

## EXERCISE 8(A)

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**Question: 1****Define the term current and state its S.I. unit.****Solution:**

The rate of flow of charge is known as current. The S.I. unit of current is Ampere.

**Question: 2****Define the term electric potential. State its S.I. unit.****Solution:**

The amount of work done per unit charge in bringing a positive test charge from infinity to that point is known as electric potential at a point. The S.I. unit of electric potential is volt.

**Question: 3****How is the electric potential difference between the two points defined? State its S.I. unit.****Solution:**

The potential difference between two points can be defined as 'the potential difference between two points is equal to the work done per unit charge in moving a positive test charge from one point to the other. Its S.I. unit is volt.

**Question: 4****Explain the statement 'the potential difference between two points is 1 volt'.****Solution:**

The potential difference between two points is said to be 1 volt when 1 joule of work is done in bringing 1 coulomb charge from infinity to that point.

**Question: 5****(a) State whether the current is a scalar or vector? What does the direction of current convey?****(b) State whether the potential is a scalar or vector? What does the positive and negative sign of potential convey?****Solution:**

(a) Current is a scalar quantity. The direction of current conveys that the electrons flow opposite to the direction of flow of current.

(b) Potential is a scalar quantity. The positive sign of potential states that work has to be done on the positive test charge against the repulsive force due to the positive charge in bringing it from infinity. Negative sign of potential states that the work done on the negative test charge is due to the attractive force.

**Question: 6**

**Define the term resistance. State its S.I. unit.**

**Solution:**

The obstruction offered to the flow of current by the conductor is known as its resistance. The S.I. unit of resistance is Ohm.

**Question: 7**

**(a) Name the particles which are responsible for the flow of current in a metallic wire.**

**(b) Explain the flow of current in a metallic wire on the basis of movement of the particles named by you above in part (a).**

**(c) What is the cause of resistance offered by the metallic wire in the flow of current through it?**

**Solution:**

(a) Free electrons are the particles which are responsible for the flow of current in a metallic wire

(b) Free electrons are the moving charges that result in the conduction of electricity in metals. In time 't' if 'n' electrons pass through the metallic conductor, then the total charge that has flown is given by

$$Q \text{ (charge)} = n \times e \text{ (charge on an electron)}$$

(c) A metal contains free electrons and fixed positive ions.

When electrons move through a conductor such as a metal wire then an electric current flows. In the metal, the moving electrons can collide with the ions. Thus this makes it more difficult for the current to flow and therefore causes resistance.

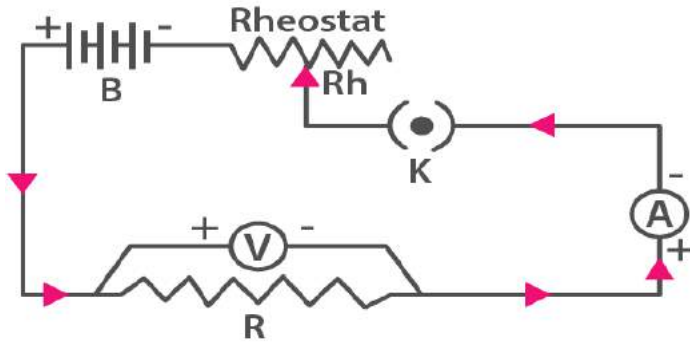
**Question: 8**

**State Ohm's law and draw a neat labelled circuit diagram containing a battery, a key, a voltmeter, an ammeter, a rheostat and an unknown resistance to verify it.**

**Solutions:**

According to Ohm's law, the current flowing in a conductor is directly proportional to the potential difference applied across its ends provided that the physical conditions and the temperature of the conductor remain constant. This is known as Ohm's law

$$V = IR$$



**Question: 9**

- (a) Name and state the law which relates the potential difference and current in a conductor.  
 (b) What is the necessary condition for a conductor to obey the law named above in part (a)?

**Solution:**

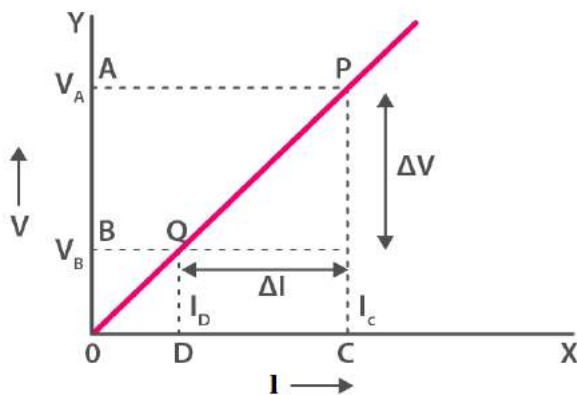
- (a) The law is known as Ohm's law. This law states that the current flowing through the conductor is directly proportional to the potential difference across its ends provided that the physical conditions and the temperature of the conductor remain constant.  
 (b) The necessary condition for a conductor to obey Ohm's law is that the temperature should remain constant.

**Question: 10**

- (a) Draw a V-I graph for a conductor obeying Ohm's law.  
 (b) What does the slope of V-I graph for a conductor represent?

**Solution:**

- (a) V-I graph for a conductor obeying Ohm's law is given below

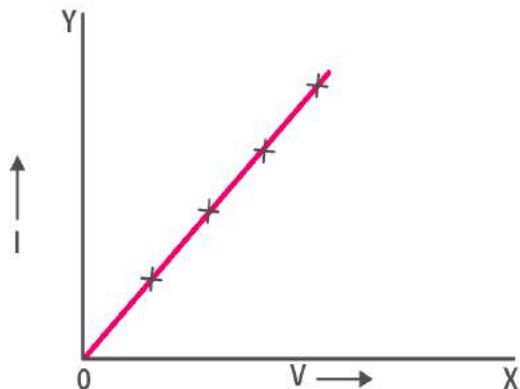


- (b) Slope of V-I graph for a conductor represents resistance.

**Question: 11**

**Draw a I-V graph for a linear resistor. What does its slope represent?**

**Solution:**



I-V graph for a linear resistor

Slope of I-V graph: The slope of I-V graph is  $\Delta I / \Delta V$   
 $\Delta I / \Delta V$  is the reciprocal resistance of the conductor i.e.

$$\text{Slope} = \Delta I / \Delta V$$

$$= 1 / \text{resistance of the conductor}$$

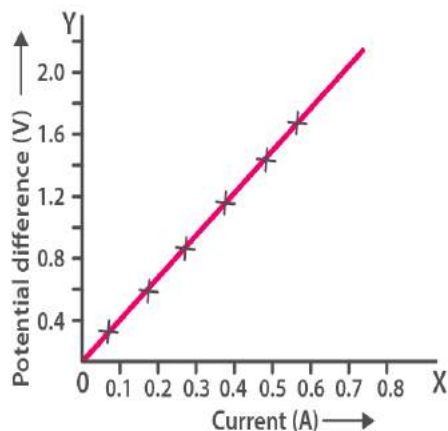
**Question: 12**

**What is an ohmic resistor? Give one example of an ohmic resistor. Draw a graph to show its current – voltage relationship. How is the resistance of the resistor determined from this graph?**

**Solution:**

The conductors which obey the Ohm's law are known as the ohmic resistors or linear resistances.

Examples: All metallic conductors such as silver, aluminium, copper, iron etc.



Resistance is determined in the form of slope from the above graph

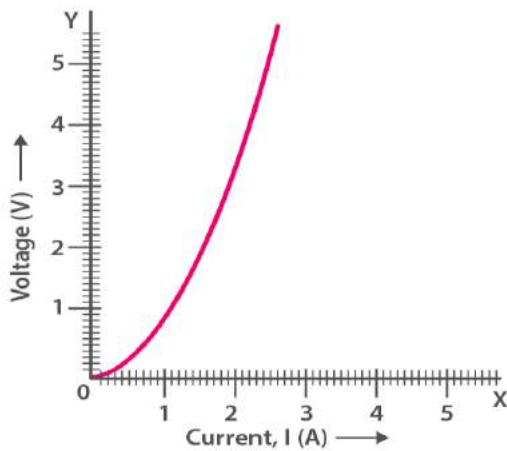
**Question: 13**

**What are non-ohmic resistors? Give one example and draw a graph to show its current-voltage relationship.**

**Solution:**

The conductors which do not obey the Ohm's law are known as the non-ohmic resistors or non-linear resistances).

Examples: LED, solar cell, junction diode, etc.



V vs I for non-ohmic conductors

**Question: 14**

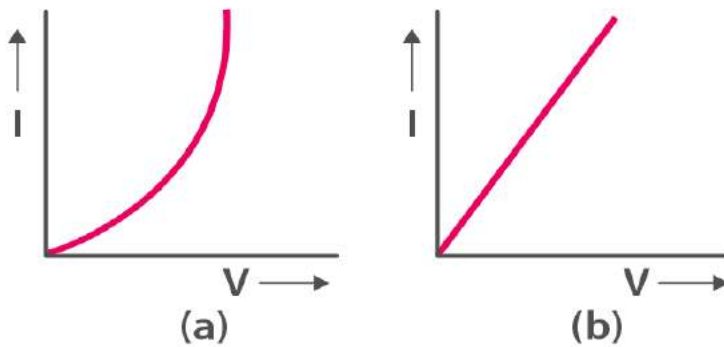
**Give two differences between an ohmic and non-ohmic resistor**

**Solution:**

Ohmic resistor	Non-ohmic resistor
It obeys the Ohm's law i.e., $V / I$ is constant for all values of $V$ or $I$ .	It does not obey the Ohm's law i.e., $V / I$ is not same for all values of $V$ or $I$ .
The slope of $V$ - $I$ graph is same at all values of $V$ or $I$ at a given temperature	The slope of $V$ - $I$ graph is different at different values of $V$ or $I$ even at a given temperature

**Question: 15**

**Fig. below shows the I-V characteristic curves for two resistors. Identify the ohmic and non-ohmic resistors. Give a reason for your answer.**



**Solution:**

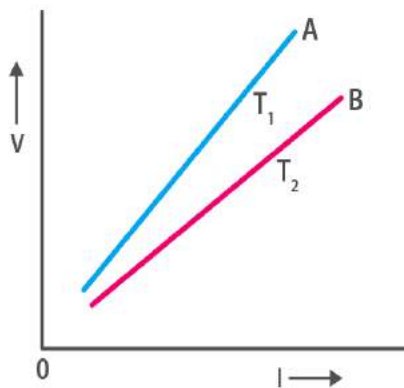
Graph (a) is non-ohmic resistor and Graph (b) is ohmic resistor

The I-V graph for (b) is a straight line or linear while the I-V graph for (a) is a curve

**Question: 16**

**Draw a V - I graph for a conductor at two different temperatures. What conclusion do you draw from your graph for the variation of resistance of conductor with temperature?**

**Solution:**



In the given graph above  $T_1 > T_2$ . The straight line A is more steeper than the line B because the resistance of conductor is more at high temperature  $T_1$  than at low temperature  $T_2$ . Hence we can conclude that resistance of a conductor increases with the increase in temperature.

**Question: 17**

- (a) How does the resistance of a wire depend on its radius? Explain your answer.
- (b) Two copper wires are of same length, but one is thicker than the other. Which will have more resistance?

**Solution:**

Resistance of a wire varies inversely as the area of cross section of the wire i.e.,

$$R \propto 1 / a$$

$$R \propto 1 / \pi^2$$

Resistance of a wire is directly proportional to its length, i.e.,  $R \propto l$  and varies inversely as the area of cross section of the wire i.e.,  $R \propto 1 / a$  or  $R \propto 1 / \pi r^2$

Since the resistance is inversely proportional to area of cross section, hence thin wire will have more resistance.

**Question: 18**

**How does the resistance of a wire depend on its length? Give a reason of your answer.**

**Solution:**

Resistance of a wire is directly proportional to the length of the wire.

$$R \propto l$$

The resistance of conductor depends on the number of collisions which the electron suffer with the fixed positive ions while moving from one end to other end of the conductor. Therefore in a long conductor, the number of collisions of free electrons with the positive ions will be more when compared to a shorter conductor. Hence a longer conductor offers more resistance.

**Question: 19**

**How does the resistance of a metallic wire depend on its temperature? Explain with reason.**

**Solution:**

With the increase in temperature of a conductor, the random motion of electrons increases. This makes the number of collisions of electrons with the positive ions to increase. Hence, the resistance of a conductor increases with an increase in its temperature.

The resistance of filament of a bulb is more when it is glowing that is when it is at a high temperature as compared to when it is not glowing that is when it is cold.

**Question: 20**

**Two wires, one of copper and other of iron, are of the same length and same radius. Which will have more resistance? Give reason.**

**Solution:**

Iron has more resistivity as compared to copper which has less resistivity. So, greater the resistivity, the more the resistance is and the smaller the resistivity, the lesser the resistance. Hence, iron wire has more resistance than copper wire of the same length and same radius.

**Question: 21**

**Name three factors on which the resistance of a wire depends and state how it is affected by the factors stated by you?**

**Solution:**

The three factors on which the resistance of wire depends are as follows

(i) Resistance of a wire is directly proportional to its length that is

$$R \propto l$$

(ii) Resistance of a wire varies inversely as the area of cross section of the wire. The resistance will be less when the area of cross section of the wire is more and vice versa

$$R \propto 1 / a$$

(iii) Resistance of a conductor increases with an increase in its temperature. As a result the number of collisions increases.

