# Current Electricity

## JEE Main Exercise

1. (D)

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

$$60 = 20[1+\alpha(500-20)]$$

$$\alpha = \frac{1}{240}/^\circ C$$

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

$$\Rightarrow \quad 25 = 20\left(1+\frac{1}{240}(T-20)\right)$$

$$\Rightarrow \quad T = 80^\circ C$$

2. (C)

At $0^\circ C$, $R_1 = 400\,\Omega$, $R_2 = 800\,\Omega$

$$R_{eq} = \frac{400\times 800}{400+800} = \frac{800}{3}\Omega$$

At $t^\circ C$,

$$\frac{1}{R'_{eq}} = \frac{1}{R'_1} + \frac{1}{R'_2}$$

$$\frac{1}{\frac{800}{3}(1+\alpha_{eq}t)} = \frac{1}{400(1+\alpha t)} + \frac{1}{400(1+4\alpha t)}$$

$$\Rightarrow \quad \frac{3}{800}(1-\alpha_{eq}t) = \frac{1}{400}(1-\alpha t) + \frac{1}{800}(1-4\alpha t)$$

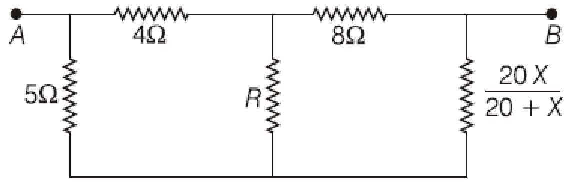
$$\Rightarrow \quad \frac{3\alpha_{eq}t}{800} = \frac{\alpha t}{400} + \frac{4\alpha t}{800}$$

$$\Rightarrow \quad \alpha_{eq} = 2\alpha$$

3. (C)

$$i = \frac{Q}{T} = \frac{Q}{\left(\frac{2\pi}{\omega}\right)} = \frac{Q\omega}{2\pi}$$

4. (D)

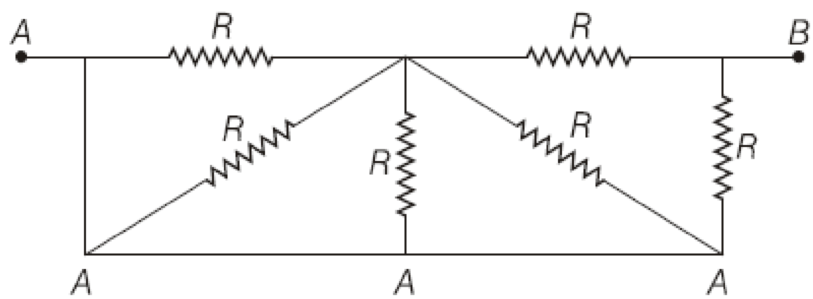


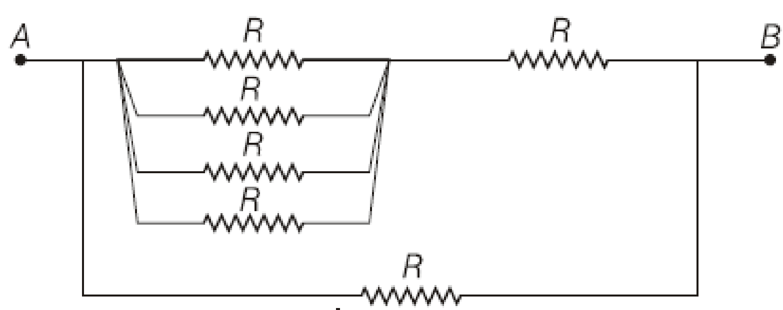

For equivalent resistance to be independent of $R$, it should be a balanced Wheatstone bridge.

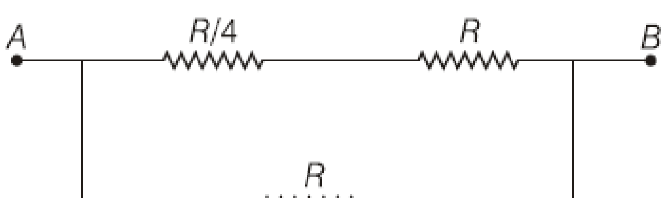
$\Rightarrow \quad 4\left(\frac{20X}{20+X}\right)=8\times 5$

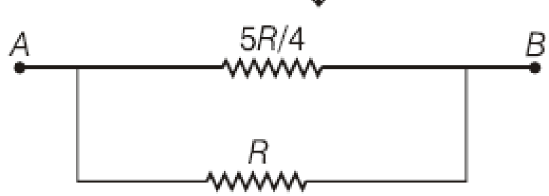
$\Rightarrow \quad x = 20\,\Omega$

5. (A)



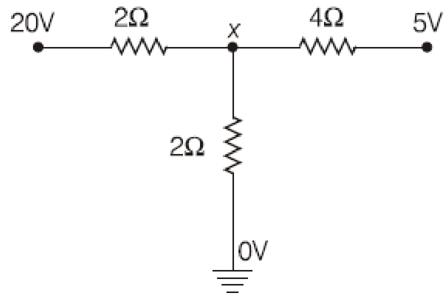




$$\frac{1}{R_{eq}}=\frac{1}{5R}+\frac{1}{R}$$

$$\Rightarrow \quad R_{eq}=\frac{5R}{9}$$

6. (A)




Lets take potential of junction to be $x$.
Applying KCL at the junction,

$$\frac{20-x}{2}+\frac{5-x}{4}+\frac{0-x}{2}=0$$

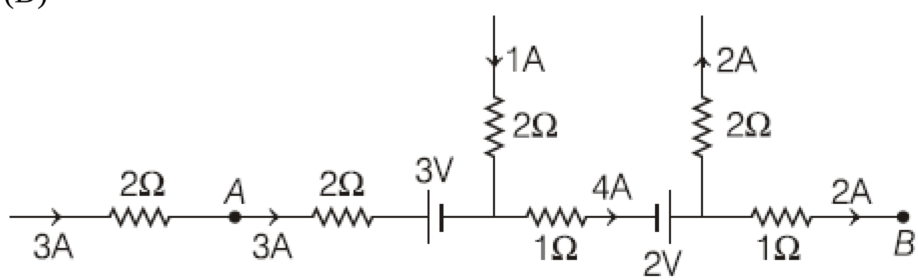
$$\Rightarrow \quad 40-2x+5-x-2x=0$$

$$x=9\,\text{V}$$

Current through the switch $=\dfrac{x-0}{2}$

$$=\frac{9-0}{2}=4.5\,\text{A}$$

7. (D)




$$V_A-3(2)-3-4(1)+2-2(1)=V_B$$

$$\Rightarrow \quad V_A-V_B=13\,\text{V}$$

8. (A)

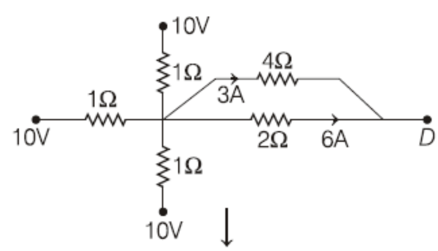
Lets take potential of the junction to be $x$.
Using KCL at the junction,

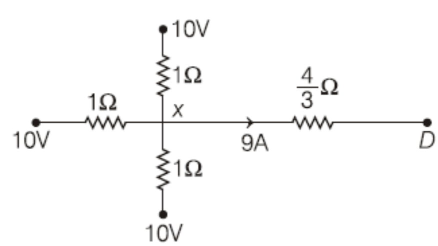
$$\frac{10-x}{1}+\frac{10-x}{1}+\frac{10-x}{1}=9$$

$$\Rightarrow \quad x=7\,\text{V}$$

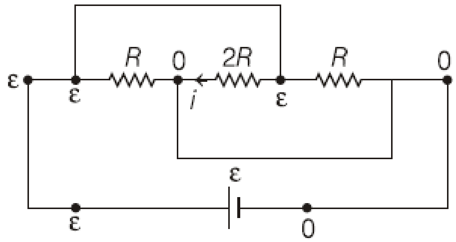
$$\frac{x-V_D}{\frac{4}{3}}=9 \Rightarrow 7-V_D=12$$

$$\Rightarrow \quad V_D=-5\,\text{V}$$



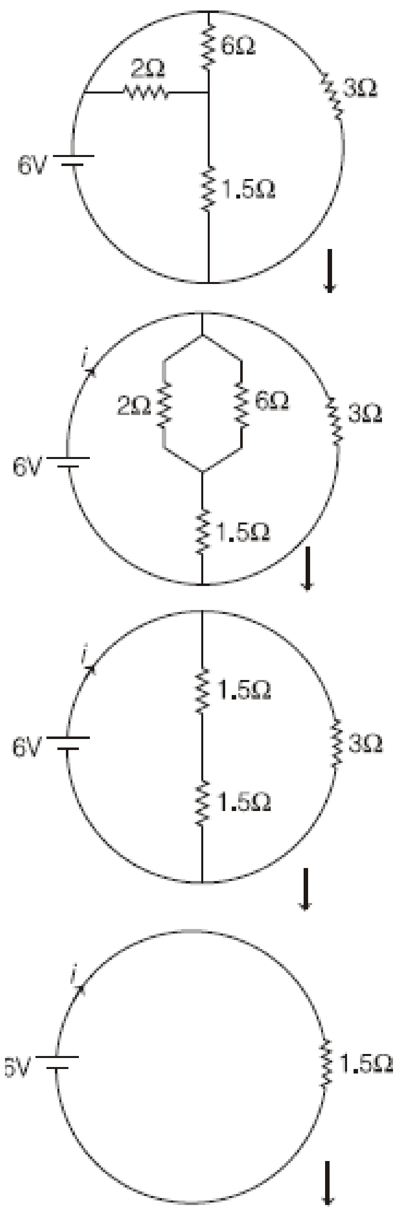



9. (B)



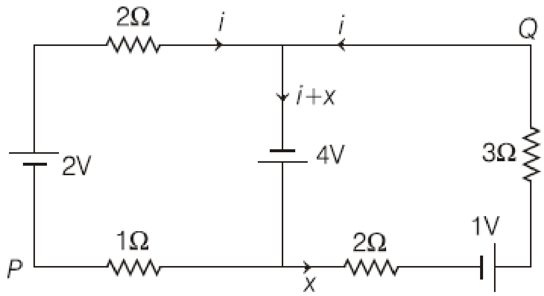

Current in a resistor flows from high potential to low potential.
So, current in $2R$ resistance will be from right to left.

10. (B)




$$i = \frac{6}{1.5} = 4\,\text{A}$$

11. (B)




Using KVL,

$$+2-2i+4-i(1)=0$$

$$\Rightarrow \quad i=2\,\text{A}$$

$$+4-2x+1-3x=0$$

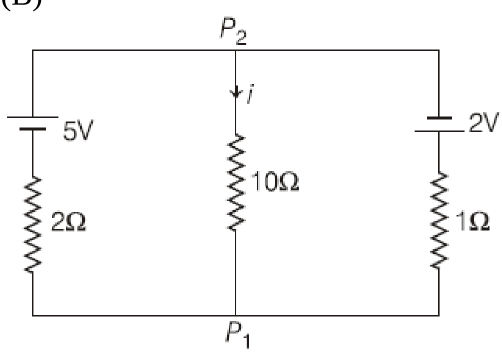
$$\Rightarrow \quad x=1\,\text{A}$$

$$V_P+2-i(2)=V_Q$$

$$\Rightarrow \quad V_P-V_Q=2i-2=2(2)-2$$

$$=2\,\text{V}$$

12. (B)

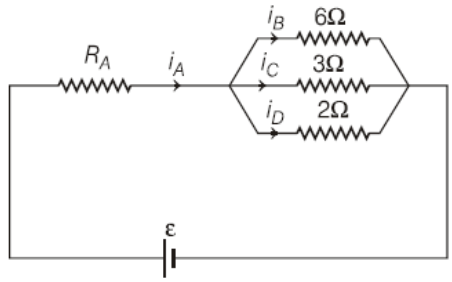



$$\varepsilon_{eq}=\frac{\frac{\varepsilon_1}{r_1}+\frac{\varepsilon_2}{r_2}}{\frac{1}{r_1}+\frac{1}{r_2}}=\frac{\frac{5}{2}-\frac{2}{1}}{\frac{1}{2}+\frac{1}{1}}=\frac{1}{3}\text{V}$$

$$r_{\text{eq}}=\frac{r_1 r_2}{r_1+r_2}=\frac{2}{3}\Omega$$

$$i=\frac{\varepsilon_{\text{eq}}}{R+r_{\text{eq}}}=\frac{\frac{1}{3}}{10+\frac{2}{3}}=\frac{1}{32}\text{A}=0.03\,\text{A}$$

13. (D)



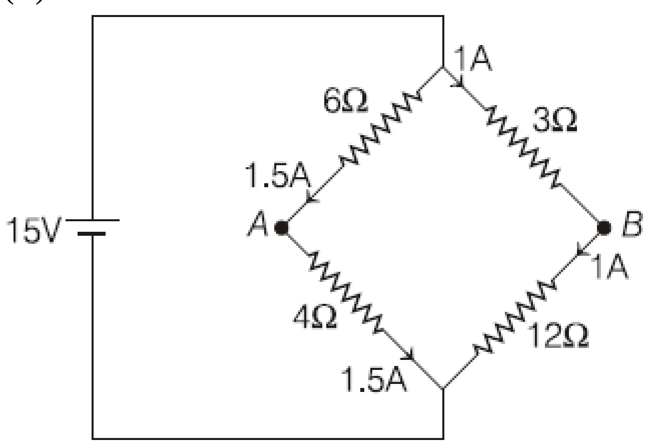

$$i_B : i_C : i_D = \frac{1}{R_B} : \frac{1}{R_C} : \frac{1}{R_D}$$

$$= \frac{1}{6} : \frac{1}{3} : \frac{1}{2} = 1 : 2 : 3$$

$$i_A = i_B + i_C + i_D$$

$\Rightarrow \quad i_A : i_B : i_C : i_D = 6 : 1 : 2 : 3$

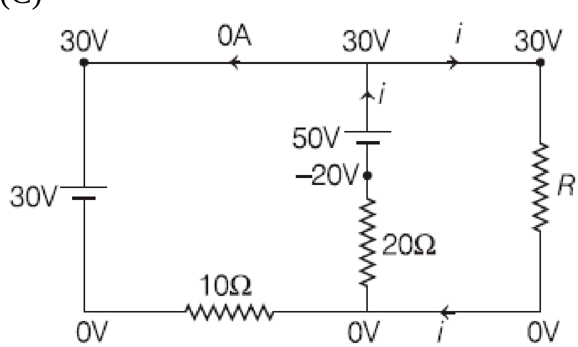
14. (B)




$V_A - 1.5(4) + 1(12) = V_B$

$V_A - V_B = -6\text{ V}$

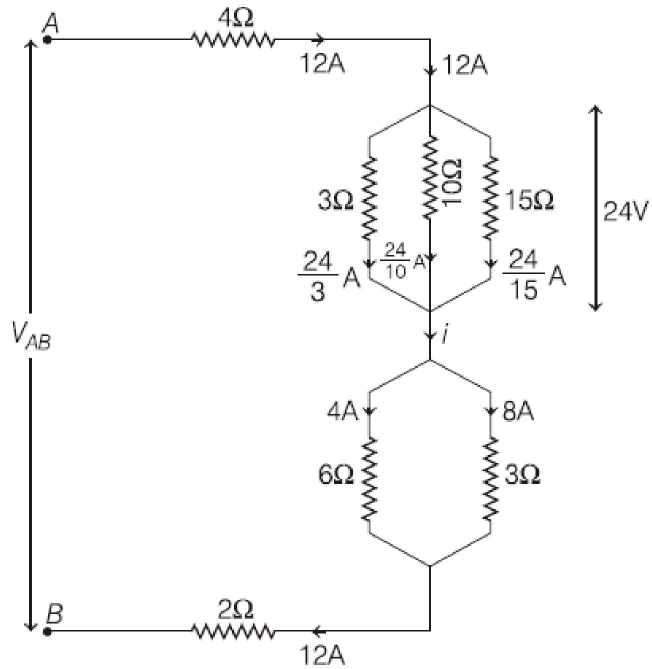
15. (C)




$$i = \frac{0-(-20)}{20} = \frac{30-0}{R}$$

$\Rightarrow \quad R = 30\,\Omega$

16. (D)

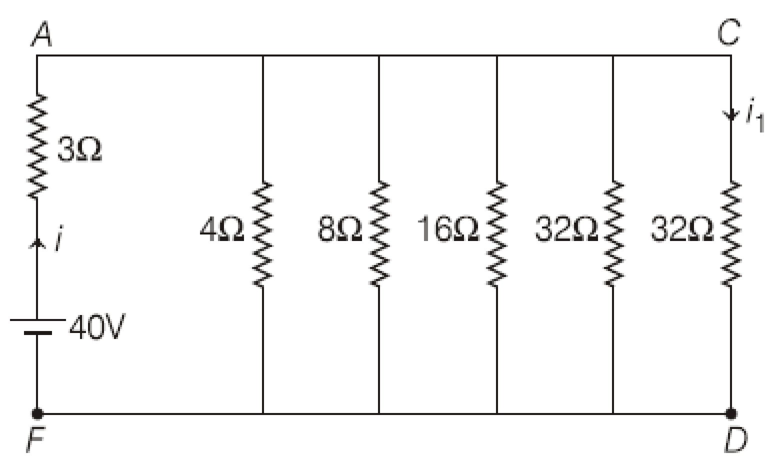



$$i = \frac{24}{15} + \frac{24}{10} + \frac{24}{3} = 12\,\text{A}$$

$$V_{AB} = 12(4) + 24 + 8(3) + 12(2)$$
$$= 120\,\text{V}$$

Current through $6\Omega$ resistor $= \frac{3}{3+6}(12) = 4\,\text{A}$

17. (C)




$$R_{\text{eq}} = 3 + \left(\frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \frac{1}{32}\right)^{-1}$$
$$= 3 + 2 = 5\Omega$$

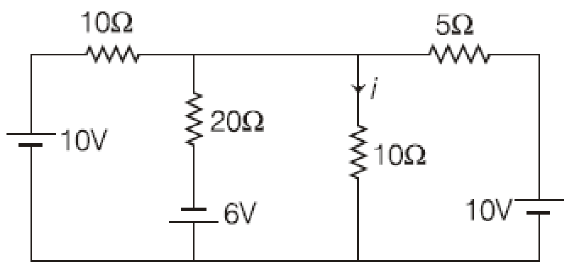
$i =$ Current through battery $= \frac{40}{5} = 8\,\text{A}$

$$i_1 = \left( \frac{\frac{1}{32}}{\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\frac{1}{32}+\frac{1}{32}} \right)(8)$$

$$i_1 = \frac{1}{2}$$

$$\frac{i_1}{i} = \frac{1/2}{8} = \frac{1}{16}$$

18. (A)




$$\varepsilon_{eq} = \frac{\frac{\varepsilon_1}{r_1}+\frac{\varepsilon_2}{r_2}+\frac{\varepsilon_3}{r_3}}{\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}}$$

$$= \frac{\frac{10}{10}-\frac{6}{20}+\frac{10}{5}}{\frac{1}{10}+\frac{1}{20}+\frac{1}{5}} = \frac{54}{7}\text{V}$$

$$i = \frac{\varepsilon_{eq}}{R+r_{eq}} = \frac{\frac{54}{7}}{10+\frac{20}{7}}$$

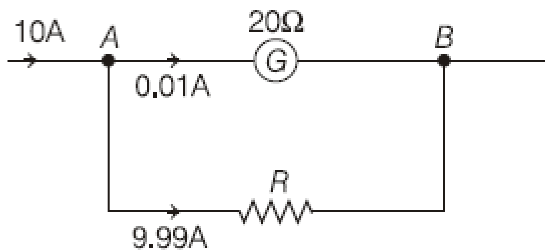
$$= \frac{54}{90} = \frac{3}{5} = 0.6\,\text{A}$$

19. (D)

Resistance of an ideal voltmeter is infinite.

20. (B)

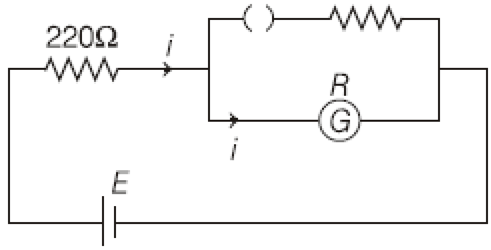
Full scale deflection current $= i_g = \frac{0.2}{20} = 0.01\,\text{A}$



21. (D)

For galvanometer, $i \propto \theta$

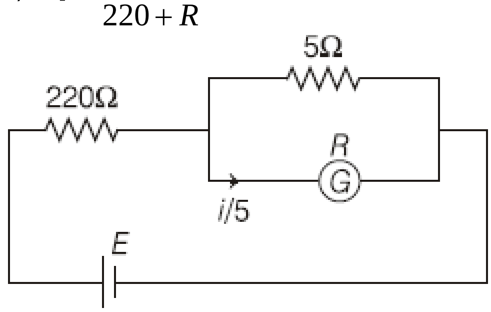
If deflection becomes $\left(\frac{1}{5}\right)$th, then current through galvanometer will also become $\left(\frac{1}{5}\right)$th.




When $K_1$ is closed and $K_2$ is open, let current through the galvanometer be $i$.

Let $R$ be resistance of the galvanometer.

$$\Rightarrow \quad i = \frac{E}{220 + R}$$




When $K_2$ is also closed, current through the galvanometer becomes $\frac{i}{5}$.

$$\frac{i}{5} = \left(\frac{E}{220 + \frac{5R}{5+R}}\right)\left(\frac{5}{5+R}\right)$$

$$\Rightarrow \quad \frac{1}{5}\left(\frac{E}{220+R}\right) = \left(\frac{E}{220 + \frac{5R}{5+R}}\right)\left(\frac{5}{5+R}\right)$$

$$\Rightarrow \quad R = 22\,\Omega$$

22. (D)

$$V = i_g\left(R_G + R\right)$$

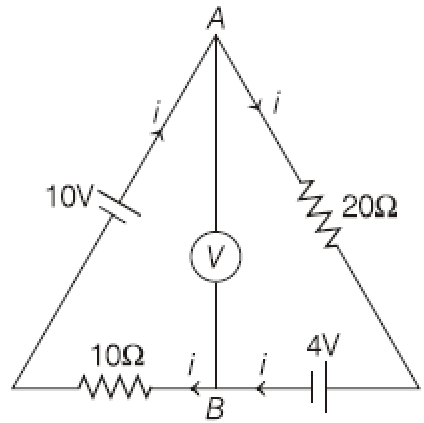
$$\Rightarrow \quad 20 = i_g\left(R_G + 1680\right) \qquad \text{...(i)}$$

$$\Rightarrow \quad 30 = i_g\left(R_G + 2930\right) \qquad \text{...(ii)}$$

Solving Eqs. (i) and (ii), we get

$R_G = 820\,\Omega$ and $i_g = 8\text{ mA}$

23. (B)




Ideal voltmeter has infinite resistance, so current through voltmeter is nearly zero.
Applying KVL in the loop,

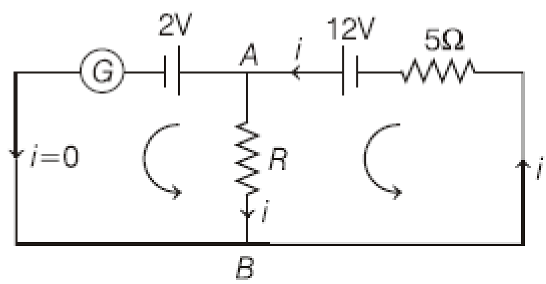
$$+10-20i-4-10i=0$$

$$\Rightarrow \quad i=0.2\,\text{A}$$

$$V_A-20(0.2)-1=V_B$$

$$V_A-V_B=8\text{ V}$$

24. (A)




Applying KVL,

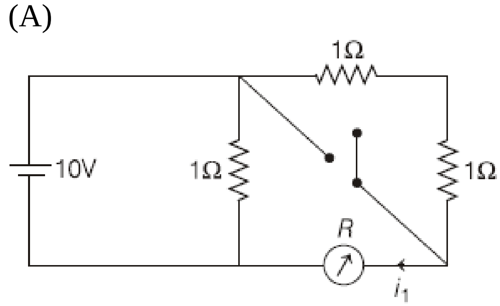
$$+12-iR-5i=0$$

$$i=\frac{12}{R+5}$$

$$V_A-2=V_B \Rightarrow V_A-Vlb=2$$

$$\Rightarrow \quad \left(\frac{12}{R+5}\right)R=2 \;\Rightarrow\; R=1\,\Omega$$

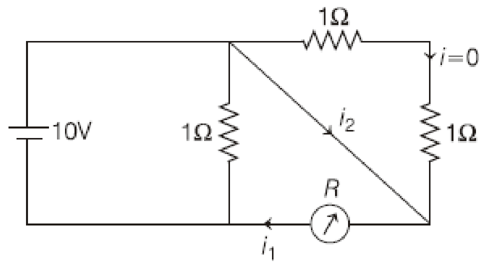
25. (A)




Let the resistance of the ammeter be $R$.
When the switch is open,

Reading of ammeter $=i_1=\dfrac{10}{R+2}$

When the switch is closed.



