Chapter 12

ELECTRICITY

Multiple Choice Questions:

1. A cell, a resistor, a key and ammeter are arranged as shown in the circuit diagrams of Figure12.1. The current recorded in the ammeter will be
(a) Maximum in (i)
(b) Maximum in (ii)
(c) Maximum in (iii)
(d) The same in all the cases
Ans: (d) The same in all the cases
   - Because in all the three fig. the ammeter is connected in series with the circuit with correct connections, so the current through all the three circuit will be same.

2. In the following circuits (Figure 12.2), heat produced in the resistor or combination of resistors connected to a 12 V battery will be
(a) Same in all the cases
(b) Minimum in case (i)
(c) Maximum in case (ii)
(d) Maximum in case (iii)
Ans: (c) Maximum in case (ii)

According to Joules' law of heating,

- The heat produced due to current is given by,

$$H = I^2Rt$$

- The heat produced depends on I^2, R and t.
- In all the above fig. the voltage applied is same, so heat produced depends only on total resistance in the circuit.
- Hence, in fig.ii) the resistors are in series so R= 2+2= 4Ω
- Thus, maximum heat is produced in circuit ii).

3. Electrical resistivity of a given metallic wire depends upon
(a) Its length
(b) Its thickness
(c) Its shape
(d) Nature of the material
Ans: (d) Nature of the material

- According to Ohm's law,

$$R = \rho\, l/A$$

$$\rho = RA/l$$

- Thus, electrical resistivity of a given metallic wire depends upon its length, area of cross section also.
- But, for a given metallic wire, the electrical resistivity will depends on nature of material only.

4. A current of 1 A is drawn by a filament of an electric bulb. Number of electrons passing through a cross section of the filament in 16 seconds would be roughly

(a) 10^{20}
(b) 10^{16}
(c) 10^{18}
(d) 10^{23}
Ans: (a) 10^{20}

$$I = Q/t \Rightarrow Q = It = 1A\ (16sec) = 16\ C$$

1C = no. of electrons * charge on one electron
$16C = n * 1.6 * 10^{-19}$
$n = 16/ (1.6 * 10^{-19})$
$n = 10^{20}$ no. of electrons

5. Identify the circuit (Figure 12.3) in which the electrical components have been properly connected.
Fig. 12.3

(a) (i)
(b) (ii)
(c) (iii)
(d) (iv)

Ans: (b) (ii)

- Because, in fig, ii) the ammeter is connected in series and voltmeter in parallel with the circuit with proper sign conventions.

6. What is the maximum resistance which can be made using five resistors each of 1/5 Ω?

(a) 1/5 Ω
(b) 10 Ω
(c) 5 Ω
(d) 1 Ω

Ans: (d) 1 Ω

- The maximum resistance is obtained only in series combination of resistors.
- When five resistors each of 1/5Ω resistance are connected in series then,

$$R = 1/5 + 1/5 + 1/5 + 1/5 + 1/5$$

$$R= 1\ \Omega$$

7. What is the minimum resistance which can be made using five resistors each of 1/5 Ω?
(a) 1/5 Ω
(b) 1/25 Ω
(c) 1/10 Ω
(d) 25 Ω

Ans: (b) 1/25 Ω

- The minimum resistance is obtained only in parallel combination of resistors.
- When five resistors each of 1/5Ω resistance are connected in parallel then,

$$1/R = 5 + 5+ 5 + 5 + 5 = 25\ \Omega$$

$$R = 1/25\ \Omega$$

8. The proper representation of series combination of cells (Figure 12.4) obtaining maximum potential is

(a) (i)

(b) (ii)

(c) (iii)

(d) (iv)

Ans: (a) (i)

- In fig.i) the cells are connected in series with proper sign conventions to obtain the maximum potential, where there is no cancellation of potential overall.

9. Which of the following represents voltage?

(a)Work done / (Current × Time)

(b) Work done × Charge

(c)(Work done × Time)/ Current

(d) Work done × Charge × Time

Ans: (a) Work done / (Current × Time)

Voltage = work/ charge =W/Q

Hence, Work done / (Current * time) = W/ (I*t)

But, I = Q/t, = W/ [(Q*t)/t]

W/Q = V

10. A cylindrical conductor of length l and uniform area of cross section A has resistance R. Another conductor of length 2l and resistance R of the same material has area of cross section

(a) A/2

(b) 3A/2

(c) 2A

(d) 3A

Ans: (c) 2A

- For a given material the resistivity is constant,

For first cylindrical conductor, $\rho = RA/l$

For second cylindrical conductor, $\rho = RA_2/2l$

Hence, $RA/l = RA_2/2l$

$A_2 = 2A$

11. A student carries out an experiment and plots the V-I graph of three samples of nichrome wire with resistances R_1, R_2 and R_3 respectively (Figure.12.5). Which of the following is true?

(a) $R_1 = R_2 = R_3$

(b) $R_1 > R_2 > R_3$

(c) $R_3 > R_2 > R_1$

(d) $R_2 > R_3 > R_1$

Ans: (c) $R_3 > R_2 > R_1$

- From graph, the current decrease for R_1 to R_3.
- And, $I \alpha 1/R$, hence $R_3 > R_2 > R_1$ is true only.

12. If the current I through a resistor is increased by 100% (assume that temperature remains unchanged), the increase in power dissipated will be

(a) 100 %

(b) 200 %

(c) 300 %

(d) 400 %

Ans: (c) 300 %

If the current I is flowing through the resistor R then power dissipated is given by,

$P = I^2R$

If the current is increased by 100% i.e. new current will be 2I.

Then the new power dissipated is = $(2I)^2R = 4I^2R = 4P$

Hence, the increase in power is = 4P– P = 3P i.e. 300%

Thus, the increase in power dissipated will be 300%.

13. The resistivity does not change if

(a) The material is changed

(b) The temperature is changed

(c) The shape of the resistor is changed

(d) Both material and temperature are changed

Ans: (c) The shape of the resistor is changed

- The resistivity of the material is given by, $\rho = RA/l$
- Thus, it depends on resistance R, area of cross section, length of the material.
- And also on the temperature & nature of the material.
- Hence, it does not changes if the shape of the resistor is changed.

14. In an electrical circuit three incandescent bulbs A, B and C of rating 40 W, 60 W and 100 W respectively are connected in parallel to an electric source. Which of the following is likely to happen regarding their brightness?