(iv) Resistance depends on the nature of conductor since different substances have different concentration of free electrons. Substances which have a large concentration of electrons, offer less resistance and hence called good conductors and substances which have negligible concentration of free electrons offer very high resistance and are called insulators.

**Question: 22**

**Define the term specific resistance and state its S.I. unit.**

**Solution:**

Specific resistance of a material is the resistance of a wire of that material of unit length and unit area of cross section. The S.I. unit of specific resistance is ohm  $\times$  metre

**Question: 23**

**Write an expression connecting the resistance of a wire and specific resistance of its material. State the meaning of symbols used.**

**Solution:**

The expression is

$$R = \rho l / a \text{ where}$$

$\rho$  = specific resistance of the material of conductor

R = resistance of conductor

l = length of conductor

A = area of cross section of conductor

**Question: 24**

**State the order of specific resistance of (i) a metal, (ii) a semiconductor and (iii) an insulator.**

**Solution:**



- (i) The specific resistance for metals is low, since it allows most of current to pass through it.
- (ii) The specific resistance for semiconductor is more than metals
- (iii) The specific resistance for insulators is very high, since the current won't pass through it

**Question: 25**

- (a) Name two factors on which the specific resistance of a wire depends?**
- (b) Two wires A and B are made of copper. The wire A is long and thin while the wire B is Short and thick. Which will have more specific resistance?**

**Solution:**

- (a) Two factors on which the specific resistance of a wire depends are
  - (i) Material of the substance and
  - (ii) Temperature of the substance
- (b) Both the wires will have the same specific resistance because the specific resistance depends on the material of the wire and not its dimensions.

**Question: 26**

**Name a substance of which the specific resistance remains almost unchanged by the increase in temperature.**

**Solution:**

The substance of which the specific resistance remains almost unchanged by the increase in temperature is manganin.

**Question: 27**

**How does specific resistance of a semi-conductor change with the increase in temperature?**

**Solution:**

With the increase in temperature, specific resistance of a semi-conductor decreases.

**Question: 28**

**How does (a) resistance, and (b) specific resistance of a wire depend on its (i) length, and (ii) radius?**

**Solution:**

- (a) Resistance is directly proportional to length of the wire and inversely proportional to the square of radius of the wire
- (b) Specific resistance of a wire do not depend on length and radius of the conductor that is independent of its length and radius.

**Question: 29**

(a) Name the material used for making the connection wires. Give reason for your answer.

(b) Why should a connection wire be thick?

**Solution:**

(a) Copper or aluminium are the materials used for making connection wires because they have small specific resistance and hence the wires of these materials possess negligible resistance

(b) The connection wires are made thick to consider their resistance as negligible to the flow of current through the circuit.

**Question: 30**

Name the material used for making a fuse wire. Give a reason.

**Solution:**

Alloy of lead and tin is used for making a fuse wire because it has high resistivity and low melting point.

**MULTIPLE CHOICE TYPE****Question: 1**

Which of the following is an ohmic resistance?

(a) LED

(b) Junction diode

(c) Filament of a bulb

(d) Nichrome wire

**Solution:**

An ohmic resistance is nichrome wire

**Question: 2**

For which of the following substances, resistance decreases with increase in temperature?

(a) Copper

(b) Mercury

(c) Carbon

(d) Platinum

**Solution:**

Resistance decreases with increase in temperature for carbon

**NUMERICALS****Question: 1**

In a conductor,  $6.25 \times 10^{16}$  electrons flow from its end A to B in 2 s. Find the current flowing through the conductor. ( $e = 1.6 \times 10^{-19}$  C)

**Solution:**

Given

Number of electrons flowing through the conductor,

$$n = 6.25 \times 10^{16} \text{ electrons.}$$

Time taken to flow from A to B = 2 s and  $e = 1.6 \times 10^{-19}$  C

Let I be the current flowing through the conductor

$$\text{Now, } I = ne / t$$

$$\text{Therefore } I = [(6.25 \times 10^{16}) (1.6 \times 10^{-19})] / 2$$

$$I = 5 \times 10^{-3} \text{ A or}$$

$$I = 5 \text{ mA}$$

Hence, 5 mA current flows from B to A

**Question: 2**

A current of 1.6 mA flows through a conductor. If charge of an electron is  $-1.6 \times 10^{-19}$  coulomb, find the number of electrons that will pass each second through the cross section of that conductor.

**Solution:**

Given

Current,  $I = 1.6 \text{ mA}$  or

$$I = 1.6 \times 10^{-3} \text{ A}$$

Charge,  $Q = -1.6 \times 10^{-19}$  coulomb

$$t = 1 \text{ s}$$

$$I = Q / t$$

$$Q = I \times t$$

$$Q = 1.6 \times 10^{-3} \times 1$$

$$\text{Number of electrons} = 1.6 \times 10^{-3} / 1.6 \times 10^{-19}$$

$$\therefore \text{Number of electrons} = 10^{16}$$

**Question: 3**

Find the potential difference required to flow a current of 200 mA in a wire of resistance 20 ohm.

**Solution:**

Given

Current  $I = 200 \text{ mA}$

$$I = 0.2 \text{ A}$$

Resistance  $R = 20 \text{ ohm}$

Potential difference  $V = ?$

Using Ohm's law

$$V = IR$$

$$V = 0.2 \times 20$$

$$V = 4 \text{ V}$$

**Question: 4**

**An electric bulb draws 1.2 A current at 6.0 V. Find the resistance of filament of bulb while glowing.**

**Solution:**

Given

Current  $I = 1.2 \text{ A}$

Potential difference or Voltage  $V = 6.0 \text{ V}$

Resistance  $R = ?$

From Ohm's law

$$V = IR$$

$$R = V / I$$

$$R = 6 / 1.2$$

$$R = 5 \text{ Ohm}$$

**Question: 5**

**A car bulb connected to a 12 volt battery draws 2 A current when glowing. What is the resistance of the filament of the bulb? Will the resistance be more, same or less when the bulb is not glowing.**

**Solution:**

Given

Potential difference or Voltage  $V = 12 \text{ V}$

Current  $I = 2 \text{ A}$

Resistance  $= ?$

According to Ohm's law

$$V = IR$$

$$R = V / I$$

$$R = 12 / 2$$

$$R = 6 \text{ Ohm}$$

Hence, when bulb is not glowing, resistance will be less

**Question: 6**

**Calculate the current flowing through a wire of resistance 5 Ohm connected to a battery of potential difference 3 V.**

**Solution:**

Given

Potential difference or Voltage  $V = 3 \text{ V}$

Resistance  $R = 5 \text{ Ohm}$

Current = ?

From Ohm's law

$$V = IR$$

$$I = V / R$$

$$I = 3 / 5$$

$$I = 0.6 \text{ A}$$

**Question: 7**

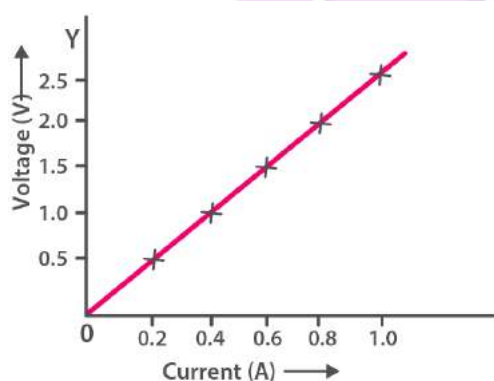
In an experiment of verification of Ohm's law, following observations are obtained.

<b>Potential difference V (in volt)</b>	<b>0.5</b>	<b>1.0</b>	<b>1.5</b>	<b>2.0</b>	<b>2.5</b>
<b>Current I (in amp)</b>	<b>0.2</b>	<b>0.4</b>	<b>0.6</b>	<b>0.8</b>	<b>1.0</b>

Draw a characteristic V-I graph and use this graph to find:

- potential difference  $V$  when the current  $I$  is  $0.5 \text{ A}$ .
- current  $I$  when the potential difference  $V$  is  $0.75 \text{ V}$ .
- resistance in circuit

**Solution:**



- Potential difference is  $1.25 \text{ V}$  when the current is  $0.5 \text{ A}$
- Current is  $0.3 \text{ A}$  when the potential difference is  $0.75 \text{ V}$
- The graph is linear and thus resistance can be found from any value of the given table.

If  $V = 2.5 \text{ Volt}$  then

Current  $I = 1.0 \text{ amp}$

Using Ohm's law

$$R = V / I$$

$$R = 2.5 / 1.0$$

$$R = 2.5 \text{ Ohm}$$

**Question: 8**

Two wires of the same material and same length have radii 1 mm and 2 mm respectively. Compare (i) their resistances (ii) their specific resistance.

**Solution:**

(i) For wire of radius  $r_1$

$$R_1 = \rho (l / A_1)$$

$$R_1 = \rho (l / \pi r_1^2)$$

(ii) For wire of radius  $r_2$

$$R_2 = \rho (l / A_2)$$

$$R_2 = \rho (l / \pi r_2^2)$$

$\therefore R_1: R_2$  will be

$$\rho (l / \pi r_1^2) : \rho (l / \pi r_2^2)$$

$$= r_2^2 : r_1^2$$

(ii) The resistivities of the two wires will be same because the material of the two wires is same. That is

$$\rho_1: \rho_2 = 1: 1$$

**Question: 9**

A given wire of resistance 1 Ohm is stretched to double its length. What will be its new resistance?

**Solution:**

Let 'l' be the length and 'a' be the area of cross section of the resistor with resistance,  $R = 1 \text{ Ohm}$

A given wire is stretched to double its length,

Therefore length  $l' = 2l$  and area of cross section  $a' = a / 2$

Now Resistance ( $R'$ ) =  $\rho l' / a'$

$$R' = \rho 2l / a / 2$$

$$R' = 4 \rho (l / a)$$

$$R' = 4R$$

$$R' = 4 \times 1$$

$$R' = 4 \text{ Ohm}$$

**Question: 10**

A wire of resistance 3 Ohm and length 10 cm is stretched to length 30 cm. Assuming that it has a uniform cross-section, what will be its new resistance?

**Solution:**

Given

Resistance  $R = 3 \text{ Ohm}$ Length  $l = 10 \text{ cm}$ The new length  $l' = 30 \text{ cm} = 3 \times l$  $R = \rho (l / A)$ 

New resistance

Stretching length will increase and area of cross section will decrease in same order

 $R' = \rho (3l / A / 3)$ 

Hence,

 $R' = 9 \rho (l / A)$  $R' = 9R$  $R' = 9 \times 3$  $R' = 27 \text{ Ohm}$ **Question: 11****A wire of resistance 9 Ohm having length 30 cm is tripled on itself. What is its new resistance?****Solution:**

Given

Resistance  $R = 9 \text{ Ohm}$ Length  $l = 30 \text{ cm}$ New length  $l' = 3 \times l$ New resistance  $R'=?$ 

Area of cross section will also change in same order with change in length

 $R' = \rho (l / 3 / 3A)$  $R' = 1 / 9 (\rho l / A)$  $R' = 1 / 9 R$  $R' = 1 \text{ Ohm}$ **Question: 12****What length of copper wire of specific resistance  $1.7 \times 10^{-8} \text{ ohm m}$  and radius 1 mm is required so that its resistance is 1 ohm.****Solution:**

Given

**Resistance  $R = 1 \text{ ohm}$** **Specific resistance =  $1.7 \times 10^{-8} \text{ ohm m}$** Radius  $r = 1 \text{ mm}$  that is  $10^{-3} \text{ m}$ Length  $l=?$

$$R = \rho l / A$$

$$l = RA / \rho$$

$$l = R\pi r^2 / \rho$$

$$l = (1 \times \pi \times 10^{-6}) / (1.7 \times 10^{-8})$$

$$l = (1 \times 3.14 \times 10^{-6}) / (1.7 \times 10^{-8})$$

$$l = 1.847 \times 10^2 \text{ m}$$

$$l = 184.7 \text{ m}$$

**Question: 13**

The filament of a bulb takes a current 100 mA when potential difference across it is 0.2 V. When the potential difference across it becomes 1.0 V, the current becomes 400 mA. Calculate the resistance of filament in each case and account for the difference.

**Solution:**

From Ohm's law

$$V = IR$$

$$R = V / I$$

$$R_1 = V_1 / I_1$$

$$R_1 = 0.2 / 0.1$$

$$R_1 = 2 \text{ ohm}$$

Similarly

$$R_2 = V_2 / I_2$$

$$R_2 = 1 / 0.4$$

$$R_2 = 2.5 \text{ ohm}$$

$\therefore$  With increase in temperature resistance of the wire increases. Thus resistance of filament increases with the increase in temperature.



### EXERCISE 8(B)

PAGE NO: 200

#### Question: 1

Explain the meaning of the terms e.m.f., terminal voltage and internal resistance of cell.

#### Solution:

e.m.f : When the cell is in open circuit, the potential difference between the terminals of the cell is called its electro-motive force or e.m.f

Terminal voltage: When the cell is in closed circuit, the potential difference between the electrodes of the cell is known as terminal voltage.