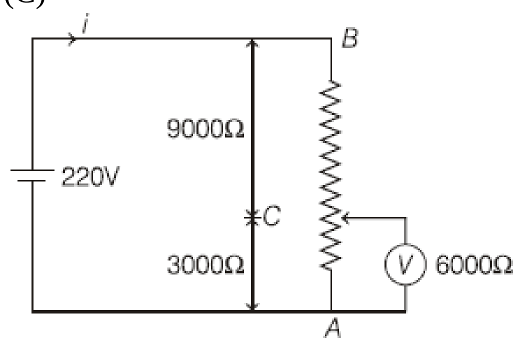

$$i_2 = \frac{10}{R}$$

$$i_2 = 2i_1$$

$$\Rightarrow \quad \frac{10}{R} = 2\left(\frac{10}{R+2}\right)$$

$$\Rightarrow \quad R = 2\Omega$$

26. (C)




$$R_{CA} = \frac{1}{4}(12000) = 3000\ \Omega$$

$$R_{BC} = \frac{3}{4}(12000) = 9000\,\Omega$$

$$i = \frac{220}{900 + \frac{6000\times3000}{6000+3000}} = 0.02\,\text{A}$$

Reading voltmeter $= (0.02)\left(\frac{6000\times3000}{6000+3000}\right) = 40\text{ V}$

27. (A)

From the graph,

When $G \to \infty$, $V = 20\,\text{V}$

Potential difference across resistor when $G \to \infty$

$$= \left(\frac{24}{R+1}\right)R = 20$$

$$\Rightarrow \quad 6R = 5R + 5$$

$$\Rightarrow \quad R = 5\Omega$$

28. (B)

For balanced Wheatstone bridge,

$$6(625) = QS$$

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

After interchanging $P$ and $Q$, condition for the balanced Wheatstone bridge,

$$Q(625+51) = PS$$

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

From Eqs. (i) and (ii), we get

$$\frac{S}{625} = \frac{676}{S}$$

$$\Rightarrow S = \sqrt{625 \times 676} = 25 \times 26 = 650\ \Omega$$

29. (5)

$$R = \frac{\rho I}{A}$$

$$R' = \frac{\rho(1+\alpha_1 \Delta T)/(1+\alpha_2 \Delta T)}{A(1+2\alpha_1 \Delta T)}$$

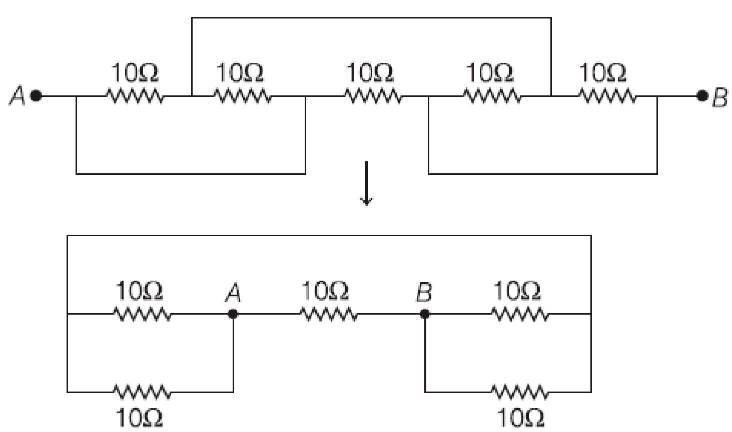
$$R' = \frac{\rho I}{A}(1+\alpha_1 \Delta T)(1-\alpha_2 \Delta T)$$

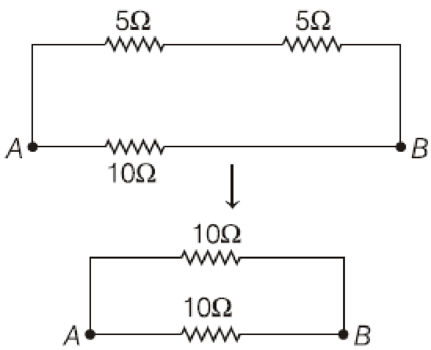
$$R' = R(1+(\alpha_1-\alpha_2)\Delta T)$$

Temperature coefficient of resistance $= \alpha_1 - \alpha_2$

$$= 6\times10^{-3} - 1\times10^{-3} = 5\times10^{-3}$$

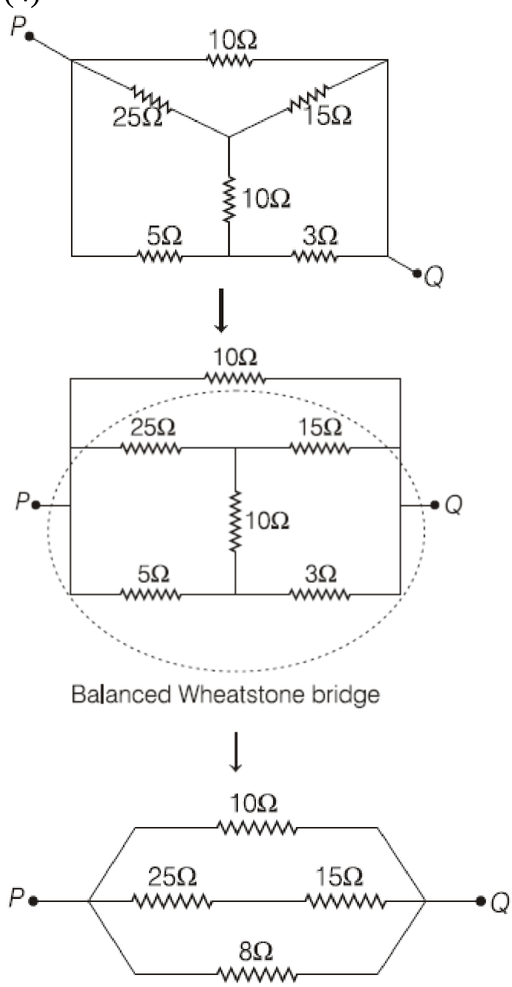
30. (5)






$$\frac{1}{R_{\text{eq}}}=\frac{1}{10}+\frac{1}{10} \Rightarrow R_{\text{eq}}=5\,\Omega$$

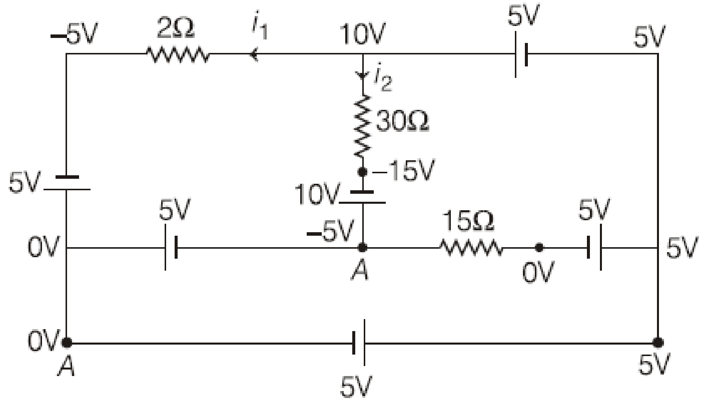
31. (4)




$$\frac{1}{R_{\text{eq}}}=\frac{1}{10}+\frac{1}{40}+\frac{1}{8}$$

$$\Rightarrow R_{\text{eq}}=4\,\Omega$$

32. (9)



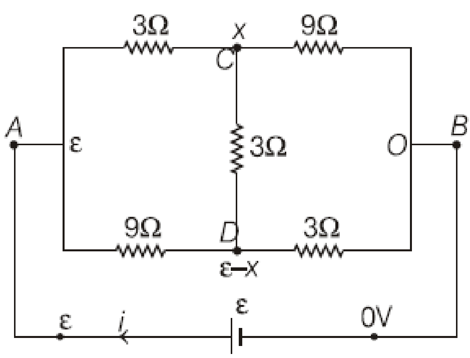

Lets take $V_A = 0$ V

$$i_1 = \frac{10-(-5)}{2} = 7.5\,\text{A}$$

$$i_2 = \frac{10-(-15)}{30} = \frac{5}{6}\,\text{A}$$

$$\frac{i_1}{i_2} = \frac{\frac{15}{2}}{\frac{5}{6}} = 9$$

33. (5)




Due to cross-symmetry, current through both 3 **Ω** resistances will be same. So, potential difference across both 3 **Ω** resistances will be also same.

Applying KCL at junction $C$,

$$\frac{\varepsilon - x}{3} + \frac{0-x}{9} + \frac{(\varepsilon - x) - x}{3} = 0$$

$\Rightarrow \quad 3\varepsilon - 3x - x + 3\varepsilon - 6x = 0$

$\Rightarrow \quad x = \frac{3\varepsilon}{5}$

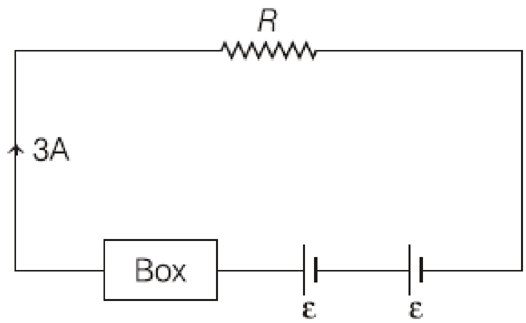
$$i = \frac{\varepsilon - x}{3} + \frac{\varepsilon - (\varepsilon - x)}{9} = \frac{2\varepsilon}{15} + \frac{\varepsilon}{15} = \frac{\varepsilon}{5}$$

$$R_{\text{eq}} = \frac{\varepsilon}{i} = 5\,\Omega$$

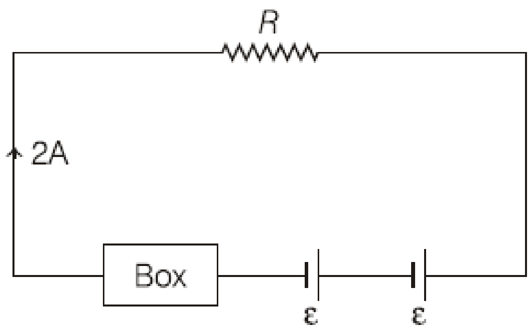
34. (1)

Lets take number of cells wrongly connected in the box to be $n$.

Equivalent emf of the box $=(12-n)\varepsilon-n\varepsilon=(12-2n)\varepsilon$




$$3=\frac{(12-2n)\varepsilon+2\varepsilon}{R} \quad \text{...(i)}$$

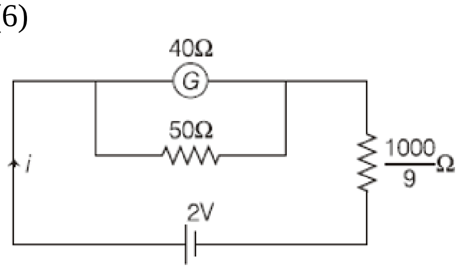



$$2=\frac{(12-2n)\varepsilon-2\varepsilon}{R} \quad \text{...(ii)}$$

Solving Eqs. (i) and (ii), we get

$n = 1$

35. (6)




Current through galvanometer $=\left(\frac{50}{50+40}\right)\times(15\text{ mA})$

$=\frac{25}{3}\text{mA}$

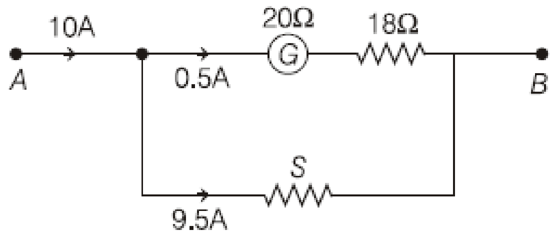
Current sensitivity $=\frac{50}{\frac{25}{3}}=6\text{ div/mA}$

$$i=\frac{2}{\frac{1000}{9}+\left(\frac{40\times50}{40+50}\right)}$$

$=158\times10^{-3}\text{ A}$

$=15\text{ mA}$

36. (2)

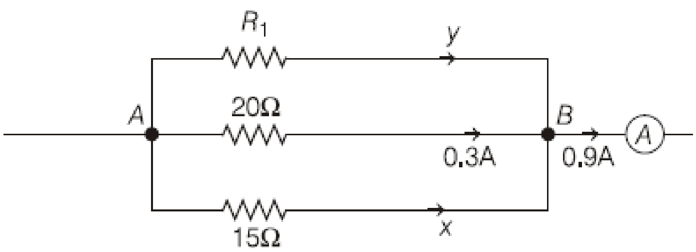



For half scale deflection, current through the galvanometer = 0.5 A

$$V_A - V_B = 0.5(20 + 118) = 9.5(S)$$

$\Rightarrow \quad S = 2\Omega$

37. (30)



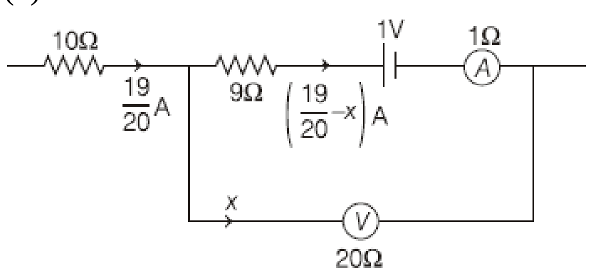

$$V_A - V_B = 20(0.3) = x(15) \Rightarrow x = 0.4\,\text{A}$$

$$x + y + 0.3 = 0.9 \Rightarrow y = 0.2\,\text{A}$$

$$V_A - V_B = 20 = (0.2)R_1$$

$\Rightarrow \quad R_1 = 30\,\Omega$

38. (7)



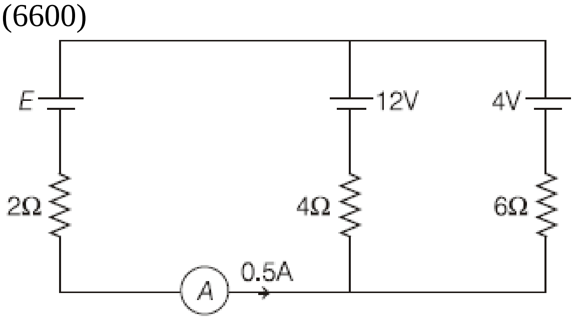

Using KVL in the loop,

$$-9\left(\frac{19}{20} - x\right) - 1 - 1\left(\frac{19}{20} - x\right) + 20x = 0$$

$\Rightarrow \quad x = 0.35\,\text{A}$

Reading of voltmeter = $= x(20) = 0.35 \times 20 = 7\text{ V}$

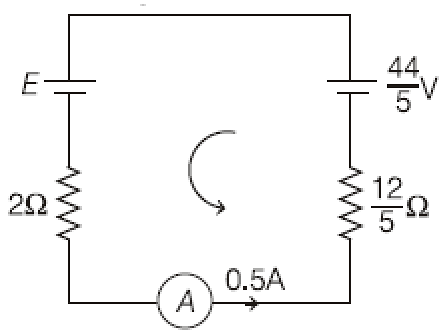
39. (6600)



$$\varepsilon_{eq} = \frac{\frac{12}{4}+\frac{4}{6}}{\frac{1}{4}+\frac{1}{6}} = \frac{44}{5}\text{V}$$

$$\frac{1}{r_{eq}} = \frac{1}{4}+\frac{1}{6}$$

$$\Rightarrow \quad r_{eq} = \frac{12}{5}\Omega$$

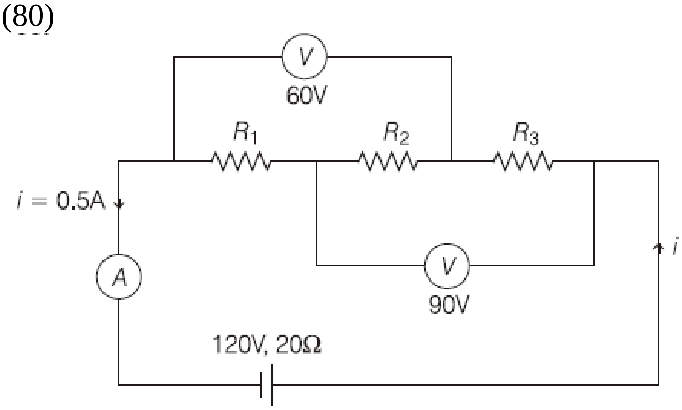



Applying KVL in the loop,

$$+\frac{44}{5} - E - 2(0.5) - \frac{12}{5}(0.5) = 0$$

$$\Rightarrow \quad E = 6.6\,\text{V} = 6600\,\text{mV}$$

40. (80)




$$i(R_1+R_2) = 60$$

$$\Rightarrow \quad 0.5(R_1+R_2) = 60$$

$$\Rightarrow \quad R_1+R_2 = 120\,\Omega \qquad \text{...(i)}$$

$$i(R_2+R_3) = 90$$

$$\Rightarrow \quad 0.5(R_2+R_3) = 90$$

$$\Rightarrow \quad R_2+R_3 = 180\,\Omega \qquad \text{...(ii)}$$

$$i = \frac{120}{R_1+R_2+R_3+20} = 0.5$$

$$\Rightarrow \quad R_1+R_2+R_3 = 220 \qquad \text{...(iii)}$$

Solving Eqs. (i), (ii) and (iii), we get

$$R_2 = 80\,\Omega$$

41. (3)

Let balance length be $I$ and unknown resistance be $R$.

For null point,

$$2(100-I)=R(I) \quad \text{...(i)}$$

When $2\Omega$ and $R$ are interchanged, balance point shifts by 20 cm.

So, for null point,

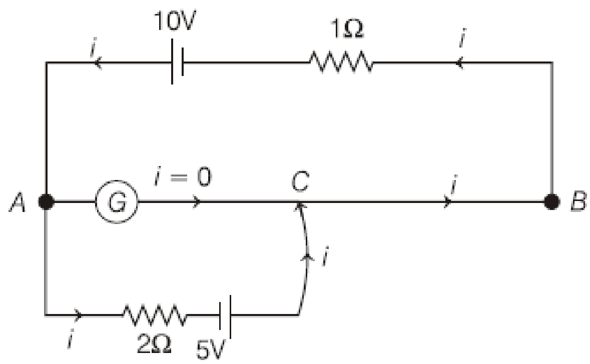
$$R(100-(I+20))=2(I+20)$$

$$\Rightarrow \quad R(80-I)=2(I+20) \quad \text{...(ii)}$$

Solving Eqs. (i) and (ii), we get

$$I=40\,\text{cm} \text{ and } R=3\Omega$$

42. (3)




Applying KVL,

$$-i+10-2i+5-iR_{BC}=0$$

$$\Rightarrow \quad i=\frac{15}{3+R_{BC}}$$

$$V_A-V_C=5-2i=0$$

$$\Rightarrow \quad i=2.5\,\text{A}$$

$$2.5=\frac{15}{3+R_{BC}}$$

$$\Rightarrow \quad R_{BC}=3\Omega$$

43. (0.2)

Current in the primary circuit $=\dfrac{3}{10+20}=0.1\,\text{A}$

Potential drop across the potentiometer wire

$$=0.1\times 20=2\text{ V}$$

$x=$potential gradient $=\dfrac{2}{10}=0.2\text{ V/m}=0.2\text{ mV/mm}$

For balance point,

$$V=xI$$

$$\Delta V=x\Delta I=\left(0.2\frac{\text{mV}}{\text{mm}}\right)(1\,\text{mm})=0.2\text{ mV}$$

1. (A)
In electric circuit ammeter is connected in series with resistance and voltmeter parallel with the net resistance.
In ohm's law, we check V = IR by varying net resistance of the circuit.

2. (B)
**(b)** Resistance between P and Q

$$r_{PQ} = r \,||\left(\frac{r}{3}+\frac{r}{2}\right) = \frac{r \times \frac{5}{6}r}{r+\frac{5}{6}r} = \frac{5}{11}r$$

Resistance between Q and R

$$r_{QR} = \frac{r}{2} \,||\, (r+\frac{r}{3}) = \frac{\frac{r}{2}\times\frac{4}{3}r}{\frac{r}{2}+\frac{4}{3}r} = \frac{4}{11}r$$

Resistance between P and R

$$r_{PR} = \frac{r}{3} \,||\left(\frac{r}{2}+r\right) = \frac{\frac{r}{3}\times\frac{3}{2}r}{\frac{r}{3}+\frac{3}{2}r} = \frac{3}{11}r$$

Hence, it is clear that $r_{PQ}$ is maximum.

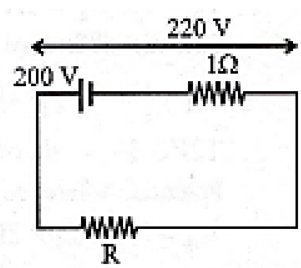
3. (C)
**(c)** As 200 V battery is charging

So, $220 = 200 + i.1$

$i = 20$ A

So, $20 \times R = 220$ V

$\Rightarrow R = 11\ \Omega$

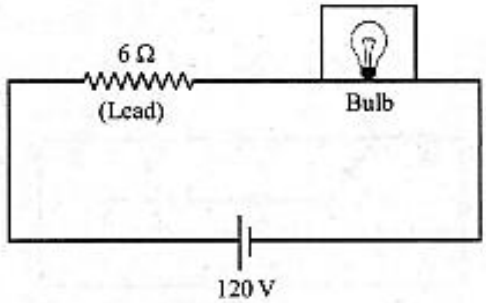



4. (C)
**(c)** $\frac{100}{R+r} = \frac{90}{R} \Rightarrow \frac{R+r}{R} = \frac{10}{9} \Rightarrow 1+\frac{0.5}{R} = \frac{10}{9}$

$\Rightarrow \frac{0.5}{R} = \frac{1}{9}\ \therefore\ R = 4.5\ \Omega$

5. (D)

(d)




Power of bulb = 60 W (given)

Resistance of bulb $= \frac{120 \times 120}{60} = 240\Omega$ $\left[\because P = \frac{V^2}{R}\right]$

Power of heater = 240W (given)

Resistance of heater $= \frac{120 \times 120}{240} = 60\Omega$

Voltage across bulb before heater is switched on,

$V_1 = \frac{240}{246} \times 120 = 117.73$ volt

Voltage across bulb after heater is switched on,

$V_2 = \frac{48}{54} \times 120 = 106.66$ volt

Hence decrease in voltage

$V_1 - V_2 = 117.073 - 106.66 = 10.04$ Volt (approximately)

6. (C)

(c) Total power consumed by electrical appliances in the building, $P_{total} = 2500W$

Watt = Volt × ampere

$\Rightarrow \quad 2500 = V \times I \Rightarrow 2500 = 220\, I$

$\Rightarrow \quad I = \frac{2500}{220} = 11.36 \approx 12A$

(Minimum capacity of main fuse)

7. (C)

(c) Current in each bulb $= \frac{\text{Power}}{\text{Voltage}} = \frac{100}{220} = 0.45A$

Current through ammeter = 0.45 × 3 = 1.35 A

8. (B)

**(b)** $V = IR = (neAv_d)\rho\frac{\ell}{A}$ $\therefore$ $\rho = \frac{VA}{n_e AV_d l} = \frac{V}{n_e V_d l}$

Here V = potential difference
l = length of wire
n = no. of electrons per unit volume of conductor.
e = no. of electrons
Placing the value of above parameters we get resistivity

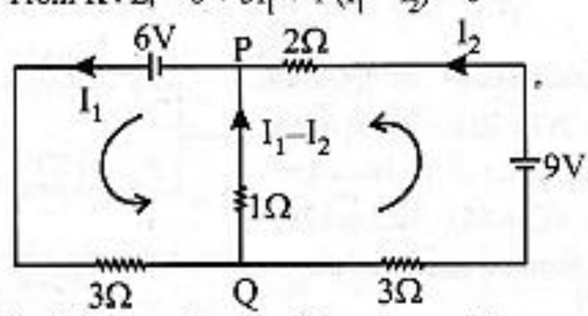
$$\rho = \frac{5}{8\times10^{28}\times1.6\times10^{-19}\times2.5\times10^{-4}\times0.1} = 1.6\times10^{-5}\Omega m$$

9. (C)

**(c)** $i = neAV_d$ and $V_d \propto \sqrt{E}$ (Given)

or, $i \propto \sqrt{E}$ or, $i^2 \propto E$ or, $i^2 \propto V$
Hence graph (c) correctly dipicts the *V-I* graph for a wire made of such type of material.

10. (A)
**(a)** From KVL, $-6 + 3I_1 + 1(I_1 - I_2) = 0$




$6 = 3I_1 + I_1 - I_2$; $4I_1 - I_2 = 6$ ...(i)
$-9 + 2I_2 - (I_1 - I_2) + 3I_2 = 0$
$-I_1 + 6I_2 = 9$ ...(ii)
On solving (i) and (ii)
$I_1 = 0.13A$
Direction Q to P, since $I_1 > I_2$.

11. (C)

(c) $i = \frac{V}{R + \frac{Rr}{R+r}} \times \left(\frac{R}{R+r}\right) = \frac{V}{R+2r}$

So, $P = i^2R = \frac{V^2R}{(R+2r)^2}$

for $H_{max}$, P is maximum

$\frac{dp}{dr} = 0 \Rightarrow \frac{(R+2r)^2 - 2(R+2r).2r}{(R+2r)^4} = 0$

$\Rightarrow (R + 2r)(R + 2r - 4r) = 0$

$\Rightarrow r = -\frac{R}{2}$ or $r = \frac{R}{2}$ $\Rightarrow r = \frac{R}{2}$ so, $f = \frac{1}{2}$

12. (A)

Given $R_1 = 100\Omega, r' = r/2, R_2 = ?$

Resistivity of wire, $R = \frac{\rho l}{A}$ $\because$ Area $\times$ lenght = volume

Hence, $R = \frac{\rho V}{A^2}$

Since, $\rho \rightarrow$ constant, $V \rightarrow$ constant

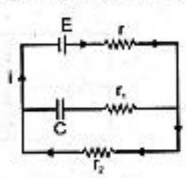
$R \propto \frac{1}{A^2}$ OR $R \propto \frac{1}{r^4}$ $\because A = \pi r^2$

$\frac{R_2}{R_1} = 16 \Rightarrow R_2 = 16 \times 100 = 1600\Omega$, Resistance of new wire.

13. (A)

(a) In steady state, flow fo current through capacitor will be zero.

Current through the circuit,




$i = \frac{E}{r + r_2}$

Potential difference through capacitor

$V_c = \frac{Q}{C} = E - ir = E - \left(\frac{E}{r + r_2}\right)r$

$\therefore \quad Q = CE\frac{r_2}{r + r_2}$

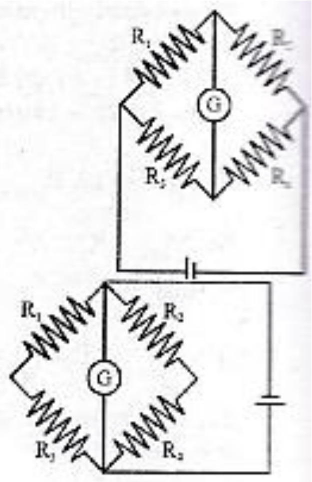
14. (B)

The potential difference in each loop is zero.

$\therefore$ No current will flow or current in each resistance is zero

15. (D)

**(d)** There is no change in null point, if the cell and the galvanometer are exchanged in a balanced wheatstone bridge.




