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

$R_{eq} = \frac{400\times800}{400+800} = \frac{800}{3}\Omega$

At $t^\circ C$,

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

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

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

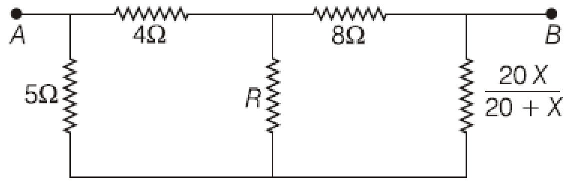
$\Rightarrow \quad \frac{3\alpha_{eq}t}{800} = \frac{\alpha t}{400} + \frac{4\alpha t}{800}$

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

3. (C)

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

4. (D)

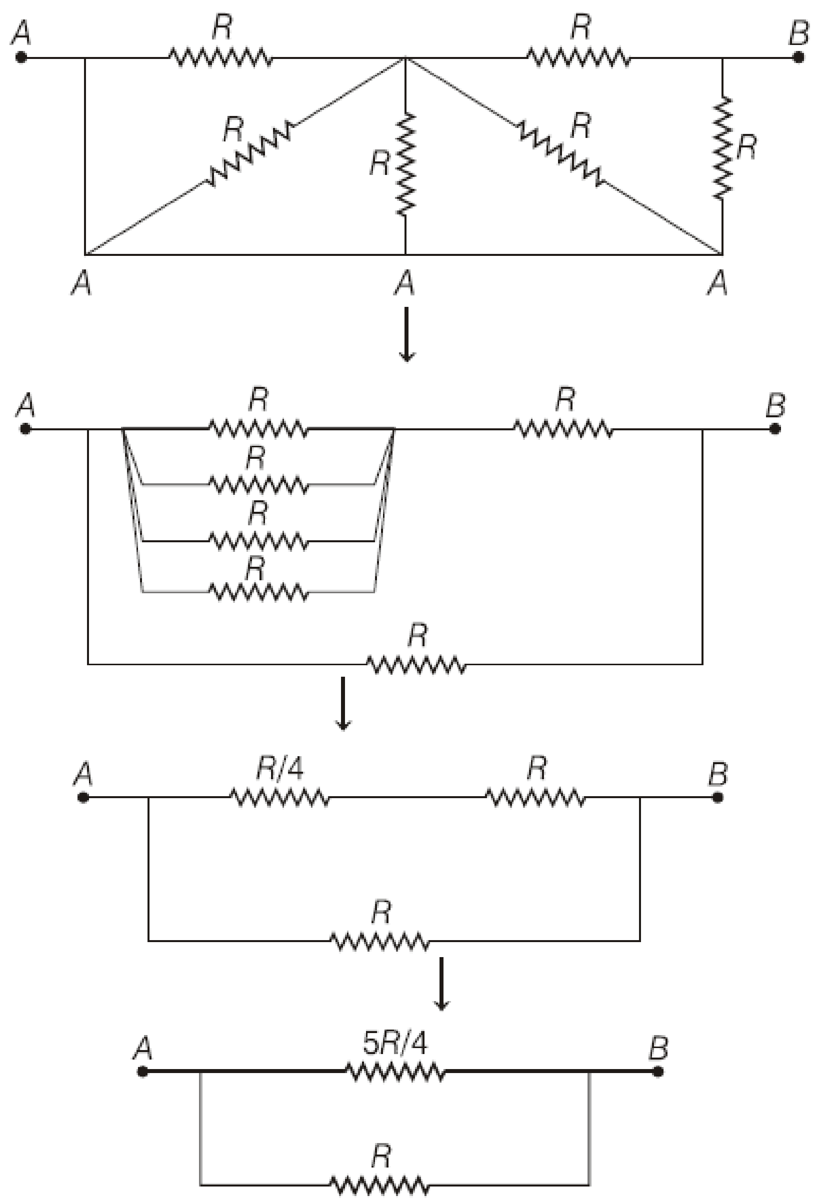


For equivalent resistance to be independent of R, it should be a balanced Wheatstone bridge.

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

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

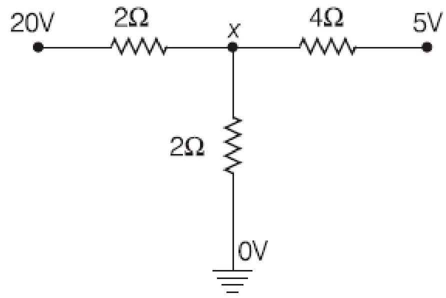
5. (A)



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

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

6. (A)



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

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

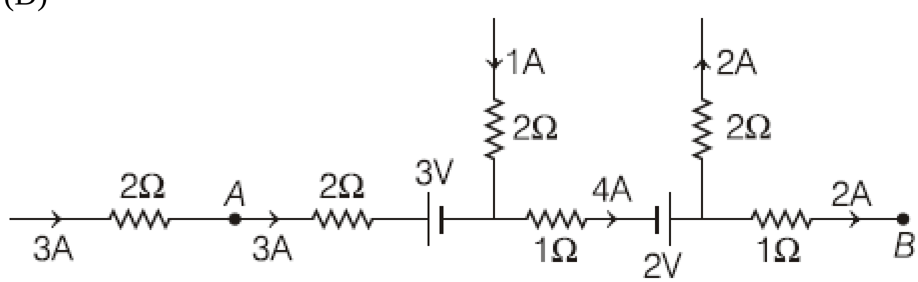
$$\Rightarrow \quad 40-2x+5-x-2x=0$$

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

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

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

7. (D)

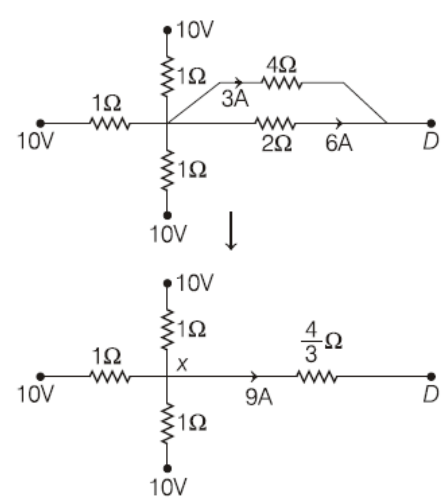


$$V_A-3(2)-3-4(1)+2-2(1)=V_B$$

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

8. (A)

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



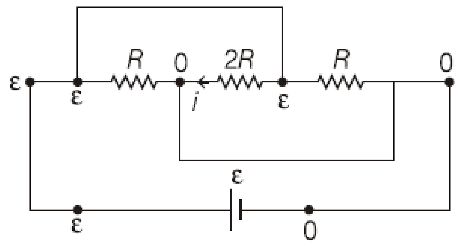
$$\frac{10-x}{1}+\frac{10-x}{1}+\frac{10-x}{1}=9$$

