Chapter – 12 Electricity

Q1. 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 ration R/R' is –

- **a) 1/25**
- **b) 1/5**
- **c) 5**
- **d) 25**

Answer: Option d)

The resistance is divided into five parts, it means that the resistance of each parts is R/5.

The equivalent resistance can be calculated as:

$$\frac{1}{R'} = \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} = \frac{5+5+5+5+5}{R} = \frac{25}{R}$$

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

The ratio of R/R' is equal to 25.

Q2. Which of the following terms does not represent electrical power in a circuit?

- **a)** $\boldsymbol{I^2R}$
- **b)** $\boldsymbol{IR^2}$
- **c)** $\boldsymbol{VI}$
- **d)** $\boldsymbol{V^2/R}$

Answer: Option b)

Electric power, $P = VI$

Using Ohm's law,

$$V = IR$$

Substituting it in the equation of electric power,

$$P = (IR) \times I$$

$$P = I^2R$$

Similarly, from ohm's law,

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

$$P = V \times \frac{V}{R} = V^2 R$$

So, $I^2 R$ does not represent electrical power in a circuit.

Q3. 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**

Answer: Option d)

Energy consumed by the appliance is,

$$P = VI = V^2 R$$

The resistance of the light bulb,

$$R = V^2/P$$

Putting the values, we get

$$R = \frac{(220)^2}{100} = 484\ ohm$$

When voltage is reduced, the resistance is same.

So, the power consumed will be,

$$P = V^2/R$$

Substituting the value,

$$P = \frac{(110)^2}{484} = 25\ W$$

So, the power consumed when the electric bulb operates at 110 V is 25 W.

Q4. 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

Answer: Option c)

Let the R_s and $R_p$be the equivalent resistance of the wires when connected in series and parallel respectively.

For same potential difference, V, the ratio of the heat produced in the circuit,

$$\frac{Hs}{Hp} = \frac{\frac{v^2}{Rs}t}{\frac{v^2}{Rp}t} = \frac{Rp}{Rs}$$

The equivalent resistance of resistor connected in series, $Rs = R + R = 2R$

The equivalent resistance of resistor connected in parallel, $Rp = \frac{1}{\frac{1}{R}+\frac{1}{R}} = \frac{R}{2}$

Hence, the ratio of the heat produced in series and parallel combination,

$$\frac{Hs}{Hp} = \frac{\frac{R}{2}}{2R} = \frac{1}{4}$$

So, the ratio of the heat produced is 1:4.

Q5. How is a voltmeter connected in the circuit to measure the potential difference between two points?

Answer:

The voltmeter should be connected in parallel between the two points, to measure the voltage between any two points.

Q6. A copper wire has diameter 0.5 mm and resistivity of $\mathbf{1.6 \times 10^{-8}}$ *ohm m*. What will be the length of this wire to make its resistance 10 ohm. How much does the resistance change if the diameter is doubled?

Answer:

The resistance of the copper wire of length (meters) and area of cross section (m^2) so;

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

The area of cross section of the wire can be calculated,

$$A = \pi \frac{(Diameter)^2}{(2)}$$

Putting the values in the formula,

$$l = \frac{RA}{\rho} = \frac{10 \times 3.14 \times \frac{(0.0005)^2}{(2)}}{(1.6 \times 10^{-8})}$$

$$= \frac{10 \times 3.14 \times 2.5}{4 \times 1.6} = 122.72\ m$$

But if the diameter of the wire is doubled, then the new diameter will be 1 mm or 0.001 m. So, the resistance can be calculated by,

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

$$= 1.6 \times 10^{-8} \times \frac{122.72\ m}{\pi \frac{(0.001)^2}{(2)}} = 250.2 \times 10^{-2} = 2.5\ ohm$$

So, the length of the wire is 122.72 m and the new resistance is $2.5\ ohm$.

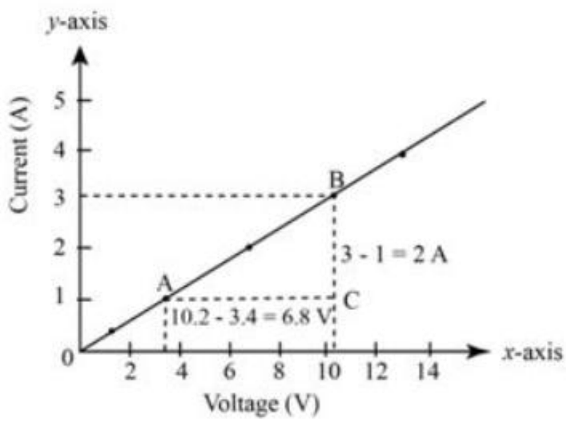
Q7. The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below –

I (Ampere)	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.

