\pi}}$$

10| As temp. Increases, the thermal vibrations in the lattice increase causing more electron scattering therefore more collisions will take place, slowing down the electron flow. As Temp. ↑, No Additional charge carriers can generate since free electrons in a metal is const. Scattering is the cause for Increase in resistance. (collisions ~~due~~ with metal ions will ~~more~~ slow down electron flow, relatively more).

11| Resistance ↓ hence $i = V/R$, current increases

12| $R_a = \frac{\rho_a l_a}{A_a}$ $R_b = \frac{\rho_b l_b}{A_b}$

hence we can't deduce a relation b/w ρ_a and ρ_b without any information abt l_a, A_a, l_b and A_b.

13| Product (z) of resistivity and conductivity $= \rho\sigma$

$\because \sigma = \frac{1}{\rho} \Rightarrow z = \rho \cdot \frac{1}{\rho} = 1$

$\Rightarrow \boxed{z=1}$ (const.) [No effect of temperature on the product]

hence as $T \uparrow$ z is const.

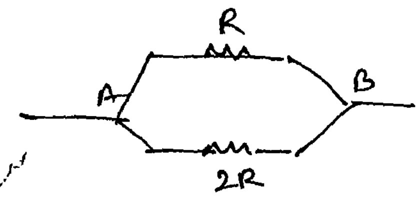
14| During charging of a battery, positive charge enters the battery at the positive terminal, moves inside the battery to the negative terminal.

15| $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 \quad r_{eq} = r_1 + r_2$

(hence 1 is correct but 2 is wrong)

16| $P = \frac{V^2}{R}$ since V is same

as $R \downarrow \quad P \uparrow$

17| 

$P_R = \frac{V_{AB}^2}{R}$

$P_{2R} = \frac{V_{AB}^2}{2R}$

$P_R : P_{2R} = 1 : \frac{1}{2}$

$P_R : P_{2R} = 2 : 1$

18| By Max^m Power Transfer Theorem

$R = r$

19| $\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$ —(1) , $r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$ —(2)

by eq^n (1) ε_{eq} will be greater than smaller of the two emfs

$\varepsilon_{eq} = \varepsilon$ If $\varepsilon_1 = \varepsilon_2 = \varepsilon$

by eq^n (2) $r_{eq} < r_1$

Also $r_{eq} < r_2$.

hence Given statement (2) is correct but 1 is wrong.

20| If polarity of n cells is reversed in N cells in series combinatio

$\varepsilon_{eq} = E_0 = (N - 2n)E$

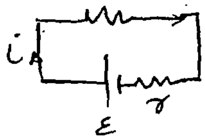
$r_0 = r + r + r - - - N$

$= Nr$

Ans;

21| for 1 case

Potential difference between the terminals $= 1.6V$



$i = \frac{\varepsilon}{R+r}$

since Potential diff. across terminal $= \varepsilon - ir$

hence $\varepsilon - \left(\frac{\varepsilon}{4+r}\right) r = 1.6$ —— (1)

similarly $\varepsilon - \left(\frac{\varepsilon}{9+r}\right) r = 1.8$ —— (2)

by (1) and (2)

$4+r = 4\varepsilon/1.6$

$9+r = 9\varepsilon/1.8$

$\Rightarrow 1.6\left(\frac{4+r}{4}\right) = 1.8\left(\frac{9+r}{9}\right)$

$\Rightarrow 1.6 + 0.4r = 1.8 + 0.2r$

$\Rightarrow 0.2r = 0.2$

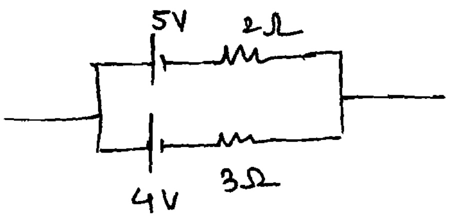
$\Rightarrow \boxed{r = 1}\,\Omega$

by eq^n (1) $\quad 4+1 = \frac{4\varepsilon}{1.6}$

$\Rightarrow 4\varepsilon = 8$

$\Rightarrow \boxed{\varepsilon = 2 \text{ Volt}}$

22|



$E_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$

$= \frac{5(3) + 4(2)}{5}$

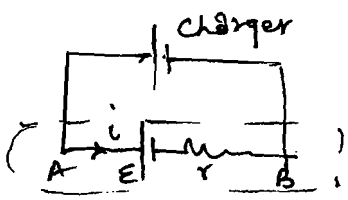
$= \frac{23}{5} = 4.6$ Volt

23| since battery is charging

$\varepsilon + ir = 12.5$

$\varepsilon + (1)(0.5) = 12.5$

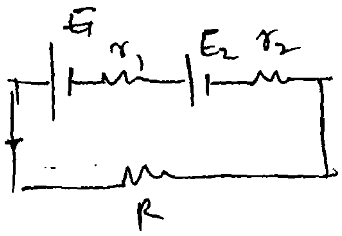
$\Rightarrow \boxed{\varepsilon = 12 \text{ Volt}}$



$V_A - \varepsilon - ir = V_B$

$\Rightarrow V_A - V_B = \varepsilon + ir$

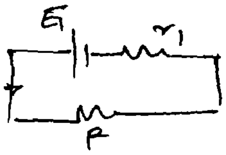
24|



Initially current through R

$\Rightarrow I_1 = \frac{E_1 + E_2}{R + r_1 + r_2}$

After short circuiting the battery



$I_2 = \frac{E_1}{R + r_1}$

condition such that

$$I_2 > I_1$$

$$\Rightarrow \frac{E_1}{R+r_1} > \frac{E_1+E_2}{R+r_1+r_2}$$

$$\Rightarrow E_1R + E_1r_1 + E_1r_2 > E_1R + E_2R + E_1r_1 + E_2r_1$$

$$\Rightarrow E_1r_2 > E_2R + E_2r_1$$

$$\Rightarrow E_1r_2 > E_2(R+r_1)$$

Ans:

25| n identical cells in series connection & terminals ~~...~~ of battery containg cells is short circuited.

hence $\varepsilon_{eq} = n\varepsilon$

$r_{eq} = nr$

hence $i = \frac{\cancel{n}\varepsilon}{\cancel{n}r}$

$i = \varepsilon/r$ = const. [doesnot depend on 'n']

hence graph of i/A will show the same nature (A is const.) Vs 'n'.

26| for the Above example. If cells are in parallel

$\varepsilon_{eq} = \varepsilon$

$r_{eq} = r/n$

$\Rightarrow \boxed{i = \frac{n\varepsilon}{r}}$ hence current changes Linearly with 'n'.

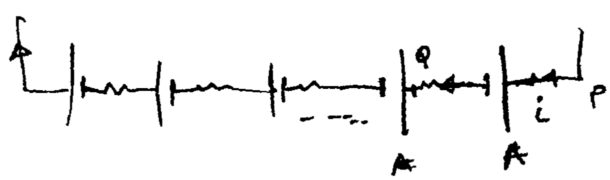
27| Out of 'n' cells two cells having reversed polarity.

$\boxed{\varepsilon_{eq} = (n-2)\varepsilon - 2\varepsilon}$

$\Rightarrow \varepsilon_{eq} = (n-4)\varepsilon$

$r_{eq} = nr$

$i = \frac{(n-4)\varepsilon}{nr}$



Potential drop across A

$= V_P - V_Q$

$V_P - \varepsilon - ir = V_Q$

$\Rightarrow V_P - V_Q = \varepsilon + ir$

$= \varepsilon + ir$

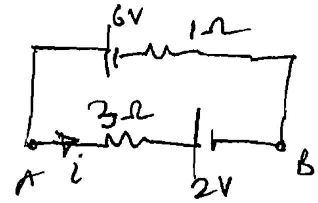
$= \varepsilon + \left(\frac{n-4}{n}\right)\varepsilon$

$= \frac{2n\varepsilon - 4\varepsilon}{n}$

$= 2\varepsilon - \frac{4\varepsilon}{n}$

$= 2\varepsilon\left(1 - \frac{2}{n}\right)$ Ans.

$\varepsilon_{eq} = 6 - 2 = 4V$



$r_{eq} = 4\Omega$

$i = \frac{4}{4} = 1$ Amp

$V_A - 3 - 2 = V_B$

$\boxed{V_A - V_B = 5V}$

29|

Terminal voltage $= \varepsilon - ir$

or can be $\varepsilon + ir$

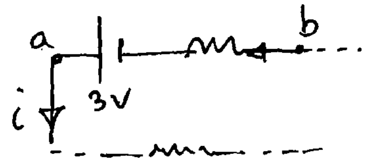
or can be zero If $\varepsilon - ir = 0$

hence can be $> \varepsilon$

can be $< \varepsilon$

can be zero

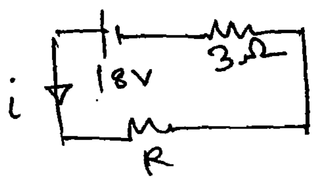
30|



$V_a - 3 + i = V_b$ $\quad \because V_a = V_b$

$\Rightarrow \boxed{i = 3}$

Now The whole circuit can be shown as



$i = \frac{18}{R+3}$

[since batteries are in series]

$\Rightarrow 3 = \frac{18}{R+3}$

$\Rightarrow R + 3 = 6$

$\Rightarrow \boxed{R = 3\Omega}$

31|

$R_T = R_1 + R_2 \quad —(1)$

$R_1 = \frac{\rho_1 L_1}{A_1}$

$R_2 = \frac{\rho_2 L_2}{A_2}$

If thermal expansion is neglected

$\Delta R_1 = \frac{\Delta\rho_1 L_1}{A_1}$

$\Delta R_2 = \frac{\Delta\rho_2 L_2}{A_2}$

$\Delta\rho_1 = \rho_1 \alpha_1 \Delta T$

$\Delta\rho_2 = \rho_2 \alpha_2 \Delta T$

by eqn (1) $\quad \Delta R_T = \Delta R_1 + \Delta R_2$

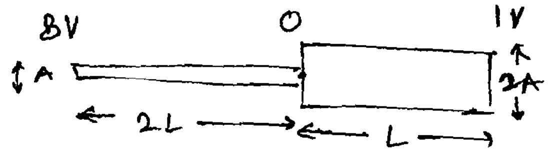
$\Rightarrow \underset{\text{(Given)}}{0} = \frac{(\rho_1 \alpha_1 \Delta T) L_1}{A_1} + \frac{(\rho_2 \alpha_2 \Delta T) L_2}{A_2}$

[$\because$ Total Resistance is independent of temperature $\therefore \Delta R_T = 0$]

$\because A_1 = A_2$

$\Rightarrow \boxed{\rho_1 \alpha_1 L_1 + \rho_2 \alpha_2 L_2 = 0}$

32|



Resistance of longer wire $= \frac{\rho(2L)}{A}$

—"— shorter wire $= \frac{\rho(L)}{2A}$

$$R_{eq} = \frac{\rho L}{A}\left(2+\frac{1}{2}\right) = \frac{5}{2}\frac{\rho L}{A}$$

$$\therefore\ i = \frac{8-1}{R_{eq}} = \cancel{\frac{14}{5}\frac{A}{\rho}}\ \frac{14}{5}\frac{A}{\rho L}$$

let junction be O

by Ohm's law

$$\frac{8-V_0}{\left[\frac{\rho(2L)}{A}\right]} = i \Rightarrow 8-V_0 = \frac{14}{5}\left(\frac{A}{\rho L}\right)\left(\frac{2\rho L}{A}\right)$$

$$\Rightarrow \cancel{8-V_0 = \left(\frac{14}{5}\frac{\rho L}{A}\right)} \qquad \Rightarrow 8-V_0 = 28/5$$

$$\Rightarrow V_0 = \frac{40-28}{5}$$

$$\Rightarrow V_0 = \frac{12}{5} = 2.4 \text{ Volt}$$

33|

$$q = 2t - 8t^2$$

$$i = \frac{dq}{dt} = 2 - 16t$$

$$\text{Total heat} = \int_0^{1/8} i^2 R\,dt = \int_0^{1/8} (2-16t)^2 R\,dt$$

$$= -\frac{R}{16}\left.\frac{(2-16t)^3}{3}\right]_0^{1/8}$$

$$= \frac{R}{16}\cdot\left(\frac{2^3}{3}\right) = \frac{R}{6}\ \text{J}$$

Ans:

34|

Initially $H = \frac{V^2}{R}$

Now R_{eq} becomes $= \frac{(R/n)}{n} = R/n^2$

[Making n equal parts hence Resistance of each part becomes R/n]

$$\therefore\ H' = \frac{V^2}{R_{eq}} = n^2\frac{V^2}{R} = n^2 H$$

Ans:

35|

$P = \frac{V^2}{R}$ as $R\downarrow$ Power $\uparrow$

$$\%\ \text{Change} = \frac{\frac{V^2}{R_2} - \frac{V^2}{R_1}}{V^2/R_1}\times 100 = \frac{\frac{1}{R_2} - \frac{1}{R_1}}{\frac{1}{R_1}}\times 100$$

$$= \frac{R_1 - R_2}{R_2}\times 100 = \frac{R_1 - 0.9R_1}{0.9R_1}\times 100 \quad [\because R_2 = 0.9R_1]$$

$$= \frac{0.1}{0.9}\times 100 = \frac{100}{9} \approx 11\%$$

36]

$R_1 = \frac{(200)^2}{300} = \frac{400}{3}\Omega \qquad R_2 = \frac{(200)^2}{600} = \frac{400}{6}\Omega$

$R_{eq} = R_1 + R_2$

Heat output $= \frac{V^2}{R_{eq}} = \frac{(200)^2}{\left(\frac{400}{3} + \frac{400}{6}\right)}$

$= \frac{200}{\left(\frac{2}{3} + \frac{2}{6}\right)} = \frac{200 \times 6}{(4+2)}$

$= 200$ Watt Ans:

37]

$R_1 = \frac{(200)^2}{60} \qquad R_2 = \frac{(200)^2}{100}$

Power $= \frac{(200)^2}{\left[\frac{(200)^2}{60} + \frac{(200)^2}{100}\right]} = \frac{600}{10+6} = \frac{600}{16}$

$= \frac{150}{4} = \frac{75}{2} = 37.5$ W Ans:

38]

Resistance of each bulb $= \frac{(120)^2}{60} = 240\,\Omega$

R_{eq} for series $= 240 + 240 + 240 = 720\,\Omega$

hence current through each resistor $= \frac{120}{720} = \frac{1}{6}$ Amp

so Power dissipated by each bulb $= i^2 R$

$= \left(\frac{1}{6}\right)^2 \times 240$

$= \frac{40}{6} = \frac{20}{3} = 6.7$ W.

39]

~~Let total current be I~~

Let total current be I (I is passing through 3R)

current through R $= \frac{I \times 2R}{3R} = \frac{2I}{3}$

$\frac{P_R}{P_{3R}} = \frac{(2I/3)^2 R}{I^2 (3R)} = \frac{4}{27}$

Ans:

40]

for short hand assume R as part of internal resistance

Now by Max^m power transfer theorem

$y = R + 2$

$\Rightarrow R = y - 2 = 5 - 2 = 3$

$\Rightarrow \boxed{R = 3\,\Omega}$ Ans:

41|

Same potential diff across R_2, R_3 and R_4

hence by $P = \frac{V^2}{R}$ less R, more P

so R_4 will dissipate more power.

Now we can compare R_1 & R_4 by current.

$P = i^2 R$ $\quad$ i is greater in R_1 as well as $R_1 > R_4$

hence

Ans is R_1.

42|

given $\frac{d^2V}{dI^2} > 0$ [convex]; as $I\uparrow$ $V\uparrow$

$P = VI$ $\quad$ hence as $I\uparrow$ $V\uparrow$

so as $I\uparrow$ P should increase at a greater rate than V-I curve.

Also nature of the graph should be convex.

43|

$I = 2.5 \pm 0.05$

$V = 10 \pm 0.1$

$V = IR \Rightarrow R = \frac{10}{2.5} = 4\Omega$

$\Rightarrow \ln V = \ln I + \ln R$

$\Rightarrow \frac{\Delta V}{V} = \frac{\Delta I}{I} + \frac{\Delta R}{R}$

Since we are dealing with indeterminant errors

$\Rightarrow \frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$ $\quad$ (for max^m error)

$\Rightarrow \Delta R = R\left[\frac{0.1}{10} + \frac{0.05}{2.5}\right]$

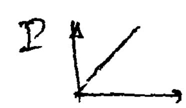
$= \frac{0.4}{10} + \frac{0.2}{2.5} = \frac{12}{100} = 0.12$

hence Resistance $R = 4 \pm 0.12\ \Omega$

44|

Metallic conductor obeys ohm's law $[V = IR]$

Slope of graph $= \frac{I}{V} = \frac{1}{R}$



So more slope, less R

$\Rightarrow$ less R, less temperature in conductor

$\therefore$ $\boxed{T_1 < T_2}$ $\quad$ ($\because$ more slope, less Resistance)

45|

After closing switch R_{eq} decreases hence $i\uparrow$ but potential difference is maintained by battery.

as $i\uparrow$ Power dissipation by $X\uparrow$ ($\because P=i^2R$)

~~hence~~ hence brightness of X increases.

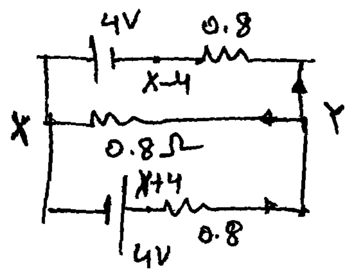
Now $i\uparrow$ so more potential drop across X hence less potential drop across Y.

so by $P=\frac{V^2}{R_y}$ $V\downarrow$ hence Power dissipation by Y decreases

so brightness of Y decreases.

46|

The equivalent circuit can be given as



by Kirchhoff's law of junction

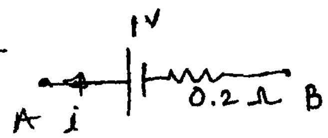
$$\frac{X+4-Y}{0.8}=\frac{Y-X}{0.8}+\frac{Y-(X-4)}{0.8}$$

$$\Rightarrow \boxed{X=Y}$$

hence No current through 0.8 Ω resistor. So the circuit becomes simpler.

$$i=\frac{8V}{1.6}=5\text{ Amp}$$

for a cell



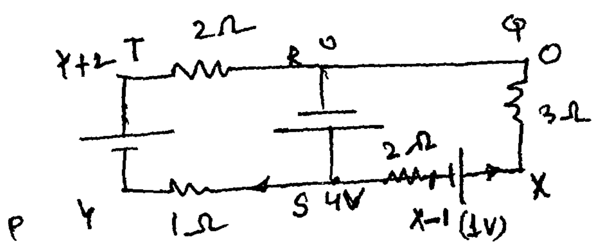
$V_B-i(0.2)+1=V_A$

$V_A-V_B=-5(0.2)+1$

$=0$

Ans:

47|



assign 'Q' as zero volt

for loop PTRS

Using

$$\frac{4-Y}{1}=\frac{Y+2}{2}$$

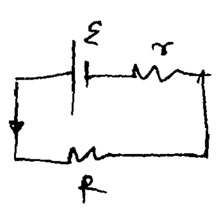
$$\Rightarrow 8-2Y=Y+2$$

$$\Rightarrow 3Y=6 \Rightarrow \boxed{Y=2}$$

hence $V_{PQ}=Y-0=Y=2V$

Ans:

48|



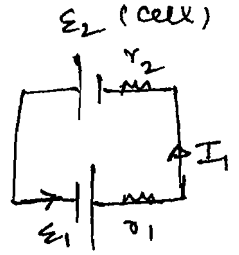
Potential difference V across R

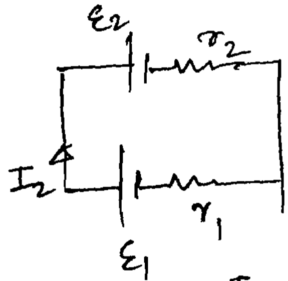
$=iR$

$$V=\left(\frac{E}{R+r}\right)R=\left(\frac{E}{1+r/R}\right)$$

as $R\to\infty$ $V\to E$

49|





$$I_1 = \frac{\varepsilon_1 + \varepsilon_2}{r_1 + r_2} \quad \text{—①}$$

$$I_2 = \frac{\varepsilon_1 - \varepsilon_2}{r_1 + r_2} \quad \text{—②}$$

by ① and ②

$$\frac{\varepsilon_1 + \varepsilon_2}{I_1} = \frac{\varepsilon_1 - \varepsilon_2}{I_2}$$

$$\Rightarrow \frac{\varepsilon_1 + \varepsilon_2}{\varepsilon_1 - \varepsilon_2} = \frac{I_1}{I_2}$$

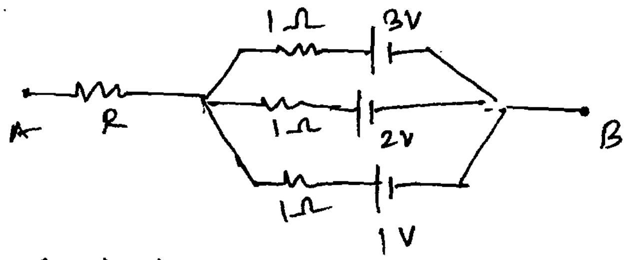
Now by componendo and dividendo

$$\Rightarrow \frac{2\varepsilon_1}{2\varepsilon_2} = \frac{I_1 + I_2}{I_1 - I_2}$$

$$\Rightarrow \varepsilon_1 = \left(\frac{I_1 + I_2}{I_1 - I_2}\right)\varepsilon_2$$

Ans:

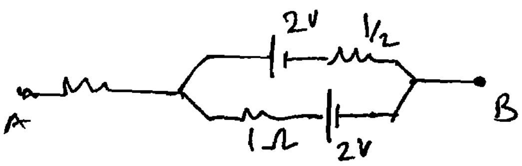
50|



equivalent of 3V and 1 V battery

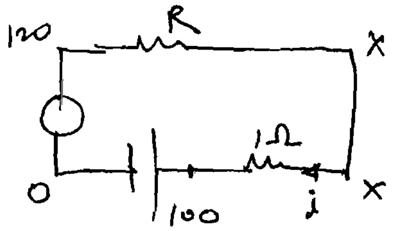
$$\varepsilon_{eq} = \frac{3+1}{2} = 2V, \quad r_{eq} = 1/2$$

hence



Again equivalent $\varepsilon_{eq} = \dfrac{1+2}{1+1/2} = \dfrac{3}{(3/2)} = 2$ Volt.

