# Chapter 4
# Electricity

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## I. Choose the best Answer.

**Question** 1.
Which of the following is correct?
(a) Rate of change of charge is electrical power.
(b) Rate of change of charge is current.
(c) Rate of change of energy is current.
(d) Rate of change of current is charge.
**Answer**:
(b) Rate of change of charge is current.

**Question** 2.
SI unit of resistance is:
(a) mho
(b) joule
(c) ohm
(d) ohm meter
**Answer**:
(c) ohm

**Question** 3.
In a simple circuit, why does the bulb glow when you close the switch?
(a) The switch produces electricity.
(b) Closing the switch completes the circuit.
(c) Closing the switch breaks the circuit.
(d) The bulb is getting charged.
**Answer**:
(b) Closing the switch completes the circuit

**Question** 4.
Kilowatt hour is the unit of:
(a) resistivity
(b) conductivity
(c) electrical energy
(d) electrical power
**Answer**:
(c) electrical energy

## II. Fill in the blanks.

1. When a circuit is open, ……. cannot pass through it.
2. The ratio of the potential difference to the current is known as …….
3. The wiring in a house consists of ……. circuits.
4. The power of an electric device is a product of …… and …….
5. LED stands for …….

**Answer**:

1. current
2. resistance
3. parallel
4. potential difference, current
5. Light Emitting Diode

## III. State whether the following statements are true or false: If false correct the statement.

1. Ohm's law states the relationship between power and voltage.
2. MCB is used to protect house hold electrical appliances.
3. The SI unit for electric current is the coulomb.
4. One unit of electrical energy consumed is equal to 1000 kilowatt hour.
5. The effective resistance of three resistors connected in series is lesser than the lowest of the individual resistances.

**Answer**:

1. False – Ohm's law states that the relationship between current and voltage.
2. True
3. False – The SI unit for electric current is ampere.
4. False – One unit of electrical energy consumed is equal to 1 kilowatt hour.
5. False – The effective resistance of three resistors connected in series is greater than the highest of the "individual resistance.

## IV. Match the items in column-1 to the items in column-ll.

| Column - I | Column - II |
|---|---|
| (i) electric current | (a) volt |
| (ii) potential difference | (b) ohm meter |
| (iii) specific resistance | (c) watt |
| (iv) electrical power | (d) joule |
| (v) electrical energy | (e) ampere |

**Answer**:
(i) – (e)
(ii) – (a)
(iii) – (b)
(iv) – (c)
(v) – (d)

## V. Assertion and reason type Questions.

Mark the correct choice as
(a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
(c) If the assertion is true, but the reason is false.
(d) If the assertion is false, but the reason is true.
1. Assertion: Electric appliances with a metallic body have three wire connections.
Reason: Three pin connections reduce heating of the connecting wires.
**Answer**:
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.

2. Assertion: In a simple battery circuit the point of highest potential is the positive terminal of the battery.
Reason: The current flows towards the point of the highest potential.
**Answer**:
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.

3. Assertion: LED bulbs are far better than incandescent bulbs.
Reason: LED bulbs consume less power than incandescent bulbs.
**Answer**:
(a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.

## VI. Very short Answer Questions.

**Question** 1.
Define the unit of current.
**Answer**:
The current flowing through a conductor is said to be one ampere, when a charge of one coulomb flows across any cross-section of a conductor, in one second. Hence,
1 ampere $= \frac{1coulomb}{1\text{second}}$

**Question** 2.
What happens to the resistance, as the conductor is made thicker?
**Answer**:
If the conductor is made a thicker area of cross-section of conduction increases that will decrease the resistance.

**Question** 3.
Why is tungsten metal used in bulbs, but not in fuse wires?
**Answer**:
Tungsten metal is used in bulbs because its melting point is the greatest.
But it is not used in fuse wires. When a current more than 5A flows tungsten wire will be melted. Hence tungsten is not used in fuse wire.

**Question** 4.
Name any two devices, which are working on the heating effect of the electric current.
**Answer**:
The heating effect of electric current is used in many home appliances such as electric iron and electric toaster.

