

NCERT CBSE Solutions for Class 10 Science Chapter 12

Electricity

In Chapter Questions: (Page:200)

1. What does an electric circuit mean?

Solution:

A continuous and closed path of an electric current is called an electric circuit. An electric circuit consists of electric power source, wires, switches and electric devices like resistors bulbs etc.

2. Define the unit of current.

Solution:

The SI unit of current is ampere (A).

Definition of ampere: When one-coulomb charge flows through an electric device in a circuit in one second, then the current flowing through the device is said to be one ampere.

$$1 \text{ A} = \frac{1 \text{ C}}{1 \text{ s}}$$

Small quantities of current are expressed in the milliampere or in microampere

$$1 \text{ mA} = 10^{-3} \text{ A}$$

$$1 \mu\text{A} = 10^{-6} \text{ A}$$

3. Calculate the number of electrons constituting one coulomb of charge.

Solution:

Charge on one electron $e = 1.6 \times 10^{-19} \text{ C}$

$$\therefore \text{Number of electrons in one coulomb} = \frac{1}{1.6 \times 10^{-19}} = 6.25 \times 10^{18}$$



In Chapter Questions: (Page:202)

1. Name a device that helps to maintain a potential difference across a conductor.

Solution:

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Cell or battery maintain potential difference across a conductor.

2. What is meant by saying that the potential difference between two points is 1 V?

Solution:

Potential difference between two points in a circuit is defined as work done or energy required in moving one coulomb of charge from one point to the other. If the potential difference is 1 V, the energy required to move one coulomb of charge from one point to the other is 1 J.

3. How much energy is given to each coulomb of charge passing through a 6 V battery?

Solution:

Potential difference created by battery $\Delta V = 6 \text{ V}$

Potential difference between two points in a circuit is defined as energy required (or work done) in moving one coulomb of charge from one point to the other.

$\Delta V = \frac{W}{q}$, Where W is work done by battery and q is charge.

$$\Rightarrow W = \Delta V \times q$$

$$= 6 \text{ V} \times 1 \text{ C} = 6 \text{ J}$$



In Chapter Questions: (Page:209)

1. On what factors does the resistance of a conductor depend?

Solution:

Resistance of a conductor can be written as $R = \frac{\rho l}{A}$

Thus, the resistance of a resistor depends on

- (i) Properties of the material of conductor, or resistivity of a material
- (ii) Length of conductor
- (iii) Area of cross-section of the conductor

The resistivity of a material depends on temperature. Therefore, the resistance of a resistor also depends on the temperature of the conductor.

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2. Will current flow more easily through a thick wire or a thin wire of the same material, when connected to the same source? Why?

Solution:

Resistance of a conductor depends on resistivity ρ , length l and on the area of cross-section A as

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

$$\Rightarrow R \propto \frac{1}{A}$$

$$\text{And } I = \frac{V}{R}$$

$$\Rightarrow I \propto \frac{1}{R} \text{ or } I \propto A$$

\therefore when connected to the same power source, current through thick wire is more compared to thin wire of same material.

3. Let the resistance of an electrical component remains constant while the potential difference across the two ends of the component decreases to half of its former value. What change will occur in the current through it?

Solution:

From Ohm's law, $I = \frac{V}{R}$

$$\Rightarrow I \propto V$$

If the potential difference is decreased to half the original value keeping the resistance constant, current through the electric component also decreases to half the original value.

4. Why are coils of electric toasters and electric irons made of an alloy rather than a pure metal?

Solution:

The resistivity of an alloy is generally higher than that of its constituent metals. Alloys do not oxidise (burn) readily at high temperatures. For this reason, they are commonly used in electrical heating devices, like electric iron, toasters etc.

5. Use the data in Table 12.2 to answer the following –

Table 12.2 Electrical resistivity of some substances at 20°C

Substances	Material	Resistivity (Ω m)
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Conductors	Silver	1.60×10^{-8}
	Copper	1.62×10^{-8}
	Aluminium	2.63×10^{-8}
	Tungsten	5.20×10^{-8}
	Nickel	6.84×10^{-8}
	Iron	10.0×10^{-8}
	Chromium	12.9×10^{-8}
	Mercury	94.0×10^{-8}
	Manganese	1.84×10^{-6}
Alloys	Constantan (alloy of Cu and Ni)	49×10^{-6}
	Manganin(alloy of Cu, Mn and Ni)	44×10^{-6}
	Nichrome (alloy of Ni, Cr, Mn and Fe)	100×10^{-6}
Insulators	Glass	$10^{10} - 10^{14}$
	Hard rubber	$10^{13} - 10^{16}$
	Ebonite	$10^{15} - 10^{17}$
	Diamond	$10^{12} - 10^{13}$
	Paper (dry)	10^{12}

- (a) Which among iron and mercury is a better conductor?
(b) Which material is the best conductor?