(a) Brightness of all the bulbs will be the same

(b) Brightness of bulb A will be the maximum

(c) Brightness of bulb B will be more than that of A

(d) Brightness of bulb C will be less than that of B

Ans: (c) Brightness of bulb B will be more than that of A

The power dissipated will be given by P = VI i.e. power depends on current I and voltage V.

But in parallel combination of bulbs, the voltage dropped across each bulb is same, so V is constant.

Then power depends only on the current flowing through the bulb.

P α I and I α glow of bulb.

If power is maximum then current flowing is also maximum and hence the bulb glows more brightly.

Here bulbs A, B and C are of rating 40W, 60W and 100W respectively. Hence, the order of glow of bulb is A< B < C.

Thus, brightness of bulb B will be more than that of A is correct.

15. In an electrical circuit two resistors of 2 Ω and 4 Ω respectively are connected in series to a 6 V battery. The heat dissipated by the 4 Ω resistor in 5 s will be

(a) 5 J

(b) 10 J

(c) 20 J

d) 30 J

Ans: (c) 20 J

The heat dissipated by the 4 Ω resistor in 5s will be $H = VIt = I^2Rt$

By ohm's law, V = IR

$$I = V/R = 6/\ (2+4) = 1A$$

Thus the heat dissipated by 4Ω resistor in 5sec will be $H = I^2Rt = 1(4)\ (5)$

$$H = 20J$$

16. An electric kettle consumes 1 kW of electric power when operated at 220 V. A fuse wire of what rating must be used for it?

(a) 1 A

(b) 2 A

(c) 4 A

(d) 5 A

Ans: (d) 5 A

We have, P 1kW, V = 220 V

And power dissipated P = VI

$$I = P/V = 1000W/220V = 4.5A$$

Thus to consume 1kW of electric power a fuse wire of rating 4.5A or more than it can be used.

Hence, the correct answer is 5A.

17. Two resistors of resistance 2 Ω and 4 Ω when connected to a battery will have

(a) Same current flowing through them when connected in parallel

(b) Same current flowing through them when connected in series

(c) Same potential difference across them when connected in series

(d) Different potential difference across them when connected in parallel

Ans: (b) Same current flowing through them when connected in series

- Because, in series combination the current through the resistors connected in series is same while the potential difference is different across the each resistor.

18. Unit of electric power may also be expressed as

(a) Volt ampere

(b) Kilowatt hour

(c) Watt second

(d) Joule second

Ans: (a) Volt ampere

- Since, electric power is given by, P = V I
- Where V is a voltage and I is current in Ampere.

Short Answer Questions:

19.A child has drawn the electric circuit to study Ohm's law as shown in Figure 12.6. His teacher told that the circuit diagram needs correction. Study the circuit diagram and redraw it after making all corrections.

Ans: A childhas drawn the electric circuit to study Ohm's law, the reasons behind the correction are as follows:

Since, ammeter is always connected in series with the circuit or resistor with positive terminal of ammeter to positive terminal of battery and negative terminal to the negative part of battery indirectly

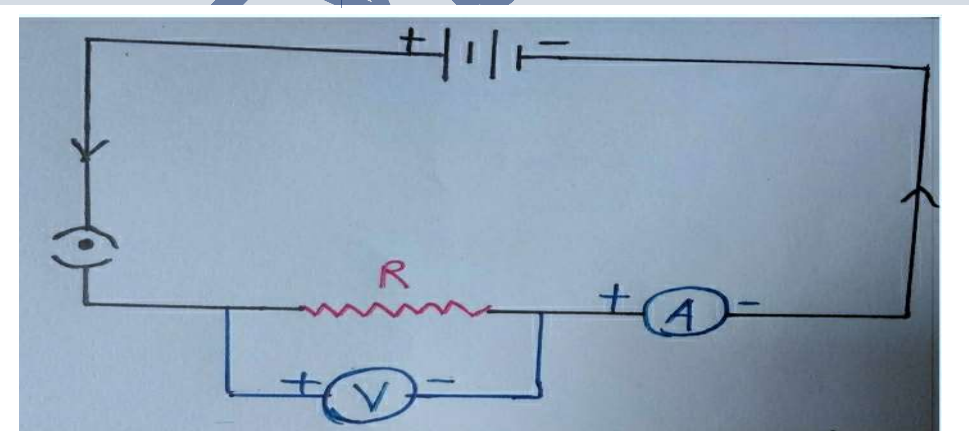


Fig. corrected electric circuit

Also the voltmeter is always connected in parallel with the circuit or resistor with positive terminal to positive terminal of battery and negative terminal to negative terminal of battery indirectly.

The ammeter gives the total current flowing through the circuit while the voltmeter measures the voltage applied.

The direction of flow of current is from positive terminal to negative terminal of battery because the direction of current is opposite to the direction of motion of electrons.

Since electrons are moving from negative to positive terminal of battery because they get attracted towards the positive terminal due to the negative charge on them.

20. Three 2 Ω resistors, A, B and C, are connected as shown in Figure 12.7. Each of them dissipates energy and can withstand a maximum power of 18W without melting. Find the maximum current that can flow through the three resistors?

Ans: From fig. the resistors B and C are connected in parallel with each other and a resistor A is in series with this parallel combination.

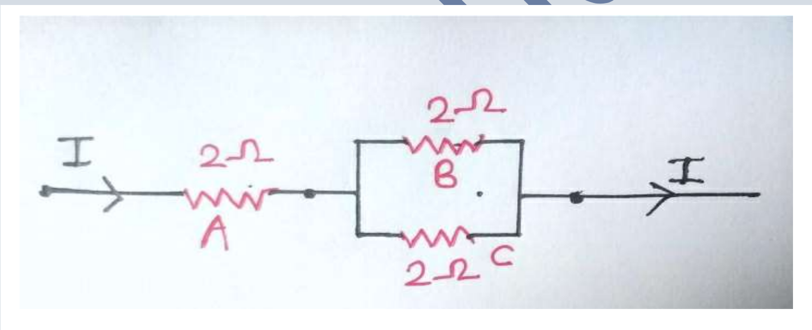


Fig. 12.7

In parallel combination the effective resistance is very low due to which maximum total current flows through the circuit and current get divided but applied voltage is constant across each resistor. And hence parallel combination is used in domestic wiring also.

