UNIT

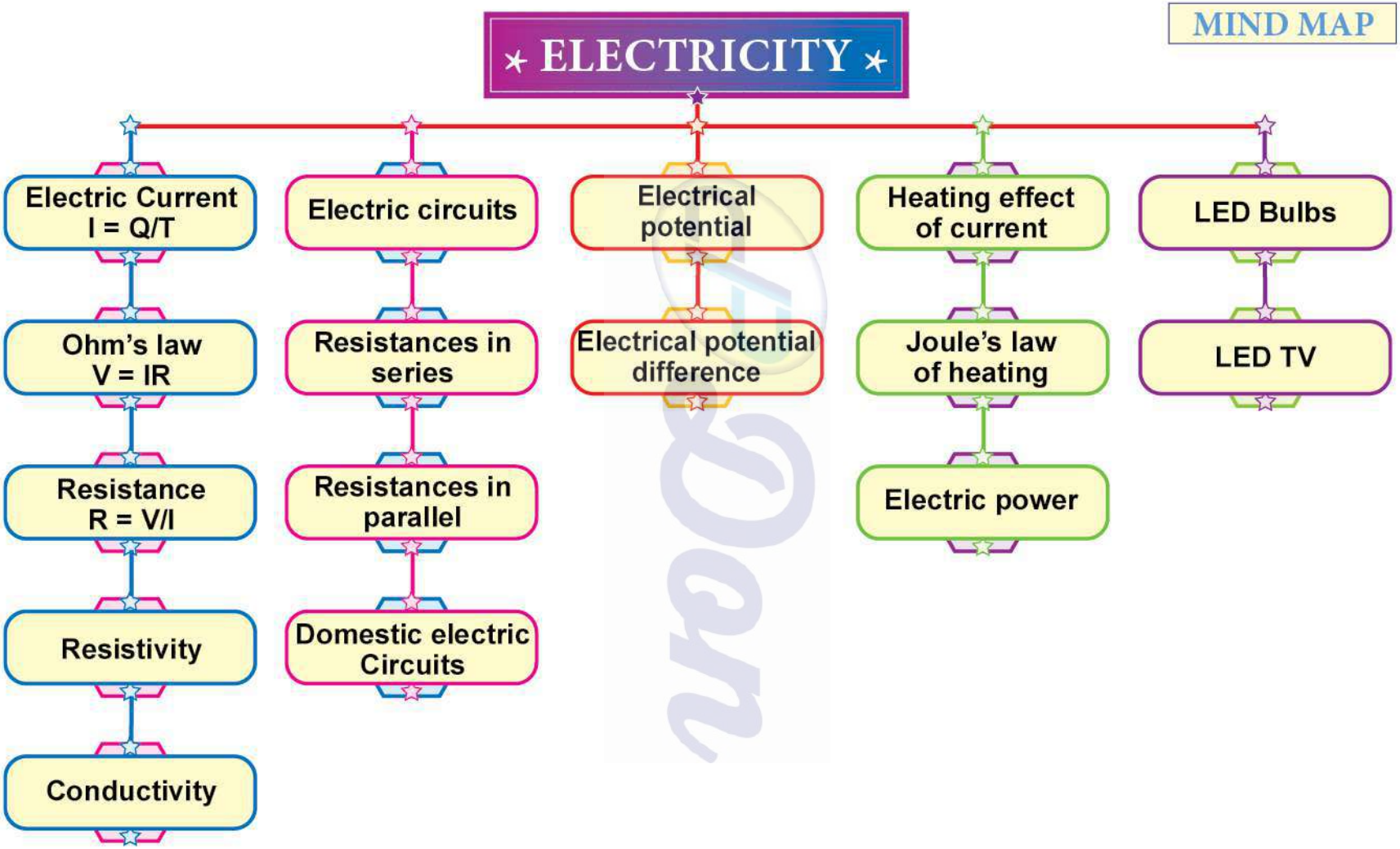
4

Electricity

POINTS TO REMEMBER

- Electricity deals with the flow of electric charges through a conductor.
- The motion of electric charges through a conductor will constitute through an electric current.
- SI unit of current is ampere.
- By convention, the direction of current is taken as the direction of flow of positive charge.
- The SI unit of electric potential or potential difference is volt.
- Potential difference V is proportional to the current.
- The SI unit of resistance is ohm.
- Electrical resistivity of a conductor is a constant for a given material.
- The reciprocal of electrical resistivity of a material is called its electrical conductivity.
- Conductivity is more for conductor than for insulators.
- Specific resistivity is the resistance of a conductor of unit length and unit area of cross section.
- Electrical resistance is the ratio between the potential difference across the ends of a conductor and the current flowing through it.
- Electrical conductance is the reciprocal of resistance.
- Electrical conductivity is the reciprocal of electrical resistivity of a material.
- If resistors are connected in series same current passes through each of them.
- The heating effect of current is used in devices like electric heater, electric iron etc.
- The electric power is the product of the electric current and the potential difference.
- One watt is the power consumed when an electric device is operated at a potential difference of one volt and it carries a current of one ampere.
- Ohm's law is defined as the relation between the potential difference and current.
- Electrical potential difference is defined as the amount of work done in moving a unit positive charge from one point to another against the electric force.
- Earth wire serves as a protective conductor, which saves us from electric shocks.
- An LED bulb is a semiconductor device that emits visible light when an electric current passes through it.

MIND MAP



Formulae	
Electric Current	$I = \frac{Q}{t} = \frac{\text{Charge}}{\text{Time}} \Rightarrow Q = It$
Potential difference	$V = \frac{W}{Q} = \frac{\text{Workdone}}{\text{charge}} \Rightarrow W = vQ$
Ohm's law	$V = IR; R = \frac{V}{I}$
Electrical Resistivity (or) specific resistance	$\rho = \frac{RA}{L}$
Conductance	$G = \frac{1}{R} = \frac{1}{\text{resistance}}$
Conductivity	$\sigma = \frac{1}{\rho} = \frac{1}{\text{resistivity}}$
Equivalent resistance in a series combinations	$R_s = R_1 + R_2$
When 'n' resistors are connected in a series combinations	$R_s = nR;$
When 'n' resistors are connected in parallel.	$R_p = \frac{R}{n}$
Total resistance in the circuit	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
Series connection of parallel resistors	$R_{total} = R_{P1} + R_{P2}$
Parallel connection of series resistors	$\frac{1}{R_{total}} = \frac{1}{R_{S1}} + \frac{1}{R_{S2}}$
Joule's law of heating	$H = I^2 Rt ; H = VI t$