On balancing condition $\frac{R_1}{R_3} = \frac{R_2}{R_4}$

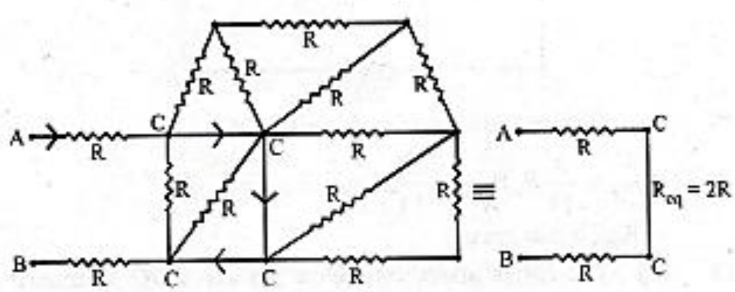
After exchange

On balancing condition

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

16. (A)

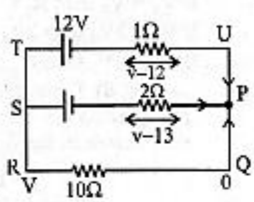
**(a)** Current will follow the path ACCCCB so we will get our final circuit as shown below




17. (B)

(b) Using Kirchhoff's law at $P$ we get

$\frac{V-12}{1} + \frac{V-13}{2} + \frac{V-0}{10} = 0$




[Let potential at P, Q, U = 0 and at R = V]

$\Rightarrow \frac{V}{1} + \frac{V}{2} + \frac{V}{10} = \frac{12}{1} + \frac{13}{2} + \frac{0}{10}$

$\Rightarrow \frac{10+5+1}{10} V = \frac{24+13}{2} \Rightarrow V\left(\frac{16}{10}\right) = \frac{37}{2}$

$\Rightarrow V = \frac{37 \times 10}{16 \times 2} = \frac{370}{32} = 11.56 \text{ volt}$

18. (A)

**(a)** Rate of heat i.e., Power developed in the wire

$= P = \dfrac{V^2}{R}$

Resistance of the wire of length, $L$ $R_1 = \dfrac{\rho L}{A} = \dfrac{\rho L}{\pi r^2}$

$\therefore$ Power, $P_1 = \dfrac{V^2}{R_1}$

Resistance of the wire when length is halved i.e., $L/2$

$$R_2 = \frac{\rho \frac{L}{2}}{\pi(2r)^2} = \frac{\rho L}{\pi 8 r^2} = \frac{R_1}{8}$$

$\therefore$ Power, $P_2 = \dfrac{V}{\frac{R_1}{8}} = \dfrac{8V}{R_1}$ or, $P_2 = 8P_1$

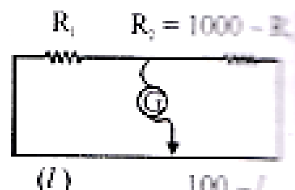
i.e., power increased 8 times of previous or original wire.

19. (B)

Using formula, internet resistance,

$r = \left(\dfrac{l_1 - l_2}{l_2}\right)s = \left(\dfrac{52-40}{40}\right) \times 5 = 1.5\Omega$ $R_1$

20. (C)




**(c)** $R_1 + R_2 = 1000$

$\Rightarrow R_2 = 1000 - R_1$

On balancing condition

$R_1(100 - l) = (1000 - R_1)l$ ...(i)

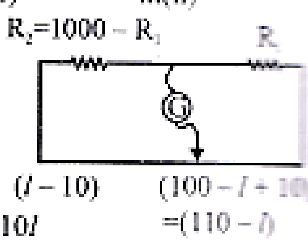
On Interchanging resistance balance point shifts left by 10 cm.

On balancing condition

$(1000 - R_1)(110 - l) = R_1(l - 10)$

or, $R_1(l - 10) = (1000 - R_1)(110 - l)$ ...(ii)

Dividing eqn (i) by (ii)




$$\frac{100 - l}{l - 10} = \frac{l}{110 - l}$$

$\Rightarrow (100 - l)(110 - l) = l(l - 10)$

$\Rightarrow 11000 - 100l - 110l + l^2 = l^2 - 10l$

$\Rightarrow 11000 = 200l$ or, $l = 55$

Putting the value of '$l$' in eqn (i)

$R_1(100 - 55) = (1000 - R_1)55 \Rightarrow R_1(45) = (1000 - R_1)55$

$\Rightarrow R_1(9) = (1000 - R_1)11 \Rightarrow 20R_1 = 11000$

$\therefore$ $R_1 = 550K\Omega$

21. (D)

(d) Charge mobility

$(\mu) = \frac{V_d}{E}$ [Where $V_d$ = drift velocity]

and resistivity $(\rho) = \frac{E}{j} = \frac{EA}{I} \Rightarrow E = \frac{I(\rho)}{A}$

$$\Rightarrow \mu = \frac{V_d}{E} = \frac{V_d A}{I\rho} = \frac{1.1\times10^{-3}\times\pi\times\left(5\times10^{-3}\right)^2}{5\times1.7\times10^{-8}}$$

$$\Rightarrow \mu = 1.0\frac{m^2}{Vs}$$

22. (B)

(b) Equation of straight line from graph

$y = -mx + c$

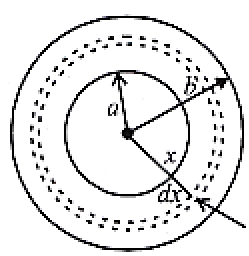
$$\Rightarrow \ln R = -m\left(\frac{1}{T^2}\right) + c$$

here, m & c are constants

$$R = e^{\left[-m\left(\frac{1}{T^2}\right)+c\right]} = e^{-m\left(\frac{1}{T^2}\right)} \times e^c \Rightarrow R(T) = R_0 e^{\frac{-T_0^2}{T^2}}$$

23. (A)

(a) $dR = \frac{(\rho)(dx)}{4\pi x^2}$




$R = \int dR$

$$\int dR = \rho\int_a^b \frac{dx}{4\pi x^2}$$

$$\Rightarrow R = \frac{\rho}{4\pi}\left[\frac{-1}{x}\right]_a^b \Rightarrow R = \left(\frac{\rho}{4\pi}\right)\cdot\left(\frac{1}{a}-\frac{1}{b}\right)$$

24. (C)

25. (A)

Clearly, from graph

Current, $I = \frac{dq}{dt} = 0$ at $t = 4s$ [Since q is constant]

26. (A)

Using, $I = neAv_d$

$\therefore$ Drift speed $v_d = \frac{1}{neA}$

$$= \frac{1.5}{9\times10^{28}\times1.6\times10^{-19}\times5\times10^{-6}} = 0.02 \text{ mms}^{-1}$$

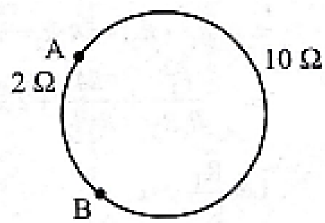
27. (C)

**(c)** When length becomes double its resistance becomes

$(R \propto l^2)$

$R = 4 \times 3 = 12\ \Omega$

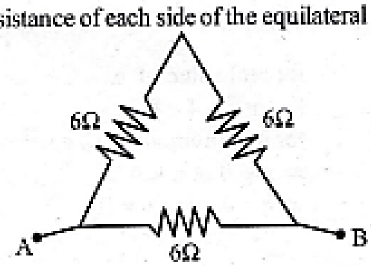
$R_{eq} = \frac{2\times10}{12} = \frac{5}{3}\Omega$




28. (A)

**(a)** Resistance, $R \propto l$ so resistance of each side of the equilateral triangle = 6 Ω

Resistance $R_{eq}$ between any two vertices




$$\frac{1}{R_{eq}} = \frac{1}{12} + \frac{1}{6} \Rightarrow R_{eq.} = 4\Omega$$

29. (D)

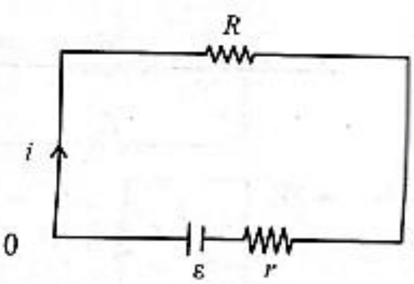
**(d)** $i = \left(\frac{\varepsilon}{R+r}\right)$

Power delivered to R.

$P = i^2R = \left(\frac{\varepsilon}{R+r}\right)^2 R$

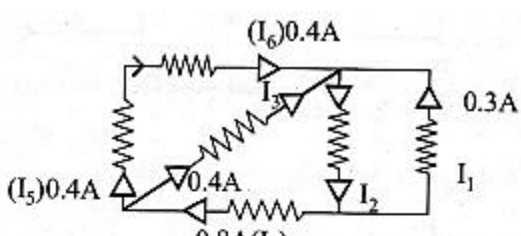
P to be maximum, $\frac{dP}{dR} = 0$

or $\frac{d}{dR}\left[\left(\frac{\varepsilon}{R+r}\right)^2 R\right] = 0$ or $R = r$




30. (B)

**(b)**




From KCL, $I_3 = 0.8 - 0.4 = 0.4$ A

$I_2 = 0.4 + 0.4 + 0.3 = 1.1$ A

and $I_6 = 0.4$ A

31. (A)

(a) As $R = \frac{V^2}{P}$, so $R_1 = \frac{220^2}{25}$ and $R_2 = \frac{220^2}{100}$

Current flown $i = \frac{220}{R_1 + R_2}$

$$P_1 = i^2 R_1 = \frac{220^2}{\left(\frac{220^2}{25} + \frac{220^2}{100}\right)} \times \frac{220^2}{25} = 16 \text{ W}$$

Similarly, $P_2 = i^2 R_2 = 4$ W

32. (B)

(b) When two resistances are connected in series,

$R_{eq} = 2R$

Power consumed, $P = \frac{\varepsilon^2}{R_{eq}} = \frac{\varepsilon^2}{2R}$

In parallel condition, $R_{eq} = R/2$.

New power, $P' = \frac{\varepsilon^2}{(R/2)}$

or $P' = 4P = 240$ W ($\because$ $P = 60$ W)

33. (A)

(a) Colour code for carbon resistor

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Bl, | Br, | R, | O, | Y, | G, | Blue, | V, | Gr, | W |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

Resistance, $R = AB \times C \pm D$

$\therefore$ Resistance, $R = 50 \times 10^2\ \Omega$

Now using formula, Power, $P = i^2 R$

$$\therefore i = \sqrt{\frac{P}{R}} = \sqrt{\frac{2}{50 \times 10^2}} = 20\text{mA}$$

34. (A)

(a) Power, $P = I^2 R$

$4.4 = 4 \times 10^{-6} \times R \Rightarrow R = 1.1 \times 10^6 \Omega$

When supply of 11 v is connected

$$\text{Power, } P' = \frac{v^2}{R} = \frac{11^2}{1.1} \times \frac{11^2}{1.1} \times 10^{-6} = 11 \times 10^{-5} \text{ W}$$

35. (C)

**(c)** We have given

$$\frac{dR}{d\ell} \propto \frac{1}{\sqrt{\ell}} \Rightarrow \frac{dR}{d\ell} = k \times \frac{1}{\sqrt{\ell}} \quad \text{(where k is constant)}$$

$$dR = k\frac{d\ell}{\sqrt{\ell}}$$

Let $R_1$ and $R_2$ be the resistance of AP and PB respectively.
Using wheatstone bridge principle

$$\therefore \frac{R'}{R'} = \frac{R_1}{R_2} \text{ or } R_1 = R_2$$

$$\text{Now, } \int dR = k\int \frac{d\ell}{\sqrt{\ell}} \quad \therefore R_1 = k\int_0^{\ell} \ell^{-1/2} d\ell = k.2.\sqrt{\ell}$$

$$R_2 = k\int_{\ell}^{1} \ell^{-1/2} d\ell = k.(2 - 2\sqrt{\ell})$$

Putting $R_1 = R_2$

$$k2\sqrt{\ell} = k(2 - 2\sqrt{\ell}) \quad \therefore 2\sqrt{\ell} = 1 \Rightarrow \sqrt{\ell} = \frac{1}{2}$$

i.e., $\ell = \frac{1}{4}\text{m} \Rightarrow 0.25 \text{ m}$

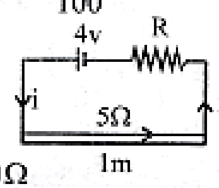
36. (C)

**(c)** Current flowing through the circuit (I) is given by

$$I = \left(\frac{4}{R+5}\right)A$$

Resistance of length 10 cm of wire $= 5 \times \frac{10}{100} = 0.5\Omega$

According to question,




$$5 \times 10^{-3} = \left(\frac{4}{R+5}\right).(0.5)$$

$$\therefore \frac{4}{R+5} = 10^{-2} \text{ or } R + 5 = 400\Omega$$

$$\therefore R = 395\Omega$$

37. (C)

**(c)** Let x be the length AJ at which galvanometer shows null deflection current,

$$i = \frac{\varepsilon}{12r + r} = \frac{3}{13r} \Rightarrow i\left(\frac{x}{L}12r\right) = \frac{\varepsilon}{2}$$

$$\Rightarrow \frac{\varepsilon}{13r}\left[\frac{x}{L}\cdot 12r\right] = \frac{\varepsilon}{2} \Rightarrow \frac{\varepsilon}{13r}\left[\frac{x}{L}\cdot 12r\right] = \frac{\varepsilon}{2} \Rightarrow x = \frac{13L}{24}$$

38. (B)

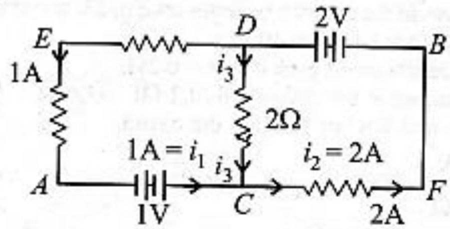
$\rho_M = 98 \times 10^{-8}; \rho_A = 2.65 \times 10^{-8}$

$\rho_C = 1.724 \times 10^{-8}; \rho_T = 5.65 \times 10^{-8}$

$\therefore \rho_M > \rho_T > \rho_A > \rho_C$

39. (D)

(d)




Let us assume the potential at $A = V_A = 0$

Using Kirchoff's junction rule at $C$, we get

$i_1 + i_3 = i_2$

$1\text{A} + i_3 = 2\text{ A} \Rightarrow i_3 = 2A$

Now using Kirchoff's loop law along $ACDB$

$V_A + 1 + i_3(2) - 2 = V_B$

$\Rightarrow V_A + 1 + i_3(1) - 2 = V_B \Rightarrow V_B - V_A = 3 - 2 = 1$ volt

40. (D)

**(d)** Given : Power, $P = 1\text{ kW} = 1000\text{ W} = P_{output}$

$R = 2\Omega,\ V = 220\text{ V}$

Current, $I = \dfrac{P}{V} = \dfrac{1000}{220}$

$P_{loss} = I^2R = \left(\dfrac{1000}{220}\right)^2 \times 2$

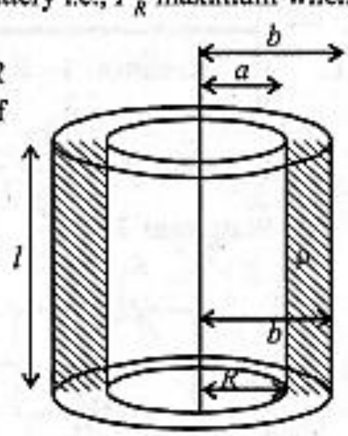
$P_{in} = P_{output} + P_{loss}$

$\therefore$ Efficiency $= \dfrac{1000}{1000 + P_{loss}} \times 100 = 96\%.$

41. (B)

**(b)** Maximum power in external resistance is generated when it is equal to internal resistance of battery i.e., $P_R$ maximum when $r = R$

The maximum Joule heating in $R$ will take place for, the resistance of small element




$$dR = \frac{\rho dr}{2\pi r l} \Rightarrow R = \frac{\rho}{2\pi l}\int_a^b \frac{dr}{r}$$

$$\Rightarrow R = \frac{\rho}{2\pi l}\ln\frac{b}{a}$$

42. (D)

**(d)** The voltmeter of resistance $10k\Omega$ is parallel to the resistance of $400\Omega$. So, their equivalent resistance is

$$\frac{1}{R'} = \frac{1}{10\,k\Omega} + \frac{1}{400\Omega} = \frac{1}{10000} + \frac{1}{400}$$

$$\Rightarrow \frac{1}{R'} = \frac{1+25}{10000} = \frac{26}{10000} \Rightarrow R' = \frac{10000}{26}\Omega$$

Using Ohm's law, current in the circuit

$$I = \frac{\text{Voltage}}{\text{Net Resistance}} = \frac{6}{\frac{10000}{26}+800}$$

Potential difference measured by voltmeter

$$V = IR' = \frac{6}{\frac{10000}{26}+800} \times \frac{10000}{26} \Rightarrow V = \frac{150}{77} = 1.95 \text{ volt}$$

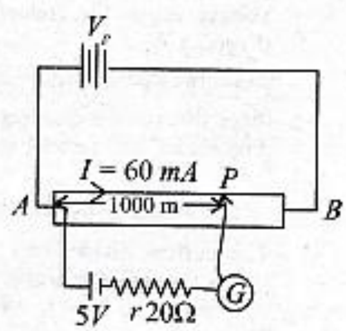
43. (D)

**(d)** Let R be the resistance of the whole wire

Potential gradient for the potentiometer wire

$$'AB' = -\frac{dV}{d\ell} = \frac{I \times R}{\ell}$$

$$= \left[\frac{60 \times R}{\ell_{AB}}\right] mv/m$$




$$V_{AP} = \left(\frac{dV}{d\ell_{AB}}\right)\ell_{AP}$$

$$= \frac{60 \times R}{1200} \times 1000 mV$$

$\Rightarrow V_{AP} = 50$ R $mV$

Also, $V_{AP} = 5\ V$ (for balance point at $P$)

$$\therefore R = \frac{V_{AP}}{50 \times 10^{-3}} = \frac{5}{50 \times 10^{-3}} = 100\Omega$$

44. (D)

**(d)** From colour code for electric resistance,

| Violet | Green | Red | Gold |
|---|---|---|---|
| 7 | 5 | 2 | 5% |

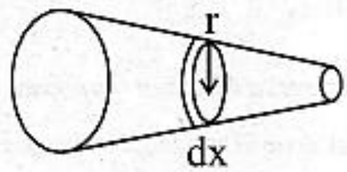
$\therefore R = 75 \times 10^2 \pm 5\%$ of $7500 \Rightarrow R = (7500\ \pm 375)\Omega$.

45. (A)

**(a)** Current is constant in the conductor. I = constant

Resistance of element of conductor, $dR = \frac{\rho dx}{\pi r^2}$

$dV = idR = \frac{i\rho dx}{\pi r^2}$




$E = \frac{dV}{dx} = \frac{i\rho}{\pi r^2}$

Drift velocity,

$V_d = \frac{eE\tau}{m}$ As $V_d \propto E$ and $E \propto \frac{1}{r^2}$

So, if r decreases, E will increase and hence $V_d$.

46. (C)

**(c)** From formula, drift velocity, $V_d = neV_d\bar{A}$

$$\Rightarrow \quad n = \frac{1}{AeV_d} = \frac{10}{5\times10^{-6}\times1.6\times10^{-19}\times2\times10^{-3}}$$

$= 625 \times 10^{25}$

47. (B)

**(b)** Given, $i = \alpha_0 t + \beta t^2$

Put $\alpha_0 = 20$ and $\beta = 8$, we get $i = 20t + 8t^2$

$$\text{Current, } i = \frac{dq}{dt} \Rightarrow \int dq = \int i dt \Rightarrow q = \int_0^{15} (20t + 8t^2)dt$$

$$\Rightarrow q = \left(\frac{20t^2}{2} + \frac{8t^3}{3}\right)_0^{15} = 20\times\left(\frac{15^2 - 0^2}{2}\right) + \frac{8}{3}(15^3 - 0^3)$$

$$\Rightarrow q = 10 \times (15)^2 + \frac{8(15)^3}{3} \Rightarrow q = 2250 + 9000 = 11250\text{ C}$$

48. (B)

**(b)** Resistance, $R = \frac{\rho\ell}{A} = \frac{\rho\ell^2}{(\text{Vol.})}$ or $R \propto \ell^2$

or, $\frac{R_1}{R_2} = \frac{\ell_1^2}{\ell_2^2}$

As length increases 25%, if $\ell_1 = \ell$ then

$\ell_2 = \ell + \ell \times \frac{25}{100} = 1.25\ell$

$\therefore \quad \frac{R}{R_2} = \frac{\ell^2}{(1.25\ell)^2}$ or, $R_2 = 1.5625R$

$\therefore$ % increase in resistance $R = 56\%$

49. (B)

(b) $R_{net} = \dfrac{R_1 R_2}{R_1 + R_2}$

$$R_{\text{net}} = \left(\frac{\rho_1\rho_2}{\rho_1+\rho_2}\right)\frac{l}{A} \Rightarrow l = \frac{(\rho_{i+}\rho_A)AR_{\text{net}}}{\rho_i\,\rho_a}$$

Putting the required value we get $l = 97$ m

50. (A)

(a) $i_r = \dfrac{25}{5+R}$

in parallel, $E_{eq} = E = 5V$

$r_{eq} = \dfrac{r}{5} = \dfrac{1}{5}\Omega$ $\qquad i_2 = \dfrac{5}{R+\dfrac{1}{5}}$

putting $i_1 = i_2$,

we get, $4R = 4 \Rightarrow R = 1\Omega$.

51. (A)

(a) Given, Power of electric bulb , P = 500W

$R = V_I \Rightarrow 500 = V_I$

$\Rightarrow I = 5$ Amp

As current remains same in series, using ohm's law

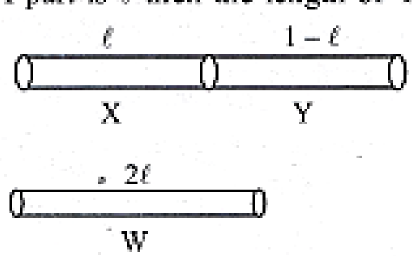
$V = I \times R_{eq}$

$\Rightarrow 200 = 5 \times R \;\; \Rightarrow R_{eq} = 40$

$\therefore R + 20 = 40 \Rightarrow R = 20\,\Omega$

52. (B)

(b) Consider of the length of X part is $\ell$ then the length of Y part will be $1-\ell$.




$$\frac{R_X}{R_Y} = \frac{\ell_X}{\ell_Y} \quad \left(\because \;\; R = \frac{\rho\ell}{A}\right)$$

When wire is stretched to double of its length, then resistance becomes 4 times.

$R_W = 4R_X = 2R_Y$

$\dfrac{R_X}{R_Y} = \dfrac{1}{2}$ So $\dfrac{\ell_X}{\ell_Y} = \dfrac{1}{2}$.

