Current Electricity

SOLUTIONS

Exercise-I (Conceptual Questions)

1. $I = \frac{dq}{dt} = \frac{10^6 \times 1.6 \times 10^{-19}}{1} = 1.6 \times 10^{-13}$ A

2. $\because\ I = \frac{dQ}{dt} \quad \Rightarrow \quad dQ = Idt$

$Q = \int Idt = \int_2^3 (2t + 3t^2)dt$

on solving $Q = 24$ C

3. $i = \frac{q}{t} = \frac{10^4 \times 1.6 \times 10^{-19}}{60} = 0.25 \times 10^{-16}$ A

4. $i = neA\,v_d$

$v_d = \frac{i}{neA} = 1.56 \times 10^{-5}$ m/s

5. $V_d = \frac{I}{neA} = 2.5 \times 10^{-3}$ m/s

6. Ampere

7. If no. current passes through a conductor then average velocity of all electrons in conductor is zero for time.

8. $I = neAv_d$

$= \frac{N}{V}eAv_d = \frac{N}{A\ell}eAv_d$

$I = \frac{N}{\ell}ev_d$ solve it.

9. $i = 4.1 \times 10^{18} \times 1.6 \times 10^{-19}$

= 0.66 A towards right

10. $I = neAv_d$

$\Rightarrow \quad v_d \propto \frac{1}{n}$

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

11. $j = \frac{I}{A} = nev_d$

$\frac{4I}{\pi d^2} = nev$ ...(i)

$\frac{16I}{\pi d^2} = nev'$ ...(ii)

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

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

13. $q = \int i\,dt$ = area under i – t curve

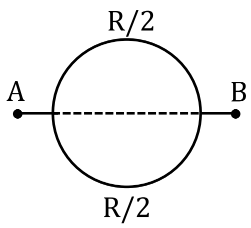
$q_1 = 2C,\ q_2 = 2C,\ q_3 = 2C$

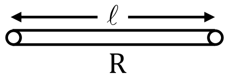
So, $q_1 : q_2 : q_3 = 1 : 1 : 1$

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

$R_1 = \frac{\rho\ell}{A} \qquad R_2 = \rho\left(\frac{4\ell}{A}\right) \qquad R_3 = \rho\frac{\ell}{4A}$

$R_3 < R_1 < R_2$



15. 

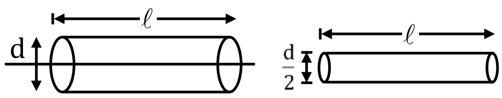
$\Rightarrow R_{AB} = \left(\frac{R/2}{2}\right) = \frac{R}{4}$

16. Material same $\Rightarrow \rho$ unchanged

$R = \frac{\rho\ell}{A} = \frac{\rho\ell}{\pi a^2} \Rightarrow R \propto \frac{\ell}{a^2}$

Therefore $R' \propto \frac{2\ell}{(2a)^2}$

$\Rightarrow R' = \frac{R}{2}$

17. 

Initial volume = final volume

$\frac{\pi d^2\ell}{4} = \frac{\pi d^2 L}{16}$ $\boxed{L = 4\ell}$ $A_f = \frac{A_i}{4}$

$R_i = \frac{\rho\ell}{A_i} \quad R_f = \rho\left(\frac{4\ell}{A_i}\right) = 16\,R_i$

18. $T\uparrow\ \rho\uparrow\ \sigma\downarrow$

$\rho \times \sigma$ = constant

19. $V_{old} = A\ell$

$V = AL \qquad R = \frac{\rho L}{A}$

New

$L' = L + \frac{L}{5} = \frac{6}{5}L$

$V = A'L' = AL$

$A' = \frac{5A}{6}$

$R' = \frac{\rho L'}{A'} = \frac{36}{25}R$

$\% \text{ change} = \frac{R' - R}{R} \times 100 = 44\%$

20. Volume remains same $\Rightarrow AL = A'(2L)$

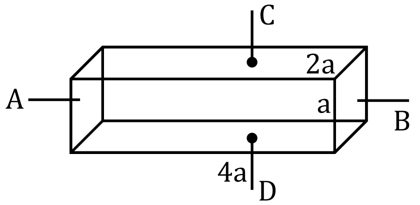
$A' = \frac{A}{2}$; $R_i = \frac{\rho L}{A}$

$R_f = \frac{\rho(2L)}{(A/2)} = 4R_i$

$\%\text{change} = \frac{4R_i - R_i}{R_i} \times 100 = 300\%$

21. Increase and decrease respectively.

22.



$x > z > y$

$\left(R = \rho\frac{\ell}{A}\right)$, A = Area of crossection.

23. The value ρ does not depends on geometry but increases with increase in temperature

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

$1 = R_0[1 + \alpha(27)]$

$2 = R_0[1 + \alpha(T)] \Rightarrow \frac{1}{2} = \frac{1+\alpha\times 27}{1+\alpha\times T}$ solve it.

25. For I – V slope $= \frac{I}{V} \propto \frac{1}{R} \propto \frac{1}{T}$ curve

Slope $\downarrow$ R $\uparrow$ T $\uparrow$

$\because R_2 > R_1 \therefore T_2 > T_1$

26. $\frac{2R}{2+R} = \frac{6}{5}$

$10R = 12 + 6R$; $R = 3\ \Omega$

27. $R = R_0 (1 + \propto\Delta t)$

$3R_0 = R_0(1 + 4 \times 10^{-3}\ T)$

$2 = 4 \times 10^{-3}\ T \quad \Rightarrow \quad T = \frac{1000}{2} = 500°C$

28. For conductor, $T\downarrow \rho\downarrow$

For semiconductor, $T\downarrow \rho\uparrow$

29. $R_1 = R_{01} (1+\alpha\Delta T)$

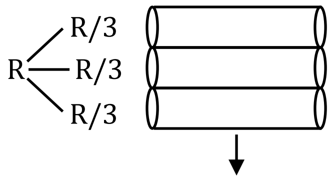
$R_2 = R_{02}(1 - \beta.\Delta T)$

$R_{series} = R_1 + R_2 = R_{01} + (R_{01}\alpha - R_{02}\beta)\Delta T + R_{02}$

Not depend on temperature

$R_{01}\alpha - R_{02}\beta = 0 \quad \Rightarrow \quad \frac{R_{01}}{R_{02}} = \frac{\beta}{\alpha}$

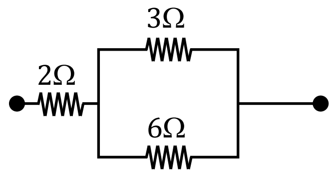
30.



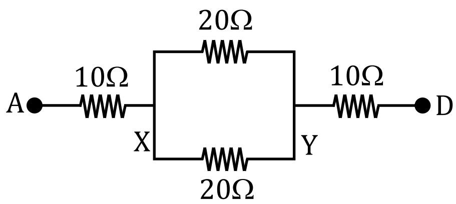
Parallel combination

$R_{eq} = \frac{R}{9}$

31.