In case of series combination, the effective resistance is very high due to which low total current flows through the circuit and the current flowing the circuit remains constant throughout the circuit.

Here, the current I is passing through A is I which is then divided for resistors B and C of same resistors connected in parallel.

Hence maximum current through A is I and through resistors B and C is I/2.

By ohm's law, $V = I R$ and $P = V I = I^2 R$

$$I^2 = P/R = 18/2 = 9$$

$$I = 3A$$

Thus, maximum current through resistor A is 3A.

And maximum current through resistors B and C is I/2=3/2 = 1.5A

21. Should the resistance of an ammeter be low or high? Give reason.

Ans: The ammeter resistance should be low. The ammeter is connected in series with electrical circuit or resistor to measure the current flowing through it.

In series connection the current flowing through the each resistor connected in series remains same.

By Ohm's law, V = I R i.e. $I \alpha 1/R$

If R is more I is less and if R less then R is more. Thus for maximum current the circuits are designed such that they must have low resistance. Hence to obtain maximum current the resistance of ammeter should be low in the circuit.

For an ideal ammeter the resistance should be zero and infinite current flows through it.

22. Draw a circuit diagram of an electric circuit containing a cell, a key, an ammeter, a resistor of 2 Ω in series with a combination of two resistors (4 Ω each) in parallel and a voltmeter across the parallel combination. Will the potential difference across the 2 Ω resistor be the same as that across the parallel combination of 4Ω resistors? Give reason.

Ans:

For parallel combination of resistors, the effective resistance is given by

$$1/R = ¼ + ¼ = 2/4$$

$$R = 2\Omega$$

The 2Ω resistor is connected in series with the parallel combination of 2 resistors of each resistance 4 Ω. The effective resistance of parallel combination is also 2Ω.

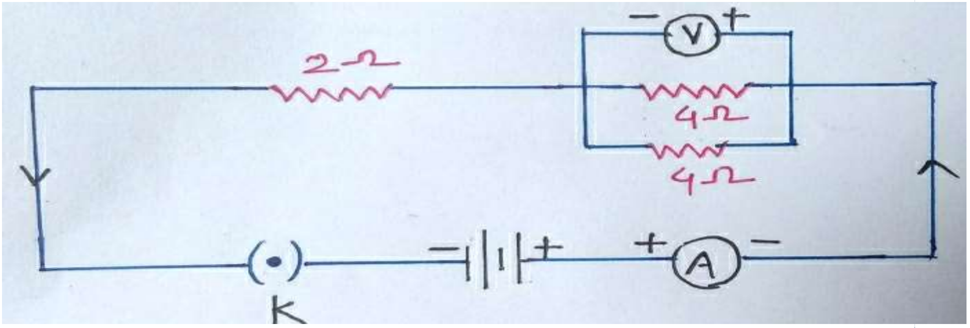


Fig. 22.1 electric circuit

In series combination of resistors, the current flowing through the resistors is same but the potential difference across each resistor is different. Here two 2Ω resistors are in series with parallel combination of two 4Ω resistors, so the total voltage get divided across this combination but the potential difference across 2Ω resistor be same as that of across the parallel combination of 4Ω resistors.

23. How does use of a fuse wire protect electrical appliances?

Ans: Fuse wire is a safety device connected in series in electrical circuit to protect the circuit from extra current flow. The rating of fuse wires is fixed, when the extra current greater than the rating flows through the circuit this fuses get heated and then melted to break that branch and to protect the whole circuit.

In our home appliance we have seen that, all the electrical devices are connected in parallel combination to provide same voltage and by their need they can draw the current.

In parallel combination if anyone branch get damaged then it will not affect to others and whole circuit cannot stop working. The fuses are used to protect the home electrical appliances like refrigerators, induction, TV and so on from extra-large current.

When maximum current flows, firstly the fuses get heated and then melts in that way breaks that branch so that electrical appliances are protected from large current and damaging. The fuses are having specific melting point, if temperature is increased due to extra current and heating and if temperature becomes more than melting point of fuses they get melts and protect the circuits.

And whole circuit works as it is with no any time lag. Thus fuses are mostly used to protect electrical appliances.

24. What is electrical resistivity? In a series electrical circuit comprising a resistor made up of a metallic wire, the ammeter reads 5 A. The reading of the ammeter decreases to half when the length of the wire is doubled. Why?

Ans:

According to Ohm's law, the voltage V applied is directly proportional to the current I flowing through the circuit and the proportionality constant R taken is called as resistance which if constant for a given conductor.

$$V \propto I \Rightarrow V = RI$$

After that, when they studied the factors depending on resistance of the conductor and found that, resistance also changes with some properties of the material and found that,

$$R \propto l/A \Rightarrow R = (\rho l)/A$$

The constant of proportionality is called as electrical resistivity of the material and it is different for different materials.

When $l = 1m$ and $A = 1m^2$ then $R = \rho$

Thus, electrical resistivity of the material is the resistance of the conductor of unit length and unit area of cross section made of that material.

Since, the resistance of the conductor depends on its length. If length is doubled the resistance gets doubled. But current is inversely proportional to the resistance,

Hence, if length is doubled, resistance get doubled and indirectly the current get halved.

25. What is the commercial unit of electrical energy? Represent it in terms of joules.

Ans:

We know that the rate of doing work is measured in power. And power is also the rate of consumption of energy.

In case of electricity, the power is the electrical power and the energy consumed is electrical energy. The electric power is the product of Voltage and current.

P= V in volt * I in A = P in watt

But watt is a very small unit to measure electric power so it will be measured in kW which means 1000watts. The electrical energy consumed is the product of power and time and hence,

E = P in kW * t in hr = E in kWh.

When we use the power of 1000 W or 1kW for 1 hour then the energy consumed will be 1kWh.

Thus, 1kWh = 1kilo watt * 1hour

= 1000 watt * 3600 seconds

= $3.6 * 10^6$ watt sec = $3.6 * 10^6$ J

Above value gives the commercial energy in terms of joules.

26. A current of 1 ampere flows in a series circuit containing an electric lamp and a conductor of 5 Ω when connected to a 10 V battery. Calculate the resistance of the electric lamp.

Now if a resistance of 10 Ω is connected in parallel with this series combination, what change (if any) in current flowing through 5 Ω conductor and potential difference across the lamp will take place? Give reason.