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

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

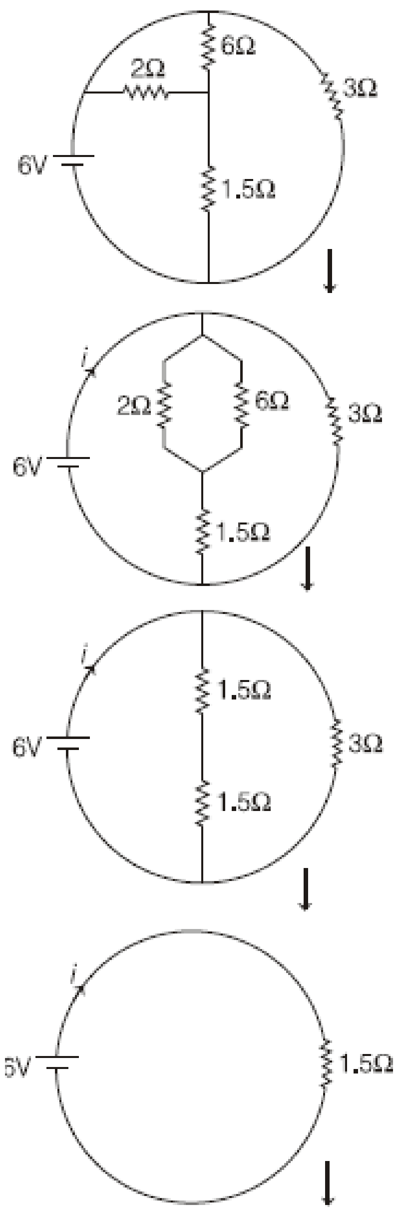
$$\Rightarrow \quad V_D=-5\,\text{V}$$

9. (B)



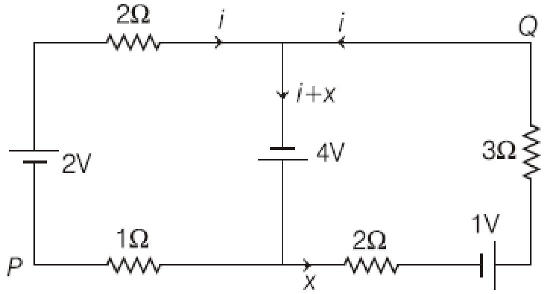
Current in a resistor flows from high potential to low potential.
So, current in $2R$ resistance will be from right to left.

10. (B)



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

11. (B)



Using KVL,

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

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

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

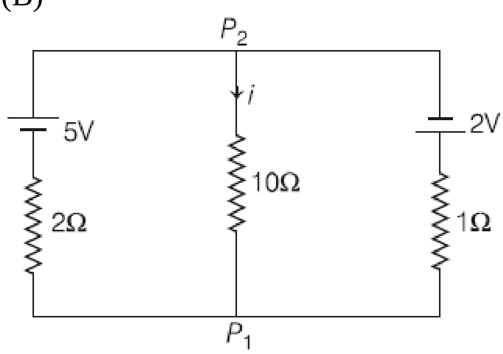
$\Rightarrow$ $x=1\,\text{A}$

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

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

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

12. (B)

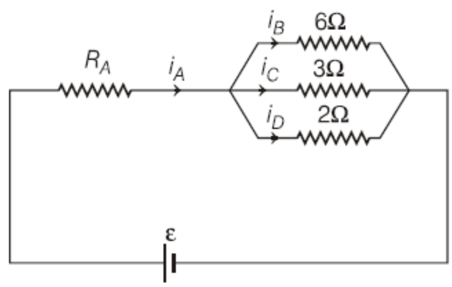


$$\varepsilon_{eq}=\frac{\frac{\varepsilon_1}{r_1}+\frac{\varepsilon_2}{r_2}}{\frac{1}{r_1}+\frac{1}{r_2}}=\frac{\frac{5}{2}-\frac{2}{1}}{\frac{1}{2}+\frac{1}{1}}=\frac{1}{3}\text{V}$$

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

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

13. (D)



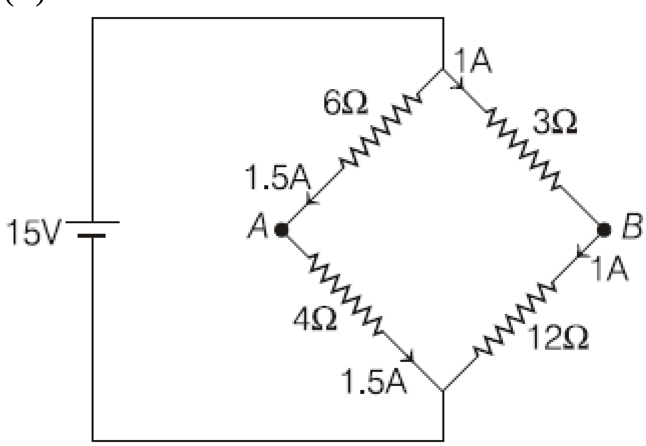
$$i_B : i_C : i_D = \frac{1}{R_B} : \frac{1}{R_C} : \frac{1}{R_D}$$

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

$$i_A = i_B + i_C + i_D$$

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

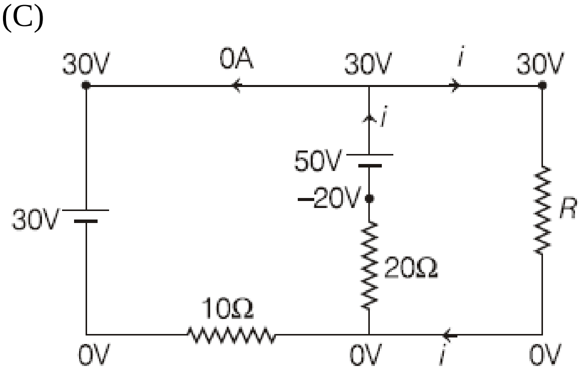
14. (B)



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

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

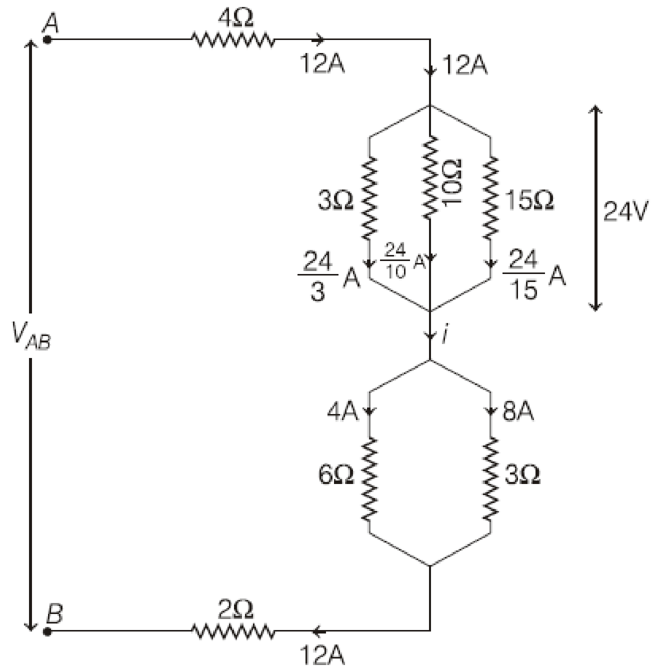
15. (C)



