PROBLEMS:

P.13.1 How many electrons pass through an electric bulb in one minute if 300 mA current is passing through it?

DATA: Charge on an electron $= e = 1.6\times10^{-19}\,C$

Time $= t = 1\,min = 60\,s$

Current $= I = 300\,mA = 300\times10^{-3}\,A = 0.3\,A$

Number of electrons $= N = ?$

Sol. As $I = \frac{Q}{t} = \frac{N\times e}{t}$

or $N = \frac{I\times t}{e} = \frac{0.3\,A\times 60\,s}{1.6\times10^{-19}\,C} = \boxed{1.125\times10^{20}}$

P.13.2 A charge of 90 C passes through a wire in 1 hour and 15 minutes. What is the current in the wire?

DATA: charge $= Q = 90\,C$

Time $= t = 1\,hr\ 15\,min = 4500\,s$

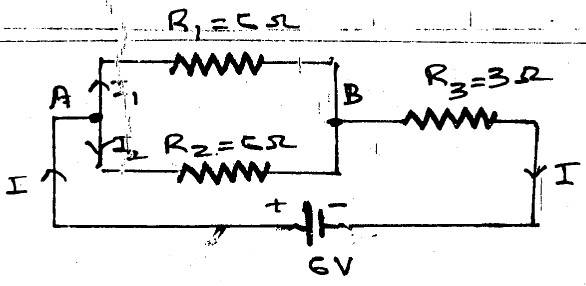
current $= I = ?$

Sol. As $I = \frac{Q}{t} = \frac{90\,C}{4500\,s} = 0.02\,A = 0.02\times10^{3}\times10^{-3}\,A$

$I = 20\times10^{-3}\,A = \boxed{20\,mA}$

P.13.2 Find the equivalent resistance of the circuit in the fig, total current drawn from the source and the current through each resistor.

(P.T.O)

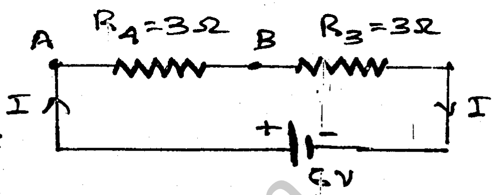


Sol. R_1 and R_2 are connected in parallel between points 'A' and 'B' then

$$\frac{1}{R_4} = \frac{1}{R_1} + \frac{1}{R_2}$$

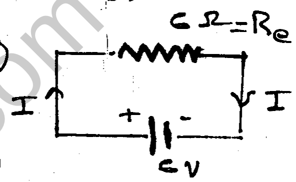
$$= \frac{1}{6} + \frac{1}{6} = \frac{1}{3}$$

$$\therefore R_4 = 3\Omega \quad \text{——— (1)}$$



Now R_4 and R_3 are in series. The equivalent resistance R_e is given by

$$R_e = R_4 + R_3 = 3 + 3 = \boxed{6\Omega} \quad \text{——— (2)}$$



$$\text{current} = I = \frac{V}{R_e} = \frac{6V}{6\Omega} = \boxed{1.0\text{ A}} \quad \text{——— (3)}$$

<u>current through R_1</u>

$$I_1 = \frac{V_{AB}}{R_1} \qquad \because V_{AB} = IR_4 = 1 \times 3 = 3 \text{ volts}$$

$$I_1 = \frac{3\text{ volts}}{6\Omega} = \boxed{0.5\text{ A}} \quad \text{——— (4)}$$

<u>current through R_2</u>

$$I_2 = \frac{V_{AB}}{R_2} = \frac{3V}{6\Omega} = \boxed{0.5\text{ A}} \quad \text{——— (5)}$$

<u>current through R_3</u>

$$I = I_1 + I_2 = \boxed{1.0\text{ A}} \quad \text{——— (6)}$$

P.13.4 A rectangular bar of iron is 2.0 cm by 2.0 cm in cross section and 40 cm long. Calculate its resistance if the resistivity of iron is $11 \times 10^{-8}\ \Omega \times m$.

DATA. Area of bar $= A = 2cm \times 2cm = 4\ cm^2 = 4 \times 10^{-4}\ m^2$

Length of bar $= L = 40cm = 0.4\ m$

Resistivity of bar $= \rho = 11 \times 10^{-8}\ \Omega \times m$

Resistance $= R = ?$

Sol. As $R = \frac{\rho L}{A} = \frac{11 \times 10^{-8}\ \Omega \times m \times 0.4\ m}{4 \times 10^{-4}\ m^2} = \boxed{1.1 \times 10^{-4}\ \Omega}$

P.13.5 The resistance of an iron wire at $0^\circ c$ is $1\times10^{-4}\,\Omega$. What is the resistance at $500^\circ c$ if the temp. co-efficient of resistance of iron is $5.2\times10^{-3}K^{-1}$?

