CHAPTER NO. 13(CURRENT ELECTRICITY)

Question 13.1:- How many electrons pass through an electric bulb in one minute if the 300 mA current is passing through it?

Solution:- Current = I = 300 mA = 300 x 10^{-3} A = 0.3 A

Time = 1 minute = 60 s

Current = I = Charge/time = q/t

q = It = (0.3)(60) = 1.8 C

We know that total charge passing through the bulb in terms of electronic charge e is **q = ne.**

We can say that q = ne

n = q/e = $\frac{1.8}{1.60 \, x \, 10^{-19}}$ = 1.12 x 10^{19}

n = 1.12 x 10^{19}

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

Solution:- Charge = q = 90 C

Time = t = 1 hour 15 minutes = 75 minutes = 75 x 60 s = 4500 s

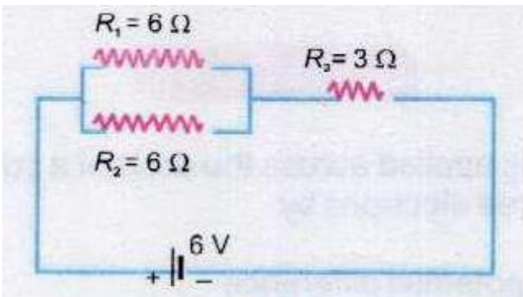
Current = I = Charge/time = q/t

I = 90/4500 = 1/50 A

I = 0.02 A

I = 20 mA

Question 13.3:- Find the equivalent resistance of the circuit, total current drawn from the source and the current through each resistor.



Solution:- EMF of battery = V = 6 V

We can see that R_1 and R_2 are connected in parallel. The parallel combination of R_1 and R_2 is connected in series with R_3.

We can solve parallel combination as $\frac{1}{R_{12}} = \frac{1}{R_1} + \frac{1}{R_2}$

$R_{12} = \frac{R_1 R_2}{R_1 + R_2} = \frac{(6)(6)}{6+6} = 3 \, \Omega$

$R_T = R_{12} + R_3 = 3 + 3$ **∴ R_{12} is in series with R_3**

$R_T = 6 \, \Omega$

The current drawn from the source is $I_T = V/R_T = 6/6$

I_T = 1 A

Since R_1 and R_2 are connected in parallel, voltage drop is same across them but current coming from the source V is divided in two part I_1 and I_2.

The potential drop across parallel combination of R_1 and R_2 = $V_{12} = I_T R_{12}$ = (1)(3) = 3 V

Current through $R_1 = I_1 = V_{12}/R_1 = 3/6$

$I_1 = 0.5$ A

Current through $R_2 = I_2 = V_{12}/R_2 = 3/6$

$I_2 = 0.5$ A

The current passing through R_1 and R_2 is added up to pass through R_3.

Current through $R_3 = I_3 = I_T = I_1 + I_2$

$I_3 = 1$ A

Question 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 11×10^{-8} Ω m.

Solution:- Resistivity of iron = $\rho = 11 \times 10^{-8}$ Ω m

Length of iron bar = 40 cm = 0.4 m

Width of iron bar = W = 2.0 cm = 0.02 m

Breadth of iron bar = B = 2.0 cm = 0.02 m

Area of cross section = A = Width x Breadth = W x B = 0.02 x 0.02 = 4×10^{-4} m^2

Resistance = $R = \rho \frac{L}{A} = (11 \times 10^{-8}) \left(\frac{0.4}{4 \times 10^{-4}}\right)$

$R = 1.1 \times 10^{-4}$ Ω

Question 12.5:- The resistance of an iron wire at 0 °C is 1×10^4 Ω. What is the resistance at 500 °C if the temperature coefficient of resistance of iron is 5.2×10^{-3} K^{-1}?

Solution:- Temperature coefficient of resistance of iron = $\alpha = 5.2 \times 10^{-3}$ K^{-1}

Resistance at 0 °C = $R_o = 1 \times 10^4$ Ω

Initial temperature = t_1 = 0 °C = 273 K

Final temperature = t_2 = 500 °C = 773 K

Rise in temperature = $t = t_2 - t_1$ = 773 – 273 = 500 K

We know that $\alpha = \frac{R_t - R_o}{R_o t}$

Rearranging gives $R_t = R_o (1 + \alpha t)$

$R_t = (1 \times 10^4) [1 + (5.2 \times 10^{-3})(500)] = (1 \times 10^4)(1 + 2.6)$

$R_t = 3.6 \times 10^4$ Ω

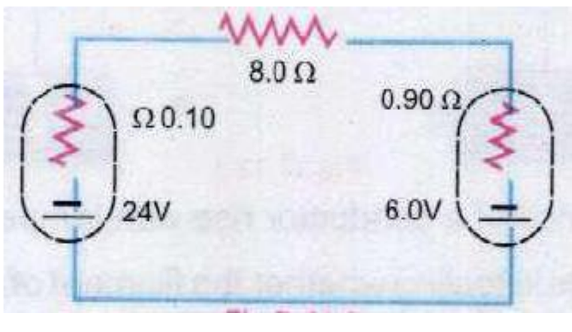
Question 13.6:- Calculate the terminal potential difference of each of cells in circuit of figure.

Solution:- EMF of first cell = E_1 = 24 V

Internal resistance of first cell = r_1 = 0.10 Ω

EMF of second cell = E_2 = 6 V

Internal resistance of second cell = r_2 = 0.90 Ω



External resistance = R = 8.0 Ω

EMF of first cell = E_1 = 24 V

Internal resistance of first cell = r_1 = 0.10 Ω

In the given circuit, both batteries oppose each other as positive terminals of both are connected to each other. The circuit is a series circuit. The current is being supplied by the first battery E_1 and second battery is being charged by current of first battery.