53. (A)

**(a)** Resistance, $R_1 = \rho \frac{L_1}{A_1}$

$$R_2 = \rho\left(\frac{3L_1}{A_1/3}\right) = 9\rho\frac{L_1}{A_1} \qquad \therefore \frac{R_2}{R_1} = \frac{9\rho\frac{L_1}{A_1}}{\rho\frac{L_1}{A_1}} = 9$$

54. (A)

**(a)** We know that

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

So, $2 = R_0(1+\alpha\times 10)$ ...(i)

$3 = R_0(1+\alpha\times 30)$ ...(ii)

Dividing (i) by (ii), we get

$$\frac{3}{2} = \frac{1+30\alpha}{1+10\alpha} \Rightarrow 3 + 30\alpha = 2 + 60\alpha \Rightarrow 1 = 30\alpha$$

$$\Rightarrow \alpha = \frac{1}{30} = 0.033\ ^{\circ}\mathrm{C}^{-1}$$

55. (C)

$$R = \frac{\rho l}{A}$$

$$\frac{\Delta R}{R} = \frac{\Delta l}{l} - \frac{\Delta A}{A}$$

[**Note:** This is not relative error case, so –ve sign comes with $\frac{\Delta A}{A}$]

Now, $V$ = constant

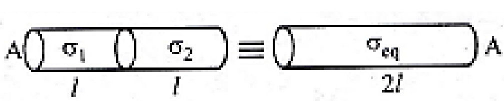
$Al$ = constant

$$\Rightarrow \frac{\Delta A}{A} + \frac{\Delta l}{l} = 0 \Rightarrow -\frac{\Delta A}{A} = \frac{\Delta l}{l}$$

So, $\frac{\Delta R}{R} = \frac{\Delta l}{l} + \frac{\Delta l}{l} \quad \left[\because \frac{\Delta l}{l} = -\frac{\Delta A}{A}\right]$

$$= \frac{2\Delta l}{l} = 2\times 0.4 = 0.8\%$$

56. (B)

**(b)** 


Let length of wire be '$\ell$' and area of wire as 'A'

For equivalent wire length = $2\ell$; area will be A

Equivalent thermal resistance in series will be given as

$R_{eq} = R_1 + R_2$

$$\Rightarrow \quad \frac{2\ell}{\sigma_{eq} A} = \frac{\ell}{\sigma_1 A} + \frac{\ell}{\sigma_1 A} \qquad \left[\because\ R = \frac{\ell}{\sigma A}\right]$$

$$\Rightarrow \quad \frac{2\ell}{\sigma_{eq}} = \frac{\ell}{\sigma_1} + \frac{\ell}{\sigma_2} \quad \Rightarrow \sigma_{eq} = \frac{2\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$$

57. (B)

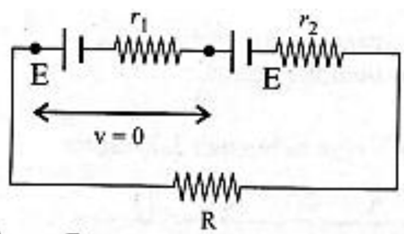
**(b)** As $R = \frac{\rho l}{A} \Rightarrow R_i = 14\Omega = \frac{\rho l_0}{\pi r_0^2}$

$$R_f = \frac{\rho l_0}{\pi\left(\frac{r_0}{3}\right)^2} = 9\frac{\rho l_0}{\pi r_0^2} = 9R_i = 9 \times 14 = 126\Omega$$

$$R_{eq} = \frac{R_f}{7} = \frac{126}{7} = 18\Omega$$

58. (A)

**(a)**




We have, $E - ir_1 = 0 \qquad [\because\ V_{r_1} = 0]$

$\Rightarrow \quad E - ir_1$

Now, $i = \frac{2E}{r_1 + r_2 + R}$

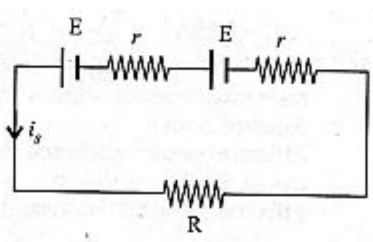
$$\Rightarrow \quad \frac{E}{r_1} = \frac{2E}{r_1 + r_2 + R} \qquad \left[\because\ i = \frac{E}{r_1}\right]$$

$\Rightarrow \quad r_1 + r_2 + R = 2r_1$

$\Rightarrow \quad R = r_1 - r_2$

59. (A)

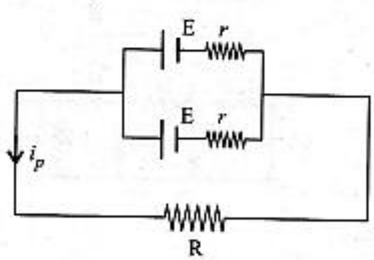
**(a) In series**




$$i_s = \frac{2E}{2r + 2}$$

**In parallel**

$$i_p = \frac{E}{\frac{r}{2} + 2} = \frac{2E}{r + 4}$$




as, $i_s = i_p$

$$\Rightarrow \frac{2E}{2r + 2} = \frac{2E}{r + 4}$$

$\Rightarrow r = 2\Omega$

60. (A)

We, have,

$$i = \frac{E_{net}}{R_{net}} = \frac{2E}{R + x_1 + x_3}$$

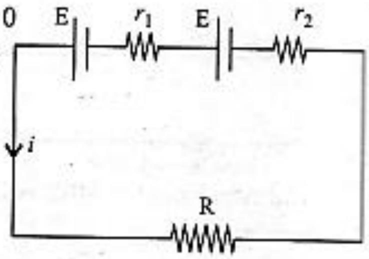
As. P.d across second cell = 0

$\Rightarrow$ E-$ir_2$ = 0 [$\because$ $V = E - iR$]

$$\Rightarrow E - \frac{2Er_2}{R + r_1 + r_2} = 0$$

$\Rightarrow R + r_1 + r_2 - 2r_3 = 0$

$\Rightarrow R = r_2 - r_1$

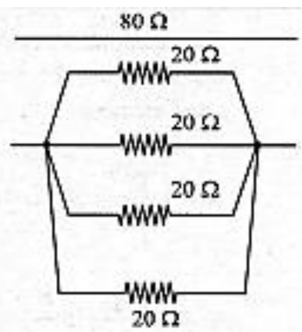



61. (C)

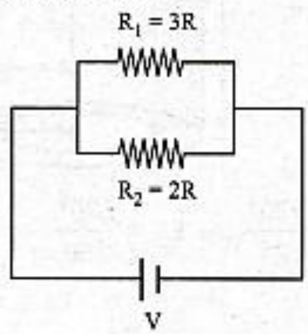
**(c) Statement 1 - R = 80 Ω**

$R_1 = R_2 = R_3 = R_4 = 20\ \Omega$

In parallel $R_{eq} = \frac{20}{4} = 5\ \Omega$




**Statement 2 –**




$$P_{th} = \frac{v^2}{R} \Rightarrow P \propto \frac{1}{R}$$

So, $\frac{P_1}{P_2} = \left(\frac{R_2}{R_1}\right) = \frac{2}{3}$ (where P is power)

62. (B)

**(b)** Given

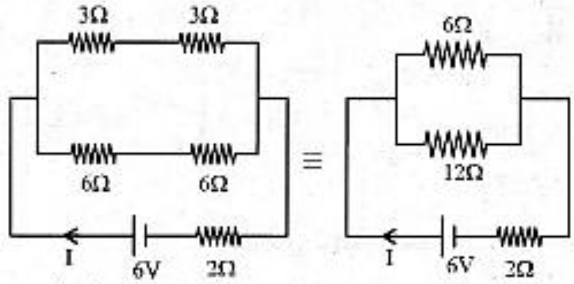
$\frac{1}{2} \cdot \frac{\Delta U}{\Delta t} = P_{Bulb} \times N$, where $N$ = no. of bulb

$$\Rightarrow \frac{9 \times 10^4 \times 10 \times 40}{2 \times 3600} = 100 \times N \left[\because \frac{\Delta U}{\Delta t} = \frac{mgh}{3600}\frac{J}{S}\right]$$

$$\Rightarrow N = \frac{36 \times 10^6}{72 \times 10^4} \Rightarrow N = \frac{1}{2} \times 100 \Rightarrow N = 50$$

63. (A)

**(a)** Balanced wheat stone bridge in circuit so there is no current in $5\Omega$ resistor so it can be removed from the circuit.




The equivalent resistance will be

$$R_{eq} = \frac{6\times 12}{6+12} + 2 = 6\,\Omega$$

Now, apply K.V.L, we have

$$I = \frac{V}{R_{eq}} = \frac{6}{6} = 1A$$

64. (2)

**(2)** Current through $AB$, $i_1 = \frac{40}{40+60} = 0.4$

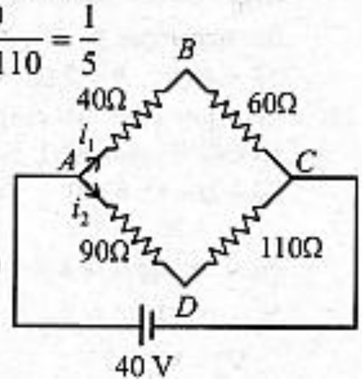
Current through $AD$, $i_2 = \frac{40}{90+110} = \frac{1}{5}$

Using KVL in BAD loop

$V_B + i_1(40) - i_2(90) = V_D$

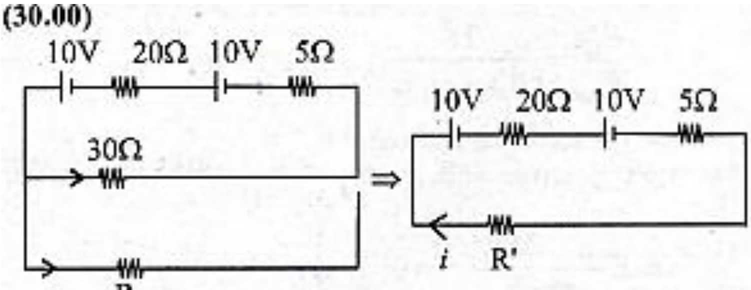
$\Rightarrow V_B - V_D = \frac{1}{5}(90) - \frac{4}{10}(40)$

$\Rightarrow V_B - V_D = 18 - 16 = 2\,V$




65. (30.00)

**(30.00)**




The resistance of $30\Omega$ is in parallel with $R$. Their effective resistance

$$\frac{1}{R'}=\frac{1}{30}+\frac{1}{R} \Rightarrow R'=\frac{30R}{30+R}$$

Now, $10-i\times 20=0$
$i=0.5$ A

as, $i=\dfrac{E}{R_{eq}} \Rightarrow 0.5=\dfrac{10+10}{R'+25}$

$$\Rightarrow 0.5-\frac{20}{\frac{30R}{R+30}+25} \Rightarrow R=30\Omega$$

66. (12)

**(12)** We know that

$E \propto \ell$ where $l$ is the balancing length

$\therefore$ E = $k$(560) ....(i)

When the balancing length changes by 60 cm

$$\frac{E}{r+10}10=k\,(500) \qquad \text{...(ii)}$$

Dividing (i) by (ii) we get

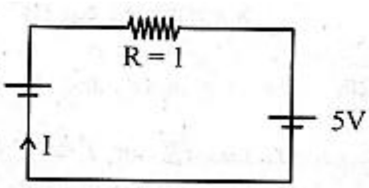
$$\Rightarrow \quad \frac{r+10}{10}=\frac{56}{50} \Rightarrow 50\,r+500=560$$

$$\Rightarrow \quad r=\frac{6}{5}\Omega=\frac{N}{10}\Omega \Rightarrow N=12$$

67. (1)

**(1)** From graph (figure 1)
voltage at t = 3.2s = 6V

Current, $I=\dfrac{V}{R}=\dfrac{6-5}{1}=1A$




68. (4)

**(4)** $l_1=l_2=l_{eq}$
$A_1=A_2=A$ and $A_{eq}=2A$

$$R_{eq}=\frac{R_1R_2}{R_1+R_2} \Rightarrow \frac{\rho(l)}{2A}=\frac{\left(\frac{\rho_1 l}{A}\right)\left(\frac{\rho_2 l}{A}\right)}{\frac{\rho_1 l}{A}+\frac{\rho_2 l}{A}}$$

$$\Rightarrow \quad \frac{\rho}{2}=\frac{\rho_1\rho_2}{\rho_1+\rho_2} \Rightarrow \frac{\rho}{2}=\frac{\rho_1\rho_2}{(\rho_1+\rho_2)}=\frac{6\times 3}{(6+3)}=2$$

$\therefore \quad \rho=4$

69. (5)

(5) Given : Conductivity of wire, $\sigma = 5\times10^7$ S/m

Radius of wire, $r = 0.5\text{ mm} = 5\times10^{-4}$ m

Electric field, $E = 10\times10^{-3}$ V/m

$J = \sigma E = 10\times10^{-3}\times5\times10^7 \Rightarrow J = 5\times10^5$

Since, $J = \frac{i}{A} \Rightarrow \frac{i}{A} = 5\times10^5$

$\Rightarrow i = 5\times10^5\times\pi r^2 = 5\times10^5\times\pi\times(5\times10^{-4})^2$

$= 125\pi\times10^{-3}$ A

$\therefore i = 125\pi$ mA $\quad \therefore i = 5^3\pi$ mA $\quad \therefore x = 5$

70. (300)

(300) Given,

Charge, $q = 20$ C, potential difference, $\Delta V = 15$ V

Work done, $W = q\Delta V = 20\times15 = 300$ J

71. (4)

(4) Equivalent resistance in series, $s = R_1 + R_2$

Equivalent resistance in parallel $P = \frac{R_1R_2}{R_1+R_2}$

Given $(R_1 + R_2) = n\left(\frac{R_1R_2}{R_1+R_2}\right)$

$\Rightarrow \quad R_1^2 + R_2^2 + 2R_1R_2 = nR_1R_2$

$\Rightarrow \quad \frac{R_1^2}{R_1R_2} + \frac{R_2^2}{R_1R_2} + 2 = n \Rightarrow \frac{R_1}{R_2} + \frac{R_2}{R_1} + 2 = n$

Let $\frac{R_1}{R_2} = \alpha$

Then, $\alpha + \frac{1}{\alpha} + 2 = n \Rightarrow \alpha^2 + \alpha(2-n) + 1 = 0$

for real value of '$\alpha$'

$(2-n)^2 - 4 \ge 0$

for minimum value $(2-n)^2 - 4 = 0$

$\Rightarrow n = 0$ or $n = 4$

$\Rightarrow n = 4 \quad [\because n \ne 0]$

72. (20)

**(20)** in series current $i_1$ will be $i_1 = \frac{20}{10+10n} = \frac{2}{1+n}$

Current in parallel will be $i_2 = \frac{20}{\frac{10}{n}+10} = \frac{2}{1+n}$

$$\frac{i_2}{i_1} = 20 \Rightarrow \frac{\left(\frac{2n}{1+n}\right)}{\left(\frac{2}{1+n}\right)} = 20 \Rightarrow n = 20$$

73. (15)

**(15)** Here, $I = \frac{E}{R+r}$ $\therefore$ Terminal voltage $V = IR = \frac{ER}{R+r}$

When potential difference, V = 1.25V and $R_L = 5\Omega$, then

$$1.25 = \frac{E(5)}{5+r} \quad ...(i)$$

when potential difference V = 1 V and $R_L = 2\Omega$ then

$$l = \frac{E(2)}{2+r} \quad ...(ii)$$

From eq. (i) and (ii)

we get $E = \frac{3}{2} = \frac{15}{10}$ $\therefore$ value of x = 15

74. (4)

**(4)** First case $P_1 = \frac{V^2}{R} = \frac{(240)^2}{36}$

Second case $P_2 = \frac{V^2}{R/2} \times 2 = \frac{4v^2}{R} = \frac{4 \times (240)^2}{36}$

$\therefore \frac{P_1}{P_2} = \frac{1}{4}$ x = 4.00

75. (3840)

**(3840)** Rate of energy dissipated

$$= \frac{192J}{15} = i^2R \Rightarrow 192 = 42 \times R, R = 12\Omega$$

Energy = $i^2 Rt = (8)^2 \times 12 \times 5 = 3840\ J$

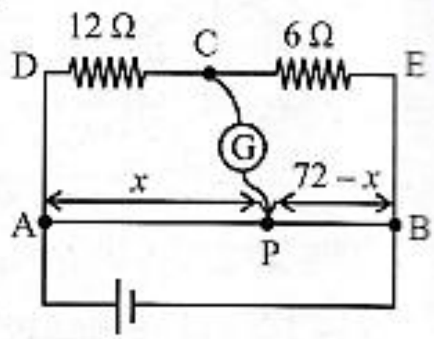
76. (2500)

**(2500)** From, $H = i^2 R\Delta T$

$$10\times10^{-3} = (2\times10^{-3})^2 \times R\times 1 \quad \therefore R = 2500\ \Omega$$

77. (48)

**(48)** In balanced condition,




$$\frac{x}{12} = \frac{72-x}{6}$$

$\Rightarrow x = 2(72 - x)$

or, $3x = 144$

$\therefore \quad x = \frac{144}{3} = 48$ cm

78. (144)

**(144)** We have

$R$ = slope of $I - V$ curve = tan 45° = 1

$$\text{As, } R = \frac{\rho l}{A} \Rightarrow \rho = \frac{RA}{l} = \frac{1\times\pi\times(1.2\times10^{-2})^2}{31.4\times10^{-2}}$$

$$= 144\times10^{-3}\ \Omega\text{cm}$$

79. (48)

**(48)** I = J A

$$= 4\times10^6\left[\pi R^2 - \pi\left(\frac{R}{2}\right)^2\right] = 4\pi\times10^6\left[\frac{3R^2}{4}\right]$$

$$= \pi\times10^6\times3\times16\times10^{-6} = 48\ \pi\ \text{A}$$

80. (300)

**(300)** If length is increased by $n$ times then, resistance increased by $n^2$ times

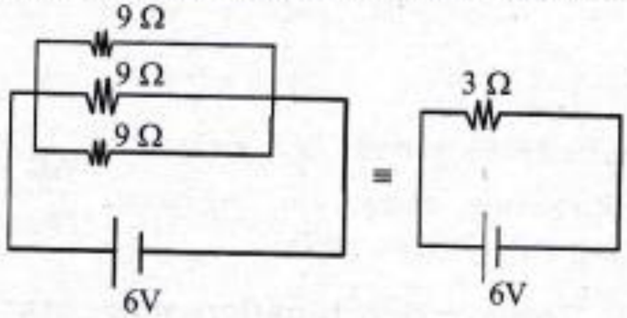
So, $R_f = 4R_i$

$\Delta R = R_f - R_i = 3R_i$

$$\%\ \Delta R = \frac{3R_i}{R_2}\times100 = 300\%$$

81. (2)

**(2)** Equivalent circuit of the above circuit is as shown below




$I = \frac{6}{3} = 2\text{A}$

82. (10)

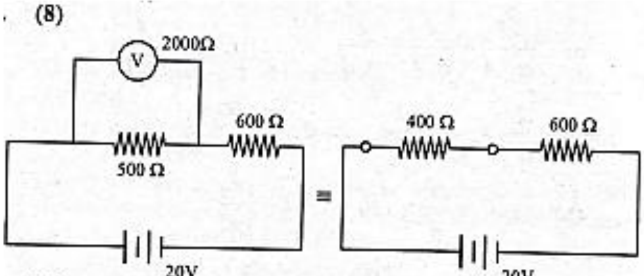
We have $i = \frac{15}{1+2} = 5\,\text{A}$

And, $V_A = V_B = -15 + iR = -15 + 5 \times 1 = -10\,\text{V}$

So, $V_B - V_A = 10\,\text{V}$ .

83. (8)

**(8)**




Voltage measured by voltmeter

= voltage across 400Ω

$= \frac{400}{400+600} \times 20 = 8\text{V}$

84. (4)

**(4)** $E_{eq} = \dfrac{\frac{E_1}{r_1} + \frac{E_2}{r_2} + \frac{E_3}{r_3}}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}} = \dfrac{\frac{2}{1} + \frac{4}{1} + \frac{4}{1}}{\frac{1}{1} + \frac{1}{1} + \frac{1}{1}} = \frac{12}{3}\,\text{V}$

$r_{eq} = \frac{1}{3}\,\text{k}\Omega$

So, $V_o = E_{eq} - i r_{eq} = \frac{12}{3} - 0 \times \frac{1}{3} = 4\text{ V}$

85. (14)

For Bulb 1

$$R_1 = \frac{V^2}{P} = \frac{220^2}{100} = 484$$

For Bulb 2

$$R_2 = \frac{V^2}{P} = \frac{220^2}{60} = 484\left(\frac{10}{6}\right)$$

$$I = \frac{220}{484 + 484 \times \frac{10}{6}} \qquad \left[\because I = \frac{E}{R_1 + R_2}\right]$$

$P_1 = I^2R_1 = 14.06$ W

86. (15)

**(15)** Thermal energy, $H = \frac{V^2}{R}t$

So, $H = \frac{V^2}{R_1} \times 20$ ...(i)

$H = \frac{V^2}{R_2} \times 60$ ...(ii)

Dividing (ii) by (i), we get

$1 = \frac{R_2}{R_1} \times \frac{1}{3} \Rightarrow R_2 = 3R_1$

Now, as $H = \frac{V^2}{R_{eq}} \times t \Rightarrow \frac{V^2}{R_1} \times 20 = \frac{V^2 \times t}{R_{eq}}$ [from (i)]

$\Rightarrow \frac{20}{R_1} = \frac{t}{\frac{3R_1}{4}}$ $\left[\because R_{eq} = \frac{R_1 . 3R_1}{R_1 + 3R_1}\right]$

$\Rightarrow t = 15$ minutes

87. (975)

**(975)** As, $P = Vi$

$\Rightarrow 5 = 25i \Rightarrow i = 0.2A$

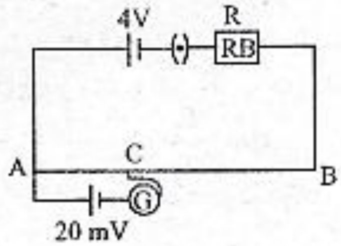
Now, $i = \frac{V_R}{R} \Rightarrow 0.2 = \frac{220 - 25}{R}$

$R = \frac{195}{0.2} = 975\,\Omega$

88. (780)

**(780)** Given null point for cell is, AC = 60 cm and AB = 300 cm

$$E = \frac{AC}{AB}(V_A - V_B)$$



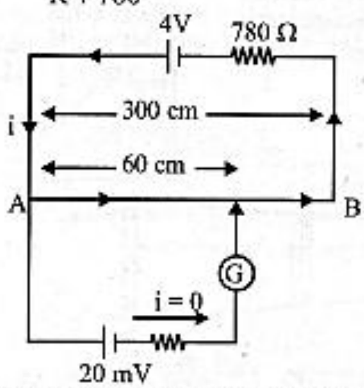

$$\therefore \quad 20 \times 10^{-3} = \frac{60}{300} \times \frac{4 \times 20}{R + 20}$$

$\therefore \quad R = 780\ \Omega$

89. (20)

**(20)** Let resistance of potentiometers wire is R.
The current in the circuit,

$$i = \frac{4}{R + 780}$$




Potential difference across AB, $V_{AB} = iR$

$$= \frac{4}{R + 780}$$

Potential difference across AC, $V_{AC} = iR$

$$= \frac{4R \times 60}{(R + 780) \times 300} = \frac{4R}{5(R + 780)}$$

This should be equal to 20 mV.

$$\frac{4R}{5(R + 780)} = 20 \times 10^{-3} \Rightarrow 4R = 5 \times 20 \times 10^{-3}(R + 780)$$

$$\Rightarrow \quad 40\,R = R + 780 \Rightarrow 39\,R = 780$$

$$R = \frac{780}{39} = 20\ \Omega$$

90. (54)

**(54)** As, E = K$\ell$

1.2 = (Potential Gradient) × 36

1.8 = (Potential Gradient) × x

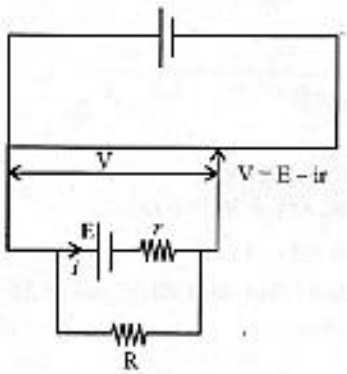
On dividing, we get

$$\frac{2}{3} = \frac{36}{x} \Rightarrow x = 18 \times 3 = 54 \text{ cm}$$

91. (8)

**(8)** We have

$$\frac{V_1}{V_2} = \frac{K \times 3}{K \times 2} = \frac{3}{2}$$




Also, $\frac{V_1}{V_2} = \frac{E - i_1 r_1}{E - i_2 r_2} = \frac{E - \frac{E}{8+r} \times r}{E - \frac{E}{4+r} \times r}$

$$\frac{V_1}{V_2} = \frac{8(4+r)}{4(8+r)}$$

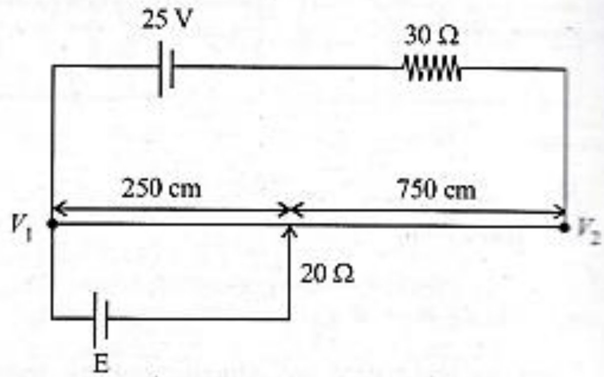
From (i) & (ii), we get

$$\frac{3}{2} = \frac{8}{4}\left(\frac{4+r}{8+r}\right) \Rightarrow \frac{3}{4} = \frac{4+r}{8+r}$$

$$\Rightarrow 24 + 3r = 16 + 4r \Rightarrow 8 = r \Rightarrow r = 8\Omega$$

92. (25)

**(25)** Current $i = \frac{25V}{(30+20)\Omega}$




$\Rightarrow i = 0.5A$

So, $v_1 - v_2 = 20i = 20 \times 0.5 = 10\ v$

$E$ = Potential gradient $\times$ 250 $= \frac{10}{1000} \times 250$

$= 2.5\ V = \frac{25}{10} V$

Solutions to "In-chapter Excercises" Learners Chemistry

Questions based on 'concepts learned so far'

**Sol^n : 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]

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

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

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

~~Sol^n 2~~

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

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

~~$S = 1m$~~

~~$time = \frac{1}{10^{-3}} = 10^3\ sec$~~

~~distance travelled = speed × time~~

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

~~so required distance = $10^6 \times 10^3\ m = 10^9\ m$~~

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

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

**Sol^n : 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)

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

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

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

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

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

$\underline{\text{Sol}^n\ 5:}$

change in resistance is small

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

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

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

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

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

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

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

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

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

$\boxed{i = 5A}$

$\underline{\text{Sol}^n\ 8:}$ $\cancel{R_{eq}}$ $\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$ [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 $2\,\Omega$ Resistor $= 30V$

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

—"— —"— $3\,\Omega$ resistor $= \frac{30}{3} = 10A$

—"— —"— $6\,\Omega$ resistor $= \frac{30}{6} = 5A$

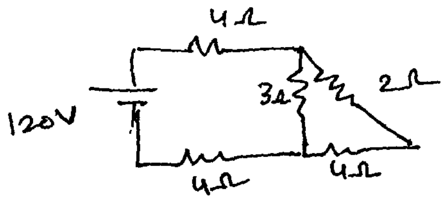
Sol$^n$ 9: $R_{eq} = 1 + 1 = 2\Omega$

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

Sol$^n$ 10:

$2\Omega$, $1\Omega$ in series $= 3\Omega$

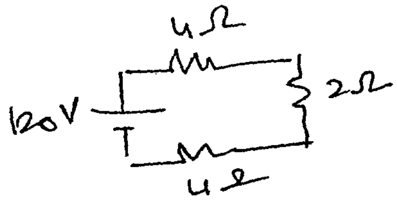
this $3\Omega$, $6\Omega$ are in parallel $\Rightarrow \frac{3\times 6}{3+6} = 2\Omega$



Now $2\Omega$, $4\Omega$ in series $= 6\Omega$

$6\Omega$ in parallel with $3\Omega$

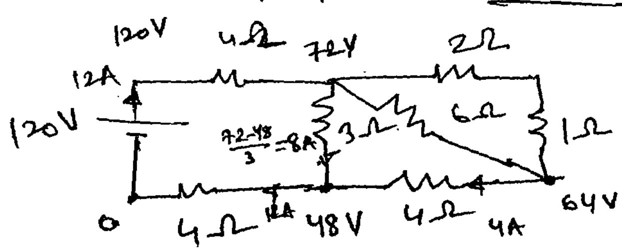
$= 2\Omega$



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

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

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



hence current through $6\Omega$

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

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

so remaining current will pass through $2\Omega$ hence current in $2\Omega$

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

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

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

Sol$^n$ 11:

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

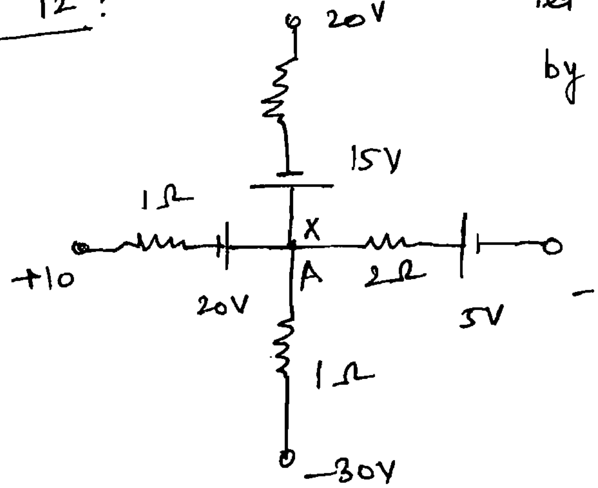
Since Resistance depends only on material hence It is consta for bulb.