Internal resistance: The resistance offered by the electrolyte inside the cell, to the flow of current, is known as the internal resistance of the cell.

#### Question: 2

State two differences between the e.m.f. and terminal voltage of a cell.

#### Solution:

e.m.f of cell	Terminal voltage of cell
1. It is the characteristic of the cell, i.e., it does not depend on the amount of current drawn from the cell	1. It depends on the amount of current drawn from the cell. More the current drawn from the cell, less is the terminal voltage
2. It is equal to the terminal voltage when the cell is not in use, while greater than the terminal voltage when cell is in use	2. It is equal to the e.m.f. of cell when cell is not in use, while less than the e.m.f. when cell is in use.

#### Question: 3

Name *two* factors on which the internal resistance of a cell depends and state how does it depend on the factors stated by you.

#### Solution:

The factors on which the internal resistance of a cell depends are:

- (i) The surface area of the electrodes - larger the surface area of electrodes, less is the internal resistance.
- (ii) The distance between the electrodes – more the distance between the electrodes, greater is the internal resistance.

#### Question: 4

A cell of e.m.f.  $\epsilon$  and internal resistance  $r$  is used to send current to an external resistance  $R$ . Write expressions for (a) the total resistance of circuit, (b) the current drawn from the cell, (c) the p.d. across the cell, and (d) voltage drop inside the cell.

#### Solution:

- (a) The total resistance of circuit =  $R + r$   
 (b) The current drawn from the cell

We know that,

$$\begin{aligned}\varepsilon &= V + v \\ &= IR + Ir \\ &= I(R + r) \\ I &= \varepsilon / (R + r)\end{aligned}$$

- (c) p.d. across the cell:  $[\varepsilon / (R + r)] \times R$   
 (d) voltage drop inside the cell:  $[\varepsilon / (R + r)] \times r$

**Question: 5**

A cell is used to send current to an external circuit. (a) How does the voltage across its terminal compare with its emf? (b) Under what condition is the emf of the cell equal to its terminal voltage?

**Solution:**

- (a) When current is drawn from a cell, its terminal voltage  $V$  is less than its e.m.f.  
 $\therefore$  Terminal voltage  $<$  e.m.f.  
 (b) When no current is drawn, then the e.m.f. is equal to the terminal voltage.

**Question: 6**

Explain why the p.d. across the terminals of a cell is more in an open circuit and reduced in a closed circuit.

**Solution:**

The current flows through the circuit when the electric cell is in a closed circuit. There is a fall of potential across the internal resistance of the cell. Hence, the p.d. across the terminals in a closed circuit is less than the p.d. across the terminals in an open circuit by an amount equal to the potential drop across the internal resistance of the cell.

**Question: 7**

Write the expressions for the equivalent resistance  $R$  of three resistors  $R_1$ ,  $R_2$  and  $R_3$  joined in (a) parallel, (b) series.

**Solution:**

- (a) Total resistance in parallel is given by  

$$1 / R = 1 / R_1 + 1 / R_2 + 1 / R_3$$
  
 (b) Total resistance in series is given by  

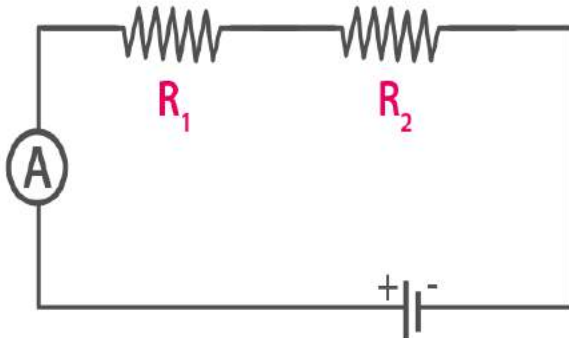
$$R = R_1 + R_2 + R_3$$

**Question: 8**

How would you connect two resistors in series? Draw a diagram. Calculate the total

equivalent resistance.

**Solution:**



If current  $I$  is drawn from the battery, the current will also be  $I$  through each resistor.

Applying Ohm's law to the two resistors separately, we get,

$$V_1 = IR_1$$

$$V_2 = IR_2$$

$$V = V_1 + V_2$$

$$IR = IR_1 + IR_2$$

$$R = R_1 + R_2$$

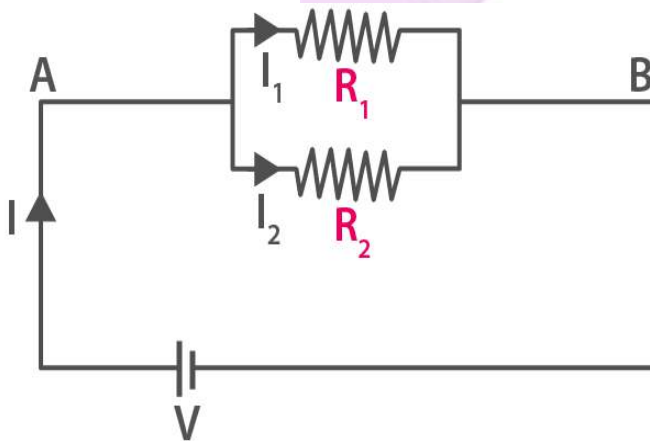
Thus total resistance in series is

$$R = R_1 + R_2 + R_3$$

**Question: 9**

Show by a diagram how two resistors  $R_1$  and  $R_2$  are joined in parallel. Obtain an expression for the total resistance of the combination.

**Solution:**



Applying Ohm's law separately to the two resistors, we have

$$I_1 = V / R_1$$

$$I_2 = V / R_2$$

$$I = I_1 + I_2$$

$$V / R = V / R_1 + V / R_2$$

$$1 / R = 1 / R_1 + 1 / R_2$$

**Question: 10**

State how are the two resistors joined with a battery in each of the following cases when:

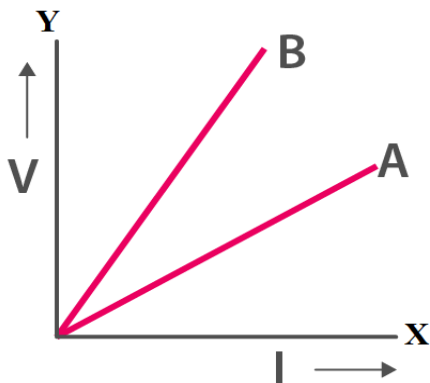
- (a) same current flows in each resistor
- (b) potential difference is same across each resistor.
- (c) equivalent resistance is less than either of the two resistances.
- (d) equivalent resistance is more than either of the two resistances.

**Solution:**

- (a) The two resistors are in series
- (b) The two resistors are in parallel
- (c) The two resistors are in parallel
- (d) The two resistors are in series

**Question: 11**

The V-I graph for a series combination and for a parallel combination of two resistors is shown in fig. Which of the two, A or B, represents the parallel combination? Give a reason for your answer.



**Solution:**

Change in V is less for the straight line A than for the straight line B (which means the straight line A is less steeper than B). Hence, the straight line A represents small resistance and the straight line B represents more resistance. The resistance decreases in parallel combination while the resistance increases in series combination. Thus the straight line A represents the parallel combination.

**MULTIPLE CHOICE TYPE**

**Question: 1**

**In series combination of resistances:**

- (a) P.d. is same across each resistance
- (b) Total resistance is reduced
- (c) Current is same in each resistance
- (d) All of the above are true

**Solution:**

Current is same in each resistance in series combination of resistances.

**Question: 2**

**In parallel combination of resistances:**

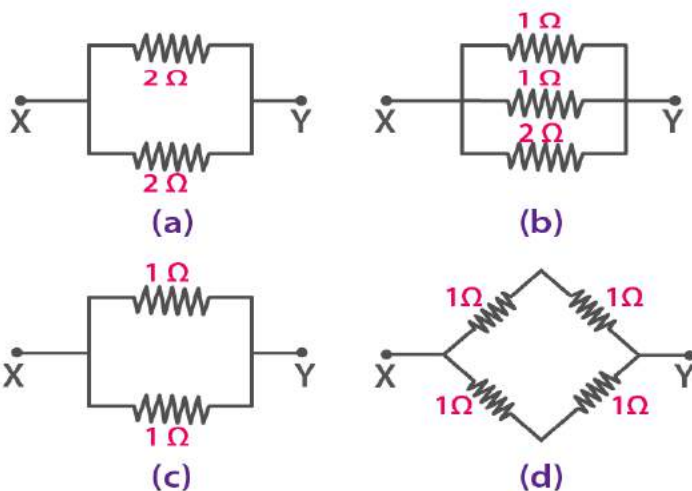
- (a) P.D. is same across each resistance
- (b) Total resistance is increased
- (c) Current is same in each resistance
- (d) All of the above are true

**Solution:**

P.D is same across each resistance in parallel combination of resistances

**Question: 3**

**Which of the following combinations have the same equivalent resistance between X and Y?**



**Solution:**

The resistors are connected in parallel in figure (a) between X and Y

Let  $R'$  be their equivalent resistance

$$\text{Now, } 1/R' = 1/2 + 1/2$$

$$= 2/2 \text{ ohm or}$$

$$R' = 1 \text{ ohm} \quad [1]$$

A series combination of two 1 ohm resistors is in parallel with another series combination of two 1 ohm resistors in figure (d)

Series resistance of two 1 ohm resistors,

$$R = (1 + 1) \text{ ohm}$$

$$R = 2 \text{ ohm}$$

Therefore we can say that 2 ohm resistors are connected in parallel across X and Y

Let  $R'$  be the net resistance across X and Y.

$$\text{Then, } 1/R' = 1/2 + 1/2$$

$$1/R' = 2/2 \text{ ohm or}$$

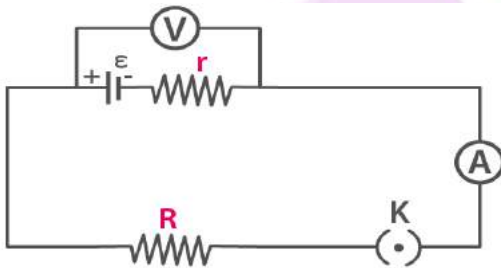
$$R' = 1 \text{ ohm} \quad [2]$$

Thus it is clear from equation [1] and [2] that the figures (a) and (d) have the same equivalent resistance between X and Y

## NUMERICALS

### Question: 1

The diagram in figure shows a cell of e.m.f.  $\epsilon = 2$  volt and internal resistance  $r = 1$  ohm connected to an external resistance  $R = 4$  ohm. The ammeter A measures the current in the circuit and the voltmeter V measures the terminal voltage across the cell. What will be the readings of the ammeter and voltmeter when (i) the key K is open, and (ii) the key K is closed



### Solution:

(i) Because of no current, ammeter reading = 0

$$\text{Voltage } V = \epsilon - Ir$$

$$V = 2 - 0 \times 1$$

$$V = 2 \text{ volt}$$

(ii) Ammeter reading

$$I = \epsilon / (R + r)$$

$$I = 2 / (4 + 1)$$

$$I = 2 / 5$$

$$I = 0.4 \text{ amp}$$

Voltage reading

$$\begin{aligned} \text{Voltage } V &= \varepsilon - Ir \\ V &= 2 - 0.4 \times 1 \\ V &= 2 - 0.4 \\ V &= 1.6 \text{ V} \end{aligned}$$

**Question: 2**

A battery of e.m.f. 3.0 V supplies current through a circuit in which resistance can be changed. A high resistance voltmeter is connected across the battery. When the current is 1.5 A, the voltmeter reads 2.7 V. Find the internal resistance of the battery.

**Solution:**

Given

$$\varepsilon = 3 \text{ volt}$$

$$I = 1.5 \text{ A}$$

$$V = 2.7 \text{ V}$$

$$V = \varepsilon - Ir$$

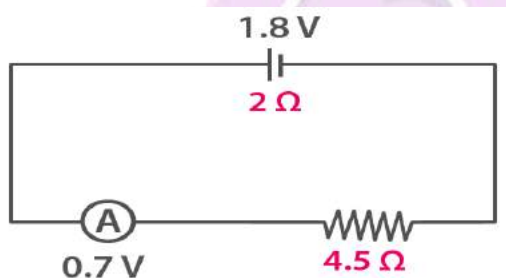
$$r = (\varepsilon - V) / I$$

$$r = (3 - 2.7) / 1.5$$

$$r = 0.2 \text{ ohm}$$

**Question: 3**

A cell of emf 1.8 V and internal resistance 2 ohm is connected in series with an ammeter of resistance 0.7 ohm and resistance of 4.5 ohm as shown in figure.



(a) What would be the reading of the ammeter?

(b) What is the potential difference across the terminals of the cell?