32. Redraw circuit



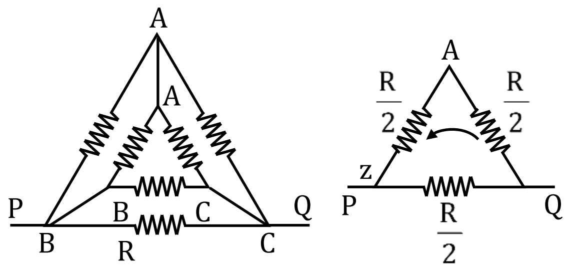
$R_{AD} = 30\ \Omega$

33. $\frac{(R+3).10}{(R+3)+10} + 3 = R$ (given)

solve it $(10R + 30) = (R - 3)(R + 13)$

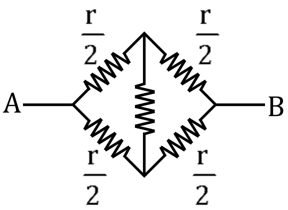
$10R + 30 = R^2 - 39 + 10R$ or $R = \sqrt{69}\ \Omega$

34.



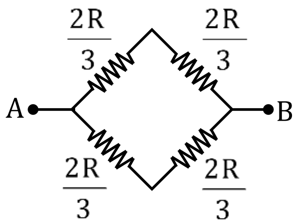
$R_{eq} = \frac{R}{3}$

35. After folding symmetry



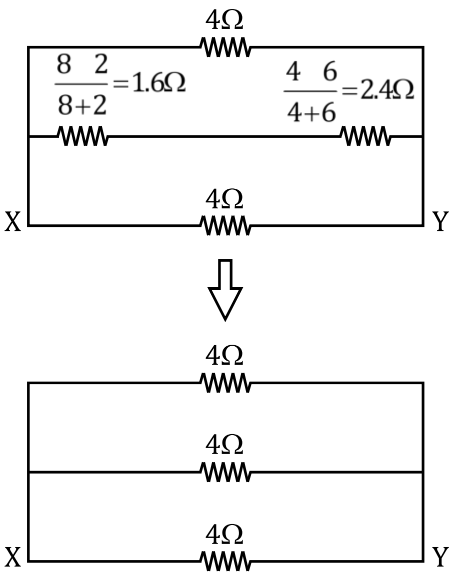
$R_{eq} = \frac{r}{2}$

36. It is balance Wheat Stone Bridge



$R_{AB} = \frac{2R}{3}\Omega$

37. Redrawing the circuit



$\text{Req} = \frac{4}{3}$

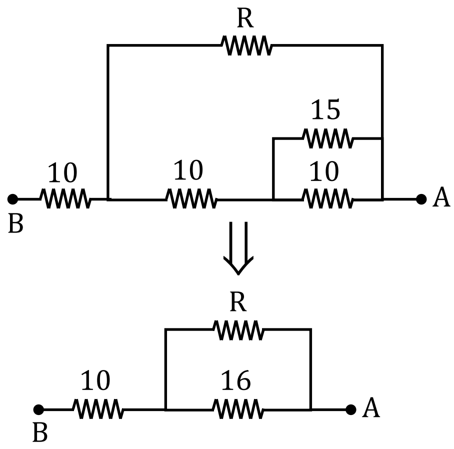
38. When they are connected in parallel

Then $R = \frac{r}{n} \Rightarrow r = nR$

When they are connected in series

Then $R_{eq.} = nr = n \times nR = n^2R$

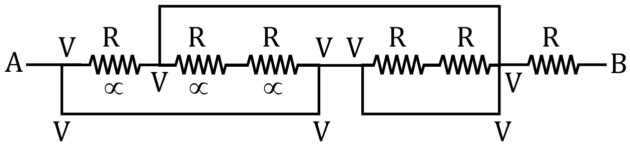
39.



$\frac{16R}{16+R} + 10 = 18$

40. $R_{AB} = 20\Omega$ Multiple W.S.B.

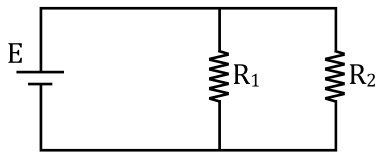
41.



$R_{eq} = R$

42. $R_{eq} = 6\Omega$

43.



$\frac{R_1R_2}{R_1 + R_2} = 6\Omega \Rightarrow R_1$ could be $= 8\Omega$

44. $I_{in} = I_{out}$

$10 + 1 + 2 = I \Rightarrow \boxed{I = 13A}$

45. $V_x + 2 \times 1 - 3 \times 1 = V_y$

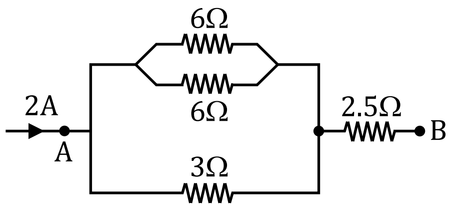
$V_x - V_y = +1$ volt

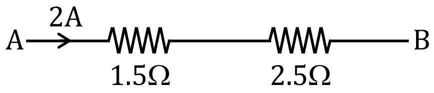
46. $I = \frac{V}{R_{eq}} = \frac{9}{\frac{9}{5}} = 5$ A

47. $i = 0.25 = \frac{12}{R+6} \Rightarrow R + 6 = 48 \Rightarrow R = 42\ \Omega$

48. $i = 2\ A = \frac{6}{2+R} \Rightarrow R = 1\Omega$

49.





$R_{eq} = 4\Omega \qquad V_{eq} = 8V$

50. In loop AHDCBA

$-30\ I_1 - 45 - I_3 - 40\ I_3 = 0$

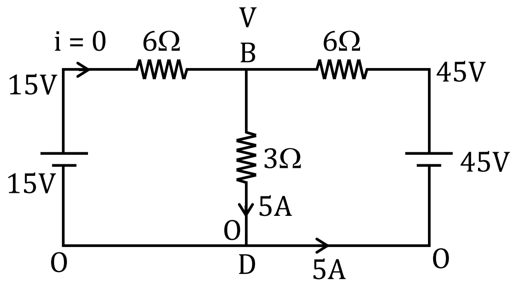
$-30\ I_1 - 41\ I_3 - 45 = 0$

In loop AHDCBA

$-30\ I_1 + 20\ I_2 + 1\ I_2 - 80 = 0$

$-30\ I_1 + 21\ I_2 - 80 = 0$

51.



$$\frac{V-15}{6}+\frac{V}{3}+\frac{V-45}{6}$$

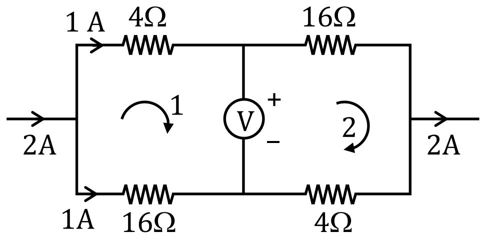
$V - 15 + 2V + V - 45 = 0$

$4V = 60$

$V = 15\ V$

$\therefore\ i_{BD} = \frac{V}{3} = \frac{15}{3} A = 5A$

52.



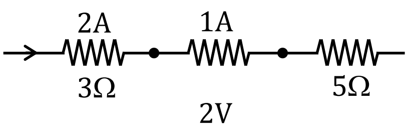
By KVL in loop (1)

$-4 \times 1 - V + 16 \times 1 = 0$

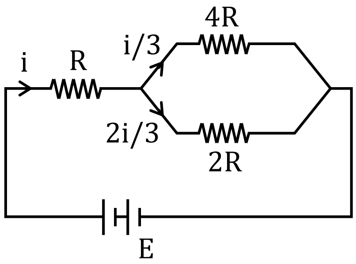
$V = 12$ Volts

53. $V_{JG} = \frac{32}{32+34} \times 60 = 20V$

54.