51|



$$V = iR$$

$$\frac{X - 100}{1} = 10$$

$$\Rightarrow \boxed{X = 110}$$

Now Also

$$\frac{(120 - X)}{I} = R$$

$$\Rightarrow R = \frac{10}{10} = 1\,\Omega$$

Ans.

52| $R_{25} > R_{100}$ $\because$ Resistance of 25 W bulb will be more $\because$ less Power $R = V^2/P$

In series current is same.

more Resistance means more potential drop.

hence $V_{25} > V_{100}$ (Potential drop across resistor)

hence for 440 V line

$\therefore V_{25} > 220V$ so 25 W is likely to fuse.

53|

Rate of dissipation per unit volume

$$= \frac{i^2R}{\text{Volume}}$$

$$= \frac{i^2 \rho \cancel{l}}{A \cancel{l} A}$$

$$= \left(\frac{i}{A}\right)\left(\frac{i}{A}\right)\rho$$

$$= j \cdot j \rho$$

$$= jE$$

Ans:

$\because j = \sigma E$

$j = \frac{E}{\rho}$

$\Rightarrow j\rho = E$

54|

n = no. of e^- per unit volume

Specific charge $= \frac{e}{m} = S$

let volume be Al. Total no. of e^-s $= (nAl)$

hence momentum per unit length $= \frac{(nA\cancel{l})mV_d}{\cancel{l}}$

$$= nA\left(\frac{e}{S}\right)V_d$$

$$= \frac{neAV_d}{S}$$

$$= I/S$$ Ans:

55|

Total current $= \int j\,ds$

$$= \int_0^{R/2} J_0\left(2x/R - 1\right) 2\pi x\,dx + \int_{R/2}^{R} J_0 \frac{x}{R} 2\pi x\,dx$$

$$= \left[2\pi \frac{J_0 x^3}{3R} - \frac{J_0 2\pi x^2}{2}\right]_0^{R/2} + \left[\frac{J_0}{R} 2\pi \frac{x^3}{3}\right]_{R/2}^{R}$$

$$= 2\pi\left[\frac{J_0 R^3}{24R} - \frac{J_0 2\pi R^2}{8}\right] + \frac{J_0 2\pi}{R}\left[\frac{R^3}{3} - \frac{R^3}{24}\right]$$

56|

let Resistance of wire is R

$\frac{(3\varepsilon)^2}{R}$ is heat Generated

$$ms\,\Delta T = \frac{(3\varepsilon)^2}{R}t \quad -(1)$$

Now for the other wire mass $= 2m$

$R' = 2R$

$$2ms\,\Delta T = \frac{(N\varepsilon)^2}{2R}t \quad -(2)$$

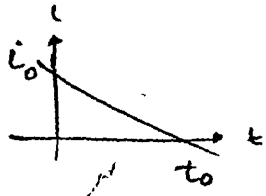
$$\left(\frac{3}{N}\right)^2 = \frac{1}{4} \qquad \text{by (1) and (2)}$$

$$\Rightarrow \quad N^2 = 36 \quad \Rightarrow \boxed{N=6} \quad \text{Ans:}$$

57|

let at $t=0$ current is i_0

and $\Delta t = t_0$



Area under the graph $= \int i\,dt$

$= \text{charge}$

$$\Rightarrow \frac{1}{2} i_0 t_0 = q \qquad \Rightarrow i_0 = \frac{2q}{t_0}$$

by graph we have

$$i = -\frac{2q}{t_0^2}t + i_0$$

$$i = -\frac{2q}{t_0^2}t + \frac{2q}{t_0}$$

$\because H = \int i^2 R\,dt$

$$\text{Heat Generated} = \int_0^{t_0}\left(-\frac{2q}{t_0^2}t + \frac{2q}{t_0}\right)^2 R\,dt$$

$$-\frac{t_0^2}{2q}\left[\frac{\left(-\frac{2q}{t_0^2}t + \frac{2q}{t_0}\right)^3}{3}\right]_0^{t_0} R$$

$$= \left(\frac{8q^3R}{3t_0^3}\right)\left(\frac{t_0^2}{2q}\right) = \frac{4}{3}\frac{q^2R}{t_0}$$

$\because t_0 = \Delta t$

$$H = \frac{4}{3}\frac{q^2R}{\Delta t} \qquad \text{Ans:}$$

58|

by effective grouping of cells

for max^m current

mn = total no. of cells

$$\because I = \frac{mn\varepsilon}{nr + mR}$$

$\because R = 0$

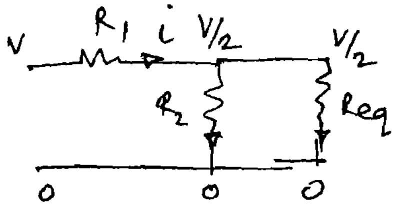
$$I = m\varepsilon$$

for I_{max}, m should be max^m

m no. of rows

n no. of cells in each row.

59 |



Total current $i = V/R_{eq}$

$\therefore$ current in $R_{eq} = \frac{V/2}{R_{eq}} = i/2$

hence current in R_2 is also $i/2$

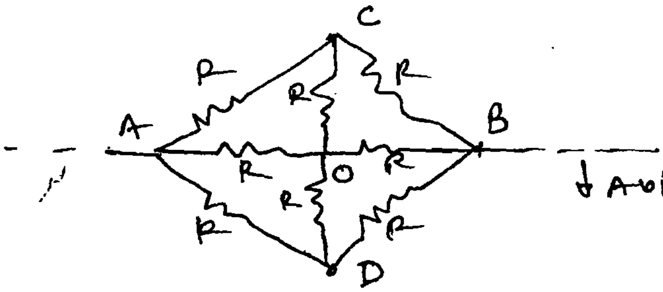
We can write

$$(V - V/2) = iR_1 \quad \text{—(1)}$$

$$V/2 = (i/2)R_2 \quad \text{—(2)}$$

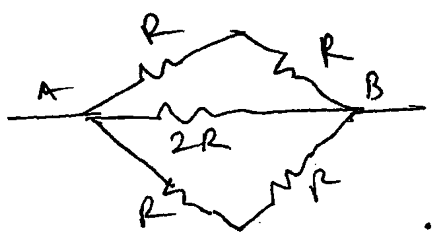
$$\Rightarrow \frac{R_2}{2} = R_1 \Rightarrow \boxed{\frac{R_1}{R_2} = \frac{1}{2}}$$

60 |

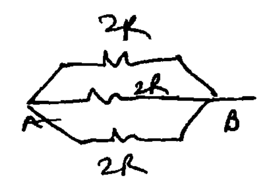


By symmetry ⊥ branches CO and OD will have no current.

hence simplified circuit is

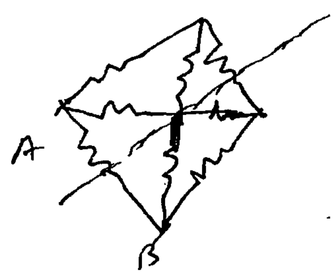


Req =



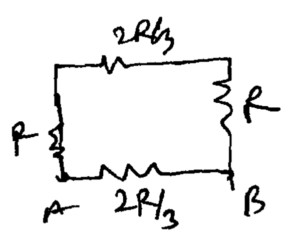
$= 2R/3$ Ans.

61 |

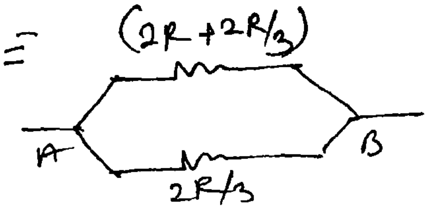


by symmetry

≡



≡

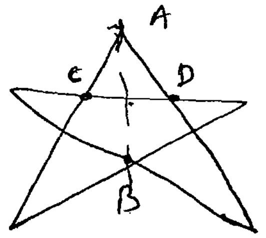


$$\equiv \frac{(8R/3) \times (2R/3)}{8R/3 + 2R/3}$$

$$= \frac{16R^2}{3(10R)} = \frac{16R}{30} = \frac{8R}{15}$$

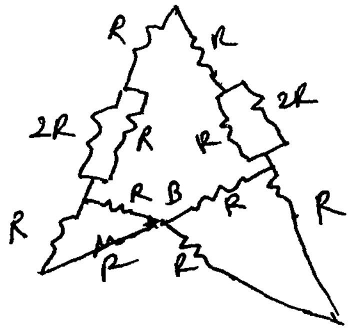
Ans.

62

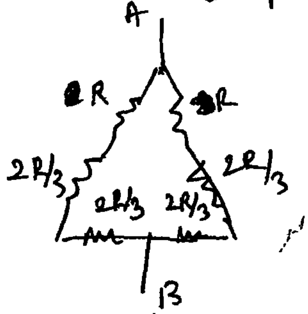


by symmetry ⊥ branch will have no current hence we can remove ~~[illegible]~~ resistor CD.

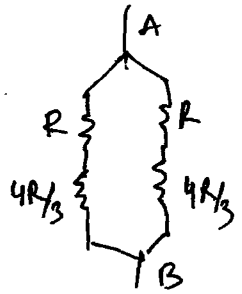
circuit becomes



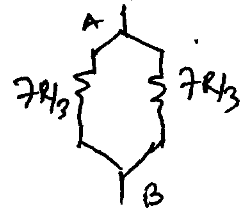
≡



≡

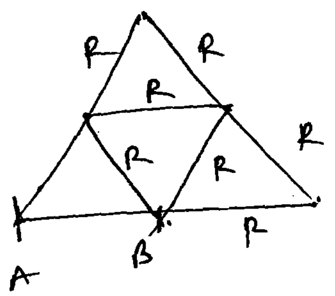


≡

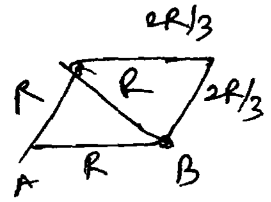


$R_{eq} = 7R/6$

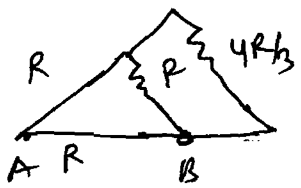
63



≡

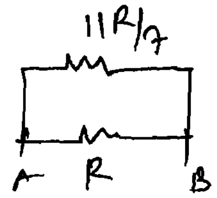


≡



≡

≡

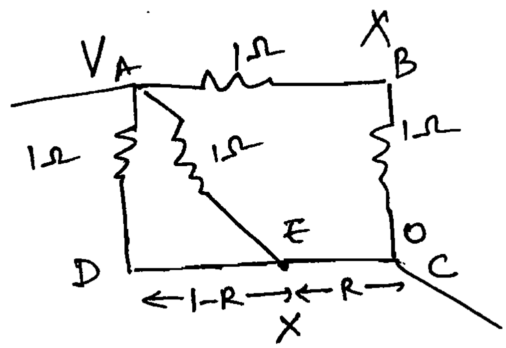


$$\equiv \frac{11R/7 \times R}{11R/7 + R} = \frac{11R}{18} \text{ Ans}$$

64| When they are in series current is same. When current is 1 Amp both will have same potential drop of 10 volt. [see Graphs]

hence for total potential drop of 20 volt the current in circuit is 1 Amp. After 1 Amp, Q has no resistance for current while P can't ~~permit~~ permit more than 1 Amp. hence Max^m current will pass through the circuit is 1 Amp. Elements P and Q are in series. So below 10 V, current through Q is less. Hence when both put in series, current characteristic will be same as shown by Q because in series current has to be same. This characteristics will be shown up to 20V. After that P will decide the current.

65|



Assign voltage
at A $= V$
at C $= 0$
at E $= X$ = at B (Given)

let Resistance of EO $= R\Omega$
then Resist of DX $= (1-R)\Omega$

function Rule at 'B' $\quad \dfrac{V-X}{1} = \dfrac{X}{1} \Rightarrow \boxed{V = 2X}$ —①

at 'E' $\quad \dfrac{V-X}{2-R} + \dfrac{V-X}{1} = \dfrac{X-0}{R}$ —②

$\Rightarrow$ by eq^{n}① $\Rightarrow \dfrac{X}{2-R} + X = \dfrac{X}{R}$

$\Rightarrow \dfrac{1}{2-R} + 1 = \dfrac{1}{R}$

$\Rightarrow (1+2-R)R = 2-R$

$\Rightarrow 3R - R^2 = 2 - R \Rightarrow R^2 - 4R + 2 = 0$

$R = \dfrac{4 \pm \sqrt{16-8}}{2} = \dfrac{4-2\sqrt{2}}{2}$ $[\because R < 1]$

$\boxed{R = 2-\sqrt{2}}$

hence $\dfrac{CE}{ED} = \dfrac{R}{1-R} = \dfrac{2-\sqrt{2}}{\sqrt{2}-1} = \dfrac{\sqrt{2}(\sqrt{2}-1)}{\sqrt{2}-1} = \sqrt{2}$

Ans.

66

Total length $= l$, Total Resistance $= R$

fraction x of length $= lx$, Remaining length $= l(1-x)$

Resistance of this length $= Rx$

Remaining Resistance $= R - Rx = R(1-x)$

final length l_2

$$l_2 + l(1-x) = \frac{3}{2}l$$

$$\Rightarrow \boxed{l_2 = \frac{l}{2} + lx}$$

but $\frac{R_1}{R_2} = \frac{l_1^2}{l_2^2}$ ($\because$ Volume const.)

$$\Rightarrow R_2 = \frac{\cancel{l^2}\left(\frac{1}{2}+x\right)^2}{x^2\cancel{l^2}} \cdot Rx = \frac{(1+2x)^2 R}{4x}$$

but It's given $R_2 + R(1-x) = 4$ (original Resistance)

$$\Rightarrow R_2 + R(1-x) = 4R$$

$$\Rightarrow \frac{(1+2x)^2}{4x}R + R(1-x) = 4R$$

$$\Rightarrow (1+2x)^2 + 4x(1-x) = 16x$$

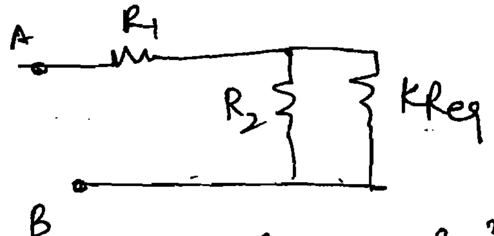
$$\Rightarrow 1 + \cancel{4x^2} + 4x + 4x - \cancel{4x^2} = 16x$$

$$\Rightarrow 8x + 1 = 16x$$

$$\Rightarrow 8x = 1 \Rightarrow \boxed{x = 1/8} \text{ Ans.}$$

67

Equivalent circuit can be represented by



$$R_{eq} = R_1 + \frac{R_2 K R_{eq}}{R_2 + K R_{eq}}$$

($\because K = 1/2$ given)

$$\Rightarrow R_{eq}R_2 + \frac{R_{eq}^2}{2} = R_1R_2 + \frac{R_1R_{eq}}{2} + \frac{R_2R_{eq}}{2}$$

Let $R_{eq} = x$

$$\Rightarrow \frac{x^2}{2} + \frac{x}{2}(R_2 - R_1) - R_1R_2 = 0$$

$$\Rightarrow x^2 + x(R_2 - R_1) - 2R_1R_2 = 0$$

$$\Rightarrow x = \frac{(R_1 - R_2) \pm \sqrt{(R_2-R_1)^2 + 8R_1R_2}}{2}$$

$$\Rightarrow x = R_{eq} = \frac{(R_1 - R_2) + \sqrt{R_1^2 + R_2^2 + 6R_1R_2}}{}$$

68| Resistivity of semiconductor decreases with increase in temperature. Effect of heating a semiconductor frees additional electrons (and holes); at high temp. more charge carriers.

69| Copper is conductor and Germanium is semiconductor.

70| Potential difference across $20\Omega = 20 \times 0.3 = 6$ Volt

Current in $15\Omega = \frac{6}{15} = 0.4$ Amp

hence current in $R_1 = 0.8 - (0.4 + 0.3)$

$= 0.1$ Amp.

by Ohm's law

$(0.1)R_1 = 6\,V$ (parallel combination)

$\Rightarrow \boxed{R_1 = 60\Omega}$ Ans:

71| $R_{eq} = 60 + \frac{120 \times 60}{120 + 60}$

$= 60 + 40 = 100\,\Omega$

Hence $i = \frac{120}{100} = 1.2$ Amp

Potential drop across $R_1 = iR_1 = 1.2 \times 60 = 72\,V$

Hence potential drop across voltmeter

$= 120 - 72 = 48\,V$

72| When S_2 is closed, R_{eq} is ~~less~~ more than when S_1 is closed. ~~so more current.~~ so less current. Hence potential drop across 'R' is less than case I. so when potential drop across R is less, across 6R is more.

so $V_2 > V_1$.

When both S_1 and S_2 are closed. R_{eq} is least among three cases. So current through circuit is greater than case I and case II. So potential drop across resistor 'R' is greater hence remaining potential difference (potential difference across 3R & 6R) is less.