Ans:

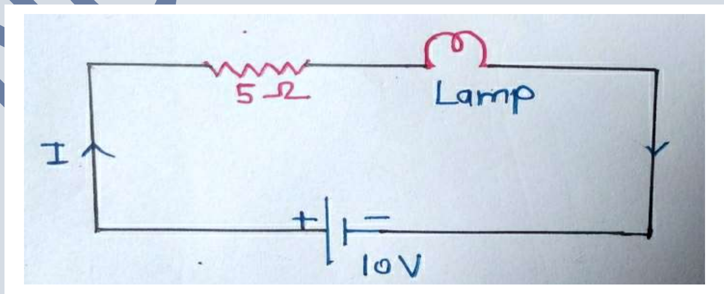


Fig.26.a) an electric circuit

Here, 5 Ω resistor and lamp are connected inseries, hence $R_e = R_L + 5\Omega$

Given that, 1A current flows in a series circuit connected to a 10V battery.

$$V = I\,R_e = I\,(R_L + 5\Omega)$$

$$10 = 1\,(RL + 5\Omega)$$

$$R_L = 10\text{-}5 = 5\Omega$$

Hence, the resistance of the electric lamp is 5Ω.

Now, if a resistance of 10 Ω is connected in parallel with this series combination, then

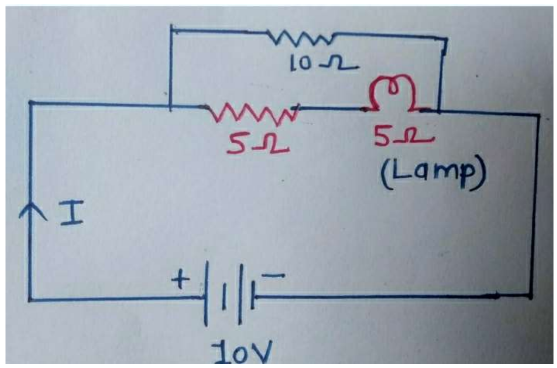


Fig.26.b) an electric circuit

Since, the 10 Ωresistor is in parallel combination with series combination of 5 Ω resistor and a lamp of resistance 5 Ω also i.e. here is the parallel combination of 10 Ω resistor with the 10 Ω resistor.

$1/Re = 1/10 + 1/\,(R_L + 5\Omega) = 1/10 + 1/10 = 1/5$

$Re = 5\Omega$ and $V = I\,R$

$10 = I * 5$

$I = 10/5 = 2A$

Hence, the current through the circuit flowing is 2A and it gets divided at A in equal two parts i.e. 1A through the 10Ω resistor and 1A through series combination of 5Ω resistor and lamp of resistance 5Ω.

Thus, the current through the conductor of resistance 5Ω is 1A which is the same as earlier.

In parallel combination, the potential difference remains same.

Hence, the potential difference across the lamp also remains same.

27. Why is parallel arrangement used in domestic wiring?

Ans:

In parallel combination, the voltage dropped across each component which are connected in parallel remains same and which is equal to voltage applied.

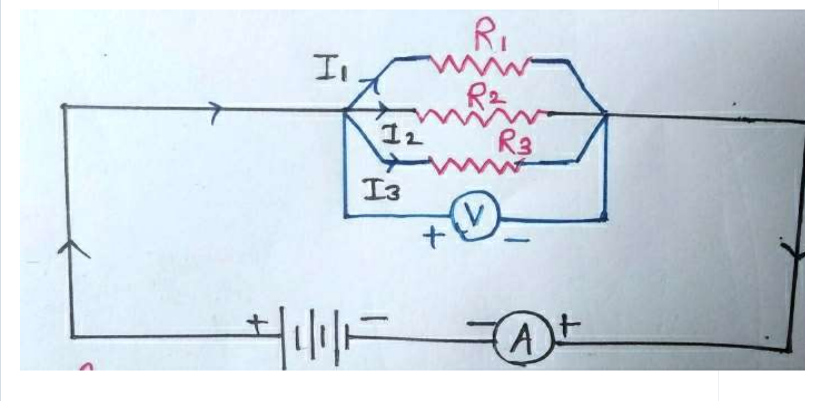


Fig.27 an electric circuit showing parallel combination of resistors

The total effective resistance of resistors connected in parallel combination becomes low or less than the resistances connected.

The current through each component in parallel combination is also different.

In parallel combination, if any one of the component get damaged then the whole circuit not get damaged. In parallel combination we can make one component ON and other OFF at a time.

Thus, from fig. $I_1 + I_2 + I_3 = I$ and $1/R_e = 1/R_1 + 1/R_2 + 1/R_3$ and $V_e = V_{applied}$

Now, if the parallel combination is used in domestic wiring, then voltage dropped across each electrical device will be same which is equal to the voltage applied.

Due to parallel combination, the effective resistance will be low and hence maximum current will be obtained. So that each device can draw a current requiring to it. Hence, the current flowing through each branch will be different due to parallel combination.

Also, if we want to turn OFF any one device and others have to make ON then we have to use parallel combination only. Also if any one of the device get damaged due to extra current then that device will be stopped only and whole circuit will be working, this is possible only in parallel combination.

Because of the all above advantages, the parallel combination is used in domestic wiring.

28. B_1, B_2 and B_3 are three identical bulbs connected as shown in Figure 12.8. When all the three bulbs glow, a current of 3A is recorded by the ammeter A.

Ans:

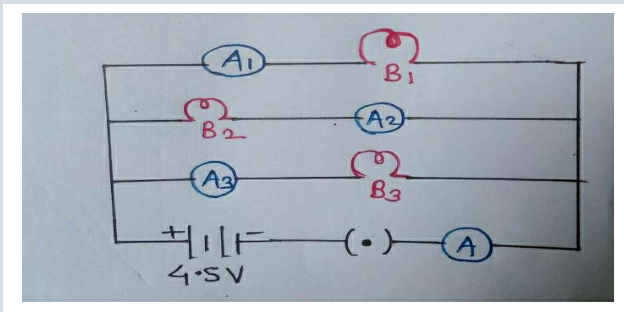


Fig.12.8

i)What happens to the glow of the other two bulbs when the bulb B_1 gets fused?

In fig. bulbs B_1, B_2 and B_3 are connected in parallel combination.

In parallel combination, the potential difference across each bulb remains same but the current flowing through each bulb gets divided and hence it is different.

If the bulb B_1 get fused, the current through it is not flowing and that branch is broken. But, other bulbs are till glowing because there is constant potential difference is applied across them.