Electric power	$P = \frac{work}{time} = \frac{VIt}{t} (or) P = V I$
Electrical energy	E = power × time = VI t = VQ
Resistance	$\text{Resistance (R)} = \frac{Voltage\ (V)}{Current\ (I)}$
Electric power	$P = \frac{V^2}{R}$ (or) $P = VI = I^2 = V^2/R$

Textbook Evaluation

I. Choose the most suitable answer from the given four alternatives and write the option code and corresponding answer:

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.

2. **SI unit of resistance is** ★★
   a) mho
   b) joule
   c) ohm
   d) ohm meter

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.

4. **Kilowatt hour is the unit of** ★★
   a) resistivity
   b) conductivity
   c) electrical energy
   d) electrical power

Ans:

1.	b) Rate of change of charge is current.	3.	b) Closing the switch completes the circuit.
2.	c) ohm	4.	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 _____.**

Ans:

1.	Current	4.	voltage and current
2.	resistance	5.	Light Emitting Diode
3.	parallel		

III. State whether the following statements are true or false. It take Correct the statement.

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

IV Match the items in columns -I to the items in column-II.

1.

Column I		Column II	
1) Electric current	-	a) volt	(e)
2) Potential difference	-	b) ohm meter	(a)
3) Specific resistance	-	c) watt	(b)
4) Electrical power	-	d) joule	(c)
5) Electrical energy	-	e) ampere	(d)

V. Reason and Assertion

Mark the correct choice as

a) If both the assertion and the reason are trueand 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

Ans : c) If the assertion is true, but the reason is false.

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

Ans : c) If the assertion is true, but the reason is false.

3. **Assertion:** LED bulbs are far better than incandescent bulbs.
Reason: LED bulbs consume less power than incandescent bulbs.

Ans : a) If both the assertion and the reason are trueand the reason is the correct explanation of the assertion.

VI. Very short answer questions.

1. Define the unit of current. ★ ★ ★

- The SI unit of 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.
- $\boxed{1 \text{ ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}}$

2. What happens to the resistance, as the conductor is made thicker? ★ ★

- Resistance is inversely proportional to area of cross section.
- A thicker wire has larger area of cross section and hence the **resistance decreases.**
- $\text{Resistance} \propto \frac{\text{Length}}{\text{Area}}$
- $\boxed{R \propto \frac{l}{A}}$

3. Why is tungsten metal used in bulbs, but not in fuse wires? ★

- **Melting point** of tungsten is very.
- Hence it is used in a **filament** bulb.
- But a fuse wire should be made up of material which has **low melting point.**

4. Name any two devices, which are working on the heating effect of the electric current.

- Electric heater
- Electric iron work on the heating effect of current.