(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

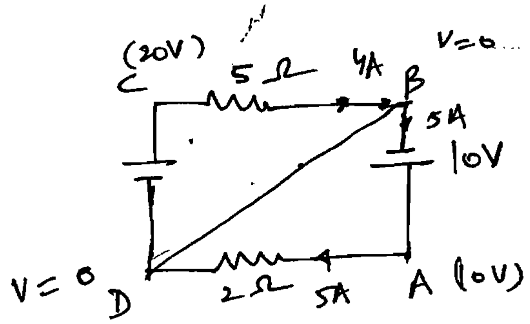
$$\frac{x-20-10}{1} + \frac{x-15-20}{2} + \frac{x+45}{2} + \frac{x+30}{1} = 0$$

$\Rightarrow 6x + 10 = 0$

$\Rightarrow x = -5/3$

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

Sol$^n$ 13:




let at D potential = 0

hence current in CB

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

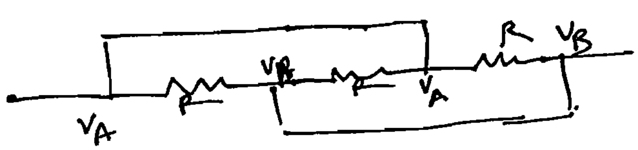
Sol$^n$ 14: $R_1 = \frac{(200)^2}{50}$ $R_2 = \frac{(200)^2}{100}$ $R_3 = \frac{(200)^2}{25}$

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

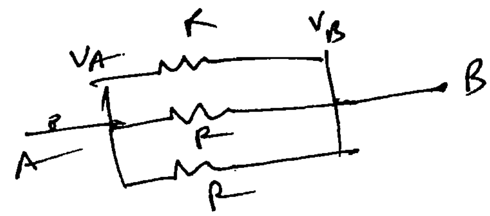
Since higher resistance, will glow more ($\because$ I same)

$B_3$ will glow more.

Sol$^n$ 15:



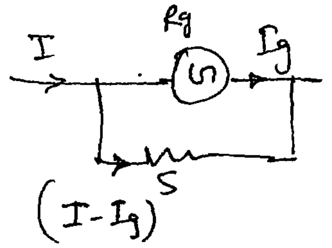

so we can have modified circuit as




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

## Ex-II Questions based on concepts learned so far

1.

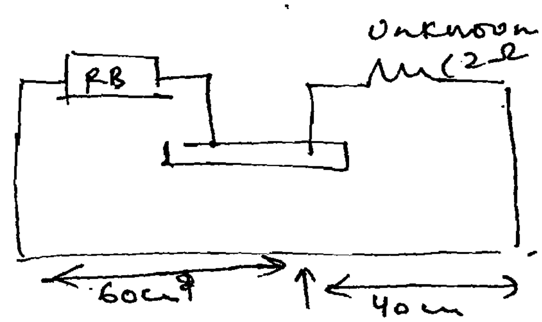



$R_g I_g = (I - I_g)S$

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

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

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)

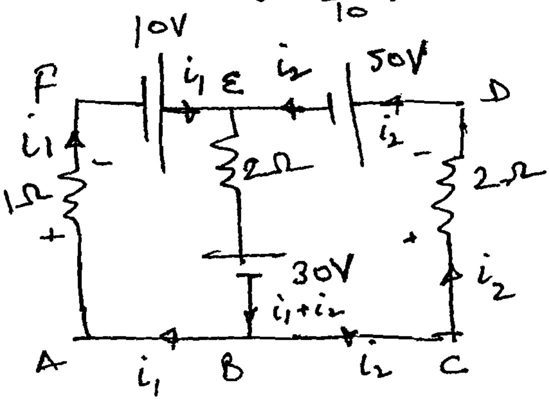
5. (A)

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

$i_1 \cdot 1 \cdot 0 + 2(i_1+i_2) + 30 = 0$

$\boxed{3i_1 + 2i_2 + 20 = 0}$ — (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)

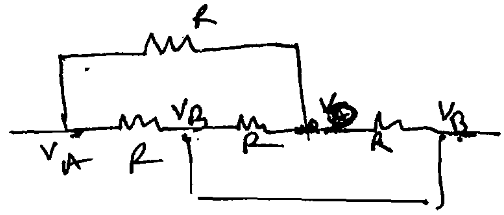
$i_1 = 10\text{A}, \; i_2 = -25\text{A}$

current in wire AF = 10A from A to F

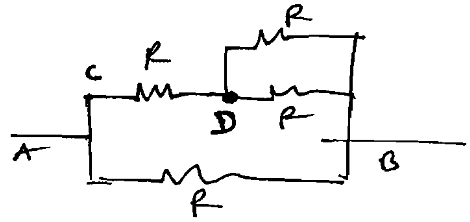
— " — EB = 15A from B to E

— " — DE = 25A from E to D

**Sol^n 8**



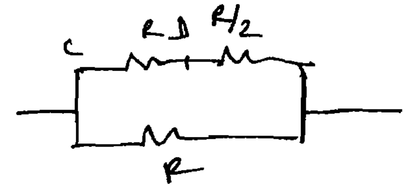

$\equiv$




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

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

$\equiv$




current in CD

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

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

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

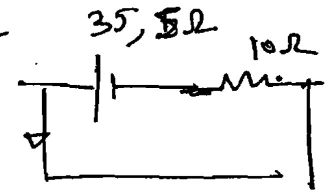
**Ans!**

**Sol^n 9 :**

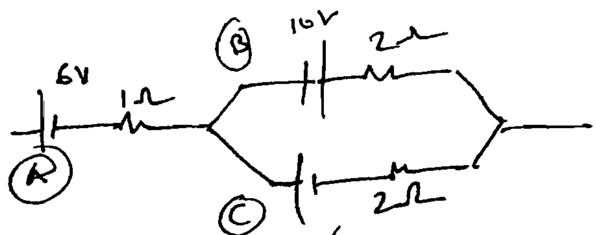
$\mathcal{E}_{eq} = 35\,V$

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

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




**Sol^n 10 :**

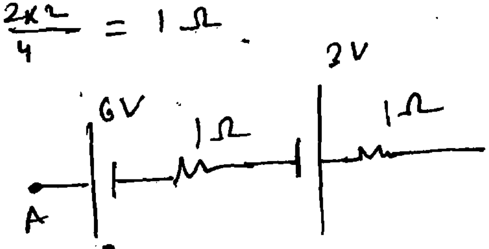



B & C are in parallel with opposite polarity. so

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

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

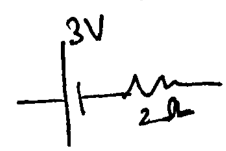
**hence**




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

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

$\equiv$



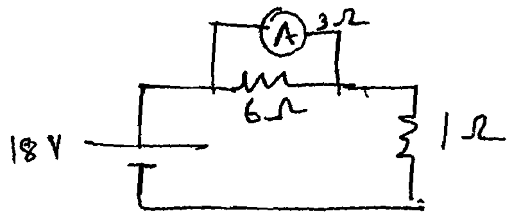

**Sol^n (11)**

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)




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

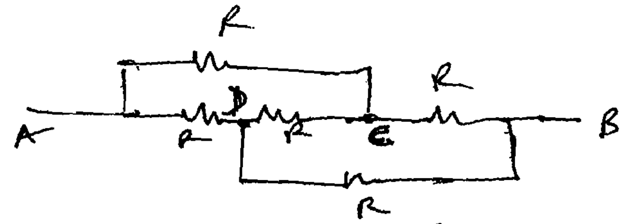
current from battery $= \frac{18}{3} = 6\,A$

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

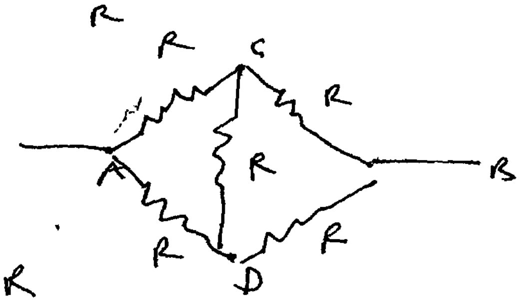
No, its not the current through the $6\,\Omega$ resistor.

[$\because$ Ammeter is not in series with $6\,\Omega$]

(13)

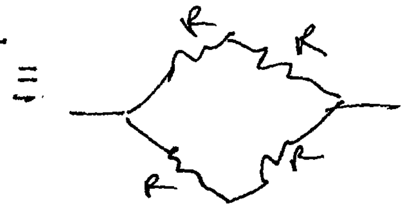



this can be modified




this is balanced Wheatstone bridge

hence




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

(14) balanced wheatstone bridge hence can remove $20\,\Omega$ 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 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

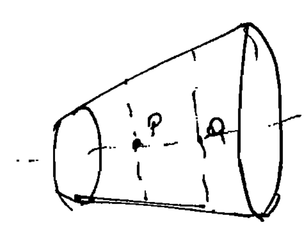
$ne\left(\frac{\pi d^2}{4}\right)V = ne\left(\pi (d/4)^2\right)V'$

$\Rightarrow V' = \frac{16}{4}V = 4V \Rightarrow \boxed{V' = 4V}$ Ans:

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), $A = S$, $e = \nu$

$I = neAV_d$

$I = pqSV_d$

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

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 $\rho_a$ and $\rho_b$ 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 ↑ 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.

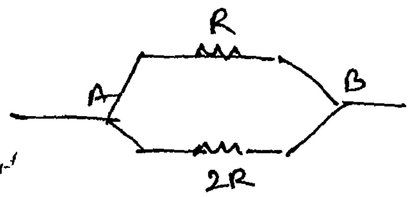
15| $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 \quad r_{eq} = r_1 + r_2$

(hence 1 is correct but 2 is wrong)

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

as $R \downarrow \; P \uparrow$

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) $\varepsilon_{eq}$ 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

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

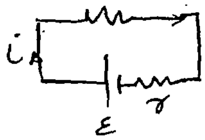
$r_0 = r + r + r \dots N$

$= Nr$

Ans;

21|  for 1 case

Potential difference between the terminals $= 1.6V$




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

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

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

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

by (1) and (2)

$4 + r = 4\varepsilon / 1.6$

$9 + r = 9\varepsilon / 1.8$

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

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

$\Rightarrow 0.2r = 0.2$

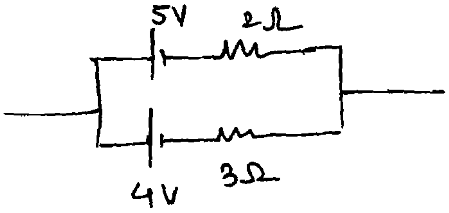
$\Rightarrow \boxed{r = 1}\ \Omega$

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

$\Rightarrow 4\varepsilon = 8$

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

22|




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

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

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

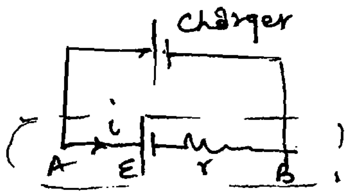
23|

since battery is charging

$\varepsilon + ir = 12.5$

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

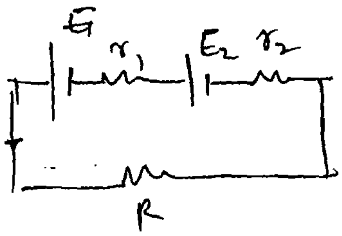
$\Rightarrow \boxed{\varepsilon = 12 \text{ Volt}}$




$V_A - \varepsilon - ir = V_B$

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

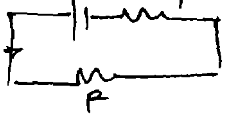
24|




Initially current through R

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

After short circuiting the battery




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

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'.

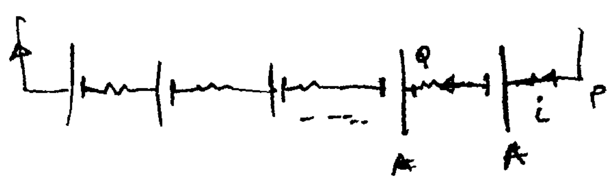
27| Out of 'n' cells two cells having reversed polarity.

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

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

$r_{eq} = nr$

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




Potential drop across A

$= V_P - V_Q$

$= \varepsilon + ir$

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

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

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

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

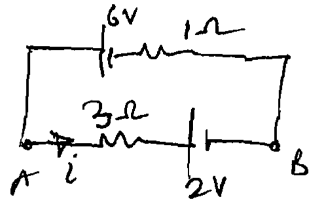
$V_P - \varepsilon - ir = V_Q$

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

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

$r_{eq} = 4\Omega$

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




$V_A - 3 - 2 = V_B$

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

29| Terminal voltage $= \varepsilon - ir$

or can be $\varepsilon + ir$

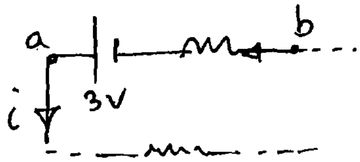
or can be zero If $\varepsilon - ir = 0$

hence can be $> \varepsilon$

can be $< \varepsilon$

can be zero

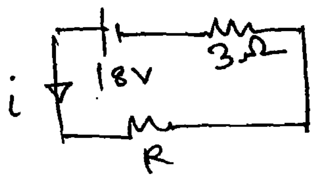
30|




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

$\Rightarrow \boxed{i=3}$

Now The whole circuit can be shown as




[since batteries are in series]

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

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

$\Rightarrow R+3=6$

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

31| $R_T = R_1 + R_2$ —(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 eq$^n$(1) $\quad \Delta R_T = \Delta R_1 + \Delta R_2$

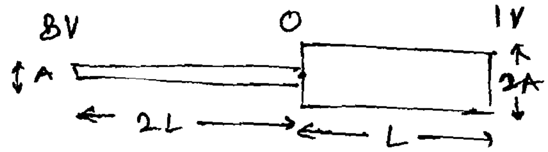
$\Rightarrow \underset{\text{(Given)}}{0} = \frac{(\rho_1 \alpha_1 \Delta T) L_1}{A_1} + \frac{(\rho_2 \alpha_2 \Delta T) L_2}{A_2}$

[$\because$ 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 $= \frac{\rho(L)}{2A}$

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

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

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 ↓ Power ↑

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

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

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

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|

a ~~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.

$P = i^2 R$    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↑ V↑

$P = VI$ hence as I↑ V↑

so as I↑ 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 (for max^m error)

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

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

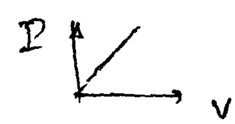
$= \frac{0.4}{10} + \frac{0.2}{2.5} = \frac{12}{100} = 0.12$

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

$\therefore$ $\boxed{T_1 < T_2}$ ($\because$ 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 $x\uparrow$ $(\because P = i^2R)$

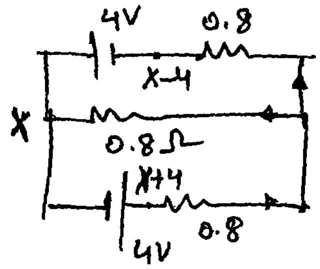
~~hence~~ hence brightness of $x$ increases.

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

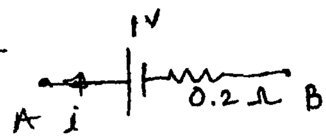
$$\frac{X+4-Y}{0.8} = \frac{Y-X}{0.8} + \frac{Y-(X-4)}{0.8}$$

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

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

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

for a cell



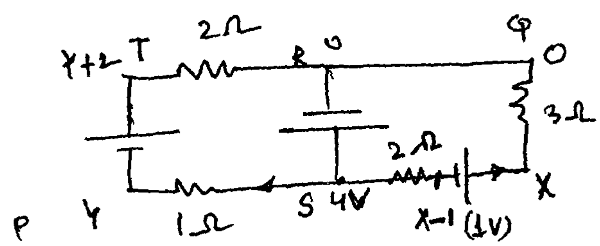

$$V_B - i(0.2) + 1 = V_A$$

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

$$= 0$$

Ans:

**47|**




assign 'Q' as zero volt

for loop PTRS

Using

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

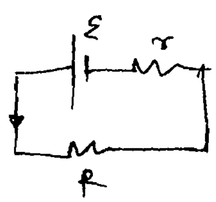
$$\Rightarrow 8 - 2Y = Y + 2$$

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

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

Ans:

**48|**



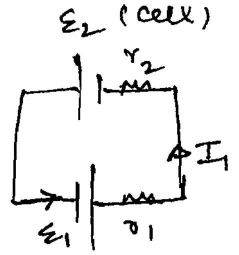

Potential difference $V$ across $R$

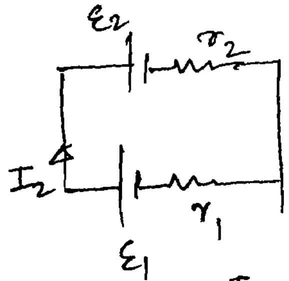
$$= iR$$

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

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

49|




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

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

by (1) and (2)

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

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

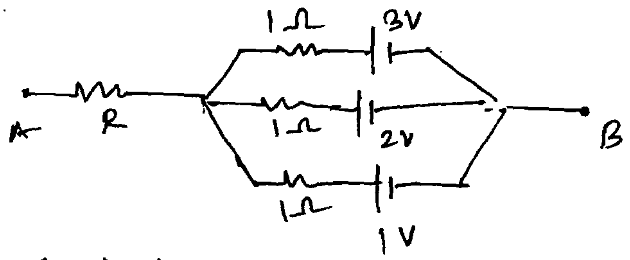
Now by componendo and dividendo

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

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

Ans:

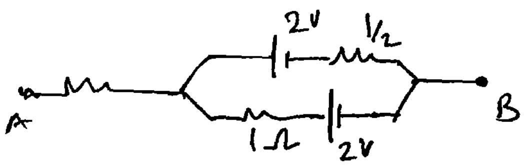
50|




equivalent of 3V and 1 V battery

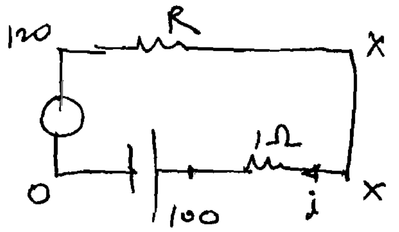
$$\varepsilon_{eq} = \frac{3+1}{2} = 2V, \quad r_{eq} = 1/2$$

hence




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

$$= \frac{i^2R}{\text{Volume}}$$
$$= \frac{i^2 \rho \cancel{l}}{A\cancel{l}\,A}$$
$$= \left(\frac{i}{A}\right)\left(i/A\right)\rho$$
$$= j \cdot j\rho$$
$$= jE$$

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 $= \int j\,ds$

$$= \int_0^{R/2} J_0\left(2x/R - 1\right) 2\pi x\,dx + \int_{R/2}^{R} J_0 \frac{x}{R}\, 2\pi x\,dx$$
$$= \left[2\pi \frac{J_0 x^3}{3R} - \frac{J_0\, 2\pi x^2}{2}\right]_0^{R/2} + \frac{J_0}{R} 2\pi \left[\frac{x^3}{3}\right]_{R/2}^{R}$$
$$= 2\pi\left[\frac{J_0 R^3}{24R}\right] - \frac{J_0\, 2\pi R^2}{8} + \frac{J_0 2\pi}{R}\left[\frac{R^3}{3} - \frac{R^3}{24}\right]$$

**56|** let Resistance of wire is R

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

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

Now for the other wire mass $= 2m$

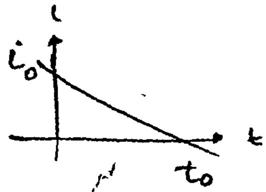
$R' = 2R$

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

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

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

**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

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

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

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

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

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

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

$\because t_0 = \Delta t$

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

**58|** by effective grouping of cells

for max^m current

$mn$ = total no. of cells

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

$\because R = 0$

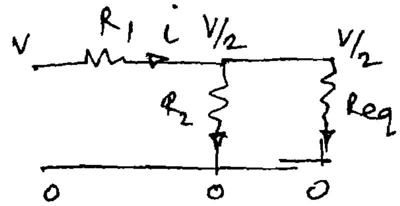
$$I = m\varepsilon$$

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 $R_{eq} = \dfrac{V/2}{R_{eq}} = i/2$

hence current in $R_2$ is also $i/2$

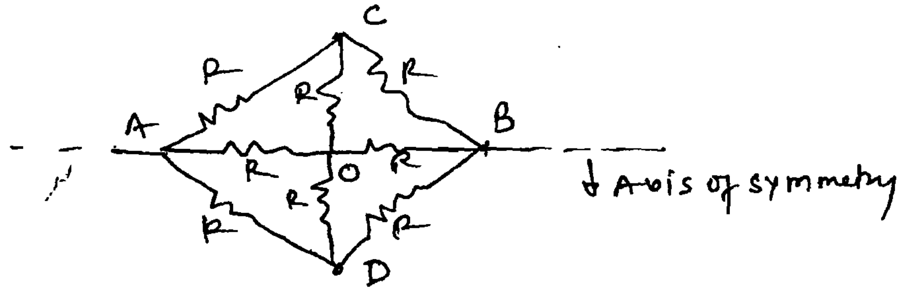
We can write

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

$$V/2 = (i/2)R_2 \quad \text{—(2)}$$

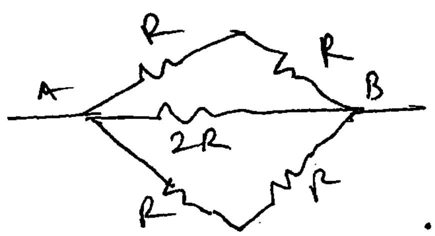
$$\Rightarrow \frac{R_2}{2} = R_1 \Rightarrow \boxed{\frac{R_1}{R_2} = \frac{1}{2}}$$

60 |

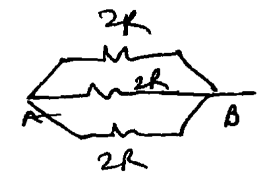



By symmetry ⊥ branches CO and OD will have no current.

Hence simplified circuit is

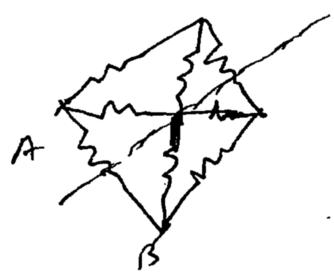



$R_{eq} =$



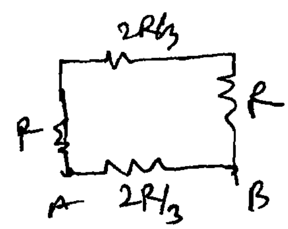

$= 2R/3$ Ans.

61 |

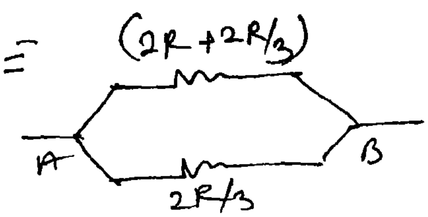



by symmetry


$\equiv$




$\equiv$

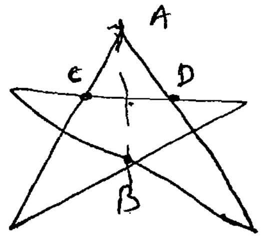



$$\equiv \frac{(8R/3) \times (2R/3)}{8R/3 + 2R/3}$$

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

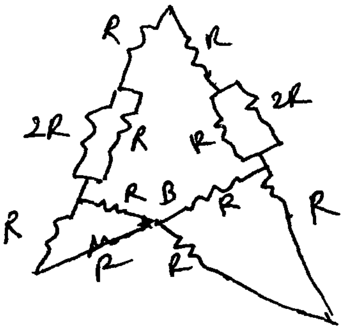
Ans.

