ELECTRIC CURRENT IN CONDUCTORS
CHAPTER - 32

1. $Q(t) = At^2 + Bt + c$

   a) $At^2 = Q$

   $\Rightarrow A = \frac{Q}{t^2} = \frac{A'T'}{T^{-2}} = A^1T^{-1}$

   b) $Bt = Q$

   $\Rightarrow B = \frac{Q}{t} = \frac{A'T'}{T} = A$

   c) $C = [Q]$

   $\Rightarrow C = A'T'$

   d) Current $t = \frac{dQ}{dt} = \frac{d}{dt}\left(At^2 + Bt + C\right)$

   $= 2At + B = 2 \times 5 \times 5 + 3 = 53$ A.

2. No. of electrons per second $= 2 \times 10^{16}$ electrons / sec.

   Charge passing per second $= 2 \times 10^{16} \times 1.6 \times 10^{-9}$ $\frac{\text{coulomb}}{\text{sec}}$

   $= 3.2 \times 10^{-9}$ Coulomb/sec

   Current $= 3.2 \times 10^{-3}$ A.

3. $i' = 2\ \mu A$, $t = 5$ min $= 5 \times 60$ sec.

   $q = i\,t = 2 \times 10^{-6} \times 5 \times 60$

   $= 10 \times 60 \times 10^{-6}$ c $= 6 \times 10^{-4}$ c

4. $i = i_0 + \alpha t$, $t = 10$ sec, $i_0 = 10$ A, $\alpha = 4$ A/sec.

   $q = \int_0^t i dt = \int_0^t (i_0 + \alpha t)dt = \int_0^t i_0 dt + \int_0^t \alpha t dt$

   $= i_0 t + \alpha\frac{t^2}{2} = 10 \times 10 + 4 \times \frac{10 \times 10}{2}$

   $= 100 + 200 = 300$ C.

5. $i = 1$ A, $A = 1\ mm^2 = 1 \times 10^{-6}\ m^2$

   f' cu $= 9000$ kg/m^3

   Molecular mass has N_0 atoms

   $=$ m Kg has $(N_0/M \times m)$ atoms $= \frac{N_0 Al 9000}{63.5 \times 10^{-3}}$

   No.of atoms = No.of electrons

   $n = \frac{\text{No.of electrons}}{\text{Unit volume}} = \frac{N_0 Af}{mAl} = \frac{N_0 f}{M}$

   $= \frac{6 \times 10^{23} \times 9000}{63.5 \times 10^{-3}}$

   $i = V_d\, n\, A\, e.$

   $\Rightarrow V_d = \frac{i}{nAe} = \frac{1}{\frac{6 \times 10^{23} \times 9000}{63.5 \times 10^{-3}} \times 10^{-6} \times 1.6 \times 10^{-19}}$

   $= \frac{63.5 \times 10^{-3}}{6 \times 10^{23} \times 9000 \times 10^{-6} \times 1.6 \times 10^{-19}} = \frac{63.5 \times 10^{-3}}{6 \times 9 \times 1.6 \times 10^{26} \times 10^{-19} \times 10^{-6}}$

$= \dfrac{63.5 \times 10^{-3}}{6 \times 9 \times 1.6 \times 10} = \dfrac{63.5 \times 10^{-3}}{6 \times 9 \times 16}$

$= 0.074 \times 10^{-3}$ m/s = 0.074 mm/s.

6. ℓ = 1 m, r = 0.1 mm = 0.1×10^{-3} m

R = 100 Ω, f = ?

$\Rightarrow R = f\ell / a$

$\Rightarrow f = \dfrac{Ra}{\ell} = \dfrac{100 \times 3.14 \times 0.1 \times 0.1 \times 10^{-6}}{1}$

$= 3.14 \times 10^{-6} = \pi \times 10^{-6}\ \Omega$-m.

7. $\ell' = 2\ell$

volume of the wire remains constant.

$A\ell = A'\ell'$

$\Rightarrow A\ell = A' \times 2\ell$

$\Rightarrow A' = A/2$

f = Specific resistance

$R = \dfrac{f\ell}{A}$; $R' = \dfrac{f\ell'}{A'}$

$100\ \Omega = \dfrac{f2\ell}{A/2} = \dfrac{4f\ell}{A} = 4R$

$\Rightarrow 4 \times 100\ \Omega = 400\ \Omega$

8. ℓ = 4 m, A = 1 mm^2 = 1×10^{-6} m^2

I = 2 A, n/V = 10^{29}, t = ?

$i = n A V_d e$

$\Rightarrow e = 10^{29} \times 1 \times 10^{-6} \times V_d \times 1.6 \times 10^{-19}$

$\Rightarrow V_d = \dfrac{2}{10^{29} \times 10^{-6} \times 1.6 \times 10^{-19}}$

$= \dfrac{1}{0.8 \times 10^{4}} = \dfrac{1}{8000}$

$t = \dfrac{\ell}{V_d} = \dfrac{4}{1/8000} = 4 \times 8000$

$= 32000 = 3.2 \times 10^{4}$ sec.

9. $f_{cu} = 1.7 \times 10^{-8}\ \Omega$-m

A = 0.01 mm^2 = 0.01×10^{-6} m^2

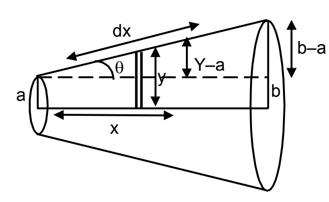
R = 1 KΩ = $10^{3}\ \Omega$

$R = \dfrac{f\ell}{a}$

$\Rightarrow 10^{3} = \dfrac{1.7 \times 10^{-8} \times \ell}{10^{-6}}$

$\Rightarrow \ell = \dfrac{10^{3}}{1.7} = 0.58 \times 10^{3}$ m = 0.6 km.

10. dR, due to the small strip dx at a distanc x d = R = $\dfrac{fdx}{\pi y^2}$ …(1)



$\tan\theta = \dfrac{y-a}{x} = \dfrac{b-a}{L}$

$\Rightarrow \dfrac{y-a}{x} = \dfrac{b-a}{L}$

$\Rightarrow L(y-a) = x(b-a)$

$\Rightarrow$ Ly – La = xb – xa

$\Rightarrow$ $L\frac{dy}{dx} - 0 = b - a$ (diff. w.r.t. x)

$\Rightarrow$ $L\frac{dy}{dx} = b - a$

$\Rightarrow$ dx = $\frac{Ldy}{b-a}$ …(2)

Putting the value of dx in equation (1)

dR = $\frac{fLdy}{\pi y^2 (b-a)}$

$\Rightarrow$ dR = $\frac{fl}{\pi(b-a)}\frac{dy}{y^2}$

$\Rightarrow$ $\int_0^R dR = \frac{fl}{\pi(b-a)}\int_a^b \frac{dy}{y^2}$

$\Rightarrow$ R = $\frac{fl}{\pi(b-a)}\frac{(b-a)}{ab} = \frac{fl}{\pi ab}$.

11. r = 0.1 mm = 10^{-4} m

R = 1 KΩ = 10^3 Ω, V = 20 V

a) No.of electrons transferred

i = $\frac{V}{R} = \frac{20}{10^3}$ = 20 $\times$ 10^{-3} = 2 $\times$ 10^{-2} A

q = i t = 2 $\times$ 10^{-2} $\times$ 1 = 2 $\times$ 10^{-2} C.

No. of electrons transferred = $\frac{2\times 10^{-2}}{1.6\times 10^{-19}} = \frac{2\times 10^{-17}}{1.6}$ = 1.25 $\times$ 10^{17}.

b) Current density of wire

= $\frac{i}{A} = \frac{2\times 10^{-2}}{\pi\times 10^{-8}} = \frac{2}{3.14}\times 10^{+6}$

= 0.6369 $\times$ 10^{+6} = 6.37 $\times$ 10^5 A/m^2.

12. A = 2 $\times$ 10^{-6} m^2, I = 1 A

f = 1.7 $\times$ 10^{-8} Ω-m

E = ?

R = $\frac{f\ell}{A} = \frac{1.7\times 10^{-8}\times \ell}{2\times 10^{-6}}$

V = IR = $\frac{1\times 1.7\times 10^{-8}\times \ell}{2\times 10^{-6}}$

E = $\frac{dV}{dL} = \frac{V}{l} = \frac{1.7\times 10^{-8}\times \ell}{2\times 10^{-6}\ell} = \frac{1.7}{2}\times 10^{-2}\,V/m$

= 8.5 mV/m.

13. I = 2 m, R = 5 Ω, i = 10 A, E = ?

V = iR = 10 $\times$ 5 = 50 V

E = $\frac{V}{l} = \frac{50}{2}$ = 25 V/m.