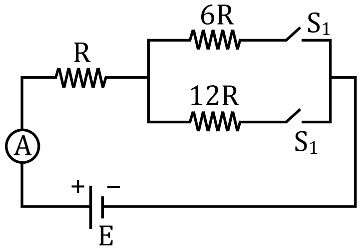


55. $i = \frac{3E}{7R}$



$$V = (2R)\frac{2}{3}\left(\frac{3E}{7R}\right) = \frac{4}{7}E$$

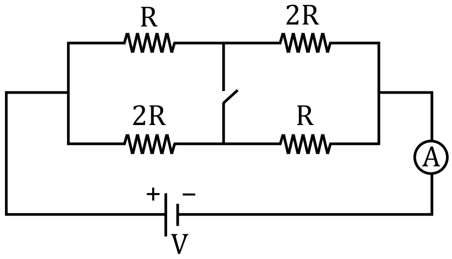
56.



$I_1 = \frac{E}{7R} \qquad I_2 = \frac{E}{13R} \qquad I_3 = \frac{E}{5R}$

$I_3 > I_1 > I_2$

57.



when key open

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

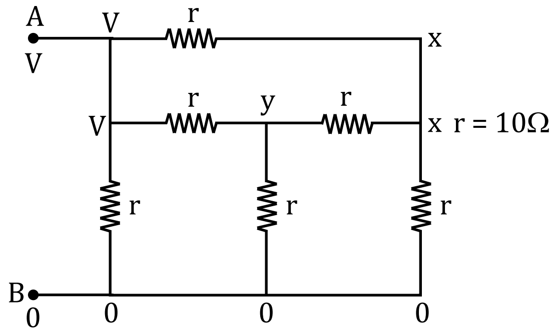
$i_0 = \frac{2V}{3R}$

when key closed

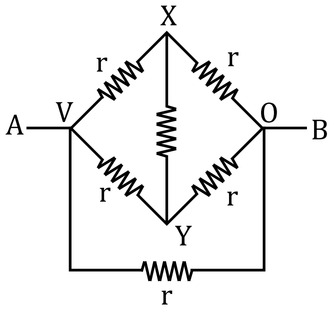
$R_{eq} = \frac{4R}{3}$

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

58.



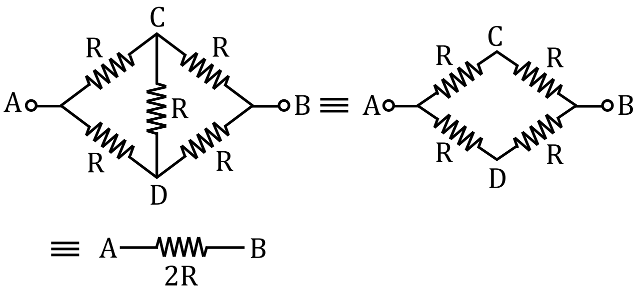
Balanced Wheat Stone Bridge



$R_{AB} = \frac{r}{2} = 5\Omega$

59. Given circuit can be reduced to

Balanced Wheat Stone Bridge

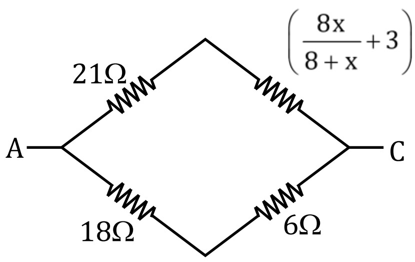


Required current = $\frac{V}{2R}$

60. Option (3) is correct.

61. Wheatstone bridge is in balance condition

62.

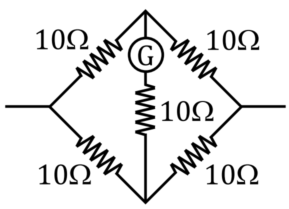


$\Rightarrow \frac{P}{Q} = \frac{R}{S}$

63. For balance wheat stone bridge

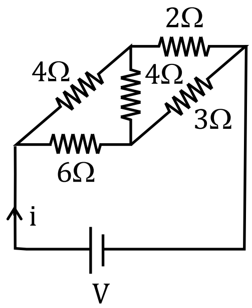
$\frac{16}{4} = \frac{x}{1/2}$; $x = 2\Omega$.

64. $R_{eq} = 10\ \Omega$



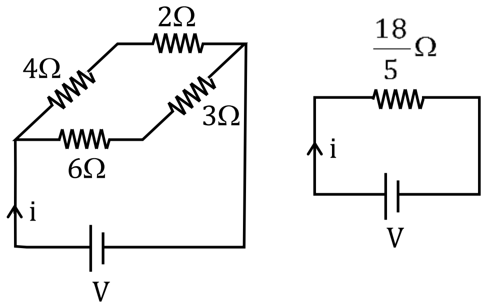
$R_{eq} = 10\Omega$

65.



Here $\frac{4}{6} = \frac{2}{3} \Rightarrow$ Balanced Wheat Stone Bridge

Therefore given circuit can be reduced to



$\Rightarrow i = \frac{5V}{18}$

66. $V = E - Ir = 4 - \frac{10}{20} \times 8 = 0V$ ($\because I = \frac{10}{20} = \frac{1}{2} A$)

67. When battery is connected to external resistance

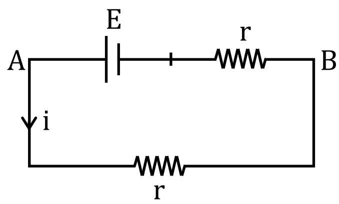
$\frac{4}{2+r} = 1 \Rightarrow r = 2\Omega$

When terminals of battery are connected directly

$i = 4/2 = 2A$

68. All

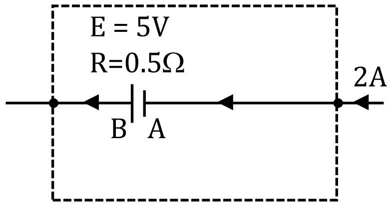
69.



$V_{AB} = 3 \quad \Rightarrow \quad i = 3/r$

$E - ir = 3 \quad \Rightarrow \quad E = 3 + ir = 3 + 3 = 6V$

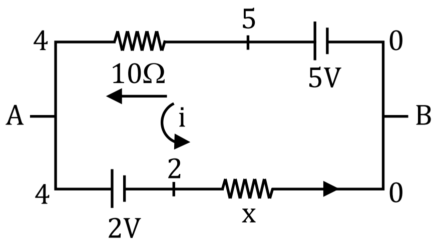
70.



$V_A + 5 - 2 \times 0.5 = V_B$

$10 + 5 - 1 = V_B \quad \Rightarrow \quad V_B = 14V$

71.



$i = \dfrac{5-4}{10} = 0.1A$

$x \times 0.1 = 2 \quad \Rightarrow \quad x = 20\Omega$

72. emf is basically work

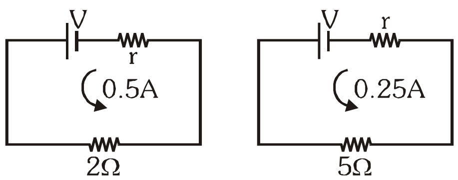
73. $\because I = \dfrac{E}{2+r}$, terminal potential $\dfrac{E}{2} = E - Ir$

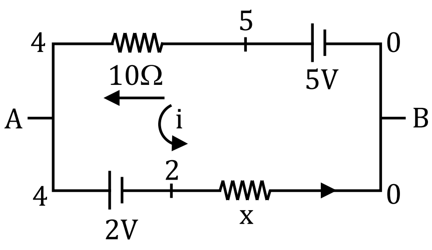
$\Rightarrow \dfrac{E}{2} = E - \dfrac{E}{2+r} r$

$\Rightarrow 2 + r = 2r$

$\Rightarrow r = 2\Omega$

74.