**Solution:**

(a)  $\varepsilon = 1.8 \text{ V}$

$$\text{Total resistance} = 2 + 4.5 + 0.7$$

$$= 7.2 \text{ W}$$

$$I = ?$$

$$I = \varepsilon / R \text{ (total resistance)}$$

$$I = 1.8 / 7.2$$

$$I = 0.25 \text{ A}$$

(b) Current  $I = 0.25 \text{ A}$  [calculated in (a) part]

$$\begin{aligned} \text{Now, excluding internal resistance total resistance} &= 4.5 + 0.7 \\ &= 5.2 \text{ ohm} \end{aligned}$$

$$V = IR$$

$$V = 0.25 \times 5.2$$

$$V = 1.3 \text{ V}$$

**Question: 4**

A battery of emf 15 V and internal resistance 3 ohm is connected to two resistors of resistances 3 ohm and 6 ohm in series. Find:

(a) the current through the battery

(b) the p.d. between the terminals of the battery.

**Solution:**

$$(a) \varepsilon = 15 \text{ V}$$

$$R = 6 + 3$$

$$R = 9 \text{ ohm}$$

$$r = 3 \text{ ohm}$$

$$I = ?$$

$$I = \varepsilon / (R + r)$$

$$I = 15 / (9 + 3)$$

$$I = 15 / 12$$

$$I = 1.25 \text{ A}$$

(b) Current  $I = 1.25 \text{ A}$  [calculated in part (a)]

$$\text{External resistance } R = 6 + 3$$

$$R = 9 \text{ ohm}$$

$$V = IR$$

$$V = 1.25 \times 9$$

$$V = 11.25 \text{ V}$$

**Question: 5**

A cell of e.m.f.  $\varepsilon$  and internal resistance  $r$  sends current 1.0 A when it is connected to an external resistance 1.9 ohm. But it sends current 0.5 A when it is connected to an external resistance of 3.9 ohm. Calculate the values of  $\varepsilon$  and  $r$ .

**Solution:**

In first case

$$I = 1 \text{ A}, R = 1.9 \text{ ohm}$$

$$\varepsilon = I(R + r)$$

$$= 1(1.9 + r)$$



$$= 1.9 + r \quad [1]$$

In second case

$$I = 0.5 \text{ A}, R = 3.9 \text{ ohm}$$

$$\varepsilon = I(R + r)$$

$$= 0.5(3.9 + r)$$

$$= 1.95 + 0.5r \quad [2]$$

From equation [1] and [2]

$$1.9 + r = 1.95 + 0.5r$$

$$r = 0.05 / 0.5$$

$$r = 0.1 \text{ ohm}$$

Now, substituting the value of r

$$\varepsilon = 1.9 + r$$

$$\varepsilon = 1.9 + 0.1$$

$$\varepsilon = 2 \text{ V}$$

**Question: 6**

Two resistors having resistance 4 ohm and 6 ohm are connected in parallel. Find their equivalent resistance.

**Solution**

Let the equivalent resistance of the 4 ohm and 6 ohm resistors connected in parallel be  $R'$

$$\text{Then, } 1/R' = 1/4 + 1/6$$

$$= (3 + 2) / 12$$

$$= 5 / 12 \text{ ohm or}$$

$$R' = 12 / 5$$

$$R' = 2.4 \text{ ohm}$$

**Question: 7**

Four resistors each of resistance 2 ohm are connected in parallel. What is the effective resistance?

**Solution:**

$$R_1 = 2 \text{ ohm}$$

$$R_2 = 2 \text{ ohm}$$

$$R_3 = 2 \text{ ohm}$$

$$R_4 = 2 \text{ ohm}$$

$$1/R = 1/R_1 + 1/R_2 + 1/R_3 + 1/R_4$$

$$1/R = 1/2 + 1/2 + 1/2 + 1/2$$

$$1/R = 2$$

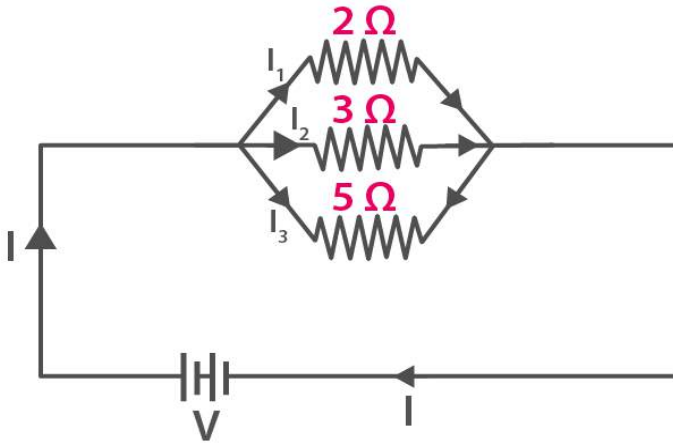
$$R = 0.5 \text{ ohm}$$

**Question: 8**

You have three resistors of values  $2\ \Omega$ ,  $3\ \Omega$  and  $5\ \Omega$ . How will you join them so that the total resistance is less than  $1\ \Omega$ ? Draw diagram and find the total resistance.

**Solution:**

To get a total resistance less than  $1\ \Omega$ , the three resistors should be connected in parallel



Let the total resistance be  $R'$

$$\text{Then, } 1/R' = 1/2 + 1/3 + 1/5$$

$$1/R' = (15 + 10 + 6) / 30$$

$$1/R' = 31 / 30\ \Omega \text{ or}$$

$$R' = 30 / 31$$

$$R' = 0.97\ \Omega$$

**Question: 9**

Three resistors each of  $2\ \text{W}$  are connected together so that their total resistance is  $3\ \text{W}$ . Draw a diagram to show this arrangement and check it by calculation.

**Solution:**

A parallel combination of two resistors, in series with one resistor.

$$R_1 = 2\ \text{ohm}$$

$$R_2 = 2\ \text{ohm}$$

$$R_3 = 2\ \text{ohm}$$

$$1/R' = 1/R_1 + 1/R_2$$

$$1/R' = 1/2 + 1/2$$

$$1/R' = 1$$

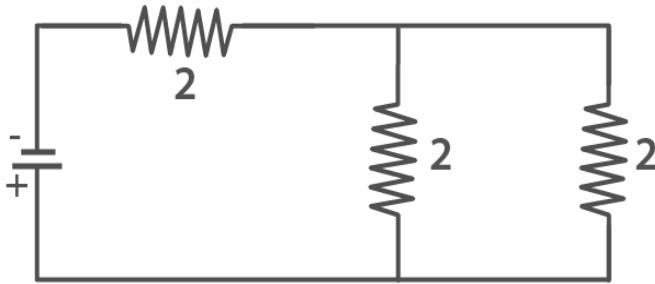
$$R' = 1\ \text{ohm}$$

$$R = R' + R_3$$

$$R = 1 + 2$$

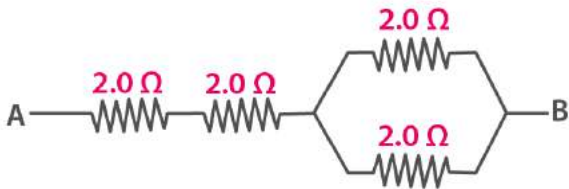
$$R = 3\ \text{ohm}$$

Diagram is shown below



**Question: 10**

Calculate the equivalent resistance between the points A and B in figure if each resistance is  $2.0 \Omega$



**Solution:**

For a parallel resistances

$$R_{\text{eff}} = (R_1 R_2) / (R_1 + R_2)$$

$$R_{\text{eff}} = (2 \times 2) / (2 + 2)$$

$$R_{\text{eff}} = 4 / 4$$

$$R_{\text{eff}} = 1 \Omega$$

$$\text{Hence, total resistance} = 2 + 2 + 1 \\ = 5 \Omega$$

**Question: 11**

A combination consists of three resistors in series. Four similar sets are connected in parallel. If the resistance of each resistor is 2 ohm, find the resistance of the combination.

**Solution:**

Resistance of each set:

$$r_1 = 2 + 2 + 2 = 6 \text{ ohm}$$

$$r_2 = 2 + 2 + 2 = 6 \text{ ohm}$$

$$r_3 = 2 + 2 + 2 = 6 \text{ ohm}$$

$$r_4 = 2 + 2 + 2 = 6 \text{ ohm}$$

Now, the above resistances are arranged in parallel

$$1/r = 1/r_1 + 1/r_2 + 1/r_3 + 1/r_4$$

$$1/r = 1/6 + 1/6 + 1/6 + 1/6$$

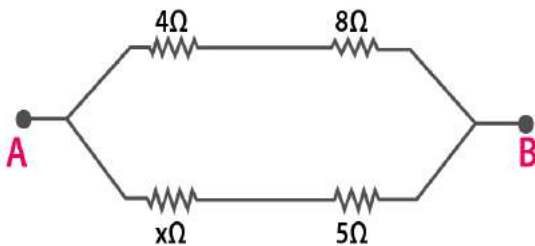
$$1/r = 4/6$$

$$r = 6/4$$

$$r = 1.5 \text{ ohm}$$

**Question: 12**

In the circuit shown below in figure, calculate the value of  $x$  if the equivalent resistance between the points A and B is 4 ohm



**Solution:**

$$r_1 = 4 \text{ ohm}$$

$$r_2 = 8 \text{ ohm}$$

$$r_3 = x \text{ ohm}$$

$$r_4 = 5 \text{ ohm}$$

$$r = 4 \text{ ohm}$$

$$r' = r_1 + r_2$$

$$r' = 4 + 8$$

$$r' = 12 \text{ ohm}$$

$$r'' = r_3 + r_4$$

$$r'' = (x + 5) \text{ ohm}$$

$$1/r = 1/r' + 1/r''$$

$$1/4 = 1/12 + 1/(5 + x)$$

$$1/4 - 1/12 = 1/(5 + x)$$

$$(3 - 1)/12 = 1/(5 + x)$$

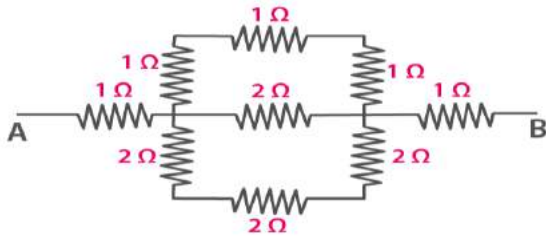
$$2/12 = 1/(5 + x)$$

$$1/6 = 1/(5 + x)$$

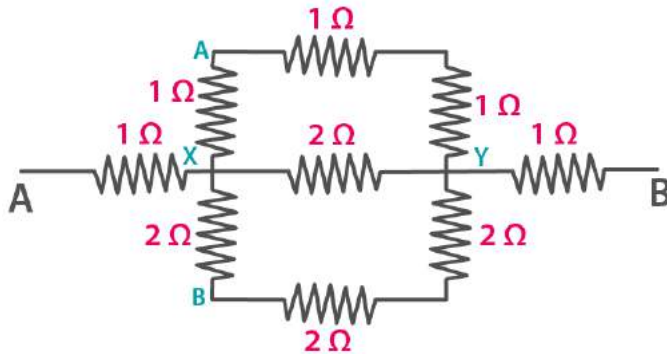
$$x = 1 \text{ ohm}$$

**Question: 13**

Calculate the effective resistance between the points A and B in the circuit shown in figure



**Solution:**



In above figure,

Resistance between XAY =  $(1 + 1 + 1)$   
= 3 ohm

Resistance between XY = 2 ohm

Resistance between XBY = 6 ohm

Let the net resistance between the points X and Y be  $R'$

Then,  $1/R' = 1/2 + 1/3 + 1/6$

$1/R' = (3 + 2 + 1)/6$

$1/R' = 6/6$

$1/R' = 1$  ohm or

$R' = 1$  ohm

Therefore, we can say that three 1 ohm resistors are connected in series between points A and B

Let the net resistance between points A and B be  $R_{AB}$

Then,  $R_{AB} = (1 + 1 + 1)$  ohm

$R_{AB} = 3$  ohm

**Question: 14**

**A uniform wire with a resistance of 27 ohm is divided into three equal pieces and then they are joined in parallel. Find the equivalent resistance of the parallel combination.**

**Solution:**

Since the wire is divided into three pieces, the new resistance =  $27 / 3 = 9$

Now, three resistance are joined in parallel

$$1/r = 1/r_1 + 1/r_2 + 1/r_3$$

$$1/r = 1/9 + 1/9 + 1/9$$

$$1/r = 3/9$$

$$1/r = 1/3$$

$$r = 3 \text{ ohm}$$

**Question: 15**

A circuit consists of a 1 ohm resistor in series with a parallel arrangement of 6 ohm and 3 ohm resistors. Calculate the total resistance of the circuit. Draw a diagram of the arrangement.