14. $R'_{Fe} = R_{Fe}(1 + \alpha_{Fe}\,\Delta\theta)$, $R'_{Cu} = R_{Cu}(1 + \alpha_{Cu}\,\Delta\theta)$

$R'_{Fe} = R'_{Cu}$

$\Rightarrow$ $R_{Fe}(1 + \alpha_{Fe}\,\Delta\theta)$, = $R_{Cu}(1 + \alpha_{Cu}\,\Delta\theta)$

$\Rightarrow$ 3.9 [1 + 5 $\times$ 10^{-3} (20 – θ)] = 4.1 [1 + 4 x 10^{-3} (20 – θ)]

$\Rightarrow$ 3.9 + 3.9 $\times$ 5 $\times$ 10^{-3} (20 – θ) = 4.1 + 4.1 $\times$ 4 $\times$ 10^{-3} (20 – θ)

$\Rightarrow$ 4.1 $\times$ 4 $\times$ 10^{-3} (20 – θ) – 3.9 $\times$ 5 $\times$ 10^{-3} (20 – θ) = 3.9 – 4.1

$\Rightarrow$ 16.4(20 – θ) – 19.5(20 – θ) = 0.2 $\times$ 10^3

$\Rightarrow$ (20 – θ) (–3.1) = 0.2 $\times$ 10^3

$\Rightarrow$ θ – 20 = 200

$\Rightarrow$ θ = 220°C.

15. Let the voltmeter reading when, the voltage is 0 be X.

$$\frac{I_1R}{I_2R} = \frac{V_1}{V_2}$$

$$\Rightarrow \frac{1.75}{2.75} = \frac{14.4 - V}{22.4 - V} \Rightarrow \frac{0.35}{0.55} = \frac{14.4 - V}{22.4 - V}$$

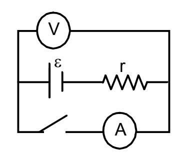
$$\Rightarrow \frac{0.07}{0.11} = \frac{14.4 - V}{22.4 - V} \Rightarrow \frac{7}{11} = \frac{14.4 - V}{22.4 - V}$$

$\Rightarrow$ 7(22.4 – V) = 11(14.4 – V) $\Rightarrow$ 156.8 – 7V = 158.4 – 11V

$\Rightarrow$ (7 – 11)V = 156.8 – 158.4 $\Rightarrow$ –4V = –1.6

$\Rightarrow$ V = 0.4 V.

16. a) When switch is open, no current passes through the ammeter. In the upper part of the circuit the Voltmenter has ∞ resistance. Thus current in it is 0.



$\therefore$ Voltmeter read the emf. (There is not Pot. Drop across the resistor).

b) When switch is closed current passes through the circuit and if its value of i.

The voltmeter reads

ε – ir = 1.45

$\Rightarrow$ 1.52 – ir = 1.45

$\Rightarrow$ ir = 0.07

$\Rightarrow$ 1 r = 0.07 $\Rightarrow$ r = 0.07 Ω.

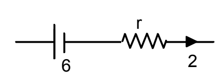
17. E = 6 V, r = 1 Ω, V = 5.8 V, R = ?

$$I = \frac{E}{R + r} = \frac{6}{R + 1}, \; V = E - Ir$$

$$\Rightarrow 5.8 = 6 - \frac{6}{R+1} \times 1 \Rightarrow \frac{6}{R+1} = 0.2$$

$\Rightarrow$ R + 1 = 30 $\Rightarrow$ R = 29 Ω.

18. V = ε + ir



$\Rightarrow$ 7.2 = 6 + 2 $\times$ r

$\Rightarrow$ 1.2 = 2r $\Rightarrow$ r = 0.6 Ω.

19. a) net emf while charging

9 – 6 = 3V

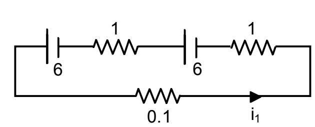
Current = 3/10 = 0.3 A

b) When completely charged.

Internal resistance ‘r’ = 1 Ω

Current = 3/1 = 3 A

20. a) $0.1i_1 + 1\, i_1 - 6 + 1i_1 - 6 = 0$



$\Rightarrow 0.1\, i_1 + 1i_1 + 1i_1 = 12$

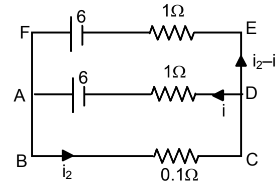
$$\Rightarrow i_1 = \frac{12}{2.1}$$

ABCDA

$\Rightarrow 0.1i_2 + 1i - 6 = 0$

$\Rightarrow 0.1i_2 + 1i$

ADEFA,



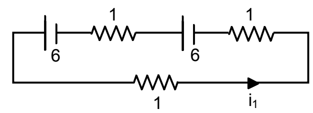
$\Rightarrow$ $i - 6 + 6 - (i_2 - i)1 = 0$

$\Rightarrow$ $i - i_2 + i = 0$

$\Rightarrow$ $2i - i_2 = 0 \Rightarrow -2i \pm 0.2i = 0$

$\Rightarrow$ $i_2 = 0$.

b) $1i_1 + 1\,i_1 - 6 + 1i_1 = 0$

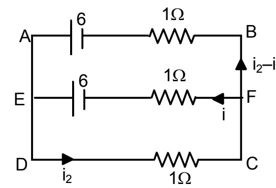


$\Rightarrow$ $3i_1 = 12 \Rightarrow i_1 = 4$

DCFED

$\Rightarrow$ $i_2 + i - 6 = 0 \Rightarrow i_2 + i = 6$

ABCDA,



$i_2 + (i_2 - i) - 6 = 0$

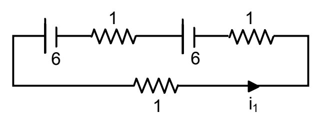
$\Rightarrow$ $i_2 + i_2 - i = 6 \Rightarrow 2i_2 - i = 6$

$\Rightarrow$ $-2i_2 \pm 2i = 6 \Rightarrow i = -2$

$i_2 + i = 6$

$\Rightarrow$ $i_2 - 2 = 6 \;\Rightarrow i_2 = 8$

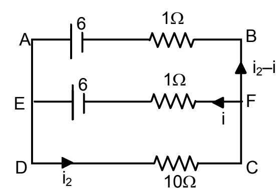
$\dfrac{i_1}{i_2} = \dfrac{4}{8} = \dfrac{1}{2}$.



c) $10i_1 + 1i_1 - 6 + 1i_1 - 6 = 0$

$\Rightarrow$ $12i_1 = 12 \Rightarrow i_1 = 1$

$10i_2 - i_1 - 6 = 0$



$\Rightarrow$ $10i_2 - i_1 = 6$

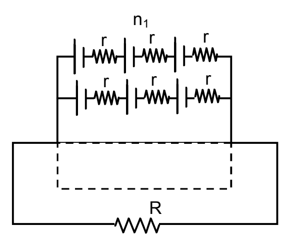
$\Rightarrow$ $10i_2 + (i_2 - i)1 - 6 = 0$

$\Rightarrow$ $11i_2 = 6$

$\Rightarrow$ $-i_2 = 0$

21. a) Total emf = n_1E

in 1 row



Total emf in all news = n_1E

Total resistance in one row = n_1r

Total resistance in all rows = $\dfrac{n_1r}{n_2}$

Net resistance = $\dfrac{n_1r}{n_2}$ + R

Current = $\dfrac{n_1E}{n_1/n_2r + R} = \dfrac{n_1n_2E}{n_1r + n_2R}$

b) I = $\dfrac{n_1n_2E}{n_1r + n_2R}$

for I = max,

$n_1r + n_2R$ = min

$\Rightarrow$ $\left(\sqrt{n_1r} - \sqrt{n_2R}\right)^2 + 2\sqrt{n_1rn_2R}$ = min

it is min, when

$\sqrt{n_1r} = \sqrt{n_2R}$

$\Rightarrow$ $n_1r = n_2R$

I is max when $n_1r = n_2R$.

22. E = 100 V, R′ = 100 kΩ = 100000 Ω

R = 1 – 100

When no other resister is added or R = 0.

$i = \frac{E}{R'} = \frac{100}{100000} = 0.001\text{Amp}$

When R = 1

$i = \frac{100}{100000+1} = \frac{100}{100001} = 0.0009\text{A}$

When R = 100

$i = \frac{100}{100000+100} = \frac{100}{100100} = 0.000999\text{ A}$.

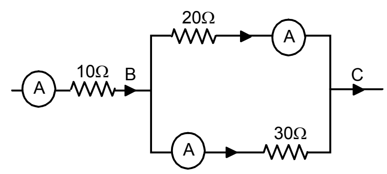
Upto R = 100 the current does not upto 2 significant digits. Thus it proved.

