

Chapter-11

Electricity

2 MARKS QUESTIONS

1. How does use of fuse wire protect electrical appliances?

Answer:

When a large quantity of current passes through the circuit, the temperature of the wire rises and the fuse wire melts. This prevents current from flowing into the house's other circuits, saving electrical appliances.

2. Define the term “volt”?

Answer:

If 1joule of energy is transferred between two points A and B, the potential difference between them is one volt. In an electric circuit, work is done to move one coulomb of charge from one point to another field.

3. Why does the connecting rod of an electric heater not glow while the heating element does?

Answer:

As its resistance is lower than that of the heating element, the connecting cord of an electric heater does not glow. As a result, the heating element produces more heat than the connecting cord, and it glows

4. Alloys are used in electrical heating devices rather than pure metals. Give a reason.

Answer:

Alloys are utilised in electricity heating devices rather than pure metals because alloys have a higher resistivity and hence produce more heat. Furthermore, alloy is non-combustible (or oxidises easily at higher temperature).

5. On what factor does the resistance of a conductor depend?

Answer:

The factors on which Resistance depends are:-

- (a) Length of the conductor
- (b) Area of cross - section
- (c) Temperature
- (d) Nature of material

6. What does an electric circuit mean?

Answer:

An electric circuit is a current route that is both continuous and closed. Current can flow through an electric circuit if it is complete.

7. Define the unit of current.

Answer:

The ampere is the SI unit for electric current. If 1 coulomb charge flows per second across a conductor cross-section, the current is said to be 1 ampere.

8. What is meant by saying that the potential difference between two points is 1v?

Answer:

If 1 joule of labour is required to move a charge of 1 coulomb from one location to another, the potential difference between the two points is said to be 1 volt.

9. Ammeter burns out when connected in parallel. Give reasons.

Answer:

When a low-resistance wire is connected in series, a huge quantity of current travels through it, causing it to be burned, or short-circuited.

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

Answer: A voltmeter is connected in parallel to the resistance across the place where the potential difference is to be determined.

4 MARKS SOLUTIONS

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

Solution:

We know that the potential difference between two points is given by the equation,

$$V = W/Q, \text{ where,}$$

W is the work done in moving the charge from one point to another

Q is the charge

From the above equation, we can find the energy given to each coulomb as follows:

$$W = V \times Q$$

Substituting the values in the equation, we get

$$W = 6V \times 1C = 6 J$$

Hence, 6 J of energy is given to each coulomb of charge passing through a 6 V of battery.

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 is given by the equation,

$$R = \rho l/A$$

where,

ρ is the resistivity of the material of the wire,

l is the length of the wire

A is the area of the cross-section of the wire.

From the equation, it is evident that the area of the cross-section of wire is inversely proportional to the resistance. Therefore, the thinner the wire, the more the resistance and vice versa. Hence, current flows more easily through a thick wire than a thin wire.

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

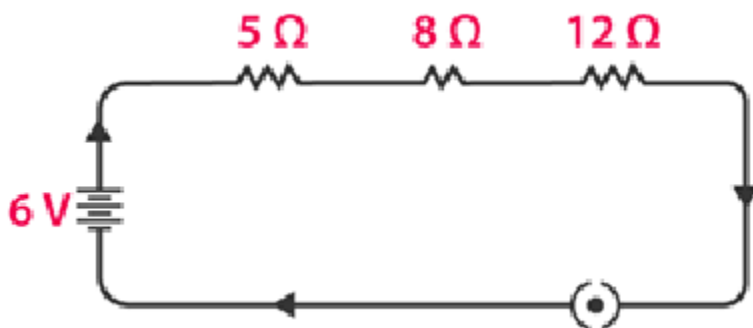
Solution:

The melting point of an alloy is much higher than a pure metal because of its high resistivity. At high temperatures, alloys do not melt readily. Therefore, alloys are used in heating appliances such as electric toasters and electric irons.

4. 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:

A battery of three cells of 2 V each equals to battery of potential 6 V. The circuit diagram below shows three resistors of resistance 12 Ω , 8 Ω and 5 Ω connected in series along with a battery of potential 6 V.