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

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

16. (D)

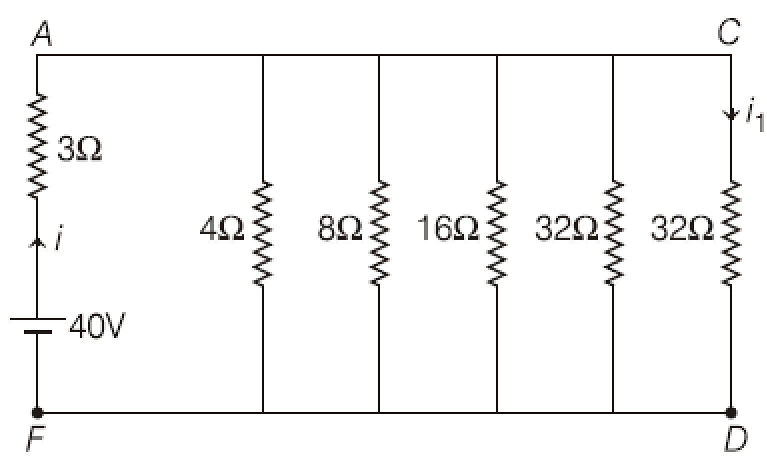


$$i = \frac{24}{15} + \frac{24}{10} + \frac{24}{3} = 12\,\text{A}$$

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

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

17. (C)



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

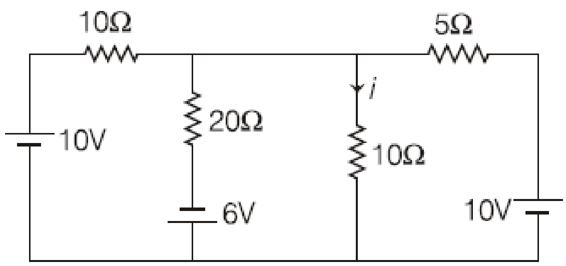
$i =$ Current through battery $= \frac{40}{5} = 8\,\text{A}$

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

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

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

18. (A)



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

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

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

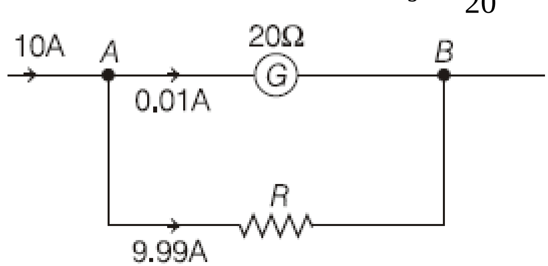
$$= \frac{54}{90} = \frac{3}{5} = 0.6\,\text{A}$$

19. (D)

Resistance of an ideal voltmeter is infinite.

20. (B)

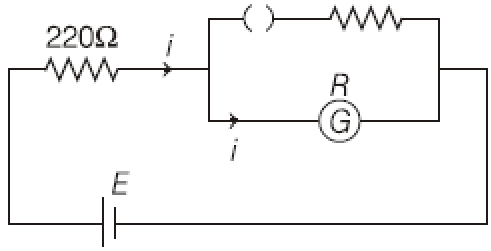
Full scale deflection current $= i_g = \frac{0.2}{20} = 0.01\,\text{A}$



21. (D)

For galvanometer, $i \propto \theta$

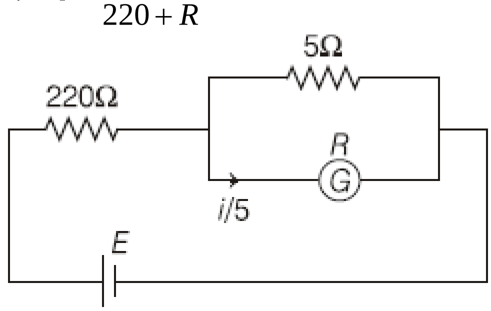
If deflection becomes $\left(\frac{1}{5}\right)$th, then current through galvanometer will also become $\left(\frac{1}{5}\right)$th.



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)

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

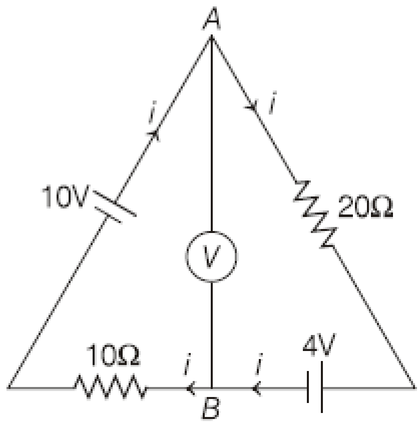
$\Rightarrow \quad 20 = i_g\left(R_G + 1680\right) \qquad \ldots(\text{i})$

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

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,

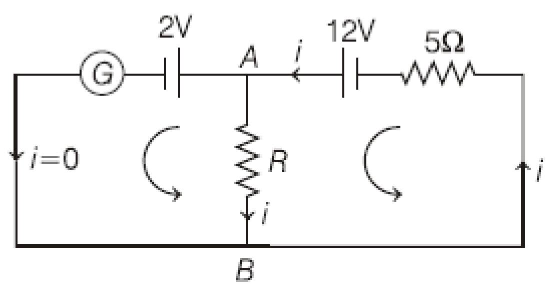
$$+10-20i-4-10i=0$$

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

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

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

24. (A)



Applying KVL,

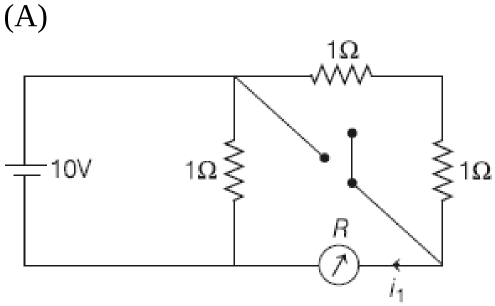
$$+12-iR-5i=0$$

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

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

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

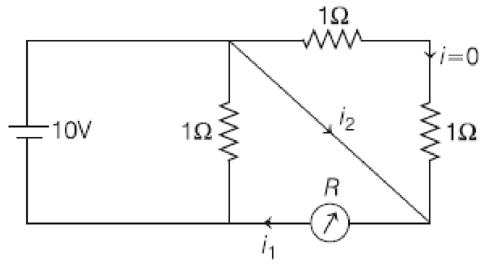
25. (A)



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.