Solution:

- (a) Conductivity of iron is $10.0 \times 10^{-8} \Omega \text{ m}$ whereas conductivity of mercury is $94.0 \times 10^{-8} \Omega \text{ m}$. Therefore, iron is good conductor compared to mercury.
(b) From the table, silver with resistivity $1.60 \times 10^{-8} \Omega \text{ m}$ is best conductor compared to other materials given.

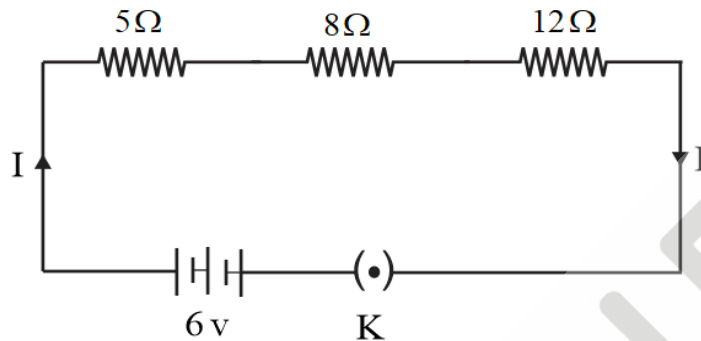


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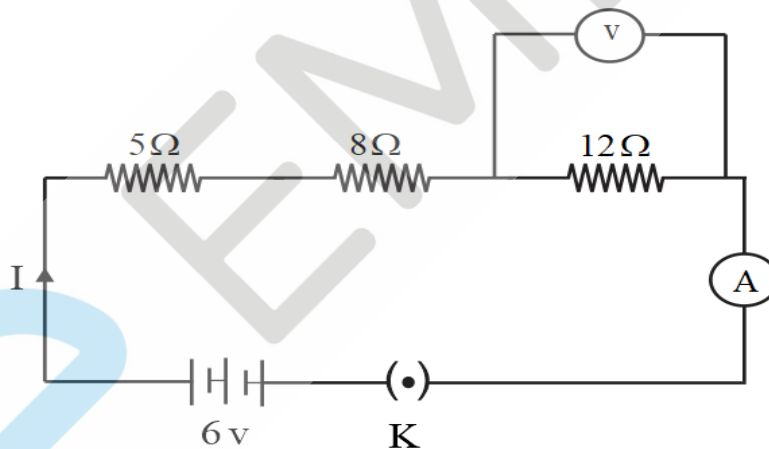
1. Draw a schematic diagram of a circuit consisting of a battery of three cells of 2 V each, a 5 Ω resistor, an 8 Ω resistor, and a 12 Ω resistor, and a plug key, all connected in series.

Solution:



2. Redraw the circuit of Question 1, putting in an ammeter to measure the current through the resistors and a voltmeter to measure the potential difference across the 12 Ω resistor. What would be the readings in the ammeter and the voltmeter?

Solution:



In the series combination, current through all resistors and in circuit will be same. Thus, current through the ammeter is

$$I = \frac{V}{R} = \frac{6}{5 + 8 + 12} = 0.24 \text{ A}$$

And potential difference across 12 Ω resistor is, $V = IR = 0.204 \times 12 = 2.88 \text{ V}$

Thus, reading of voltmeter is 2.88 V.

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In Chapter Questions: (Page:216)

1. Judge the equivalent resistance when the following are connected in parallel – (a) $1\ \Omega$ and $10^6\ \Omega$, (b) $1\ \Omega$ and $10^3\ \Omega$, and $10^6\ \Omega$.