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

Solution:

When the electrical devices are connected in parallel there is no division of voltage among the appliances. The potential difference across the devices is equal to supply voltage. Parallel connection of devices also reduces the effective resistance of the circuit.

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

Solution:

(a) If the four resistors are connected in series, their total resistance will be the sum of their individual resistances and it will be the highest. The total equivalent resistance of the resistors connected in series will be $4\ \Omega + 8\ \Omega + 12\ \Omega + 24\ \Omega = 48\ \Omega$.

(b) If the resistors are connected in parallel, then their equivalent resistances will be the lowest.

Their equivalent resistance connected in parallel is

$$R = \frac{1}{\frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24}} = \frac{24}{12} = 2\ \Omega$$

Hence, the lowest total resistance is $2\ \Omega$.

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

Solution:

The amount of heat generated can be calculated using the Joule's law of heating, which is given by the equation

$$H = VIt$$

Substituting the values in the above equation, we get,

$$H = 100 \times 5 \times 30 = 1.5 \times 10^4\ \text{J}$$

The amount of heat developed by the electric iron in $30\ \text{s}$ is $1.5 \times 10^4\ \text{J}$.

8. 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:

The power of the motor can be calculated by the equation,

$$P = VI$$

Substituting the values in the above equation, we get

$$P = 220\ \text{V} \times 5\ \text{A} = 1100\ \text{W}$$

The energy consumed by the motor can be calculated using the equation,

$$E = P \times T$$

Substituting the values in the above equation, we get

$$P = 1100\ \text{W} \times 7200 = 7.92 \times 10^6\ \text{J}$$

The power of the motor is 1100 W and the energy consumed by the motor in 2 hours is 7.92×10^6 J.

9. 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:

The value of the resistor can be calculated using Ohm's Law as follows:

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

Substituting the values in the equation, we get

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

10. 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 connection, there is no division of current. The current flowing across all the resistors is the same.

To calculate the amount of current flowing across the resistors, we use Ohm's law.

But first, let us find out the equivalent resistance as follows:

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

Now, using Ohm's law,

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

The current flowing across the 12 Ω is 0.671 A.

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:

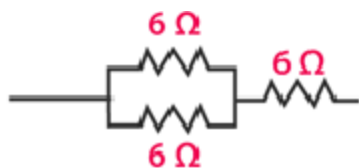
If we connect all the three resistors in series, their equivalent resistor would $6\ \Omega + 6\ \Omega + 6\ \Omega = 18\ \Omega$, which is not the desired value. Similarly, if we connect all the three resistors in parallel, their equivalent resistor would be

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

which is again not the desired value.

We can obtain the desired value by connecting any two of the resistors in either series or parallel.

Case (i)



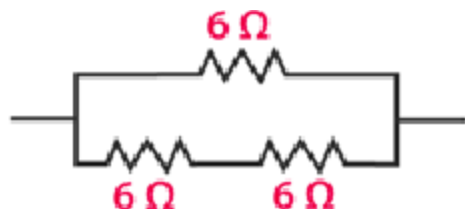
If two resistors are connected in parallel, then their equivalent resistance is

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

The third resistor is in series, hence the equivalent resistance is calculated as follows:

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

Case (ii)



When two resistors are connected in series, their equivalent resistance is given by

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

The third resistor is connected in parallel with $12 \, \Omega$. Hence the equivalent resistance is calculated as follows:

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

11. 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 of 220 V line if the maximum allowable current is 5 A?

Solution:

The resistance of the bulb can be calculated using the expression

$$P_1 = V^2/R_1$$

$$R_1 = V^2/P_1$$

Substituting the values, we get

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

The resistance of x number of electric bulbs is calculated as follows:

$$R = V/I = 220/5 = 44 \, \Omega$$

The resistance of each electric bulb is $4840 \, \Omega$.

The equivalent resistance of x bulbs is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_1} + \frac{1}{R_1} \pm \dots \text{upto } x \text{ times}$$

$$\frac{1}{R} = \frac{1}{R_1} \times x$$

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

Hence, 110 lamps can be connected in parallel.