DATA: Resistance at $0^\circ c = R_o = 1\times10^{-4}\,\Omega$

Resistance at $500^\circ c = R_t = ?$

$$\alpha = 5.2\times10^{-3}K^{-1}$$

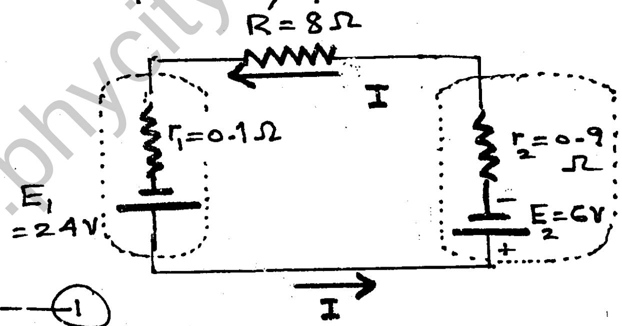
change in temp. $= t = (T - 0^\circ) = (500+273) - 273 = 500K$

Sol. As $$\alpha = \frac{R_t - R_o}{R_o \times t}$$

$$5.2\times10^{-3}K^{-1} = \frac{R_t - 1\times10^{-4}}{1\times10^{-4}\times500}$$

$$R_t = \boxed{3.6\times10^{-4}\,\Omega}$$

P.13.6 calculate terminal P.d of each of cells in the given circuit.



Sol. The circuit consists of two batteries. The total voltage in the circuit is

$$V = E_1 - E_2$$
$$= 24 - 6 = 18 \text{ Volts} \quad \text{—— (1)}$$

Total resistance of the circuit $= r_1 + R' + r_2$

$$R = 0.1 + 8 + 0.9 = 9\,\Omega \quad \text{—— (2)}$$

current flowing through the loop $= I = \frac{V}{R} = \frac{18V}{9\Omega} = 2A$ —— (3)

For battery E_1

$$V_1 = E_1 - I\times r$$
$$= 24 - 2\times0.1 = \boxed{23.8 \text{ volts}}$$

Where 'V_1' is the terminal P.d of battery E_1.

For battery E_2

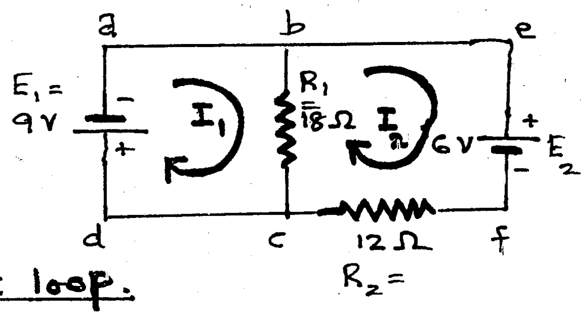
$$V_2 = E_2 + I\times r$$
$$= 6 + 2\times0.9 = \boxed{7.8 \text{ volts}}$$

Where 'V_2' is the terminal P.d of battery E_2.

This is the case when battery is being charged.

(P.T.O)

P.13.7 Find the current which flows in all the resistances of the circuit.



Sol. Let current 'I_1' is following in the left loop and current 'I_2' is flowing in the right loop. Now, using Kirchhoff's rule for the **left loop.**

$$-(I_1 - I_2)\times 18 + 9 = 0$$
$$(I_1 - I_2)\times 18 = 9$$
$$I_1 - I_2 = \frac{9}{18} = 0.5\text{ A}$$

or $\quad I_1 = I_2 + 0.5 \quad \text{———} (1)$

Using Kirchhoff's rule for the **right loop.**

$$-(I_2 - I_1)\times 18 - 12I_2 - 6 = 0$$
$$-18I_2 + 18I_1 - 12I_2 = 6\text{ volt}$$
$$-30I_2 + 18I_1 = 6$$
$$-5I_2 + 3I_1 = 1 \quad \text{———} (2)$$

Putting value of 'I_1' from eq.(1) into eq.(2), we have;

$$-5I_2 + 3(I_2 + 0.5) = 1$$
$$-5I_2 + 3I_2 + 1.5 = 1$$
$$-2I_2 = -0.5$$
$$I_2 = \frac{0.5}{2} = \boxed{0.25\text{ A}} \quad \text{———} (3)$$