## VII. Short Answer Questions.

**Question** 1.
Define electric potential and potential difference.
**Answer**:
Electric Potential: It is the amount of work done in moving unit positive charge from infinity to that point against the electric force.
Electric potential

$$= \frac{\text{work done}}{\text{charge}} \quad \Rightarrow V = \frac{W}{Q}$$

Potential difference : It is the amount of work done in moving a unit positive charge from one point to another against the electric force.

$$\text{Potential difference } V_A - V_B = \frac{W_A - W_B}{Q}$$

**Question** 2.
What is the role of the earth wire in domestic circuits?
**Answer**:

1. The earth wire provides a low resistance path to the electric current.
2. The earth wire sends the current from the body of the appliance to the Earth, whenever a live wire accidentally touches the body of the metallic electric appliance.
3. Thus, the earth wire serves as a protective conductor, which saves us from electric shocks.

**Question** 3.
State Ohm's law.
**Answer**:
According to Ohm's law, at a constant temperature, the steady current 'I' flowing through a conductor is directly proportional to the potential difference 'V' between the two ends of the conductor.
$I \propto V$. Hence, $= \frac{1}{V} =$ constant.
The value of this proportionality constant is found to $\frac{1}{R}$
Therefore, $I = (\frac{1}{R})\ V$
$V = IR$

**Question** 4.
Distinguish between the resistivity and conductivity of a conductor.
**Answer**:

| Resistivity | Conductivity |
|---|---|
| It is the resistance of a conducts of unit length and unit area of cross section. | It is the reciprocal of electrical resistivity. |
| Its unit is ohm metre. | Its unit is mho metre$^{-1}$. |
| $\rho = \frac{RA}{L}$ | $\sigma = \frac{1}{\rho}$ |

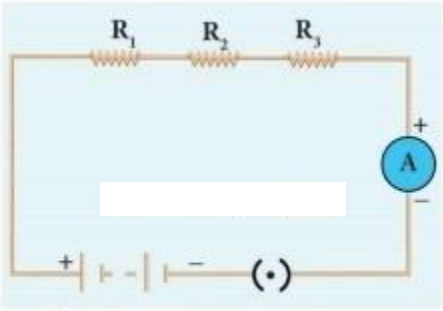
**Question** 5.
What connection is used in domestic appliances and why?
**Answer**:

1. In the domestic appliance, it is used as a parallel connection to avoid short circuit and breakage.
2. It has an alternative current (AC). Not DC current as it is from cables, so high potential flows through this.
3. One more advantage of the parallel connection of circuits is that each electric appliance gets an equal voltage.

## VIII. Long Answer Questions.

**Question** 1.
With the help of a circuit diagram derive the formula for the resultant resistance of three resistances connected:
(a) in series and
(b) in parallel
**Answer**:

(a) Resistors in series : A series circuit connects the components one after the other to form a 'single loop'. A series circuit has only one loop through which current can pass. If the circuit is interrupted at any point in the loop, no current can pass through the circuit and hence no electric appliances connected in the circuit will work. Series circuits are commonly used in devices such as flashlights. Thus, if resistors are connected end to end, so that the same current passes through each of them, then they are said to be connected in series.



Series connection of resistors

Let, three resistances $R_1$, $R_2$ and $R_3$ be connected in series. Let the current flowing through theorem be I. According to Ohm's Law, the potential differences $V_1$,$V_2$ and $V_3$ across $R_1$, $R_2$ and $R_3$ respectively, are given by:

$V_1 = I R_1$ ……. (1)

$V_2 = I R_2$ ……. (2)

$v_3 = I R_3$ ……. (3)

The sum of the potential differences across the ends of each resistor is given by:

$V = V_1 + V_2 + V_3$

Using equations (1), (2) and (3), we get

$V = I R_1 + I R_2 + I R_3$ …….. (4)

The effective resistor is a single resistor, which can replace the resistors effectively, so as to allow the same current through the electric circuit. Let, the effective resistance of the series-combination of the resistors, be $R_S$.