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

Solution:

The energy consumed by electrical appliances is given by the equation

$H = Pt$, where P is the power of the appliance and t is the time

Using this formula, the energy consumed by a TV of power rating 250 W, can be calculated as follows:

$$H = 250 \text{ W} \times 3600 \text{ seconds} = 9 \times 10^5 \text{ J}$$

Similarly, the energy consumed by a toaster of power rating 1200 W is

$$H = 1200 \text{ W} \times 600 \text{ s} = 7.2 \times 10^5 \text{ J}$$

From the calculations, it can be said that the energy consumed by the TV is greater than the toaster.

13. 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:

The rate at which the heat develops in the heater can be calculated using the following formula

$$P = I^2 R$$

Substituting the values in the equation, we get

$$P = (15\text{A})^2 \times 8 \Omega = 1800 \text{ watt}$$

The electric heater produces heat at the rate of 1800 watt

7 MARKS QUESTIONS

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

Solution:

The value of the charge of an electron is 1.6×10^{-19} C.

According to charge quantization,

$Q = nq_e$, where **n** is the number of electrons and **q_e** is the charge of an electron.

Substituting the values in the above equation, the number of electrons in a coulomb of charge can be calculated as follows:

$$1 \text{ C} = n \times 1.6 \times 10^{-19}$$

$$n = \frac{1}{1.6 \times 10^{-19}} = 6.25 \times 10^{18}$$

Therefore, the number of electrons constituting one coulomb of charge is 6.25×10^{18} .

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

Solution:

We know that the potential difference between two points is given by the equation,

$V = W/Q$, where,

W is the work done in moving the charge from one point to another

Q is the charge

From the above equation, we can find the energy given to each coulomb as follows:

$$W = V \times Q$$

Substituting the values in the equation, we get

$$W = 6V \times 1C = 6 J$$

Hence, 6 J of energy is given to each coulomb of charge passing through a 6 V of battery.

3. Let the resistance of an electrical component remain 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:

The change in the current flowing through the electrical component can be determined by Ohm's Law.

According to Ohm's Law, the current is given by

$$I = V/R$$

Now, the potential difference is reduced to half keeping the resistance constant,

Let the new voltage be $V' = V/2$

Let the new resistance be $R' = R$ and the new amount of current be I' .

The change in the current can be determined using Ohm's law as follows:

$$I' = \frac{V'}{R'} = \frac{\left(\frac{V}{2}\right)}{R} = \frac{1V}{2R} = \frac{1}{2}$$

Therefore, the current flowing the electrical component is reduced by half.

4. Use the data in the table given below and answer the following questions.

	Material	Resistivity
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	49×10^{-6}
	Manganin	44×10^{-6}
	Nichrome	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}
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a. Which among iron and mercury is a better conductor?

b. Which material is the best conductor?

Solution:

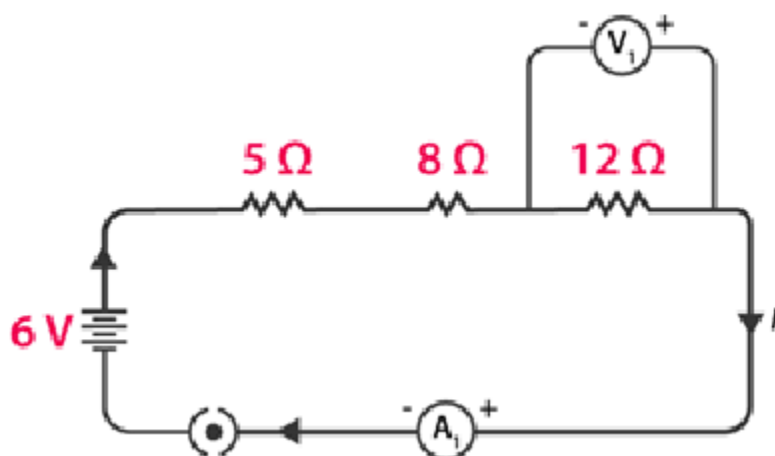
a. Iron is a better conductor than mercury because the resistivity of mercury is more than the resistivity of iron.

b. Among all the materials listed in the table, silver is the best conductor because the resistivity of silver is lowest among all, i.e., 1.60×10^{-8} .