Solution:

- (a) When $1\ \Omega$ and $10^6\ \Omega$ are connected in parallel, equivalent resistance

$$R_{eq} = \frac{1 \times 10^6}{1 + 10^6} \approx \frac{10^6}{10^6} = 1\ \Omega$$

- (b) When $1\ \Omega$, $10^3\ \Omega$, and $10^6\ \Omega$ are connected in parallel

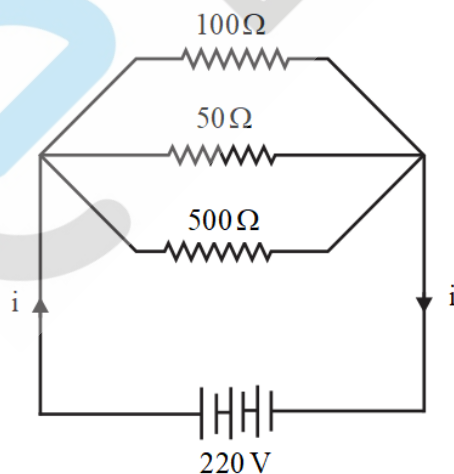
$$\begin{aligned} \frac{1}{R_{eq}} &= \frac{1}{1} + \frac{1}{10^3} + \frac{1}{10^6} \\ &= \frac{10^6 + 10^3 + 1}{10^6} \\ &= \frac{1001001}{1000000} = 1.001001\ \Omega^{-1} \end{aligned}$$

$$\Rightarrow R_{eq} = 0.999\ \Omega \approx 1\ \Omega$$

From the above two problems, when very low resistance is connected to very high resistance, the resistance of the combination will be close to low resistance.

2. An electric lamp of $100\ \Omega$, a toaster of resistance $50\ \Omega$, and a water filter of resistance $500\ \Omega$ are connected in parallel to a $220\ \text{V}$ source. What is the resistance of an electric iron connected to the same source that takes as much current as all three appliances, and what is the current through it?

Solution:



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The equivalent resistance of the parallel combination, $\frac{1}{R_{eq}} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500}$

$$\Rightarrow R_{eq} = \frac{500}{16} = 31.25 \Omega$$

Net current through all three resistors $I = \frac{220}{31.25} = 7.04 \text{ A}$

To draw the same current resistance of electric iron required is 31.25Ω and current through it is 7.04 A

3. What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series?

Solution:

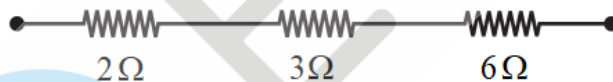
To operate properly, different electric devices need a different amount of current. In series combination all the devices get the same current, whereas in parallel combination potential difference across all the resistors is same and current will be distributed according to resistance.

In series combination, if one device fails circuit becomes broken and other devices stop working. Whereas in parallel combination all devices are independently connected to mains, even if one device fails other devices continue to work.

4. How can three resistors of resistances 2Ω , 3Ω , and 6Ω be connected to give a total resistance of (a) 4Ω , (b) 1Ω ?

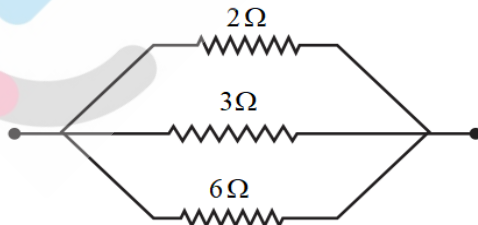
Solution:

Case 1: When all resistors are connected in series, the equivalent resistance is



$$R_{eq} = 2 + 3 + 6 = 11 \Omega$$

Case 2: When all resistors are connected in parallel, the equivalent resistance is,

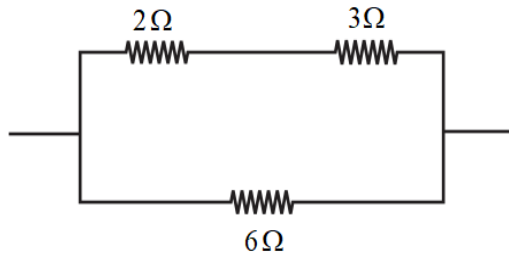


$$\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6}$$

$$\Rightarrow R_{eq} = 1 \Omega$$

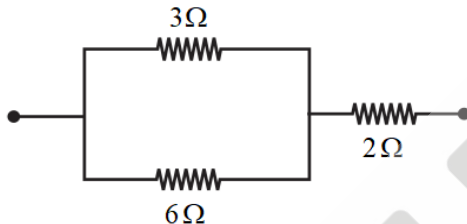
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Case 3: When $2\ \Omega$, $3\ \Omega$ are in series and $6\ \Omega$ is in parallel, the equivalent resistance is



$$R_{eq} = 6 + \frac{2 \times 3}{2+3} = 7.2\ \Omega$$

Case 4: When $3\ \Omega$ and $6\ \Omega$ are in parallel and $2\ \Omega$ is in series, the equivalent resistance is