VII. Short answer questions

1. Define electric potential and potential difference. ★ ★

Electric potential:

The electric potential at a point is defined as the amount of **work done** in moving **a unit positive charge** from **infinity** to that point **against** the **electric force.**

Electrical potential difference:

The electric potential difference between two points is defined as the amount of **work done** in moving a **unit positive charge** from **one point to another point** against the electric force.

2. What is the role of the earth wire in domestic circuits? ★ ★ ★

- The **earth wire** provides a low resistance path to the electric current.
- The earth wire sends the current from the body of the appliance to the earth, whenever a **live wire** accidently touches the body of the metallic electric appliance.
- Thus the earth wire serves as a protective conductor, which saves us from **electric shock.**

3. State Ohm's law. ✶ ✶

At a **constant temperature,** the steady **current** flowing through a conductor is **directly** proportional to the **potential difference** between the two ends of the conductor.

$I \propto V$

$\boxed{V = IR}$

4. Distinguish between the resistivity and conductivity of a conductor.

S.No	Resistivity	Conductivity
(i)	It is the **resistance** of a conductor of unit **length** and unit area of **cross section.**	The **reciprocal** of **electrical resistivity** of a material is called electrical conductivity.
(ii)	Its unit is **ohm metre**	Its unit is **ohm^{-1} metre^{-1}**
(iii)	Resistivity is less for conductor than for insulators	Conductivity is more for conductors than for inulators.
(iv)	$\rho = RA / L$	$\sigma = 1 / \rho$

5. What connection is used in domestic appliances and why?

Parallel connection is used in domestic appliances.

Reason:

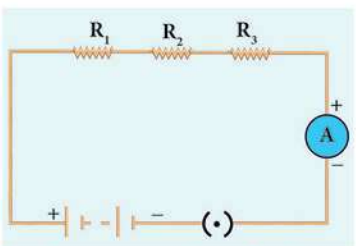
- Each appliance will get the **full voltage.**
- The parallel circuit **divides** the **current** through the appliances.
- Each appliance will get the proper current depending on its **resistance.**
- Each of them can be put on / off **independently.**

VIII. Long answer questions

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. ✶ ✶ ✶

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 them 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:

$$V_1 = I R_1 \quad \text{.....} \quad (1)$$

$$V_2 = I R_2 \quad \text{.....} \quad (2)$$

$$V_3 = I R_3 \quad \text{.....} \quad (3)$$

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

$$V = I R_1 + I R_2 + I R_3 \quad \text{.....} \quad (4)$$

- 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,

$$V = I R_S \quad \text{.....} \quad (5)$$

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

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

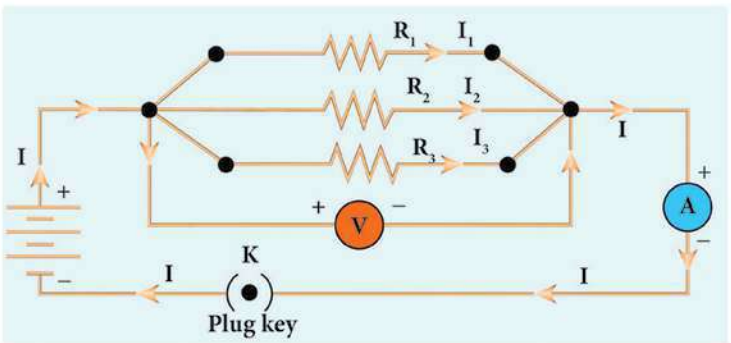
$$R_S = R_1 + R_2 + R_3 \quad \text{.....} \quad (6)$$

- 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.***

Resistances 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).
- he 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 measured using the **voltmeter**.
- The current I arriving at A divides into three branches $\mathbf{I_1}$, $\mathbf{I_2}$ **and** $\mathbf{I_3}$ passing through $\mathbf{R_1}$, $\mathbf{R_2}$ **and** $\mathbf{R_3}$ respectively.