23. A_1 = 2.4 A

Since A_1 and A_2 are in parallel,

$\Rightarrow$ 20 × 2.4 = 30 × X

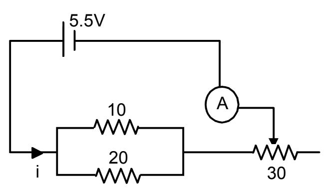
$\Rightarrow$ $X = \frac{20 \times 2.4}{30}$ = 1.6 A.

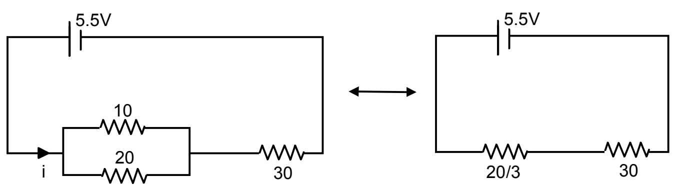


Reading in Ammeter A_2 is 1.6 A.

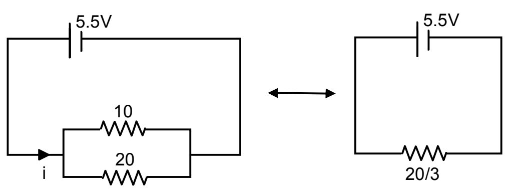
$A_3 = A_1 + A_2$ = 2.4 + 1.6 = 4.0 A.

24.





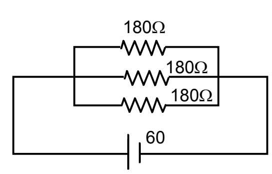
$i_{min} = \frac{5.5 \times 3}{110}$ = 0.15



$i_{max} = \frac{5.5 \times 3}{20} = \frac{16.5}{20}$ = 0.825.

25. a) $R_{eff} = \frac{180}{3}$ = 60 Ω

i = 60 / 60 = 1 A



b) $R_{eff} = \frac{180}{2}$ = 90 Ω

i = 60 / 90 = 0.67 A

c) R_{eff} = 180 Ω $\Rightarrow$ i = 60 / 180 = 0.33 A

26. Max. R = (20 + 50 + 100) Ω = 170 Ω

Min R = $\dfrac{1}{\left(\dfrac{1}{20}+\dfrac{1}{50}+\dfrac{1}{100}\right)}$ = $\dfrac{100}{8}$ = 12.5 Ω.

27. The various resistances of the bulbs = $\dfrac{V^2}{P}$

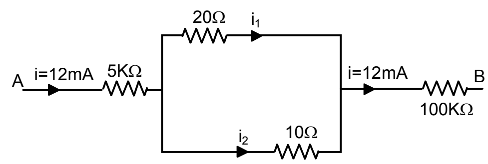
Resistances are $\dfrac{(15)^2}{10}, \dfrac{(15)^2}{10}, \dfrac{(15)^2}{15}$ = 45, 22.5, 15.

Since two resistances when used in parallel have resistances less than both.
The resistances are 45 and 22.5.

28. $i_1 \times 20 = i_2 \times 10$

$\Rightarrow \dfrac{i_1}{i_2} = \dfrac{10}{20} = \dfrac{1}{2}$

i_1 = 4 mA, i_2 = 8 mA



Current in 20 KΩ resistor = 4 mA
Current in 10 KΩ resistor = 8 mA
Current in 100 KΩ resistor = 12 mA

$V = V_1 + V_2 + V_3$
= 5 KΩ × 12 mA + 10 KΩ × 8 mA + 100 KΩ × 12 mA
= 60 + 80 + 1200 = 1340 volts.

29. $R_1 = R$, i_1 = 5 A

$R_2 = \dfrac{10R}{10+R}$, i_2 = 6A

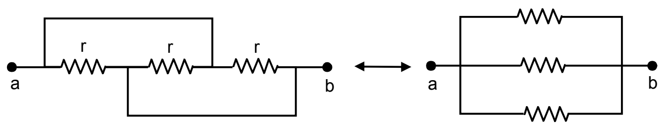
Since potential constant,
$i_1R_1 = i_2R_2$

$\Rightarrow 5 \times R = \dfrac{6 \times 10R}{10+R}$

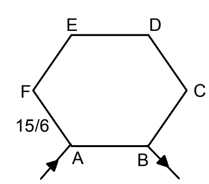
$\Rightarrow$ (10 + R)5 = 60

$\Rightarrow$ 5R = 10 $\Rightarrow$ R = 2 Ω.

30.



Eq. Resistance = r/3.



31. a) $R_{eff} = \dfrac{\dfrac{15\times5}{6}\times\dfrac{15}{6}}{\dfrac{15\times5}{6}+\dfrac{15}{6}} = \dfrac{\dfrac{15\times5\times15}{6\times6}}{\dfrac{75+15}{6}}$

$= \dfrac{15\times5\times15}{6\times90} = \dfrac{25}{12}$ = 2.08 Ω.

b) Across AC,

$R_{eff} = \dfrac{\dfrac{15\times4}{6}\times\dfrac{15\times2}{6}}{\dfrac{15\times4}{6}+\dfrac{15\times2}{6}} = \dfrac{\dfrac{15\times4\times15\times2}{6\times6}}{\dfrac{60+30}{6}}$

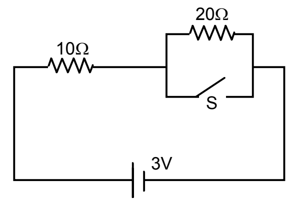
$= \dfrac{15\times4\times15\times2}{6\times90} = \dfrac{10}{3}$ = 3.33 Ω.

c) Across AD,

$$R_{eff} = \frac{\frac{15\times 3}{6}\times\frac{15\times 3}{6}}{\frac{15\times 3}{6}+\frac{15\times 3}{6}} = \frac{\frac{15\times 3\times 15\times 3}{6\times 6}}{\frac{60+30}{6}}$$

$$= \frac{15\times 3\times 15\times 3}{6\times 90} = \frac{15}{4} = 3.75\ \Omega.$$

32. a) When S is open



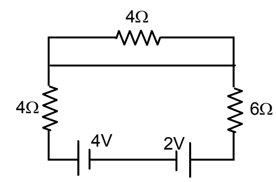
$R_{eq} = (10 + 20)\ \Omega = 30\ \Omega$.

i = When S is closed,

$R_{eq} = 10\ \Omega$

$i = (3/10)\ \Omega = 0.3\ \Omega$.

33. a) Current through (1) 4 Ω resistor = 0



b) Current through (2) and (3)

net E = 4V – 2V = 2V

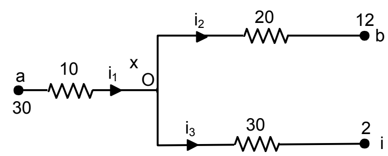
(2) and (3) are in series,

$R_{eff} = 4 + 6 = 10\ \Omega$

$i = 2/10 = 0.2$ A

Current through (2) and (3) are 0.2 A.

34. Let potential at the point be xV.



$(30 - x) = 10\, i_1$

$(x - 12) = 20\, i_2$

$(x - 2) = 30\, i_3$

$i_1 = i_2 + i_3$

$$\Rightarrow \frac{30-x}{10} = \frac{x-12}{20}+\frac{x-2}{30}$$

$$\Rightarrow 30 - x = \frac{x-12}{2}+\frac{x-2}{3}$$

$$\Rightarrow 30 - x = \frac{3x-36+2x-4}{6}$$

$\Rightarrow 180 - 6x = 5x - 40$

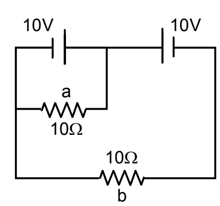
$\Rightarrow 11x = 220 \Rightarrow x = 220 / 11 = 20$ V.

$$i_1 = \frac{30-20}{10} = 1\text{ A}$$

$$i_2 = \frac{20-12}{20} = 0.4\text{ A}$$

$$i_3 = \frac{20-2}{30} = \frac{6}{10} = 0.6\text{ A}.$$

35. a) Potential difference between terminals of ‘a’ is 10 V.