[V_3 reading is least]

so $V_2 > V_1 > V_3$

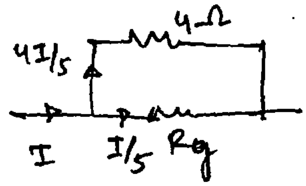
73 current is same. In parallel, two resistance are equal;

$\therefore R_g = 20\,\Omega$

74

deflection θ reduced to one fifth

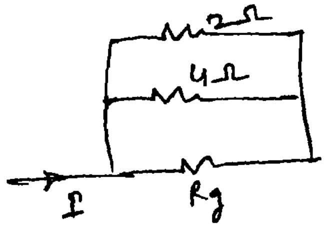
current I in Galvanometer, becomes $I/5$ 'I ∝ θ'



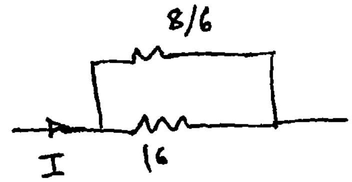
$\frac{I}{5} R_g = \frac{4I}{5} \times 4$

$R_g = 16\,\Omega$

Now



$\equiv$



current in galvanometer $= \dfrac{\frac{8}{6} I}{\frac{8}{6} + 16} = \dfrac{8I}{8+96} = \dfrac{I}{1+12} = I/13$

deflection θ becomes $\theta/13$.

reduction in deflection w.r.t. 'when shunted with 4Ω only'

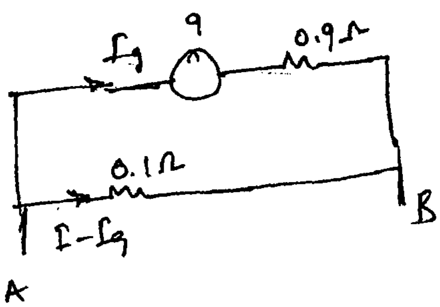
$z = \frac{\theta}{5} - \frac{\theta}{13} = \frac{8\theta}{65}$

deflection when shunted with $4\Omega = \theta/5$

hence $z = \frac{8}{13}\left(\frac{\theta}{5}\right)$

$= \frac{8}{13}$ of the deflection when shunted with 4Ω only.

75



$(I - I_g)\, 0.1 = (9.9)\, I_g$ [parallel combination]

$\Rightarrow 10 I_g = I/10$

$\Rightarrow I = 100 I_g$

$= 100 \times 10 \times 10^{-3}$

$I = 1\,\text{Amp}$

76|

Total resistance $= 90 + 910 = 1000\,\Omega$

$i' = 10\,mA$

so potential diff $= 1000 \times 10 \times 10^{-3}$

$= 10$ Volts

least count $= 0.1\,V$

$n(L.C) = 10$

$n = \frac{10}{0.1} = 100$ Ans.

77|

$(R+20)(0.10) = 12$ [current in resistor and ammeter is same)

$\Rightarrow R+20 = \frac{120\cancel{0}}{1\cancel{0}}$

$\Rightarrow R = 100\,\Omega$

78| Nearly Ideal voltmeter has very high resistance so very low current. Hence No current so emf is the voltmeter reading. $i \approx 0$

79| by putting a voltmeter of finite resistance. $R_{eq} \downarrow$ hence $I \uparrow$, so more drop across Ammeter so Voltmeter will measure less

$I > I_0$, $V < V_0$

80| when $i = 0$, voltmeter will measure only emf

by graph $V = y = \text{Emf}(\varepsilon)$ —(1)

when $V = 0$ that means $\varepsilon - ir = 0$

but by graph $V = 0$ when $i = x$ $\Rightarrow \varepsilon - xr = 0$

$\Rightarrow y = xr$ $(\because y = \varepsilon)$ by eq^n(1)

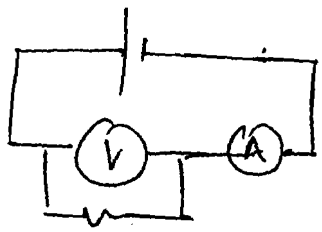
$\Rightarrow \boxed{r = y/x}$ Ans:

81|

small Resistance in series will not change R_{eq}. Hence current is almost same.

82 | High resistance in parallel will not change R_{eq}. Hence Potential diffeence to be measured does not appreciably change.

83 |



R_{eq} of circuit decreases, $I \uparrow$

Potential difference across ammeter increases. Hence potential diff. across voltmeter decreases.

Ammeter reading $\uparrow$

Voltmeter reading $\downarrow$

84 |

$$\frac{12}{x+y+r} = 1 \quad \text{—①}$$

$$\frac{1}{x} = \frac{12}{x+y+r} \quad \text{—②}$$

$$\frac{10}{x} = \frac{12}{x+r} \quad \text{(since } y \text{ is shorted)} \quad \text{—③}$$

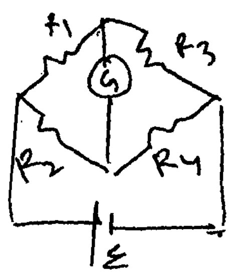
by ① and ② $\quad x = 1$

by 3 $\quad 10 = \frac{12}{1+r}$

$1 + r = 1.2$

$\Rightarrow \boxed{r = 0.2\,\Omega}$ Ans.

85 |



If $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ then current through Galvanometer remains zero.

$\frac{5R_1}{5R_2} = \frac{5R_3}{5R_4}$ hence again current through galvanometer is zero.

* doesn't depend on EMF
* Can exchange position of battery and Galvanometer.

86 |

$$\frac{P}{S} = \frac{Q}{625} \quad \text{—①} \qquad \frac{Q}{S} = \frac{P}{676} \quad \text{—②}$$

$$\frac{625}{S} = \frac{S}{676} \quad \text{by ① and ②}$$

$\Rightarrow S^2 = 676 \times 625$

$\Rightarrow \boxed{S = 650\,\Omega}$ Ans

87 | $\frac{R_1}{40} = \frac{R_2}{60}$ — (1)

$\frac{R_1}{50} = \frac{\frac{10R_2}{10+R_2}}{50}$ — (2)

by (1) $R_1 = \frac{2}{3}R_2$

$\Rightarrow$ by (2) $\frac{2}{150}\cancel{R_2} = \frac{\cancel{R_2}}{5(10+R_2)}$

$\Rightarrow 20+2R_2 = 30 \Rightarrow \boxed{R_2 = 5\Omega} \Rightarrow \boxed{R_1 = 10/3\,\Omega}$

88 | Potential gradient $= \frac{6}{1}$

hence for zero deflection $(6)(AC) = 4$

$AC = 4/6 = 2/3$ m Ans

89 | Initially $\frac{12}{x} = \frac{18}{100-x}$

$\Rightarrow 1200 = 30x$

$\Rightarrow x = 40$cm

Now $\frac{12}{y} = \frac{8}{100-y} \Rightarrow 1200 = 20y$

$\Rightarrow y = 60$cm

J have to be moved by $60-40 = 20$ cm.

90 | $i = \frac{11}{10+1} = 1$ Amp

Potential gradient $= \frac{\text{Potential drop across wire}}{\text{length}} = \frac{iR}{10}$

$= \frac{1\times 10}{10} = 1$ V/m

91 | x (potential gradient) $= \frac{\text{potential drop across wire}}{\text{length}}$

$\left(\frac{l}{3}\right)x = \varepsilon \Rightarrow x = 3\varepsilon/l$

potential diff across wire $= 3\varepsilon$

now length becomes $3l/2$

x' (New gradient) $= \frac{3\varepsilon}{(3l/2)} = 2\varepsilon/l$

$\left(\frac{2\varepsilon}{l}\right)\times(y) = \varepsilon \Rightarrow y = l/2$ Ans:

y is distance of balance point.

92 | $i = \frac{\varepsilon}{10r}$

Potential diff across potentiometer $= i(9r)$

$= \frac{9\varepsilon}{10}$

Potential Gradient $= \frac{9\varepsilon}{10L}$

$\left(\frac{9\varepsilon}{10L}\right) \times (AJ) = \varepsilon/2$

$\Rightarrow AJ = \frac{5L}{9}$ Ans

93 | Can't find a balance point. because along wire from A to B potential decreases but from connecting battery a point with higher potential is needed. So It's not possible.

94 | ε_{eq} of cells $= \frac{2(6) - 4(2)}{8} = \frac{1}{2}$ Volt

Resistance of potentiometre wire

$= 4 \times 4 = 16\,\Omega$

$i = \frac{12}{16+8} = \frac{1}{2}$ Amp

potential Gradient $= \frac{\left(\frac{1}{2}\right) \times 16}{4} = 2$ V/m

Hence. $2(y) = \frac{1}{2}$ [At balance point]

$\Rightarrow \boxed{y = \frac{1}{4}} \Rightarrow y = 25$ cm

95 | Initially given balance point is $l = L/2$

(Potential Gradient) $\frac{L}{2} = 6$ —(1)

$\Rightarrow \left(\frac{E}{L}\right)\left(\frac{L}{2}\right) = 6 \Rightarrow \boxed{E = 12V}$

Now If S_2 is closed

terminal voltage of cell

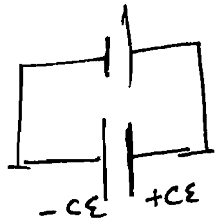
$= 6 - ir$

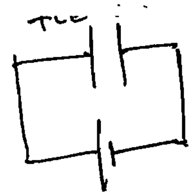
$\Rightarrow 6 - \left(\frac{6}{10+r}\right)r = \left(\frac{12}{L}\right) \times \frac{5L}{12}$

$\Rightarrow \frac{60}{10+r} = 5$

$\Rightarrow 50 + 5r = 60 \Rightarrow \boxed{r = 2\,\Omega}$

96





Charge flown through battery $= 2CE$

Work done by battery $= \varepsilon(2C\varepsilon) = 2C\varepsilon^2$

Energy stored now $= \frac{Q^2}{2C} = \frac{1}{2}C\varepsilon^2$

Energy store before $= \frac{1}{2}C\varepsilon^2$

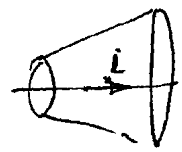
Hence produced = Workdone by battery

Heat produced $= 2C\varepsilon^2 = 4$ (Energy stored in capacitor)

Solutions

Ex-II

1| Since there is no accumulation of charge, Hence current is same.

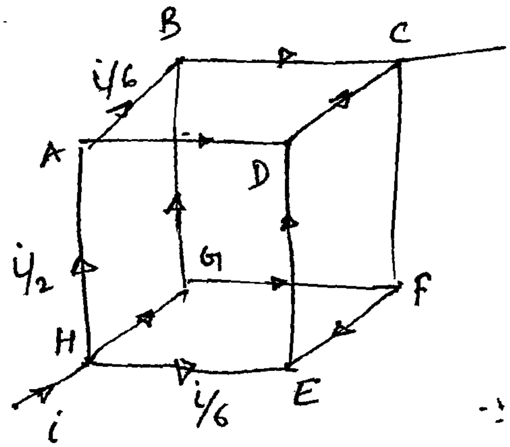


$I = neAV_d$

$\because A\uparrow$ so $V_d \downarrow$ [carrier density is const for a metallic conduc

2| Ammeter must be in series but voltmeter must be in parallel with resistor.

3|



$i_{AB} = i/6$, $i_{DC} = 2i/3$,

$i_{HA} = i/2$, $i_{GF} = i/6$, $i_{HE} = i/6$

by KCL we can find currents as shown

$i_{HG} = i - (i/2 + i/6) = i/3$

$\because i_{AB} = i/6$

$i_{AD} = i - (i/2 + i/6) = i/3$

$\because i_{DC} = 2i/3 \qquad i_{ED} = 2i/3 - i/3 = i/3$

$i_{FE} = i/3 - i/6 = i/6$ (KCL at junction E)

$\because i_{GF} = i/6 \quad \therefore i_{GB} = i_{HG} - i_{GF} = i/3 - i/6 = i/6$

$\therefore i_{BC} = i/6 + i/6 = i/3$

$\therefore$ current in cf = 0

4| i is same in series hence more R, more power, more brightness

$R = \frac{V^2}{P}$ $\quad \because P$ is same.

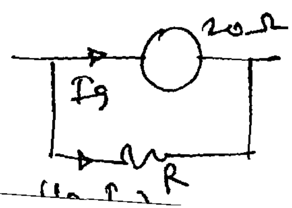
If marked voltage is high, R is high

$\therefore$ brightness $\propto R$

$\propto V^2$

Ans.

5| To convert into ammeter, resistor should be connected across it.



$(10 - I_g)R = I_g(20)$

— (1)

Given for 0.2 V galvanometer shows full deflection (I_g)

$I_g (20) = 0.2$

$\Rightarrow I_g = \frac{1}{100}$ Amp

by eq^n (1)

$(10 - I_g) R = \frac{20}{100}$

$R = \frac{20}{100 \times (10 - I_g)} \approx \frac{20}{100 \times 10} = 0.02\,\Omega$

Ans.

6| $H = \frac{V^2}{R} t$ Heat developed in time 't' is doubled if Resistance becomes half of the initial.

$R' = \frac{\rho L'}{A'}$ $R = \frac{\rho L}{A} = \frac{\rho L}{\pi R^2}$

$\therefore R' = R/2$ If both the length and the radius of wire are doubled.

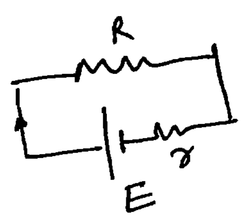
$R' = \frac{\rho (2L)}{\pi (2R)^2} = \frac{1}{2}\left(\frac{\rho L}{\pi R^2}\right) = R/2$ Ans!

7| this is charging of battery

Potential diff across points A and B $= \varepsilon + ir$

current flows from positive to -ive terminal

$V_A - V_B = \varepsilon + ir \Rightarrow V_A > V_B$

8| 

when current is zero, potential difference across resistor is E

by graph we can find

$E = 10$ Volt

when $V = 0 \Rightarrow \varepsilon - ir = 0$

$\Rightarrow \varepsilon = ir$

$\Rightarrow 10 = (2) r$ [$i = 2$ when $V = 0$ by graph]

$\Rightarrow \boxed{r = 5\,\Omega}$ Ans.

Max^m current which can be taken $= \frac{10}{5} = 2A$

9|

parallel combination decreases R_{eq}

$\therefore \quad R_1 < R$

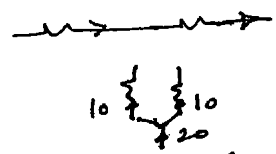
series combination increases R_{eq}

$\therefore \quad R_2 > R$

10|

Max^m current can go is 10 A. [otherwise fuse will melt].

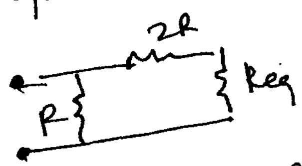
If they are in series current same the combination acts as fuse of rating 10A

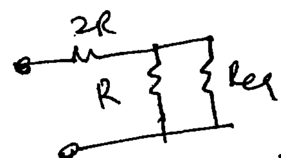


If they are in parallel 20 A current can go through both since they are identical. In parallel, the combination acts as fuse of rating 20A.

11|

Equivalent circuit for both situation





$\because R_{eq} = x$ $\qquad$ $R_{eq} = y$

$$R_{eq} = \frac{(2R+R_{eq})R}{3R+R_{eq}} \qquad\qquad R_{eq} = 2R + \frac{R\,R_{eq}}{R+R_{eq}}$$

$$\Rightarrow x = \frac{(2R+x)R}{3R+x} \qquad\qquad \Rightarrow 2Ry + 2R^2 + \cancel{yR} = y^2 + \cancel{yR}$$

$$\Rightarrow 2R^2 + xR = 3Rx + x^2 \qquad\qquad \Rightarrow y^2 - 2Ry - 2R^2 = 0$$

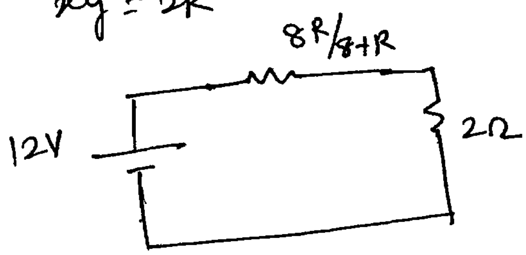
$$\Rightarrow x^2 = 2R^2 - 2Rx \qquad\qquad \Rightarrow y = \frac{2R \pm \sqrt{4R^2+8R^2}}{2}$$

$$\Rightarrow x^2 + 2Rx - 2R^2 = 0 \qquad\qquad \Rightarrow y = (\sqrt{3}+1)R$$

$$\Rightarrow x = (\sqrt{3}-1)R$$

$$\therefore xy = 2R^2$$

12|



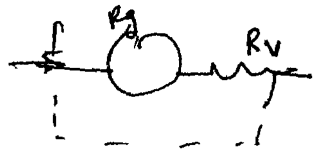
power through 2Ω is max when i is max^m

when $\frac{8R}{8+R}$ is min^n

min value is zero when $R=0$

hence at $R=0$ power in 2Ω is max^m. ($R=0$ will at $R=0$, current will not go through 8Ω behave like zero resistance) $\quad i = \frac{12}{2} = 6$

13| The resistance will be largest for series combination hence In voltmeter resistance of device will be more

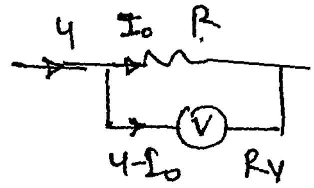


I is same hence more R_V, more range of voltmeter.
so more is the range more is the resistance of device $(R_g + R_V)$

$$I(R_g + R_V) = \text{Range of voltmeter}$$

14| An Ammeter should have small resistance otherwise current in circuit will change.
Similarly large resistance of voltmeter does not change potential to be measured appreciably.

15|



$$I_0 R = (4 - I_0) R_V = 20$$

$$\Rightarrow \quad 4 - I_0 = \frac{20}{R_V}$$

$$I_0 = 4 - \frac{20}{R_V}$$

$$\Rightarrow I_0 R = 20$$

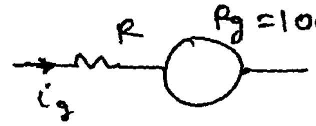
$$\Rightarrow R = \frac{20}{4 - 20/R_V}$$

hence R is greater than 5Ω

as $R_V \to \infty$ $\quad R \to 5\Omega$ (minᵐ possible R)

16|

for Voltmeter



$$(100 + R)(50 \times 10^{-6}) = 10V$$

$$\Rightarrow (100 + R)\, 5 = 10^6$$

$$\Rightarrow 500 + 5R = 10^6$$

$$\approx 5R = 10^6 \Rightarrow R = \frac{(10^3)(10^3)}{5} = 200\,k\Omega.$$

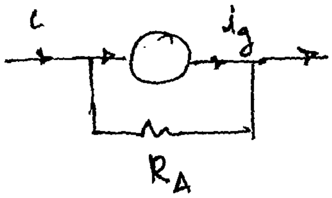
Similarly for 50 V range voltmeter

$$(100 + R) \times (50 \times 10^{-6}) = 50V$$

Hence $R > 200\,k\Omega$ $\qquad R = (10^6 - 100)\,\Omega$

For Ammeter

Resistance should be in parallel.



$$i_g R_g = R_A(i - i_g)$$

$$\Rightarrow 100 \times 50 \times 10^{-6} \approx i R_A$$

$$\Rightarrow R_A = \frac{5 \times 10^{-3}}{i}$$

If $i = 5mA$

$$R_A = 1\Omega$$

Ans.

17 ~~Measured emf~~

Potential drop across potentiometer wire should be Greater than emf to be measured. For balance to be obtained positive terminals of both ε_1 and ε_2 or -ive terminals must be joined to one end of potentiometer wire.

18 Potential drop across potentiometer wire when $R = 120\Omega$

$$= \left(\frac{20}{5+120+75}\right) \times 75 = 7.5V$$

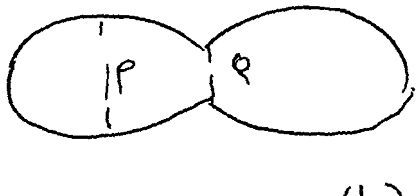
Hence potential difference can be measured 5 V, 6 V and 7 V.

19 r does not play any role at balance point.

If $R >> R_0$ in this case less potential drop across potentiometer wire.

20 number of free electrons remain same in a conductor.

21



(a) current through conductor is same throughout.

(b) $j = \sigma E \Rightarrow E = \frac{i}{A\sigma}$

∴ Same No. of free electrons are crossing at Q and at P. (Current same)

∴ Number of electrons crossing (per unit time) per unit area of cross-section at P is less than that at Q

Rate of Heat Generated per unit time at Q

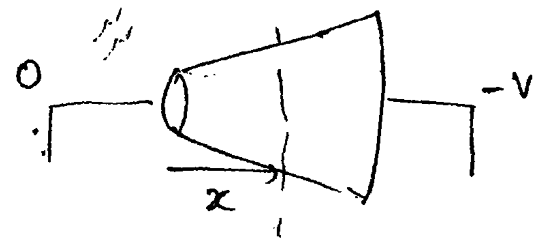
$\cancel{i^2 R}$ $i^2 R_Q$

∵ $R_Q = \dfrac{\rho\, dx}{A_Q}$ $\qquad R_P = \dfrac{\rho\, dx}{A_P}$

∵ $R_Q > R_P$ $\qquad [A_Q < A_P]$

∴ Heat Generated per unit time at Q > Heat generated per unit time at P.