$V=0.5(2+r)$ ...(i)

$V=0.25(5+r)$ ...(ii)

for (i) & (ii)

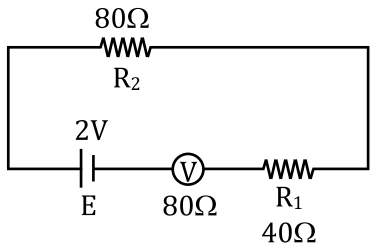
$0.5(2+r) = 0.25(5+r)$

$4 + 2r = 5 + r$

$r = 1$

$V = 0.5 \times 3 = 1.5V$

75.



$i = \dfrac{2}{200} = 0.01$ A

$V = 0.8$ V

76. $0.9 = \dfrac{V}{2+r}$

$0.3 = \dfrac{V}{7+r}$

$1.8 + 0.9r = 2.1 + 0.3r$

$0.6r = 0.3$

$r = \dfrac{1}{2}\ \Omega$

77. for maximum power $R_{internal} = R_{ext.}$

78. $R = \dfrac{v_0^2}{p_0}$; $P = \dfrac{V^2}{R} = \dfrac{V^2}{V_0^2} P_0 = \left(\dfrac{V}{V_0}\right)^2 P_0$

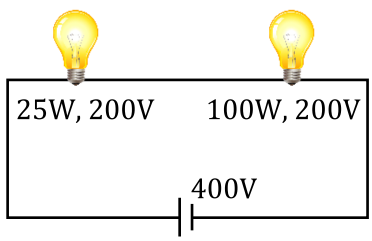
79. $P = \dfrac{V^2}{R_{eq.}} \Rightarrow R_{eq.} \downarrow P \uparrow$

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

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

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

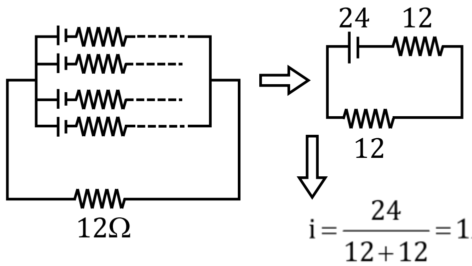
81.



$R = \dfrac{V_{rated}^2}{P_{rated}}$; $R_1 = \dfrac{(200)^2}{25}$; $R_2 = \dfrac{(200)^2}{100}$

$R_1 > R_2$; $V_1 > V_2$

thats why 25 W bulb fuse first

82. 

$$i = \frac{24}{12+12} = 1A$$

For $I_{max} = \frac{nr}{m} = R$ ...(1)

n = number of coloum

m = number of row

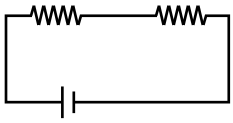
nm = 48 ...(2)

from eq (1) and (2)

n = 12

m = 4

83. $R_1 = \frac{V_1^2}{P}$ $R_2 = \frac{V_2^2}{P}$



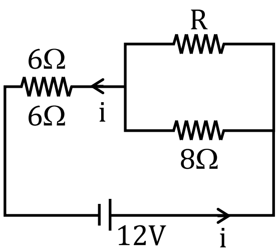
$i = \frac{\varepsilon}{\left(\frac{V_1^2}{P} + \frac{V_2^2}{P}\right)}$; Brightness $\propto$ power = (i^2R)

$$P_i = \frac{\varepsilon^2 V_1^2}{(V_1^2 + V_2^2)}$$

84. $P = \frac{V^2}{R_{eq}}$; $R_{eq} \downarrow P \uparrow$

85. For maximum power internal resistance should be equal to external resistance ($R_{ent} = R_{Int}$)

$R = \frac{r}{2}$

86. 

$i^2 6 = 6$ $\Rightarrow$ $i = \sqrt{\frac{6}{6}} = 1A$

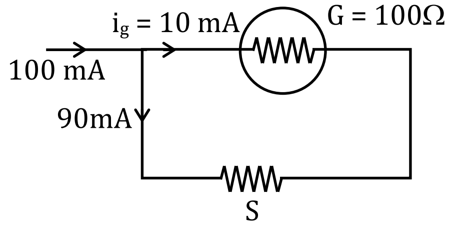
$$\left(6 + \frac{8R}{8+R}\right) = 6$$

$\frac{8R}{8+R} = 6$; $4R = 24 + 3R$ $\Rightarrow R = 24\ \Omega$

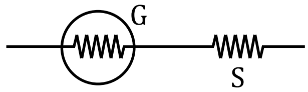
87. max $\rightarrow$ R = 1 $\Rightarrow$ $P = i^2R = 4W$

88. Net resistance of system will decrease.

$\therefore$ Reading of A will increase & reading of V will decrease.

89. 

$100 \times 10 = 90\ S \Rightarrow S = \frac{100}{9}\Omega$

90. 

$V = G\ i_g$

$nV = (G + S)i_g \Rightarrow n = \left(\frac{G+S}{G}\right) \Rightarrow S = (n - 1)\ G$

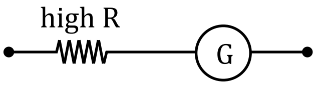
91. Initially

$\frac{R_1}{R_2} = \frac{x}{(1-x)} = \frac{10}{30} \Rightarrow x = 25$ cm

Finally after interchange

$\frac{y}{1-y} = \frac{30}{10} \Rightarrow y = 75$ cm

shifting = 50 cm

92. Voltmeter □ 

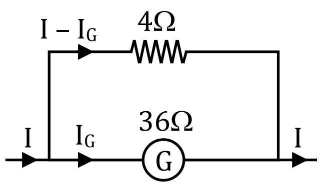
93. If radius of wire is doubled then resistance becomes 1/4 times but ratio of AC : CB remains same.

94. $V = I(R + R_A) \Rightarrow 12 = 0.1(R + 20)$

$\Rightarrow R = \frac{12}{0.1} - 20$ $R = 100\ \Omega$

95. $R = (n-1)G$

Here $n = \frac{10}{1} = 10 \Rightarrow R = (10 - 1)G = 9G$

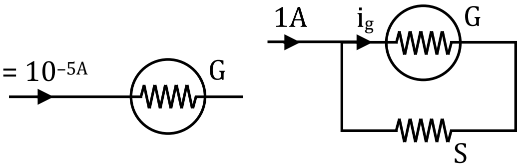
96. 

$V_G = V_R$

$\Rightarrow 4(I - I_G) = 36 I_G$

$\Rightarrow 10 I_G = I \Rightarrow \frac{I_G}{I} = \frac{1}{10}$

97. $i_g = 10^{-5}$A



$V = 10^{-3}$ V

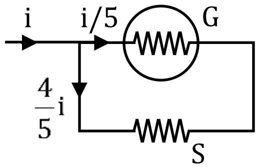
$Gi_g = S(1 - i_g)$

$10^{-3} = S(1 - 10^{-5})$

$S \approx 10^{-3}\ \Omega$

98. High resistance $\Rightarrow$ Good voltmeter

99.