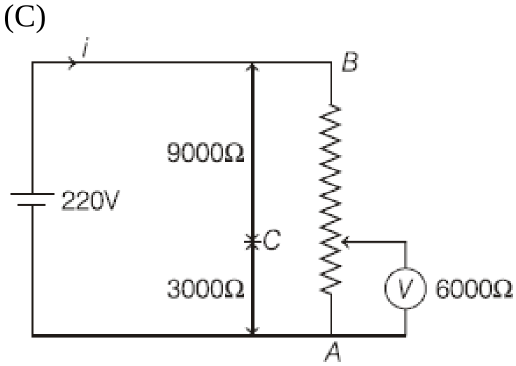
$$i_2 = \frac{10}{R}$$

$$i_2 = 2i_1$$

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

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

26. (C)



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

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

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

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

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,

$$6(625) = QS$$

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

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

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

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

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

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

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

29. (5)

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

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

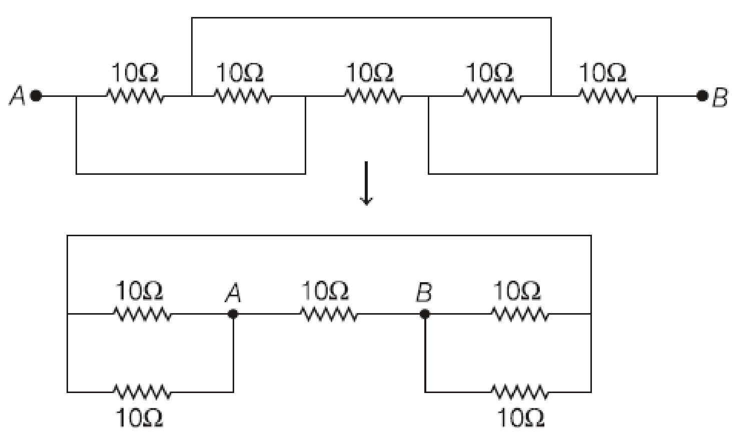
$$R' = \frac{\rho I}{A}(1+\alpha_1\Delta T)(1-\alpha_2\Delta T)$$

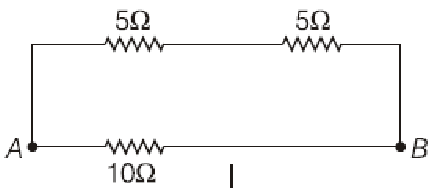
$$R' = R(1+(\alpha_1-\alpha_2)\Delta T)$$

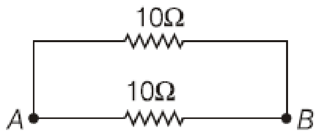
Temperature coefficient of resistance $= \alpha_1 - \alpha_2$

$$= 6\times 10^{-3} - 1\times 10^{-3} = 5\times 10^{-3}$$

30. (5)

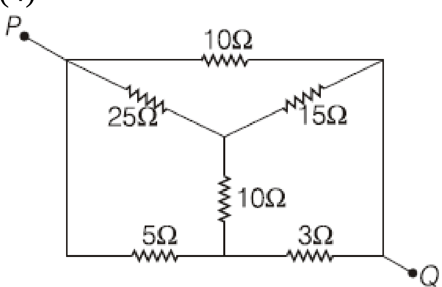


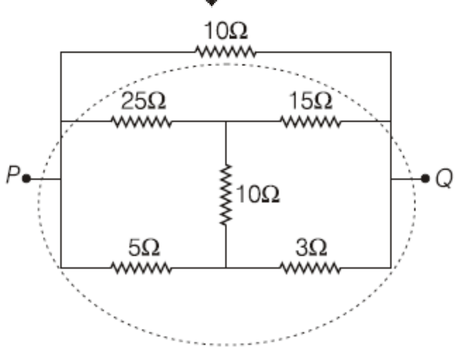




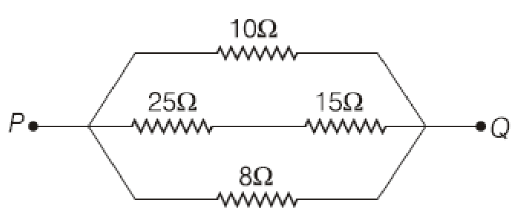
$$\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{10} \Rightarrow R_{eq} = 5\,\Omega$$

31. (4)





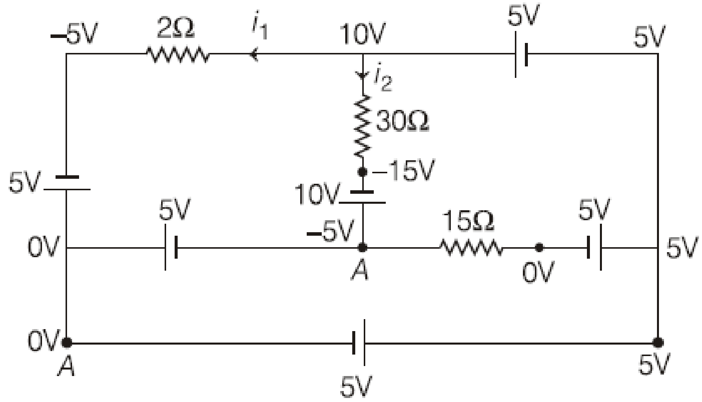
Balanced Wheatstone bridge



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

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

32. (9)



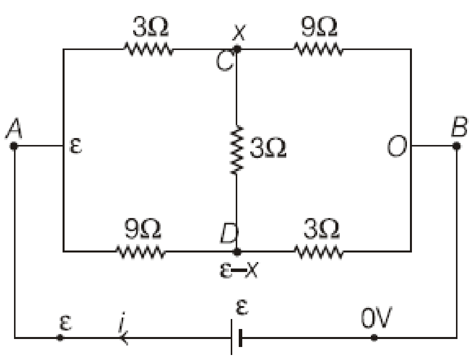
Lets take $V_A = 0$ V

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

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

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

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*,

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

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

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

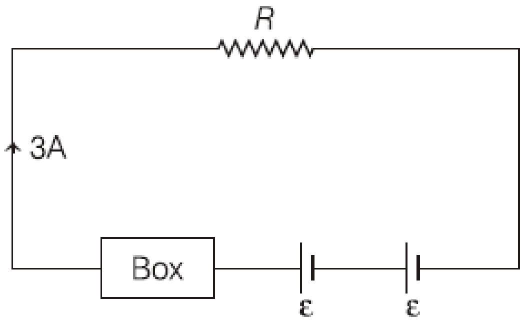
$$i = \frac{\varepsilon - x}{3} + \frac{\varepsilon - (\varepsilon - x)}{9} = \frac{2\varepsilon}{15} + \frac{\varepsilon}{15} = \frac{\varepsilon}{5}$$