22|



at a distance potential is -ive.

$E = \dfrac{I}{A\sigma}$ $\qquad (\because j = \sigma E)$

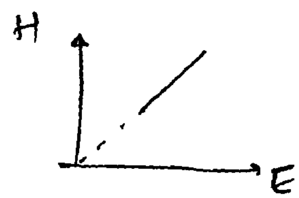
$E = \left|+\dfrac{dV}{dx}\right|$

at a distance x

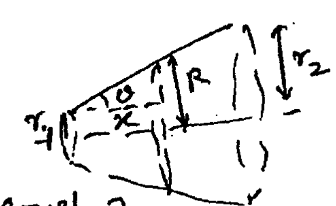
$H = (dV)\,i$

Rate of Generation of Heat per unit length

$= \left(\dfrac{dV}{dx}\right) i = E i$



Area a f^n of x



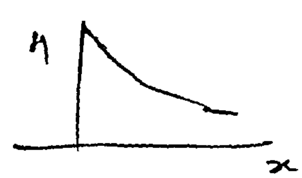
$R = x\tan\theta + r_1$

[θ and r_1 const.]

$E = \dfrac{I}{\pi (x\tan\theta + r_1)^2 \sigma}$ $\qquad$ (E Vs x is not linear)

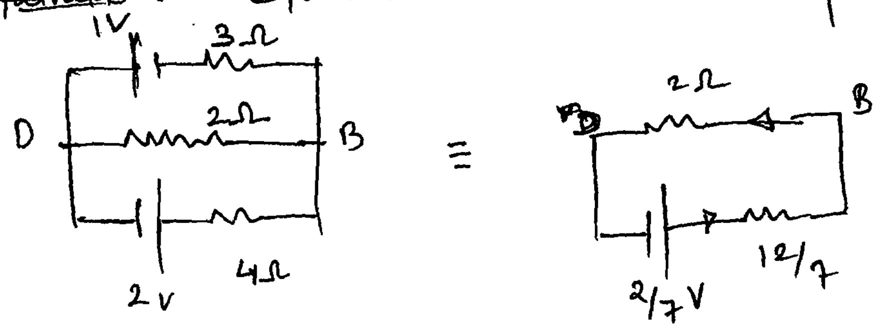
Similarly

$H = \dfrac{I^2}{\pi\sigma (x\tan\theta + r_1)^2}$



23 | Req ↑ current through battery ↑.
Potential diff remains same. current through R remains same as $i = V/R$, hence the Power by R.

24 | ~~Equivalent~~ Equivalent circuit can be represented by



(figure 1)

$$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} \quad r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

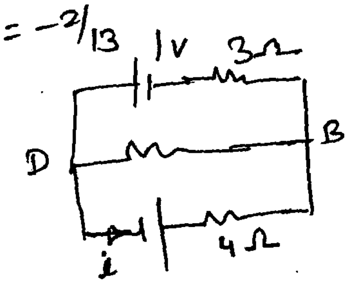
hence $i = \dfrac{2/7}{2 + 12/7} = \dfrac{2}{26} = \dfrac{1}{13}$

potential diff across $2\Omega = 2 \times \frac{1}{13} = 2/13$

$\Rightarrow V_B - V_D = 2/13$

$\Rightarrow V_D - V_B = -2/13$

Again by figure(i)



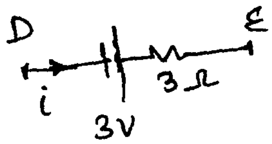
$V_D + 2 - 4i = V_B$

$\Rightarrow 2 - 4i = 2/13$

$\Rightarrow i = 6/13$

hence current through battery G and H is $6/13$ Amp

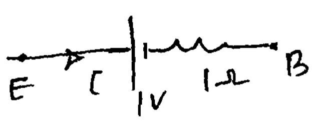
for battery G



$V_D + 3 - 3i = V_E$

$\Rightarrow V_E - V_D = 3 - 3\left(\frac{6}{13}\right) = \frac{21}{13}$ Volt

for battery H



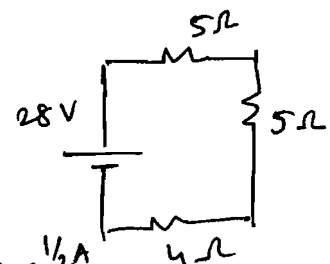
$V_E - 1 - 1(i) = V_B$

$V_E - V_B = 1 + \frac{6}{13} = \frac{19}{13}$ Ans

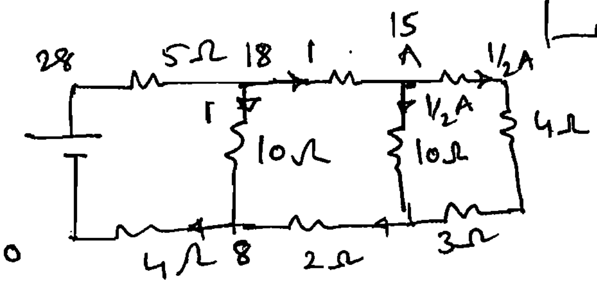
25 |

$R_{eq} = 14\Omega$

$i = \frac{28}{14} = 2A$



Now Again



$V_A - V_B = 15 - 8 = 7$ Volt .

26 |

current is same, so charge crossing in a given time is same ∴ free electron density for a conductor is const.

27 |

Average velocity of all ~~ele~~ electrons at an instant is zero. [since Momentum is zero]

for a long time average velocity of a free electron is zero [since displacement becomes zero]

28 |

$P = \left(\frac{E}{R+5}\right)^2 R$ R increases from 1Ω to 5Ω .

$P = E^2 \frac{R}{(R+5)^2} = E^2\left(\frac{R}{R+5}\right)\left(\frac{1}{R+5}\right)$

Hence as $P = E^2\left(\frac{1}{R+5} - \frac{5}{(R+5)^2}\right)$

as $R\uparrow$ first term decreases as a less rate than second terms

hence as $R\uparrow$ $P\uparrow$

29 |

It will melt if current exceeds 8A .

30 |

In short circuited battery, ~~[struck]~~ hence potential diff. is also zero.

Charging potential diff. $= \varepsilon + ir$

discharging potential diff $= \varepsilon - ir$ ... potential diff $= \varepsilon$

Ex- III

Comprehension-I

$P = 1000\ W$

$V = 220$ Volt

1. $i = \frac{P}{V} = 4.545 \approx 4.55\ A$

2. $R = \frac{V^2}{P} = \frac{(220)^2}{1000} = 48.4\ \Omega$

3. Power given = 1 kW = 1000 W

4. Heat produced in cal/sec

$= \frac{1000}{4.18} \approx 239.2$ Cal/sec

Ans: ≈ 240 cal/sec.

5. $Q = mL$

$\Rightarrow (240)\times 60 = m(540)$ $\quad(\because t = 60$ sec$)$

$\Rightarrow m = \frac{240}{9} = \frac{80}{3}$ gms Ans

Comprehension-II

6. $\alpha = -\frac{n}{T}$ $\quad \alpha = \frac{d\rho}{\rho dT}$

$\therefore \int -\frac{n\,dT}{T} = \int \frac{d\rho}{\rho}$

$\Rightarrow -n \ln T = \ln \rho + \ln K$

$\Rightarrow T^{-n} = \rho K$ $\quad\uparrow$ (const. of Integration)

$\Rightarrow \rho = \frac{1}{K} T^{-n}$ $\quad$ where $a = 1/K$

$\Rightarrow \boxed{\rho = aT^{-n}}$ (a) Ans.

7. $n = -\alpha T = 5\times10^{-4} \times 294 = 0.147$

$\therefore a = (3.5\times10^{-5})\, T^n$

$= (3.5\times10^{-5})(294)^n = 8.07\times10^{-5}$

Ans.

8. calculation of 'n' has been done in last question

$n = 0.147$

9. $T_1 = -196 + 273 = 77\ K$

$T_2 = 573\ K$

$\because a = 8 \times 10^{-5}$, $n = 0.147$

$\rho = aT^{-n}$

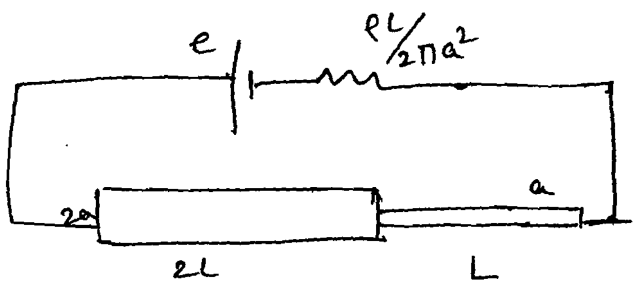
$\rho_1 = (8 \times 10^{-5})(77)^{-0.147}$

$= 4.23 \times 10^{-5}$

$\rho_2 = (8 \times 10^{-5})(573)^{-0.147}$

$= 3.15 \times 10^{-5}$ Ans

Comprehension - III



let say

$\frac{\rho L}{2\pi a^2} = R$

10. Resistance of potentiometer wire

$R_1 + R_2 = \frac{\rho(2L)}{\pi(2a)^2} + \frac{\rho(L)}{\pi a^2} = \frac{3}{2}\frac{\rho L}{\pi a^2} = 3R$

Req of potentiometer wire + internal resistance

$= \frac{2\rho L}{\pi a^2} = 4R$

$i = \frac{e}{4R}$

Potential drop across potentiometer

$= i(3R) = \frac{e}{4R} \times 3R = \frac{3}{4}e$

= Max^m Voltage which can be balanced on the potentiometer wire

11. Max^m drop across first wire

$$= i(R_1) = \frac{e}{4R} \times R = e/4$$

So balance point will occur on second wire (for emf $e/2$)

So remaining ~~em~~ drop $(e/2 - e/4)$ must be on second wire so length required is x (say)

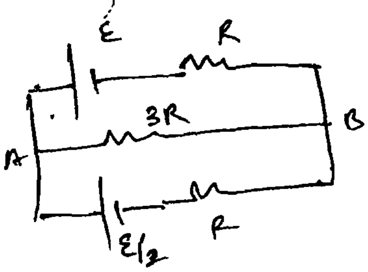
$$\left(\frac{e}{2} - \frac{e}{4}\right) = i\left(\frac{\rho x}{\pi a^2}\right)$$

$$\Rightarrow \quad \frac{e}{4} = \frac{e}{4R} \cdot \frac{\rho x}{\pi a^2}$$

$$\Rightarrow \quad x = \frac{\pi a^2 R}{\rho} = \frac{\pi a^2}{\rho} \times \frac{\rho L}{2\pi a^2} = L/2$$

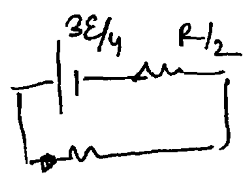
hence balancing length $= 2l + l/2 = 5l/2$ Ans

12.



$$\mathcal{E}_{eq} = \frac{\mathcal{E}_1 r_2 + \mathcal{E}_2 r_1}{r_1 + r_2} = \frac{\mathcal{E}R + \frac{\mathcal{E}}{2}R}{2R} = \frac{3\mathcal{E}}{4}$$

$$r_{eq} = R/2$$

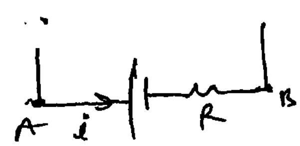


hence current in potentiometer

$$= \frac{(3\mathcal{E}/4)}{(3R + R/2)} = \frac{3\mathcal{E}}{14R}$$

$$V_A - V_B = \left(\frac{3\mathcal{E}}{14R}\right) \times 3R = \frac{9\mathcal{E}}{14}$$

current through this cell



$$V_A - \frac{\mathcal{E}}{2} - iR = V_B$$

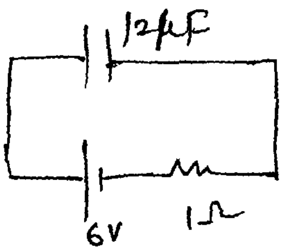
$$\Rightarrow \quad iR = \frac{9\mathcal{E}}{14} - \frac{\mathcal{E}}{2}$$

$$= \frac{9\mathcal{E} - 7\mathcal{E}}{14} = \frac{2\mathcal{E}}{14}$$

$$\boxed{i = \frac{\mathcal{E}}{7R}}$$ where $R = \frac{\rho L}{2\pi a^2}$ Ans

Comprehension - IV

13.



$\tau = 12\times10^{-6}$

$RC = 12\times10^{-6}$

$\frac{t}{RC} = 1$

$$i = \frac{\varepsilon}{R} e^{-t/RC}$$

$$= \frac{6}{1} e^{-1} = 2.207 = 2.21 \text{ Am}$$

14. $P = Vi = 2.207\times 6 = 13.24$ W

Ans

15. Heat $= i^2 R = 4.8708$ W $\left\{ \begin{array}{l} i = 2.207 \\ R = 1\Omega \end{array} \right.$

16. Rate at which energy stored in the Capacitor is increasing

$$E = \frac{Q^2}{2C} \qquad Q = CE(1-e^{-t/RC})$$

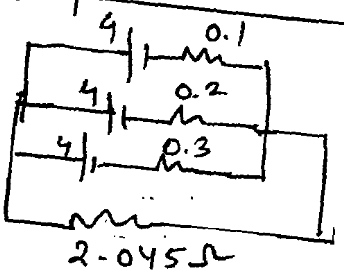
$$\frac{dE}{dt} = \frac{\cancel{2}Q\frac{dq}{dt}}{\cancel{2}C} =$$

$$= \frac{CE(1-e^{-1}).i}{C} = E(1-e^{-1})(2.207)$$

$$= 6\times(1-1/e)(2.207) = 8.3705 \text{ W}$$

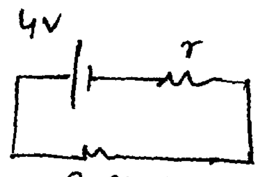
Ans

Comprehension - V



Equivalent circuit can be represented by

$\equiv$



$$r = \frac{0.3\times\left(\frac{0.1\times0.2}{0.1+0.2}\right)}{0.3+\left(\frac{0.1\times0.2}{0.1+0.2}\right)} = \frac{3}{55} = 0.0545$$

17. Equivalent resistance for calculation of current $= 2.045 + 0.0545$

$= \cancel{2.099}$

$= 2.1\ \Omega$

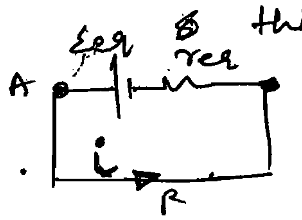
18. Eq voltage as shown $= 4V$ $\quad \because \varepsilon_1 = \varepsilon_2 = \varepsilon_3 = 4V$

19. current $= \dfrac{4}{2.1} = 1.904$ Amp

20. potential drop across resistor $= (1.90) \times (2.045)$

$= 3.8855$

& this is terminal voltage for equivalent cel (same)



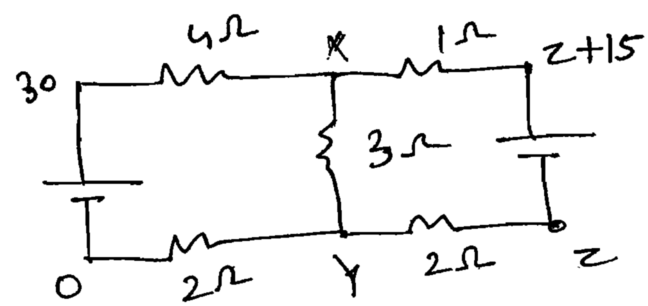
$V_A - V_B = iR$

21. for each cell terminal voltage is same as

$V_A - V_B = 3.8855$

Ans

Comprehension – VI



$$\frac{30-x}{4} = \frac{x-y}{3} + \frac{x-z-15}{1} \quad \text{— (1)} \qquad 19x - 4y - 12z = 270$$

$$\frac{y-0}{2} + \frac{y-x}{3} = \frac{z-y}{2} \quad \text{— (2)} \qquad 3z + 2x - 8y = 0$$

$$\frac{y-z}{2} = \frac{z+15-x}{1} \quad \text{— (3)} \qquad 2x + y - 3z = 0$$

hence $x = 8$, $y = 6$, $z = 4$ Volt

22. current through 30 V $= \frac{30-x}{4} = \frac{12}{4} = 3A$

23. current through 15 V $= \frac{(x+15)-x}{1} = \frac{19-18}{1} = 1A$

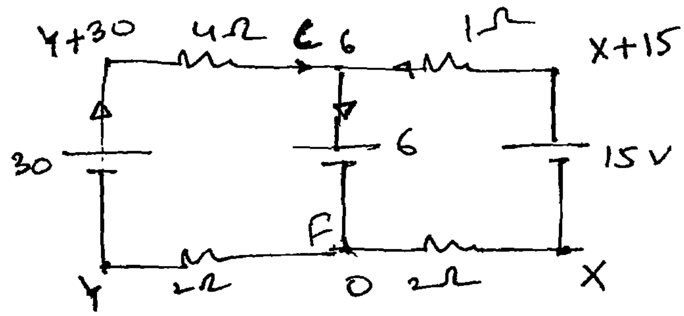
24. from each battery current is leaving hence No one is getting charged.

25. Total electrical power consumed

$$V_1 i_1 + V_2 i_2$$

$$= (30\times3) + (15\times1) = 90 + 15 = 105 W$$

Comprehension - VII



$$\frac{-Y}{2} = \frac{Y+24}{4} \quad\Rightarrow Y = -8$$

$$\frac{-x}{2} = \frac{x+9}{1} \quad\Rightarrow x = -6$$

current in BC = 4 Amp $= \left(\frac{22-6}{4}\right)$

in CD $= \frac{9-6}{1} = 3$ Amp

current in CF branch $= 4+3 = 7A$

26. (A) $V_C - V_F = 6V$

current in CF flows from C to F.

27. both loop are independent.

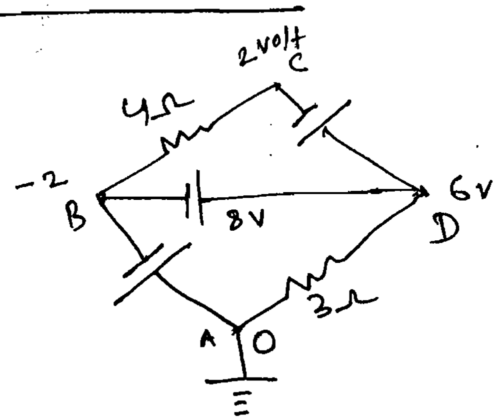
Incorrect statement is (C)

28. only 6V is getting charged

29. current in branch CF $= 4+3 = 7A$

Match the column

1.



(a) least potential is of $B = -2$ Volt

(b) The current through 3Ω resistor $= \frac{6-0}{3} = 2A$ from D to A.

(c) current through 4Ω resistor $= \frac{2-(-2)}{4} = 1A$ from C to B.

2. $RC = 3$, $E = 4V$ $t = 1$ sec

(a) $\frac{dq}{dt} = i = \frac{\varepsilon}{R} e^{-t/RC} = \frac{4}{3 \times 10^6} e^{-1/3}$

$= 0.955 \times 10^{-6}$

$= 9.6 \times 10^{-7}$

(b) Rate at which Energy stored in capacitor = Power by cell − joule heat

$= (3.8 - 2.7) \times 10^{-6}$

$= 1.1 \times 10^{-6}$

(c) Joule heat $= i^2 R$

$= (9.6)^2 \times 10^{-14} \times 3 \times 10^{6}$

$= 2.76 \times 10^{-6}$

(d) Rate at which Energy delivered by cell $= Ei$

$= 3.84 \times 10^{-6}$

Ans.