**Solution:**

$$1/r = 1/6 + 1/3$$

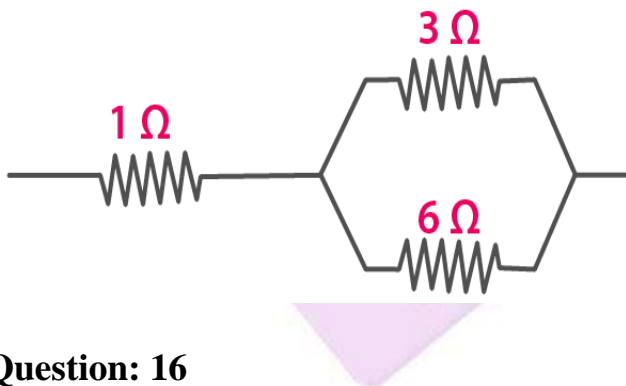
$$1/r = 1/2$$

$$r = 2 \text{ ohm}$$

$$R = 2 + 1$$

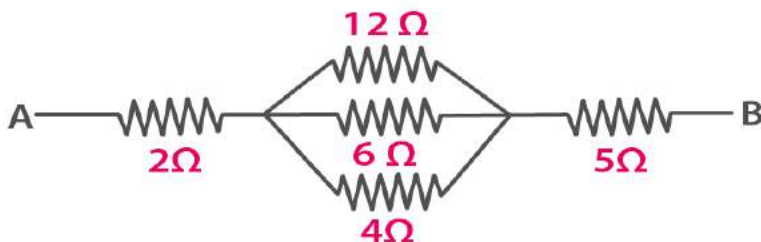
$$R = 3 \text{ ohm}$$

Diagram



**Question: 16**

Calculate the effective resistance between the points A and B in the network shown below in figure.



**Solution:**

For parallel resistance

$$1/R = 1/12 + 1/6 + 1/4$$

$$1/R = (1 + 2 + 3)/12$$

$$1/R = 6/12$$

$$R = 12/6$$

$$R = 2 \text{ ohm}$$

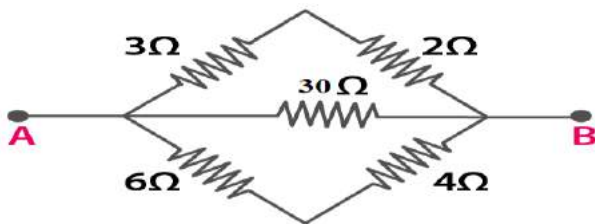
Now, all the resistances are in series

$$R = 2 + 2 + 5$$

$$R = 9 \text{ ohm}$$

**Question: 17**

Calculate the equivalent resistance between the points A and B in figure



**Solution:**

Given

$$R_1 = 3 + 2 = 5 \text{ ohm}$$

$$R_2 = 30 \text{ W}$$

$$R_3 = 6 + 4 = 10 \text{ ohm}$$

The resistors  $R_1$ ,  $R_2$  and  $R_3$  are connected in parallel

$$1/R = 1/R_1 + 1/R_2 + 1/R_3$$

$$1/R = 1/5 + 1/30 + 1/10$$

$$1/R = (6 + 1 + 3)/30$$

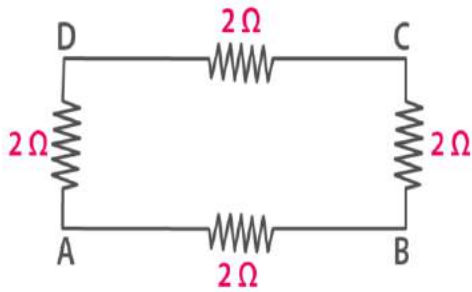
$$1/R = 10/30$$

$$1/R = 1/3$$

$$R = 3 \text{ ohm}$$

**Question: 18**

In the network shown in adjacent figure, calculate the equivalent resistance between the points (a) A and B (b) A and C



**Solution:**

(a)  $R_1 = 2 + 2 + 2$

$R_1 = 6 \text{ ohm}$

$R_2 = 2 \text{ ohm}$

$R_1$  and  $R_2$  are connected in parallel

$$1/R = 1/R_1 + 1/R_2$$

$$1/R = 1/6 + 1/2$$

$$1/R = (1 + 3)/6$$

$$1/R = 4/6$$

$$R = 6/4$$

$$R = 1.5 \text{ ohm}$$

(b)  $R_1 = 2 + 2$

$R_1 = 4 \text{ ohm}$

$R_2 = 2 + 2$

$R_2 = 4 \text{ ohm}$

The resistors  $R_1$  and  $R_2$  are connected in parallel

$$1/R = 1/R_1 + 1/R_2$$

$$1/R = 1/4 + 1/4$$

$$1/R = 2/4$$

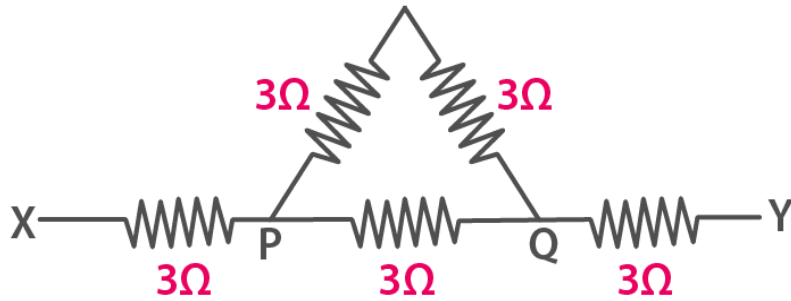
$$1/R = 1/2$$

$$R = 2 \text{ ohm}$$

**Question: 19**

Five resistors, each of 3 ohm, are connected as shown in figure. Calculate the resistance (a) between the points P and Q, and (b) between the points X and Y.





**Solution:**

(a)  $R_1 = 3 + 3$

$R_1 = 6 \text{ ohm}$

$R_2 = 3 \text{ ohm}$

$R_1$  and  $R_2$  are connected in parallel

$$1/R = 1/R_1 + 1/R_2$$

$$1/R = 1/6 + 1/3$$

$$1/R = (1 + 2)/6$$

$$1/R = 3/6$$

$$1/R = 1/2$$

$R = 2 \text{ ohm}$

(b) We know that  $R = 2 \text{ ohm}$  from the above calculation

$R_3 = 3 \text{ ohm}$

$R_4 = 3 \text{ ohm}$

$$R' = R + R_3 + R_4$$

$$R' = 2 + 3 + 3$$

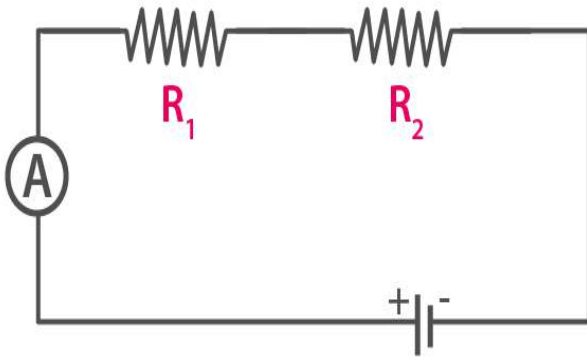
$R' = 8 \text{ ohm}$

**Question: 20**

Two resistors of 2 ohm and 3 ohm are connected (a) in series, (b) in parallel, with a battery of 6.0 V and negligible internal resistance. For each case draw a circuit diagram and calculate the current through the battery.

**Solution:**

(a)



$$R_1 = 2 \text{ ohm}$$

$$R_2 = 3 \text{ ohm}$$

$$R = R_1 + R_2$$

$$R = 2 + 3$$

$$R = 5 \text{ ohm}$$

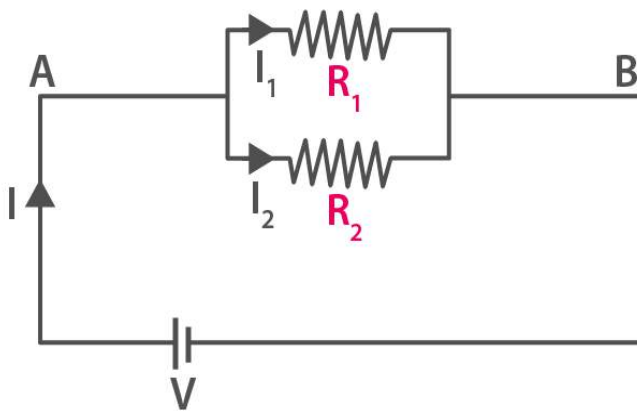
$$V = 6 \text{ V}$$

$$\text{Now, } I = V / R$$

$$I = 6 / 5$$

$$I = 1.2 \text{ ohm}$$

(b)



Here,  $R_1$  and  $R_2$  are connected in parallel

$$1 / R = 1 / R_1 + 1 / R_2$$

$$1 / R = 1 / 2 + 1 / 3$$

$$1 / R = (3 + 2) / 6$$

$$1 / R = 5 / 6$$

$$R = 6 / 5$$

$$R = 1.2 \text{ ohm}$$

$$V = 6 \text{ V}$$

We know that,

$$I = V / R$$

$$I = 6 / 1.2$$

$$I = 5 \text{ A}$$

Therefore in series: 1.2 A and in parallel: 5 A

**Question: 21**

A resistor of 6 ohm is connected in series with another resistor of 4 ohm. A potential difference of 20 V is applied across the combination. (a) Calculate the current in the circuit and (b) potential difference across the 6 ohm resistor.

**Solution:**

(a) To calculate current in the circuit

$$R_1 = 6 \text{ ohm}$$

$$R_2 = 4 \text{ ohm}$$

$$R = R_1 + R_2$$

$$R = 6 + 4$$

$$R = 10 \text{ ohm}$$

$$V = 20 \text{ V}$$

$$I = V / R$$

$$I = 20 / 10$$

$$I = 2 \text{ A}$$

(b) To calculate the potential difference across the 6 ohm resistor

$$R = 6 \text{ ohm}$$

$$I = 2 \text{ A}$$

$$V = ?$$

$$V = IR$$

$$V = 6 \times 2$$

$$V = 12 \text{ V}$$

**Question: 22**

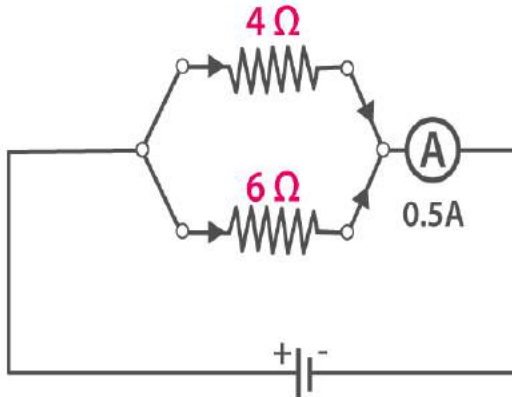
Two resistors of resistance 4  $\Omega$  and 6  $\Omega$  are connected in parallel to a cell to draw 0.5 A current from the cell.

(a) Draw a labeled diagram of the arrangement

(b) Calculate current in each resistor.

**Solution:**

(a) Circuit diagram



(b) Equivalent resistance of the circuit

$$1/R = 1/4 + 1/6$$

$$1/R = (3 + 2) / 12$$

$$1/R = 5 / 12$$

$$R = 12 / 5$$

$$R = 2.4 \text{ ohm}$$

Thus, the e.m.f. of the cell is

$$V = IR$$

$$V = 0.5 \times 2.4$$

$$V = 1.2 \text{ V}$$

∴ Current through each resistor is

$$I_4 = V / R_4$$

$$I_4 = 1.2 / 4$$

$$I_4 = 0.3 \text{ A}$$

$$I_6 = V / R_6$$

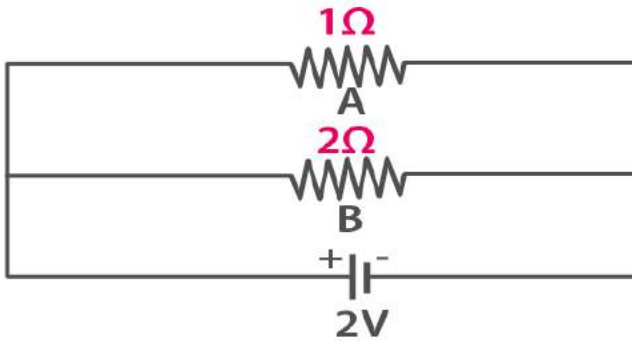
$$I_6 = 1.2 / 6$$

$$I_6 = 0.2 \text{ A}$$

Hence, 0.3 A in 4 ohm and 0.2 A in 6 ohm

**Question: 23**

Calculate the current flowing through each of the resistors A and B in the circuit shown in figure?



**Solution:**

For resistor A

$$R = 1 \text{ ohm}$$

$$V = 2 \text{ V}$$

$$I = V / R$$

$$I = 2 / 1$$

$$I = 2 \text{ A}$$

For resistor B

$$R = 2 \text{ ohm}$$

$$V = 2 \text{ V}$$

$$I = V / R$$

$$I = 2 / 2$$

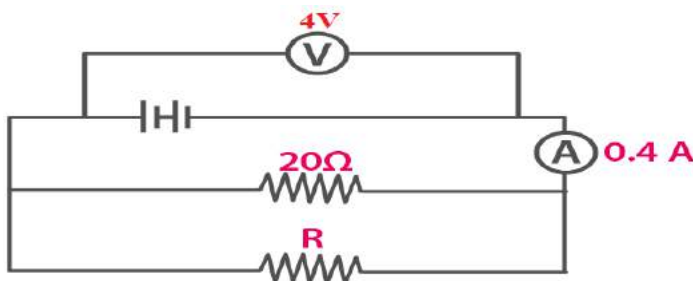
$$I = 1 \text{ A}$$

Hence, current flowing in resistor A is 2 A and current flowing in resistor B is 1 A

**Question: 24**

In figure, calculate :

- (a) the total resistance of the circuit.
- (b) the value of R, and
- (c) the current flowing in R



**Solution:**

(a) To calculate the total resistance of the circuit

$$V = 4 \text{ V}$$

$$I = 0.4 \text{ A}$$

Total resistance  $R' = ?$

$$R' = V / I$$

$$R' = 0.4 / 4$$

$$R' = 10 \text{ ohm}$$

(b) To calculate the value of  $R$

$$R_1 = 20 \text{ ohm}$$

$$R' = 10 \text{ ohm}$$

$$1 / R' = 1 / R + 1 / R_1$$

$$1 / 10 = 1 / R + 1 / 20$$

$$1 / R = 1 / 10 - 1 / 20$$

$$1 / R = (2 - 1) / 20$$

$$1 / R = 1 / 20$$

$$R = 20 \text{ ohm}$$

(c) To calculate the current flowing in  $R$

$$R = 20 \text{ ohm}$$

$$V = 4 \text{ V}$$

$$I = V / R$$

$$I = 4 / 20$$

$$I = 0.2 \text{ A}$$

### Question: 25

A particular resistance wire has a resistance of 3 ohm per meter. Find:

(a) The total resistance of three lengths of this wire each 1.5 m long, in parallel.