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

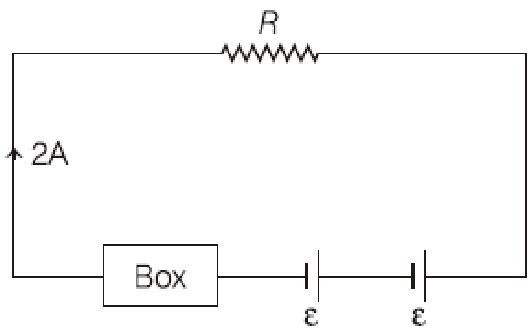
34. (1)

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

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



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

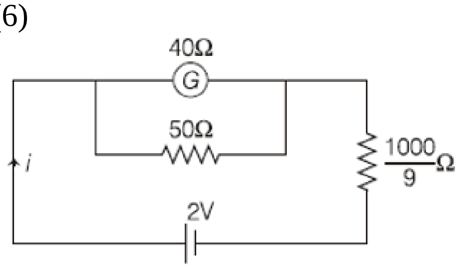


$$2=\frac{(12-2n)\varepsilon-2\varepsilon}{R} \quad ...(ii)$$

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

$n=1$

35. (6)



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

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

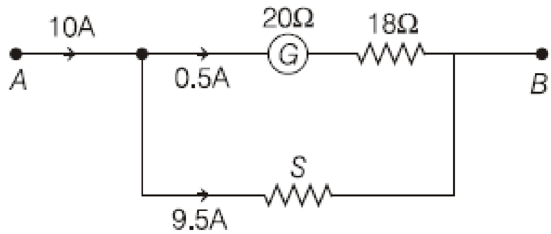
Current sensitivity $=\frac{50}{\frac{25}{3}}=6\text{ div/mA}$

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

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

$=15\text{ mA}$

36. (2)

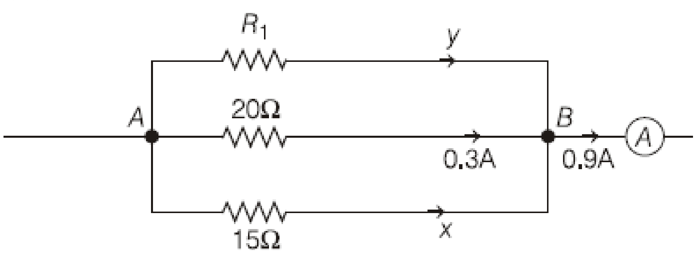


For half scale deflection, current through the galvanometer = 0.5 A

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

$\Rightarrow \quad S = 2\Omega$

37. (30)



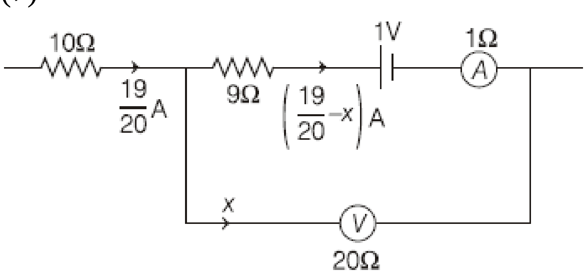
$$V_A - V_B = 20(0.3) = x(15) \Rightarrow x = 0.4\,\text{A}$$

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

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

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

38. (7)



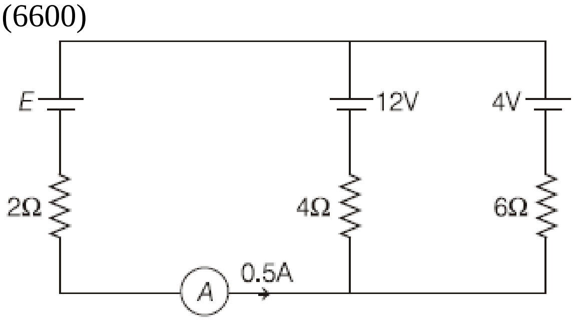
Using KVL in the loop,

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

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

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

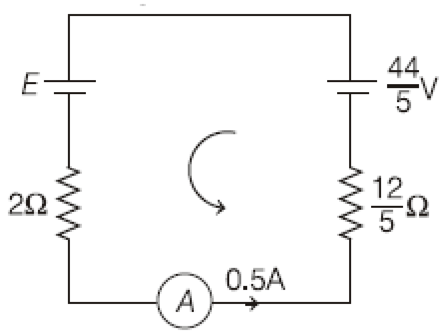
39. (6600)



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

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

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

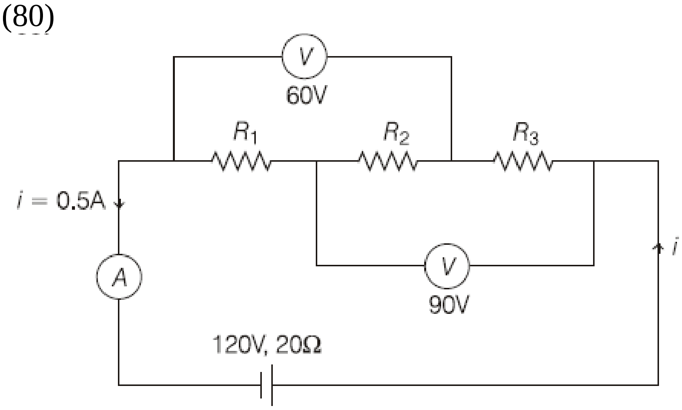


Applying KVL in the loop,

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

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

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,

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

When 2Ω and R are interchanged, balance point shifts by 20 cm.

So, for null point,

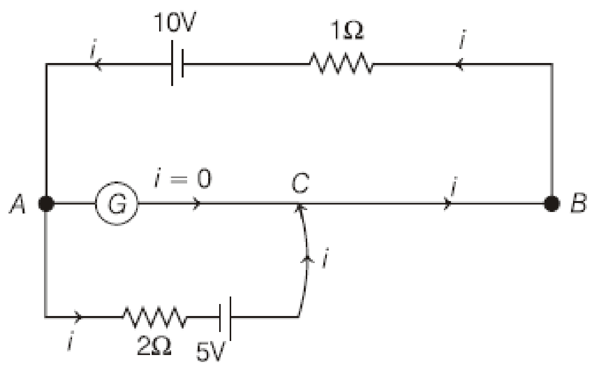
$$R(100-(I+20))=2(I+20)$$

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

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

$I=40\text{ cm}$ 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.