Current supplied by the first cell = $I = \frac{E_1 - E_2}{r_1 + r_2 + R} = \frac{24-6}{0.10+0.90+8.0}$

I = 2 A

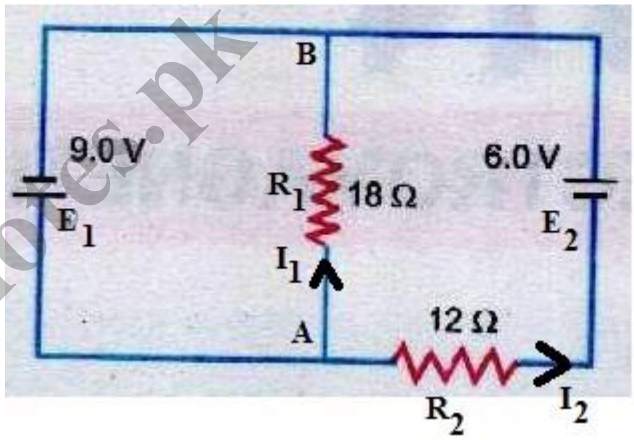
Terminal potential difference of first cell = $V_1 = E_1 - I r_1 = 24 - (2)(0.10)$

$V_1 = 23.8$ V

Terminal potential difference of first cell = $V_2 = E_2 - I r_2 = 6 + (2)(0.90)$

$V_2 = 7.8$ V

Question 13.7:- Find the current which flows in all the resistances of the circuit of figure.



Solution:- First of all, label all the branches of circuit. Assign current to R_1 and R_2 with the arrow symbol showing the direction of conventional current.

EMF of first cell = E_1 = 9.0 V

EMF of second cell = E_2 = 6.0 V

We can easily see this is a parallel circuit.

Since, R_1 and E_1 are connected in parallel:

Current through $R_1 = I_1 = E_1/R_1 = 9.0/18$

$I_1 = 0.5$ A (Direction of conventional current is from B to A)

We can also see that E_1 is in parallel with series combination of R_2 and E_2, so we can say that

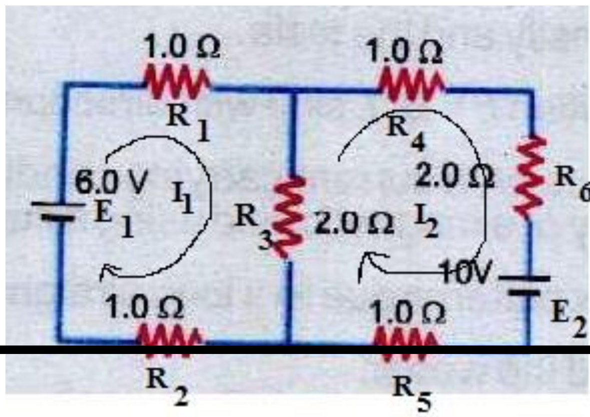
$E_1 = I_2 R_2 - E_2$

$9.0 = I_2 (12) - 6$

$I_2 = \frac{9+6}{12}$

$I_2 = 1.25$ A (Direction of conventional current is from B to A)

Question 13.8:- Find the current and power dissipated in each resistance of the circuit, shown in figure.



Solution:- First of all, label all the branches of circuit. There are two closed conducting paths i.e. loops in the circuit. We have assigned current to both loops in clockwise direction.

We will write the equations of both loops by using Kirchhoff's second rule and solve them.

LOOP 1:

$-I_1 R_1 - (I_1 - I_2) R_3 - I_1 R_3 + E_1 = 0$

Put values of R_1, R_2, R_3 and E_1.

$6 = 4 I_1 - 2 I_2$

$3 = 2 I_1 - I_2$ ----------------------- Eq. (1)

LOOP 2:

$-I_2 R_4 - I_2 R_6 - E_2 - I_2 R_5 - (I_2 - I_1) R_3 = 0$

Put values of R_3, R_4, R_5, R_6 and E_2.

$10 = 2 I_1 - 6 I_2$

$5 = I_1 - 3 I_2$ ---------------------- Eq. (2)

We can solve these equations algebraically.

CONVENTIONS	
RESISTOR	**EMF SOURCE**
a) Voltage change across a resistor is positive if traversed against the direction of current. **b)** Voltage change across a resistor is negative if traversed in the direction of current.	**a)** Voltage change across an emf source is positive if traversed from negative to positive terminal. **b)** Voltage change across an emf source is negative if traversed from positive to negative terminal.

Multiply Eq. (2) with 3 and subtract it from Eq. (2) gives the value of **$I_1 = 0.8$ A**

Put the value of $I_1 = 0.8$ A in Eq. (1) gives $3 = 2\ (0.8) - I_2$

$I_2 = -1.4$ A (The negative sign indicates that actual current is flowing opposite to the assigned direction)

Current through R_1 and $R_2 = I_1 = 0.8$ A (Clockwise direction)

Current through $R_3 = I_1 - I_2 = 0.8 - (-1.4) = 2.2$ A (Clockwise direction)

Current through R_4, R_5 and $R_6 = |I_2| = 1.4$ A (Anticlockwise direction)

Power drop across R_1 and $R_2 = I_1^2 R_1^2 = I_1^2 R_2^2 = (0.8)^2 (1) = 0.64$ W

Power drop across $R_3 = (I_1 - I_2)^2 R_3^2 = (2.2)^2 (2) = 9.68$ W

Power drop across R_4 and $R_5 = I_2^2 R_4^2 = I_2^2 R_5^2 = (1.4)^2 (1) = 1.96$ W

Power drop across $R_6 = I_2^2 R_6 = (1.4)^2 (2) = 3.92$ W