Then,

$V = I R_S$ …….(5)

Combining equations (4) and (5), we get,

$I R_S = I R_1 + I R_2 + I R_3$

$R_S = R_1 + R_2 + R_3$ ……. (6)

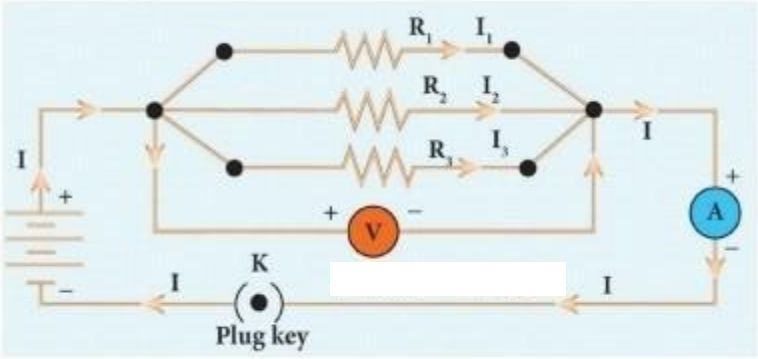
Thus, you can understand that when a number of resistors are connected in series, their equivalent resistance or effective resistance is equal to the sum of the individual resistances. When 'n' resistors of equal resistance R are connected in series, the equivalent resistance is 'n R'.

i.e., $R_S = n R$

The equivalent resistance in a series combination is greater than the highest of the individual resistances.

(b) Resistors in Parallel : A parallel circuit has two or more loops through which current can pass. If the circuit is disconnected in one of the loops, the current can still pass through

the other loop(s). The wiring in a house consists of parallel circuits.




Parallel connections of resistors

Consider that three resistors $R_1$, $R_2$ and $R_3$ are connected across two common points A and B The potential difference across each resistance is the same and equal to the potential difference between A and B. This is me sured using the voltmeter. The current I arriving at A divides into three branches $I_1$, $I_2$ and $I_3$ passing through $R_1$, $R_2$ and $R_3$ respectively. According to the Ohm's law, you have,

$$I_1 = \frac{V}{R_1} \qquad \ldots(1)$$

$$I_2 = \frac{V}{R_2} \qquad \ldots(2)$$

$$I_3 = \frac{V}{R_3} \qquad \ldots(3)$$

The total current through the circuit is given by

$I = I_1 + I_2 + I_3$

Using equations (1), (2) and (3), you get

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \quad \ldots\ldots\ldots (4)$$

Let the effective resistance of the parallel combination of resistors be $R_P$ Then,

$$I = \frac{V}{R_P} \quad \ldots\ldots\ldots (5)$$

Combining equations (4) and (5), you have

$$\frac{V}{R_P} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad \ldots(6)$$

Thus, when a number of resistors are connected in parallel, the sum of the reciprocals of the individual resistances is equal to the reciprocal of the effective or equivalent resistance. When 'n' resistors of equal resistances R are connected in parallel, the equivalent resistance is $\frac{R}{n}$

$$\text{i.e., } \frac{1}{R_P} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} \ldots + \frac{1}{R} = \frac{n}{R}$$

$$\text{Hence, } R_P = \frac{R}{n}$$

The equivalent resistance in a parallel combination is less than the lowest of the individual resistances.

**Question** 2.
(a) What is meant by electric current? Give its direction?
(b) Name and define its unit.
(c) Which instrument is used to measure the electric current? How should it be r connected in a circuit?
**Answer**:
(a) (i) Electric current is often termed as 'current' and it is represented by the symbol 'I'. It is defined as the rate of flow of charges in a conductor.
(ii) The electric current represents the number of charges flowing in any cross-section of a conductor (say a metal wire) in unit time.

(b) The SI unit of electric current is ampere (A).
The current flowing through a conductor is said to be one ampere, when a charge of one coulomb flows across any cross-section of a conductor, in one second. Hence,

$$1 \text{ ampere} = \frac{1\ coulomb}{1 \text{ second}}$$

(c) (i) The ammeter is used to measure the current.
(ii) An Ammeter is connected in series with the circuit.
(iii) The Ammeter is a low impedance device connecting it in parallel with the circuit would cause a short circuit, damaging the Ammeter or the circuit.