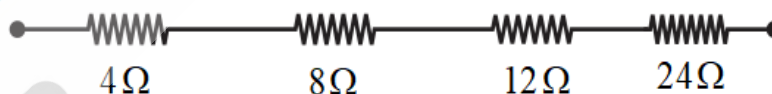
$$R_{eq} = 2 + \frac{3 \times 6}{3+6} = 4\ \Omega$$

Thus, to get $4\ \Omega$; $3\ \Omega$, and $6\ \Omega$ are connected in parallel and then $2\ \Omega$ is connected in series to this combination and to get $1\ \Omega$ all three resistors are connected in parallel.

5. What is (a) the highest, (b) the lowest total resistance that can be secured by combinations of four coils of resistance $4\ \Omega$, $8\ \Omega$, $12\ \Omega$, $24\ \Omega$?

Solution:

- (a) Highest resistance is possible when all resistors are connected in series.

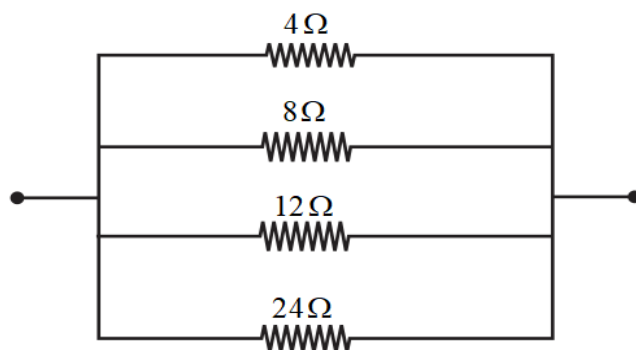


$$R_s = 4\ \Omega + 8\ \Omega + 12\ \Omega + 24\ \Omega = 48\ \Omega$$

\therefore highest resistance possible is $48\ \Omega$

- (b) Lowest resistance is possible when all resistors are connected in parallel

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$$\begin{aligned}\frac{1}{R_p} &= \frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24} \\ \Rightarrow \frac{1}{R_p} &= \frac{12}{24} \\ \Rightarrow R_p &= 2 \Omega\end{aligned}$$

∴ Lowest resistance possible is 2 Ω

In Chapter Questions: (Page:218)

1. Why does the cord of an electric heater not glow while the heating element does?

Solution:

When the same current flows through the conducting wire and heating element, the heat generated (I^2R) is very high in heating element compared to conducting wire. This is due to the resistance of the heating element is very high compared to the resistance of conducting wire. Thus, when same current flows through the conducting wire and heating element, heating element gets hot and glows.

2. Compute the heat generated while transferring 96000 coulombs of charge in one hour through a potential difference of 50 V.

Solution:

From Joule's law of heating, the heat generated can be written as $H = V \times I \times t$

$$\begin{aligned}&= 50 \text{ V} \times \frac{96000 \text{ C}}{1 \text{ hr}} \times 1 \text{ hr} \\ &= 4800000 \text{ J} = 4.8 \times 10^6 \text{ J}\end{aligned}$$

Therefore, the heat generated when 96000 coulomb of charge flows through a potential difference of 50 V is $4.8 \times 10^6 \text{ J}$

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3. An electric iron of resistance $20\ \Omega$ takes a current of $5\ \text{A}$. Calculate the heat developed in $30\ \text{s}$.

Solution:

From Joule's law of heating, the heat generated can be written as $H = V \times I \times t = I^2 \times R \times t$

$$= (5\ \text{A})^2 \times 20\ \Omega \times 30\ \text{s}$$

$$= 15000\ \text{J}$$

$$= 15 \times 10^3\ \text{J}$$

Therefore, the heat generated in $30\ \text{s}$ is $15 \times 10^3\ \text{J}$

In Chapter Questions: (Page:220)

1. What determines the rate at which energy is delivered by a current?

Solution:

The rate at which energy is delivered is the power of the electric appliance.

2. An electric motor takes $5\ \text{A}$ from a $220\ \text{V}$ line. Determine the power of the motor and the energy consumed in $2\ \text{h}$.