3. When capacitor is fully charged

~~Heat~~ Energy stored $= \frac{1}{2} C (60)^2$

$= \frac{1}{2} \times \frac{0.1}{10} \times 3600 = 180\ J$

At any instant

current in 4Ω is I then current in 6Ω will be

$I/3$ and in 3Ω be $2I/3$.

Hence Ratio of Rate of heat dissipation. $4\Omega : 6\Omega : 3\Omega$

$$I^2 4 : \frac{I^2}{9} . 6 : \frac{4I^2}{9} . 3$$

$$\Rightarrow \quad 12 : 2 : 4$$

$$\Rightarrow \quad 6 : 1 : 2$$

If total Heat produced $= H$

then heat produced by $4\Omega = 6H/9$

by $6\Omega = H/9$

by $3\Omega = 2H/9$

[but Heat = Energy of capacitor = 180 J

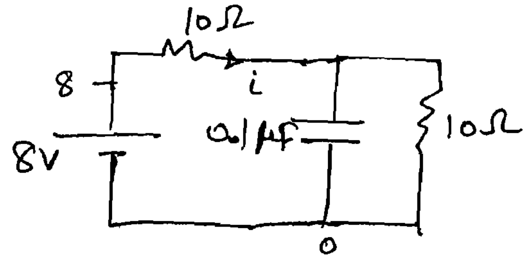
$\therefore$ (a) Heat generated across $4\Omega = 120\ J$

(b) across $6\Omega = 20\ J$

(c) across $3\Omega = 40\ J$

(d) across $4\Omega + 6\Omega = 140\ J$

(4)



Remaining circuit is replaced by a 10Ω resistor.

In steady state No current through capacitor.

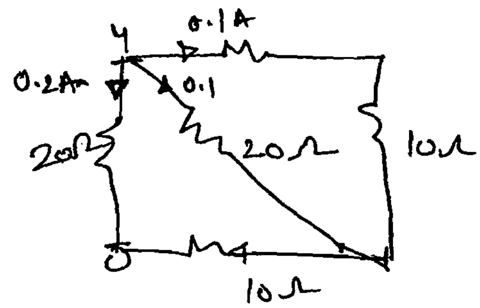
$$i = \frac{8}{20} = 0.4\ A$$

potential drop across Capacitor = $8 - (0.4)10$
$= 4\ V$

hence

(A) charge on capacitor = $0.4\ \mu C$ $(q = CV)$

(B) for current in AC branch



= 0.1 A

(∵ equal parallel resistance)

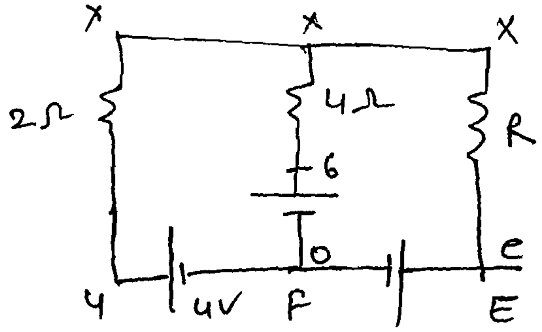
(C) current in AB Branch

$$= \frac{4}{20} = 0.2\ A$$

(d) current in resistance between

E and F = $\frac{8-4}{10} = 0.4\ A$

(5)



$$\frac{4-x}{2} = \frac{x-6}{4} + \frac{x-e}{R} \quad (1)$$

(A) current through 4Ω is zero $\Rightarrow$ $x = 6$

hence by (1)

$$\Rightarrow \quad -1 = \frac{6-e}{R}$$

$$\Rightarrow \quad -R = 6-e$$

$$\Rightarrow \quad e = 6+R \qquad \underline{e > 6 \text{ volt}}$$

(B) from F to C direction $\quad X < 6$ volt

by (1)

$$2R(4-X) = R(X-6) + 4X - 4e$$

$$\Rightarrow \quad 8R - 2RX = RX - 6R + 4X - 4e$$

$$\Rightarrow \quad 14R + 4e = (4+3R)X$$

$$\Rightarrow \quad X = \frac{14R+4e}{4+3R} < 6$$

$$\Rightarrow \quad 14R + 4e < 24 + 18R$$

$$\Rightarrow \quad 4e < 24 + 4R$$

$$\Rightarrow \quad e < 6 + R$$

for $R = 0$ $\quad e < 6$ $\qquad$ for diff R

$e = 6V$

<u>hence</u> $\qquad$ or $e > 6V$

(a), (b), (c) $\qquad$ but since R is finite

$e <$ some finite value.

(C)

For c to f direction

$e > R + 6$ $\quad$ min^m $R = 0\,\Omega$

hence $e > 6\,\Omega$

(D) current in 2Ω will be from B to A

If $X > 4$

$$\Rightarrow \frac{14R + 4e}{4 + 3R} > 4$$

$$\Rightarrow 14R + 4e > 16 + 12R$$

$$\Rightarrow 4e > 16 - 2R$$

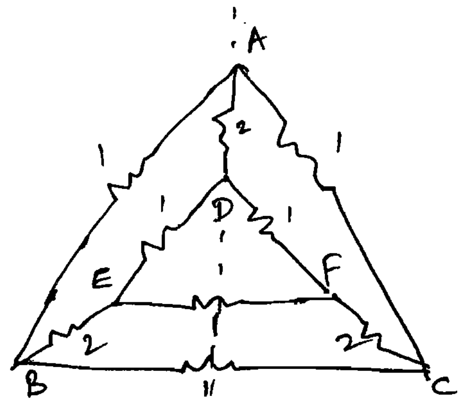
$$\Rightarrow e > 4 - R/2$$

min^m $R = 0$ $\therefore e > 4$

So ~~for~~ depending upon the value of R e can take any value from 0 to infinity.

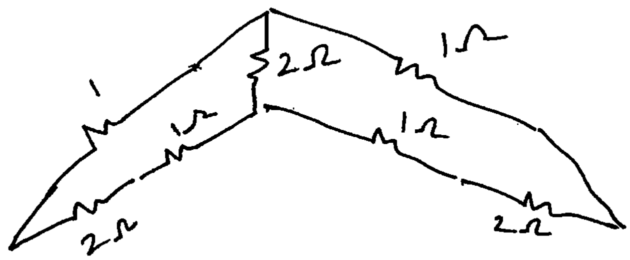
Ex – IV Solutions

1|

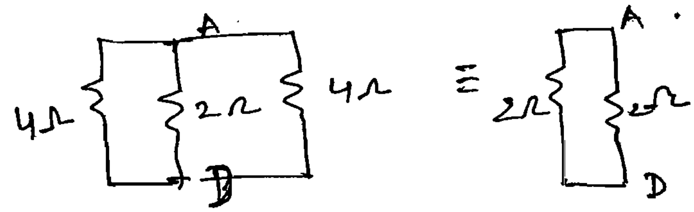


by symmetry, No current in resistor EF and BC

Equivalent circuit can be represented by

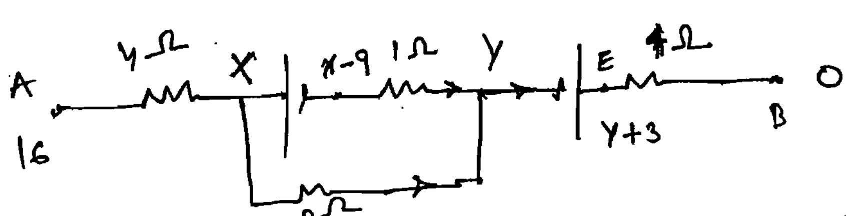


≡



$\Rightarrow R_{eq} = 1\Omega$ Ans

2|



we have $\dfrac{16-x}{4} = \dfrac{(y+3)-0}{4}$ — (1) [same current in branch AX and EB]

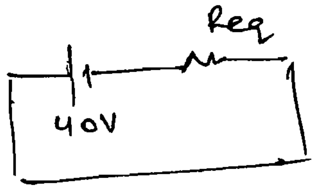
Similarly $\dfrac{x-9-y}{1} + \dfrac{x-y}{2} = \dfrac{(y+3)-0}{4}$ — (2) [at junction 'x']

by (1) $x+y=13$, by (2) $6x-7y-39=0$

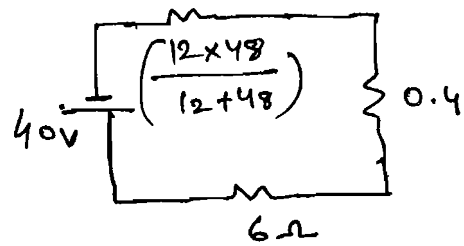
$\therefore$ $x=10$, $y=3$

current through $2\Omega = \dfrac{10-3}{2} = 7/2 = 3.5\,A$ Ans.

3| equivalent circuit for current



for Req

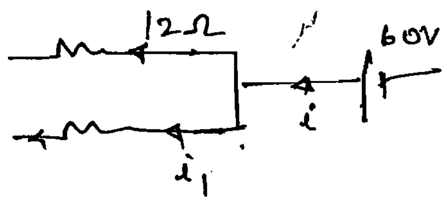


$i = \frac{40}{16} = \frac{5}{2} = 2.5$ Amp

$R_{eq} = 6 + \frac{48}{5} + \frac{4}{10}$

$= 16\,\Omega$

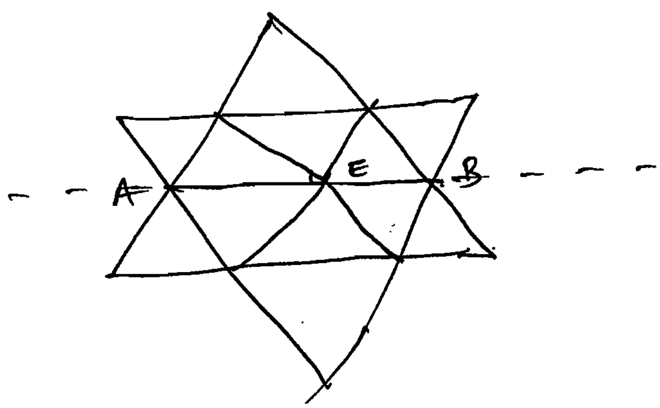
Now for voltmeter reading current through 7Ω resistor



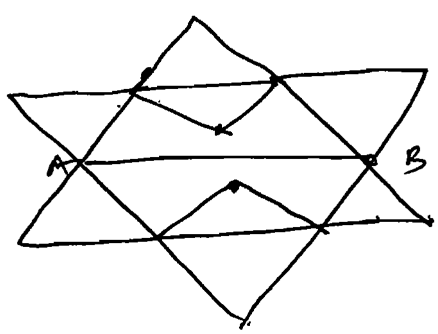
$i_1 = \left(\frac{12}{48+12}\right)i = \frac{i}{5}$

$\therefore V = (i/5)7 = \frac{5}{2}\times\frac{1}{5}\times 7 = 3.5$ Volt Ans:

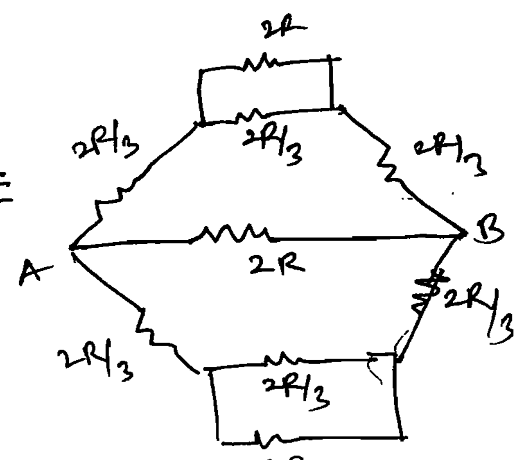
4|



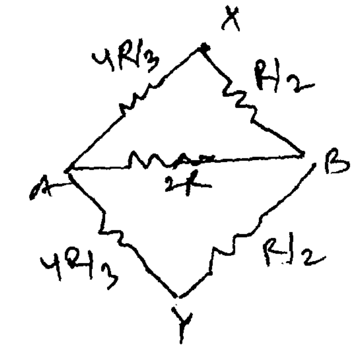
by symmetry we can disconnect the junction E as shown



=

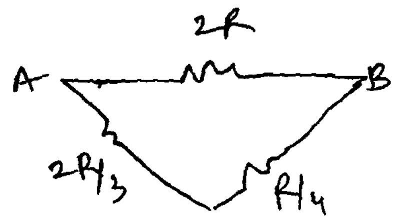


$\equiv$

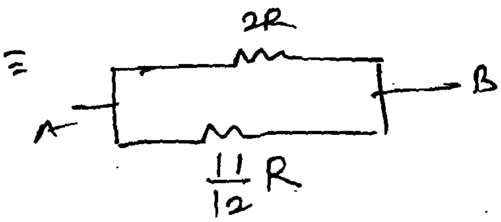


by symmetry again point X and Y are at same potential hence by folding.

$\equiv$



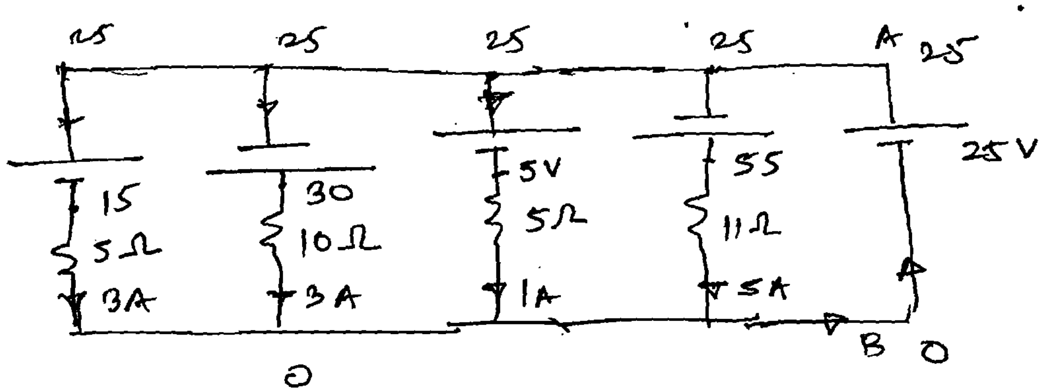
$\equiv$



$\because R = 1\Omega$

$$R_{eq} = \frac{2 \times \frac{11}{12}}{2 + \frac{11}{12}} = \frac{22}{35}\ \Omega \quad \underline{\text{Ans.}}$$

<u>5</u>|



~~some~~ Assign Potential At B = 0 Volt hence at A potential = 25V similarly other points potentials are known.

Now current can be calculated by V = IR in various branches as shown

Hence current through 25 V = 3 + 3 + 1 + 5 = 12 Amp.

Power supplied by 20V cell = − (20)1 = − 20 W

(Since current is entering into battery)

6 | by Given condition

$$\left(\frac{E}{R_1+r}\right)^2 R_1 \cancel{t} = \left(\frac{E}{R_2+r}\right)^2 R_2 \cancel{t}$$

$$\Rightarrow \frac{R_1}{(R_1+r)^2} = \frac{R_2}{(R_2+r)^2}$$

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

$\Rightarrow$ by componendo & dividendo

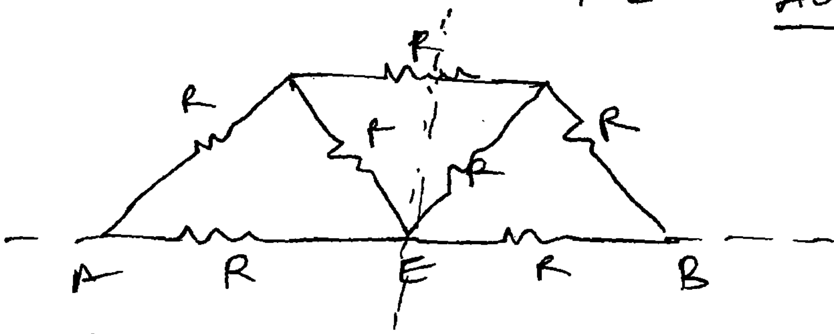
$$\Rightarrow \frac{R_1+R_2+2r}{R_2-R_1} = \frac{\sqrt{R_2}+\sqrt{R_1}}{\sqrt{R_2}-\sqrt{R_1}}$$

$$\Rightarrow (R_1+R_2)+2r = \left(\sqrt{R_2}+\sqrt{R_1}\right)^2$$

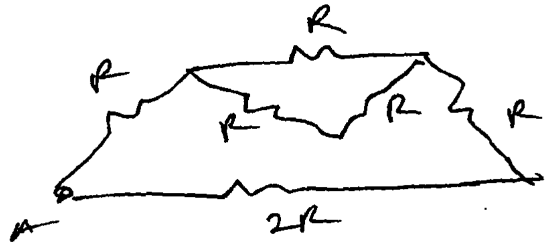
$$\Rightarrow \cancel{2}r = \cancel{2}\sqrt{R_1R_2}$$

$$\Rightarrow r = \sqrt{R_1R_2} \quad \underline{\text{Ans}}$$

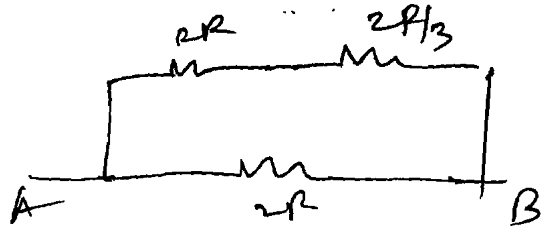
7 |



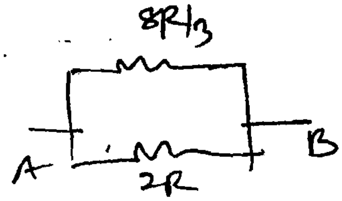
by symmetry we can disconnect junction as shown



$\equiv$

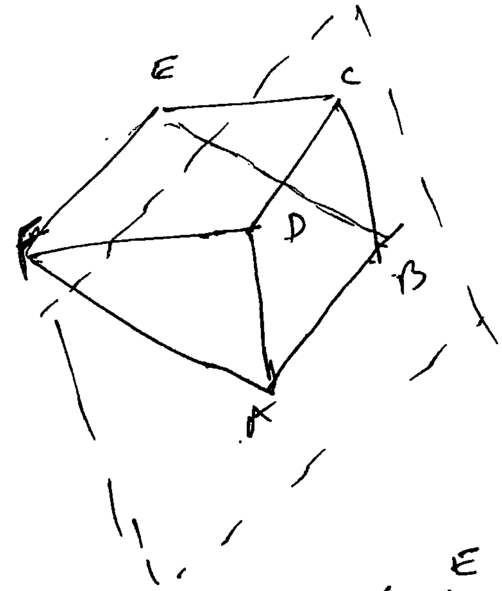


$\equiv$



$$R_{eq} = \frac{(8R/3)\times 2R}{(\frac{8}{3}+2)R} = \frac{16/3\ R}{\dots} = \frac{8}{\dots}R$$

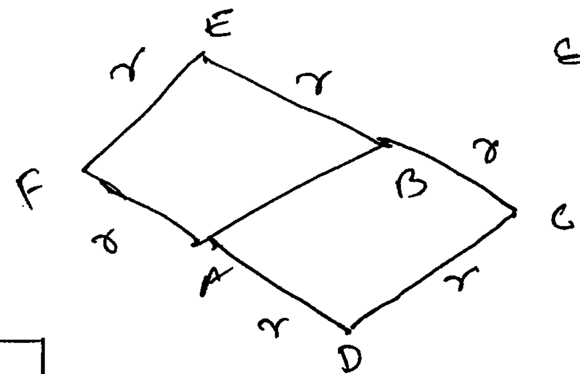
8



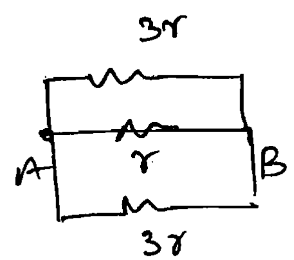
by plane of symmetry we can say current through ~~EB~~ EC and FD is zero hence ~~can~~ can remove EC and DF resistors.