**Question** 3.
(a) State Joule's law of heating.
(b) An alloy of nickel and chromium is used as the heating element. Why?
(c) How does a fuse wire protect electrical appliances?
**Answer**:
(a) Joule's law of heating states that the heat produced in any resistor is:

1. directly proportional to the square of the current passing through the resistor.
2. directly proportional to the resistance of the resistor.
3. directly proportional to the time for which the current is passing through the resistor.

(b) Because,

1. It has high resistivity,
2. It has a high melting point,

3. It is not easily oxidized.

(c) When a large current passes through the circuit, the fuse wire melts due to Joule's heating effect and hence the circuit gets disconnected. Therefore, the circuit and the electric appliances are saved from any damage.

**Question** 4.
Explain about domestic electric circuits, (circuit diagram not required)
**Answer**:

1. Electricity is distributed through the domestic electric circuits wired by the electricians.
2. The first stage of the domestic circuit is to bring the power supply to the main-box from a distribution panel, such as a transformer.
3. The important components of the main-box are: (i) a fuse box and (ii) a meter. The meter is used to record the consumption of electrical energy.
4. The fuse box contains either a fuse wire or a miniature circuit breaker (MCB).
5. The function of the fuse wire or an MCB is to protect the household electrical appliances from overloading due to excess current.

**Question** 5.
(a) What are the advantages of LED TV over the normal TV?
(b) List the merits of LED bulb.
**Answer**:
(a) Advantages of LED TV:

1. It has brighter picture quality.
2. It is thinner in size.
3. It uses less power and consumes very less energy.
4. Its life span is more.
5. It is more reliable.

(b) Advantages of LED bulb:

1. As there is no filament, there is no loss of energy in the form of heat.
2. It is cooler than the incandescent bulb.
3. In comparison with the fluorescent light, the LED bulbs have significantly low power requirement.
4. It is not harmful to the environment.
5. A wide range of colours is possible here.
6. It is cost-efficient and energy efficient.
7. Mercury and other toxic materials are not required. One way of overcoming the energy crisis is to use more LED bulbs.

## IX. Numerical problems.

**Question** 1.
An electric iron consumes energy at the rate of 420 W when heating is at the maximum rate and 180 W when heating is at the minimum rate. The applied voltage is 220 V. What is the current in each case?
**Answer**:
(i) When heating is maximum, the power
$P_1 = 420$ W
Applied voltage V = 220 V
P = VI
Current $I = \frac{P}{V}$
$I = \frac{420}{220} = 1.909$ A
I = 1.909 A

(ii) When heating is minimum
Power $P_2 = 180$ W
Applied voltage V = 220 V
P = VI
∴ Current I = PV
$I = \frac{180}{220} = 0.8181$ A
I = 0.8181 A

**Question** 2.
A 100-watt electric bulb is used for 5 hours daily and four 60 watt bulbs are used for 5 hours daily. Calculate the energy consumed (in kWh) in the month of January.
Solution:
100 W = 100 joules per second
1 watt hours = 3600 joules
The electric bulb is lighted for 5 hours daily,
100 W × 5 = 500 watt hours
500 watt hours = 1800000 joules
1 kWh = 3600000 joules
Units consumed per day $= \frac{1800000}{3600000} = 0.5$ units
Untis consumed in month = 0.5 × 31 = 15.5 units .... (1)
Now, Sum of power of four 60 watt bulbs = 240 W
240 W × 5 hours = 1200 watt hours
1200 watt hours = 4320000 joules
Energy consumed per day $= \frac{4320000}{3600000} = 1.2$ units
Energy consumed in a month = 1.2 × 31 = 37.2 units .... (2)
Total energy consumed in a month = 15.5 + 37.2 = 52.7 units
1 unit = 1 kWh
The energy consumed in the month of January = 52.7 kWh.

