The current intensity that passes in the 18 Ω resistor: $I_1 = \frac{V_B}{18} = \frac{10.8}{18} = 0.6\ A$

The current intensity that passes in the 4 Ω resistor: $I = I_1 + I_4$, $1.5 = 0.6 + I_4$, $I_4 = 0.9\ A$

The potential difference across each of the 12 Ω , 24 Ω resistors: $V_3 = I_4 \grave{R}_1 = 0.9 \times 8 = 7.2\ V$

The current intensity that passes in the 24 Ω resistor: $I_2 = \frac{V_3}{24} = \frac{7.2}{24} = 0.3\ A$

The current intensity that passes in the 12 Ω resistor: $I_3 = \frac{V_3}{12} = \frac{7.2}{12} = 0.6\ A$

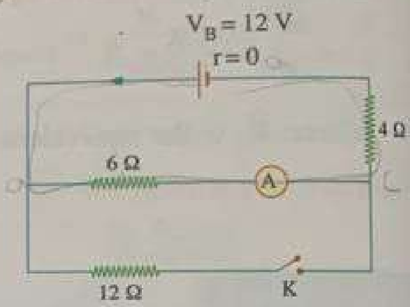
Another solution : $I_3 = I_4 - I_2 = 0.9 - 0.3 = 0.6\ A$

Example 4

Choose: ***In the opposite electric circuit, the ratio between the two readings of the ammeter before and after closing the switch is ....***

$A_1 = 1.2$

$A_2 =$



(a) $\frac{2}{3}$ (b) $\frac{3}{2}$

(c) $\frac{5}{6}$ (d) $\frac{6}{5}$

Solution

At closing or opening the switch in a circuit, you need to redistribute the current starting from the positive terminal of the battery till reaching its negative terminal to find out if the ammeter reads the total current or just a part of it.

The ammeter reading (I_1) when the switch (K) is opened:

$$I_1 = \frac{V_B}{\grave{R}_1} = \frac{12}{6+4} = 1.2\ A$$

The ammeter reading (I_2) when the switch (K) is closed:

$$\grave{R}_2 = 4 + \frac{6 \times 12}{6 + 12} = 8\ \Omega$$

$$I_{total} = \frac{V_B}{\grave{R}_2} = \frac{12}{8} = 1.5\ A$$

$$I_{total} \times \frac{6 \times 12}{6 + 12} = I_2 \times 6$$

$$I_2 = 1.5 \times \frac{4}{6} = 1\ A$$

$$\therefore \frac{I_1}{I_2} = \frac{1.2}{1} = \frac{6}{5}$$

∴ **The correct choice is (d).**

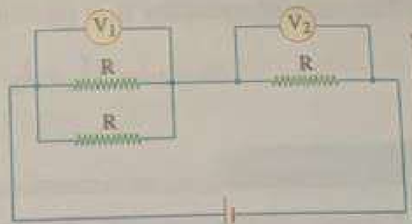
Example 2

Choose : In the opposite electric circuit, the ratio between the readings of the two voltmeters $\left(\frac{V_1}{V_2}\right)$ equals ....

ⓐ $\frac{1}{1}$ ⓑ $\frac{2}{1}$ ⓒ $\frac{1}{2}$ ⓓ $\frac{1}{4}$

Solution

For determining the electric potential difference, we have to determine firstly the two points that we try to find the potential difference between them, where in the case of connecting resistors in series, the potential difference is distributed among the resistors according to their ratio of resistances.



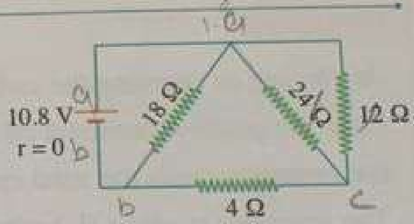
$$\frac{V_1}{V_2} = \frac{\grave{R}_1}{R} = \frac{0.5\,R}{R} = \frac{1}{2}$$

Where: $\grave{R}_1$ is the equivalent resistance between the terminals of voltmeter V_1

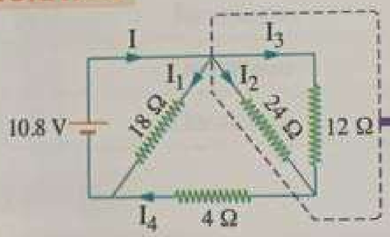
∴ The correct choice is ⓒ.