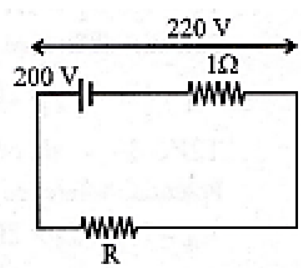
3. (C)
(c) As 200 V battery is charging

So, $220 = 200 + i.1$

$i = 20$ A

So, $20 \times R = 220$ V

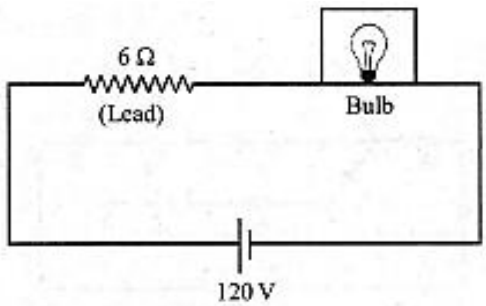
$\Rightarrow R = 11\ \Omega$



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

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)

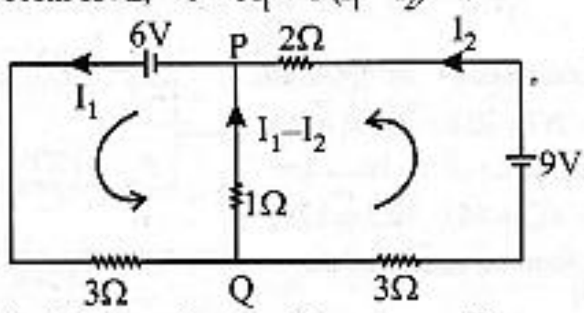
(c) $i = neAV_d$ and $V_d \propto \sqrt{E}$ (Given)

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

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

for H_{max}, P is maximum

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

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

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

12. (A)

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

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

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

Since, $\rho \to$ constant, $V \to$ constant

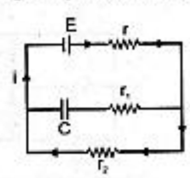
$R \propto \dfrac{1}{A^2}$ OR $R \propto \dfrac{1}{r^4}$ $\because A = \pi r^2$

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

13. (A)

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

Current through the circuit,



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

Potential difference through capacitor

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

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

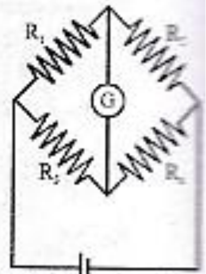
14. (B)

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.

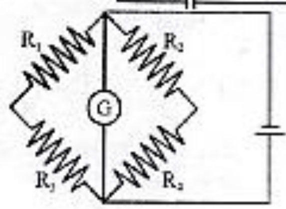


On balancing condition $\frac{R_1}{R_3} = \frac{R_2}{R_4}$

After exchange

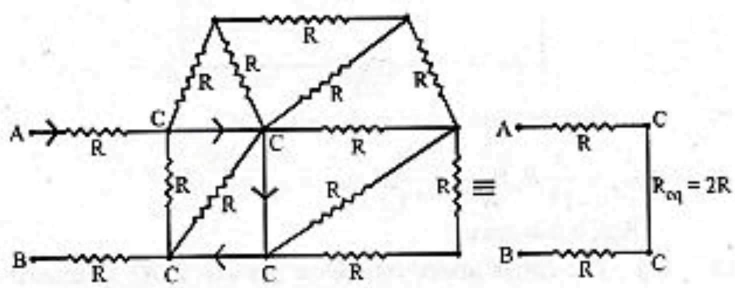
On balancing condition

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



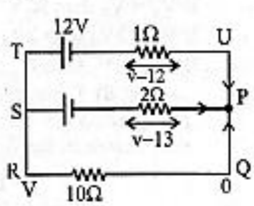
16. (A)

(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]

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

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

$\Rightarrow V = \frac{37 \times 10}{16 \times 2} = \frac{370}{32} = 11.56$ 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, $P_2 = 8P_1$

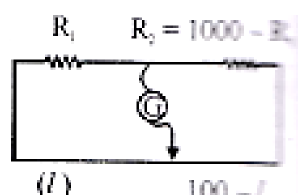
i.e., power increased 8 times of previous or original wire.

19. (B)

Using formula, internet resistance,

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

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)

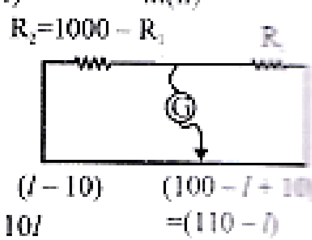
On Interchanging resistance balance point shifts left by 10 cm.

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)

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

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

$\therefore R_1 = 550 K\Omega$

21. (D)

(d) Charge mobility

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

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

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

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

22. (B)

(b) Equation of straight line from graph

$y = -mx + c$

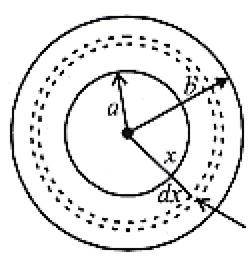
$$\Rightarrow \ln R = -m\left(\frac{1}{T^2}\right) + c$$

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 $v_d = \frac{1}{neA}$

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

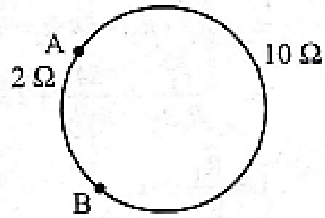
27. (C)

(c) When length becomes double its resistance becomes

$(R \propto l^2)$

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

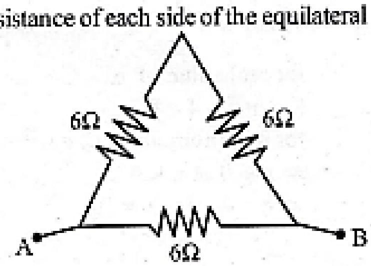
$$R_{eq} = \frac{2\times10}{12} = \frac{5}{3}\Omega$$



28. (A)

(a) Resistance, R ∝ 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)

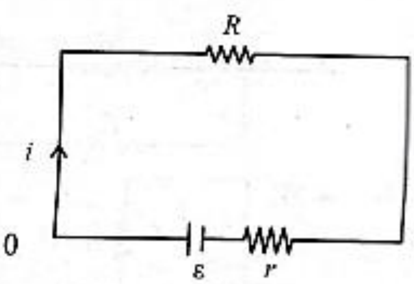
(d) $i = \left(\frac{\varepsilon}{R+r}\right)$

Power delivered to R.

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

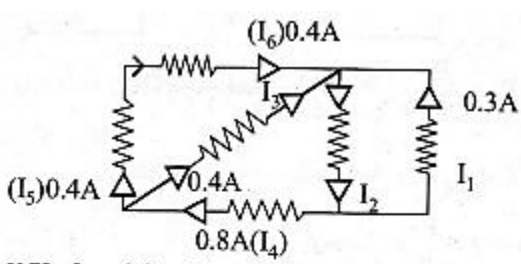
P to be maximum, $\frac{dP}{dR} = 0$

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

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

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

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, $P = i^2R$

$$\therefore i = \sqrt{\frac{P}{R}} = \sqrt{\frac{2}{50\times10^2}} = 20mA$$

34. (A)

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

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

When supply of 11 v is connected

Power, $P' = \frac{v^2}{R} = \frac{11^2}{1.1}\times\frac{11^2}{1.1}\times10^{-6} = 11\times10^{-5}\ W$

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

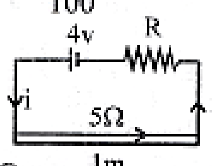
36. (C)