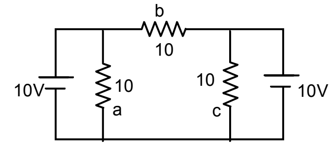


i through a = 10 / 10 = 1A

Potential different between terminals of b is 10 – 10 = 0 V

i through b = 0/10 = 0 A

b) Potential difference across ‘a’ is 10 V



i through a = 10 / 10 = 1A

Potential different between terminals of b is 10 – 10 = 0 V

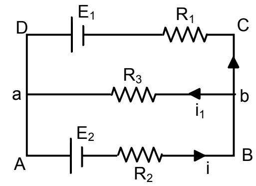
i through b = 0/10 = 0 A

36. a) In circuit, AB ba A

$E_2 + iR_2 + i_1R_3 = 0$

In circuit, $i_1R_3 + E_1 - (i - i_1)R_1 = 0$

$\Rightarrow i_1R_3 + E_1 - iR_1 + i_1R_1 = 0$



$[iR_2 + i_1R_3 \quad = -E_2]R_1$

$[iR_2 - i_1 (R_1 + R_3) = E_1]\ R_2$

$iR_2R_1 + i_1R_3R_1 \quad = -E_2R_1$

$iR_2R_1 - i_1R_2 (R_1 + R_3) \quad = E_1\ R_2$

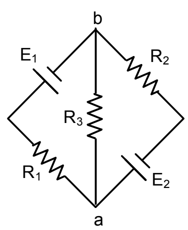
$iR_3R_1 + i_1R_2R_1 + i_1R_2R_3 = E_1R_2 - E_2R_1$

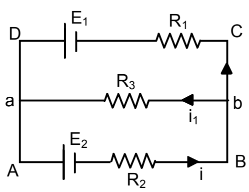
$\Rightarrow i_1(R_3R_1 + R_2R_1 + R_2R_3) = E_1R_2 - E_2R_1$

$$\Rightarrow i_1 = \frac{E_1R_2 - E_2R_1}{R_3R_1 + R_2R_1 + R_2R_3}$$

$$\Rightarrow \frac{E_1R_2R_3 - E_2R_1R_3}{R_3R_1 + R_2R_1 + R_2R_3} = \left(\frac{\frac{E_1}{R_1} - \frac{E_2}{R_2}}{\frac{1}{R_2} + \frac{1}{R_1} + \frac{1}{R_3}} \right)$$

b) $\therefore$ Same as a

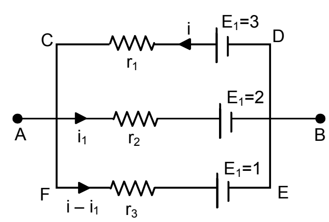




37. In circuit ABDCA,

$i_1 + 2 - 3 + i = 0$

$\Rightarrow\ i + i_1 - 1 = 0$ …(1)



In circuit CFEDC,

$(i - i_1) + 1 - 3 + i = 0$

$\Rightarrow\ 2i - i_1 - 2 = 0$ …(2)

From (1) and (2)

$3i = 3 \Rightarrow i = 1$ A

$i_1 = 1 - i = 0$ A

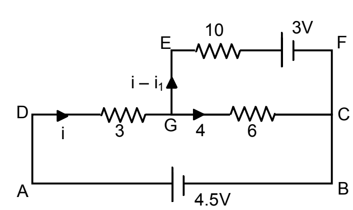
$i - i_1 = 1\text{-}\ 0 = 1$ A

Potential difference between A and B

$= E - ir = 3 - 1.1 = 2$ V.

38. In the circuit ADCBA,

$3i + 6i_1 - 4.5 = 0$



In the circuit GEFCG,

$3i + 6i_1 = 4.5 \quad = \quad 10i - 10i_1 - 6i_1 = -3$

$\Rightarrow\ [10i - 16i_1 = -3]3$ …(1)

$[3i + 6i_1 = 4.5]\ 10$ …(2)

From (1) and (2)

$-108\ i_1 = -54$

$$\Rightarrow\ i_1 = \frac{54}{108} = \frac{1}{2} = 0.5$$

$3i + 6 \times ½ - 4.5 = 0$

$3i - 1.5 = 0 \Rightarrow i = 0.5.$

Current through 10 Ω resistor = 0 A.

39. In AHGBA,

$2 + (i - i_1) - 2 = 0$

$\Rightarrow\ i - i_1 = 0$

In circuit CFEDC,

$-(i_1 - i_2) + 2 + i_2 - 2 = 0$

$\Rightarrow\ i_2 - i_1 + i_2 = 0 \Rightarrow 2i_2 - i_1 = 0.$

In circuit BGFCB,

$-(i_1 - i_2) + 2 + (i_1 - i_2) - 2 = 0$

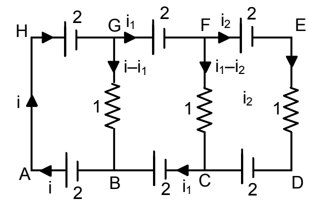
$\Rightarrow\ i_1 - i + i_1 - i_2 = 0 \qquad \Rightarrow\ 2i_1 - i - i_2 = 0 \qquad \ldots(1)$

$\Rightarrow\ i_1 - (i - i_1) - i_2 = 0 \qquad \Rightarrow\ i_1 - i_2 = 0 \qquad \ldots(2)$

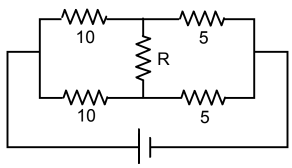
$\therefore\ i_1 - i_2 = 0$

From (1) and (2)

Current in the three resistors is 0.



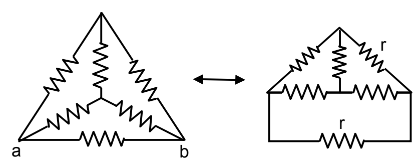
40.



For an value of R, the current in the branch is 0.

41. a) $R_{eff} = \dfrac{(2r/2)\times r}{(2r/2)+r}$

$= \dfrac{r^2}{2r} = \dfrac{r}{2}$

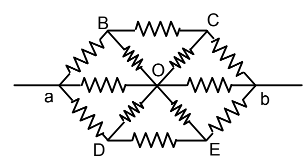


b) At 0 current coming to the junction is current going from BO = Current going along OE.

Current on CO = Current on OD

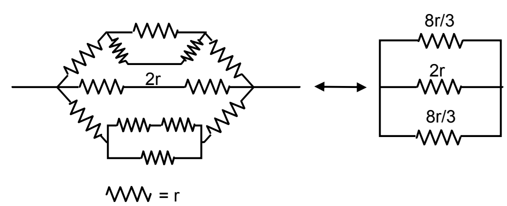
Thus it can be assumed that current coming in OC goes in OB.

Thus the figure becomes

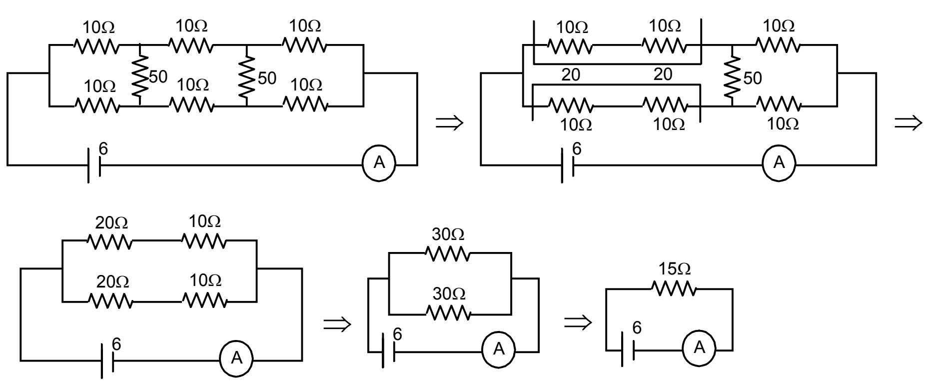


$\left[r + \left(\dfrac{2r.r}{3r}\right) + r\right] = 2r + \dfrac{2r}{3} = \dfrac{8r}{3}$

$R_{eff} = \dfrac{(8r/6)\times 2r}{(8r/6)+2r} = \dfrac{8r^2/3}{20r/6} = \dfrac{8r^2}{3}\times\dfrac{6}{20} = \dfrac{8r}{10} = 4r.$



42.



$I = \dfrac{6}{15} = \dfrac{2}{5} = 0.4\ A\ .$

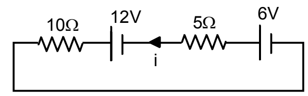
43. a) Applying Kirchoff's law,

$10i - 6 + 5i - 12 = 0$

$\Rightarrow$ $10i + 5i = 18$

$\Rightarrow$ $15i = 18$

$\Rightarrow$ $i = \frac{18}{15} = \frac{6}{5}$ = 1.2 A.



b) Potential drop across 5 Ω resistor,

$i\,5 = 1.2 \times 5$ V = 6 V

c) Potential drop across 10 Ω resistor

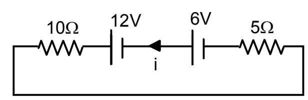
$i\,10 = 1.2 \times 10$ V = 12 V

d) $10i - 6 + 5i - 12 = 0$

$\Rightarrow$ $10i + 5i = 18$

$\Rightarrow$ $15i = 18$

$\Rightarrow$ $i = \frac{18}{15} = \frac{6}{5}$ = 1.2 A.