(b) The potential difference of the battery which gives a current of 2 A in each of the 1.5 m length when connected in the parallel to the battery (assume that resistance of the battery is negligible).

(c) The resistance of 5 m length of a wire of the same material, but with twice the area of cross section.

### Solution:

(a) Resistance of wire per meter = 3 ohm

So, resistance of three lengths of this wire each 1.5 m long =  $3 \times 1.5 = 4.5 \text{ W}$

$$1 / R = 1 / 4.5 + 1 / 4.5 + 1 / 4.5$$

$$1 / R = 3 / 4.5$$

$$R = 1.5 \text{ ohm}$$

(b)  $I = 2 \text{ A}$

$$V = IR$$

$$V = 2 \times 4.5$$

$$V = 9 \text{ V}$$

(c)  $R = 3 \text{ ohm}$  for 1 meter wire

For 5 m

$$R = 3 \times 5$$

$$R = 15 \text{ ohm}$$

Here the area is twice i.e 2 A and Resistance is inversely proportional to area. Thus resistance becomes half

$$R = 15 / 2$$

$$R = 7.5 \text{ ohm}$$

**Question: 26**

A cell supplies a current of 1.2 A through two 2 ohm resistors connected in parallel. When resistors are connected in series, it supplies a current of 0.4 A. Calculate: (i) the internal resistance and (ii) e.m.f. of the cell.

**Solution:**

In parallel  $R = 1 / 2 + 1 / 2 = 1 \text{ ohm}$

$$I = 1.2 \text{ A}$$

$$\epsilon = I (R + r)$$

$$\epsilon = 1.2 (1 + r)$$

$$\epsilon = 1.2 + 1.2r$$

In series

$$R = 2 + 2$$

$$R = 4 \text{ ohm}$$

$$I = 0.4 \text{ A}$$

$$\epsilon = I (R + r)$$

$$\epsilon = 0.4 (4 + r)$$

$$\epsilon = 1.6 + 0.4r$$

This means:

$$1.2 + 1.2r = 1.6 + 0.4r$$

$$1.2r - 0.4r = 1.6 - 1.2$$

$$0.8r = 0.4$$

$$r = 0.4 / 0.8$$

$$r = 0.5 \text{ ohm}$$

(i) Internal resistance  $r = 0.5 \text{ ohm}$

(ii)  $\epsilon = I(R + r)$

$$\epsilon = 1.2 (1 + 0.5)$$

$$\epsilon = 1.8 \text{ V}$$

**Question: 27**

A battery of emf 15 V and internal resistance 3 ohm is connected to two resistors 3

ohm and 6 ohm connected in parallel. Find (a) the current through the battery (b) p.d. between the terminals of the battery (c) the current in 3 ohm resistor (d) the current in 6 ohm resistor.

**Solution:**

(a) In parallel

$$1/R = 1/3 + 1/6$$

$$1/R = (2 + 1)/6$$

$$1/R = 3/6$$

$$1/R = 1/2$$

$$R = 2 \text{ ohm}$$

$$r = 3 \text{ W}$$

$$\varepsilon = 15 \text{ V}$$

$$\varepsilon = I(R + r)$$

$$15 = I(2 + 3)$$

$$I = 15/5$$

$$I = 3 \text{ A}$$

(b)  $V = ?$

$$R = 2 \text{ ohm}$$

$$V = IR$$

$$V = 3 \times 2$$

$$V = 6 \text{ V}$$

(c)  $V = 6 \text{ V}$

$$R = 3 \text{ ohm}$$

$$I = V/R$$

$$I = 6/3$$

$$I = 2 \text{ A}$$

(d)  $R = 6 \text{ ohm}$

$$V = 6 \text{ V}$$

$$I = V/R$$

$$I = 6/6$$

$$I = 1 \text{ A}$$

**Question: 28**

The circuit diagram in figure shows three resistors 2 ohm, 4 ohm and R ohm connected to a battery of e.m.f. 2 V and internal resistance 3 ohm. If main current of 0.25 A flows through the circuit, find:

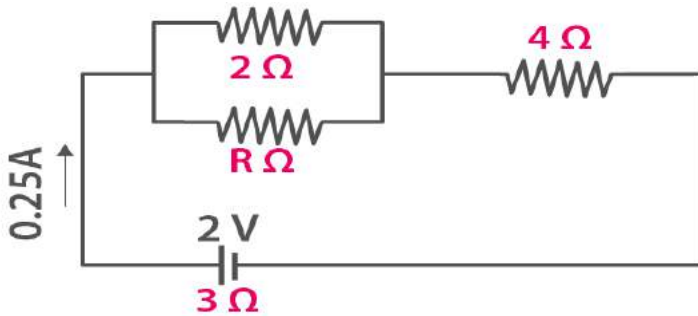
(a) the p.d. across the 4 ohm resistor

(b) the p.d. across the internal resistance of the cell,

(c) the p.d. across the R ohm or 2 ohm resistor, and



(d) the value of R.



**Solution:**

(a) To calculate the p.d. across the 4 ohm resistor

$$R = 4 \text{ ohm}$$

$$I = 0.25 \text{ A}$$

$$V = IR$$

$$V = 0.25 \times 4$$

$$V = 1 \text{ V}$$

(b) To calculate the p.d. across the internal resistance of the cell

Internal resistance  $r = 3 \text{ ohm}$

$$I = 0.25 \text{ A}$$

$$V = IR$$

$$V = 0.25 \times 3$$

$$V = 0.75 \text{ V}$$

(c) To calculate the p.d. across the 2 ohm resistor

Effective resistance of parallel combination of 2 ohm resistances = 1 ohm

$$V = I / R$$

$$V = 0.25 / 1$$

$$V = 0.25 \text{ V}$$

(d) To calculate the value of R

$$I = 0.25 \text{ A}$$

$$\varepsilon = 2 \text{ V}$$

$$r = 3 \text{ ohm}$$

$$\varepsilon = I (R' + r)$$

$$2 = 0.25 (R' + 3)$$

$$R' = 5 \text{ W}$$

$$[2R / 2 + R] + 4 = 5$$

$$R = 2 \text{ ohm}$$

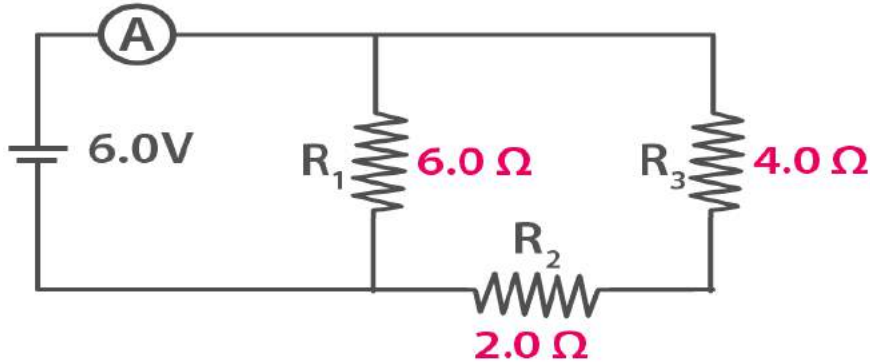
**Question: 29**

Three resistors of 6.0 ohm, 2.0 ohm and 4.0 ohm are joined to an ammeter A and a

cell of emf 6.0 V as shown in figure. Calculate:

(a) the effective resistance of the circuit.

(b) the reading of ammeter



**Solution:**

$$(a) R_1 = 6 \text{ W}$$

$$R' = R_2 + R_3$$

$$R' = 2 + 4$$

$$R' = 6 \text{ W}$$

R<sub>1</sub> and R' are connected in parallel

$$1/R = 1/R_1 + 1/R'$$

$$1/R = 1/6 + 1/6$$

$$1/R = 2/6$$

$$1/R = 1/3$$

$$R = 3 \text{ ohm}$$

$$(b) R = 3 \text{ ohm}$$

$$V = 6 \text{ V}$$

$$I = ?$$

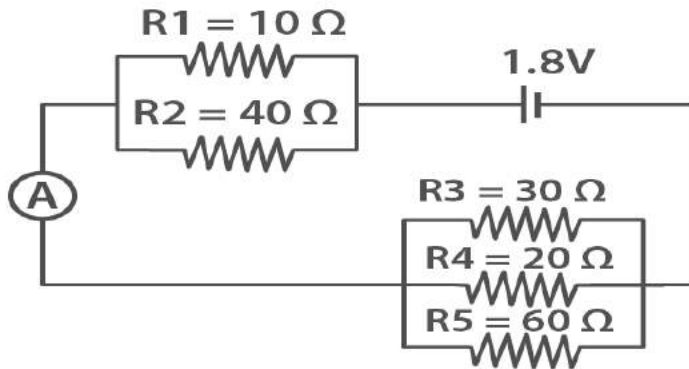
$$I = V/R$$

$$I = 6/3$$

$$I = 2 \text{ A}$$

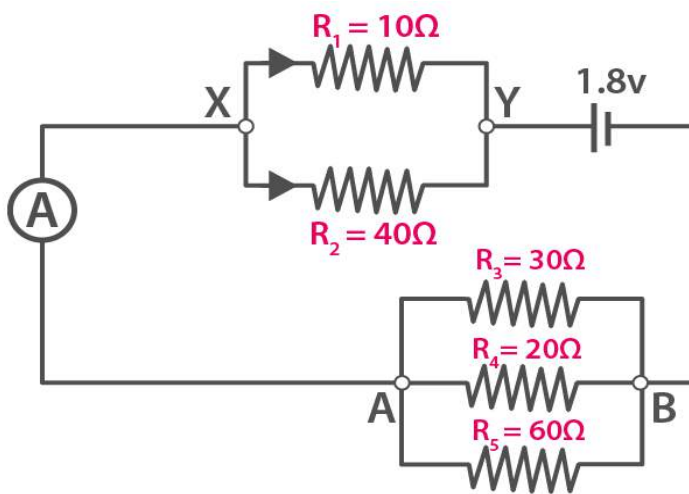
**Question: 30**

The diagram below in Fig., shows the arrangement of five different resistances connected to a battery of e.m.f. 1.8 V. Calculate:



- The total resistance of the circuit
- The reading of ammeter A.

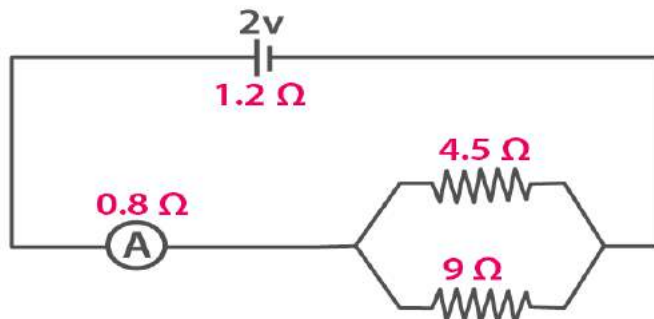
**Solution:**



- (a) In the above figure,  
Let  $R_{XY}$  be the resistance between X and Y  
Then,  $1 / R_{XY} = 1 / 10 + 1 / 40$   
 $1 / R_{XY} = (4 + 1) / 40$   
 $1 / R_{XY} = 5 / 40 \text{ ohm}$   
Or  $R_{XY} = 8 \text{ ohm}$   
Let the net resistance between points A and B be  $R_{AB}$   
Then,  $1 / R_{AB} = 10 \text{ ohm}$   
 $\therefore$  The total resistance of the circuit =  $8 \text{ ohm} + 10 \text{ ohm}$   
=  $18 \text{ ohm}$
- (b) Current  $I = \text{Voltage} / \text{Total resistance}$   
 $I = 1.8 / 18 \text{ A}$   
 $I = 0.1 \text{ A}$   
Hence, the reading of ammeter is  $0.1 \text{ A}$

**Question: 31**

A cell of e.m.f. 2 V and internal resistance  $1.2 \Omega$  is connected to an ammeter of resistance  $0.8 \Omega$  and two resistors of  $4.5 \Omega$  and  $9 \Omega$  as shown in fig.