  According to the Ohm's law, you have,

$$\mathbf{I_1 = \frac{V}{R_1}} \quad \text{.....} \quad (7)$$

$$\mathbf{I_2 = \frac{V}{R_2}} \quad \text{.....} \quad (8)$$

$$\mathbf{I_3 = \frac{V}{R_3}} \quad \text{.....} \quad (9)$$

  The total current through the circuit is given by

$$\mathbf{I = I_1 + I_2 + I_3}$$

  Using equations (7), (8) and (9), you get

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} \quad \text{.....} \quad (10)$$

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

$$\mathbf{I = \frac{V}{R_P}} \quad \text{.....} \quad (11)$$

  Combining equations (10) and (11), you have

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

$$\mathbf{\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \quad \text{.....} \quad (12)$$

- 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 $\mathbf{\frac{R}{n}}$.

  i.e., $\frac{1}{R_P} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} \ldots + \frac{1}{R} = \frac{n}{R}$ ..... (13)

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

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

2. a) What is meant by electric current?
b) Name and define its unit.
c) Which instrument is used to measure the electric current? How should it be connected in a circuit? ✶ ✶

a) Electric current:

- 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.
- This means that the electric current represents the amount of charges flowing in **any cross section** of a conductor (say a metal wire) in **unit time.**
- If a net charge **'Q' passes** through any cross section of a conductor in **time 't',** then the current flowing through the conductor is

$$I = \frac{Q}{t}$$

b) SI unit of electric current:

- 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,

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

c) Ammeter is used to measure the electric current. It should be connected in series in a circuit.

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? ✶ ✶ ✶

a) Joule's law of heating:

Joule's law of heating states that the heat produced in any resistor is:

- directly proportional to the **square** of the **current** passing through the resistor.
- directly proportional to the **resistance** of the resistor.
- directly proportional to the **time** for which the current is passing through the resistor.

b) (i) it has **high resistivity,** (ii) it has a **high melting point**, (iii) it is **not easily oxidized.**

c) The fuse wire is connected in series, in an electric circuit. 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**. The fuse wire is made up of a material whose melting point is relatively low.

4. Explain about domestic electric circuits. (circuit diagram not required)

- The electricity produced in power stations is distributed to all the domestic and industrial consumers through **overhead and underground cables.**
- In our homes, electricity is distributed through the domestic electric circuits wired by the electricians.
- 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.**

Main Box Contains:

i) Fuse Box:

- The fuse box contains either a **fuse wire** or a miniature circuit breaker (MCB).
- The function of the fuse wire or a MCB is to protect the house hold electrical appliances from **overloading** due to excess current.
- It has a spring attached to the switch, which is attracted by an **electromagnet** when an excess current passes through the circuit.
- An **MCB** is a **switching device**, which can be activated **automatically** as well as manually.
- Hence, the circuit is broken and the protection of the appliance is ensured.

ii) Meter:

- The meter is used to **record** the **consumption** of electrical energy.

Insulated Wire:

- The electricity is brought to houses by **two** insulated wires.
- Out of these two wires, one wire has a **red insulation** and is called the **'live wire'.**
- The other wire has a **black insulation** and is called the **'neutral wire'.**
- Both, the live wire and the neutral wire enter into a box where the **main fuse** is connected with the **live wire.**
- After the electricity meter, these wires enter into the **main switch,** which is used to discontinue the electricity supply whenever required.
- After the main switch, these wires are connected to live wires of **two separate circuits.**

5A rating circuit:

- Out of these two circuits, one circuit is of a **5 A rating,** which is used to run the electric appliances with a **lower power rating**, such as tube lights, bulbs and fans.

15 A rating circuit:

- The other circuit is of a **15 A rating,** which is used to run electric appliances with a **high power rating**, such as air-conditioners, refrigerators, electric iron and heaters.
- It should be noted that all the circuits in a house are connected in **parallel**, so that the disconnection of one circuit does not affect the other circuit.
- The electricity supplied to your house is actually an alternating current having an electric potential of 220 V.
- One more advantage of the parallel connection of circuits is that each **electric appliance gets an equal voltage.**

5. a) What are the advantages of LED TV over the normal TV?
b) List the merits of LED bulb.

a) Advantages of LED television:

- It has brighter picture quality.
- It is thinner in size.
- It uses less power and consumes very less energy.
- Its life span is more.
- It is more reliable.

b) Merits of a LED bulb:

- As there is no filament, there is no loss of energy in the form of heat. It is cooler than the incandescent bulb
- In comparison with the fluorescent light, the LED bulbs have significantly low power requirement.
- It is not harmful to the environment.
- A wide range of colours is possible here.
- It is cost-efficient and energy efficient.
- Mercury and other toxic materials are not required.

IX. Numerical Problems:

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?