Substituting the value of 'I_2' in eq.(1), we have

$$I_1 = 0.25 + 0.5 = \boxed{0.75\text{ A}} \quad \text{———} (4)$$

Now,

Current through 18Ω resistance $= I_1 - I_2$

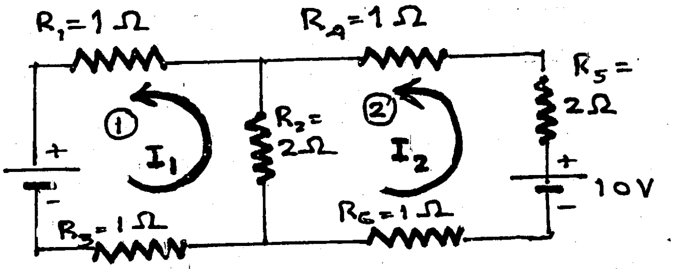
$$I = 0.75 - 0.25$$
$$= \boxed{0.5\text{ A}}$$

Current through 12Ω resistance $= I_2 = \boxed{0.25\text{ A}}$

(P.T.O)

P.13.8: Find the current and power dissipated in each resistance of the circuit as shown.

Sol.



Let 'I_1' (Anticlockwise) be the current flowing through loop 1 and 'I_2' (Anticlockwise) be the current flowing through loop 2. Applying Kirchhoff's second rule to solve this circuit.

For loop 1

$$-6 - 1\times I_1 - 2(I_1 - I_2) - 1\times I_1 = 0$$

$$-4I_1 + 2I_2 = +6$$

$$\text{or} \quad -2I_1 + I_2 = +3 \quad \text{——} (1)$$

For loop 2

$$+10 - 1\times I_2 - 2(I_2 - I_1) - 1\times I_2 - 2\times I_2 = 0$$

$$+2I_1 - 6I_2 = -10 \quad \text{——} (2)$$

Adding eqs. (1) and (2), we have

$$-5I_2 = -7$$

$$I_2 = \frac{7}{5} = \boxed{1.4\,A} \quad \text{——} (3)$$

Putting this value of 'I_2' in eq. (1), we have

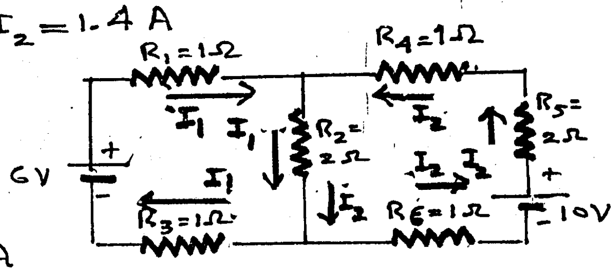
$$-2I_1 + 1.4 = +3$$

$$2I_1 = -3 + 1.4$$

$$I_1 = \frac{-1.6}{2} = \boxed{-0.8\,A} \quad \text{——} (4)$$

The negative sign with 'I_1' shows that actually it is flowing through the loop is in clockwise direction

$\therefore \quad I_1 = 0.8\,A$ and $I_2 = 1.4\,A$



current through R_1 and R_3 $= I_1 = 0.8\,A$

current through R_2

$= I_1 + I_2 = 1.4 + 0.8 = 2.2\,A$

current through R_4, R_5 & $R_6 = I_2 = 1.4\,A$

(P.T.O)

Power dissipation

Power dissipated in $R_1 = I_1^2 R_1$

$\therefore \quad P_1 = (0.8)^2 \times 1 = 0.64$ watt.

Power dissipated in $R_3 = I_1^2 \times R_3$

$\therefore \quad P_3 = (0.8)^2 \times 1 = 0.64$ watt.

Power dissipated in $R_2 = (I_1 + I_2)^2 \times R_2$

$\therefore \quad P_2 = (2.2)^2 \times 2 = 9.68$ watt.

Power dissipated in $R_4 = I_2^2 \times R_4 =$

$\therefore \quad P_4 = (1.4)^2 \times 1 = 1.96$ watt.

Power dissipated in $R_6 = I_2^2 \times R_6$

$\therefore \quad P_6 = (1.4)^2 \times 1 = 1.96$ watt

Power dissipated in $R_5 = I_2^2 \times R_5$

$\therefore \quad P_5 = (1.4)^2 \times 2 = 3.92$ watt.