**Find:**

- The reading of the ammeter,
- The potential difference across the terminals of the cells, and
- The potential difference across the  $4.5 \text{ ohm}$  resistor.

**Solution:**

The total resistance of the circuit is

$$R_{\text{eq}} = R_{\text{cell}} + R_{\text{ammeter}} + R_1 \parallel R_2$$

$$\therefore R_{\text{eq}} = 1.2 + 0.8 + (R_1 R_2) / R_1 + R_2$$

$$\therefore R_{\text{eq}} = 2 + (4.5 \times 9) / 4.5 + 9$$

$$R_{\text{eq}} = 2 + 40.5 / 13.5$$

$$\therefore R_{\text{eq}} = 5 \text{ ohm}$$

(a) The current through the ammeter is

$$I = E_{\text{cell}} / R_{\text{eq}}$$

$$I = 2 / 5$$

$$I = 0.4 \text{ A}$$

(b) The potential difference across the ends of the cells is

$$V_{\text{cell}} = E_{\text{cell}} - IR_{\text{cell}}$$

$$V_{\text{cell}} = 2 - 0.4 \times 1.2$$

$$V_{\text{cell}} = 2 - 0.48$$

$$\therefore V_{\text{cell}} = 1.52 \text{ V}$$

(c) The potential difference across the  $4.5 \text{ ohm}$  resistor is

$$V_{4.5} = V_{\text{cell}} - V_{\text{ammeter}}$$

$$V_{4.5} = 1.52 - 0.4 \times 0.8$$

$$V_{4.5} = 1.52 - 0.32$$

$$\therefore V_{4.5} = 1.2 \text{ V}$$

## EXERCISE 8(C)

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**Question: 1**

Write an expression for the electrical energy spent in flow of current through an electrical appliance in terms of current, resistance and time.

**Solution:**

The expression for the electrical energy spent in flow of current through an electrical appliance in terms of current, resistance and time is

$$\text{Electrical energy, } W = I^2Rt \text{ joule}$$

**Question: 2**

Write an expression for the electrical power spent in flow of current through a conductor in terms of (a) resistance and potential difference, (b) current and resistance.

**Solution:**

(a) Expression for electrical power spent in flow of current through a conductor in terms of resistance and potential difference is

$$\text{Electrical Power, } P = V^2 / R$$

(b) Expression for electrical power spent in flow of current through a conductor in terms of current and resistance is

$$\text{Electrical Power, } P = I^2R$$

**Question: 3**

Electrical power  $P$  is given by the expression  $P = (Q \times V) \div \text{time}$

(a) What do the symbols  $Q$  and  $V$  represent?

(b) Express the power  $P$  in terms of current and resistance explaining the meanings of symbols used there in.

**Solution:**

(a) The symbol  $Q$  represents Charge and the symbol  $V$  represents Voltage

(b) Electrical Power,  $P = I^2R$

-where  $I$  represents current and  $R$  represents resistance

**Question: 4**

Name the S.I. unit of electrical energy. How is it related to Wh?

**Solution:**

Joule is the S.I. unit of electrical energy. It is related to Wh as

$$1 \text{ Wh} = 3600 \text{ J}$$

**Question: 5**

Explain the meaning of the statement 'the power of an appliance is 100 W'.

**Solution:**

The power of an appliance is 100 W. This means that 100 J of electrical energy is consumed by the appliance in 1 second.

**Question: 6**

**State the S.I. unit of electrical power.**

**Solution:**

Watt is the S.I. unit of electrical power.

**Question: 7**

**(i) State and define the household unit of electricity.**

**(ii) What is the voltage of the electricity that is generally supplied to a house?**

**(iii) What is consumed while using different electrical appliances, for which electricity bills are paid?**

**Solution:**

(i) Kilowatt hour (kWh) is the household unit of electricity. The electrical energy consumed by an electrical appliance of power 1 kW when it is used for one hour is One kilowatt hour (kWh)

(ii) The voltage of the electricity that is generally supplied to a house is 220 volt.

(iii) The electrical energy is consumed while using different electrical appliances, for which electricity bills are paid

**Question: 8**

**Name the physical quantity which is measured in (i) kW, (ii) kWh. (iii) Wh**

**Solution:**

(i) The quantity which is measured in kW is electrical power

(ii) The quantity which is measured in kWh is electrical energy

**Question: 9**

**Define the term kilowatt - hour and state its value in S.I. unit.**

**Solution:**

The electrical energy consumed by an electrical appliance of power 1 kW when it is used for one hour is one kilowatt hour (kWh). Its value in S.I. unit is  $1\text{kWh} = 3.6 \times 10^6 \text{ J}$

**Question: 10**

**How do kilowatt and kilowatt-hour differ?**

**Solution:**

Kilowatt- hour is the unit of electrical energy whereas the kilowatt is the unit of electrical power.

**Question: 11****Complete the following:**(a)  $1 \text{ kWh} = (1 \text{ volt} \times 1 \text{ ampere} \times \dots\dots\dots) / 1000$ 

(b)

 $1 \text{ kWh} = \text{_____ J}$ **Solution:**(a)  $1 \text{ kWh} = (1 \text{ volt} \times 1 \text{ ampere} \times 1 \text{ hour}) / 1000$ (b)  $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$ **Question: 12****What do you mean by power rating of an electrical appliance? How do you use it to calculate (a) the resistance of the appliance and (b) the safe limit of the current in it, while in use?****Solution:**

The power rating is an electrical appliance such as electric bulb, geyser etc. is rated with power (P) and voltage (V). If an electric bulb is rated as 50 W – 220 V, it means that when the bulb is lighted on a 220 V supply, 50 W electrical power is consumed by it.

(a) To calculate the resistance of the appliance, the expression is:

$$\text{Resistance, } R = V^2 / P$$

(b) The safe limit of current in it, while in use is

$$I = P / V$$

**Question: 13****An electric bulb is rated '100 W, 250 V'. What information does this convey?****Solution:**

An electric bulb is rated '100 W, 250 V' means that if the bulb is lighted on a 250 V supply, it consumes 100 W electric power (which means 100 J of electrical energy is converted into the light and heat energy in 1 second in the filament).

**Question: 14****List the names of three electrical gadgets used in your house. Write their power, voltage rating and approximate time for which each one is used in a day. Hence find the electrical energy consumed by each in a month of 30 days.****Solution:**

Appliance	Power (in watt)	Voltage (in volts)	Time (hours)	Electrical energy (E = P × t)
Television set	120	220	4	0.48 kWh
Refrigerator	150	220	24	3.6 kWh
Fluorescent tube	40	220	12	0.48 kWh

**Question: 15**

Two lamps, one rated 220 V, 50 W and the other rated 220 V, 100 W, are connected in series with mains of voltage 220 V. Explain why does the 50 W lamp consume more power.

**Solution:**

Resistance of 220 V, 50 W lamp is

$$R_1 = V^2 / P_1$$

$$R_1 = (220)^2 / 100$$

$$R_1 = 968 \text{ ohm}$$

Resistance of 220 V, 100 W lamp is

$$R_2 = V^2 / P_2$$

$$R_2 = (220)^2 / 100$$

$$R_2 = 484 \text{ ohm}$$

Same current I passes through each lamp because the two lamps are connected in series.

Power consumed in 220 V, 50 W lamp is

$$P_1 = I^2 R_1$$

Power consumed in 220 V, 100 W lamp is

$$P_2 = I^2 R_2$$

Here,  $R_1 > R_2$

So,  $P_1 > P_2$

Thus 50 W lamp consumes more power

**Question: 16**

Name the factors on which the heat produced in a wire depends when current is passed in it, and state how does it depend on the factors stated by you.

**Solution:**

The amount of heat produced in a wire on passing current through it, depends on the following three factors.

- (i) The amount of current passing through the wire
- (ii) The resistance of wire and



(iii) The time for which current is passed in the wire

(i) Dependence of heat produced on the current in wire: The amount of heat  $H$  produced in the wire is directly proportional to the square of current  $I$  passing through the wire, i.e.,  $H \propto I^2$

(ii) Dependence of heat produced on the resistance of wire: The amount of heat  $H$  produced in the wire is directly proportional to the resistance  $R$  of the wire, i.e.,  $H \propto R$

(iii) Dependence of heat produced on the time: The amount of heat  $H$  produced in a wire is directly proportional to the time  $t$  for which current is passed in the wire i.e.,  $H \propto t$

### MULTIPLE CHOICE TYPE

#### Question: 1

When a current  $I$  flows through a resistance  $R$  for time  $t$ , the electrical energy spent is:

- (a)  $IRt$
- (b)  $I^2Rt$
- (c)  $IR^2t$
- (d)  $I^2R / t$

#### Solution:

The electrical energy spent when a current  $I$  flows through a resistance  $R$  for time  $t$  is  $I^2Rt$

#### Question: 2

An electrical appliance has a rating 100 W, 120 V. The resistance of element of appliance when in use is:

- (a) 1.2 ohm
- (b) 144 ohm
- (c) 120 ohm
- (d) 100 ohm

#### Solution:

The resistance of element of appliance when in use is 144 ohm

### NUMERICALS

#### Question: 1

An electric bulb of resistance 500 ohm draws current 0.4 A from the source. Calculate: (a) the power of bulb and (b) the potential difference at its end.

#### Solution:

Given

Resistance of electric bulb ( $R$ ) = 500 ohm

Current drawn from the source ( $I$ ) = 0.4 A

(a) Power of the bulb ( $P$ ) =  $VI$

$$V = I \times R$$

$$V = 0.4 \times 500$$

$$V = 200 \text{ V}$$

(b) The potential difference at its end is 200 V

Therefore,

$$\text{Power (P)} = VI$$

$$P = 200 \times 0.4$$

$$P = 80 \text{ W}$$

Hence, the power of the bulb is 80 Watt

### Question: 2

A current of 2 A is passed through a coil of resistance  $75 \Omega$  for 2 minutes. (a) How much heat energy is produced? (b) How much charge is passed through the resistance?

#### Solution:

Given,

$$\text{Current (I)} = 2 \text{ A}$$

$$\text{Resistance, } R = 75 \Omega$$

$$\text{Time, } t = 2 \text{ min or } 120 \text{ s}$$

$$\text{(a) Heat produced, } H = I^2Rt \text{ or}$$

$$H = (2)^2 (75) (120) \text{ J} = 36000 \text{ J}$$

$$\text{(b) Charge passed through the resistance, } Q = It \text{ or}$$

$$Q = (2) (120) \text{ C}$$

$$Q = 240 \text{ C}$$

### Question: 3

Calculate the current through a 60 W lamp rated for 250 V. If the line voltage falls to 200 V, how is power consumed by the lamp affected?

#### Solution:

Given,

$$\text{Power, } P = 60 \text{ W}$$

$$\text{Voltage, } V = 250 \text{ V}$$

We know that,

$$\text{Power, } P = VI$$

$$I = P / V$$

$$I = 60 / 250$$

$$I = 0.24 \text{ A}$$

$$\text{Resistance of lamp } R = V^2 / P$$

$$R = (250)^2 / 60$$

$$R = 1041.6 \text{ ohm}$$

If voltage falls to 200 V, then the power consumed will be

$$P = V^2 / R$$

$$P = (200)^2 / 1041.6$$

$$P = 38.4 \text{ W}$$

Hence, consumed reduces to 38.4 W

**Question: 4**

An electric bulb is rated '100 W, 250 V'. How much current will the bulb draw if connected to a 250 V supply?

**Solution:**

Given,

$$\text{Power, } P = 100 \text{ W}$$

$$\text{Voltage, } V = 250 \text{ V}$$

We know that,

$$\text{Power, } P = VI$$

$$I = P / V$$

$$I = 100 / 250$$

$$I = 0.4 \text{ A}$$

**Question: 5**

An electric bulb is rated at 220 V, 100 W. (a) What is its resistance? (b) What safe current can be passed through it?

**Solution:**

(a) Given,

$$\text{Power, } P = 100 \text{ W}$$

$$\text{Voltage, } V = 220 \text{ V}$$

We know that,

$$\text{Power, } P = V^2 / R$$

$$R = (220)^2 / 100$$

$$R = 484 \text{ ohm}$$

(b) The safe limit of current that can be passed through it is

$$I = P / V$$

$$I = 100 / 220$$

$$I = 0.45 \text{ A}$$

**Question: 6**

A bulb of power 40 W is used for 12.5 h each day for 30 days. Calculate the electrical energy consumed.