(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)

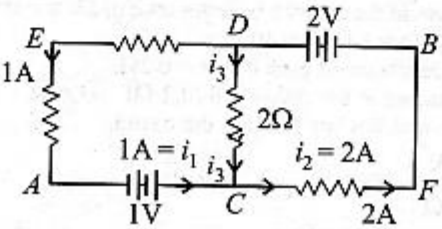
$\rho_M = 98 \times 10^{-8}; \rho_A = 2.65 \times 10^{-8}$

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

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

39. (D)

(d)



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

Using Kirchoff's junction rule at C, we get

$i_1 + i_3 = i_2$

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

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, $I = \frac{P}{V} = \frac{1000}{220}$

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

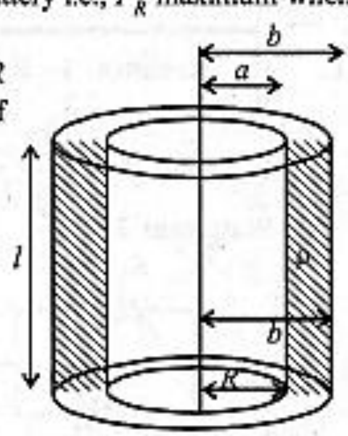
$P_{in} = P_{output} + P_{loss}$

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

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 10kΩ is parallel to the resistance of 400Ω. 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

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

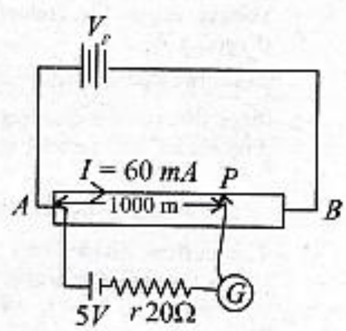
43. (D)

(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%

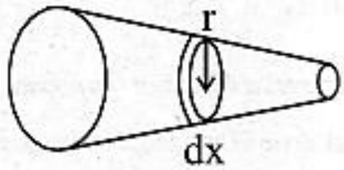
$\therefore R = 75 \times 10^2 \pm 5\%$ of $7500 \Rightarrow R = (7500 \pm 375)\Omega$.

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, $V_d = neV_d\bar{A}$

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

$= 625 \times 10^{25}$

47. (B)

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

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

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

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

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

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

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

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

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

49. (B)

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

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

Putting the required value we get l = 97 m

50. (A)

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

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

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

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

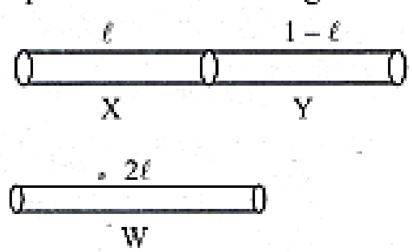
$V = I \times R_{eq}$

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

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

52. (B)

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



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

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

$R_W = 4R_X = 2R_Y$

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

53. (A)

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

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

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

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

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

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

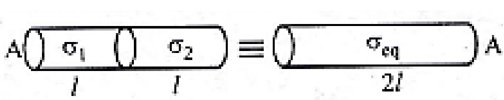
Al = constant

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

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

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

56. (B)

(b) 

Let length of wire be 'ℓ' and area of wire as 'A'

For equivalent wire length = 2ℓ; 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)

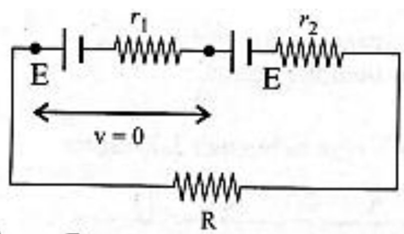
(b) As $R = \frac{\rho l}{A} \Rightarrow R_i = 14\Omega = \frac{\rho l_0}{\pi r_0^2}$

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

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

58. (A)

(a)



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

$\Rightarrow \quad E - ir_1$

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

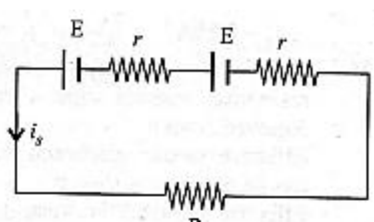
$$\Rightarrow \quad \frac{E}{r_1} = \frac{2E}{r_1 + r_2 + R} \qquad \left[\because i = \frac{E}{r_1}\right]$$

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

$\Rightarrow \quad R = r_1 - r_2$

59. (A)

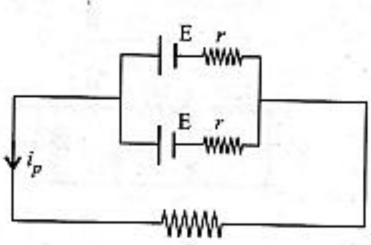
(a) In series



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

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,

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

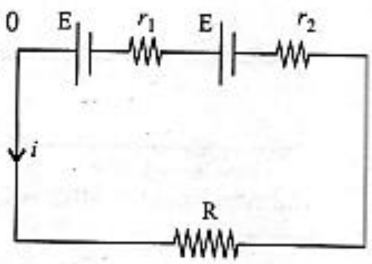
As. P.d across second cell = 0

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

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

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

$\Rightarrow R = r_2 - r_1$

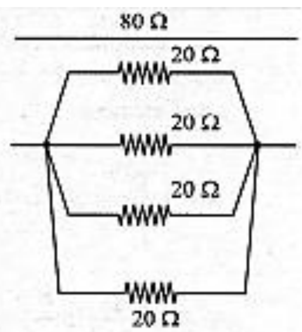


61. (C)

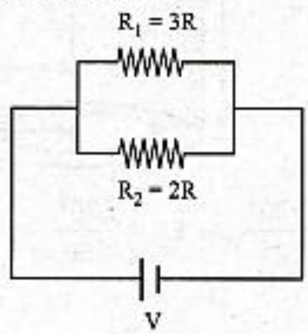
(c) Statement 1 - $R = 80\ \Omega$

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

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

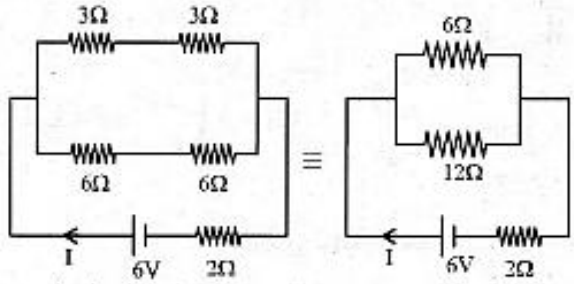
$\frac{1}{2} \cdot \frac{\Delta U}{\Delta t} = P_{Bulb} \times N$, where N = no. of bulb

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

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

63. (A)

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



The equivalent resistance will be

$$R_{eq} = \frac{6\times12}{6+12} + 2 = 6\,\Omega$$

Now, apply K.V.L, we have

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

64. (2)