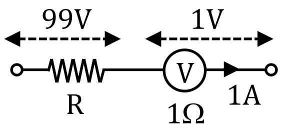
$$\frac{i}{5}G = \frac{4i}{5}S\ ;\ S = \frac{G}{4}$$

100. $\frac{R_1 + 10}{R_2} = \frac{50}{50} = 1 \Rightarrow R_1 + 10 = R_2$ ... (i)

$\frac{R_1}{R_2} = \frac{40}{60} \Rightarrow 3R_1 = 2R_2$ ... (ii)

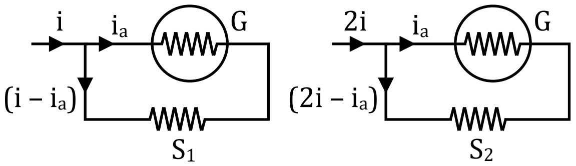
$R_1 + 10 = \frac{3}{2}R_1 \Rightarrow R_1 = 20\ \Omega$

101.



$99 = 1 \times R \Rightarrow R = 99\Omega$

102.



$Gi_a = S_1(i - i_a)$ ...(i)

$Gi_a = (2i - i_a)S_2$ ...(ii)

Equation (i) = (ii)

$$S_1(i - i_a) = S_2(2i - i_a) \Rightarrow \frac{S_1}{S_2} = \left(\frac{2i - i_a}{i - i_a}\right)$$

Exercise-II (Previous Year Questions)

1. Resistance = (0.5Ω/km) (150 km) = 75Ω

Total voltage drop = (8 V/km) (150 km) = 1200V

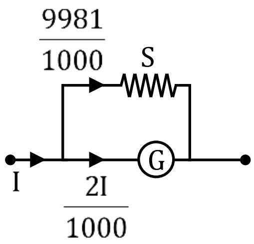
$$\text{Power loss} = \frac{(\Delta V)^2}{R} = \frac{(1200)^2}{75}\text{ W}$$

= 19200 W = 19.2 kW

2. $\frac{5}{R} = \frac{\ell_1}{100 - \ell_1}$ and $\frac{5}{R/2} = \frac{1.6\ell_1}{100 - 1.6\ell_1}$

$\Rightarrow R = 15\Omega$

3.



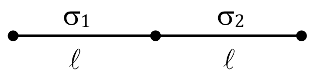
$$\left(\frac{2I}{1000}\right)G = \left(\frac{998I}{1000}\right)S$$

$$\Rightarrow S = \frac{G}{499}$$

Total resistance of Ammeter

$$R = \frac{SG}{S+G} = \frac{\left(\frac{G}{499}\right)}{\left(\frac{G}{499}\right) + G} = \frac{G}{500}$$

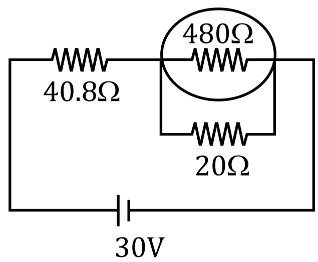
4.



$R_{eq} = R_1 + R_2$

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

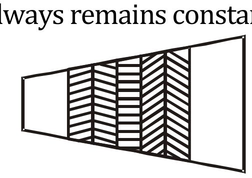
5.



$$R_{eff} = 40.8 + \frac{480 \times 20}{480 + 20} = 40.8 + 19.2 = 60\ \Omega$$

$$I = \frac{V_{eff}}{R_{eff}} = 0.5\text{ A}$$

6. Metallic conductor can be considered as the combination of various conductors connected in series combination. In series combination the current always remains constant.



7. Effective resistance of B & C = $\frac{(1.5R)(3R)}{1.5R+3R}=R$

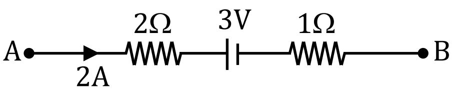
In series sequence $V \propto R$

so voltage across 'A' = voltage across B & C

Now B & C are parallel so $V_B = V_C$

$\Rightarrow$ $V_A = V_B = V_C$

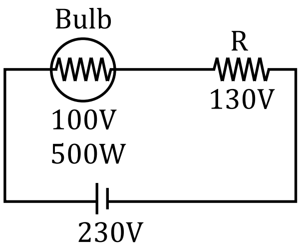
8.



$V_B = V_A - (2 \times 2) - 3 - (2 \times 1)$

$\Rightarrow V_A - V_B = 9V$

9.



Current through bulb = $\frac{P}{V}=\frac{500W}{100V}=5A$

Therefore $R=\frac{130V}{5A}=26\Omega$

10. $R=\frac{\rho\ell}{A}=\frac{\rho\ell^2}{\text{volume}}\Rightarrow R\propto\ell^2$

$\Rightarrow R_2 = n^2R_1$

11. $I=\frac{E}{nR+R}$ ... (1)

$10I=\frac{E}{\frac{R}{n}+R}=\frac{nE}{R+nR}$ ... (2)

From (1) & (2),

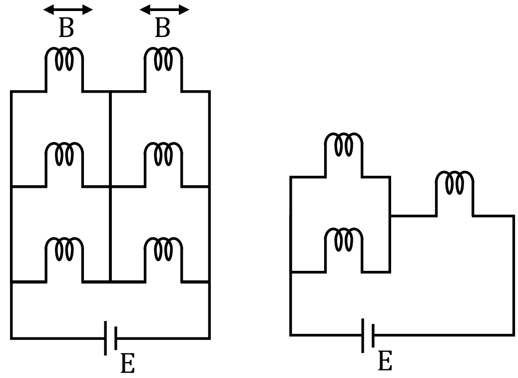
$n\frac{E}{R+nR}=10\left(\frac{E}{nR+R}\right)$ $\Rightarrow$ n = 10

12. $I=\frac{nE}{nr}=\frac{E}{r}=\text{constant}$

13. $\frac{\theta}{i}=\frac{50}{10^{-3}}=5000,\ \frac{\theta}{V}=20$

$\frac{\theta/i}{\theta/V}=\frac{5000}{10}=250 \Rightarrow \frac{V}{i}=R=250\Omega$

14.



Case-I **Case-II**

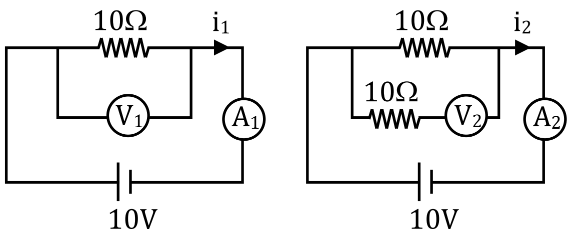
$R_{eq_1}=2R/3$ $R_{eq_2}=R/2+R=\frac{3R}{2}$

$P_{eq_1}=\frac{E^2}{2R/3}=\frac{3P}{2}$ $P_{eq_2}=\frac{E^2}{3R/2}=\frac{2P}{3}$

$\therefore\ P_{eq_1}:P_{eq_2}=9:4$

15. Fuse is used for protection.

16.