Given:

Energy consumed when heating is maximum = 420 W at a given rate

i.e., $P_1 = 420$ W

Energy consumed when heating is minimum at a given rate $P_2 = 180$ W

Applied voltage = 220 V

Current in each case = ?

Formula used:

Power = Voltage × Current

$$P = V \times I$$

case (i) $$I_1 = \frac{P_1}{V} = \frac{420}{220} = \mathbf{1.9\ A}$$

case (ii) $$I_2 = \frac{P_2}{V} = \frac{180}{220} = \mathbf{0.81\ A}$$

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. ★ ★ ★

Given:

Formula used:

$E = P \times t$

Power of the first electric bulb = 100 W = 100 / 1000 = 0.1 kW

Time = 5 hours

Power of the second electric bulb = 60 watt = $\frac{60}{1000} = 0.06$ kW

Total number of bulbs = 4

Time = 5 hours.

Energy consumed in the month of January = ?

Energy = Power × time

Energy consumed by the first bulb in a day = 0.1 × 5 = 0.5 kWh

Energy consumed by the four 60 W bulb in a day = 0.06 × 4 × 5 = 1.2 kWh

Total energy consumed by both the bulbs = 0.5 + 1.2 = 1.7 kWh

Total energy consumed in the month of January = **31 × 1.7 = 52. 7 kWh**

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

Given:

$V = 3V$

$I = 300\ mA = 300 \times 10^{-3}\ A$ time = 4 hours

Power = ? resistance = ? energy = ?

Formula used:

$P = V \times I$

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

$E = P \times t$

(a) Power $= V \times I$

$= 3 \times 600 \times 10^{-3} = \mathbf{1.8\ W}$

(b) Resistance $= \frac{V}{I}$ [$\because V = IR$]

$= \frac{3}{600 \times 10^{-3}} = \mathbf{5\ \Omega}$

(c) Energy consumed in 4 hours

$= P \times t$

$= 1.8 \times 4$

$= \mathbf{7.2\ Wh}$

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?

a) Wire is cut into 5 equal parts. Since all dimensions are same, resistance of each wire is equal and has a value $= \frac{\mathbf{R}}{\mathbf{5}}$

b) Formula for finding the effective resistance when connected in parallel is

$$\frac{1}{R_p'} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$$

Formula used:

Resistors in parallel

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} ..... + \frac{1}{R_n}$$

Here, $R_1 = R_2 = R_3 = R_4 = R_5 = \frac{R}{5}$

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

$$\frac{1}{R_p'} = \frac{25}{R}$$

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

c) If the resistors are connected in series, then the effective resistance will be

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

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

Formula used:

Resistors in series

$$R_s = R_1 + R_2 ..... + R_n$$

Ratio of effective resistance in series connection to that of the parallel connection is

$$\frac{R_s}{R_p} = \frac{R}{R/25} = 25$$

X. Higher Order Thinking Skills (HOTS)

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.

Given:

$R_p = 2\ \Omega$

$R_S = 9\ \Omega$

Formula used:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} ..... + \frac{1}{R_n}$$

$$R_s = R_1 + R_2$$

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_s = R_1 + R_2$$

$$\frac{1}{R_p} = \frac{R_1 + R_2}{R_1 R_2}$$

$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$

$R_p = 2\ \Omega$; $\quad R_1 + R_2 = 9\ \Omega$

$$2 = \frac{R_1 R_2}{9}\ ; \quad R_1 R_2 = 18\ \Omega$$

On solving, $\mathbf{R_1 = 3\ \Omega}$ $\quad R_1 = 6\ \Omega$

(or)

$\mathbf{R_2 = 6\ \Omega}$ $\quad R_2 = 3\ \Omega$

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

Given:

$I = 5\ A$

$t = 1\ s$

Number of electrons?

Formula used:

$$\mathbf{q = It}$$

$$n = \frac{q}{e}$$

$\mathbf{q = It} = 5 \times 1 = 5\ C$

q = ne where n is the number of electrons; e is the charge of an electron which is equal to 1.6×10^{-19} C

$$n = \frac{q}{e} = \frac{5}{1.6 \times 10^{-19}} = 3.125 \times 10^{19} = \mathbf{31.25 \times 10^{18}\ electrons.}$$

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.