Potential drop across 5 Ω resistor = 6 V

Potential drop across 10 Ω resistor = 12 V

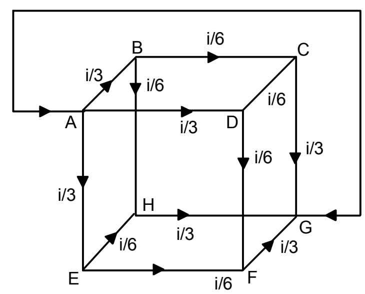
44. Taking circuit ABHGA,

$$\frac{i}{3r} + \frac{i}{6r} + \frac{i}{3r} = V$$

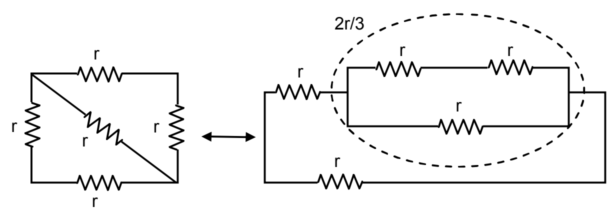
$$\Rightarrow \left(\frac{2i}{3} + \frac{i}{6}\right)r = V$$

$$\Rightarrow V = \frac{5i}{6}r$$

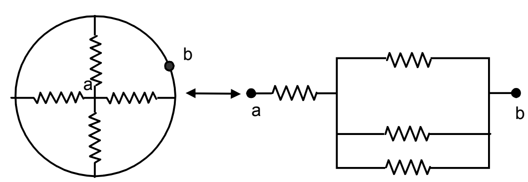
$$\Rightarrow R_{eff} = \frac{V}{i} = \frac{5}{6r}$$



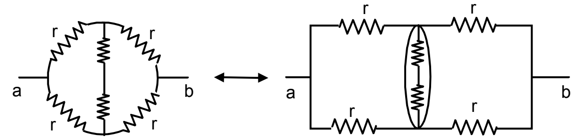
45. $$R_{eff} = \frac{\left(\frac{2r}{3} + r\right)r}{\left(\frac{2r}{3} + r + r\right)} = \frac{5r}{8}$$



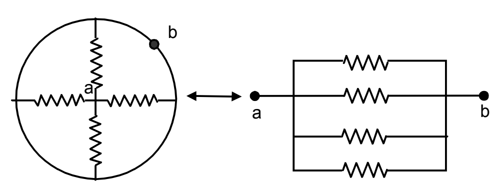
$$R_{eff} = \frac{r}{3} + r = \frac{4r}{3}$$



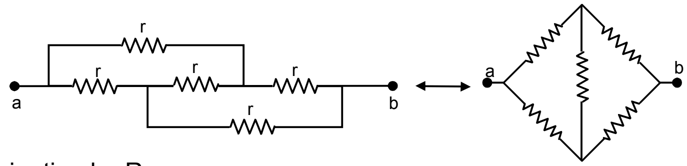
$$R_{eff} = \frac{2r}{2} = r$$



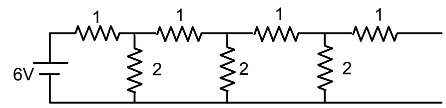
$$R_{eff} = \frac{r}{4}$$



$R_{eff} = r$

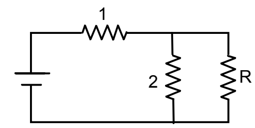


46. a) Let the equation resistance of the combination be R.



$$\left(\frac{2R}{R+2}\right)+1=R$$

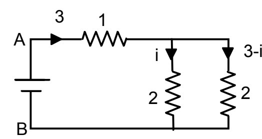
$$\Rightarrow \frac{2R+R+2}{R+2}=R \Rightarrow 3R + 2 = R^2 + 2R$$



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

$$\Rightarrow R = \frac{+1\pm\sqrt{1+4.1.2}}{2.1}=\frac{1\pm\sqrt{9}}{2}=\frac{1\pm 3}{2} = 2\ \Omega.$$

b) Total current sent by battery = $\frac{6}{R_{eff}}=\frac{6}{2}=3$



Potential between A and B

$3.1 + 2.i = 6$

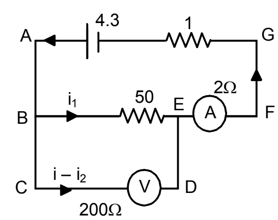
$\Rightarrow 3 + 2i = 6 \Rightarrow 2i = 3$

$\Rightarrow i = 1.5$ a

47. a) In circuit ABFGA,

$i_1\ 50 + 2i + i - 4.3 = 0$

$\Rightarrow 50i_1 + 3i = 4.3$ …(1)



In circuit BEDCB,

$50i_1 - (i - i_1)200 = 0$

$\Rightarrow 50i_1 - 200i + 200i_1 = 0$

$\Rightarrow 250\ i_1 - 200i = 0$

$\Rightarrow 50i_1 - 40i = 0$ …(2)

From (1) and (2)

$43i = 4.3$ $\Rightarrow i = 0.1$

$5i_1 = 4 \times i = 4 \times 0.1$ $\Rightarrow i_1 = \frac{4\times 0.1}{5} = 0.08$ A.

Ammeter reads a current = i = 0.1 A.

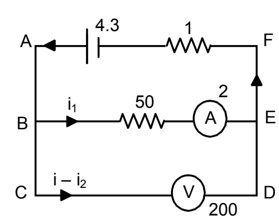
Voltmeter reads a potential difference equal to $i_1 \times 50 = 0.08 \times 50 = 4$ V.

b) In circuit ABEFA,

$50i_1 + 2i_1 + 1i - 4.3 = 0$

$\Rightarrow 52i_1 + i = 4.3$

$\Rightarrow 200 \times 52i_1 + 200\ i = 4.3 \times 200$ …(1)



In circuit BCDEB,

$(i - i_1)200 - i_1 2 - i_1 50 = 0$

$\Rightarrow 200i - 200i_1 - 2i_1 - 50i_1 = 0$

$\Rightarrow 200i - 252i_1 = 0$ …(2)

From (1) and (2)

$i_1(10652) = 4.3 \times 2 \times 100$

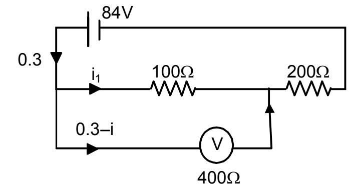
$$\Rightarrow i_1 = \frac{4.3\times 2\times 100}{10652} = 0.08$$

$i = 4.3 - 52 \times 0.08 = 0.14$

Reading of the ammeter = 0.08 a

Reading of the voltmeter = $(i - i_1)200 = (0.14 - 0.08) \times 200 = 12$ V.

48. a) $R_{eff} = \dfrac{100 \times 400}{500} + 200 = 280$



$i = \dfrac{84}{280} = 0.3$

100i = (0.3 – i) 400

$\Rightarrow$ i = 1.2 – 4i

$\Rightarrow$ 5i = 1.2 $\Rightarrow$ i = 0.24.

Voltage measured by the voltmeter = $\dfrac{0.24 \times 100}{24V}$

b) If voltmeter is not connected

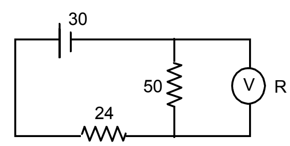
R_{eff} = (200 + 100) = 300 Ω

$i = \dfrac{84}{300}$ = 0.28 A

Voltage across 100 Ω = (0.28 × 100) = 28 V.

49. Let resistance of the voltmeter be R Ω.

$R_1 = \dfrac{50R}{50+R}$, $R_2 = 24$



Both are in series.

$30 = V_1 + V_2$

$\Rightarrow 30 = iR_1 + iR_2$

$\Rightarrow 30 - iR_2 = iR_1$

$\Rightarrow iR_1 = 30 - \dfrac{30}{R_1 + R_2} R_2$

$\Rightarrow V_1 = 30\left(1 - \dfrac{R_2}{R_1 + R_2}\right)$

$\Rightarrow V_1 = 30\left(\dfrac{R_1}{R_1 + R_2}\right)$

$$\Rightarrow 18 = 30\left(\dfrac{50R}{50 + R\left(\dfrac{50R}{50+R} + 24\right)}\right)$$

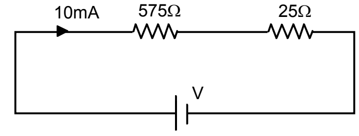
$$\Rightarrow 18 = 30\left(\dfrac{50R \times (50+R)}{(50+R) + (50R+24)(50+R)}\right) = \dfrac{30(50R)}{50R + 1200 + 24R}$$

$\Rightarrow 18 = \dfrac{30 \times 50 \times R}{74R + 1200}$ = 18(74R + 1200) = 1500 R

$\Rightarrow$ 1332R + 21600 = 1500 R $\Rightarrow$ 21600 = 1.68 R

$\Rightarrow$ R = 21600 / 168 = 128.57.