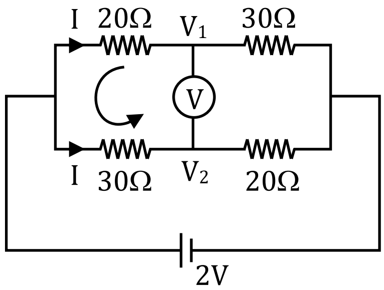
Circuit 1 Circuit 2

10Ω is in series with ideal voltmeter. Therefore it will not affect the circuit (Circuit-2)

$i_1=\frac{10}{10}=1A$ $i_2=\frac{10}{10}=1A$

$V_1 = 10V$ $V_2 = 10V$

17.



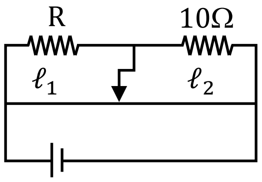
$(V_1 - V_2)=\frac{30}{25}-\frac{20}{25}=\frac{10}{25}=\frac{2}{5}=0.4\ V$

18. Interchanging cell and galvanometer do not effect balance condition.

19. $\mu=\frac{v_d}{E}=\frac{7.5\times10^{-4}}{3\times10^{-10}}=2.5\times10^{6}\ m^2/V\text{-}s$

20. For some metals like copper, resistivity is nearly proportional to temperature although a non linear region always exists at very low temperature.

21.



$$\frac{R}{10}=\frac{\ell_1}{\ell_2} \Rightarrow \frac{R}{10} = \frac{3}{2} \Rightarrow R = 15\Omega$$

Length of 15Ω resistance wire is 1.5 m

$\therefore$ length of 1Ω resistance wire = $\frac{1.5}{15}$ = 0.1 m

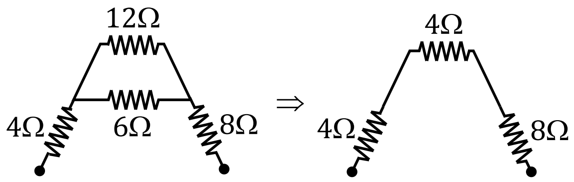
22. $I = \frac{2+4}{4+1+1} = \frac{6V}{6\Omega} = 1\ A$

23. By KVL

$-I_2R_2 - E_2 + E_3 + I_3R_1 = 0$

$I_2R_2 + E_2 - E_3 - I_3R_1 = 0$

24.



$\Rightarrow R_{AB} = 16\Omega$

25. Resistance of conductor, $R=\frac{\rho\ell}{A} \Rightarrow A=\frac{\rho\ell}{R}$

$$\Rightarrow \frac{A_1}{A_2}=\frac{\rho_1}{\rho_2}\times\frac{\ell_1}{\ell_2}\times\left(\frac{R_2}{R_1}\right)=1$$

[$\because$ $R_1 = R_2$, $\ell_1 = \ell_2$ and for same material $\rho_1 = \rho_2$]

26. (A) $\upsilon_d=\left(\frac{eE}{m}\right)\tau$

(B) $J = \sigma E = E/\rho \Rightarrow \rho = E/J$

(C) $\rho=\frac{E}{ne\upsilon_d}$

$\upsilon_d=\frac{E}{ne\rho}$

$\frac{eE}{m}\tau=\frac{E}{ne\rho}$

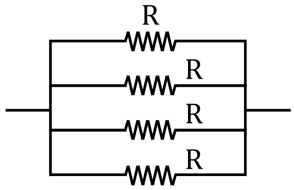
$\tau=\frac{m}{ne^2\rho}$

(D) $I = neA\upsilon_d$

$\frac{i}{A}=ne\upsilon_d$

$J = ne\upsilon_d$

27. $R_l = \frac{R}{4} = 0.25\,\Omega$



R = 1 Ω

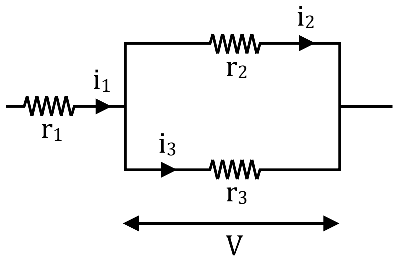
R_{series} = 4R = 4(1) = 4Ω

28. V = ir

$i=\frac{V}{r}$

$i\propto\frac{1}{r}$ [V is same for r_2 & r_3]

$\frac{i_2}{i_3}=\frac{r_3}{r_2}$



$i_3=\frac{r_2}{r_2+r_3}i_1$

$\frac{i_3}{i_1}=\frac{r_2}{r_2+r_3}$

29. $V=\frac{1}{4\pi\epsilon_0}\cdot\frac{Q}{R}$

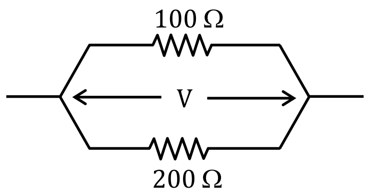
$\frac{1}{4\pi\epsilon_0}=\text{constant}$

Q = same (Given)

$\therefore V\propto\frac{1}{R}$

$\therefore$ Potential is more on smaller sphere.

30.



As both resistors are in parallel combination so potential drop (V) across both are same.

$P=\frac{V^2}{R}\Rightarrow P\propto\frac{1}{R}$

$\frac{P_1}{P_2}=\frac{R_2}{R_1}=\frac{200}{100}=\frac{2}{1}$ = 2 : 1

31. For conductors α is (+)ve

For semiconductors & Insulators α is (–)ve

32. Radius of wire $= \dfrac{10^{-2}}{\sqrt{\pi}}$

Cross sectional area A = $\pi r^2 = 10^{-4}$ m²

$j = \dfrac{i}{A} = \left(\dfrac{V}{R}\right) \cdot \dfrac{1}{A} = \dfrac{E\ell}{RA} \qquad R = \dfrac{\rho\ell}{A}$

$j = \dfrac{10\times10}{10\times10^{-4}} = 10^5\ A/m^2$

or

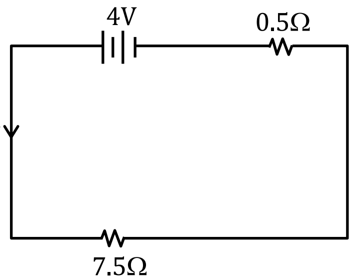
$J = \sigma E \Rightarrow \dfrac{E}{\rho} = \dfrac{E\ell}{RA} = \dfrac{10\times10\times\pi}{10\times10^{-4}\times\pi}$

$\Rightarrow 10^5\ A/m^2$

33. Resistance of P & Q should be approx. equal as it decreases error in experiment.

34. $i = \dfrac{4}{7.5+0.5}$

= 0.5A

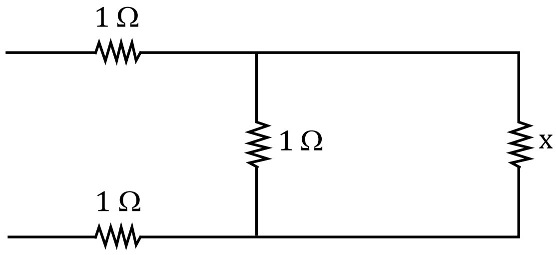


TPD = 4 – 0.5 × 0.5

= 4 – 0.25

TPD = 3.75 volt

35. If effective resistance is x,



$\Rightarrow x = 1 + \dfrac{x\times1}{x+1} + 1$

$\Rightarrow (x-2) = \dfrac{x}{x+1}$

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

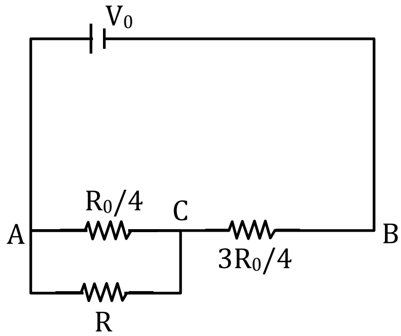
$\Rightarrow x^2 - 2x - 2 = 0$

So, $x = \dfrac{2\pm\sqrt{12}}{2} = 1 \pm \sqrt{3}\,\Omega$

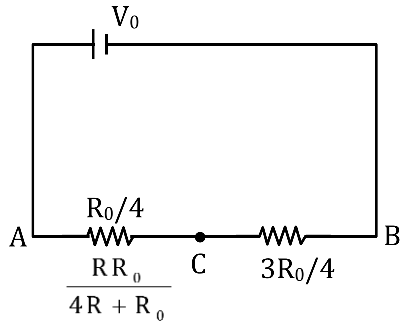
neglecting negative value, $x = 1 + \sqrt{3}\,\Omega$

36. Conductance = $\dfrac{1}{\text{Resistance}}$

37.