Given:

$R = 10\ \Omega$; original length = l, new length $l' = 3l$: Area will decrease by 3 times.

$$R' = \rho \frac{l'}{A'} = \rho \frac{3l}{A/3} = \frac{9\rho l}{A} = 9R = 9\ (10) = \mathbf{90\ \Omega}$$

Formula used:

New resistance value

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

Additional Questions

I. Choose the most suitable answer from the given four alternatives and write the option code and corresponding answer:

1. The rate of flow of electric charge in a conductor is

a) electric current
b) electric potential
c) potential difference
d) none of the above

2. The SI unit of potential is

a) volt
b) ampere
c) joule
d) none

3. The number of the free electrons constitute one coulomb of charge is

a) 6.25×10^{10} electrons
b) 100 electrons
c) 1000 electrons
d) 6.25×10^{18} electrons

4. The potential difference across any of the electrical home appliance is

a) 200 V
b) 220 V
c) 100 V
d) 140 V

5. When 2 V is the potential difference across a conductor, the current is 0.4 A, then the resistance is ★★

a) 5 Ω
b) 50 Ω
c) 0.8 Ω
d) 2 Ω

6. The SI unit of conductivity is

a) ohm m
b) $ohm^{-1}m^{-1}$
c) $ohm\ m^{-1}$
d) ohm

7. A resistor of 18 Ω is connected to 9 V battery, the current in the circuit is

a) 5 A
b) 50 A
c) 0.5 A
d) 1 A

8. The SI unit of power is

a) watt
b) joule
c) ampere
d) volt

9. A fuse has ★

a) high resistance and high melting point
b) high resistance and low melting point
c) low resistance and low melting point
d) None of the above

10. Fuse wire is made up of

a) Alloy of lead and tin
b) Alloy of lead and copper
c) Alloy of tin and copper
d) None of the above

11. **Switch is always connected to**
    a) neutral wire b) live wire
    c) earth wire d) None of the above

12. **1 HP =** ★
    a) 746 W b) 0.746 W c) 74.6 W d) 7.46 W

13. **In series combination of resistances**
    a) Potential difference is same across each resistance
    b) total resistance is reduced
    c) current is same in each resistance
    d) all above are true.

14. **In parallel combination of resistances**
    a) potential difference is same across each resistance
    b) total resistance is increased
    c) current is same in each resistance
    d) all above are true.

15. **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

Ans:

1.	a) electric current	9.	b) high resistance and low melting point
2.	a) volt	10.	a) Alloy of lead and tin
3.	d) 6.25×10^{18} electrons	11.	b) live wire
4.	b) 220 V	12.	a) 746 W
5.	a) 5 Ω	13.	c) current is same in each resistance
6.	b) $ohm^{-1}m^{-1}$	14.	a) potential difference is same across each resistance
7.	c) 0.5 A	15.	b) I^2Rt
8.	a) watt		

II. Fill in the blanks

1. **The motion of _____ through a conductor constitute an electric current.**
2. **Galvanometer is used to _____ of current.** ★
3. **Voltmeter is used to measure the _____.**
4. **The potential difference required for the flow of charges is provided by the _____.**
5. **The electrons flow from the _____ terminal to the _____ terminal of the battery.**
6. **A difference in _____ is needed for the flow of electric charges in a conductor**
7. **_____ established the relation between the potential difference and current.**
8. **The SI unit of resistance is _____**
9. **_____ is conductor with highest resistivity**
10. **_____ is the unit for conductance.**

11. The reciprocal of electrical resistivity is called as _____ . ✱
12. The wiring in a house consists of _____ circuits.
13. The passage of electric current through a wire results in the production of _____.
14. The SI unit of electric power is _____
15. Electrical energy consumed is taken as the product of _____ and _____. ✱
16. 1 kWh is equal to _____ J
17. _____ is used to record the consumption of electrical energy.
18. The function of the fuse wire is used to protect the appliances from _____ due to excess current.
19. In India domestic circuits are supplied with an alternating current of frequency _____.
20. When a live wire comes in contact with a neutral wire, it causes _____.

Ans:

1.	electric charges (or) electrons	11.	electrical conductivity
2.	indicate the direction	12.	parallel
3.	potential difference	13.	heat
4.	battery	14.	watt
5.	negative, positive	15.	electric power and time
6.	electric potential	16.	3.6×10^6 J
7.	George Simon Ohm	17.	Meter
8.	ohm	18.	overloading
9.	Nichrome	19.	50 Hz
10.	ohm^{-1}	20.	short circuit

III. State whether the following statements are true or false. It take Correct the statement.

1. **Ammeter is used to select the magnitude of current through a circuit.** **False**
   A Rheostat is used to select the magnitude of current through a circuit.
2. **The circuit must be closed in order that the current passes through it.** **True**
3. **In a conductor the charges will flow from a point which is at lower electric potential to a point at higher electric potential.** ✱ **False**
   In a conductor the charges will flow from a point which is at higher electric potential to a point at lower electric potential.
4. **Resistance is constant for a given material at a given temperature,** **True**
5. **Resistance is same for different materials.** **False**
   Resistance is different for different material.