**Solution:**

Energy consumed for each day,  $E = P \times t$

$$E = 40 \times 12.5$$

$$E = 500 \text{ Wh}$$

Energy consumed for 30 days

$$E = 500 \times 30$$

$$E = 15000 \text{ Wh}$$

$$E = 15 \text{ kWh}$$

**Question: 7**

An electric press is rated '750 W, 230 V'. Calculate the electrical energy consumed by the press in 16 hours

**Solution:**

Energy,  $E = \text{Power} \times \text{time}$

$$E = 750 \times 16$$

$$E = 12000 \text{ Wh}$$

$$E = 12 \text{ kWh}$$

**Question: 8**

An electrical appliance having a resistance of 200 ohm is operated at 200 V. Calculate the energy consumed by the appliance in 5 minutes (i) in joule, (ii) in kWh

**Solution:**

Given,

$$\text{Resistance, } R = 200 \text{ ohm}$$

$$\text{Voltage, } V = 200 \text{ V}$$

$$\text{Time, } t = 5 \text{ minutes}$$

$$t = 5 \times 60 \text{ sec}$$

$$t = 300 \text{ sec}$$

As we know,

$$\text{Energy, } E = V^2 t / R$$

(i) In joules

$$E = [(200)^2 \times 300] / 200$$

$$E = 60000 \text{ J}$$

(ii) In kWh

$$\text{As } 1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

$$1 \text{ J} = 1 / 3.6 \times 10^6 \text{ kWh}$$

$$60000 \text{ J} = 60000 / 3.6 \times 10^6$$

$$60000 \text{ J} = 0.0167 \text{ kWh}$$

**Question: 9**

A bulb rated 12 V, 24 W operates on a 12 volt battery for 20 minutes. Calculate:

- (i) the current flowing through it, and  
(ii) the energy consumed.

**Solution:**

Given,

$$\text{Power, } P = 24 \text{ W}$$

$$\text{Voltage, } V = 12 \text{ V}$$

$$\text{Current, } I = ?$$

We know that,

$$\text{Power, } P = VI$$

(i) The current flowing through it is

$$I = 24 / 12$$

$$I = 2 \text{ A}$$

(ii) Energy,  $E = P \times t$

$$E = 24 \times 20 \times 60$$

$$E = 28,800 \text{ J}$$

**Question: 10**

A current of 0.2 A flows through a wire whose ends are at a potential difference of 15 V. Calculate:

- (i) The resistance of the wire, and  
(ii) The heat energy produced in 1 minute.

**Solution:**

Given,

$$\text{Current, } I = 0.2 \text{ A}$$

$$\text{Potential difference, } V = 15 \text{ V}$$

$$\text{Time, } t = 60 \text{ sec}$$

$$\text{As } V = IR$$

(a) To calculate the resistance of the wire

$$R = V / I$$

$$R = 15 / 0.2$$

$$R = 75 \text{ ohm}$$

(b) To calculate the heat energy produced in 1 minute

$$\text{Heat energy, } H = I^2Rt$$

$$H = (0.2)^2 \times 75 \times 60$$

$$H = 180 \text{ J}$$

**Question: 11**

What is the resistance, under normal working conditions, of an electric lamp rated at '240 v', 60 W? If two such lamps are connected in series across a 240 V mains supply, explain why each one appears less bright.

**Solution:**

Given,

$$\text{Voltage, } V = 240 \text{ V}$$

$$\text{Power, } P = 60 \text{ W}$$

We know that,

$$P = V^2 / R$$

$$R = V^2 / P$$

$$R = (240)^2 / 60$$

$$R = 960 \text{ ohm}$$

$$I = P / V$$

$$I = 60 / 240$$

$$I = 0.25 \text{ A}$$

Thus when one lamp is connected across the mains, it draws 0.25 A current. If two such lamps are connected in series across the mains, current through each bulb becomes  $[240 / (960 + 960) \text{ ohm}] = 0.125 \text{ A}$  (i.e., current is halved.) Hence, heating ( $= I^2Rt$ ) in each bulb becomes one fourth, so each bulb appears less bright.

**Question: 12**

Two bulbs are rated 60 W, 220 V and 60 W, 110 V respectively. Calculate the ratio of their resistances.

**Solution:**

Given,

$$\text{Voltage, } V_1 = 220 \text{ V}$$

$$V_2 = 110 \text{ V}$$

$$\text{Power, } P_1 = P_2 = P = 60 \text{ W}$$

We know that,  $R = V^2 / P$

$$R_1 = V_1^2 / P$$

$$R_1 = (220)^2 / 60$$

$$R_2 = V_2^2 / P$$

$$R_2 = (110)^2 / 60$$

Now, dividing  $R_1$  and  $R_2$  we get,

$$R_1 / R_2 = [(220)^2 / 60] / [(110)^2 / 60]$$

$$R_1 / R_2 = 4 / 1$$

$$R_1 : R_2 = 4 : 1$$

**Question: 13**

An electric bulb is rated 250 W, 230 V.

- (i) the energy consumed in one hour, and  
(ii) the time in which the bulb will consume 1.0 kWh energy when connected to 230 V mains?

**Solution:**

Given,

$$\text{Power, } P = 250 \text{ W}$$

$$\text{Voltage, } V = 230 \text{ V}$$

$$\text{(i) Energy, } E = P \times t$$

$$\text{Time, } t = 1 \times 60 \times 60$$

$$t = 3600 \text{ sec}$$

We know that,

$$E = 250 \times 3600$$

$$E = 9 \times 10^5 \text{ J}$$

$$\text{(ii) } 1000 \text{ Wh} = 250 \times t$$

$$\text{time, } t = 1000 / 250$$

$$t = 4 \text{ hours}$$

**Question: 14**

Three heaters each rated 250 W, 100 V are connected in parallel to a 100 V supply.

Calculate:

- (i) The total current taken from the supply,  
(ii) The resistance of each heater, and  
(iii) The energy supplied in kWh to the three heaters in 5 hours.

**Solution:**

Given,

$$\text{Power, } P = 250 \text{ W}$$

$$\text{Voltage, } V = 100 \text{ V}$$

$$\text{(i) Current through each heater, } I = ?$$

$$\text{As } P = VI$$

$$I = P / V$$

$$I = 250 / 100$$

$$I = 2.5 \text{ A}$$

$$\therefore \text{Current taken for the three heaters}$$

$$= 3 \times 2.5$$

$$= 7.5 \text{ A}$$

$$\text{(ii) Resistance for each heater, } R = V / I$$

$$R = 100 / 2.5$$

$$R = 40 \text{ ohm}$$

(iii) Time for which energy is supplied,  $t = 5 \text{ h}$

$$\text{Energy, } E = P \times t$$

$$E = 250 \times 5$$

$$E = 1250 \text{ Wh}$$

$$E = 1.25 \text{ kWh}$$

$$\text{Energy for three heaters} = 3 \times 1.25$$

$$= 3.75 \text{ kWh}$$

**Question: 15**

**A bulb is connected to a battery of p.d. 4 V and internal resistance 2.5 ohm. A steady current of 0.5 A flows through the circuit. Calculate:**

**(i) The total energy supplied by the battery in 10 minutes,**

**(ii) The resistance of the bulb, and**

**(iii) The energy dissipated in the bulb in 10 minutes.**

**Solution:**

Given,

$$\text{Voltage, } V = 4 \text{ V}$$

$$\text{Resistance of the battery, } R_B = 2.5 \text{ ohm}$$

$$\text{Current, } I = 0.5 \text{ A}$$

(i) Energy supplied by the battery,  $E = V^2t / R$

$$t = 10 \times 60$$

$$t = 600 \text{ sec}$$

$$R = V / I$$

$$R = 4 / 0.5$$

$$R = 8 \text{ ohm}$$

$$E = [(4)^2 \times 600] / 8$$

$$E = 1200 \text{ J}$$

(ii) Total resistance,  $R = 8 \text{ ohm}$

$$\text{Resistance of the battery, } R_B = 2.5 \text{ ohm}$$

$$\text{Resistance of the bulb, } R_b = 8 - 2.5 \text{ ohm}$$

$$R_b = 5.5 \text{ ohm}$$

(iii) Energy dissipated in the bulb in 10 min,  $E = I^2Rt$

$$E = (0.5)^2 \times 5.5 \times 600$$

$$E = 825 \text{ J}$$

**Question: 16**

**Two resistors A and B of 4 ohm and 6 ohm respectively are connected in parallel. The combination is connected across a 6 volt battery of negligible resistance.**



**Calculate: (i) the power supplied by the battery, (ii) the power dissipated in each resistor.**

**Solution:**

Given,

Resistance,  $R_A = 4 \text{ ohm}$

Resistance,  $R_B = 6 \text{ ohm}$

Voltage,  $V = 6 \text{ V}$

(i) Since the resistances are connected in parallel

Equivalent Resistance,  $1/R = 1/R_A + 1/R_B$

$$1/R = 1/4 + 1/6$$

$$1/R = 10/24$$

$$R = 2.4 \text{ ohm}$$

We know that,

Power,  $P = V^2/R$

$$P = (6)^2/2.4$$

$$P = 15 \text{ W}$$

(ii) Power dissipation across each resistor,  $P = VI$

Current across resistor  $R_A$ ,  $I_A = V/R_A$

$$I_A = 6/4 = 1.5 \text{ A}$$

Power dissipation across resistor  $R_A$ ,

$$P = VI_A$$

$$P = 6 \times 1.5$$

$$P = 9 \text{ W}$$

(iii) Current across resistor  $R_B$ ,  $I_B = V/R_B$

$$I_B = 6/6$$

$$I_B = 1 \text{ A}$$

Power dissipation across resistor  $R_B$ ,

$$P = VI_B$$

$$P = 6 \times 1$$

$$P = 6 \text{ W}$$

**Question: 17**

**A battery of e.m.f. 15 V and internal resistance 2 ohm is connected to two resistors of resistances 4 ohm and 6 ohm joined in series. Find the electrical energy spent per minute in 6 ohm resistor.**

**Solution:**

Given,

e.m.f. of battery,  $V = 15 \text{ V}$

Internal resistance of battery,  $R_B = 2 \text{ ohm}$

Resistances given in circuit,

$$R_1 = 4 \text{ ohm and } R_2 = 6 \text{ ohm}$$

(i) When resistors are connected in series,

$$\text{Equivalent resistance, } R = R_B + R_1 + R_2$$

$$R = 12 \text{ ohm}$$

$$\text{Current in the circuit, } I = 15 / 12$$

$$I = 1.25 \text{ A}$$

Now,

$$\text{Voltage across resistor } R_2, V_2 = IR = 1.25 \times 6$$

$$V_2 = 7.50 \text{ V}$$

$$\text{Time, } t = 1 \text{ min} = 60 \text{ sec}$$

$$\text{Energy across } R_2, E = V^2 t / R$$

$$E = [(7.5)^2 \times 60] / 6$$

$$E = 562.5 \text{ J}$$

### Question: 18

**Water in an electric kettle connected to a 220 V supply took 5 minutes to reach its boiling point. How long will it take if the supply had been of 200 V?**

**Solution:**

$$P = V^2 / R$$

$$\text{Heat gained} = (V^2 / R) \times t$$

$$(V_1^2 / R) \times t_1 = (V_2^2 / R) \times t_2$$

$$t_2 = (V_1 / V_2)^2 \times t_1$$

$$t_2 = (220 / 200)^2 \times 300$$

$$t_2 = 363 \text{ s}$$

$$t_2 = 6.05 \text{ min}$$

### Question: 19

**An electric toaster draws current 8 A in a circuit with source of voltage 220 V. It is used for 2 h. Find the cost of operating the toaster if the cost of electrical energy is ₹ 4.50 per kWh**

**Solution:**

Given,

$$\text{Voltage, } V = 220 \text{ V}$$

$$\text{Current, } I = 8 \text{ A}$$

$$\text{Time, } t = 2 \text{ h}$$

$$\text{Energy, } E = VIt$$

$$E = 220 \times 8 \times 2$$

$$E = 3520 \text{ Wh}$$

$$E = 3.52 \text{ kWh}$$

$$\text{Cost of energy} = ₹ 4.50 \text{ per kWh}$$

$$\begin{aligned} \therefore \text{Cost of 3.52 kWh of energy} &= ₹ 4.50 \times 3.52 \text{ kWh} \\ &= ₹ 15.84 \end{aligned}$$

**Question: 20**

An electric kettle is rated 2.5 kW, 250 V. Find the cost of running the kettle for two hours at ₹ 5.40 per unit.

**Solution:**

Given,

$$\text{Power of kettle, } P = 2.5 \text{ kW}$$

$$\text{Voltage, } V = 250 \text{ V}$$

$$\text{Time, } t = 2 \text{ h}$$

$$\text{As, Energy, } E = P \times t$$

$$E = 2.5 \times 2$$

$$E = 5 \text{ kWh}$$

$$\text{Cost per unit of energy} = ₹ 5.40$$

$$\text{Cost for 5 kWh of energy} = 5.40 \times 5 = ₹ 27$$

**Question: 21**

A geyser is rated 1500 W, 250 V. This geyser is connected to 250 V mains. Calculate:

(i) The current drawn,

(ii) The energy consumed in 50 hours, and

(iii) The cost of energy consumed at ₹ 4.20 per kWh.

**Solution:**

Given,

$$\text{Power of geyser, } P = 1500 \text{ W}$$

$$\text{Voltage, } V = 250 \text{ V}$$

$$(i) \text{ Current, } I = P / V$$

$$I = 1500 / 250$$

$$I = 6 \text{ A}$$

$$(ii) \text{ Time, } t = 50 \text{ h}$$

$$\text{Energy, } E = P \times t$$

$$E = 1500 \times 50$$

$$E = 75000 \text{ Wh}$$

$$E = 75 \text{ kWh}$$

$$(iii) \text{ Cost per unit of energy} = ₹ 4.20$$

$$\text{Cost for 75 kWh of energy} = 4.20 \times 75 = ₹ 315$$