Example 3

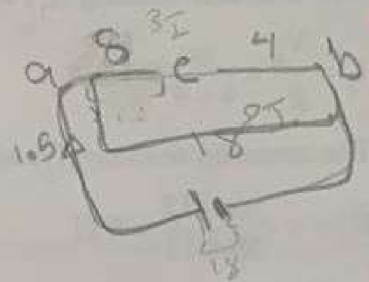
In the electric circuit shown in the opposite figure, calculate the passing current intensity in each resistor.



Solution

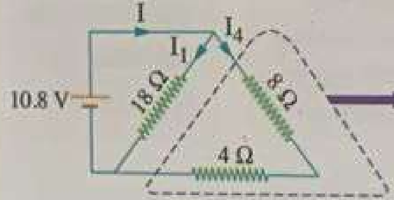


$$\grave{R}_1 = \frac{12 \times 24}{12 + 24} = 8\ \Omega$$

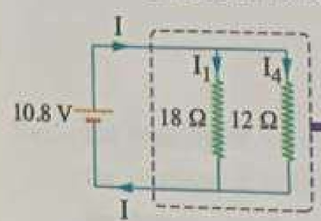


R = 7.2

$I_{t} = \frac{10.8}{7.2} = 1.5$



$$\grave{R}_2 = 8 + 4 = 12\ \Omega$$



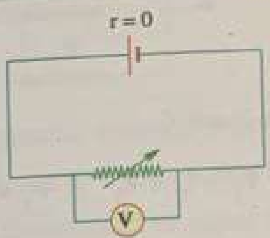
$$\grave{R} = \frac{12 \times 18}{12 + 18} = 7.2\ \Omega$$

The current intensity that passes in the circuit: $I = \frac{V_B}{\grave{R}} = \frac{10.8}{7.2} = 1.5\ A$

Guideline:

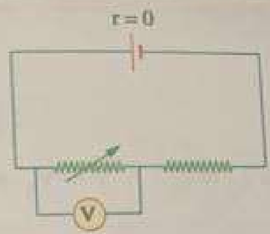
When a voltmeter is connected across the terminals of a variable resistor, where:

The variable resistor is connected between the terminals of an electric source of negligible internal resistance



The voltmeter reading **doesn't change** by **changing** the value of the variable resistor and its reading remains always equal to the electromotive force of the source.

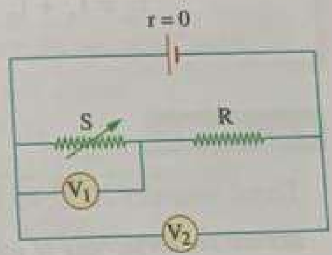
The variable resistor is part of the circuit resistances



The voltmeter reading **increases** by **increasing** the value of the variable resistor.

Example

Choose: ***What happens to the readings of each voltmeter V_1 and V_2, when increasing the variable resistance S?***



	Reading of voltmeter V_1	Reading of voltmeter V_2
a	Increases	Decreases
b	Increases	Doesn't change
c	Decreases	Increases
d	Decreases	Doesn't change

Solution

By increasing the variable resistance (S) → The total resistance (R) of the circuit increases → So, the intensity of current in the circuit decreases according to the relation : $I = \frac{V}{R}$

→ So, the potential difference across the terminals of resistor R decreases

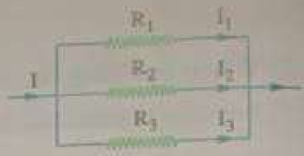
→ So, the potential difference across the terminals of resistor S increases

i.e., - the reading of voltmeter V_1 **increases** since $V_B = V_1 + V_R$

- the reading of voltmeter V_2 **doesn't change** since it is connected between the terminals of an electric source of negligible internal resistance.

∴ **The correct choice is b.**

Guideline:



- **To calculate the electric current intensity in one of multiple branches that are connected in parallel, follow the following steps:**

① Calculate the equivalent resistance of the group of resistors from the relation:

$$\frac{1}{\grave{R}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

② Calculate the potential difference across the terminals of the equivalent resistance which equals the potential difference across the terminals of any branch using the relation:

$$V = V_1 = V_2 = V_3 \quad , \quad V = I\grave{R}$$

Where: I is the total electric current intensity.