Equivalent circuit can be shown as

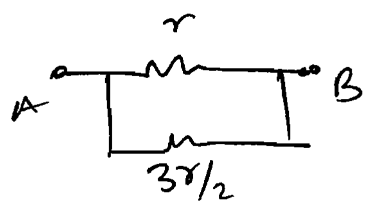
≡



≡

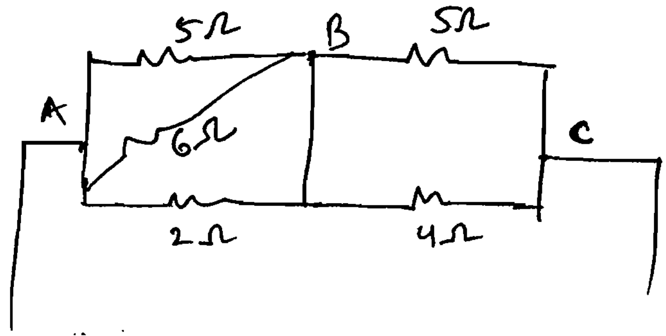


≡



$$R_{eq} = \frac{\left(\frac{3r}{2}\right) r}{\frac{3r}{2} + r} = \frac{3r}{5} \quad \underline{\text{Ans}}$$

9



across BC

potential drop is same

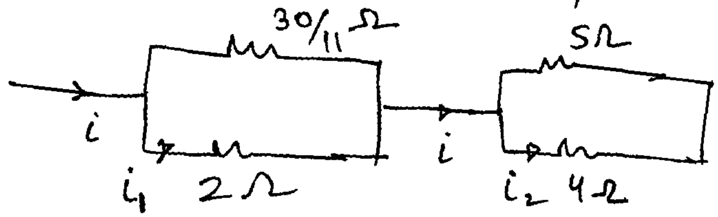
hence $P = V^2/R$

4Ω will produce more power.

Similarly across AB 2Ω will produce more heat.
Now b/w 2Ω & 4Ω we have to compare which one is producing more heat.

let total current be I

Equivalent circuit can be represented by



$$i_1 = \left(\frac{\frac{30}{11}}{\frac{30}{11}+2}\right) i \qquad i_2 = \left(\frac{5}{5+4}\right) i$$

$$= \frac{30}{52} i = \frac{15}{26} i \qquad i_2 = \frac{15}{27} i$$

H_1 = Heat produced in 2Ω $= \left(\frac{15 i}{26}\right)^2 \times 2t$

$= 0.665\, i^2 t$

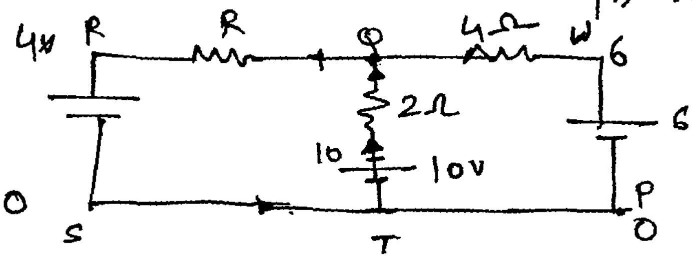
Heat produced in 4Ω (H_2) $= \left(\frac{15}{27} i\right)^2 \times 4t$

$= 1.23\, i^2 t$

$\therefore H_2 > H_1$

Heat produced in 4Ω is greater than heat produced in 2Ω.

10) $\because$ since current through 4Ω is zero.



Assign voltage at point P = 0

Voltage at W = 6V

$V_Q = 6V$ also ($\because$ No current in 4Ω)

$V_S = V_T = 0$

$\therefore$ Current in TQ branch $= \frac{10 - V_Q}{2}$

$= \frac{10-6}{2} = 2$ Amp — (1)

Current in RQ branch $= \frac{V_Q - V_R}{R} = 2$ Amp by eqn (1)

$\Rightarrow \frac{6-4}{R} = 2$ Amp

$\Rightarrow$ $R = 1\Omega$ Ans.

11 Initially when both swiches are open

$$i_1 = \frac{\mathcal{E}}{450}$$

When both are closed

$$i_2 = \frac{\mathcal{E}}{300 + \frac{100R}{100+R}}$$

[No current through 50Ω ∵ It is short-circuited]

∵ Reading of Ammeter is same

$$\therefore \quad \frac{\cancel{\mathcal{E}}}{450} = \left(\frac{\cancel{\mathcal{E}}}{300 + \frac{100R}{100+R}}\right) \times \frac{R}{R+100}$$

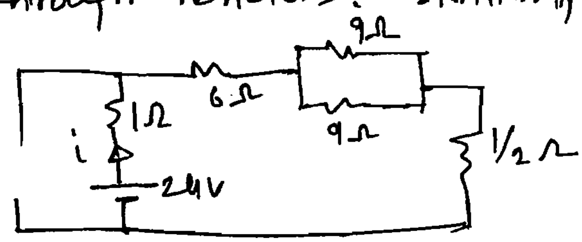
$$\Rightarrow \quad \frac{1}{450} = \frac{R}{300(R+100) + 100R}$$

$$\Rightarrow \quad 400R + 30000 = 450R$$

$$\Rightarrow \quad 50R = 30000 \Rightarrow \underline{R = 600\,\Omega}$$

Ans.

12 S_1 must be open otherwise current will not go through resistors. Similarly S_2 & S_3 are open.



because for less current through battery, more should be the Resistance.

Current $i = \frac{24}{R_{eq}}$

$i = \frac{24}{12} = 2\,\text{Amp}$

$R_{eq} = 6 + \frac{9}{2} + \frac{1}{2} + 1\Omega$
$= 11 + 1$
$= 12\,\Omega$

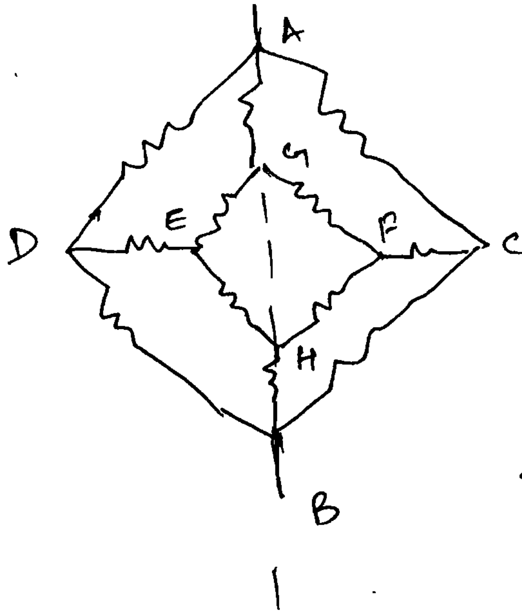
for potential diff. calculation current in AB branch $= 1\,\text{Amp}$.

[current 2A will be divided equally in two resistors ∵ both resistors are same]

$\therefore \quad V_{AB} = iR$
$= (1)(1\Omega) = 1\,\text{Volt}$

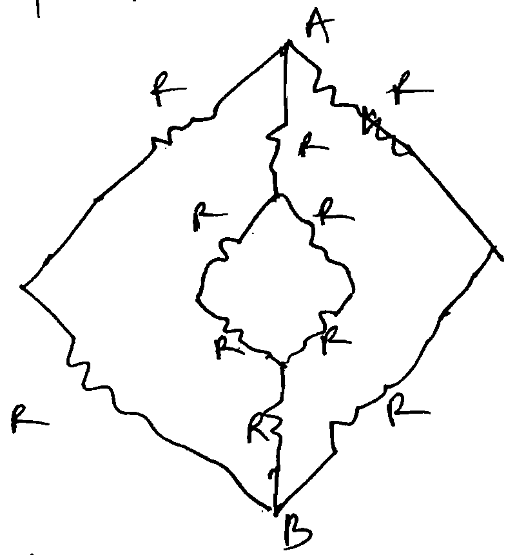
Ans

131

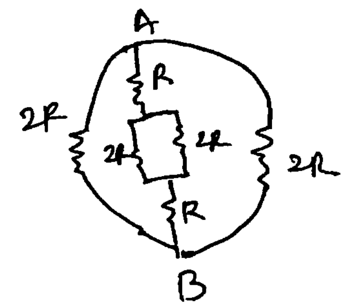


by symmetry branches DE and CF will have no current. hence can remove these resistance.

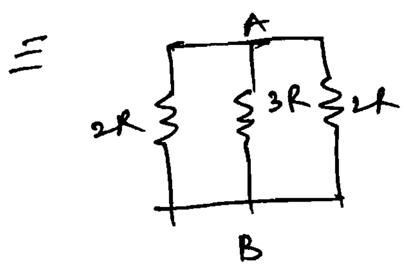
Equivalent circuit is given below



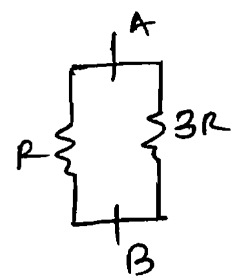
$\equiv$



$\equiv$



$\equiv$



$$R_{eq} = \frac{3R^2}{3R+R}$$

$$= \frac{3}{4}R$$

$\because R = 12\,\Omega$

$$R_{eq} = \frac{3}{4} \times 12 = 9\,\Omega$$

Ans:

14|

potential gradient $= \left(\dfrac{\left(\frac{10}{20}\right) \times 10}{L} \right) = 5/L = \frac{5}{1}$ volts/metre

ε_{eq} (cell) $= \dfrac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$ $\quad r_{eq} = \dfrac{r_1 r_2}{r_1 + r_2}$

$= \dfrac{10+4}{6}$

Hence during balance

$\dfrac{14}{6} = (5)\,x$

$\Rightarrow x = \dfrac{14}{30}\,m = \dfrac{1400}{30}\,cm$

$= 46.666\ cm$

$= 46.67\ cm$ Ans

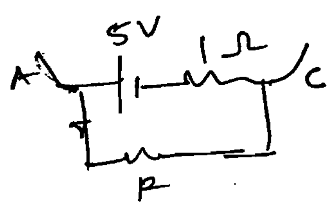
15|

potential Gradient $= \dfrac{\frac{10}{10} \times 10}{1} = 10\,V/m$

potential drop across AC

$= 10 \times 0.4 = 4$ volt

by cell
potential drop $= \varepsilon - ir$

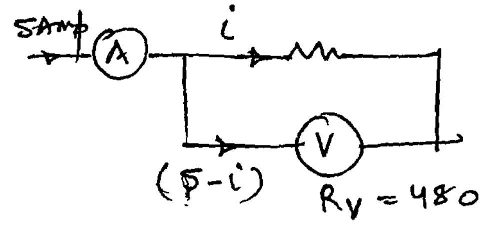


$5 - \left(\dfrac{5}{R+1}\right) 1 = 4$

$\Rightarrow 1 = \dfrac{5}{R+1}$

$\Rightarrow R = 4\,\Omega$ Ans.

16



$$(5-i)(480) = i(R) = 96$$

$$\Rightarrow 5 \times 480 = [(480)+R]\,i$$

$$\Rightarrow i = \frac{480 \times 5}{480+R}$$

but $iR = 96$

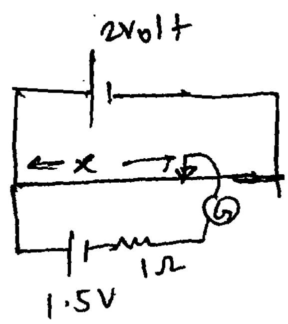
$$\Rightarrow \left(\frac{480 \times 5}{480+R}\right)R = 96$$

$$\Rightarrow 25R = 480 + R$$

$$\Rightarrow 24R = 480$$

$$\Rightarrow R = 20\,\Omega \quad \underline{\text{Ans}}$$

17



potential gradient $= \frac{2}{10}$ V/m

for zero deflection $\left(\frac{2}{10}\right)x = 1.5$

$$\Rightarrow x = 15/2 = 7.5\text{ m}$$

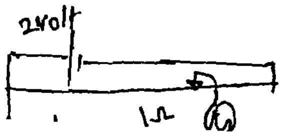
(a) When 5Ω is placed in series $i' = 2/35$ Amp

potential gradient $= \left(\frac{\frac{2}{35} \times 30}{10}\right)$ V/m

$$\left(\frac{6}{35}\right)x = 1.5$$

$$\Rightarrow x = 8.75\text{ m}$$

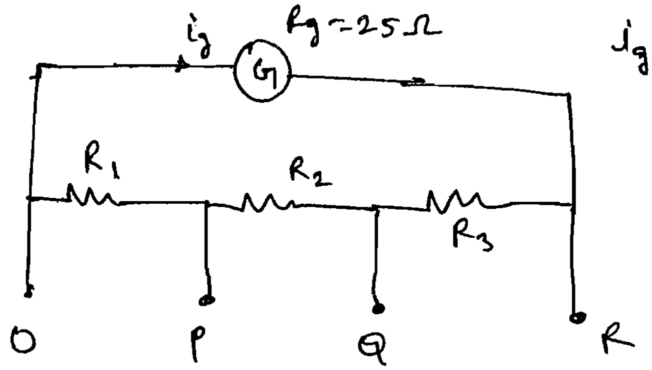
(b)



$$\left(\frac{2}{10}\right)x = \varepsilon - ir$$

$$\Rightarrow \quad = 3 - \left(\frac{3}{2}\right)1$$

18



$i_g = 10\,mA$

We can have following eqn's (taking current in mA)

$$10(25 + R_2 + R_3) = (10^4 - 10)R_1$$ [when terminals O and P are taken

$$\Rightarrow 25 + R_2 + R_3 = (10^3 - 1)R_1 \quad \text{--- (1)}$$

$$25 + R_3 = (10^2 - 1)(R_1 + R_2) \quad \text{--- (2)}$$ [O and Q are taken

$$25 = (10 - 1)(R_1 + R_2 + R_3) \quad \text{--- (3)}$$

by eqn (2)

$$99(R_1 + R_2) = 25 + R_3 \quad \text{--- (4)}$$

by eqn (3)

$$R_1 + R_2 = \frac{25}{9} - R_3$$

$R_1 + R_2$ put in eqn (4)

$$99\left(25/9 - R_3\right) = 25 + R_3$$

$$\Rightarrow 25 \times 11 - 99R_3 = 25 + R_3$$

$$\Rightarrow 100R_3 = 25(11 - 1)$$

$$\Rightarrow \boxed{R_3 = 2.5\,\Omega}$$ Ans

$$\therefore R_1 + R_2 = \frac{25}{9} - 5/2 = 5/18$$

Now by eqn (1)

$$\Rightarrow 25 + R_2 + 5/2 = 999\left(5/18 - R_2\right)$$

$$\Rightarrow 1000R_2 = \frac{555}{2} - 55/2 = \frac{500}{2}$$

$$\Rightarrow \boxed{R_2 = \frac{1}{4} = 0.25\,\Omega}$$

Ans

$$R_1 = \frac{25}{9} - \left(\frac{1}{4} + 5/2\right)$$

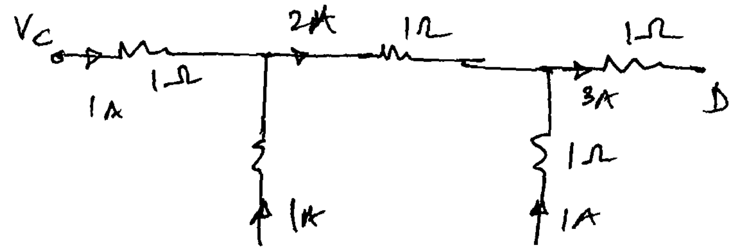
$$= \frac{25}{9} - \frac{11}{4}$$

$$= \frac{100 - 99}{36} = \frac{1}{36}$$

$$= 0.0278\,\Omega$$

Ans

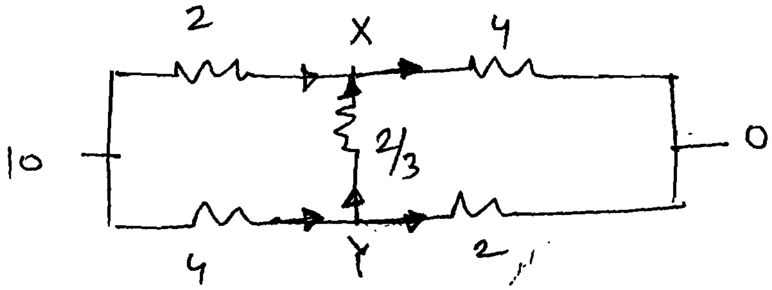
19|



$V_c - (1) - (2) - (3) = V_D$

$V_c - V_D = 6$ Volt Ans.

20|



by Kirchoff's junction Rule

$$\frac{10-x}{2} + \frac{(y-x)3}{2} = \frac{x}{4} \quad \text{—①}$$

$$\frac{10-y}{4} = \frac{(y-x)3}{2} + \frac{y}{2} \quad \text{—②}$$

by ① $9x - 6y = 20$ by ② $-6x + 9y = 10$

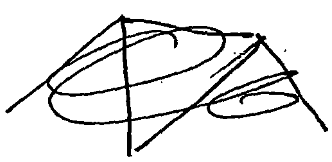
hence $x = 16/3$, $y = 14/3$

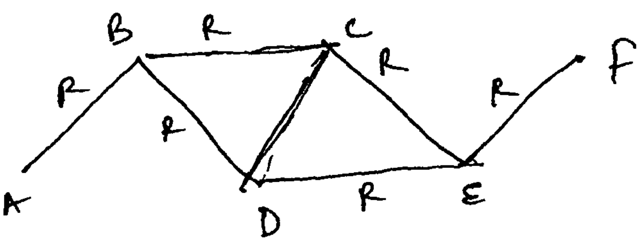
$\therefore x - y = 2/3$

$\therefore$ current $= \dfrac{2/3}{2/3} = 1$ Amp Ans

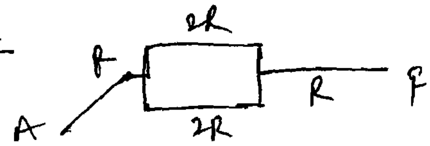
21|

$R_1 = 5R$, In latter case



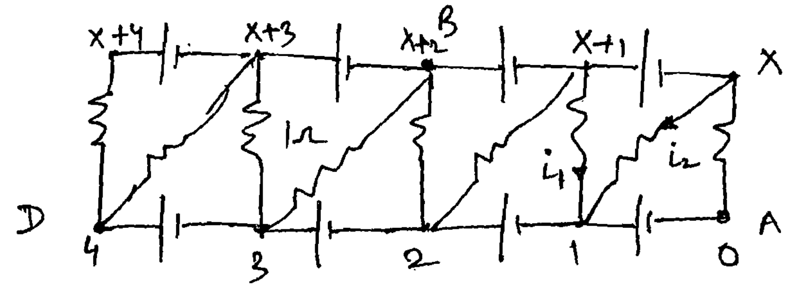


by wheatstone bridge No current in 'CD' hence can remove. Hence



R ... R + R + R = 3R

22



$j_1 = \frac{x}{1}$ $\quad i_2 = \frac{x-1}{1}$

junction law at 'D'

$$3\left[\left(\frac{x-1}{1}\right) + \frac{x}{1}\right] + \frac{x-0}{1} = \frac{-x}{1} + \frac{1-x}{1}$$

$\Rightarrow \quad 3x - 3 + 3x + x = -2x + 1$

$\Rightarrow \quad 9x = 4 \quad \Rightarrow x = 4/9$ Volt

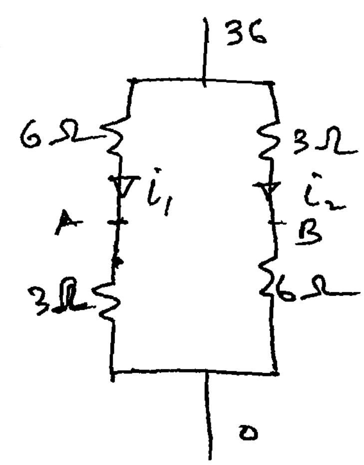
Hence $\quad V_A - V_B = 0 - (x+2)$

$= 0 - (4/9 + 2) = -22/9$ Volt

Ans

23

When s is open



$i_1 = \frac{36}{9} = 4$ Am

$i_2 = \frac{36}{9} = 4$ Amp

potential drop across 6Ω in left branch

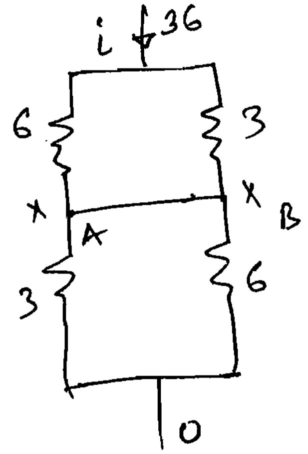
$= 6 \times 4 = 24$

hence $\quad V_A = 36 - 24 = 12$ Volt

similarly $\quad V_B = 36 - 12 = 24$ Volt

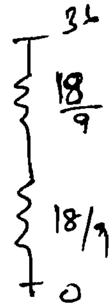
(i) $\quad V_A - V_B = -12$ Volt

23 | (ii)



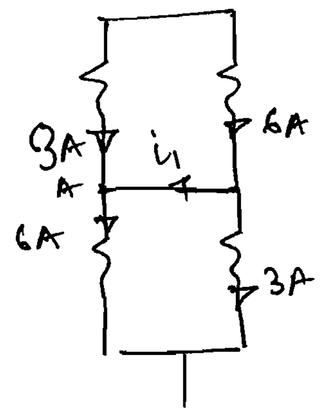
$R_{eq} = 4\Omega$

$i = \frac{36}{4} = 9$ Amp



current through 6Ω will be 3A and current through 3Ω will 6A.

