Ch-3

Exercises

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3.1) EMF (E) = 12 V
Internal resistance (R) = 0.4 Ω

Then, $E = IR$

$\Rightarrow I = \frac{E}{R}$

$= \frac{12}{0.4}$

$= 30\ A$.

3.2) EMF = 10 V
Internal resistance (R) = 3 Ω.
I = 0.5 A.

Then, $I = \frac{E}{R+r}$

$\Rightarrow 0.5 = \frac{10}{3+r}$

$\Rightarrow 1.5 + 0.5r = 10$

$\Rightarrow 0.5r = 8.5$

$\Rightarrow r = \frac{8.5}{0.5}$ 17

$= 17\ \Omega$.

So, $V = IR$

$= 0.5 \times 17$

$= 8.5\ V$.

∴ The terminal voltage of the battery is 8.5V when the circuit is closed.

3.3) a) $R_{eq} = R_1 + R_2 + R_3$

$= 1 + 2 + 3$

$= 6\ \Omega$.

b) EMF = 12 V.

Then, $I = \frac{V}{R_{eq}}$

$= \frac{12}{6}$

$= 2\ A$.

So, $V_1 = IR_1$

$= 2 \times 1$

$= 2V$.

$V_2 = IR_2$

$= 2 \times 2$

$= 4V$.

$V_3 = IR_3$

$= 2 \times 3$

$= 6V$.

∴ The potential drop across each resistor is 2V, 4V and 6V respectively.

3.4) a) ~~$R_{eq} = \frac{1}{R_T}$~~

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\Rightarrow \frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5}$$

$$\Rightarrow \frac{1}{R_{eq}} = \frac{10+5+4}{20}$$

$$\Rightarrow \frac{1}{R_{eq}} = \frac{19}{20}$$

$$\Rightarrow R_{eq} = \frac{20}{19}\ \Omega.$$

b) EMF = 20 V.

$$I_1 = \frac{V}{R_1}$$

$$= \frac{20}{2}$$

$$= 10\ A.$$

$$I_2 = \frac{V}{R_2}$$

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

$$= 5\ A.$$

$I_3 = \frac{V}{R_3}$

$= \frac{20}{5}$

$= 4 A.$

∴ The current through each resistor is 10 A, 5A and respectively.

Total current in circuit, $I = \frac{V}{R_{eq}}$

$= \frac{20}{\frac{20}{19}}$

$= 20 \times \frac{19}{20}$

$= 19 A.$

35) Initial temperature $(T) = 27°C$.

Resistance of the heating element at temp. T $= 100 \Omega$.

Let the increased temp. be T_1,
Increased resistance $(R_1) = 117 \Omega$.

Coefficient of material of resistor $(\alpha) = 1.7 \times 10^{-4} °C^{-1}$

So,

$$\alpha = \frac{R_1 - R}{R(T_1 - T)}$$

$\Rightarrow 1.7 \times 10^{-4} = \frac{117 - 100}{100(T_1 - 27)}$

$\Rightarrow 1.7 \times 10^{-4} = \frac{17}{100T_1 - 2700}$

$\Rightarrow 100T_1 - 2700 = \frac{~~17~~ 10}{~~1.7~~ \times 10^{-4}}$

$\Rightarrow 100T_1 - 2700 = 10^5$

$\Rightarrow T_1 - 27 = 10^3$

$\Rightarrow T_1 = 1000 + 27$
$= 1027°C.$

3.6) length of wire $(l) = 15$ m.
Cross-section area $(A) = 6.0 \times 10^{-7} m^2$
Resistance $(R) = 5 \Omega$.

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

$\Rightarrow 5 = \frac{\rho \times 15}{6 \times 10^{-7}}$

$\Rightarrow \frac{~~30~~ 2 \times 10^{-7}}{~~15~~} = \rho$

$\Rightarrow \rho = 2 \times 10^{-7}$.

3.7) Resistance of silver wire $(R) = 2.1\,\Omega$
Temp. $(T) = 27.5\,°C$

At temp. $(T_1) = 100°C$.
Increased resistance $(R_1) = 2.7\,\Omega$.