62




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

circuit becomes

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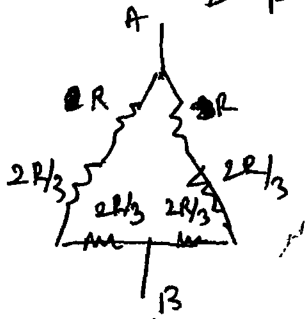


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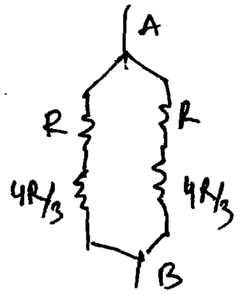


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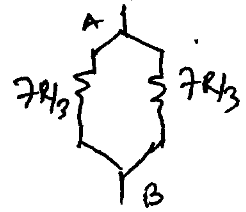
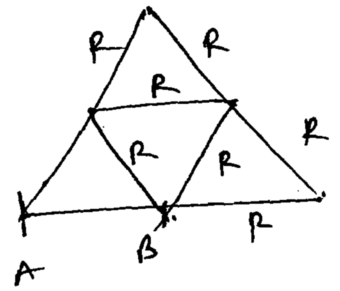



$R_{eq} = 7R/6$

63

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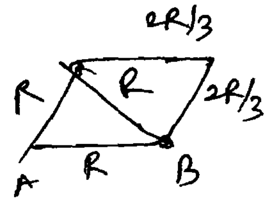


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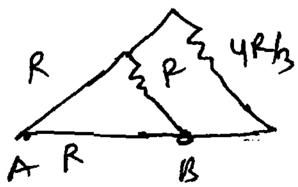


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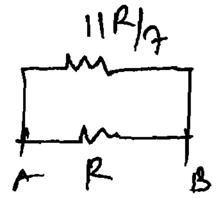
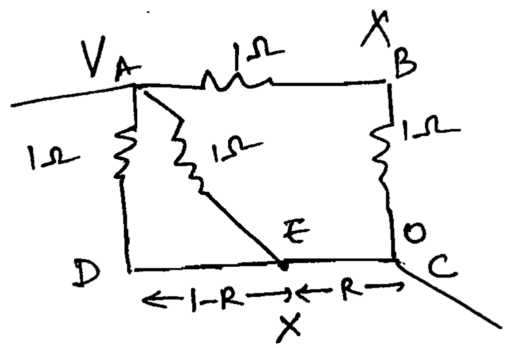



$$\equiv \frac{11R/7 \times R}{11R/7 + R} = \frac{11R}{18} \text{ Ans}$$

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 Ω
then Resist of DX = (1−R) Ω

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

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

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

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

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

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

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

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

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

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 $l_2$

$$l_2 + l(1-x) = 3/2\, l$$

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

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)

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

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

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

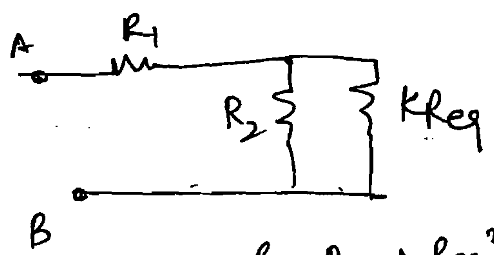
$$\Rightarrow 1 + 4\cancel{x^2} + 4x + 4x - \cancel{4x^2} = 16x$$

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

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

**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)

$$\Rightarrow R_{eq} R_2 + \frac{R_{eq}^2}{2} = R_1 R_2 + \frac{R_1 R_{eq}}{2} + \frac{R_2 R_{eq}}{2}$$

let $R_{eq} = x$

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

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

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

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

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 $V_2 > V_1 > V_3$

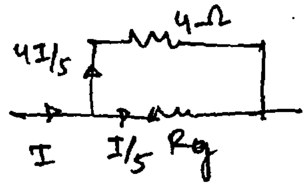
73 | current is same. In parallel, two resistances are equal;

$\therefore\ R_g = 20\,\Omega$

74 |

deflection $\theta$ reduced to one fifth

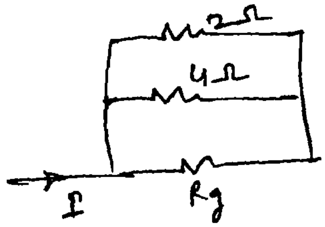
current $I$ in Galvanometer, becomes $I/5$ | '$I \propto \theta$'



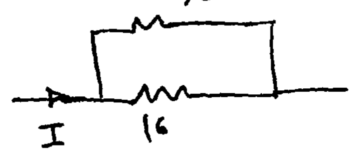

$$\frac{I}{5} R_g = \frac{4I}{5} \times 4$$

$$R_g = 16\,\Omega$$

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 $\theta$ becomes $\theta/13$.

reduction in deflection w.r.t. 'when shunted with $4\Omega$ only'

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

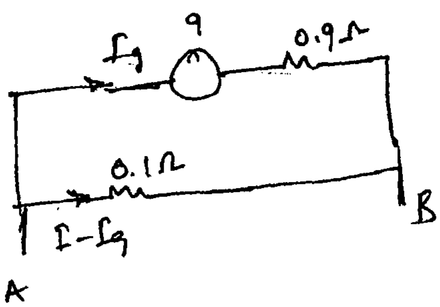
deflection when shunted with $4\,\Omega = \theta/5$

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

$= \dfrac{8}{13}$ of the deflection when shunted with

$4\,\Omega$ 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)

$\Rightarrow R+20 = \frac{1200}{10}$

$\Rightarrow R = 100\,\Omega$

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)

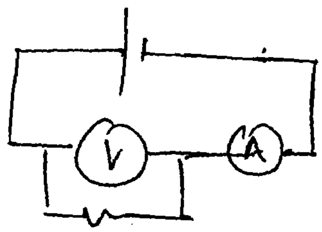
$\Rightarrow \boxed{r = y/x}$ Ans:

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 difference 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 |

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

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

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

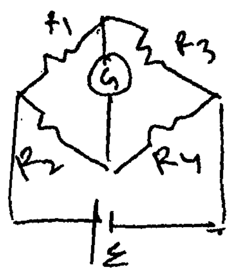
by (1) and (2) $x = 1$

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

$$\frac{R_1}{40} = \frac{R_2}{60} \quad \text{— ①}$$

$$\frac{R_1}{50} = \frac{\frac{10R_2}{10+R_2}}{50} \quad \text{— ②}$$

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 |

$i = \frac{\mathcal{E}}{10r}$

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

$= \frac{9\mathcal{E}}{10}$

potential Gradient $= \frac{9\mathcal{E}}{10L}$

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

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

$\mathcal{E}_{eq}$ 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

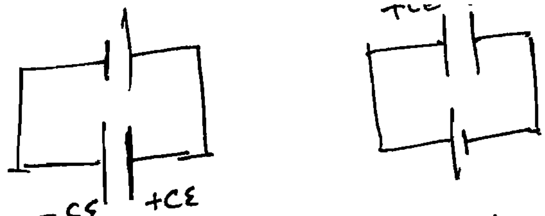
$= 6 - ir$

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

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

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

96




charge flown
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 $= \frac{1}{2}C\varepsilon^2$

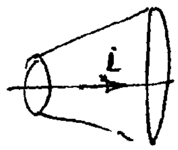
Hence produced = Work done by battery

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.

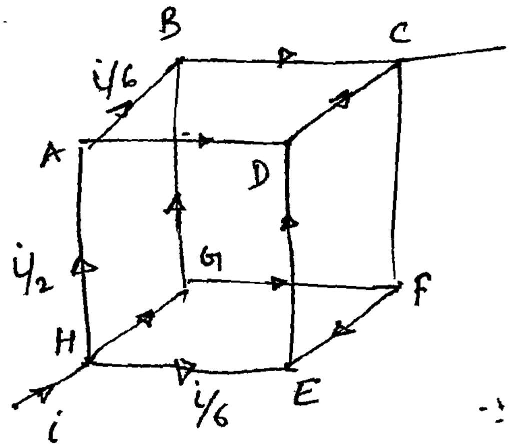



$I = neAV_d$ [Carrier density is const for a metallic conduc

$\because A \uparrow$ so $V_d \downarrow$

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

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

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

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

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

$i_{FE} = i/3 - i/6 = i/6$ (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.

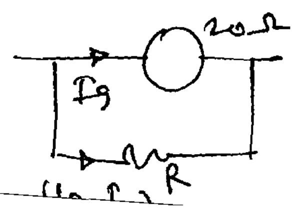
If marked voltage is high, R is high

$\therefore$ 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 ($I_g$)

$$I_g(20) = 0.2$$

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

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.

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

$\therefore R' = R/2$ 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!

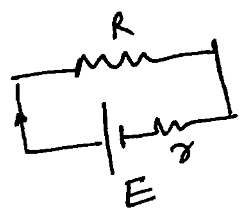
7| this is charging of battery

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

current flows from positive to -ive terminal

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

8|



when current is zero, potential difference across resistor is E

by graph we can find

$E = 10$ Volt

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

$$\Rightarrow \varepsilon = ir$$

$$\Rightarrow 10 = (2)r \qquad [i = 2 \text{ when } V = 0 \text{ by Graph}]$$

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

Ans.

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

9) parallel combination decreases $R_{eq}$

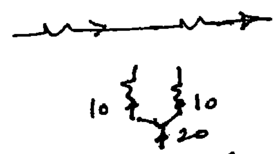
$\therefore \quad R_1 < R$

series combination increases $R_{eq}$

$\therefore \quad R_2 > R$

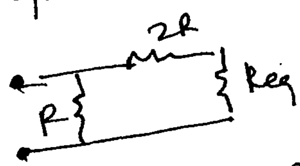
10) Max$^m$ current can go is 10A. [otherwise fuse will melt].

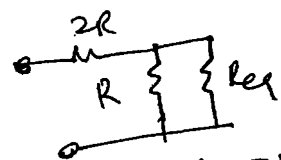
If they are in series
current same the combination
acts as fuse of rating 10A




If they are in parallel 20A 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




$\because R_{eq} = x$

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

$$\Rightarrow x = \frac{(2R + x)R}{3R + x}$$

$$\Rightarrow 2R^2 + xR = 3Rx + x^2$$

$$\Rightarrow x^2 = 2R^2 - 2Rx$$

$$\Rightarrow x^2 + 2Rx - 2R^2 = 0$$

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

$R_{eq} = y$

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

$$\Rightarrow 2Ry + 2R^2 + \cancel{yR} = y^2 + \cancel{yR}$$

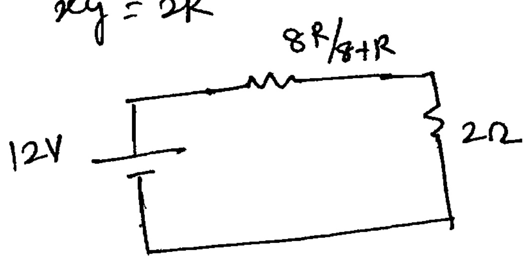
$$\Rightarrow y^2 - 2Ry - 2R^2 = 0$$

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

$$\Rightarrow y = (\sqrt{3} + 1)R$$

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

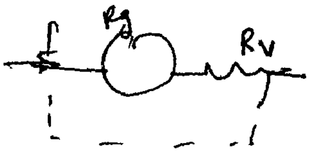
12)




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

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



Voltmeter

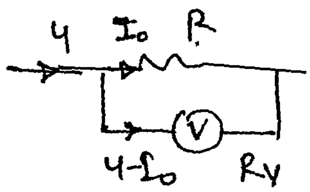
$I$ is same hence more $R_V$, more range of voltmeter.

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|




$$I_0R = (4-I_0)R_V = 20$$

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

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

$$\Rightarrow I_0R = 20$$

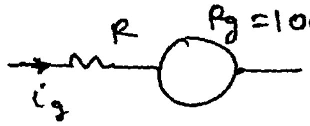
$$\Rightarrow R = \frac{20}{4 - 20/R_V}$$

hence $R$ is greater than $5\Omega$

as $R_V \to \infty$ $\quad R \to 5\Omega$ (min$^n$ possible $R$)

16|

for Voltmeter




$$(100+R)(50\times10^{-6}) = 10V$$

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

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

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

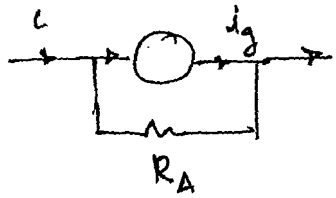
Similarly for 50V range voltmeter

$$(100+R)\times(50\times10^{-6}) = 50V$$

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

For Ammeter

Resistance should be in parallel.




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

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

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

If $i = 5mA$

$R_A = 1\Omega$

<u>Ans.</u>

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 $\varepsilon_1$ and $\varepsilon_2$ or -ive terminals must be joined to one end of potentiometer wire.

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

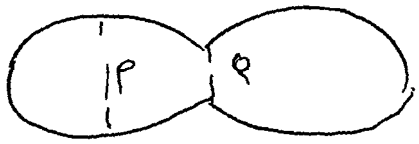
$$= \left(\frac{20}{5+120+75}\right) \times 75 = 7.5V$$

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

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) $j = \sigma E \Rightarrow E = \dfrac{i}{A\sigma}$

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

$\therefore$ 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

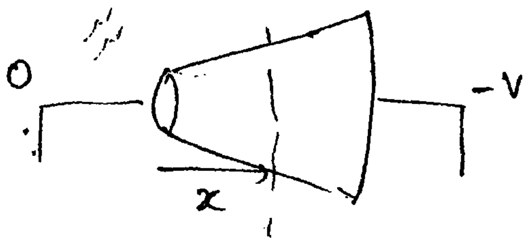
$\cancel{i^2 R}$ $i^2 R_Q$

$\because$ $R_Q = \dfrac{\rho\, dx}{A_Q}$ $\quad R_P = \dfrac{\rho\, dx}{A_P}$

$\because$ $R_Q > R_P$ $\quad [A_Q < A_P]$

$\therefore$ Heat Generated per unit time at Q > Heat generated per unit time at P.

22|




At a distance potential is -ive.

$E = \dfrac{I}{A\sigma}$ $\quad (\because J = \sigma E)$

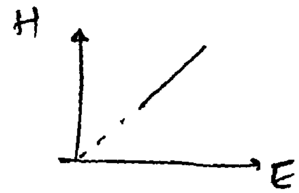
$E = \left| \dfrac{dV}{dx} \right|$

at a distance $x$

$H = (dV)\, i$

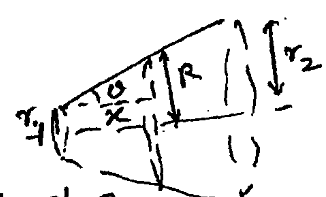
Rate of Generation of Heat per unit length

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




Area a $f^n$ of $x$

$R = x \tan\theta + r_1$

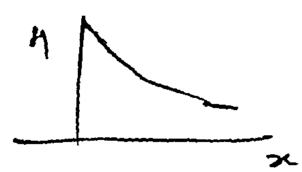



[$\theta$ and $r_1$ const.]

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

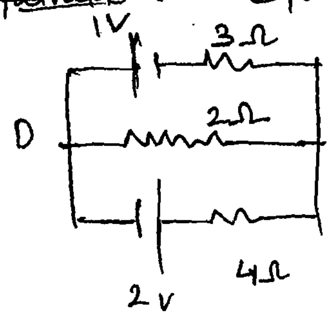
Similarly

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



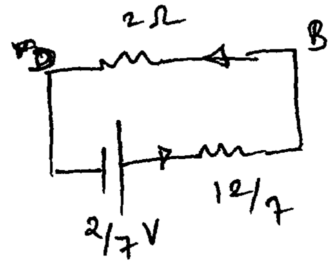
23 | Req ↑ current through battery ↑.
Potential diff remains same. current through R remains same as $i = V/R$, hence the power by R.

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




( figure 1)

≡




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

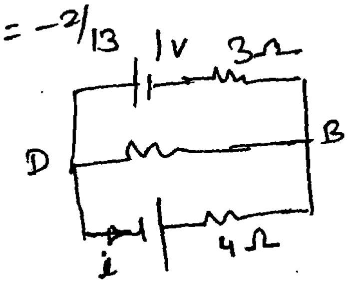
hence $i = \dfrac{2/7}{2 + 12/7} = \dfrac{2}{26} = \dfrac{1}{13}$.

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)



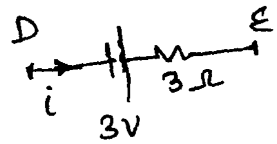

$V_D + 2 - 4i = V_B$

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

$\Rightarrow i = 6/13$

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

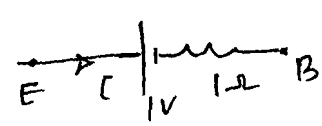
for battery G




$V_D + 3 - 3i = V_E$

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

for battery H



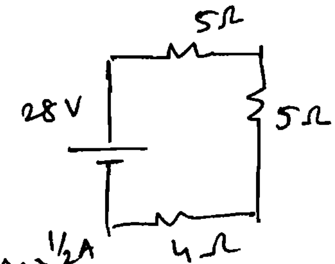

$V_E - 1 - 1(i) = V_B$

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

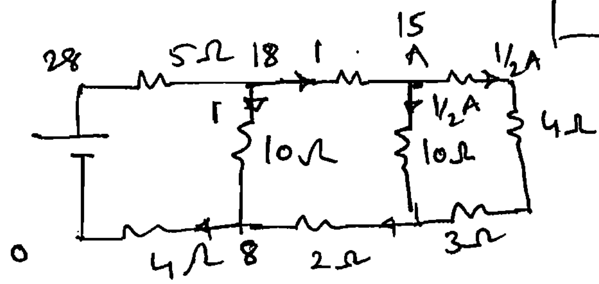
25 |

$R_{eq} = 14\Omega$

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




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 ~~elec~~ 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, ~~[illegible]~~ 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: $\approx 240$ cal/sec.

5. $Q = mL$

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

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

Comprehension-II

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

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

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

$\Rightarrow T^{-n} = \rho K$ ↑ (const. of integration)

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

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

7. $n = -\alpha T = 5\times10^{-4} \times 294 = 0.147$ ~~0.15~~

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

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

Ans.

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

$n = 0.147$

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

$T_2 = 573\,K$

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

$\rho = a T^{-n}$

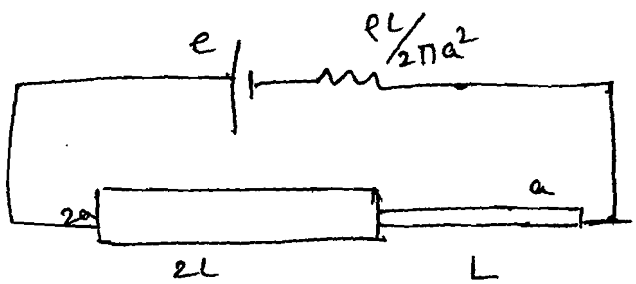
$\rho_1 = (8 \times 10^{-5})(77)^{-0.147}$

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

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

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

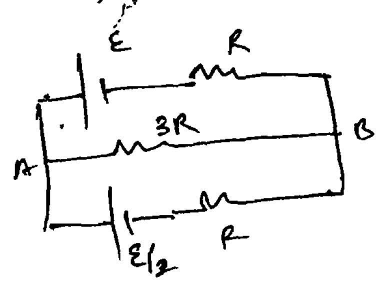
$$\left(\frac{e}{2} - \frac{e}{4}\right) = i\left(\frac{\rho x}{\pi a^2}\right)$$

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

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

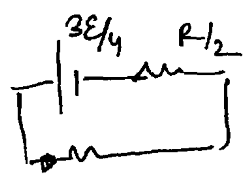
hence balancing length $= 2l + l/2 = 5l/2$ Ans

12.



$$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} = \frac{\varepsilon R + \frac{\varepsilon}{2} R}{2R} = \frac{3\varepsilon}{4}$$

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

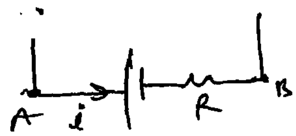


hence current in potentiometer

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

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

current through this cell



$$V_A - \frac{\varepsilon}{2} - iR = V_B$$

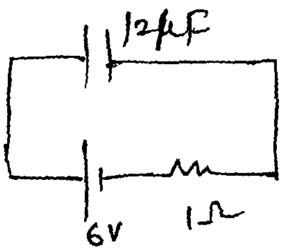
$$\Rightarrow \quad iR = \frac{9\varepsilon}{14} - \frac{\varepsilon}{2}$$

$$= \frac{9\varepsilon - 7\varepsilon}{14} = \frac{2\varepsilon}{14}$$

$$\boxed{i = \frac{\varepsilon}{7R}} \quad \text{where } R = \frac{\rho L}{2\pi a^2} \quad \text{Ans}$$

## Comprehension - IV

13.




$\tau = 12 \times 10^{-6}$

$RC = 12 \times 10^{-6}$

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

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

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

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

Ans

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

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

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

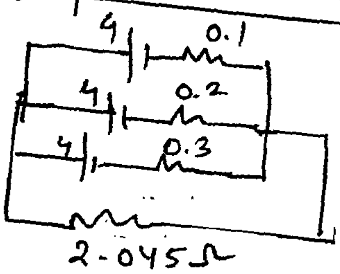
$$\frac{dE}{dt} = \frac{\cancel{2}Q \frac{dq}{dt}}{\cancel{2}C}$$

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

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

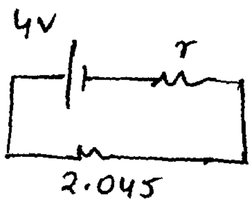
Ans

## Comprehension - V




Equivalent circuit can be represented by

$\equiv$




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

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

$\cancel{= 2.099}$

$= 2.1\ \Omega$

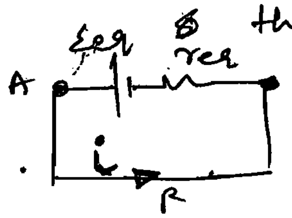
18. Eq voltage as shown $= 4V$ $\quad \because \varepsilon_1 = \varepsilon_2 = \varepsilon_3 = 4V$

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)



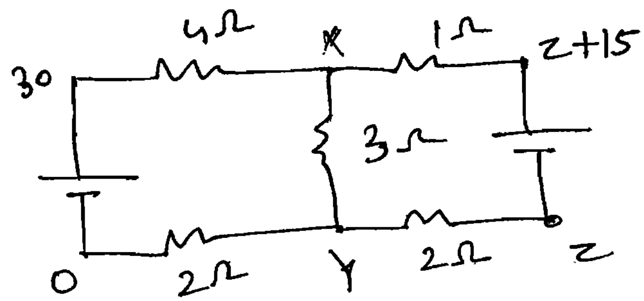

$V_A - V_B = iR$

21. for each cell terminal voltage is same as

$V_A - V_B = 3.8855$

Ans

Comprehension – VI




$\dfrac{30 - x}{4} = \dfrac{x - y}{3} + \dfrac{x - z - 15}{1}$ — ① $\quad 19x - 4y - 12z = 270$

$\dfrac{y - 0}{2} + \dfrac{y - x}{3} = \dfrac{z - y}{2}$ — ② $\quad 3z + 2x - 8y = 0$

$\dfrac{y - z}{2} = \dfrac{z + 15 - x}{1}$ — ③ $\quad 2x + y - 3z = 0$

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 $= \frac{(z+15)-x}{1} = \frac{19-18}{1} = 1A$

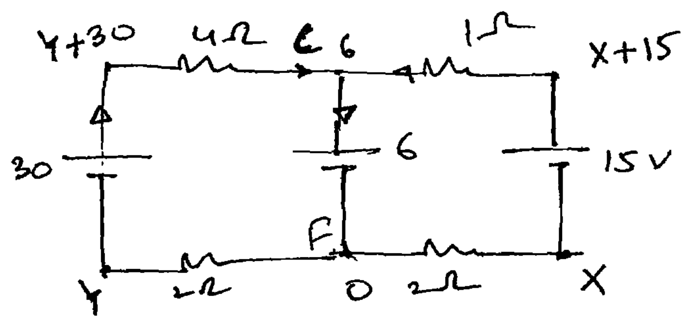
24. from each battery current is leaving hence No one is getting charged.

25. Total electrical power consumed

$$V_1 i_1 + V_2 i_2$$

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

Comprehension - VII




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

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

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

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

current in ~~BC~~ 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.

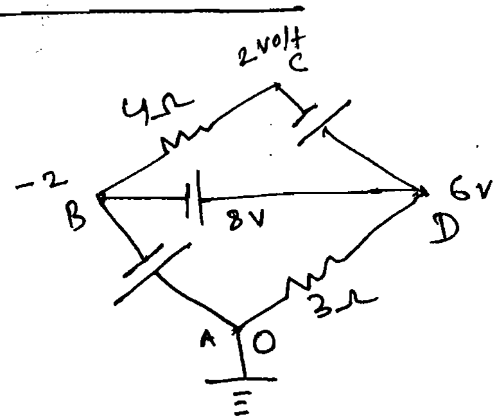
Incorrect statement is (C)

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 3 Ω resistor $= \frac{6-0}{3} = 2A$ from D to A.

(c) current through 4 Ω 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 $4\Omega$ is $I$ then current in $6\Omega$ will be

$I/3$ and in $3\Omega$ be $2I/3$.

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

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

$\Rightarrow 12 : 2 : 4$

$\Rightarrow 6 : 1 : 2$

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

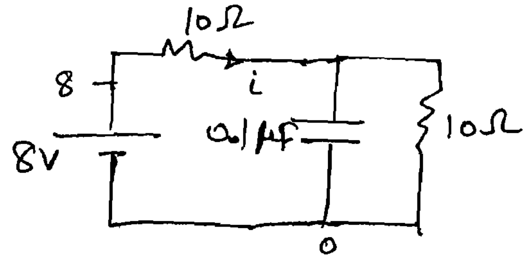
$\therefore$ (a) Heat generated across $4\Omega = 120$ J

(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.