③ Calculate the current in any branch using the relation: $I_{branch} = \frac{V}{R_{branch}} = \frac{I\grave{R}}{R_{branch}}$

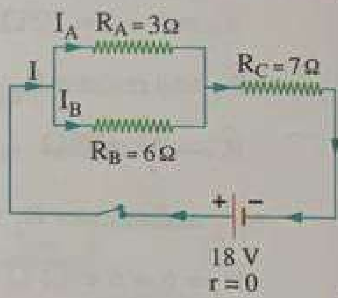
Example 1

In the opposite electric cricuit, calculate:

(a) The total resistance.

(b) The total electric current intensity passing in the circuit.

(c) The passing electric current intensity in each of the resistors R_A and R_B



Solution

$R_A = 3\ \Omega$ | $R_B = 6\ \Omega$ | $R_C = 7\ \Omega$ | $V_B = 18\ V$ | $\grave{R} = ?$ | $I = ?$ | $I_A = ?$ | $I_B = ?$

(a) $\grave{R} = \frac{R_A R_B}{R_A + R_B} + R_C = \frac{3 \times 6}{3+6} + 7 = 2 + 7 = 9\ \Omega$

(b) $I = \frac{V_B}{\grave{R}} = \frac{18}{9} = 2\ A$

(c) To calculate the current intensity in both resistors R_A and R_B, we calculate first the potential difference across them:

$$R_{AB} = \frac{3 \times 6}{3+6} = 2\ \Omega$$

$$V_{AB} = IR_{AB} = 2 \times 2 = 4\ V$$

$$I_A = \frac{V_{AB}}{R_A} = \frac{4}{3} = 1.33\ A$$

$$I_B = \frac{V_{AB}}{R_B} = \frac{4}{6} = 0.67\ A$$

Solution

(*i*) **When opening the switch from both directions, the three resistors R_1, R_2 and R_3 become connected in series and no current passes in resistor R_4:**

$R_t = R_1 + R_2 + R_3 = 6 + 6 + 6 = 18\ \Omega$

$\therefore$ **The correct choice is (d).**

(*ii*) **When closing the switch in direction (1), the circuit can be redrawn as follows:**

- The two resistors R_3 and R_4 are connected in parallel:

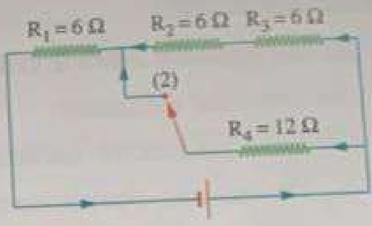
$\grave{R}_1 = \frac{6 \times 12}{6 + 12} = 4\ \Omega$

- $\grave{R}_1$ and the two resistors R_1 and R_2 are connected in series:

$R_t = 4 + 6 + 6 = 16\ \Omega$

$\therefore$ **The correct choice is (c).**

(*iii*) **When closing the switch in direction (2), the circuit can be redrawn as follows:**



- The two resistors R_2 and R_3 are connected in series:

$\grave{R}_1 = 6 + 6 = 12\ \Omega$

- $\grave{R}_1$ and resistor R_4 are connected in parallel:

$\grave{R}_2 = \frac{12}{2} = 6\ \Omega$

- $\grave{R}_2$ and resistor R_1 are connected in series:

$R_t = 6 + 6 = 12\ \Omega$

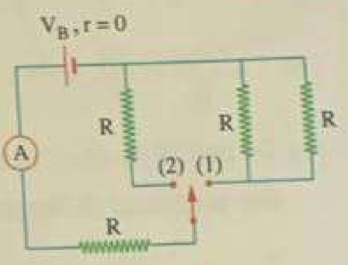
$\therefore$ **The correct choice is (a).**

Answered

4 **Test yourself**

1 **Choose the correct answer:**

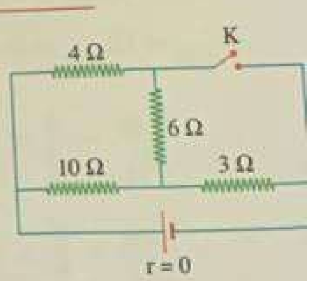
In the opposite electric circuit, the ratio between the reading of the ammeter in the case of connecting the switch in direction (1) and in the case of connecting it in direction (2) respectively equals ....



(a) $\frac{1}{1}$ (b) $\frac{1}{2}$ (c) $\frac{4}{3}$ (d) $\frac{3}{4}$

2 **Calculate** the equivalent resistance of the opposite electric circuit when:

(a) switch K is open. **(b)** switch K is closed.