(ii) What happens to the reading of A_1, A_2, A_3 and A when the bulb B_2 gets fused?

When bulb B_2 get fused, that branch only is broken. So current I is divided only in two branches of bulbs B_1 and B_3. So the value of current through A_1 and A_3 get increased to maintain constant current through the whole circuit.

Thus, A measures the same current while A_1 and A_3 measures the high readings than previous and less than total current I. and the current through the A_2 will be zero because it gets fused.

(iii) How much power is dissipated in the circuit when all the three bulbs glow together?

The power dissipated in circuit when the three bulbs are glowing is P = V I

P = (total voltage applied) * (total current) = 4.5 * 3 = 13.5W

Long Answer Questions:

29. Three incandescent bulbs of 100 W each are connected in series in an electric circuit. In another circuit another set of three bulbs of the same wattage are connected in parallel to the same source.

Ans: (a) Will the bulb in the two circuits glow with the same brightness? Justify your answer.

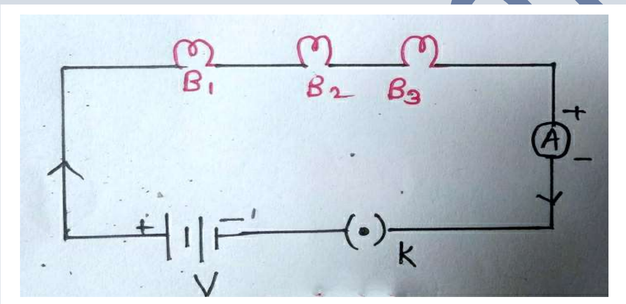


Fig.1 series combination of bulbs

In fig.1 all the bulbs are connected in series. Let R be the resistance of the each bulb. In series combination, the current through all the bulb is same.

We know that, current flowing is directly proportional to glow of bulb

Here, $I_{total} = V/R_e = V / (R+R+R) = V/3R$

In fig.2 all the bulbs are connected in parallel. In parallel combination the potential difference across each bulb remains same but current get divided in parallel combination.

Here, $I_{total} = V/Re$ and $1/Re = 1/R + 1/R + 1/R$

$Re = R/3$

Hence, $I_{total} = V/ (R/3) = 3V/R$

Thus from total current in parallel and series combination of bulbs, the maximum current flows through the parallel combination of bulbs because effective resistance decreases in parallel combination and current increases which increases the brightness of the bulbs.

Thus, all bulbs in parallel combination will be glowing more than in series combination.

(b) Now let one bulb in both the circuits get fused. Will the rest of the bulbs continue to glow in each circuit? Give reason.

In fig.1, 3 bulbs are in series combination, if any one of the three bulb get fused then total circuit get broken and current not flows through it. Hence, if anyone bulb get fused in series combination all bulbs get offed.

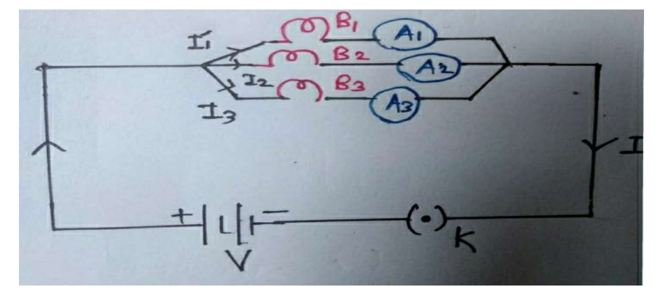


Fig.2 parallel combination of bulbs

In fig.2, 3 bulbs are in parallel, if out of three bulbs anyone get fused then only that branch is brooked and other are still working, so the circuit not get damaged because there is potential difference across each bulb which have applied.

Hence, in parallel combination other bulbs glow even if anyone of them get fused.

Because of this advantages of parallel combination, domestic wiring or electrical appliances are always connected in parallel combination only.

30. State Ohm's law? How can it be verified experimentally? Does it hold well under all conditions? Comment.

Ans

In1827, aGerman physicistGeorg Simon Ohm found out the relation between the current I flowing in a metallic wire and the potential difference across its two ends. This relation is called as Ohm's law.

According to Ohm's law, the potential difference across the two ends of the conductor in an electric circuit is directly proportional to current passing through it, provided the temperature and physical conditions of the conductor remains unchanged.

If V is the potential difference across two ends of a conductor and I is the current through it then by Ohm's law $V \propto I$

$$V/I = \text{constant} = R \text{ i.e. } V = IR$$

Where, R is the resistance for a given conductor which remains constant.

And it is the property of the conductor to resist or oppose the flow of current through the conductor.

The resistors are connected in circuit to regulate the current flowing through the circuit.

To explain the Ohm's law experimentally consider the following circuit.

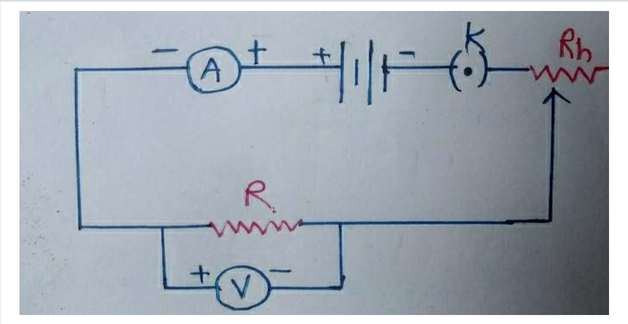


Fig. an electric circuit to study Ohm's law

Consider an electric circuit in which ammeter, resistor and rheostat to take different values of resistances in order to regulate the current are connected in series as shown in fig.

A voltmeter is connected in parallel with the circuit as shown in fig.

The device or component which is used to regulate i.e. to increase or decrease the current without changing the applied voltage is called as variable resistance and the device is called as rheostat.

Thus the current through the circuit is controlled by adjusting the rheostat and corresponding readings of ammeter and voltmeter are taken.

If we plot the graph between potential difference V and the current I, it is found that the nature of graph is a straight line passing through origin. This nature of graph indicates that, the potential difference V is directly proportional to current I flowing through the circuit. This verifies the Ohm's law.