5. 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 $12\ \Omega$ resistor. What would be the readings in the ammeter and the voltmeter?

Solution:

An ammeter should always be connected in series with resistors while the voltmeter should be connected in parallel to the resistor to measure the potential difference as shown in the figure below.



Using Ohm's Law, we can obtain the reading of the ammeter and the voltmeter.

The total resistance of the circuit is $5\ \Omega + 8\ \Omega + 12\ \Omega = 25\ \Omega$.

We know that the potential difference of the circuit is 6 V, hence the current flowing through the circuit or the resistors can be calculated as follows:

$$I = V/R = 6/25 = 0.24\text{A}$$

Let the potential difference across the $12\ \Omega$ resistor be V_1 .

From the obtained current V_1 can be calculated as follows:

$$V_1 = 0.24\text{A} \times 12\ \Omega = 2.88\ \text{V}$$

Therefore, the ammeter reading will be 0.24 A and the voltmeter reading be 2.88 V.

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

Solution:

(a) When $1\ \Omega$ and 10^6 are connected in parallel, the equivalent resistance is given by

$$\frac{1}{R} = \frac{1}{1} + \frac{1}{10^6}$$

$$R = \frac{10^6}{1 + 10^6} \approx \frac{10^6}{10^6} = 1\ \Omega$$

Therefore, the equivalent resistance is $1\ \Omega$.

(b) When $1\ \Omega$, $10^3\ \Omega$, and $10^6\ \Omega$ are connected in parallel, the equivalent resistance is given by

$$\frac{1}{R} = \frac{1}{1} + \frac{1}{10^3} + \frac{1}{10^6}$$

Solving, we get

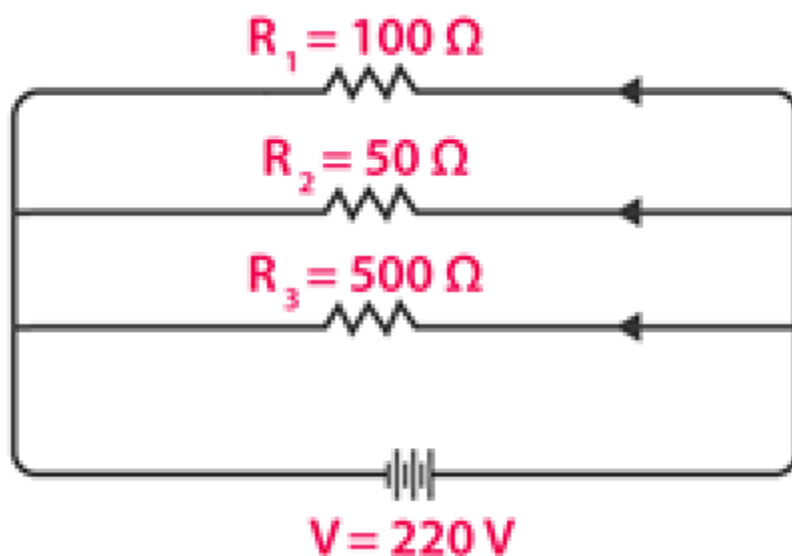
$$R = \frac{10^6 + 10^3 + 1}{10^6} = \frac{1000000}{1000001} = 0.999 \, \Omega$$

Therefore, the equivalent resistance is $0.999 \, \Omega$.

7. 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:

The electric lamp, the toaster and the water filter connected in parallel to a $220 \, \text{V}$ source can be shown as using a circuit diagram as follows:



The equivalent resistance of the resistors can be calculated as follows:

$$\frac{1}{R} = \frac{1}{100} + \frac{1}{50} + \frac{1}{500}$$

$$= \frac{5 + 10 + 1}{500} = \frac{16}{500}$$

$$R = \frac{500}{16} \Omega$$

Now, using Ohm's law, the current flowing across the circuit can be calculated as follows:

$$I = \frac{V}{R} = \frac{220}{\frac{500}{16}}$$

$$I = \frac{220 \times 16}{500} = 7.04 \text{ A}$$

As the appliances are connected in parallel, the current drawn across all of them is 7.04 A.