$\Rightarrow$

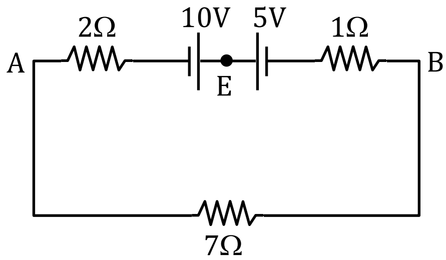


In series, potential divides in direct ratio of resistance,

So, $V_{AC} = \dfrac{R_{AC}}{R_{AC}+R_{CB}} V_0$

$= \dfrac{\dfrac{RR_0}{4R+R_0}}{\dfrac{RR_0}{4R+R_0} + \dfrac{3R_0}{4}} \times V_0 = \dfrac{4RV_0}{16R+3R_0}$

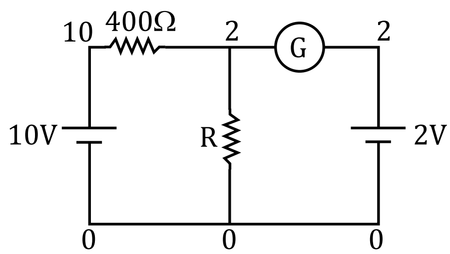
38. $i = \dfrac{10-5}{10} = \dfrac{5}{10}$ A



= 0.5 A

from A to B through E.

39. For no reading galvanometer. Potential across it is same.



$$i_{400\Omega} \Rightarrow \frac{10-2}{400} = \frac{8}{400} = \frac{1}{50} = i_R$$

$$i_R \Rightarrow \frac{V_R}{R} \Rightarrow \frac{2}{R} = \frac{1}{50} \Rightarrow R = 100\Omega$$

40. $R_T = R_0\left[1+\alpha\left(T-T_0\right)\right]$

$6.8 = 2[1+\alpha(80-\alpha)]$

$\alpha = \frac{2.4}{80} = 0.03/°C = 3 \times 10^{-2}/°C$

41. $I_S = \frac{E}{10R}$ ... (1)

$I_P = \frac{E}{R/10} = \frac{10E}{R}$ ... (2)

$n = \frac{I_P}{I_S} = 100 \Rightarrow n = 100$

42. $R = \frac{\rho L}{A}$ If diameter becomes thrice then cross Section area will become 9 times so

$R \propto \frac{1}{A}$ Resistance will become $\frac{1}{9}$ times

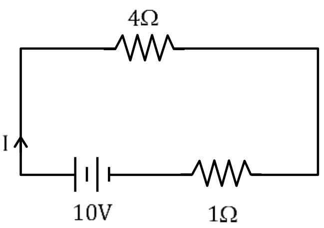
$R' = \frac{81\Omega}{9} = 9\Omega$

43. $I = neAV_d$

$V_d = \frac{I}{neA} = \frac{10}{10^{22} \times 1.6 \times 10^{-19} \times \pi \times 10^{-6}}$

$V_d = \frac{6.25}{\pi} \times 10^3\ ms^{-1}$

44.



$I = \frac{E}{R+r} = \frac{10}{4+1} = 2A$

$V_T = E - Ir$

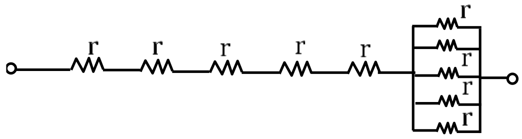
$= 10 - 2\ (1)$

$= 8V$

45. Wire resistance = 100Ω

Divided into 10 equal parts

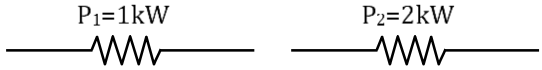
so each part resistance $r = \frac{100}{10} = 10\Omega$



Req. $= 5(10) + \frac{10}{5}$

$= 52\ \Omega$

46.



In series $P_S = \frac{P_1P_2}{P_1+P} = \frac{1\times 2}{1+2} = \frac{2}{3}$kW

In parallel $P_P = P_1 + P_2 = 1 + 2 = 3$kW

$\Rightarrow \frac{P_S}{P_P} = \frac{\frac{2}{3}}{3} = \frac{2}{9}$

47. Using $i = neAv_d$

$100 \times 10^{-3} = n \times \pi\left(\frac{d}{2}\right)^2 ev$ .....(1)

$200 \times 10^{-3} = n \times \pi\left[\frac{d/2}{2}\right]^2 \times e \times v'$ .....(2)

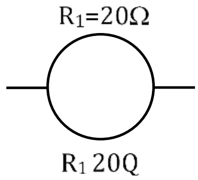
On Solving ; v' = 8v

48. $\ell \rightarrow 10\Omega$

$\because R \propto \ell^2$

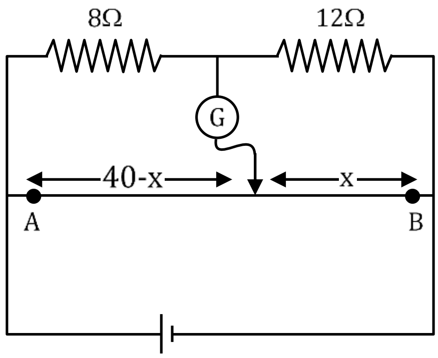
$\therefore$ for 2ℓ length R = 40Ω

Now



$R_{eff} = \frac{R_1}{2} = 10\Omega$

49.



8 (x) = 12(40 – x)

2x = 120 – 3x ⇒ 5x = 120 ⇒ x = 24 cm

Exercise-III (Analytical Questions)

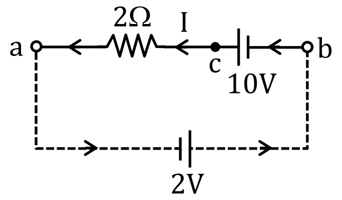
1. $\because V_1$ and V_2 are in series

$\therefore V \propto R$

$\therefore V_1 \neq V_2$ (as $R_1 \neq R_2$)

$V_1 + V_2 = V_3$ (as V is same in parallel)

2.



$I = \frac{12}{2} = 6A$

Apply KVL from a to c

$V_a + 6 \times 2 = V_c$

$V_a - V_c = -12$ Volt

3. $E = 10V$, $I_{max} = \frac{E}{r} = 2$ Amp.