6. **Conductivity is more for insulators than for conductors.** **False**
   Conductivity is more for conductors than for insulators.

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

8. **In series connection if one appliance is disconnected others will work independently.** **False**
   In parallel connection if one appliance is disconnected others will work independently..

9. **The heating effect of current is used in electric iron.** **True**

10. **Nichrome is an alloy of Nickel and copper.** **False**
    Nichrome is an alloy of Nickel and Chromium.

IV Match the items in columns -I to the items in column-II.

1.

Column I		Column II	
1) Ammeter	-	a) used to select the magnitude of the current	(b)
2) Voltmeter	-	b) used to measure the current	(c)
3) Galvanometer	-	c) used to measure the voltage	(d)
4) Rheostat	-	d) used to indicate the flow of current	(a)

2.

Column I		Column II ★	
1) 1 horse power	-	a) 50 Hz	(c)
2) 1 kWh	-	b) 1.6×10^{-19} C	(d)
3) Domestic frequency	-	c) 746 W	(a)
4) Charge of an electron	-	d) 3.6×10^{6} J	(b)

3.

Column I		Column II	
1) LED	-	a) Horse Power	(c)
2) LCD	-	b) Miniature circuit breaker	(d)
3) MCB	-	c) Light Emitting Diode	(b)
4) hp	-	d) Liquid Crystal Display	(a)

4.

Column I		Column II	
1) Electric heater	-	a) Tungsten	(c)
2) Fuse wire	-	b) Gallium Arsenide	(d)
3) Filament in bulb	-	c) Nichrome	(a)
4) LED bulbs	-	d) Lead and tin	(b)

V. Reason and Assertion

Mark the correct choice as

a) If both the assertion and the reason are trueand 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:** Resistance is different for different materials.
   Reason: Resistance of a material is its property to oppose the flow of charges and hence passage of current through it.

Ans : a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.

2. **Assertion:** Nichrome is used in making heating elements.
   Reason: Nichrome is a conductor with highest conductivity

Ans : c) If the assertion is true, but the reason is false.

3. **Assertion:** When we touch motor casing of a fan, it is warm, due to the heating effect of current
   Reason: For continuous drawing of current the source has continuously spend its energy. A part of the energy is converted into useful work and the rest will be converted into heat energy.

Ans : a) If both the assertion and the reason are true and the reason is the correct explanation of the assertion.

4. **Assertion:** One way of overcoming the energy crisis is to use more LED bulbs.
   Reason: LED is a semiconductor device that emits visible light when an electric current passes through it.

Ans : b) If both the assertion and the reason aretrue, but the reason is not the correct explanation of the assertion.

5. **Assertion:** Conductivity is more for insulators than for conductors.
   Reason: Electrical resistivity of a conductor is a measure of the resisting power of a specified material to the passage of current. ★

Ans : d) If the assertion is false, but the reason is true.

VI. Very short answer questions.

1. What is an electric circuit?

An electric circuit is a closed conducting loop (or) path which has a network of electrical components through which electrons are able to flow.

2. What is conductance? Give its unit.

Conductance is defined as the **reciprocal** of its **resistance**. It's unit is **ohm^{-1}.**

3. What is electrical conductivity? Give its unit?

The **reciprocal** of **electrical resistivity** is electrical conductivity. It's unit is **ohm^{-1} m^{-1}**

4. Define Power. ★

- Power is defined as the rate of doing work.
- Power = Voltage × current
- $\boxed{P = V I}$

5. Convert 1 kWh into joules.

1 kWh = 1000 watt hour

= 1000 × 60 × 60 watt second = **3.6 × 10^6 J.**

6. What is the function of fuse wire or MCB? ★★

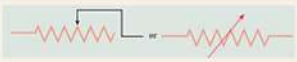
The function of fuse wire or an MCB is to protect the house hold electrical appliances from **overloading** due to **excess current.**

7. How does the overloading happen?

Overloading happens when a large number of appliances are connected in series to the same source of electric power.