Solution:

Power of the motor, $P = VI$

$$= 220\ \text{V} \times 5\ \text{A}$$

$$= 1100\ \text{W}$$

Energy consumed in $2\ \text{h}$ is, $E = P \times t$

$$= 1100\ \text{W} \times 2\ \text{h} \times (60 \times 60) \frac{\text{s}}{\text{h}}$$

$$= 7.92 \times 10^6\ \text{J}$$

NCERT Back of the Book Questions:

1. A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R' , then the ratio R/R' is –

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- (A) 1/25
- (B) 1/5
- (C) 5
- (D) 25

Solution: (D)

We know that resistance $R \propto \frac{1}{l}$

As the wire is cut into 5 parts, new resistance of each part is $\frac{R}{5}$

When these 4 wires joined parallelly, $R' = \left(\frac{R}{5}\right) = \frac{R}{25}$

$$\Rightarrow \frac{R'}{R} = \frac{1}{25}$$

2. Which of the following terms does not represent electrical power in a circuit?

- (A) I^2R
- (B) IR^2
- (C) VI
- (D) $\frac{V^2}{R}$

Solution: (B)

Electric power can be written as

$$P = \frac{V^2}{R} = I^2R = VI$$

3. An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be –

- (A) 100 W
- (B) 75 W
- (C) 50 W
- (D) 25 W

Solution: (D)

From the result, $P = \frac{V^2}{R}$, Resistance of the bulb is, $R = \frac{V^2}{P}$

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$$\Rightarrow R = \frac{220^2}{100} = 484 \Omega$$

When it is connected to the 110 V, power consumed, $P = \frac{110^2}{484}$

$$\Rightarrow P = 25 \text{ W}$$

4. Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then parallel in a circuit across the same potential difference. The ratio of heat produced in series and parallel combinations would be –

- (A) 1:2
- (B) 2:1
- (C) 1:4
- (D) 4:1

Solution: (C)

As the resistance (R) depends on resistivity (ρ), length (l) and area of cross-section (A) as $R = \frac{\rho l}{A}$, resistances of two wires are the same.

When two resistors are connected in series equivalent resistance is $R + R = 2R$

Power consumed is $P_1 = \frac{V^2}{2R}$

When two resistors connected in parallel, the equivalent resistance is $\frac{R \times R}{R + R} = \frac{R}{2}$

Power consumed in this case is, $P_2 = \frac{V^2}{\left(\frac{R}{2}\right)} = \frac{2V^2}{R}$

$$\Rightarrow \frac{P_1}{P_2} = \frac{\left(\frac{V^2}{2R}\right)}{\left(\frac{2V^2}{R}\right)} = \frac{1}{4}$$

5. How is a voltmeter connected in the circuit to measure the potential difference between two points?

Solution:

Voltmeter is always connected in parallel with circuit element to measure the potential difference across it.

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6. A copper wire has a diameter 0.5 mm and resistivity of $1.6 \times 10^{-8} \Omega \text{ m}$. What will be the length of this wire to make its resistance 10Ω ? How much does the resistance change if the diameter is doubled?

Solution:

The resistance of a wire can be written as $R = \frac{\rho l}{A}$

$$\Rightarrow 10 = \frac{1.6 \times 10^{-8} \times l}{\left(\frac{\pi \times 0.5^2 \times 10^{-6}}{4}\right)}$$

$$\Rightarrow l = \frac{10 \times \pi \times 0.5^2 \times 10^{-6}}{4 \times 1.6 \times 10^{-8}}$$

$$\Rightarrow l = 122.72 \text{ m}$$

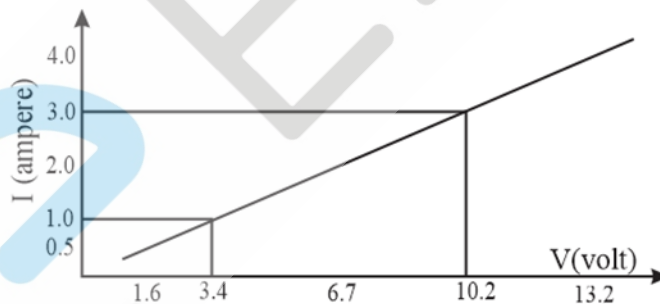
As $R \propto \frac{1}{A}$, if the diameter is doubled, the area gets quadrupled, so the resistance decrease by 4 times. The new resistance would be 2.5Ω

7. The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below –

I (amperes)	0.5	1.0	2.0	3.0	4.0
V (volts)	1.6	3.4	6.7	10.2	13.2

Plot a graph between V and I and calculate the resistance of that resistor.