$r = \frac{E}{2} \Rightarrow r = \frac{10}{2} = 5\Omega$

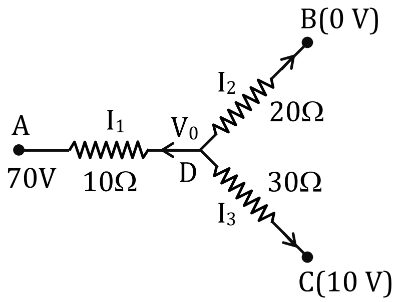
4. $\frac{V^2}{R}t$ = constant

$\therefore t \propto R$

In series $t_s = t_1 + t_2$

In parallel $t_p = \frac{t_1 t_2}{t_1 + t_2}$

5.



$I_1 + I_2 + I_3 = 0$

$\frac{V_0 - 70}{10} + \frac{V_0 - 0}{20} + \frac{V_0 - 10}{30} = 0$

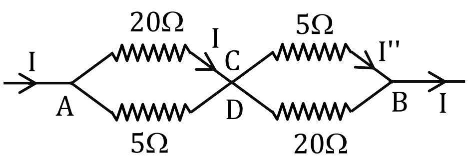
$\Rightarrow V_0 = 40$ volt

$I_1 = 3A$

$I_2 = 2A$

$I_3 = 1A$

6.

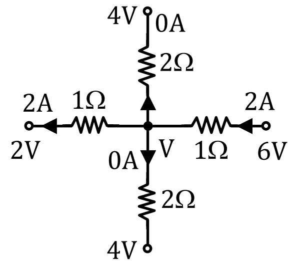


$I' = \frac{5}{25}I = \frac{I}{5}$ $\qquad R_{eq} = 4 + 4 = 8\Omega$

$I'' = \frac{20}{25}I = \frac{4I}{5}$ $\qquad$ Also $= V_C = V_D$

Current in DC $= \frac{4I}{5} - \frac{I}{5} = 3I/5$

7.



$\frac{V-2}{1} + \frac{V-6}{1} + \frac{V-4}{2} + \frac{V-4}{2} = 0$

$2V - 4 + 2V - 12 + V - 4 + V - 4 = 0$

$6V = 24$

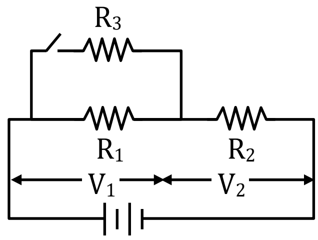
$V = 4$

2A, – 2A, 0A, 0A

8. i = constant

as area $\uparrow \Rightarrow R/\ell \downarrow$ & $E\downarrow \Rightarrow \frac{V}{L}\downarrow$ & $J = \frac{i}{A}\downarrow$

9.



After closing the switch $V_1\downarrow$ and $V_2\uparrow$

$\Rightarrow$ i through $R_1\downarrow$ and i through $R_2\uparrow$.

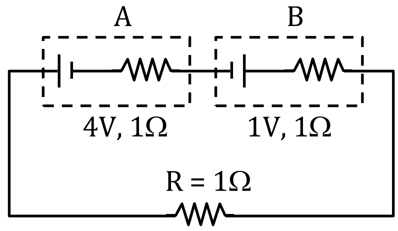
10. $V = \frac{\text{Work}}{q} = \frac{[ML^2T^{-2}]}{[AT]} = [ML^2T^{-3}A^{-1}]$

$R = \frac{V}{i} = [ML^2T^{-3}A^{-2}]$

$\rho = \frac{RA}{\ell} = [ML^3T^{-3}A^{-2}]$

$\sigma = \frac{1}{\rho} = [M^{-1}L^{-3}T^3A^2]$

11.



$$i=\frac{4-1}{1+1+1}=1A$$

Now TPD of A = 4 – 1 × 1 = 3V

TPD of B = 1 + 1 × 1 = 2V

Power consumed by R = $1^2 \times 1$ = 1W

P.D. of R = 1 × 1 = 1V

12. Increase in temperature causes atoms to vibrate more, which increases the number of collisions electrons suffer and decrease the drift velocity.

OR $\vec{v}_d=\mu E=\left(\frac{e\tau}{m}\right)\vec{E}$ & $\sigma=\frac{ne^2\tau}{m}$

$v_d \propto \tau$, $\sigma \propto \tau$ (temp. ↑; τ↓)

13. $S(i-i_0)=i_0G$

$$\Rightarrow i=i_0\left(1+\frac{G}{S}\right)$$

∴ As S↑ i↓

∴ Value of shunt is more in mili ammeter.

$$R_{net}=\frac{GS}{S+G}=\frac{G}{1+\frac{G}{S}}$$

∴ S↑ ⇒ R_{net}↑

⇒ $R_{\text{mili ammeter}} > R_{\text{ammeter}}$

14. A current carrying wire is not charged.

15. In balanced condition, current through galvanometer is zero and does not affect main current.

16. For rating, $P=\frac{V^2}{R}$ ∴ P↑ ⇒ R↓

17. * For maximum power R = r

* $P = I^2R \propto I^2$ (if R = constant)

18. At higher currents, joule's heating will be larger, increasing the temperature sharply. Since,

$R = R_0(1 + \propto \Delta T)$, resistance varies and $V \propto I$ doesn't hold anymore.

19. For meter bridge experiment, unknown resistance $S=\frac{100-\ell}{\ell}R$

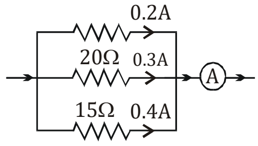
20. $\Delta KE = q(\Delta V)$

21. As i changes (in same resistor); n remain constant

by i = JA ; J become double

by $i = nAeV_d$; V_d become double

23.



$0.2R_1 = 20 \times 0.3 = 15 \times 0.4$

26. For (A) :

$$\vec{E}=-\frac{\partial V}{\partial x}\hat{i}-\frac{\partial V}{\partial y}\hat{j}-\frac{\partial V}{\partial z}\hat{k}=\frac{1}{x^2}\hat{i}+\frac{1}{y^2}\hat{j}+\frac{1}{z^2}\hat{k}$$

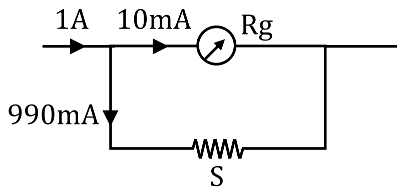
$$\Rightarrow |\vec{E}|=|\hat{i}+\hat{j}+\hat{k}|=\sqrt{3}\ N/C$$

For (B) :

$I=\frac{dQ}{dt}=4-4t$, current will be zero at t = 1s

Total heat produced

$$\int_0^1 I^2R\,dt=\int_0^1(4-4t)^2(6)dt=(16\times 6)\left[\frac{(1-t)^3}{-3}\right]_0^1=32J$$



For(C) (10 mA) (Rg) = (990 mA) (s)

$$\Rightarrow s=\frac{0.99}{99}=0.01\Omega$$

For(D) $U=-\vec{p}.\vec{E}$ Here $\vec{p}=\pm qd\hat{i}$

$|\vec{P}| = (10 \times 10^{-3})(8 \times 10^{-2}) = \pm(8 \times 10^{-4})\ \hat{i}$ C-m

$U = -pE\cos\theta$

$U = (8 \times 10^{-4})(500)$

U = 0.4 J