Hence, the current drawn by the electric iron connected in parallel to the same source is 7.04 A.

We can find the resistance of the iron box using Ohm's law as follows:

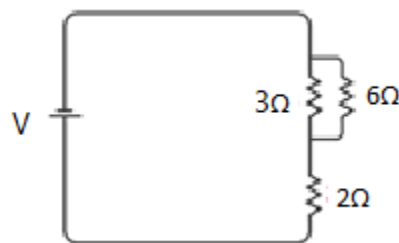
$$R = \frac{V}{I} = \frac{220 \text{ V}}{7.04 \text{ A}} = 31.25 \Omega$$

The resistance of the electric iron box is 31.25 Ω .

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

Solution:

(a) The circuit diagram below shows the connection of three resistors



From the circuit above, it is understood that 3 Ω and 6 Ω are connected in parallel. Hence, their equivalent resistance is given by

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

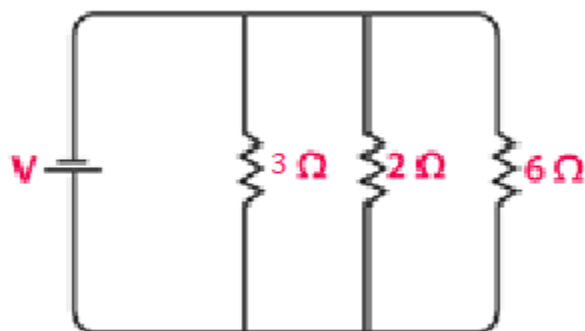
$$R = \frac{1}{\frac{1}{6} + \frac{1}{3}} = \frac{6 \times 3}{6 + 3} = 2 \Omega$$

The equivalent resistor 2Ω is in series with the 2Ω resistor. Now the equivalent resistance can be calculated as follows:

$$R_{eq} = 2 \Omega + 2 \Omega = 4 \Omega$$

Hence, the total resistance of the circuit is 4Ω .

(b) The circuit diagram below, shows the connection of three resistors.



From the circuit, it is understood that all the resistors are connected in parallel. Therefore, their equivalent resistance can be calculated as follows:

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

The total resistance of the circuit is 1Ω .

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

Solution:

(a) If the four resistors are connected in series, their total resistance will be the sum of their individual resistances and it will be the highest. The total equivalent resistance of the resistors connected in series will be $4\ \Omega + 8\ \Omega + 12\ \Omega + 24\ \Omega = 48\ \Omega$.

(b) If the resistors are connected in parallel, then their equivalent resistances will be the lowest.

Their equivalent resistance connected in parallel is

$$R = \frac{1}{\frac{1}{4} + \frac{1}{8} + \frac{1}{12} + \frac{1}{24}} = \frac{24}{12} = 2\ \Omega$$

Hence, the lowest total resistance is 2 Ω .

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

Solution:

The heat generated can be computed by Joule's law as follows:

$$H = VIt$$

where,

V is the voltage, $V = 50\ \text{V}$

I is the current

t is the time in seconds, 1 hour = 3600 seconds

The amount of current can be calculated as follows:

$$\text{Amount of Current} = \frac{\text{Amount of charge}}{\text{Time flow of charge}}$$

Substituting the value, we get

$$I = \frac{96000}{3600} = 26.66 \text{ A}$$

Now, to find the heat generated,

$$H = 50 \times 26.66 \times 3600 = 4.8 \times 10^6 \text{ J}$$

The heat generated is $4.8 \times 10^6 \text{ J}$.

11. 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:

Answer: 25 W

Explanation:

The energy consumed by the appliance is given by the expression

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

The resistance of the light bulb can be calculated as follows:

$$R = V^2/P$$

Substituting the values, we get

$$R = (220)^2/100 = 484 \Omega$$

Even if the supply voltage is reduced, the resistance remains the same. Hence, the power consumed can be calculated as follows:

$$P = V^2/R$$

Substituting the value, we get

$$P = (110)^2 V/484 \Omega = 25 W$$

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

12. A copper wire has 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 10 Ω ? How much does the resistance change if the diameter is doubled?