Answer:

The plot between current and voltage is called as V-I characteristics. The current is plotted on the y-axis and voltage is plotted on x-axis.



The slope of the line is value of resistance i.e

$$Slope = \frac{1}{R} = \frac{BC}{AC} = 2/6.8$$

To calculate R,

$$R = \frac{6.8}{2} = 3.4\ ohm$$

The resistance of the resistor is $3.4\ ohm$.

Q8. 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.

Answer:

Using Ohm's law,

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

Substituting the values in the equation,

$$R = \frac{12}{2.5 \times 10^{-8}} = 4.8 \times 10^{3} ohm = 4.8\ kilo - ohm$$

Q9. A battery of 9 V is connected in series with resistors of $\mathbf{0.2\ \Omega}$, $\mathbf{0.3\ \Omega}$, $\mathbf{0.4\ \Omega}$, $\mathbf{0.5\ \Omega}$, and $\mathbf{12\ \Omega}$ respectively. How much current would flow through the $\mathbf{12\ \Omega}$ resistor?

Answer:

There is no division in series connection. The current flowing across all the resistors is the same. So, to calculate the amount of current flowing across the resistor, ohm's law is used,

Let's find out the equivalent resistance first;

$$R = 0.2\ \Omega + 0.3\ \Omega + 0.4\ \Omega + 0.5\ \Omega + 12\ \Omega = 13.4\Omega$$

Using Ohm's law,

$$I = \frac{V}{R} = \frac{9\ V}{13.4\ \Omega} = 0.671\ A$$

So, the current flowing across the $12\ \Omega$ is $0.671\ A$

Q10. How many $\mathbf{176\ \Omega}$ resistors (in parallel) are required to carry $\mathbf{5\ A}$ on a $\mathbf{220\ V}$ line?

Answer:

Considering the number of resistors required as 'x'.

Thus equivalent resistance of parallel combination of resistor R is:

$$\frac{1}{R} = x \times \frac{1}{176} = R = \frac{176}{x}$$

Using Ohm's law, the number of resistors can be calculated,

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

Substituting the values,

$$\frac{176}{x} = \frac{V}{I}$$

$$x = \frac{176 \times 5}{220} = 4$$

The number of resistor's required is 4.

Q11. Show how you would connect three resistors, each of resistance $6\,\Omega$, so that the combination has a resistance of (i) $9\,\Omega$ (ii) $4\,\Omega$.

Answer:

Connecting all the three resistors in series, their equivalent resistors is;

$$6\,\Omega + 6\,\Omega + 6\,\Omega = 18\,\Omega$$

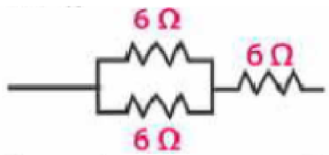
$18\,\Omega$ is not the desired values.

If we connect all three resistors in parallel, their equivalent resistor is;

$$R = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} = \frac{3}{6} = \frac{1}{2}$$

It is not the desired value.

Case – 1: - If two resistors are connected in parallel, their equivalent resistance is;



$$\frac{1}{\frac{1}{6} + \frac{1}{6}} = \frac{6 \times 6}{6 \times 6} = 3\,\Omega$$

The third resistor is in series, so the equivalent resistance is calculated as;

$R = 6\,\Omega + 3\,\Omega = 9\,\Omega$

Case – 2: - If two resistors are connected in series, their equivalent resistance is;

$$R = 6\,\Omega + 6\,\Omega = 12\,\Omega$$

Third resistor is connected in parallel with $12\,\Omega$. So, the equivalent resistance is calculated;

$$R = \frac{1}{6} + \frac{1}{12} = \frac{12 \times 6}{12 + 6} = 4\,\Omega$$

Q12. Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires 220 V if the maximum allowable current is 5 A?

Answer:

resistance of the bulb is;

$$P_1 = V^2/R_1$$

$$R_1 = V^2/P_1$$

Substituting the values,

$$R = \frac{(220)^2}{10} = 4840\,\Omega$$

resistance of x number of electric bulbs is:

$$R = \frac{V}{I} = \frac{200}{5} = 44\,\Omega$$

resistance of each electric bulb is 4840 Ω

equivalent resistance of x bulbs is,

$$x = \frac{R_1}{R} = \frac{4840}{44} = 110$$

So, 110 lamps is connected in parallel.