50. Full deflection current = 10 mA = (10×10^{-3})A

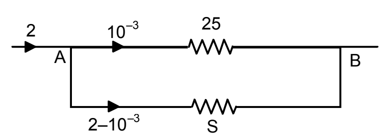


R_{eff} = (575 + 25)Ω = 600 Ω

$V = R_{eff} \times i = 600 \times 10 \times 10^{-3} = 6$ V.

51. G = 25 Ω, Ig = 1 ma, I = 2A, S = ?

Potential across A B is same

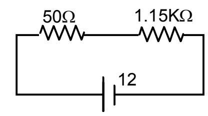


$25 \times 10^{-3} = (2 - 10^{-3})S$

$\Rightarrow S = \dfrac{25 \times 10^{-3}}{2 - 10^{-3}} = \dfrac{25 \times 10^{-3}}{1.999}$

$= 12.5 \times 10^{-3} = 1.25 \times 10^{-2}$.

52. $R_{eff} = (1150 + 50)\Omega = 1200\ \Omega$

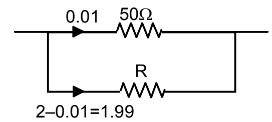


$i = (12 / 1200)A = 0.01$ A.

(The resistor of 50 Ω can tolerate)

Let R be the resistance of sheet used.

The potential across both the resistors is same.

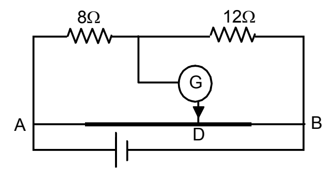


$0.01 \times 50 = 1.99 \times R$

$\Rightarrow R = \dfrac{0.01\times 50}{1.99} = \dfrac{50}{199} = 0.251\ \Omega$.

53. If the wire is connected to the potentiometer wire so that $\dfrac{R_{AD}}{R_{DB}} = \dfrac{8}{12}$, then according to wheat stone's bridge no current will flow through galvanometer.

$\dfrac{R_{AB}}{R_{DB}} = \dfrac{L_{AB}}{L_B} = \dfrac{8}{12} = \dfrac{2}{3}$ (Acc. To principle of potentiometer).



$I_{AB} + I_{DB} = 40$ cm

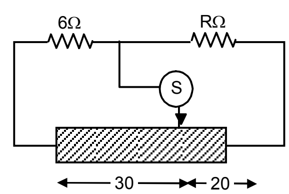
$\Rightarrow I_{DB}\ 2/3 + I_{DB} = 40$ cm

$\Rightarrow (2/3 + 1)I_{DB} = 40$ cm

$\Rightarrow 5/3\ I_{DB} = 40 \Rightarrow L_{DB} = \dfrac{40\times 3}{5} = 24$ cm.

$I_{AB} = (40 - 24)$ cm = 16 cm.

54. The deflections does not occur in galvanometer if the condition is a balanced wheatstone bridge.



Let Resistance / unit length = r.

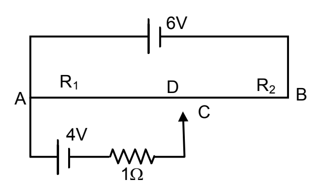
Resistance of 30 m length = 30 r.

Resistance of 20 m length = 20 r.

For balanced wheatstones bridge = $\dfrac{6}{R} = \dfrac{30r}{20r}$

$\Rightarrow 30\ R = 20 \times 6 \Rightarrow R = \dfrac{20\times 6}{30} = 4\ \Omega$.

55. a) Potential difference between A and B is 6 V.



B is at 0 potential.

Thus potential of A point is 6 V.

The potential difference between Ac is 4 V.

$V_A - V_C = 0.4$

$V_C = V_A - 4 = 6 - 4 = 2$ V.

b) The potential at D = 2V, $V_{AD} = 4$ V ; $V_{BD} =$ OV

Current through the resisters R_1 and R_2 are equal.

Thus, $\dfrac{4}{R_1} = \dfrac{2}{R_2}$

$\Rightarrow \dfrac{R_1}{R_2} = 2$

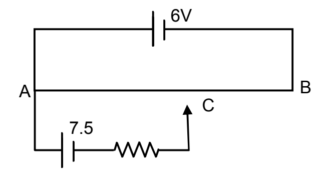
$\Rightarrow \dfrac{I_1}{I_2} = 2$ (Acc. to the law of potentiometer)

$I_1 + I_2 = 100$ cm

$\Rightarrow I_1 + \dfrac{I_1}{2} = 100 \text{ cm} \Rightarrow \dfrac{3I_1}{2} = 100$ cm

$\Rightarrow I_1 = \dfrac{200}{3}$ cm = 66.67 cm.

AD = 66.67 cm



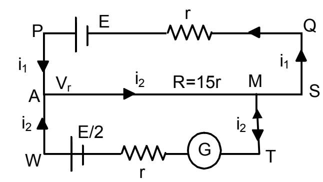
c) When the points C and D are connected by a wire current flowing through it is 0 since the points are equipotential.

d) Potential at A = 6 v

Potential at C = 6 – 7.5 = –1.5 V

The potential at B = 0 and towards A potential increases.

Thus –ve potential point does not come within the wire.



56. Resistance per unit length = $\frac{15r}{6}$

For length x, Rx = $\frac{15r}{6} \times x$

a) For the loop PASQ $(i_1 + i_2)\frac{15}{6}rx + \frac{15}{6}(6 - x)i_1 + i_1R = E$ …(1)

For the loop AWTM, $-i_2.R - \frac{15}{6}rx\,(i_1 + i_2) = E/2$

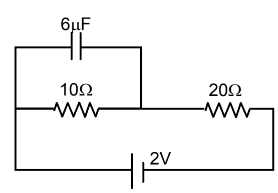
$\Rightarrow i_2R + \frac{15}{6}r \times (i_1 + i_2) = E/2$ …(2)

For zero deflection galvanometer $i_2 = 0 \Rightarrow \frac{15}{6}rx\,.\,i_1 = E/2 = i_1 = \frac{E}{5x \cdot r}$

Putting $i_1 = \frac{E}{5x \cdot r}$ and $i_2 = 0$ in equation (1), we get x = 320 cm.

b) Putting x = 5.6 and solving equation (1) and (2) we get $i_2 = \frac{3E}{22r}$.

57. In steady stage condition no current flows through the capacitor.



$R_{eff} = 10 + 20 = 30\ \Omega$

$i = \frac{2}{30} = \frac{1}{15}A$

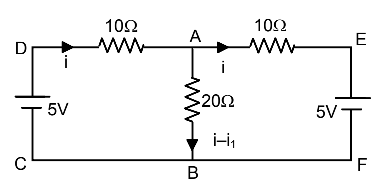
Voltage drop across 10 Ω resistor = i × R

$= \frac{1}{15} \times 10 = \frac{10}{15} = \frac{2}{3}V$

Charge stored on the capacitor (Q) = CV

$= 6 \times 10^{-6} \times 2/3 = 4 \times 10^{-6}$ C = 4 μC.

58. Taking circuit, ABCDA,



$10i + 20(i - i_1) - 5 = 0$

$\Rightarrow 10i + 20i - 20i_1 - 5 = 0$

$\Rightarrow 30i - 20i_1 - 5 = 0$ …(1)

Taking circuit ABFEA,

$20(i - i_1) - 5 - 10i_1 = 0$

$\Rightarrow 10i - 20i_1 - 10i_1 - 5 = 0$

$\Rightarrow 20i - 30i_1 - 5 = 0$ …(2)

From (1) and (2)

$(90 - 40)i_1 = 0$

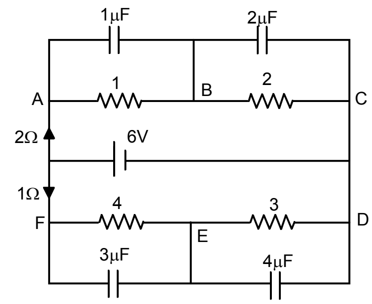
$\Rightarrow i_1 = 0$

$30i - 5 = 0$

$\Rightarrow i = 5/30 = 0.16$ A

Current through 20 Ω is 0.16 A.

59. At steady state no current flows through the capacitor.



$R_{eq} = \dfrac{3 \times 6}{3 + 6} = 2\ \Omega.$

$i = \dfrac{6}{2} = 3.$

Since current is divided in the inverse ratio of the resistance in each branch, thus 2Ω will pass through 1, 2 Ω branch and 1 through 3, 3Ω branch

$V_{AB} = 2 \times 1 = 2V.$

Q on 1 μF capacitor = 2 × 1 μc = 2 μC

$V_{BC} = 2 \times 2 = 4V.$

Q on 2 μF capacitor = 4 × 2 μc = 8 μC

$V_{DE} = 1 \times 3 = 2V.$

Q on 4 μF capacitor = 3 × 4 μc = 12 μC

$V_{FE} = 3 \times 1 = V.$

Q across 3 μF capacitor = 3 × 3 μc = 9 μC.