Solution:

The resistance of the copper wire of length in meters and area of cross-section m^2 is given by the formula

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

The area of cross-section of the wire can be calculated as follows

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

Substituting the values in the formula, we get

$$l = \frac{RA}{\rho} = \frac{10 \times 3.14 \times \left(\frac{0.0005^2}{2} \right)}{(1.6 \times 10^{-8})} = \frac{10 \times 3.14 \times 25}{4 \times 1.6} = 122.72 \text{ m}$$

If the diameter of the wire is doubled, then the new diameter will be 1 mm or 0.001 m.

Therefore, the resistance can be calculated as follows:

$$R = \rho \frac{l}{A} = 1.6 \times 10^{-8} \times \frac{122.72 \text{ m}}{\pi \left(\frac{0.001}{2} \right)^2} = 250.2 \times 10^{-2} = 2.5 \Omega$$

The length of the wire is 122.72 m and the new resistance is 2.5 Ω .

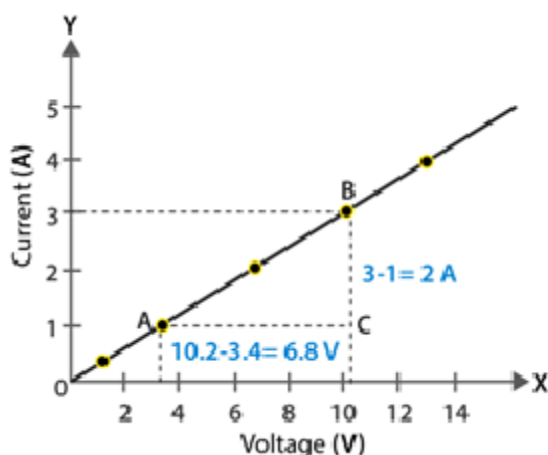
13. The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below –

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.

Solution:

The plot between voltage and current is known as IV characteristic. The current is plotted in the y-axis while the voltage is plotted in the x-axis. The different values of current for different values of voltage are given in the table. The I V characteristics for the given resistor is shown below.



The slope of the line gives the value of resistance.

The slope can be calculated as follows:

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

To calculate R ,

$$R = 6.8/2 = 3.4 \, \Omega$$

The resistance of the resistor is 3.4Ω .

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

Solution:

Let us consider the number of resistors required as 'x.'

The equivalent resistance of the parallel combination of resistor R is given by

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

Now, using Ohm's law, the number of resistors can be calculated as follows:

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

Substituting the values, we get

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

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

The number of resistors required is 4.

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

Solution:

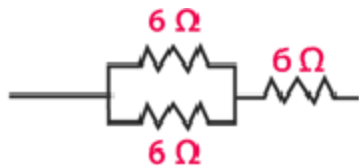
If we connect all the three resistors in series, their equivalent resistor would $6 \Omega + 6 \Omega + 6 \Omega = 18 \Omega$, which is not the desired value. Similarly, if we connect all the three resistors in parallel, their equivalent resistor would be

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

which is again not the desired value.

We can obtain the desired value by connecting any two of the resistors in either series or parallel.

Case (i)



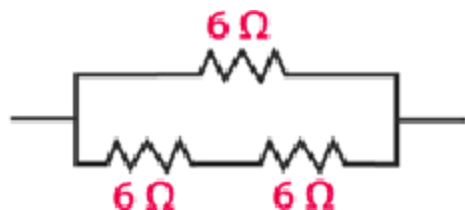
If two resistors are connected in parallel, then their equivalent resistance is

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

The third resistor is in series, hence the equivalent resistance is calculated as follows:

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

Case (ii)



When two resistors are connected in series, their equivalent resistance is given by

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

The third resistor is connected in parallel with $12\ \Omega$. Hence the equivalent resistance is calculated as follows:

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

16. 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 of 220 V line if the maximum allowable current is 5 A?