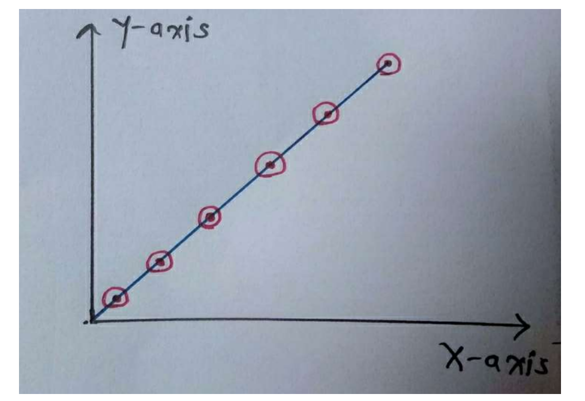


Fig. verification of Ohm's law from graph

The Ohm's law is applicable only when the temperature and physical conditions of the conductor remains unchanged.

Only small amount of current should be allowed through the circuit to maintain the temperature of the conductor to be constant.

The conductor using should not be subjected to any kind of stress or strain or tension.

31. What is electrical resistivity of a material? What is its unit? Describe an experiment to study the factors on which the resistance of conducting wire depends.

Ans:

We know that the flow of electrons contributes to flow of current in a conductor. But the motion of electrons is restricted by the atoms inside the conductor and this restriction to the motion of electrons is called as resistance of that conductor.

For a conductor with less resistance, conductivity is more. Insulators are having more resistance, so current cannot flow through them.

Why insulators does not conduct and conductor are conducting? The main reason is dependence of resistance of conductor on some factors. The resistance of a conductor varies with its length l, cross sectional area A and temperature Tof the conductor.

The resistance of a conductor is directly proportional to its length l and inversely proportional to area of cross section A.

$$R \propto l \text{ and } R \propto 1/A$$

$$R \propto l/A$$

$$R = \rho\, l/A$$

Where ρ is the constant called as specific resistance or resistivity of that conductor.

Thus electrical resistivity of a material is the resistance of the conductor of that material of unit length and unit area of cross section.

The SI unit of resistivity is ohm meter.

Let us do an experiment to study the factors on which resistance of a material depends:

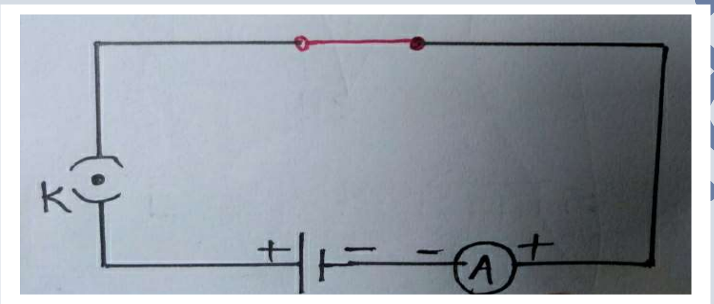


Fig. an electric circuit to study the factors on which resistance of the wire depends

Construct an electrical circuit in which a cell, an ammeter and a nichrome wire of length l is connected with the plug key.

First we will take observations for nichrome wire of length l, close the key and note the current in ammeter.

Now we replace the nichrome wire by the wire of length 2l and measured the current.

After that we will take a thicker nichrome wire of length l and corresponding current is measured.

Finally we take copper wire instead of nichrome wire of same length and same thickness as in first case and we have noted that the corresponding readings of current in ammeter

If we observed the readings then it will be observed that for a nichrome wire of length l the current I flows and when for same wire but of length 2L if taken then the current value becomes halved.

In third case when we take nichrome wire of length l and thickness greater, then the current through ammeter is increased and which is greater than I.

Now when we used copper wire of length l instead of nichrome wire then it is also observed that the current through circuit is increased than current I.

Thus, it is true that the current through the conductor is directly proportional to area and inversely proportional to length.

Hence, the resistance of a conductor is directly proportional to length of the wire and inversely proportional to area of cross section.

Also the current for copper wire is more than for nichrome wire i.e. the resistance of the material will also depends on the nature of the material used.

The resistance of the material depends on following factors:

- Length of the conductor
- Area of cross section
- Nature of the material of the conductor
- And also on the temperature of the material

32. How will you infer with the help of an experiment that the same current flows through every part of the circuit containing three resistances in series connected to a battery?

Ans:

In series combination of resistors, the effective resistance is the sum of resistances connected in series combination. And hence the effective resistance is greater than individual resistance. And hence the total current through the circuit decreases. The total current is equal to the current through the each resistor.

To infer that the current flowing through the resistors connected in series we can do the following experiment:

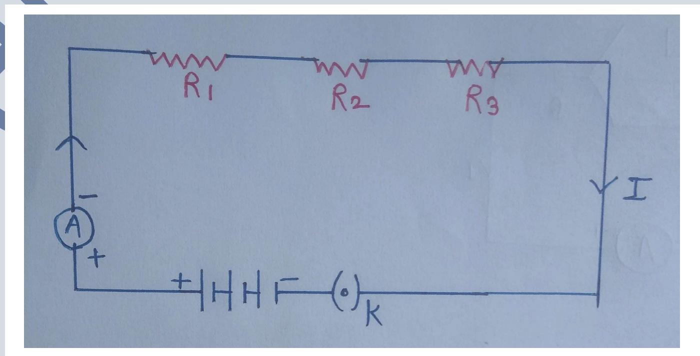


Fig.1

Consider the three resistors R_1, R_2 and R_3 are connected in series and battery of voltage V is connected to them in series. Now we can connect an ammeter A as shown in fig.1 to measure the total current through the circuit. And let the current noted is I.

Now we connect the same ammeter A_1 near to resistor R_1 as shown in fig.2 to measure the current through the resistor and we will note the same current I.

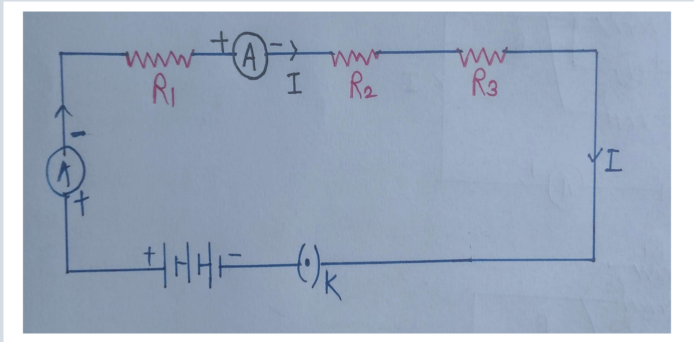


Fig.2

To measure the current through resistor R_2 we will connect the ammeter A_2 as shown in fig.3 and we get the same current I.