60. C_{eq} = [(3 μf p 3 μf) s (1 μf p 1 μf)] p (1 μf)

= [(3 + 3)μf s (2μf)] p 1 μf

= 3/2 + 1 = 5/2 μf

V = 100 V

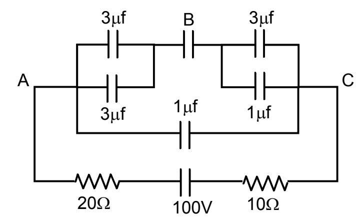
Q = CV = 5/2 × 100 = 250 μc

Charge stored across 1 μf capacitor = 100 μc

C_{eq} between A and B is 6 μf = C

Potential drop across AB = V = Q/C = 25 V

Potential drop across BC = 75 V.



61. a) Potential difference = E across resistor

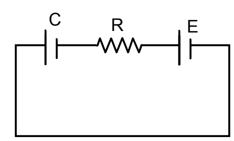
b) Current in the circuit = E/R

c) Pd. Across capacitor = E/R

d) Energy stored in capacitor = $\dfrac{1}{2}CE^2$

e) Power delivered by battery = E × I = $E \times \dfrac{E}{R} = \dfrac{E^2}{R}$

f) Power converted to heat = $\dfrac{E^2}{R}$



62. $A = 20\ cm^2 = 20 \times 10^{-4}\ m^2$

$d = 1\ mm = 1 \times 10^{-3}\ m$; R = 10 KΩ

$C = \dfrac{E_0 A}{d} = \dfrac{8.85 \times 10^{-12} \times 20 \times 10^{-4}}{1 \times 10^{-3}}$

$= \dfrac{8.85 \times 10^{-12} \times 2 \times 10^{-3}}{10^{-3}} = 17.7 \times 10^{-2}$ Farad.

Time constant = $CR = 17.7 \times 10^{-2} \times 10 \times 10^{3}$

$= 17.7 \times 10^{-8} = 0.177 \times 10^{-6}\ s = 0.18\ \mu s.$

63. $C = 10\ \mu F = 10^{-5}\ F$, emf = 2 V

$t = 50\ ms = 5 \times 10^{-2}\ s$, $q = Q(1 - e^{-t/RC})$

$Q = CV = 10^{-5} \times 2$

$q = 12.6 \times 10^{-6}\ F$

$\Rightarrow 12.6 \times 10^{-6} = 2 \times 10^{-5}\ (1 - e^{-5\times10^{-2}/R\times10^{-5}})$

$\Rightarrow \dfrac{12.6 \times 10^{-6}}{2 \times 10^{-5}} = 1 - e^{-5 \times 10^{-2} / R \times 10^{-5}}$

$\Rightarrow$ 1 – 0.63 = $e^{-5 \times 10^{3}/R}$

$\Rightarrow \dfrac{-5000}{R} = \ln 0.37$

$\Rightarrow$ R = $\dfrac{5000}{0.9942}$ = 5028 Ω = 5.028 $\times$ $10^3\Omega$ = 5 KΩ.

64. C = 20 $\times$ 10^{-6} F, E = 6 V, R = 100 Ω
t = 2 $\times$ 10^{-3} sec
q = EC (1 – $e^{-t/RC}$)
= $6 \times 20 \times 10^{-6}\left(1 - e^{\frac{-2 \times 10^{-3}}{100 \times 20 \times 10^{-6}}}\right)$
= 12 x 10^{-5} (1 – e^{-1}) = 7.12 $\times$ 0.63 $\times$ 10^{-5} = 7.56 $\times$ 10^{-5}
= 75.6 $\times$ 10^{-6} = 76 μc.

65. C = 10 μF, Q = 60 μC, R = 10 Ω
a) at t = 0, q = 60 μc
b) at t = 30 μs, q = $Qe^{-t/RC}$
= 60 $\times$ 10^{-6} $\times$ $e^{-0.3}$ = 44 μc
c) at t = 120 μs, q = 60 $\times$ 10^{-6} $\times$ $e^{-1.2}$ = 18 μc
d) at t = 1.0 ms, q = 60 $\times$ 10^{-6} $\times$ e^{-10} = 0.00272 = 0.003 μc.

66. C = 8 μF, E = 6V, R = 24 Ω
a) I = $\dfrac{V}{R} = \dfrac{6}{24} = 0.25A$
b) q = Q(1 – $e^{-t/RC}$)
= (8 $\times$ 10^{-6} $\times$ 6) [1 – c^{-1}] = 48 $\times$ 10^{-6} $\times$ 0.63 = 3.024 $\times$ 10^{-5}
V = $\dfrac{Q}{C} = \dfrac{3.024 \times 10^{-5}}{8 \times 10^{-6}} = 3.78$
E = V + iR
$\Rightarrow$ 6 = 3.78 + i24
$\Rightarrow$ i = 0.09 Å

67. A = 40 m^2 = 40 $\times$ 10^{-4}
d = 0.1 mm = 1 $\times$ 10^{-4} m
R = 16 Ω ; emf = 2 V
C = $\dfrac{E_0A}{d} = \dfrac{8.85 \times 10^{-12} \times 40 \times 10^{-4}}{1 \times 10^{-4}}$ = 35.4 $\times$ 10^{-11} F
Now, E = $\dfrac{Q}{AE_0}(1 - e^{-t/RC}) = \dfrac{CV}{AE_0}(1 - e^{-t/RC})$
= $\dfrac{35.4 \times 10^{-11} \times 2}{40 \times 10^{-4} \times 8.85 \times 10^{-12}}(1 - e^{-1.76})$
= 1.655 $\times$ 10^{-4} = 1.7 $\times$ 10^{-4} V/m.

68. A = 20 cm^2, d = 1 mm, K = 5, e = 6 V
R = 100 $\times$ 10^3 Ω, t = 8.9 $\times$ 10^{-5} s
C = $\dfrac{KE_0A}{d} = \dfrac{5 \times 8.85 \times 10^{-12} \times 20 \times 10^{-4}}{1 \times 10^{-3}}$
= $\dfrac{10 \times 8.85 \times 10^{-3} \times 10^{-12}}{10^{-3}}$ = 88.5 $\times$ 10^{-12}

$q = EC(1 - e^{-t/RC})$

$= 6 \times 88.5 \times 10^{-12}\left(1 - e^{\frac{-89\times10^{-6}}{88.5\times10^{-12}\times10^{4}}}\right) = 530.97$

Energy = $\frac{1}{2}\times\frac{500.97\times530}{88.5\times10^{-12}}$

$= \frac{530.97\times530.97}{88.5\times2}\times10^{12}$

69. Time constant RC = $1 \times 10^6 \times 100 \times 10^6$ = 100 sec

a) $q = VC(1 - e^{-t/CR})$

I = Current = dq/dt = VC.(-) $e^{-t/RC}$, (–1)/RC

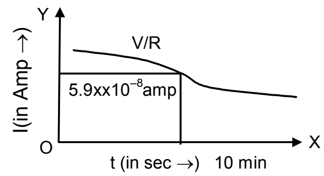
$= \frac{V}{R}e^{-t/RC} = \frac{V}{R\cdot e^{t/RC}} = \frac{24}{10^6}\cdot\frac{1}{e^{t/100}}$

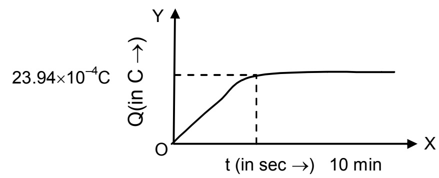
$= 24 \times 10^{-6}\ 1/e^{t/100}$

t = 10 min, 600 sec.