Solution:



From Ohm's law, $V = IR$

$$\Rightarrow I = \frac{1}{R}V$$

Thus, the slope of graph I vs V gives $\frac{1}{R}$

$$\Rightarrow \frac{1}{R} = \frac{3.0 - 1.0}{10.2 - 3.4} = \frac{2.0}{6.8}$$

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$$\Rightarrow R = 3.4 \Omega$$

8. When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

Solution:

From Ohm's law, $V = IR$

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

$$\Rightarrow R = \frac{12}{2.5 \times 10^{-3}} = 4.8 \times 10^3 \Omega$$

9. A battery of 9 V is connected in series with resistors of 0.2 Ω , 0.3 Ω , 0.4 Ω , 0.5 Ω and 12 Ω , respectively. How much current would flow through the 12 Ω resistor?

Solution:

In series combination current through all the resistors will be the same.

$$R_{eq} = 0.2 + 0.3 + 0.4 + 0.5 + 12 = 13.4 \Omega$$

Current through 12 Ω resistor is $I = \frac{V}{R}$

$$\Rightarrow I = \frac{9}{13.4}$$

$$\Rightarrow I = 0.67 \text{ A}$$

10. How many 176 Ω resistors (in parallel) are required to carry 5 A on a 220 V line?

Solution:

Let the required number of resistors be n .

Equivalent parallel combination resistance $R_{eq} = \frac{176}{n}$

From Ohm's law, $V = IR$

$$\Rightarrow 220 = 5 \times \frac{176}{n}$$

$$\Rightarrow n = \frac{5 \times 176}{220} = 4$$

Therefore 4 resistors of 176 Ω are required to draw 5 A current on 220 V line.

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11. Show how you would connect three resistors, each of resistance $6\ \Omega$ so that the combination has a resistance of (i) $9\ \Omega$, (ii) $4\ \Omega$.

Solution:

If all the three resistors are connected in series, equivalent resistance becomes,

$$R_1 = 3 \times 6 = 18\ \Omega$$

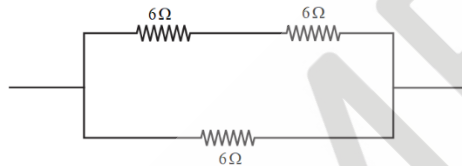
If all the three resistors are in parallel, equivalent resistance becomes,

$$R_2 = \frac{6}{3} = 2\ \Omega$$

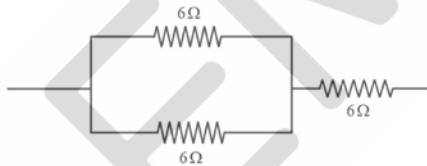
If two resistors are connected in series and one is in parallel, $R_3 = \frac{(6+6) \times 6}{6+6+6} = 4\ \Omega$

If two resistors are in parallel and one is in series, $R_4 = \frac{6}{2} + 6 = 9\ \Omega$

- (i) Thus, if two resistors are connected in parallel and one is in series, equivalent resistance becomes $9\ \Omega$



- (ii) Similarly, if two resistors are connected in series and one is in parallel the equivalent resistance becomes $4\ \Omega$



12. Several electric bulbs designed to be used on a $220\ \text{V}$ electric supply line, are rated $10\ \text{W}$. How many lamps can be connected in parallel with each other across the two wires of $220\ \text{V}$ line if the maximum allowable current is $5\ \text{A}$?

Solution:

$$\text{Resistance of each bulb } R = \frac{V^2}{P}$$

$$= \frac{220^2}{10} = 4840\ \Omega$$

As the all resistors in parallel are similar, current divides equally among them.

$$\Rightarrow n \times i = 5\ \text{A}$$

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$$\Rightarrow n \times \frac{220}{4840} = 5$$

$$\Rightarrow n = 110$$

Therefore 110 bulbs in parallel are required to draw a current of 5 A on 220 V line

13. A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of 24Ω resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?