∴



by junction A

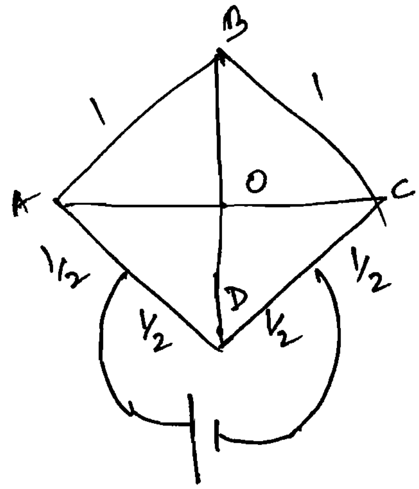
$i_1 + 3 = 6$

$i_1 = 3$ Amp

[3 Amp from B to A]
current through S.

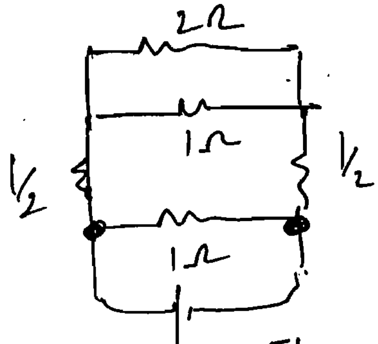
Ans.

24 |

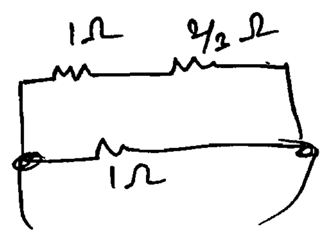


By symmetry
BO and OD will have no current.

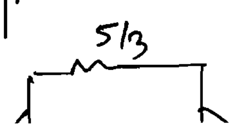
hence



≡

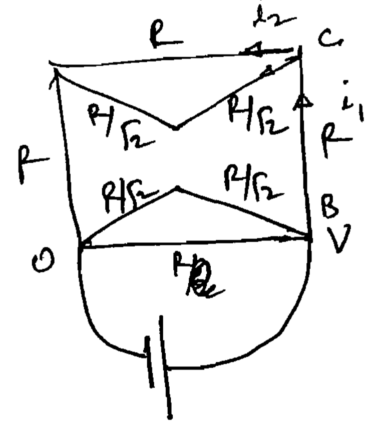


≡

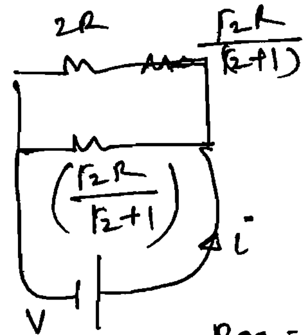


$R_{eq} = \frac{5/3}{5/3+1} = 5/8\ \Omega$

25. By symmetry we can make equivalent circuit as given below



for Req calculation:



$$R_{eq} = \frac{\left(2R + \frac{\sqrt{2}R}{\sqrt{2}+1}\right) \times \frac{\sqrt{2}R}{\sqrt{2}+1}}{2R + \frac{2\sqrt{2}R}{\sqrt{2}+1}}$$

$$R_{eq} = \frac{(3\sqrt{2}+2)\sqrt{2}\,R}{2(\sqrt{2}+1)(2\sqrt{2}+1)}$$

$$i = \frac{V}{R_{eq}}$$

let current in the circuit is i

current in branch

$$BC,\ i_1 = \frac{\left(\frac{\sqrt{2}R}{\sqrt{2}+1}\right)}{2R + \frac{2\sqrt{2}R}{\sqrt{2}+1}} \cdot i$$

$$= \frac{\sqrt{2}}{2(2\sqrt{2}+1)}\, i$$

current in CD

i_2 can be calculated as

$$= \frac{\sqrt{2}R}{(\sqrt{2}+1)R}\, i_1$$

$$= \frac{\sqrt{2}}{(\sqrt{2}+1)} \times \frac{\sqrt{2}}{2(2\sqrt{2}+1)}\, i$$

$$= \frac{i}{(\sqrt{2}+1)(2\sqrt{2}+1)}$$

$\therefore$ Power in CD $= i_2^2 R = \dfrac{i^2 R}{(\sqrt{2}+1)^2(2\sqrt{2}+1)^2} = \dfrac{V^2 R}{R_{eq}^2(\sqrt{2}+1)^2(2\sqrt{2}+1)^2}$

Power in AB $= \dfrac{V^2}{R}$

Ratio of Heat liberated $= \dfrac{P_{AB}}{P_{CD}}$

$$\frac{P_{AB}}{P_{CD}} = \frac{V^2/R}{V^2 R} R_{eq}^2 (\sqrt{2}+1)^2 (2\sqrt{2}+1)^2$$

$$= \frac{1}{\cancel{R^2}} \cdot \frac{(3\sqrt{2}+2)^2 \cdot \cancel{R^2} \cancel{(\sqrt{2}+1)^2} \cancel{(2\sqrt{2}+1)^2}}{2 \cancel{(\sqrt{2}+1)^2} \cancel{(2\sqrt{2}+1)^2}}$$

$$= \frac{18+4+12\sqrt{2}}{2}$$

$$= \frac{22+12\sqrt{2}}{2}$$

$$= 11+6\sqrt{2}$$ Ans

AIEEE Solutions

1) $P_1 = \frac{(220)^2}{R}$, in second case $R_{eq} = \frac{R/2}{2} = R/4$

$$P_2 = \frac{(220)^2}{(R/4)} \Rightarrow \frac{P_1}{P_2} = \frac{1}{4}$$

$\Rightarrow P_2 : P_1 = 4$ Ans

2) for voltmeter High resistance in series.

3) Given $\frac{(15)^2}{R_{eq}} = 150$

$$\Rightarrow R_{eq} = \frac{15}{10}$$

$$\Rightarrow \frac{2R}{2+R} = \frac{3}{2} \Rightarrow 4R = 6 + 3R \Rightarrow R = 6\,\Omega$$

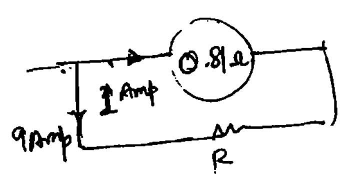
4) for a conductor $\rho \uparrow$ as $T \uparrow$

semiconductor $\rho \downarrow$ as $T \downarrow$

5) $R = \frac{(220)^2}{1000} = \frac{22 \times 22}{10}$

$$P_{consumed} = \frac{(110)^2}{R} = \frac{11 \times 11 \times 100 \times 10}{22 \times 22} = 250\,W$$

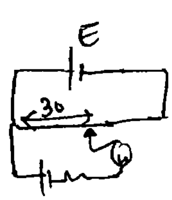
6) $R_{eq} = \frac{6 \times 3}{6+3} = 2\,\Omega$ $\quad i = \frac{3}{2} = 1.5\,A$

7) 

$0.81 = 9R$

$\Rightarrow R = 0.09\,\Omega$ ANS

8) copper is conductor hence resistance $\downarrow$ as $T \downarrow$
germanium is semi conductor resistance $\uparrow$ as $T \downarrow$

9) 

$$30\left(\frac{E}{100}\right) = e$$

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

10)

$$\frac{R_2}{R_1} = \frac{l_2^2}{l_1^2} \qquad l_2 = 2l_1 \text{ (Given)}$$

100% increase

$$\Rightarrow \frac{R_2}{R_1} = 4$$

$$\Rightarrow \frac{R_2 - R_1}{R_1} \times 100 = (4-1)\times 100 = 300\%$$

Ans

11)

$$ms\Delta T = Pt$$

1mL = 1cc

$1L = 10^{-3}\, m^3$, $\rho = 10^3\, kg/m^3$

$$\Rightarrow (10^{-3} \times 10^3) . s_w (30) = 836\, t$$

$$\Rightarrow 10^3 \times 4.18 \times 30 = 836t$$

$\cancel{(s_w = 4.18) \times}$

$S_w = 4186\ J/kg\,K$

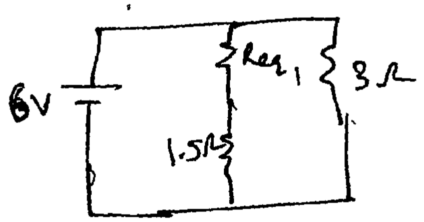
$= 4.18 \times 10^3$

$$\Rightarrow \frac{300}{2} = t$$

$$\Rightarrow \boxed{t = 150 \text{ sec}}$$

Ans

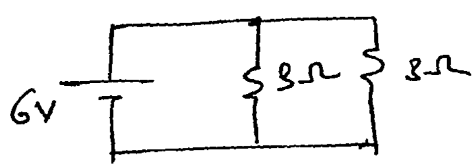
12)



$$Req_1 = \frac{6\times 2}{6+2} = 12/8 = 3/2$$

Req_1 & 1.5Ω are in series

≡



$$i = \frac{6}{(3/2)} = 4A$$

$Req = 3/2$

13)

$$R_1 + R_2 = S \qquad \frac{R_1 R_2}{R_1 + R_2} = P$$

$$\Rightarrow R_1 + R_2 = n\left(\frac{R_1 R_2}{R_1 + R_2}\right)$$

$$\Rightarrow (R_1 + R_2)^2 = nR_1R_2 \Rightarrow R_1^2 + R_2^2 + (2-n)R_1R_2 = 0$$

$$\Rightarrow \cancel{R_1^2 + R_2^2 + (2-n)R_1R_2 = 0}$$

$$\Rightarrow \frac{R_1}{R_2} + \frac{R_2}{R_1} = (n-2)$$

$$\Rightarrow (n-2) = x + \frac{1}{x} \qquad \frac{R_1}{R_2} = x$$

∴ for min^m n $\quad x = \frac{1}{x} = 1$

$$\Rightarrow (n-2) = 2$$

$$\Rightarrow \boxed{n = 4}$$

14) $R_1 = \rho \frac{l_1}{A_1}$ $R_2 = \frac{\rho l_2}{A_2}$ $\frac{l_1}{l_2} = 4/3$

$$\frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)\left(\frac{A_2}{A_1}\right) \qquad \frac{r_1}{r_2} = 2/3$$

$$= \left(\frac{4}{3}\right)\left(\frac{9}{4}\right) = 3$$

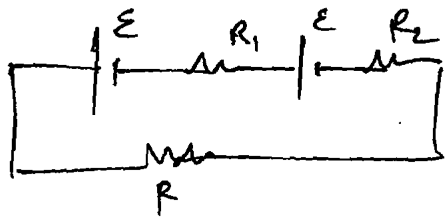
∴ Current will be inversely proportional to resistances in parallel i.e. $1/3$

15) $\frac{X}{20} = \frac{Y}{80} \Rightarrow \boxed{4X = Y}$ hence for $4X$ & Y

$$\Rightarrow \frac{4X}{l} = \frac{Y}{100-l}$$

$\Rightarrow l = 100 - l \Rightarrow \boxed{l = 50}$ cm Ans

16)



$$i = \frac{2E}{R_1 + R_2 + R}$$

& $E - iR_2 = 0$

$\Rightarrow E = iR_2$

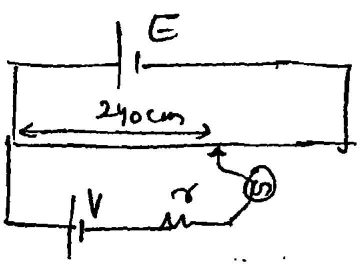
$\Rightarrow i = \frac{2iR_2}{R_1 + R_2 + R} \Rightarrow R_1 + R_2 + R = 2R_2$

$\Rightarrow \boxed{R = R_2 - R_1}$

17) $P' = \frac{V^2}{R'} = \frac{V^2}{(R/2)} = 2\frac{V^2}{R} = 2P_{initial}$

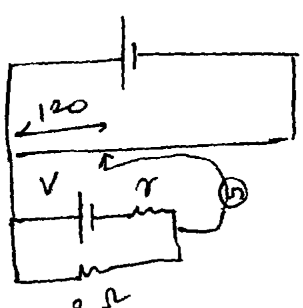
hence heat generated is doubled.

18)



$$V = \frac{E}{L} \times 240$$

Now



$$V - \left(\frac{V}{2+r}\right) r = \frac{E}{L} \times 120$$

$\Rightarrow \frac{E}{L} \times 240 \left[1 - \frac{r}{2+r}\right] = \frac{E}{L} \times 120$

$\Rightarrow \frac{1}{2} = \frac{r}{2+r}$

$\Rightarrow 2 + r = 2r \Rightarrow \boxed{r = 2\,\Omega}$

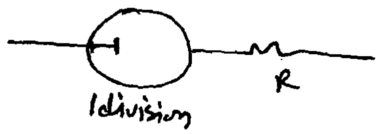
19)

$$R_H = \frac{(200)^2}{100} = 400\,\Omega$$

$$R_c = \frac{R_H}{10} = 40\,\Omega$$

Ans

20)



Potential drop in 1 division $= \frac{10^{-3}}{2}$ volt

Hence Potential drop across R is $\left(1 - \frac{10^{-3}}{2}\right)V$

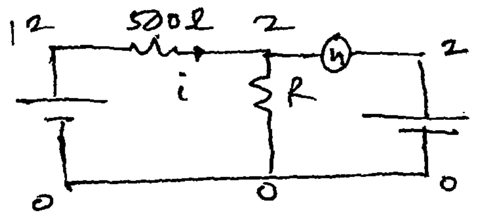
current for 1 division $= 10^{-4}$ Amp

$$\Rightarrow \quad iR = \left(1 - \frac{10^{-3}}{2}\right)$$

$$\Rightarrow \quad 10^{-4}R = 1 - \frac{10^{-3}}{2}$$

$$\Rightarrow \quad R = 10^4 - 10/2 = 10000 - 5 = 9995\,\Omega$$ Ans

21)



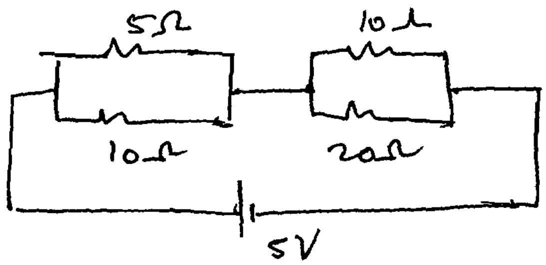
$$i = \frac{12-2}{500}$$

$$\left(\frac{12-2}{500}\right)R = 2$$

$$\Rightarrow \quad R = \frac{1000}{10} = 100\,\Omega$$

Ans

22) Balanced Wheatstone bridge so equivalent Circuit can be shown as



$$R_{eq} = \left(\frac{10\times5}{10+5}\right) + \left(\frac{10\times20}{10+20}\right)$$

$$= \frac{50}{15} + \frac{20}{3}$$

$$= \frac{50+100}{15} = \frac{150}{15}$$

$$= 10\,\Omega$$

$$\therefore \; I = \frac{5}{10} = 0.5\text{ A}$$

Ans

23)

$$\frac{P}{Q} = \frac{R}{S_{eq}} \qquad S_{eq} = \frac{S_1 S_2}{S_1 + S_2}$$

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

Ans

24)
$$R_1 = R_0(1+\alpha T_1)$$

R_0 is resistance at 0°C.

$$\Rightarrow 100 = R_0(1+\alpha(100))$$

$$\Rightarrow 200 = R_0(1+T\alpha)$$

divide

$$\Rightarrow 2 = \frac{1+T\alpha}{1+100\alpha} \Rightarrow 2+200\alpha = 1+T\alpha$$

$$\Rightarrow T = \frac{1+200\alpha}{\alpha} = \frac{1}{\alpha}+200$$

$$\therefore T = 400^\circ C$$

<u>Ans</u>

25)
$$R_B = \frac{(220)^2}{100}$$

$$P_{consumed} = \frac{(110)^2}{(220)^2} \times 100 = 25\,W$$

26)
$\rho_B = 2\rho_A$

$d_B = 2d_A$

$$R_A = \frac{\rho_A l_A}{\pi d_A^2} \times 4$$

$$R_B = \frac{\rho_B l_B}{\pi d_B^2} \times 4$$

$$\Rightarrow R_A = R_B$$

$$\Rightarrow \frac{\rho_B l_B}{d_B^2} = \frac{\rho_A l_A}{d_A^2} \Rightarrow \frac{l_A}{l_B} = \left(\frac{\rho_B}{\rho_A}\right)\left(\frac{d_A^2}{d_B^2}\right)$$

$$= 2 \times \frac{1}{4} = 1/2$$

<u>Ans</u>

27)
$\Sigma i = 0$ conservation of charge

$\Sigma E = 0$ conservation of Energy

28)
$$R_1 = R_0(1+\alpha T_1) \Rightarrow 5 = R_0(1+\alpha(50))$$

$$\Rightarrow 6 = R_0(1+\alpha 100)$$

$$\frac{\left(\frac{5}{R_0}-1\right)}{50} = \frac{\frac{6}{R_0}-1}{100} \Rightarrow \frac{10}{R_0}-2 = \frac{6}{R_0}-1$$

29)

$$\frac{55}{20} = \frac{R}{80}$$

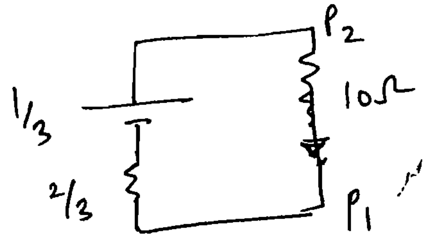
$$R = 4(55) = 220\,\Omega \quad \underline{\text{Ans}}$$

30)

Equivalent battery $\dfrac{\varepsilon_1 r_2 - \varepsilon_2 r_1}{r_1 + r_2} = \dfrac{(5\times 1) - (2\times 2)}{3}$

$$= 1/3\ V$$

$$r_{eq} = \frac{r_1 r_2}{r_1 + r_2} = \frac{2}{3}\,\Omega$$



$$i = \frac{1/3}{10 + 2/3} = \frac{1}{32}\ \text{A}$$

$\therefore$ 0.03 A from P_2 to P_1.