Then, $\alpha = \dfrac{R_1 - R}{R(T_1 - T)}$

$= \dfrac{2.7 - 2.1}{2.1(100 - 27.5)}$

$= \dfrac{0.6}{2.1 \times 72.5}$

$= 0.0039\,°C^{-1}$.

3.8) Supply voltage $(V) = 230\,V$.

Initial current $(I) = 3.2\,A$.

Resistance $(R) = \dfrac{V}{I}$

$= \dfrac{230}{3.2}$

$= 71.875\,\Omega$.

~~Final cur~~ Reduced current $(I_1) = 2.8\,A$.

Then, resistance $(R_1) = \dfrac{V}{I_1}$

~~$= \dfrac{3.2}{71.875}$~~ $= \dfrac{230}{2.8}$

~~= 0.0445 Ω.~~ =

~~= 0.045 Ω (approx).~~

Initial temp. (T) = 27°C (Given)

Coefficient of material (α) = $1.7 \times 10^{-4}\,°C^{-1}$ (given)

Then, $\alpha = \dfrac{R_1 - R}{R(T_1 - T)}$

~~$\Rightarrow 1.7 \times 10^{-4} = 0.045 - 71.875$~~

$\Rightarrow 1.7 \times 10^{-4} = \dfrac{82.142 - 71.875}{71.875(T_1 - 27)}$

$\Rightarrow 71.875(T_1 - 27) = \dfrac{10.267}{1.7 \times 10^{-4}}$

$\Rightarrow T_1 - 27 = \dfrac{10.267}{71.875 \times 1.7 \times 10^{-4}}$

$\Rightarrow T_1 = 840.265 + 27$

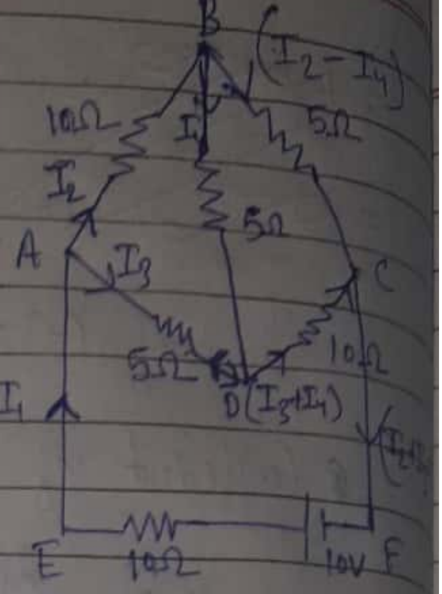
$= 867.265\,°C$.

∴ The increased temperature of the element is 867.265°C

3.9) Let the current through AB $= I_2$

Similarly,

the current through AD, BD, CD and BC are = $I_3, I_4, I_3 + I_4$ and $I_2 - I_4$ respectively.