Q13. A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of $24\,\Omega$ resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?

Answer:

Case (i): When coils are used separately

Using Ohm's law,

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

Substituting the values,

$$I = \frac{220\ V}{24\ \Omega} = 9.166\ A$$

$9.166\ A$ of current flows through each resistor when they are used separately.

Case (ii): When coils connected in series

total resistance in the series circuit is $24\ \Omega + 24\ \Omega = 48\ \Omega$

current flowing through the series circuit is,

$$I = \frac{V}{R} = \frac{220\ V}{48\ \Omega} = 4.58\ A$$

So, a current of $4.58\ A$ flows through the series circuit.

Case (iii): When coils connected in parallel

When the coils are connected in parallel, the equivalent resistance is ,

$$R = \frac{24 \times 24}{24 + 24} = \frac{576}{48} = 12\ \Omega$$

Using ohm's law, the current flowing through the parallel circuit,

$$I = \frac{V}{R} = \frac{220}{12} = 18.33\ A$$

Thus current in the parallel circuit is $18.33\ A$

Q14. Compare the power used in the $2\ \Omega$ resistor in each of the following circuits: (i) a 6 V battery in series with $1\ \Omega$ and $2\ \Omega$ resistor, and (ii) a 4 V battery in parallel with $12\ \Omega$ and $2\ \Omega$ resistors.

Answer:

i) Potential difference is 6 V and the resistors $1\ \Omega$ and $2\ \Omega$ are connected in series, hence their equivalent resistance is given by;

$$1\ \Omega + 2\ \Omega = 3\ \Omega$$

The current in the circuit can be calculated using the ohm's law as;

$$I = \frac{V}{R} = \frac{6}{3} = 2\ A$$

$2\ A$ current will flow across all the components in the circuit because there is no decision of current in a series circuit.

The power in $2\ \Omega$ resistor can be calculated as;

$$P = I^2 R = (2)^2 \times 2 = 8\ W$$

$So, the\ power\ consumed\ by\ the\ 2\ \Omega\ is\ 8\ W.$

ii) When $12\ \Omega$ and $2\ \Omega$ resistor are connected in parallel, the voltage across the resistor remains the same. Voltage across $2\ \Omega$ resistor is 4 V, power consumed can be calculated as

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

The power consumed by the $2\ \Omega$ resistor is $8\ W$.

Q15. Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to electric mains supply. What current is drawn from the line if the supply voltage is 220 V?

Answer:

Two lamps are connected in parallel, the voltage will be same,

Current by the bulb of rating 100 W is:

$$P = V \times I$$

$$I = \frac{P}{V}$$

Substituting,

$$I = \frac{100}{220} A$$

current by the bulb of rating 60 W is;

$$I = \frac{60}{220} A$$

So, the current from the link is,

$$\frac{100}{220} + \frac{60}{220} = 0.727\ A$$

Q16. Which uses more energy, a 250 W T.V set in 1 hour or a 1200 W toaster in 10 minutes?

Answer:

The energy consumed by the electrical appliances is,

$$H = P \times t$$

P is the power & t is the time.

energy consumed by a T.V of power ratio 250 W;

$$H = 250\, W \times 3600\, seconds = 9 \times 10^5 J$$

energy consumed by a toaster of power rating 1200 W is

$$H = 1200\, W \times 600\, sec = 7.2 \times 10^5 J$$

The energy consumed by the T.V is greater than the toaster.

Q17. An electric heater of resistance 8 Ω draws 15 A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.

Answer:

The rate at which heat develops in the heater is calculated;

$$P = I^2 R$$

$$P = (15)^2 \times 8\, \Omega = 1800\, J/s$$

The electric heater produces heat at the rate of $1800\, J/s$.

Q18. Explain the following;

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

Answer:

a) The resistivity and melting point of tungsten is high. So, it doesn't burn when heated. Electric lamps operate at high temperature. So, tungsten is a metal for the filament of electric lamps.
b) The conductors are alloys because of their resistivity and produces large amount of heat.

c) The voltage is divided in series circuits so each component in the circuit receives a small voltage and the amount of current decreases, the device gets hot and does not work properly.
d) Resistance is inversely proportional to the area of cross section. When the area of cross increases the resistance decreases and vice-versa.
e) Copper and aluminium are good conductors of electricity and have low resistivity, so are used for electricity transmission.