31)

$$\alpha_{series} = \frac{\Delta R_{series}}{(R_{initial})_{series} \times \Delta T}$$

$$= \frac{R_0\alpha_1 T + R_0\alpha_2 T}{(2R_0)\,T} = \frac{\alpha_1 + \alpha_2}{2}$$

$R_i = R_{initial}$

$$\alpha_{parallel} = \frac{\dfrac{R_0(1+\alpha_1 T)\,R_0(1+\alpha_2 T)}{R_0(1+\alpha_1 T) + R_0(1+\alpha_2 T)} - (R_i)_{parallel}}{(R_i)_{parall} \times T}$$

$$= \frac{\dfrac{R_0^2\,(1+\alpha_1 T + \alpha_2 T)}{2R_0 + R_0(\alpha_1 T + \alpha_2 T)}\left(\dfrac{2}{R_0}\right) - 1}{T}$$

$$= \frac{\cancel{2} + 2\alpha_1 T + 2\alpha_2 T - \cancel{2} - \alpha_1 T - \alpha_2 T}{T\,(2 + \alpha_1 T + \alpha_2 T)}$$

$$= \frac{\alpha_1 + \alpha_2}{2 + (\alpha_1 + \alpha_2)T}$$

$$\approx \frac{\alpha_1 + \alpha_2}{2} \quad \underline{\text{Ans}}$$

32) $x\%$ increment and If x is small
resistance increases by ~~2x~~ $2x\%$

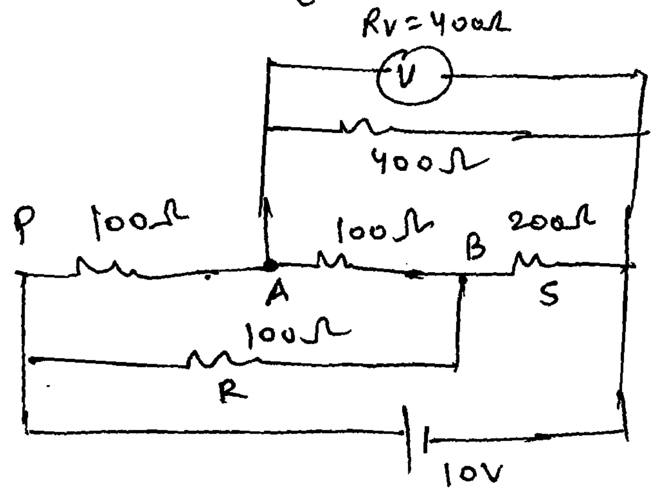
$\therefore$ $2 \times 0.1\,\%$

$= 0.2\%$ increment in resistance.

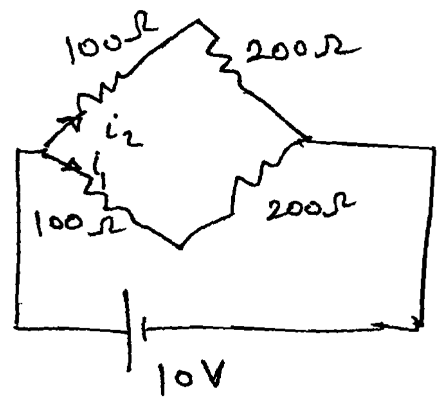
Ans

Previous JEE Problems

1) The Given Circuit actually forms a balanced Wheatstone's bridge (including the voltmeter) as shown below:



≡



$$i_1 = i_2 = \frac{10}{100+200} = \frac{1}{30} \text{ A}$$

∴ Potential difference across voltmeter $= 200\left(\frac{1}{30}\right) = \frac{20}{3}$ Volt

2) (i) D current only

(ii) $M^{-1}L^{-3}T^{3}A^{2}$

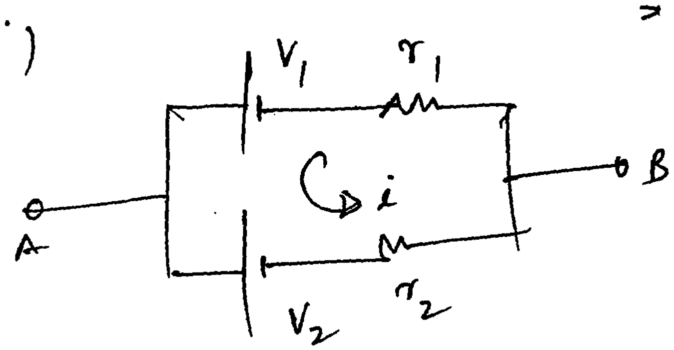
$$j = \sigma E$$

$$\Rightarrow \frac{[j]}{[E]} = [\sigma]$$

$$\Rightarrow \frac{q L^{-2} A}{M L T^{-2}} = [\sigma]$$

$$\Rightarrow [\sigma] = M^{-1} L^{-3} A^{2} T^{3}$$

(iii)



$$i = \frac{V_1 - V_2}{r_1 + r_2}$$

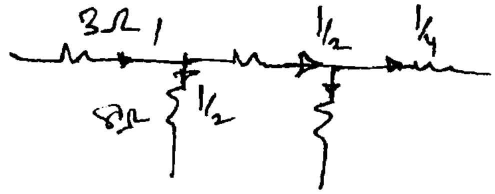
$$V_A - V_2 - r_2\left(\frac{V_1 - V_2}{r_1 + r_2}\right) = V_B$$

$$\Rightarrow V_A - V_B = \frac{V_2 r_1 + \cancel{V_2 r_2} + V_1 r_2 - \cancel{r_2 V_2}}{r_1 + r_2} = \frac{V_1 r_2 + V_2 r_1}{r_1 + r_2}$$

$r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$ parallel combination b/w A and B.

3)

$R_{eq} = 9\,\Omega \qquad i = \frac{9}{9} = 1\text{ Amp}$



$\therefore$ current through $4\,\Omega = 0.25\text{A}$

since equal resistors are in parallel.

4)

No current through S

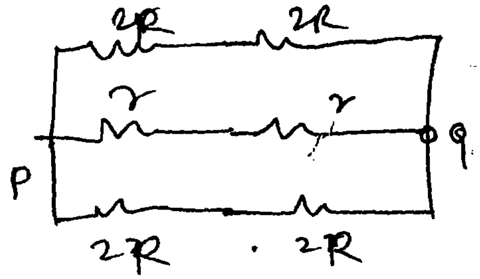
$\therefore \; I_R = I_G$

[bridge is balanced]

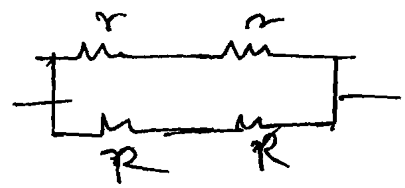
5)

$\perp$ resistances to PQ Branch can remove

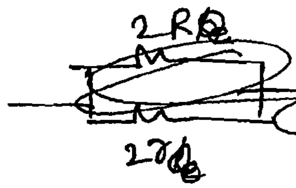
hence



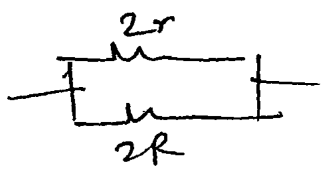
Now by folding



$\equiv$



$\equiv$



$R_{eq} = \frac{4Rr}{2(R+r)} = \frac{2Rr}{R+r}$

6)

$R_1 = \frac{V^2}{P_1} = \frac{V^2}{100}, \quad R_2 = \frac{V^2}{60}, \quad R_3 = \frac{V^2}{60}$

$R_1 < R_2 \qquad R_2 = R_3$

$\therefore$ in B_1 & B_2 current same $\quad \therefore \; i^2R_1 < i^2R_2$

$\therefore \; W_1 < W_2$

$W_1 = \frac{(250)^2}{(R_1+R_2)^2} R_1 \qquad W_2 = \frac{(250)^2}{(R_1+R_2)^2} R_2$

$W_3 = \frac{(250)^2}{R_3}$

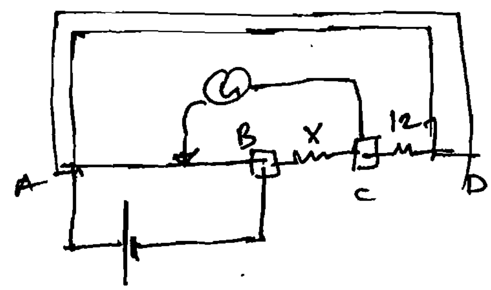
$W_1 : W_2 : W_3 = 15 : 25 : 64$

$\therefore \; W_1 < W_2 < W_3$

7)

(a) There are no +ive and -ive terminals on the galvanometer because only zero deflection is needed.

(b)



position of Galvanometer and battery can be exchanged also.

(c) $\frac{60}{12} = \frac{40}{x} \Rightarrow x = 8\,\Omega$ Ans.

[balanced wheatstone bridge]

8) $P = i^2R$ Current is same so $P \propto R$.

Req Case I $= r/3$ Case II $3r$

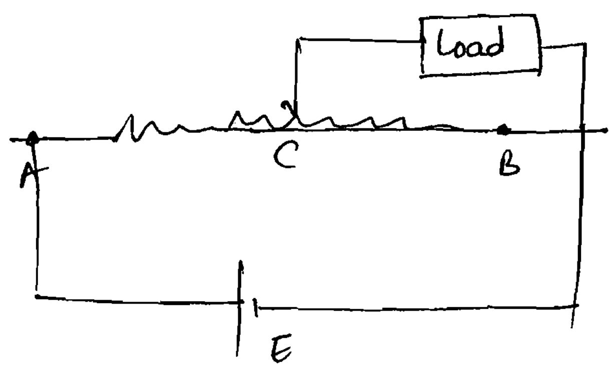
Case III $= 3r/2$ Case IV $2r/3$

$\therefore P_2 > P_3 > P_4 > P_1$

9) $\frac{R_1}{R_2} = \frac{x}{l-x}$ —(1) $\frac{R_1}{R_2} = \frac{\cancel{l}(x_1)/\cancel{A}}{\cancel{l}(l-x_1)/\cancel{A}} = \frac{x_1}{l-x_1}$

$\Rightarrow \frac{x}{l-x} = \frac{x_1}{l-x_1} \Rightarrow x_1 = x$ ~~Same~~ Same

10)



Battery Should be connected ~~between~~ across A and B.

Output can be taken across the terminals B and C or A and C.

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

$\therefore$ R_{PQ} is max^m.

12) $I = \frac{\varepsilon}{R} e^{-t/RC}$ (while charging)

$\ln I = \ln \frac{E}{R} - \frac{t}{RC}$

as R is doubled, slope decreases Intercept on Y Axis decreases. (magnitude wise)

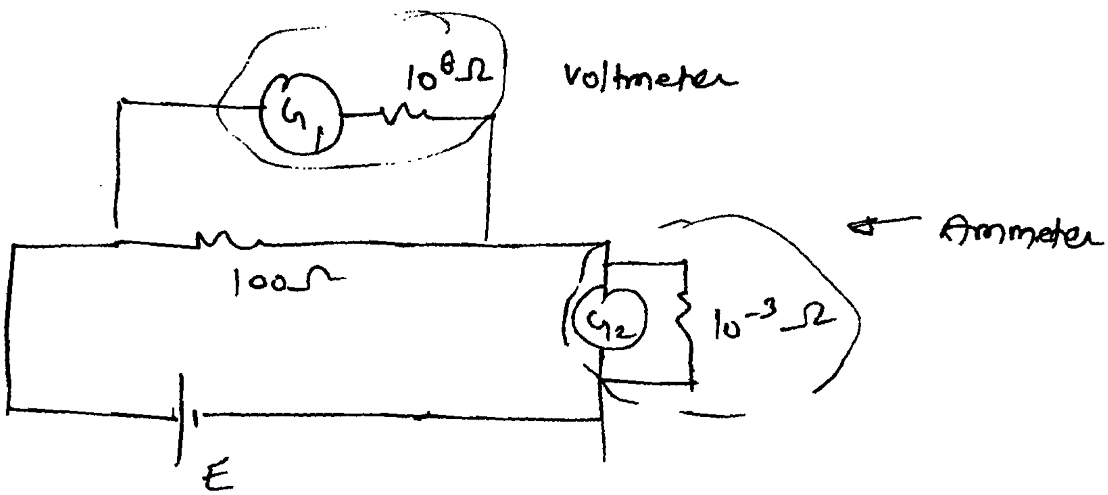
hence Q

Ans

13) See post office box ans (A and D b/w)

BC, CD and BA are known resistances.

14)



15) current in the respective loop will remain confined in the loop itself. Therefore current through 2Ω is zero.

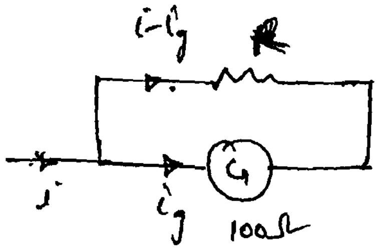
16) $C = 4\mu F$, $R = 2.5 \times 10^6 \Omega$, $E = 12$ Volt

$V_c = 3V_R = 3(V - V_c)$ $\Rightarrow V_c = \frac{3}{4} V$

$\Rightarrow \cancel{V}(1 - e^{-t/RC}) = \frac{3}{4}\cancel{V}$

$\Rightarrow \frac{1}{4} = e^{-t/RC}$ $\Rightarrow \frac{t}{RC} = \ln 4 \Rightarrow t = 10 \ln 4$

17)



$i_g = 100\,\mu A$, $R = 0.1\,\Omega$

$$i_g\, 100 = (i - i_g) R$$

$$\Rightarrow \quad i_g (1000) = i - i_g$$

$$\Rightarrow \quad i = (1001) i_g = 1001 \times 10^{-4}\ A$$

$$\Rightarrow \quad i = 100.1\ mA$$

18) Slide wire is most sensitive when the resistance of all the four arms is same.

So B is the most accurate answer ($\because r_1 = r_2$ at B)

$x = \frac{r_1 R}{r_2}$

$\left|\frac{\delta x}{x}\right| = \left|\frac{\delta r_1}{r_1}\right| + \left|\frac{\delta r_2}{r_2}\right|$ $\quad |\delta r_1| = |\delta r_2|$

$\left|\frac{\delta x}{x}\right| = \left(\frac{r_1 + r_2}{r_1 r_2}\right)\Delta$ $\quad \left[\because r_1 + r_2 = \text{con}, \; r_1 r_2 \text{ max}^m \text{ when } r_1 = \right.$

$\boxed{\text{for } \left|\frac{\delta x}{x}\right| \text{ to be min}^m \Rightarrow r_1 = r_2}$

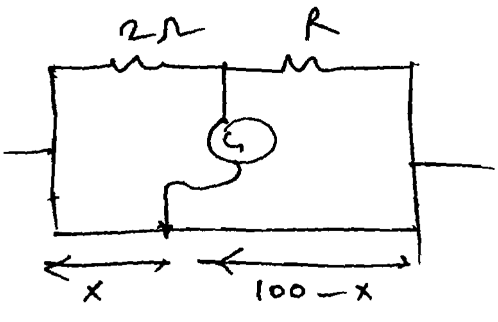
19) current is same

$H \propto R$ [Heat produced $\propto$ Resistance as i same]

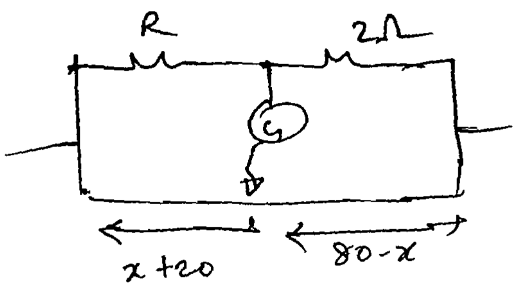
$$\frac{H_{AB}}{H_{BC}} = \frac{R_{AB}}{R_{BC}} = \frac{\left(\frac{1}{2R}\right)^2}{\left(\frac{1}{R}\right)^2} = \frac{1}{4}$$

$\Rightarrow$ ~~$H_{AB} = 4H_{BC}$~~ $\Rightarrow \boxed{H_{BC} = 4H_{AB}}$

20)



$$\frac{2}{R} = \frac{x}{100 - x} \quad \text{--- (1)}$$



$$\frac{R}{2} = \frac{x + 20}{80 - x} \quad \text{--- (2)}$$

by (1) and (2) $\quad x = 40\,cm$

$R = 3\,\Omega$ Ans

21) $P = \frac{V^2}{R}$, $R_1 = 1\,\Omega$, [Equivalent] $R_2 = 0.5\,\Omega$ [Equivalent] , $R_3 = 2\,\Omega$

$\because$ V is same

$\therefore \quad P_3 < P_1 < P_2$

Ans

22) with Increase in temperature , the value of unknown resistance will increase.

In balanced wheatstone bridge condition

$$\frac{R}{X} = \frac{l_1}{l_2}$$

R = [Standard Resistance]

X = [Unknown Resistance]

To take null point at same point $\frac{l_1}{l_2}$ remains unchanged

$\frac{R}{X}$ should also remain unchanged.

If X is increasing , R should also increase.

Hence option (d) is correct.

Ans

23)

$$R_{eq} = \frac{9}{7.5} + 2 = \frac{24}{7.5}\ k\Omega$$

$$i = \frac{24}{(24/7.5 \times 10^3)} = 7.5 \times 10^{-3} A = 7.5\ mA$$

If R_1 and R_2 are interchanged.

$$R_{eq} = \frac{3}{3.5} + 6 = \frac{24}{3.5}\ k\Omega$$

$i_{new} = 3.5\ mA$

$\cancel{i_{new} = \frac{24 \times 4.5 \times 10^{-3}}{30} A}$

Power in R_L initially dissipated $= \frac{(24 - 7.5 \times 10^{-3} \times 2 \times 10^3)^2}{R_L}$

$$= \frac{(24 - 15)^2}{R_L} = \frac{9^2}{R_L}$$

New power in R_L $= (24 -$

$\therefore \quad \frac{P_{new}}{P_{old}} = \frac{(3)^2}{(9)^2} = \left(\frac{1}{3}\right)^2 = \frac{1}{9}$

Ans

24) $R_H = R_C (1 + \alpha \Delta T)$ $\quad R_H = R_{Hot}$

$R_C = R_{Cold}$

~~$R_{100} = \frac{V^2}{100}$, $R_{60} = \frac{V^2}{60}$, $R_{40} = \frac{V^2}{40}$~~

$(R_{100})_H = \frac{V^2}{100} \qquad (R_{60})_H = \frac{V^2}{60} \qquad (R_{40})_H = \frac{V^2}{40}$

$\therefore (R_{100})_H < (R_{60})_H < (R_{40})_H$

$\Rightarrow$

$\frac{1}{(R_{100})_H} > \frac{1}{(R_{60})_H} > \frac{1}{(R_{40})_H}$

$\therefore \frac{1}{R_{100}} > \frac{1}{R_{60}} > \frac{1}{R_{40}}$

Ans

25) $\because$ voltmeter should be in parallel

& Ammeter should be in series.

Correct Ans is (C)

26) $R = \frac{\rho L}{A} = \frac{\rho \cancel{L}}{\cancel{L} t} = \frac{\rho}{t}$ $\quad \therefore$ independent of L

Ans

27) $\varepsilon_{eq} = 2\varepsilon, \quad r_{eq} = 2\,\Omega$

$P_1 = i^2 R \Rightarrow J_1 = \left(\frac{2\varepsilon}{2+R}\right)^2 R$

$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} = \varepsilon$

$r_{eq} = 1/2 \qquad J_2 = \left(\frac{\varepsilon}{1/2 + R}\right)^2 R$

$J_1 = 2.25\, J_2$

$\Rightarrow \dfrac{4\, \cancel{\varepsilon^2 R}}{(2+R)^2} = \dfrac{9}{\cancel{4}} \dfrac{\cancel{\varepsilon^2 R}}{(1+2R)^2} \cdot \cancel{4}$

$\Rightarrow 4(1+2R)^2 = 9(2+R)^2$

$\Rightarrow 4 + 16R^2 + 16R = 9R^2 + 36 + 36R$

$\Rightarrow 7R^2 - 20R - 32 = 0$

$\Rightarrow 7R^2 - 28R + 8R - 32 = 0$

$\Rightarrow 7R(R-4) + 8(R-4) = 0 \quad \Rightarrow \boxed{R = 4\,\Omega}$ Ans

(28)

$4 = 10\left(1 - e^{-t/4}\right) \qquad RC = 4$

$\Rightarrow e^{-t/4} = 0.6$

$\Rightarrow \dfrac{t}{4} = \ln\left(\dfrac{1}{0.6}\right) = \ln 10 - \ln 2 - \ln 3$

$\Rightarrow \dfrac{t}{4} = \ln 5 - \ln 3 = 0.5$

$\Rightarrow \boxed{t = 2\ \text{secs}}$ Ans

(29)

By Wheatstone bridge

$\dfrac{x}{10} = \dfrac{52+1}{48+2}$

$\Rightarrow x = \dfrac{53}{5} = 10.6\,\Omega$ Ans

(30)

$\varepsilon_{eq} = \dfrac{6(2)+3(1)}{2+1} = \dfrac{15}{3} = 5\,V$ Ans