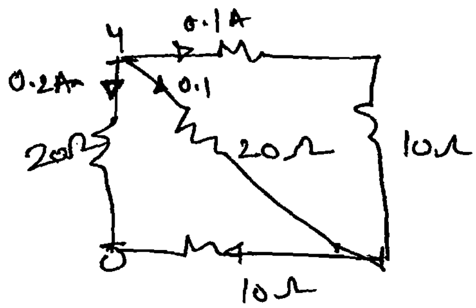
$$i = \frac{8}{20} = 0.4 \text{ A}$$

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)

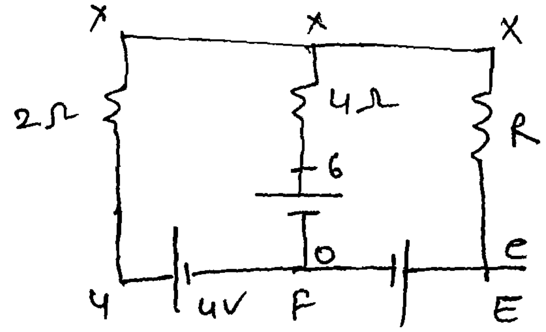
(C) current in AB Branch

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

(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)

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

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

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

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

by (1)

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

$$\Rightarrow 8R - 2Rx = Rx - 6R + 4x - 4e$$

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

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

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

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

$$\Rightarrow e < 6 + R$$

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

hence $\qquad e = 6V$

(a), (b), (c) $\qquad$ or $e > 6V$

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 $2\Omega$ will be from B to A

If $x > 4$

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

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

$\Rightarrow 4e > 16 - 2R$

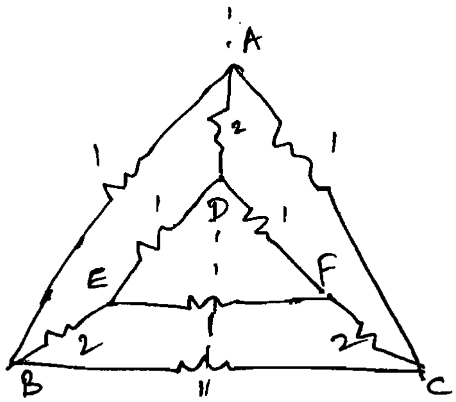
$\Rightarrow e > 4 - R/2$

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

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

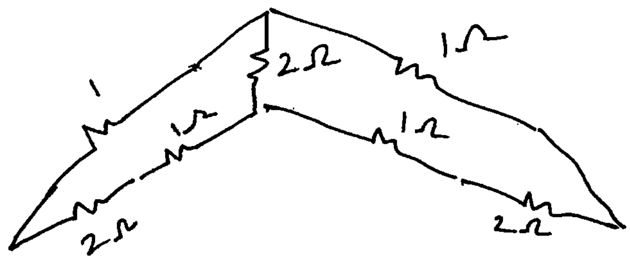
Ex – IV  Solutions

1)




by symmetry, No current in resistor EF and BC

Equivalent circuit can be represented by

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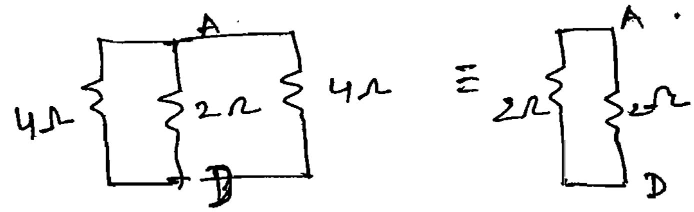
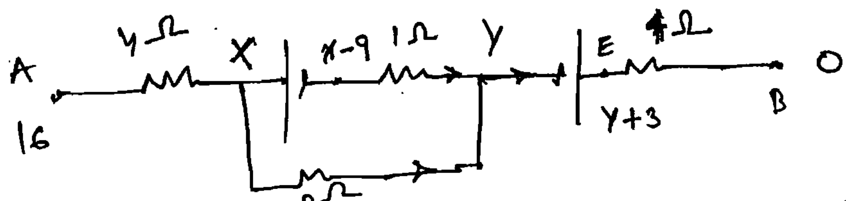



⇒ $R_{eq} = 1\Omega$ Ans

2)




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

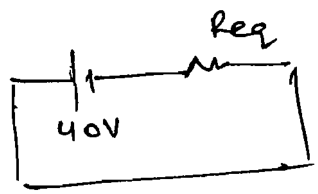
Similarly $\dfrac{x-9-y}{1} + \dfrac{x-y}{2} = \dfrac{(y+3)-0}{4}$ —(2) [at junction 'x']

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

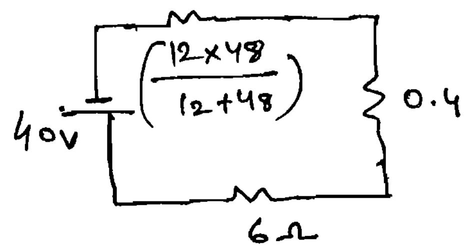
$\therefore \; x=10, \; y=3$

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

3| equivalent circuit for current



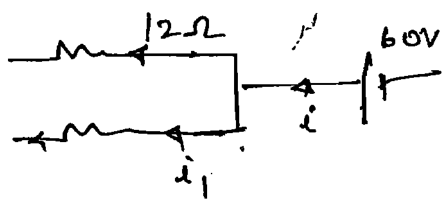

for Req




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

$$R_{eq} = 6 + \frac{48}{5} + \frac{4}{10}$$
$$= 16\,\Omega$$

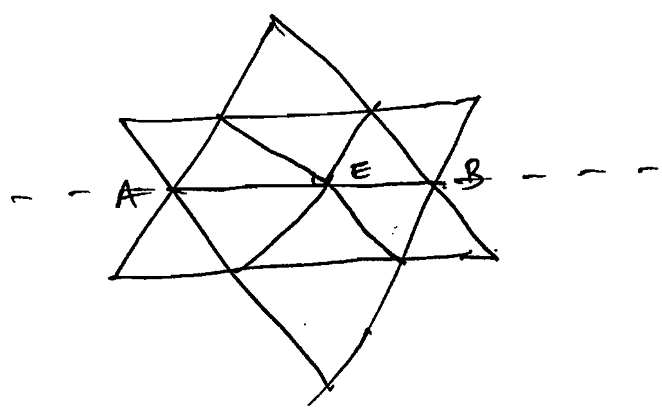
Now for voltmeter reading current through 7Ω resistor



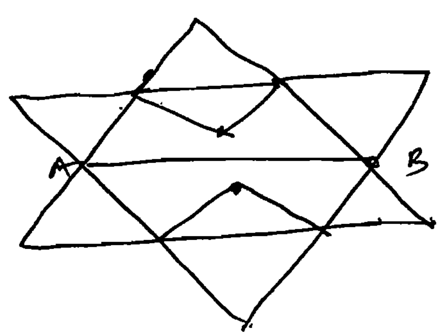

$$i_1 = \left(\frac{12}{48+12}\right)i = \frac{i}{5}$$

$$\therefore V = (i/5)7 = \frac{5}{2}\times\frac{1}{5}\times7 = 3.5 \text{ Volt} \quad \underline{\text{Ans:}}$$

4|




by symmetry we can disconnect the junction E as shown

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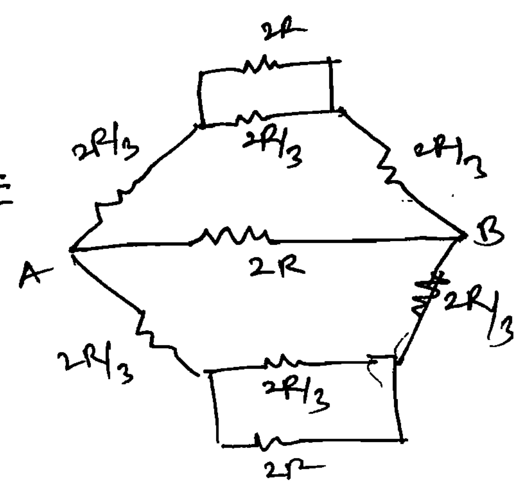

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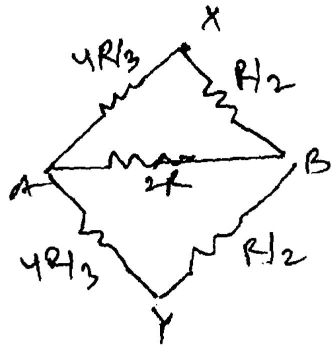
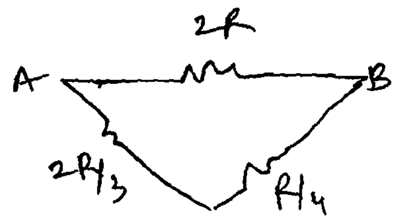



by symmetry again point X and Y are at same potential hence by folding.

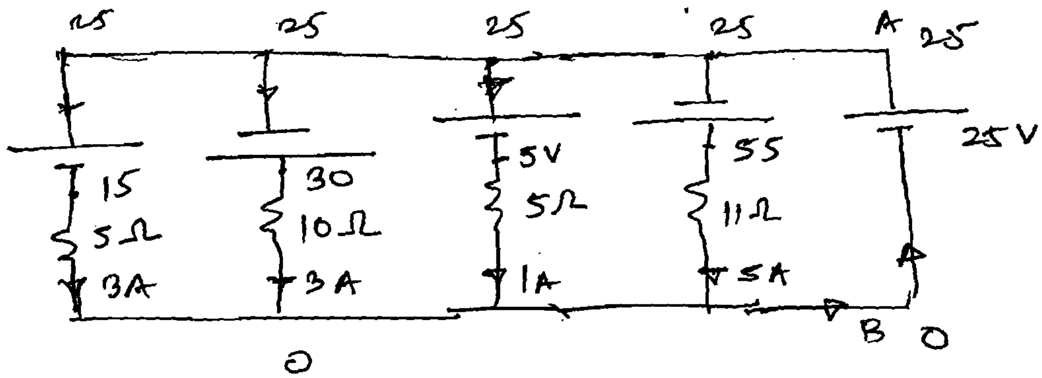
≡




≡


$\because R = 1\,\Omega$ $\quad R_{eq} = \dfrac{2 \times \frac{11}{12}}{2 + \frac{11}{12}} = \dfrac{22}{35}\,\Omega$ Ans.