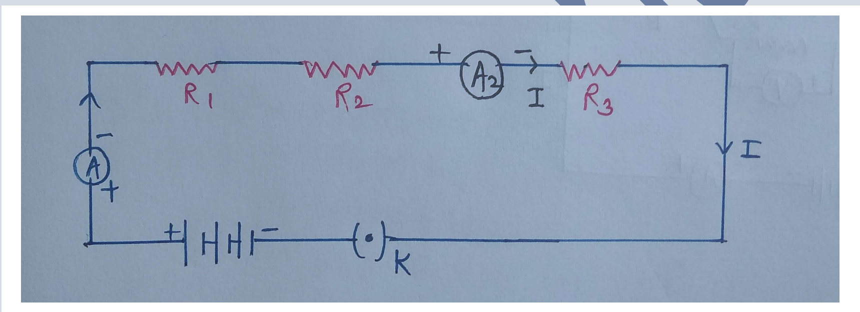


Fig.3

Finally when we connect the ammeter A_3 as shown in fig.4 to measure the current through the resistor R_3 we get the same current as I.

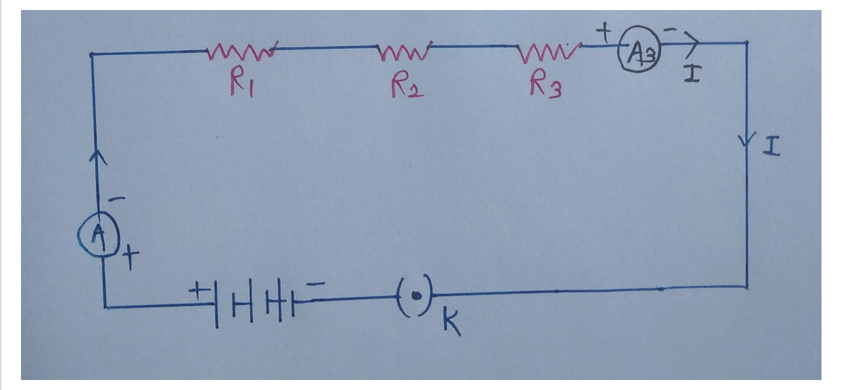


Fig.4

Thus from above all procedure, it is conclude that in series combination of resistors the current through each resistor is equal to the total current through the whole circuit.

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

33. How will you conclude that the same potential difference (voltage) exists across three resistors connected in a parallel arrangement to a battery?

Ans:

In parallel combination of resistors the voltage across each resistor will be same as the voltage applied to the circuit. The effective resistance of parallel combination of resistors is very low due to which high current flows through the circuit. But the current through each resistor is different and their total sum is equal to the total current through the circuit. Because of this advantage the parallel combination is used in domestic wiring to protect the circuit from high currents and to adjust the appliances simultaneously.

Now to infer that the potential difference across each resistor connected in parallel is same let us consider an electric circuit in which three resistors R_1, R_2 and R_3 are connected in parallel and battery of voltage V is applied across them in a series.

Now first we measure the voltage at points A and B by voltmeter V and we have noted the voltage as V as shown in fig.1

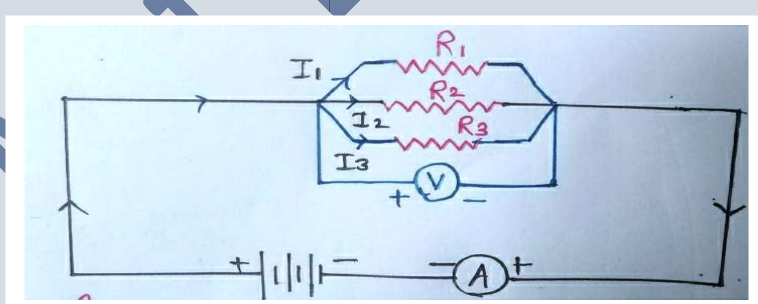


Fig.1

Now, to measure the potential difference across the resistor R_1 we connect the voltmeter V_1 parallel to it as shown in fig2 and noted the voltage as V.

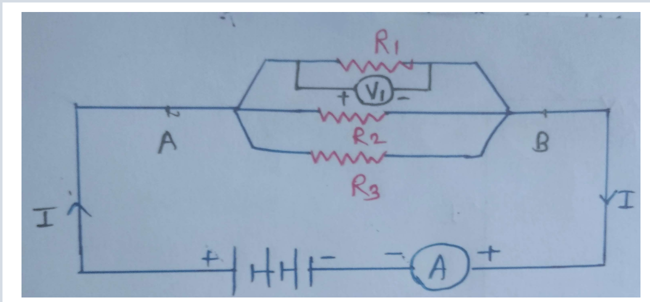


Fig.2

Similarly to measure the potential difference across the resistor R_2 we will connect a voltmeter V_2 parallel to it as shown in fig.3 and noted the same voltage V.

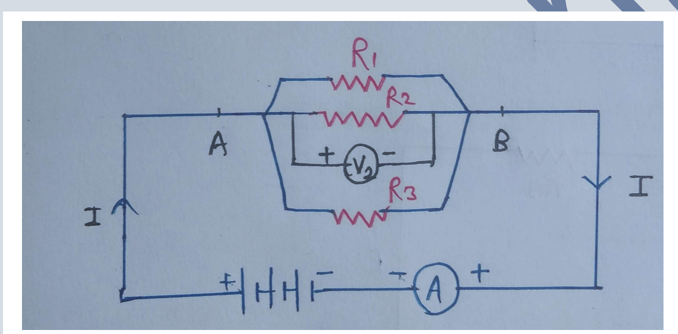


Fig.3

Finally we will connect the voltmeter V_3 parallel to resistor R_3 and measure the voltage across it we will get it as V as shown in fig.4

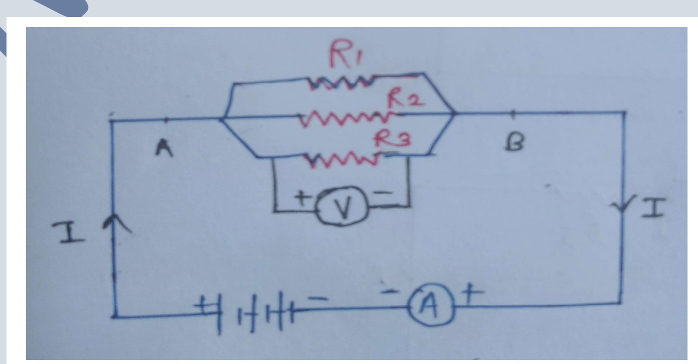


Fig.4

Thus from above experiment we conclude that the potential difference across each resistor in parallel combination is same.