In circuit ABDA,

$$10 I_2 + 5 I_4 - 5 I_3 = 0$$

$$\Rightarrow 2I_2 + I_4 - I_3 = 0$$

$$\Rightarrow I_3 = 2I_2 + I_4 \quad \text{—— (1)}$$

In circuit BCDB,

$$5(I_2 - I_4) - 10(I_3 + I_4) - 5 I_4 = 0$$

$$\Rightarrow I_2 - I_4 - 2(I_3 + I_4) - I_4 = 0$$

$$\Rightarrow I_2 - I_4 - 2I_3 - 2I_4 - I_4 = 0$$

$$\Rightarrow I_2 - 2I_3 - 4I_4 = 0$$

$$\Rightarrow I_2 = 2I_3 + 4I_4 \quad \text{—— (2)}$$

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In circuit ABCFEA,

$$-10 + 10I_1 + 10I_2 + 5(I_2 - I_4) = 0$$

$$\Rightarrow -10 + 10I_1 + 10I_2 + 5I_2 - 5I_4 = 0$$

$$\Rightarrow 10I_1 + 15I_2 - 5I_4 - 10 = 0$$

$$\Rightarrow 2I_1 + 3I_2 - I_4 - 2 = 0 \quad \text{—— (3)}$$

From eq. (1) and (2),

$$I_2 = 2(2I_2 + I_4) + 4I_4$$

$$= 4I_2 + 2I_4 + 4I_4$$

$$= 2I_2 + I_4 + 2I_4$$

$$= 2I_2 + 3I_4 \quad \text{—— (4)}$$

$$I_3 = 2(2I_3 + 4I_4) + I_4$$

$$\Rightarrow I_3 = 4I_3 + 8I_4 + I_4$$

$$\Rightarrow I_3 - 4I_3 = 9I_4$$

$$\Rightarrow -3I_3 = 9I_4$$

$$\Rightarrow I_3 = -3I_4 \quad \text{—— (4)}$$

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Putting value of I3 obtained in eq. 4, in the equation 2,

$I_2 = 2I_3 + 4I_4$

$\Rightarrow I_2 = 2(-3I_4) + 4I_4$

$\Rightarrow I_2 = -6I_4 + 4I_4$

$\Rightarrow I_2 = -2I_4$. ——— (5)

Now, As $I_1 = I_2 + I_3$

$\Rightarrow I_1 = -2I_4 + (-3I_4)$

$= -5I_4$. ——— (6)

Putting the values of I_1 and I_2 in eq. (3),

$2I_1 + 3I_2 - I_4 - 2 = 0$

$\Rightarrow 2(-5I_4) + 3(-2I_4) - I_4 - 2 = 0$

$\Rightarrow -10I_4 - 6I_4 - I_4 = 2$

$\Rightarrow -17I_4 = 2$

$\Rightarrow I_4 = \frac{-2}{17}$ A.

Now, putting the value of I_4 in eq. (4), (5) and (6),

$I_3 = -3 I_4$

$= -3 \times \frac{-2}{17}$

$= \frac{6}{17}$ A.

$I_2 = -2 I_4$

$= -2\left(\frac{-2}{17}\right)$

$= \frac{4}{17}$ A.

$I_1 = -5 I_4$

$= -5\left(\frac{-2}{17}\right)$

$= \frac{10}{17}$ A.

Current in BC branch $= I_2 - I_4$

$= \frac{4}{17} - \left(\frac{-2}{17}\right)$

$= \frac{4}{17} + \frac{2}{17}$

$= \frac{6}{17}$ A.

Current in DC branch $= I_3 + I_4$

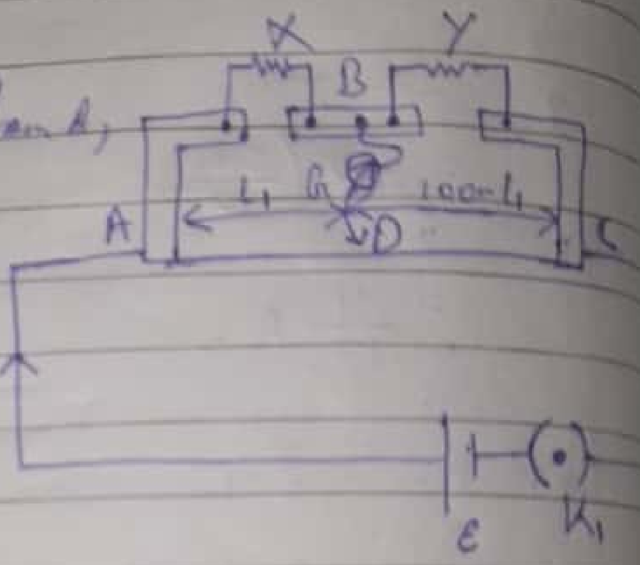
$= \frac{6}{17} + \left(\frac{-2}{17}\right)$

$= \frac{4}{17}$ A.