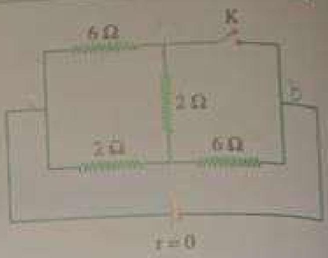
....

....

....

Example 1

Choose: In the opposite electric circuit, the equivalent resistance of the circuit when switch K is:



(i) open equals ....

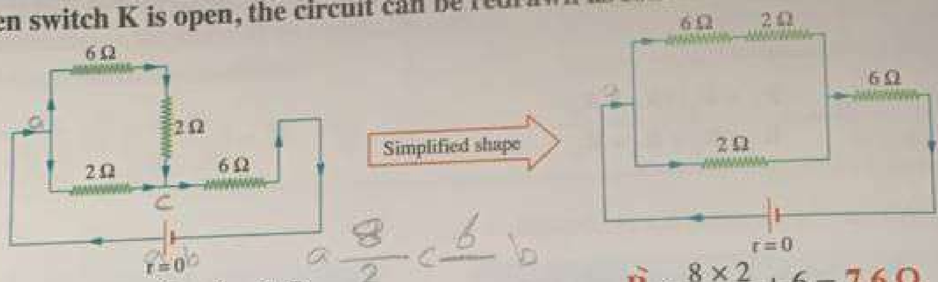
ⓐ 1.6 Ω ⓑ 3.8 Ω ⓒ 7.6 Ω ⓓ 8.9 Ω

(ii) closed equals ....

ⓐ 1.4 Ω ⓑ 2.2 Ω ⓒ 3.5 Ω ⓓ 5.3 Ω

Solution

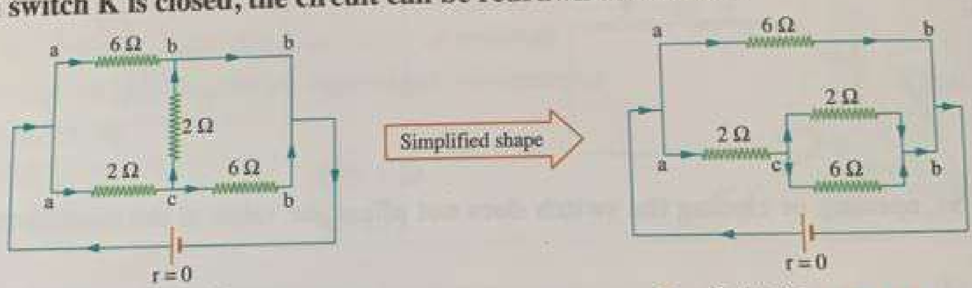
(i) When switch K is open, the circuit can be redrawn as follows:



$R_{\text{upper branch}} = 6 + 2 = 8\ \Omega$, $\grave{R} = \frac{8 \times 2}{8 + 2} + 6 = 7.6\ \Omega$

∴ The correct choice is ⓒ.

(ii) When switch K is closed, the circuit can be redrawn as follows:

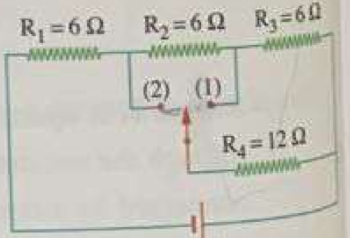


$R_{\text{lower branch}} = \frac{2 \times 6}{2 + 6} + 2 = 3.5\ \Omega$, $\grave{R} = \frac{3.5 \times 6}{3.5 + 6} = 2.2\ \Omega$

∴ The correct choice is ⓑ.

Example 2

Choose: The opposite figure illustrates an electric circuit containing a set of resistors connected together, so the equivalent resistance of the circuit in the case of:



(i) opening the switch from both directions equals ....

ⓐ 12 Ω ⓑ 14 Ω ⓒ 16 Ω ⓓ 18 Ω

(ii) closing the switch in direction (1) equals ....

ⓐ 12 Ω ⓑ 14 Ω ⓒ 16 Ω ⓓ 18 Ω

(iii) closing the switch in direction (2) equals ....

ⓐ 12 Ω ⓑ 14 Ω ⓒ 16 Ω ⓓ 18 Ω