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

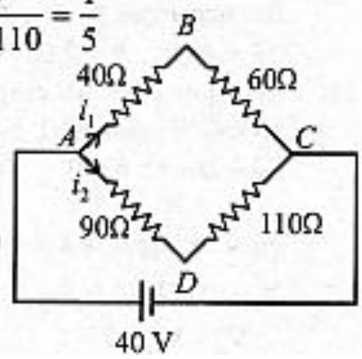
Current through AD, $i_2 = \frac{40}{90+110} = \frac{1}{5}$

Using KVL in BAD loop

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

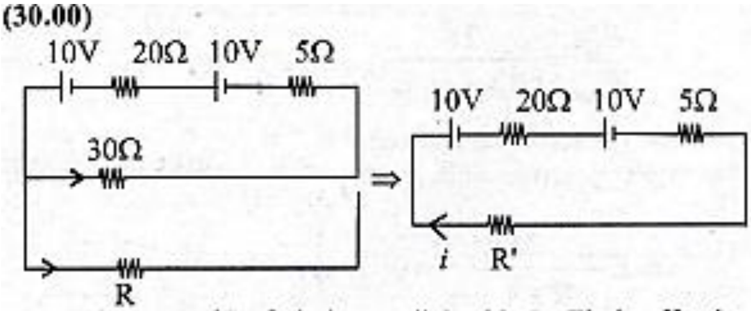
$\Rightarrow V_B - V_D = \frac{1}{5}(90) - \frac{4}{10}(40)$

$\Rightarrow V_B - V_D = 18 - 16 = 2\text{V}$



65. (30.00)

(30.00)



The resistance of 30Ω is in parallel with R. Their effective resistance

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

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

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

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

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

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

Dividing (i) by (ii) we get

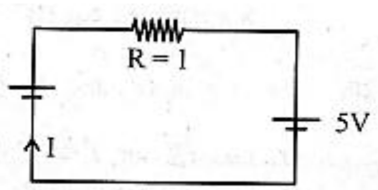
$$\Rightarrow \frac{r+10}{10} = \frac{56}{50} \Rightarrow 50r + 500 = 560$$

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

67. (1)

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

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



68. (4)

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

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

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

$\therefore \rho = 4$

69. (5)

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

Radius of wire, $r = 0.5$ 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 'α'

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

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

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

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

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

$$1 = \frac{E(2)}{2+r} \quad ...(ii)$$

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

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

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)

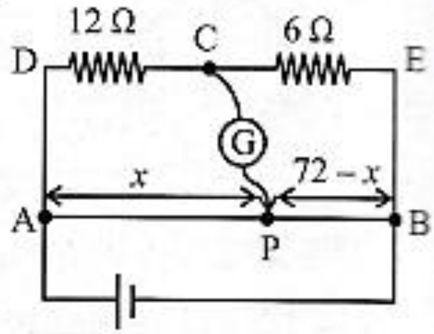
(48) In balanced condition,

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

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

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

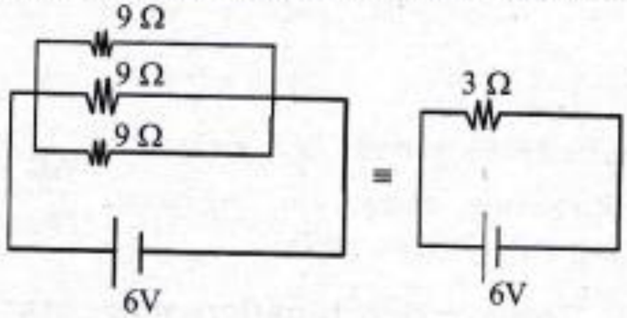
So, $R_f = 4R_i$

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

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

81. (2)

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



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

82. (10)

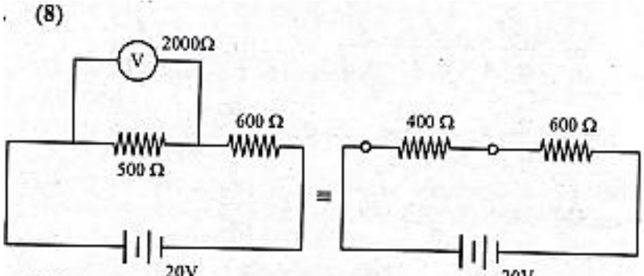
We have $i = \frac{15}{1+2} = 5\,\text{A}$

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

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

84. (4)

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

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

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

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, $P = Vi$

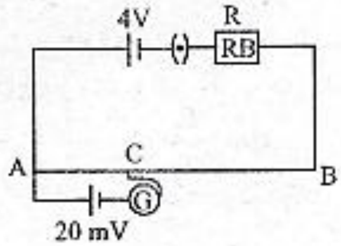
$\Rightarrow 5 = 25i \Rightarrow i = 0.2A$

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



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

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

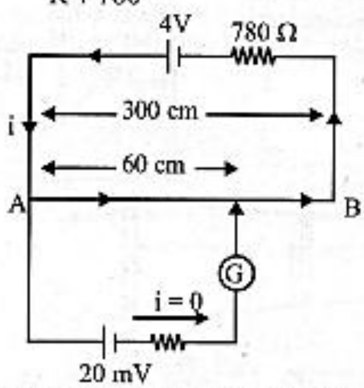
$\therefore \quad R = 780\ \Omega$

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, $E = K\ell$

$1.2 = (\text{Potential Gradient}) \times 36$

$1.8 = (\text{Potential Gradient}) \times x$

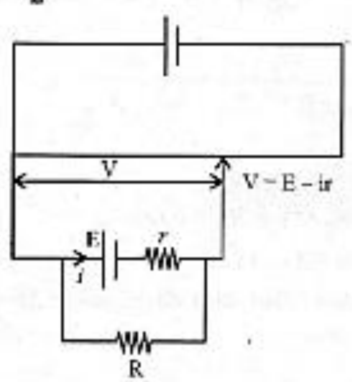
On dividing, we get

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

91. (8)

(8) We have

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



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

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

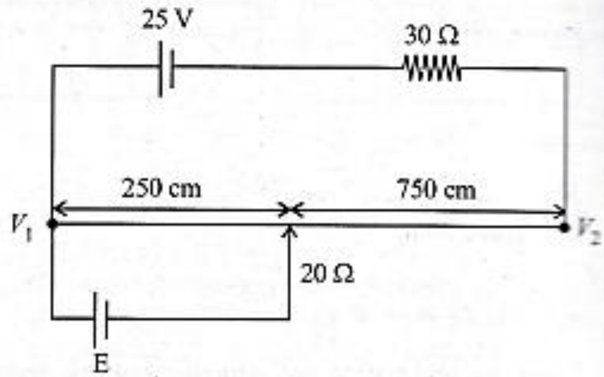
From (i) & (ii), we get

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

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

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 × 250 $= \frac{10}{1000} \times 250$

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