Solution:

The resistance of the bulb can be calculated using the expression

$$P_1 = V^2/R_1$$

$$R_1 = V^2/P_1$$

Substituting the values, we get

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

The resistance of x number of electric bulbs is calculated as follows:

$$R = V/I = 220/5 = 44 \, \Omega$$

The resistance of each electric bulb is 4840 Ω .

The equivalent resistance of x bulbs is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_1} + \frac{1}{R_1} \pm \dots \text{upto } x \text{ times}$$

$$\frac{1}{R} = \frac{1}{R_1} \times x$$

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

Hence, 110 lamps can be connected in parallel.

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

Solution:

Case (i) When coils are used separately

Using Ohm's law, we can find the current flowing through each coil as follows:

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

Substituting the values, we get

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

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

Case (ii) When coils connected in series

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

The current flowing through the series circuit is calculated as follows:

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

Therefore, 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 calculated as follows:

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

Using Ohm's law, the current flowing through the parallel circuit is given by

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

The current in the parallel circuit is 18.33 A.

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

Solution:

(i) The potential difference is $6\ \text{V}$ 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 follows:

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

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

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

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

Therefore, the power consumed by the $2\ \Omega$ is $8\ \text{W}$.

(ii) When $12\ \Omega$ and $2\ \Omega$ resistors are connected in parallel, the voltage across the resistors remains the same. Knowing that the voltage across $2\ \Omega$ resistor is $4\ \text{V}$, we can calculate the power consumed by the resistor as follows:

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

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

19. 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-toasters 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 its area of cross-section?**
- e. Why copper and aluminium wires are usually employed for electricity transmission?**

Solution:

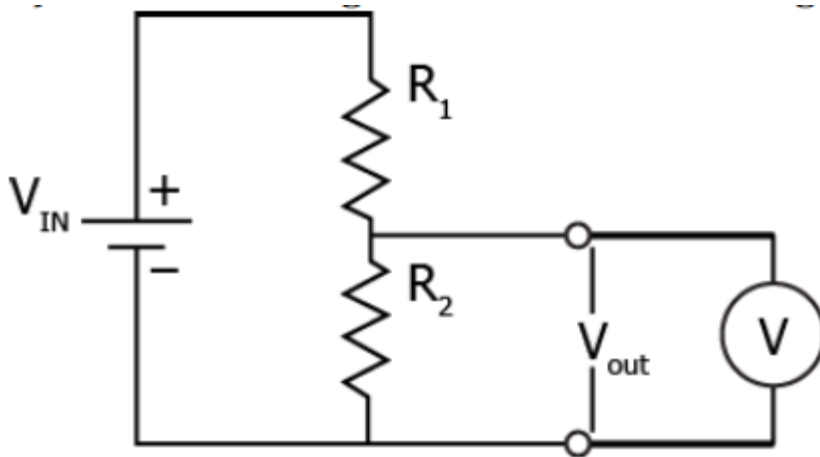
- a. The resistivity and melting point of tungsten is very high. Due to this property, it doesn't burn readily when heated. Electric lamps operate at high temperature. Hence, tungsten is a choice of metal for the filament of electric lamps.
- b. The conductors of electric heating devices are alloys because of their high resistivity. Alloys have higher resistivity than pure metals. Due to its high resistivity, a large amount of heat is produced when current passes through it.
- c. The series arrangement is not used for domestic circuits due to the following reasons:
 - The overall voltage gets distributed in a series circuit. As a result, electric appliances may not get the rated power for their operation.
 - All the connected appliances cannot be operated independently. If one device is defective, then the entire circuit will not function.
 - The total resistance becomes large, and as a result, the current is reduced.

d. Resistance is inversely proportional to the area of cross section. When the area of cross section increases the resistance decreases and vice versa.

e. Copper and aluminium are good conductors of electricity and have low resistivity, because of which they are usually employed for electricity transmission. Due to low resistivity, the power losses in the form of heat are also significantly less when electricity is transmitted through them.

MULTIPLE CHOICE QUESTIONS

1) The image shows a circuit diagram.



What is being measured using the voltmeter?