Solution:

Case 1: When resistance 24Ω is only used,

From Ohm's law, $I = \frac{V}{R}$

$$\Rightarrow I = \frac{220}{24} = 9.17 \text{ A}$$

Current 9.17 A flows when resistors are used separately.

Case 2: When resistors are used in series combination,

From Ohm's law, $I = \frac{V}{R}$

$$\Rightarrow I = \frac{220}{2 \times 24} = 4.58 \text{ A}$$

Current 4.58 A flows when resistors are used in series combination

Case 3: When resistors are used in parallel combination,

From Ohm's law, $I = \frac{V}{R}$

$$\Rightarrow I = \frac{220}{\left(\frac{24}{2}\right)} = 18.33 \text{ A}$$

Current 18.33 A flows when resistors are used in parallel combination

14. Compare the power used in the 2Ω resistor in each of the following circuits: (i) a 6 V battery in series with 1Ω and 2Ω resistors, and (ii) a 4 V battery in parallel with 12Ω and 2Ω resistors.

Solution:

(i) Power used $P = I^2 R = \frac{V^2}{R}$

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Here I is the current through resistor and V is the potential difference across the resistor

$$P = \left(\frac{6}{1+2}\right)^2 \times 2$$
$$= 8 \text{ W}$$

(ii) Power used $P = I^2 R = \frac{V^2}{R}$

Here I is the current through resistor and V is the potential difference across the resistor

$$P = \frac{4^2}{2} = 8 \text{ W}$$

Power consumed by 2Ω resistor in both the cases is the same and is equal to 8 W

15. Two lamps, one rated 100 W at 220 V , and the other 60 W at 220 V , are connected in parallel to the electric mains supply. What current is drawn from the line if the supply voltage is 220 V ?

Solution:

Resistance of the first lamp, $R_1 = \frac{V^2}{P_1} = \frac{220^2}{100} = 484 \Omega$

Resistance of the second lamp, $R_2 = \frac{V^2}{P_2} = \frac{220^2}{60} = 806.67 \Omega$

If these two resistors are joined in parallel, equivalent resistance, $R_{eq} = \frac{484 \times 806.67}{484 + 806.67}$

Current drawn from the line, $I = \frac{V}{R_{eq}}$

$$\Rightarrow I = \frac{220}{\left(\frac{484 \times 806.67}{484 + 806.67}\right)} = \frac{220}{302.5} = 0.727 \text{ A}$$

16. Which uses more energy, a 250 W TV set in 1 hr , or a 1200 W toaster in 10 minutes?

Solution:

Power rating of TV set is 250 W

Energy consumed by TV set in 1 hr , $E_{TV} = 250 \times 60 \times 60 = 9 \times 10^5 \text{ J}$

Power rating of toaster is 1200 W

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Energy consumed by toaster in 10 minutes, $E_{toaster} = 1200 \times 10 \times 60 = 7.2 \times 10^5 \text{ J}$

Thus, toaster consumes more energy compared to the TV set.

17. An electric heater of resistance 8Ω draws 15 A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.

Solution:

Given: Current $I = 15 \text{ A}$

Resistance $R = 8 \Omega$

Time $t = 2$ hours

Power consumed can be written as $P = I^2 R$

$$= 15^2 \times 8$$

$$= 1800 \text{ W}$$

18. Explain the following.

- Why is the tungsten used almost exclusively for filament of electric lamps?
- Why are the conductors of electric heating devices, such as bread-toasters and electric irons, made of an alloy rather than a pure metal?
- Why is the series arrangement is not used for domestic circuits?
- How does the resistance of a wire vary with its area of cross-section?
- Why are copper and aluminium wires usually employed for electricity transmission?

Solution:

- Melting point and resistivity of tungsten are very high. Bulbs give light at very high temperatures, and tungsten is the best material to withstand such high temperatures.
- Resistivity of alloy is more compared to resistivity of a pure metal. Thus, conductors of electric heating devices such as bread-toasters and electric irons made of an alloy rather than a pure metal.
- In series connection if one circuit element gets damaged circuit breaks at that point and rest of the elements doesn't work. Moreover, in series connection voltage distributes among the circuit elements and each element doesn't get appropriate voltage to work.
- Resistance (R) of a wire is inversely proportional its area of cross-section (A).

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$$R \propto \frac{1}{A}$$

- (e) Resistivity of copper and aluminium wires are very low and heat generated in them while passing current is very less. Thus copper and aluminium wires are usually employed for electric transmission.

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