34. What is Joule's heating effect? How can it be demonstrated experimentally? List its four applications in daily life.

Ans:

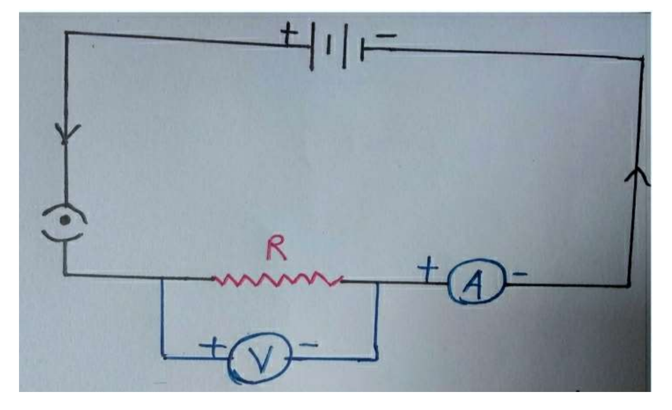
Joule's law of heating gives the heating effect of an electric current. According to Joule's law of heating, the heat produced in a resistor R is directly proportional to

- Square of the current through the resistor
- Resistance for a given current
- Time for which the current flows through the resistor

  Mathematically, $H = I^2Rt$

  To study the experimental demonstration of Joule's heating effect consider an electric circuit in which a cell, plug key and ammeter are connected in series with resistor R. the voltmeter to measure the voltage is connected parallel to the resistor as shown in fig.
  When potential difference V is applied to resistor R then current I flows through it and current is the rate of flow of charge.
  Let for time t the current I flows through the resistor i.e. t be the time required to flow the charge Q through the circuit. In moving the charge Q through the potential difference V the circuit the work is to be done and is given by W= VQ. This work is to be stored in the form of energy and hence energy supplied will be VQ.
  Then the power of the circuit is P = (VQ)/t = VI
  And hence the energy supplied in time t is P*t.

Fig. to study Joule's heating effect



This is the heat energy produced due to an electric current and is given by H = P*t = VIt.
Now, what about this energy produced? This energy produced in a circuit will be dissipated as heat energy in the resistor. Thus the current flowing through the resistor R for a time t produces a heat energy $H = VIt = I^2Rt$.
This heat energy produced depends on current, resistance and time for which the current is flowing. This proves the Joule's law experimentally.
The heat produced due to Joule's heating effect is sometimes useful and sometimes it damage the circuit also. The heat produced is used for lot of applications in daily life.

1) There are lots of applications of Joule's effect in daily life.
In electric bulbs, the light is produced due to heating effect. The tungsten filament retains the heat energy produced and get heated thereby producing light. It is a strong metal having high melting point, so it cannot melts easily.
2) In fuse wire circuits also heating effect occurs. The fuse wires are made from metal or an alloy of particular melting point like aluminum, copper, iron, lead etc. if large current flows through the circuit, the temperature of the fuse wire increases and due to which fuse wire get melted and circuit breaks. To protect the circuit from large current or heat produced due to large current fuses are used.
3) The electric iron we use in daily life is also working on the Joule's law of heating. In which electrical energy is converted into heat energy that can be used to press the cloths.
4) Also, in electric heaters the Joule's heating effect is observed, in which large current produces heat energy. This heat energy produced is used to heat the water. The proper metals or an alloys of high melting point are used for electric heaters.
In this way there large applications of Joule's heating effect in daily life.

35. Find out the following in the electric circuit given in Figure 12.9

Ans:

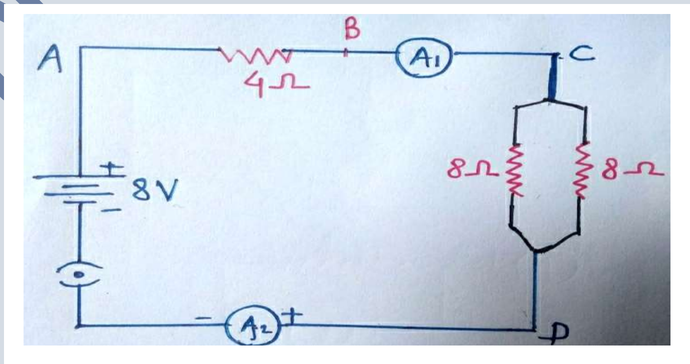


Fig.12.9

a) Effective resistance of two 8 Ω resistors in the combination

From fig. the 8Ω resistors are connected in parallel combination.

Thus, in parallel combination the effective resistance is given by

$1/R_e = 1/R_1 + 1/R_2$

Here, $R_1 = R_2 = 8\Omega$, $1/R_e = 1/8 + 1/8 = 1/4$

$$R_e = 4\Omega$$

(a) Current flowing through 4 Ω resistor

The total current through the circuit is same and it is flowing through the 4Ω resistor also. But two 8Ω resistors are connected in parallel combination at which current get divided. Hence, the total current due to resistor 4Ω, 8Ω and 8Ω is given by Ohm's law,

$$V = I R$$

$$\text{But, } R = R_1 + (R_2 * R_3)/(R_2 + R_3) =$$

$$R = 4 + (8*8)/(8 + 8)$$

$$R = 8\Omega$$

$$\text{Thus, } V = I R$$

$$I = V/R = 8/8 = 1A$$

Thus, current through the 4Ω resistor is 1A.

(b) Potential difference across 4 Ω resistance

Current through the 4Ω resistor is 1A and by Ohm's law

$V = I R = 1*4 = 4V$

Hence, potential difference across 4Ω resistor is 4V.

(c) Power dissipated in 4 Ω resistor

The power dissipated in 4Ω resistor is given by,

$P = I^2 R = 1^2 * 4 = 4W$

(d) Difference in ammeter readings, if any

4Ω resistor and parallel combination of two 8Ω resistor are in series. Hence, the current through the circuit remains constant and hence no difference will be observed in ammeter readings A_1 and A_2.