- (a) Current in the circuit
- (b) Voltage in the circuit
- (c) The voltage across the resistor
- (d) The resistance offered by the resistor

Correct Answer: Option (c)

2) The least resistance obtained by using $2\ \Omega$, $4\ \Omega$, $1\ \Omega$ and $100\ \Omega$ is

- (a) $< 100\ \Omega$
- (b) $< 4\ \Omega$
- (c) $< 1\ \Omega$
- (d) $> 2\ \Omega$

Correct Answer: Option (c)

3) Work of 14 J is done to move 2 C charge between two points on a conducting wire. What is the potential difference between the two points?

- (a) 28 V
- (b) 14 V
- (c) 7 V
- (d) 3.5 V

Correct Answer: Option (c)

4) A fuse wire repeatedly gets burnt when used with a good heater. It is advised to use a fuse wire of

- (a) More length
- (b) Less radius
- (c) Less length
- (d) More radius

Correct Answer: Option (d)

5) A circuit has a charge of 2C moving through it in 3 s. Which electrical component in the circuit, if present, will show the current?

- (a) Voltmeter will show a current of 6 A
- (b) Ammeter will show a current of 0.7 A

(c) Rheostat will show a current of 0.7 A

(d) Resistor will show a current of 0.35 A

Correct Answer: Option (b)

6) Electrical resistivity of a given metallic wire depends upon

(a) Its length

(b) Its thickness

(c) Its shape

(d) Nature of the material

Correct Answer: Option (d)

7) Two devices are connected between two points, say A and B, in parallel. The physical quantity that will remain the same between the two points is

(a) Current

(b) Voltage

(c) Resistance

(d) None of these

Correct Answer: Option (b)

8) Unit of electric power may also be expressed as

- (a) Volt-ampere
- (b) Kilowatt-hour
- (c) Watt second
- (d) Joule second

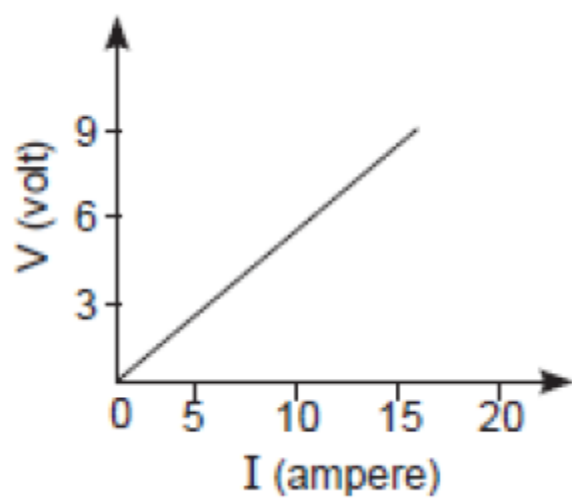
Correct Answer: Option (b)

9) What is the relationship between resistance and current?

- (a) They are directly related to each other
- (b) They are inversely related to each other
- (c) The resistance has a greater magnitude than the current
- (d) The current has a greater magnitude than the resistance

Correct Answer: Option (b)

Q10) The resistance whose V – I graph is given below is



- (a) $5/3 \, \Omega$
- (b) $3/5 \, \Omega$
- (c) $5/2 \, \Omega$
- (d) $2/5 \, \Omega$

Correct Answer: Option (b)

FILL IN THE BLANKS

1. Electricity is the flow of _____ through a conductor.

Answer: electrons

2. The unit of electrical resistance is _____.

Answer: ohm

3. A device that stores electrical energy is called a _____.

Answer: capacitor

4. The SI unit of electric current is _____.

Answer: ampere

5. The process of transforming electrical energy into other forms is known as _____.

Answer: electrical power

6. A material with high electrical conductivity is referred to as a good _____.

Answer: conductor

7.The opposition to the flow of electric current in a circuit is called _____.

Answer: resistance

8.The rate at which electrical energy is consumed is measured in _____.

Answer: watts

9.A closed loop through which an electric current can flow is called an _____.

Answer: electric circuit

10.The phenomenon where an electric current produces a magnetic field is known as _____.

Answer: electromagnetism