Q = 24 × 10+–4 × $(1 - e^{-6})$ = 23.99×10^{-4}

I = $\frac{24}{10^6}\cdot\frac{1}{e^6} = 5.9\times10^{-8}$ Amp. .





b) $q = VC(1 - e^{-t/CR})$

70. $Q/2 = Q(1 - e^{-t/CR})$

$\Rightarrow \frac{1}{2} = (1 - e^{-t/CR})$

$\Rightarrow e^{-t/CR} = ½$

$\Rightarrow \frac{t}{RC} = \log 2 \Rightarrow n = 0.69.$

71. $q = Qe^{-t/RC}$

q = 0.1 % Q RC ⇒ Time constant

$= 1 \times 10^{-3}$ Q

So, 1×10^{-3} Q = Q × $e^{-t/RC}$

$\Rightarrow e^{-t/RC} = \ln 10^{-3}$

⇒ t/RC = –(–6.9) = 6.9

72. $q = Q(1 - e^{-n})$

$\frac{1}{2}\frac{Q^2}{C} =$ Initial value ; $\frac{1}{2}\frac{q^2}{c} =$ Final value

$\frac{1}{2}\frac{q^2}{c}\times 2 = \frac{1}{2}\frac{Q^2}{C}$

$\Rightarrow q^2 = \frac{Q^2}{2} \Rightarrow q = \frac{Q}{\sqrt{2}}$

$\frac{Q}{\sqrt{2}} = Q(1 - e^{-n})$

$\Rightarrow \frac{1}{\sqrt{2}} = 1 - e^{-n} \Rightarrow e^{-n} = 1 - \frac{1}{\sqrt{2}}$

$\Rightarrow n = \log\left(\frac{\sqrt{2}}{\sqrt{2}-1}\right) = 1.22$

73. Power = CV^2 = Q × V

Now, $\frac{QV}{2} = QV \times e^{-t/RC}$

$\Rightarrow$ ½ = $e^{-t/RC}$

$\Rightarrow \dfrac{t}{RC} = -\ln 0.5$

$\Rightarrow$ –(–0.69) = 0.69

74. Let at any time t, q = EC (1 – $e^{-t/CR}$)

E = Energy stored = $\dfrac{q^2}{2c} = \dfrac{E^2C^2}{2c}(1-e^{-t/CR})^2 = \dfrac{E^2C}{2}(1-e^{-t/CR})^2$

R = rate of energy stored = $\dfrac{dE}{dt} = \dfrac{-E^2C}{2}\left(\dfrac{-1}{RC}\right)^2(1-e^{-t/RC})e^{-t/RC} = \dfrac{E^2}{CR}\cdot e^{-t/RC}\left(1-e^{-t/CR}\right)$

$\dfrac{dR}{dt} = \dfrac{E^2}{2R}\left[\dfrac{-1}{RC}e^{-t/CR}\cdot(1-e^{-t/CR})+(-)\cdot e^{-t/CR(1-/RC)}\cdot e^{-t/CR}\right]$

$\dfrac{E^2}{2R} = \left(\dfrac{-e^{-t/CR}}{RC}+\dfrac{e^{-2t/CR}}{RC}+\dfrac{1}{RC}\cdot e^{-2t/CR}\right) = \dfrac{E^2}{2R}\left(\dfrac{2}{RC}\cdot e^{-2t/CR}-\dfrac{e^{-t/CR}}{RC}\right)$ …(1)

For R_{max} dR/dt = 0 $\Rightarrow$ 2.$e^{-t/RC}$ –1 = 0 $\Rightarrow$ $e^{-t/CR}$ = 1/2

$\Rightarrow$ –t/RC = –$\ln^2$ $\Rightarrow$ t = RC ln 2

$\therefore$ Putting t = RC ln 2 in equation (1) We get $\dfrac{dR}{dt} = \dfrac{E^2}{4R}$.

75. C = 12.0 μF = 12 × 10^{-6}

emf = 6.00 V, R = 1 Ω

t = 12 μc, i = i_0 $e^{-t/RC}$

= $\dfrac{CV}{T}\times e^{-t/RC} = \dfrac{12\times10^{-6}\times6}{12\times10^{-6}}\times e^{-1}$

= 2.207 = 2.1 A

b) Power delivered by battery

We known, V = V_0 $e^{-t/RC}$ (where V and V_0 are potential VI)

VI = V_0I $e^{-t/RC}$

$\Rightarrow$ VI = V_0I × e^{-1} = 6 × 6 × e^{-1} = 13.24 W

c) U = $\dfrac{CV^2}{T}(e^{-t/RC})^2$ [$\dfrac{CV^2}{T}$ = energy drawing per unit time]

= $\dfrac{12\times10^{-6}\times36}{12\times10^{-6}}\times\left(e^{-1}\right)^2$ = 4.872.

76. Energy stored at a part time in discharging = $\dfrac{1}{2}CV^2(e^{-t/RC})^2$

Heat dissipated at any time

= (Energy stored at t = 0) – (Energy stored at time t)

= $\dfrac{1}{2}CV^2 - \dfrac{1}{2}CV^2(-e^{-1})^2 = \dfrac{1}{2}CV^2(1-e^{-2})$

77. $\int i^2 R dt = \int i_0^2 Re^{-2t/RC}\,dt = i_0^2 R\int e^{-2t/RC}dt$

= $i_0^2R(-RC/2)e^{-2t/RC} = \dfrac{1}{2}Ci_0^2R^2e^{-2t/RC} = \dfrac{1}{2}CV^2$ (Proved).

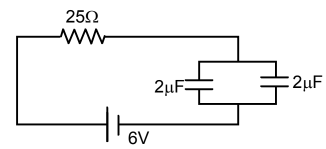
78. Equation of discharging capacitor

= $q_0e^{-t/RC} = \dfrac{K\in_0 AV}{d}e^{\frac{-1}{(\rho dK\in_0 A)/Ad}} = \dfrac{K\in_0 AV}{d}e^{-t/\rho K\in_0}$

$\therefore \tau = \rho K\in_0$

$\therefore$ Time constant is $\rho K\in_0$ is independent of plate area or separation between the plate.

79. $q = q_0(1 - e^{-t/RC})$

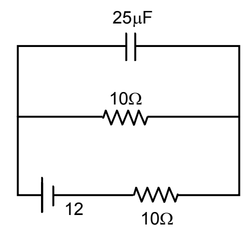


$= 25(2 + 2) \times 10^{-6} \left(1 - e^{\frac{-0.2\times10^{-3}}{25\times4\times10^{-6}}}\right)$

$= 24 \times 10^{-6} (1 - e^{-2}) = 20.75$

Charge on each capacitor = 20.75/2 = 10.3

80. In steady state condition, no current passes through the 25 μF capacitor,



$\therefore$ Net resistance = $\frac{10\Omega}{2} = 5\Omega$.

Net current = $\frac{12}{5}$

Potential difference across the capacitor = 5

Potential difference across the 10 Ω resistor

$= 12/5 \times 10 = 24$ V

$q = Q(e^{-t/RC}) = V \times C(e^{-t/RC}) = 24 \times 25 \times 10^{-6} \left[e^{-1\times10^{-3}/10\times25\times10^{-4}}\right]$

$= 24 \times 25 \times 10^{-6}\, e^{-4} = 24 \times 25 \times 10^{-6} \times 0.0183 = 10.9 \times 10^{-6}$ C

Charge given by the capacitor after time t.

Current in the 10 Ω resistor = $\frac{10.9\times10^{-6}\,C}{1\times10^{-3}\,\text{sec}} = 11\text{mA}$.

81. C = 100 μF, emf = 6 V, R = 20 KΩ, t = 4 S.

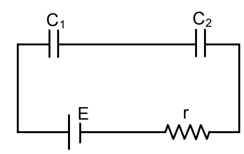
Charging : $Q = CV(1 - e^{-t/RC})$ $\left[\frac{-t}{RC} = \frac{4}{2\times10^4\times10^{-4}}\right]$

$= 6 \times 10^{-4}(1 - e^{-2}) = 5.187 \times 10^{-4}$ C = Q

Discharging : $q = Q(e^{-t/RC}) = 5.184 \times 10^{-4} \times e^{-2}$

$= 0.7 \times 10^{-4}$ C = 70 μc.

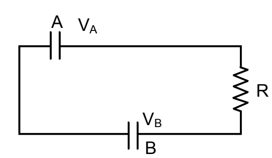
82. $C_{eff} = \frac{C_1C_2}{C_1 + C_2}$



$Q = C_{eff}\, E(1 - e^{-t/RC}) = \frac{C_1C_2}{C_1 + C_2}\, E(1 - e^{-t/RC})$

83. Let after time t charge on plate B is +Q.

Hence charge on plate A is Q – q.



$V_A = \frac{Q-q}{C}$, $V_B = \frac{q}{C}$

$V_A - V_B = \frac{Q-q}{C} - \frac{q}{C} = \frac{Q-2q}{C}$

Current = $\frac{V_A - V_B}{R} = \frac{Q-2q}{CR}$

Current = $\frac{dq}{dt} = \frac{Q-2q}{CR}$

$\Rightarrow \frac{dq}{Q-2q} = \frac{1}{RC}\cdot dt \quad \Rightarrow \int_0^q \frac{dq}{Q-2q} = \frac{1}{RC}\cdot\int_0^t dt$

$\Rightarrow -\frac{1}{2}[\ln(Q-2q) - \ln Q] = \frac{1}{RC}\cdot t \Rightarrow \ln\frac{Q-2q}{Q} = \frac{-2}{RC}\cdot t$

$\Rightarrow Q - 2q = Q\,e^{-2t/RC} \Rightarrow 2q = Q(1 - e^{-2t/RC})$

$\Rightarrow q = \frac{Q}{2}(1 - e^{-2t/RC})$

84. The capacitor is given a charge Q. It will discharge and the capacitor will be charged up when connected with battery.

Net charge at time t = $Qe^{-t/RC} + Q(1 - e^{-t/RC})$.