**Question** 3.
A torch bulb is rated at 3 V and 600 mA. Calculate it's
(a) power
(b) resistance
(c) energy consumed if it is used for 4 hour.
**Answer**:
Voltage V = 3 V
Current I = 600 mA
(a) Power = VI
$= 3 \times 600 \times 10^{-3}$
$= 1800 \times 10^{-3}$
= 1.8 W

(b) Power $P = \frac{V^2}{R}$

$\therefore$ Resistance $R = \frac{V^2}{P} = \frac{(3)^2}{1.8}$

$R = \frac{9}{1.8} = \frac{1}{0.2} = 5\Omega$

(c) Time = 4h
Energy consumed E = P × t
E = 1.8 × 4
= 7.2 W

**Question** 4.
A piece of wire having a resistance R is cut into five equal parts.
(a) How will the resistance of each part of the wire change compared with the original resistance?
(b) If the five parts of the wire are placed in parallel, how will the resistance of the combination change?
(c) What will be ratio of the effective resistance in series connection to that of the parallel connection?
**Answer**:
(a) Original resistance

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

$\therefore R \alpha l$

After cutting length of each piece

$r = \frac{l}{5}$

New resistance

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

$R' \alpha l'$

$$\frac{R}{R'} = \frac{l}{l'} = \frac{l}{\frac{l}{5}} = 5$$

R : R′ = 5 : 1

(b) When five parts of the wire are placed in parallel.
Effective Resistance

$$\frac{1}{R_p} = \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}}$$

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

$$\frac{1}{R_P} = \frac{25}{R}$$

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

Resistance of the combinations

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

(c) When resistance are connected in series

$$= \frac{R}{5} + \frac{R}{5} + \frac{R}{5} + \frac{R}{5} + \frac{R}{5}$$

$R_S = R$
When resistance are connected in parallel
$R_P = R25$
$R_S : R_P = R : R25$
$= 25\ R : R\_1$
$R_S : R_P = 25 : 1$

## X. HOT Questions.

**Question** 1.
Two resistors when connected in parallel give the resultant resistance of 2 ohm; but when connected in series the effective resistance becomes 9 ohm. Calculate the value of each resistance.
**Answer**:
Let the resistance be R, and R2 when two resistances are connected in series
$R_S = R_1 + R_2$
$= 9$
$R_1 + R_2 = 9$ .....(1)
When two resistance are connected in parallel

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2}$$

$$\frac{R_1 + R_2}{R_1 R_2} = \frac{1}{2} \quad \ldots(2)$$

Using (1) equation (2) becomes

$$\frac{9}{R_1 R_2}$$

$R_1 R_2 = 18$ .....(3)

$(R_1 - R_2)^2 = (R_1 + R_2)^2 - 4R_1R_2$

$= (9)^2 - 4 \times 18$

$= 81 - 72 = 9$

$\therefore (R_1 - R_2) = \sqrt{9} = 3$ .....(4)

From (1)

$R_1 + R_2 = 9$

$2R_1 = 12$

$\therefore R_1 = \frac{12}{2} = 6$ ohm

From (1)

$R_2 = 9 - R_1$

$= 9 - 6 = 3\Omega$

The values of resistances are

$R_1 = 6$ ohm

$R_2 = 3$ ohm

**Question** 2.

How many electrons are passing per second in a circuit in which there is a current of 5 A?

Solution:

Current I = 5A

Time (t) = 1 second

Charge of electron e = $1.6 \times 10^{-19}$ C

$I = \frac{q}{t} = \frac{ne}{t}$

Number of electron, $n = \frac{It}{e} = \frac{5 \times 1}{1.6 \times 10^{-19}}$

$n = 3.125 \times 10^{19}$.

**Question** 3.

A piece of wire of resistance 10 ohm is drawn out so that its length is increased to three times its original length. Calculate the new resistance.

**Answer**:

Resistance R = 10Ω

Let l be the length of the wire $R \propto l$

When the length is increased to three times,

$l' = 3l$

∴ New Resistance

$R' \propto l' \propto 3l$

$\therefore \frac{R}{R'} = \frac{l}{3l} = \frac{1}{3}$

$\therefore R' = 3R$

New resistance = 3 times the original resistance.