5|




~~~~ 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

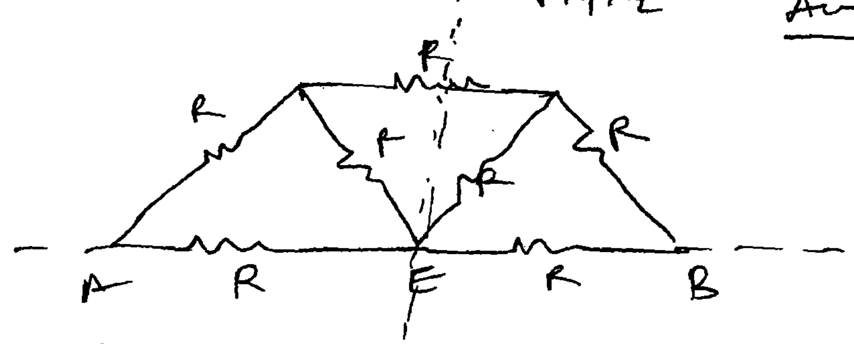
$$\Rightarrow \frac{R_1+R_2+2r}{R_2-R_1} = \frac{\sqrt{R_2}+\sqrt{R_1}}{\sqrt{R_2}-\sqrt{R_1}}$$

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

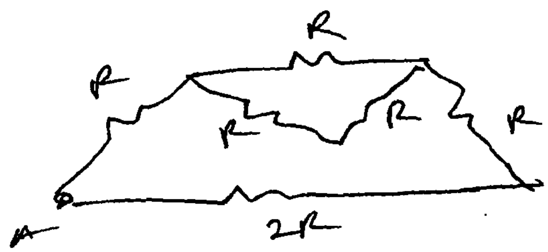
$$\Rightarrow \cancel{2}r = \cancel{2}\sqrt{R_1R_2}$$

$$\Rightarrow r = \sqrt{R_1R_2}$$ Ans

7|




by symmetry we can disconnect junction as shown

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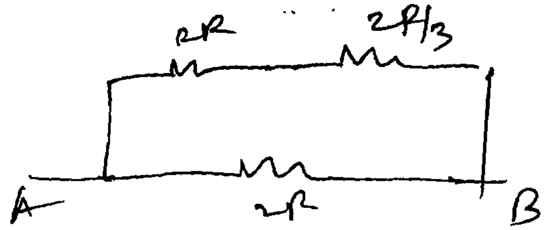


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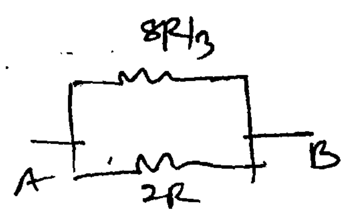
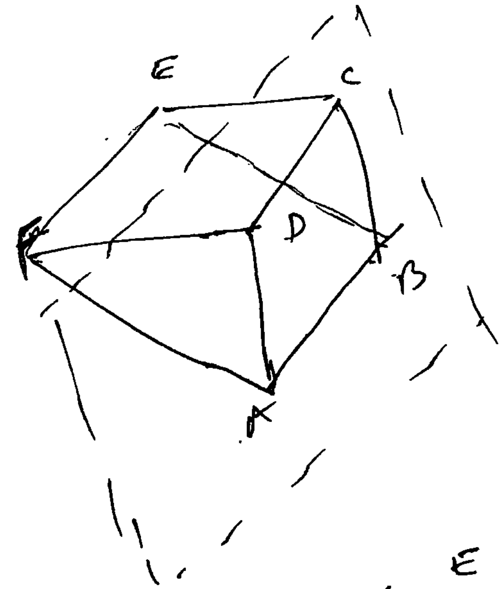



$$R_{eq} = \frac{(8R/3)\times 2R}{(\frac{8}{3}+2)R} = \frac{16/3\, R}{\ldots} = \frac{8}{\ldots} R$$

8

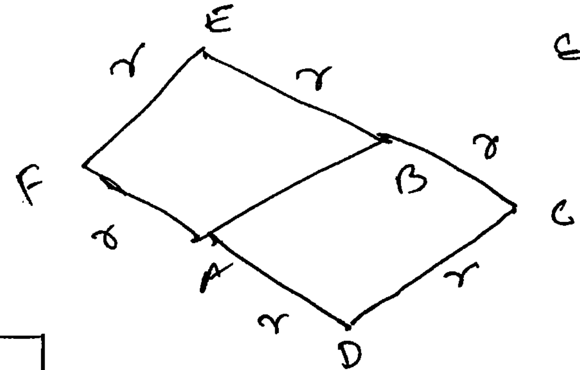



by plane of symmetry we can say current through EC and FD is zero

hence ~~can~~ can remove EC and DF resistors.

Equivalent circuit can be shown as

≡

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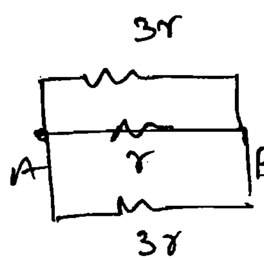


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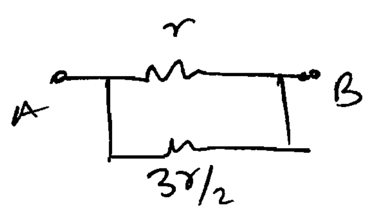
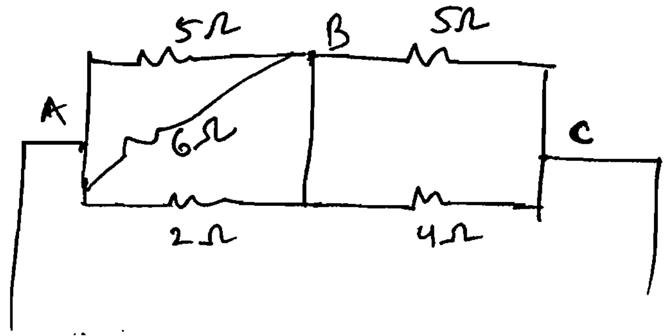



$$R_{eq} = \frac{\left(\frac{3r}{2}\right) r}{\frac{3r}{2} + r} = \frac{3r}{5}$$ Ans

9




across BC

potential drop is same

hence $P = V^2/R$

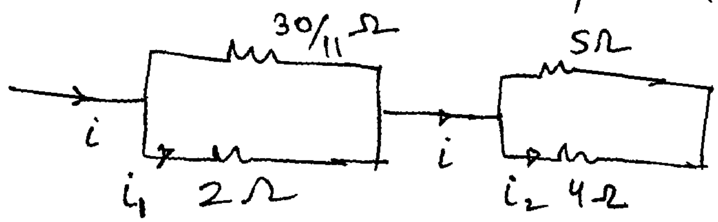
4Ω will produce more power.

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 $= \left(\frac{15i}{26}\right)^2 \times 2t$

$= 0.665\, i^2 t$

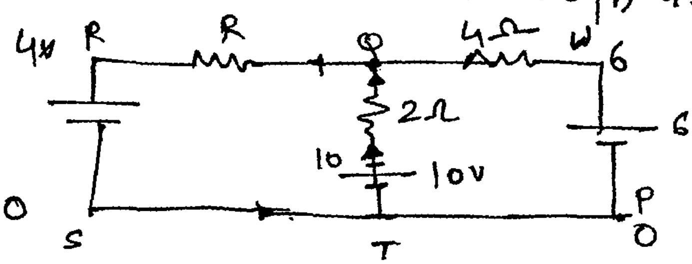
Heat produced in 4Ω ($H_2$) $= \left(\frac{15}{27} i\right)^2 \times 4t$

$= 1.23\, i^2 t$

$\therefore H_2 > H_1$

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 = 6 V

$V_Q$ = 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

$\Rightarrow$ $\underline{R = 1\,\Omega}$ 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 $50\Omega$ ∵ It is short-circuited]

∵ Reading of Ammeter is same

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

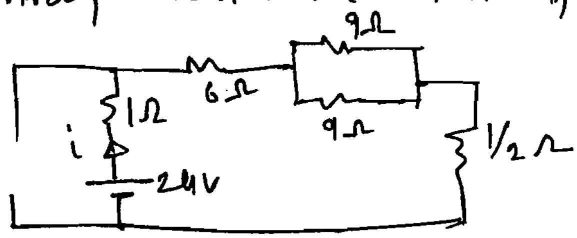
$$\Rightarrow \frac{1}{450} = \frac{R}{300(R+100) + 100R}$$

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

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

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 Amp.

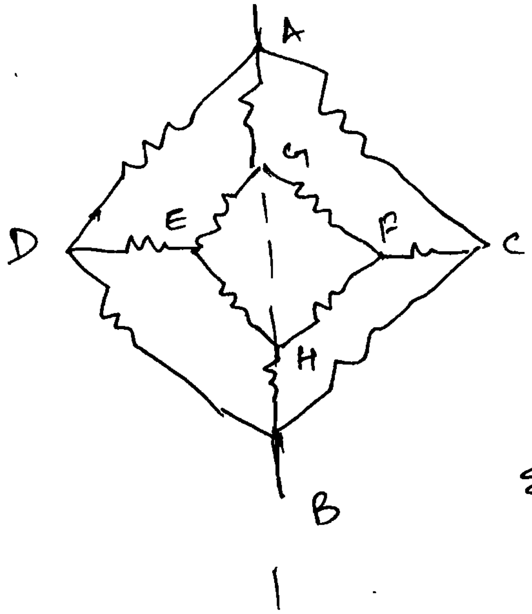
[current 2A will be divided equally in two resistors ∵ both resistors are same]

$\therefore V_{AB} = iR$

$= (1)(1\Omega) = 1\,\text{Volt}$

Ans

131

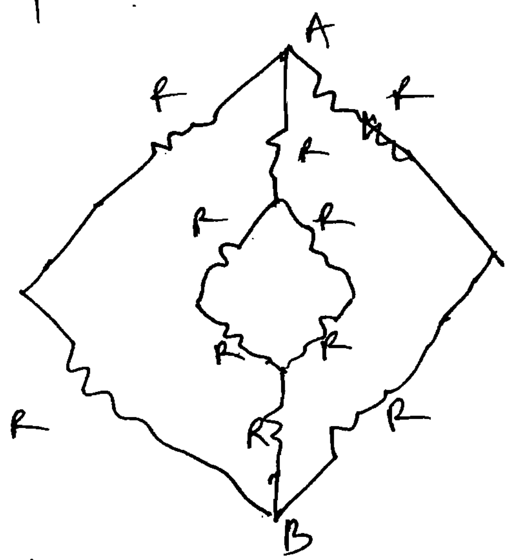



by symmetry

branches DE and CF will have no current.

hence can remove these resistance.

Equivalent circuit is given below

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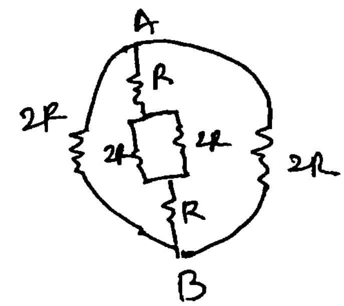


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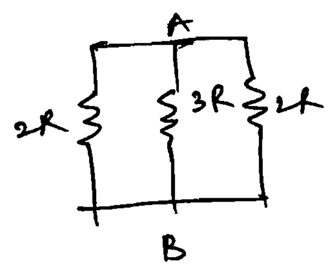


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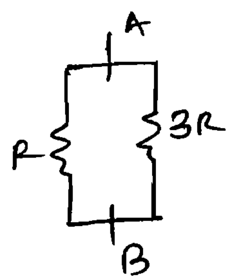



$$R_{eq} = \frac{3R^2}{3R+R}$$

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

$\because R = 12\,\Omega$

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

Ans:

14|

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

$\varepsilon_{eq}$ (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

$\frac{14}{6} = (5) x$

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

$= 46.666$ cm

$= 46.67$ cm Ans

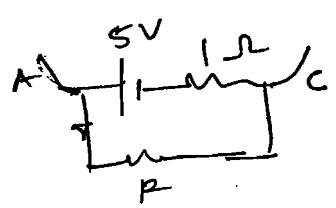
15|

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 $= \varepsilon - ir$

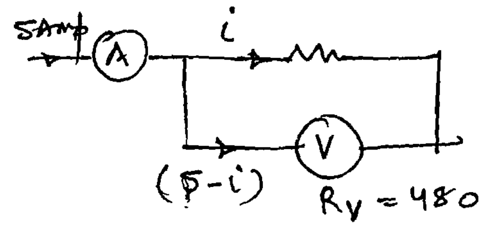



$5 - \left(\frac{5}{R+1}\right) 1 = 4$

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

$\Rightarrow$ $\underline{R = 4\,\Omega}$ Ans.

**16**




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

$$\Rightarrow 5\times480 = [(480)+R]\,i$$

$$\Rightarrow i = \frac{480\times5}{480+R}$$

but $iR = 96$

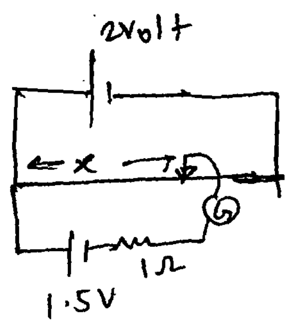
$$\Rightarrow \left(\frac{480\times5}{480+R}\right)R = 96$$

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

$$\Rightarrow 24R = 480$$

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

**17**




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

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

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

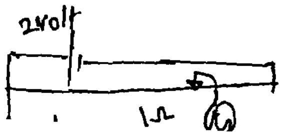
(a) When 5Ω is placed in series $i' = 2/35$ Amp

potential gradient $= \left(\dfrac{\frac{2}{35}\times30}{10}\right)$ V/m

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

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

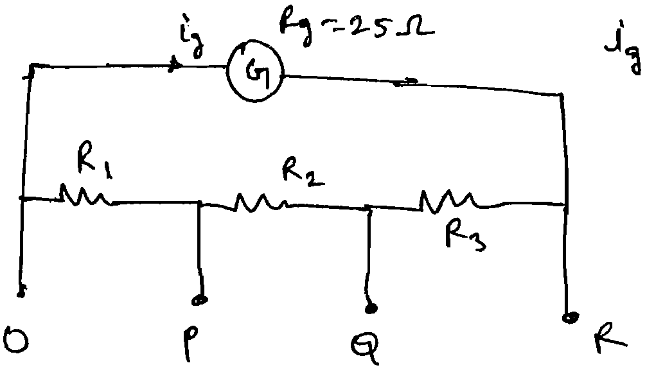
(b)




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

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

18.




$i_g = 10\,mA$

We can have following eq$^n$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 eq$^n$ (2)

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

$R_1+R_2$ by eq$^n$ (3) put in eq$^n$ (4)

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

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

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

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

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

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

Now by eq$^n$ (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

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

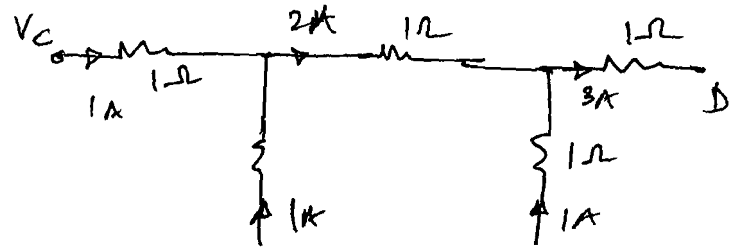
$$= \frac{25}{9} - \frac{11}{4}$$

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

$$= 0.0278\,\Omega$$

Ans

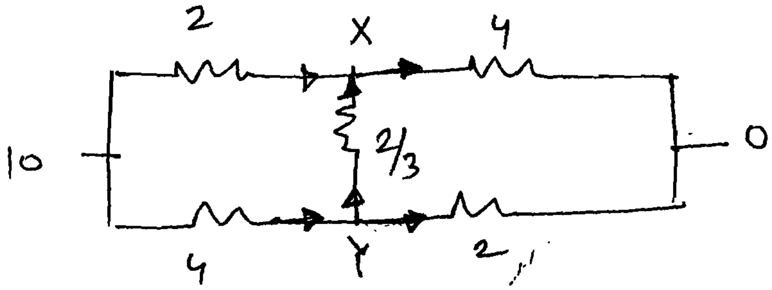
19|




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

$V_C - V_D = 6$ Volt <u>Ans.</u>

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) $-6x + 9y = 10$

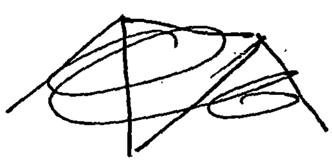
<u>hence</u> $x = 16/3$, $y = 14/3$

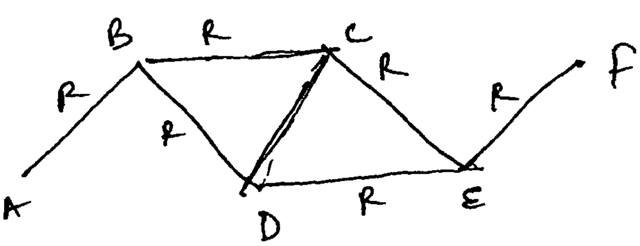
$\therefore x - y = 2/3$

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

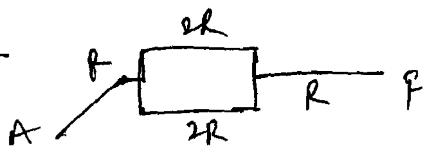
21|

$R_1 = 5R$ , In latter <u>case</u>



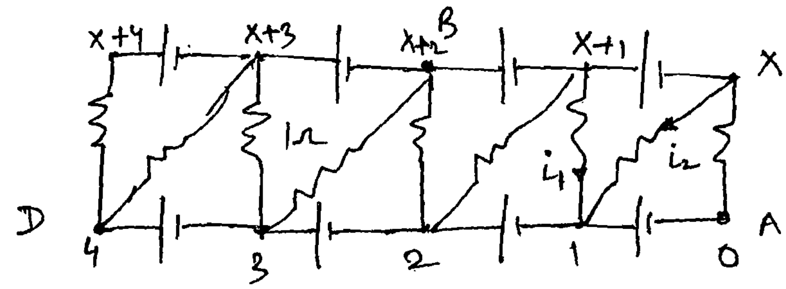



by wheatstone bridge No current in 'CD' hence can remove. <u>Hence</u>




... R + R = 3R

22|




$i_1 = \frac{x}{1}$   $i_2 = \frac{x-1}{1}$

junction law at 'D'

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

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

$$\Rightarrow \quad 9x = 4 \quad \Rightarrow x = 4/9 \text{ Volt}$$

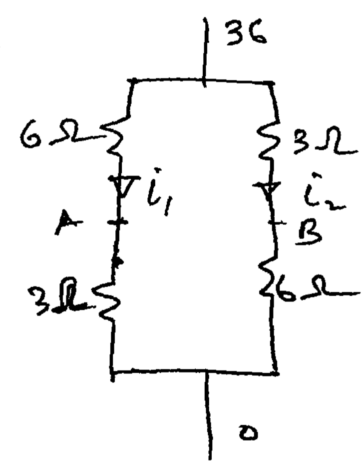
Hence $V_A - V_B = 0 - (x+2)$

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

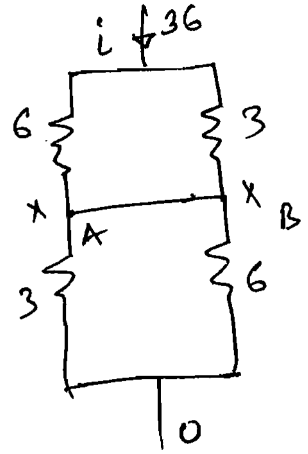
$= 6 \times 4 = 24$

hence $V_A = 36 - 24 = 12$ Volt

similarly $V_B = 36 - 12 = 24$ Volt

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

23 (ii)

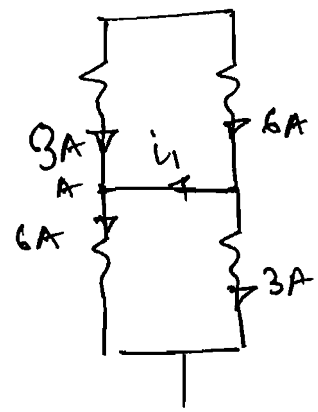



$R_{eq} = 4\Omega$

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


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

∴




by junction A

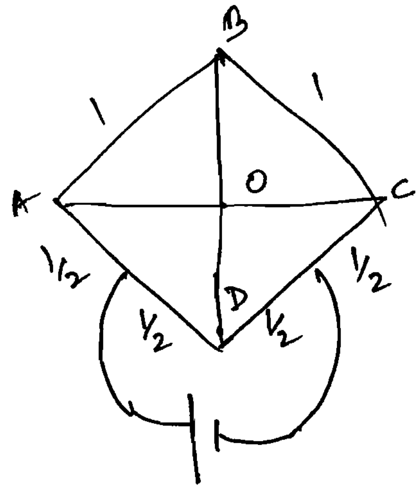
$i_1 + 3 = 6$

$i_1 = 3$ Amp

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

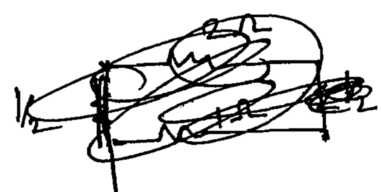
Ans.

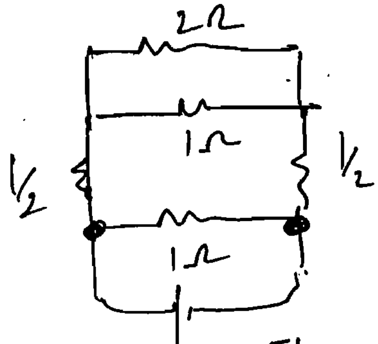
24




By symmetry
BO and OD will have no current.

hence



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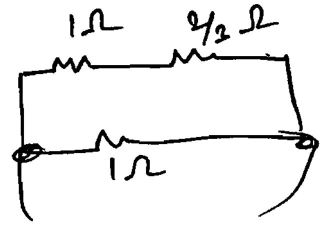


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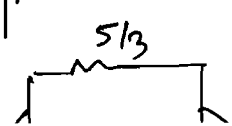
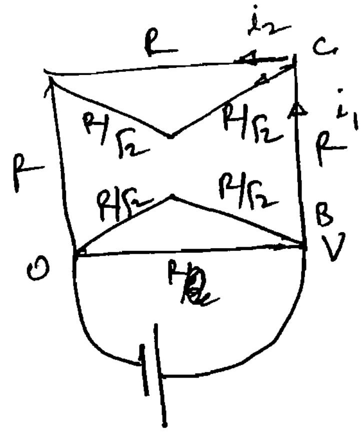
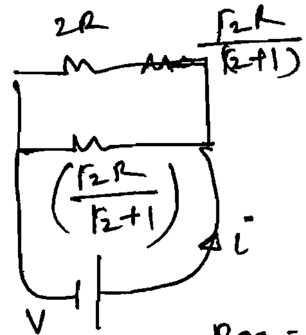



$R_{eq} = \frac{5/3}{\frac{5}{3}+1} = 5/8\ \Omega$

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




for Req calculation:




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

$$Req = \frac{(3\sqrt{2}+2)\sqrt{2}R}{2(\sqrt{2}+1)(2\sqrt{2}+1)}$$

$$i = \frac{V}{Req}$$

let current in the circuit is $i$

current in branch

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

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

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 $= i_2^2 R = \frac{i^2 R}{(\sqrt{2}+1)^2(2\sqrt{2}+1)^2} = \frac{V^2 R}{Req^2 (\sqrt{2}+1)^2(2\sqrt{2}+1)^2}$

Power in AB $= \frac{V^2}{R}$

Ratio of Heat liberated $= \frac{P_{AB}}{P_{CD}}$

$$\frac{P_{AB}}{P_{CD}} = \frac{V^2/R}{V^2 R} \, R_{eq}^2 \, (\sqrt{2}+1)^2 \, (2\sqrt{2}+1)^2$$

$$= \frac{1}{\cancel{R^2}} \cdot \frac{(3\sqrt{2}+2)^2 \cdot \cancel{R^2} \, \cancel{(\sqrt{2}+1)^2} \, \cancel{(2\sqrt{2}+1)^2}}{2 \, \cancel{(\sqrt{2}+1)^2} \, \cancel{(2\sqrt{2}+1)^2}}$$

$$= \frac{18+4+12\sqrt{2}}{2}$$

$$= \frac{22+12\sqrt{2}}{2}$$

$$= 11+6\sqrt{2}$$

Ans

## Only One Option Correct

1. (C)

**(c)** In case of balanced meter bridge

$$\frac{R}{l}=\frac{X}{100-l} \quad \text{Given: } X=90\ \Omega,\ l=40.0\text{ cm}$$

$$\therefore\ R=\frac{Xl}{100-l}=\frac{90\times 40}{60}=60\Omega$$

$$\therefore\ \frac{\Delta R}{R}=\frac{\Delta l}{l}+\frac{\Delta(100-l)}{100-l}\Rightarrow\frac{\Delta R}{60}=\frac{0.1}{40}+\frac{0.1}{60}$$

$$\therefore\ \Delta R=0.25\Omega$$

Therefore, $R=(60\pm 0.25)\Omega$

2. (B)

**(b)** As resistance of wire, $R=\int\rho\frac{l}{A}$

$$R_{Fe}=\frac{\rho_{Fe}\times l_{Fe}}{A_{Fe}}=\frac{10^{-7}\times 50\times 10^{-3}}{4\times 10^{-6}}=\frac{25}{2}\times 10^{-4}$$

$$R_{Al}=\frac{\rho_{Al}\times l_{Al}}{A_{Al}}=\frac{2.7\times 10^{-8}\times 50\times 10^{-3}}{(49-4)\times 10^{-6}}=\frac{2.7\times 50}{45}\times 10^{-5}$$

$=0.3\times 10^{-4}$

As potential difference across both resistors is same, so they are in parallel combination.

$$\therefore\ R_{PQ}=\frac{R_{Fe}\times R_{Al}}{R_{Fe}+R_{Al}}=\frac{12.5\times 10^{-4}\times 0.3\times 10^{-4}}{12.8\times 10^{-4}}=\frac{1875}{64}\mu\Omega$$

3. (C)

**(c)** Electric field at a distance $r$ from line charge

$$E=\frac{\lambda}{2\pi\varepsilon r}=\frac{dV}{dr} \qquad (\lambda = \text{linear charge density of wire})$$

$$dV=-\frac{\lambda}{2\pi\varepsilon r}dr$$

Current through the elemental shell

$$I=\frac{|dV|}{dr}=\frac{\frac{\lambda}{2\pi\varepsilon r}dr}{\frac{1}{\sigma}\times\frac{dr}{2\pi rl}}=\frac{\lambda\sigma l}{\varepsilon}$$

$$(\because R = \rho \frac{l}{A} \therefore dR = \rho \frac{dr}{2\pi r l} = \frac{1}{\sigma} \frac{dr}{2\pi r l})$$

This current is radially outwards,

$$\therefore \frac{d}{dt}(\lambda l) = \frac{-\lambda \sigma l}{\varepsilon} \Rightarrow \int_{\lambda_0}^{\lambda} \frac{d\lambda}{\lambda} = -\left(\frac{\sigma}{\varepsilon}\right)\int_0^t dt$$

$$\Rightarrow \lambda = \lambda_0 e^{-(\sigma/\varepsilon)t}$$

$$\therefore J = \frac{I}{2\pi r l} = \frac{\lambda \sigma l}{2\pi \varepsilon r l} = \frac{\lambda \sigma}{2\pi \varepsilon r}$$

or, $J = \left(\frac{\lambda_0 \sigma}{2\pi \varepsilon r}\right) e^{-(\sigma/\varepsilon)t} \Rightarrow J = J_0 e^{-(\sigma/\varepsilon)t}$

## One or More than One Option Correct

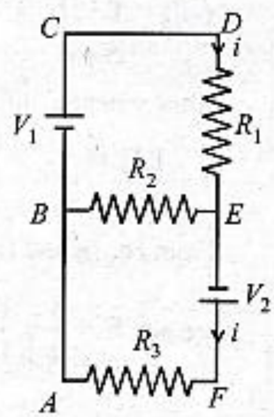
1. (A, B, D)

**(a, b, d)** No current is flowing through resistance $R_2$.

Applying KVL in loop

$$V_1 - iR_1 + V_2 - iR_3 = 0$$

$$\therefore \ i = \frac{V_1 + V_2}{R_1 + R_3} \quad \text{... (i)}$$




Applying KVL in loop BCDEB

$$v_1 - iR_1 = 0 \ \therefore \ i = \frac{V}{R_1} \quad \text{...(ii)}$$

From eq. (i) & (ii) $\frac{V_1}{R_1} = \frac{V_1 + V_2}{R_1 + R_3}$

$\therefore \quad V_1R_1 + V_1R_3 = V_1R_1 + V_2R_1$

$\Rightarrow \quad V_1R_3 = V_2R_1$

If $V_1 = V_2$ then $R_1 = R_3 = R_2$

If $V_1 = V_2$ then $R_1 = R_3 = 2R_2$

If $V_1 = 2V_2$ then $2R_3 = R_1$

If $2V_1 = V_2$ then $R_3 = 2R_1 = R_2$

2. (B, D)

**(b, d)** Heat produced, $H = \left(\frac{V^2}{R}\right) t = \frac{V^2}{R} \times 4$ ...(i)

where $R = \rho \frac{l}{A} = \frac{4\rho l}{\pi d^2}$

When resistances are connected in series

Total resistance $= R_1 + R_2 = 2\left[\frac{4\rho l}{4\pi d^2}\right] = 2 \times \frac{R}{4} = \frac{R}{2}$

$\therefore\ H = \frac{V^2}{R/2} \times t_2$ ...(ii)

From eq. (i) and (ii) $t_2 = 2$ min.

When resistance are connected in parallel

Total resistance $= \frac{R_1 R_2}{R_1 + R_2} = \frac{R_1^2}{2R_1} = \frac{R/4}{2} = \frac{R}{8}$

$\therefore\ H = \frac{V^2}{R/8} \times t_2$ ...(iii)

From eq. (i) and (iii) $t_2 = 0.5$ min

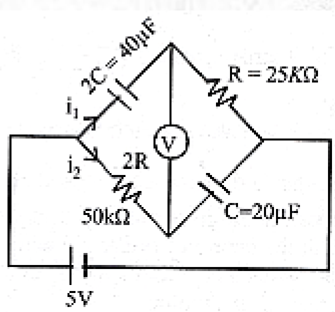
3. (A, B, C, D)

**(a, b, c, d)** At $t = 0$, i.e., As soon as the key is pressed, Capacitors act as short circuit and voltmeter display reading, $-5V$

At $t = \infty$, i.e., after a long time of key press, Capacitor acts as open circuit and no current flows through voltmeter ($\because$ very high resistance of voltmeter) so it display $+5V$.

$q_1 = 2CV\left(1 - e^{-t/2CR}\right)$, $\qquad i_1 = \frac{V}{R} e^{-\frac{t}{2CR}}$

$q_2 = CV\left(1 - e^{-t/2CR}\right)$, $\qquad i_2 = \frac{V}{2R} e^{-\frac{t}{2CR}}$



$$\therefore\ \Delta V = -i_2 \times 2R + \frac{CV_1}{2C} = V\left[1 - 2e^{-t/2CR}\right] = 0$$

i.e., At time t = ln 2s voltmeter will display reading 0 V.

At $\tau$ = 1sec, $i = \frac{i_o}{e}$ $\left[\because i = i_o\, e^{-t/\tau}\right]$

i.e., After 1s current in the ammeter becomes $\frac{1}{e}$ of the initial value.

After a long time no current flows since both capcitor and voltmeter do not allow current to flow.

4. (C, D)

With the use of filament and the evaporation involved, the filament will become thinner thereby decreasing the area of cross-section and increasing the resistance. Therefore the filament will consume less power towards the end of life.

As power, $P = \frac{V^2}{R}$ or, $P \propto \frac{1}{r}$ ($\because V = \text{constant}$)

As the evaporation is non-uniform, the area of cross-section will be different at different cross-section. Therefore tempter distribution will be non-uniform. The filament will break at the point where the temperature is maximum.

When the filament temperature is higher $\left(\lambda_n \propto \frac{1}{T}\right)$, it emits light of lower wavelength or higher band of frequencies.

5. (A, C, D)

**(a, c, d)** Resistance of elementary strips

$$\int \frac{1}{d_R} = \int_{R_1}^{R_2} \frac{t\,dx}{\rho \pi x} \Rightarrow \frac{1}{R} = \frac{t}{\pi\rho} ln\left(\frac{R_2}{R_1}\right)$$

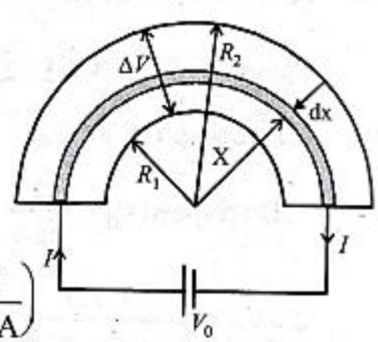
$$\text{Resistance, } R = \frac{\pi\rho}{t\,ln\left(\frac{R_2}{R_1}\right)} \quad \Rightarrow I = \frac{V_0}{R} = \frac{V_0 t\, ln\left(\frac{R_2}{R_1}\right)}{\pi\rho}$$

Hence option (a) is correct.

And, for circular motion of electron, $\Delta V$ develops

Inner surface at higher potential so that electric field develops radially outward.

So option (b) is correct.




$$\frac{mV_d^2}{r} = q\vec{E} \Rightarrow \vec{E} = \frac{mV_d^2}{qr}$$

$$\vec{E} = \frac{mI^2}{n^2 e^2 A^2 qr}$$

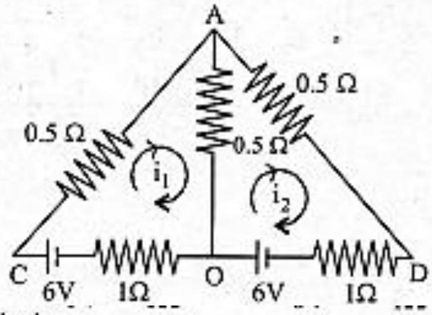
$$\left(\because \text{ Drift velocity, } V_d = \frac{I}{neA}\right)$$

$$\Delta V = \int \vec{E}.\vec{dr} \quad \text{or, } \Delta V \propto V_d^2 \quad \therefore \Delta V \propto I^2$$

Hence option (d) is correct.

6. (A, B, C, D)

**(a,b,c,d)** Here we have folding symmetry, so circuit can be redrawn as




By mesh analysis:

**In circuit ACO**

$0.5i_1 + 0.5(i_1 - i_2) + i_1 - 6 = 0$

$0.5i_1 + 0.5i_1 - 0.5i_2 + i_1 - 6 = 0$

$2i_1 - 0.5i_2 = 6$

$8i_1 - 2i_2 = 24$ ....(i)

**In circuit ADO**

$0.5i_2 + 1 \times i_2 - 12 + 0.5(i_2 - i_1) = 0$

$2i_2 - 0.5i_1 = 12$ ....(ii)

from (i) and (ii), we get

$7.5i_1 = 36$

$i_1 = \frac{36}{7.5} = 4.8A$

So, current through '$R_1$' $= i_1 = 4.8$ A

Putting $i_1 = 4.8A$ in (ii), we get

$2i_2 - 2.4 = 12$

$2i_2 = 14.4 \Rightarrow i_2 = 7.2$ A $\Rightarrow$ Current through $R_1 = 7.2$ A

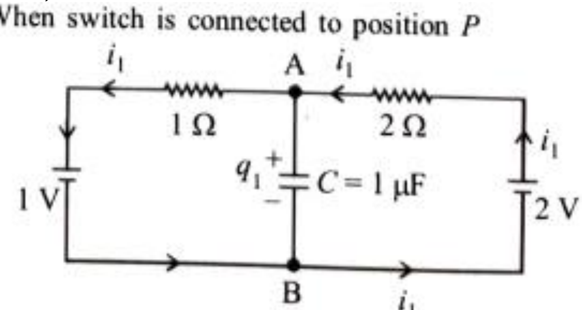
So, current through $R_2 = \frac{|i_2 - i_1|}{2} = 1.2A$

Current through $R_5 = \frac{i_1}{2} = 2.4A$

## Stem Type Questions

1. (1.33)

When switch is connected to position $P$




From KVL,

$$V_A - 1 \cdot i_1 - 1 + 2 - 2i_1 = V_A \Rightarrow 3i_1 = 1 \qquad \therefore\ i_1 = \frac{1}{3}\text{A}$$

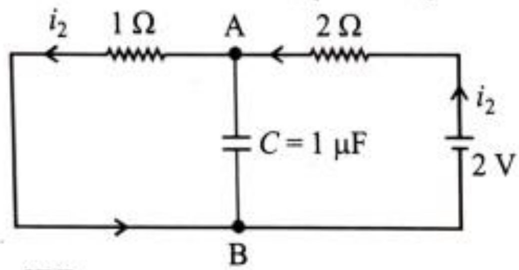
Again $V_A - 1 \cdot i_1 - 1 = V_B$ or, $V_A - V_B = 1 + i_1 = \frac{4}{3}\text{V}$

Potential drop across capacitor $\Delta V = \frac{4}{3}\text{V}$

$\therefore$ Charge on capacitor, $q_1 = C\Delta V = 1 \times \frac{4}{3}\mu\text{C}$

$q_1 = \mathbf{1.33\ \mu C}$

When switch is connected to position $Q$




From KVL,

$$V_A - 1 \cdot i_2 + 2 - 2i_2 = V_A \Rightarrow 3i_2 = 2 \qquad \therefore\ i_2 = \frac{2}{3}\text{A}$$

Again, $V_A - i_2 \times 1 = V_B$

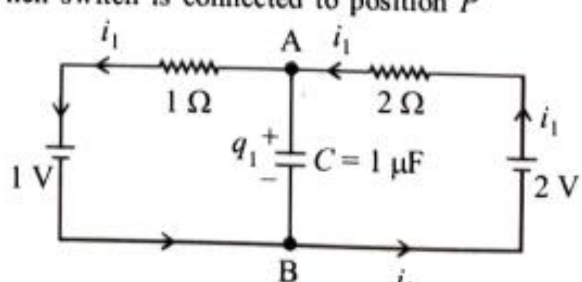
$$V_A - V_B = i_2 \times 1 = \frac{2}{3}\text{V}$$

Potential difference across capacitor $\Delta V = \frac{2}{3}\text{V}$

$\therefore$ Charge on capacitor, $q_2 = C\Delta V = \mathbf{1 \times \frac{2}{3} = 0.67 \mu C}$

2. (0.67)

When switch is connected to position $P$




From KVL,

$$V_A - 1\cdot i_1 - 1 + 2 - 2i_1 = V_A \Rightarrow 3i_1 = 1 \qquad \therefore\ i_1 = \frac{1}{3}\text{A}$$

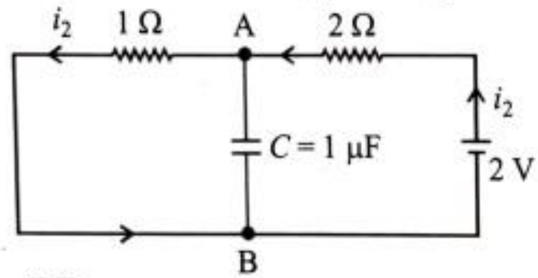
Again $V_A - 1\cdot i_1 - 1 = V_B$ or, $V_A - V_B = 1 + i_1 = \frac{4}{3}\text{V}$

Potential drop across capacitor $\Delta V = \frac{4}{3}\text{V}$

$\therefore$ Charge on capacitor, $q_1 = C\Delta V = 1\times\frac{4}{3}\mu\text{C}$

$q_1 = \mathbf{1.33\ \mu C}$

When switch is connected to position $Q$




From KVL,

$$V_A - 1\cdot i_2 + 2 - 2i_2 = V_A \Rightarrow 3i_2 = 2 \qquad \therefore\ i_2 = \frac{2}{3}\text{A}$$

Again, $V_A - i_2 \times 1 = V_B$

$$V_A - V_B = i_2 \times 1 = \frac{2}{3}\text{V}$$

Potential difference across capacitor $\Delta V = \frac{2}{3}\text{V}$

$\therefore$ Charge on capacitor, $q_2 = C\Delta V = \mathbf{1\times\frac{2}{3} = 0.67\mu C}$

## Integer / Numerical Answer Type

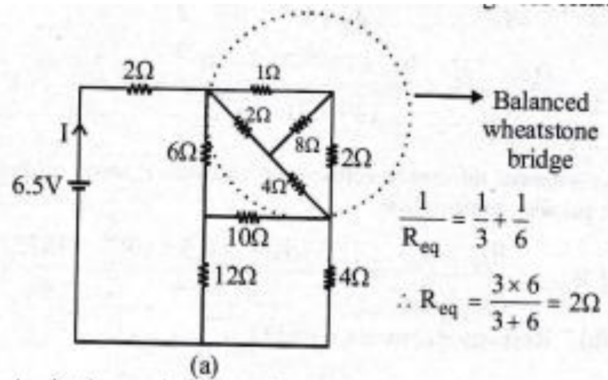
1. (5)

(5) From $\left(\frac{I-I_g}{I_g}\right)S = \frac{V}{I_g} - R$

$$\frac{1.5-0.006}{0.006}\times\frac{2n}{249} = \frac{30}{0.006} - 4990 \ \therefore\ n = \frac{2490}{498} = 5$$

2. (1)

In the figure (a) no current flows through $8\Omega$ resistance



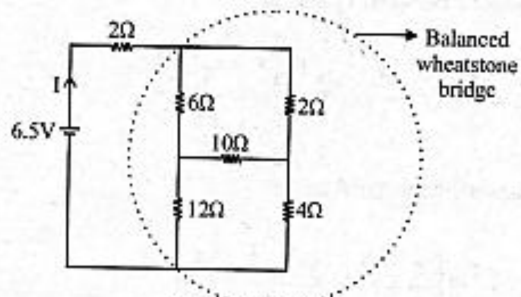

$$\frac{1}{R_{eq}} = \frac{1}{3} + \frac{1}{6}$$

$$\therefore R_{eq} = \frac{3 \times 6}{3+6} = 2\Omega$$

(a)

Again the equivalent resistance of balanced wheatstone bridge fig (b) no current through 10Ω resistance.

$$\therefore R_{eq} = \frac{6 \times 18}{24} = \frac{9}{2}\Omega$$




(b)

Therefore the current through the resistor $R = 2\Omega$

$$I = \frac{V}{R} = \frac{6.5}{2 + \frac{9}{2}} = \frac{6.5}{6.5} = 1A$$

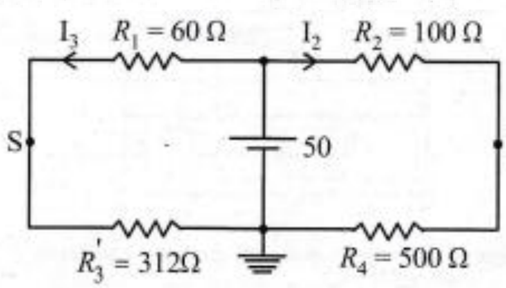
3. (0.27)

**(0.27)** According to question, resistance $R_3$ has temperature coefficient, $\alpha = 0.0004°C^{-1}$

And temperature is increased by 100° C i.e., $\Delta T = 100°$ C

$R'_3 = R_0(1 + \alpha\Delta T) = 300(1 + \alpha\Delta T)$

$\therefore R'_3 = 312\Omega$




Here, $I_1 = \frac{V}{R_1 + R_3} = \frac{50}{372}$ and $I_2 = \frac{V}{R_2 + R_4} = \frac{50}{600}$

$V_S - V_T = 312I_1 - 500I_2$

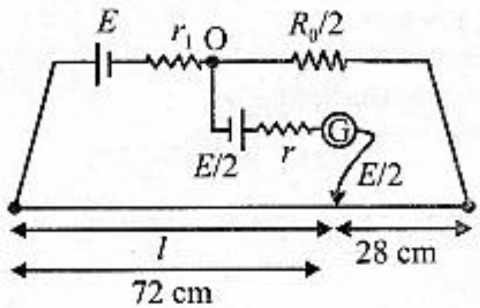
$= 312 \times \frac{50}{372} - 50 \times \frac{500}{600} = 41.94 - 41.67 = 0.27V$

Hence voltage developed between S and T = 0.27 Volt

4. (3)

**(3)** Here null point is at 72 cm

$$i\left(\frac{R_0}{2}+0.28R_0\right)=\frac{E_0}{2}$$




$$\Rightarrow \quad i\times 0.78R_0=\frac{E_0}{2}$$

$$i=\frac{E_0}{2\times 0.78R_0}=\frac{E_0}{r_1+\frac{3}{2}R_0}$$

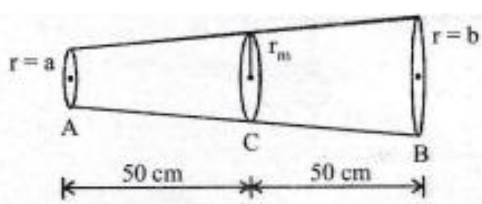
or, $r_1+1.5\ R_0=1.56\ R_0$

$\Rightarrow$ $r_1=1.56\ R_0-1.5\ R_0=0.06\ R_0$

$\therefore$ $r_1=0.06\times 50=3\ \Omega$

5. (5)

**(5)**




For a frustum, $R=\frac{\rho\ell}{\pi ab}$ and $r_m=\frac{a+b}{2}$

So, $R_{AC}=\frac{\rho\ell_{/2}}{\pi(ar_m)}$

$R_{CB}=\frac{\rho\ell_{/2}}{\pi r_m b}$. By wheatstone bridge principal

$\frac{R_1}{R_2}=\frac{R_{AC}}{R_{CB}}\Rightarrow\frac{R_1}{1}=\frac{b}{a}=\frac{1}{0.2}=5$

So, $R_1=5\Omega$