∴ Current in branches of EA, AB, AD, BD, BC and [illegible] are $\frac{10}{17}$ A, $\frac{4}{17}$ A, $\frac{6}{17}$ A, $\frac{-2}{17}$ A, $\frac{6}{17}$ A and $\frac{4}{17}$ [illegible]

respectively.

3.10) a) Balance point is at 39.5 cm from A,



$l_1 = 39.5$ cm.

$100 - l_1 = 100 - 39.5$

$= 60.5$ cm.

~~Again~~ $Y = 12.5\ \Omega$ (Given)

According to the formula,

$$\frac{X}{l_1} = \frac{Y}{100-l_1}$$

$$\Rightarrow \frac{X}{39.5} = \frac{12.5}{100-39.5}$$

$$\Rightarrow X = \frac{12.5 \times 39.5}{60.5}$$

$$= 8.16\ \Omega.$$

b) If X and Y are interchanged,

$$\frac{Y}{l_1} = \frac{X}{100 - l_1}$$

$$\Rightarrow \frac{12.5}{l_1} = \frac{8.16}{100 - l_1}$$

$$\Rightarrow 8.16 \times l = (100 - l_1)(12.5)$$

$$\Rightarrow 8.16 l = 1250 - 12.5 l$$

$$\Rightarrow 20.66 l = 1250$$

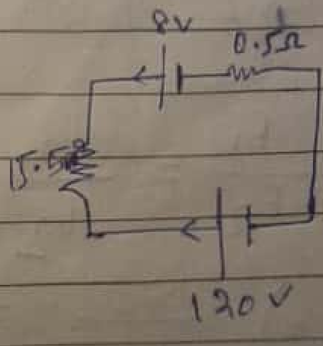
$$\Rightarrow l = \frac{1250}{20.66}$$

$$= 60.5 \text{ cm}.$$

∴ The balance point is at 60.5 cm from end A after interchanging X and Y.

c) If the galvanometer and cell are interchanged, the position of the balance point remains unchanged, so the galvanometer shows no current.

3.11) Emf of battery = 8 V.
Internal resistance (r) = 0.5 Ω.
Series resistor (R) = 15.5 Ω.
Supply voltage = 120 V.



Net voltage = 120 − 8 = 112 V.

Net resistance = 15.5 + 0.5 (As resistor is connected in series)
= 16 Ω.

Then, Current (I) = $\frac{V_{net}}{R_{net}}$

= $\frac{112}{16}$

= 7 A.

As the battery is ~~being~~ charging / being charged,

Terminal voltage = $\varepsilon + Ir$
= 8 + 7 × 0.5

= 8 + 3.5
= 11.5 V.

A series resistor limits the current flowing in the circuit, otherwise it can be dangerous. So it is needed in a charging circuit.

3.12) EMF of 1st cell (E_1) = 1.25 V
Balance point (l_1) = 35 cm.
l_2 = 63 cm (Shifted balance point)
Then,
EMF of 2nd cell (E_2) is given by,

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\Rightarrow \frac{1.25}{E_2} = \frac{35}{63}$$

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$\Rightarrow \frac{E_2}{1.25} = \frac{63}{35}$

$\Rightarrow E_2 = \frac{63 \times 1.25}{35}$

$= 2.25 V.$

∴ The EMF of 2nd cell is 2.25 V.

8.18) Number density (n) = $8.5 \times 10^{28} m^{-3}$
Length of wire = 3 m.
Area of cross-section = $2 \times 10^{-6} m^2$.
Current in wire = 3 A.
Charge of an electron = 1.6×10^{-19} C.

By formula,

$I = neAV_d$

$\Rightarrow I = \frac{neAL}{t}$ $\left[\because V_d = \frac{L}{t}\right]$

$\Rightarrow 3 = \frac{8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 2 \times 10^{-6} \times 3}{t}$

$\Rightarrow t = 8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 2 \times 10^{-6}$

$= 27.2 \times 10^{3}$ seconds

$= 2.72 \times 10^{4}$ seconds.

∴ An electron takes 2.72×10^{4} seconds to drift from one end of wire to another end.