VII. Short answer questions

1. Name any 5 components of a circuit. Write the uses and draw the symbols used.

COMPONENT	USE OF THE COMPONENT	SYMBOL USED
Resistor	Used to fix the magnitude of the current through a circuit	
Variable resistor or Rheostat	Used to select the magnitude of the current through a circuit.	
Ammeter	Used to measure the current.	
Voltmeter	Used to measure the potential difference.	
Galvanometer	Used to indicate the direction of current.	

2. Define the unit of resistance.

- The SI unit of resistance is **ohm**.
- Resistance of a conductor is said to be one ohm if a current of **one ampere** flows through it when a potential difference of **one volt** is maintained across its ends.

3. Differentiate series and parallel circuits.

S.No.	CRITERIA	SERIES	PARALLEL
1	Equivalent resistance	**More** than the **highest** resistance.	**Less** than the **lowest** resistance.
2	Amount of current	Current is **less** as effective resistance is **more**.	Current is **more** as effective resistance is **less**.
3	Switching ON/OFF	If one appliance is disconnected, others also **do not work.**	If one appliance is disconnected, others **will work independently.**

4. a) What is Nichrome? ★

b) What are the characteristics of a good heating element?.

a) Nichrome is an alloy of Nickel and chromium.

b) A good heating element should have

- high resistivity
- high melting point
- not easily oxidized

5. How does the earth wire serve as a protective conductor which saves us from electric shocks?

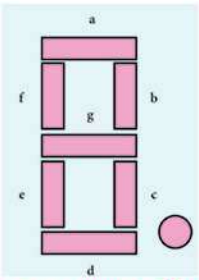
- In domestic circuits, a third wire called the earth wire having a green insulation is usually connected to the body of the metallic electric appliance.
- The other end of the earth wire is connected to a metal tube or a metal electrode, which is buried into the Earth.
- This wire provides a low resistance path to the electric current.
- 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.
- Thus, the earth wire serves as a protective conductor, which saves us from electric shocks. .

6. Write a note on LED Bulbs.

- An LED bulb is a semiconductor device that emits visible light when an electric current passes through it.
- The colour of the emitted light will depend on the type of materials used.
- With the help of the chemical compounds like Gallium Arsenide and
- Gallium Phosphide, the manufacturer can produce LED bulbs that radiates red, green, yellow and orange colours.
- Displays in digital watches and calculators, traffic signals, street lights, decorative lights, etc., are some examples for the use of LEDs.

7. Write a note on seven segment display. ✶

- A 'Seven Segment Display' is the display device used to give an output in the form of numbers or text.
- It is used in digital meters, digital clocks, micro wave ovens, etc.
- It consists of 7 segments of LEDs in the form of the digit 8.
- These seven LEDs are named as a, b, c, d, e, f and g. An extra 8th LED is used to display a dot.



Seven segment display

VIII. Long answer questions

1. With the help of circuit diagrams
(a) Explain a series connection of parallel resistors and
(b) Explain a parallel connection of series resistors. ✶ ✶

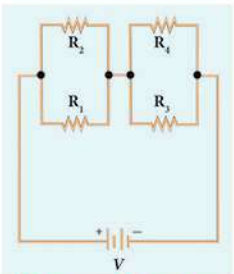
a) Series connection of Parallel resistors:

- If you consider the connection of a set of parallel resistors that are connected in series, you get a series – parallel circuit.
- Let R_1 **and** R_2 be connected in parallel to give an effective resistance of R_{P1}.

- Similarly, let R_3 **and** R_4 be connected in parallel to give an effective resistance of R_{P2}.
- Then, both of these parallel segments are connected in series

$$\frac{1}{R_{P1}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{P2}} = \frac{1}{R_3} + \frac{1}{R_4}$$

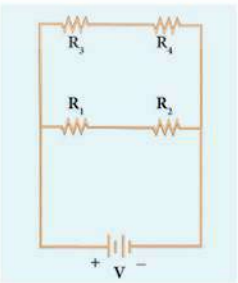


Series-parallel combination of resistors

- The net effective resistance is given by $R_{total} = R_{P1} + R_{P2}$

b) Parallel Connection of Series Resistors:

- If you consider a connection of a set of series resistors connected in a parallel circuit, you get a parallel-series circuit.
- Let R_1 **and** R_2 be connected in series to give an effective resistance of R_{S1}.
- Similarly, let R_3 **and** R_4 be connected in series to give an effective resistance of R_{S2}.
- Then, both of these serial segments are connected in parallel.



Parallel-series combinations of resistor

- Using above equation, we get

  $R_{S1} = R_1 + R_2$, $\quad R_{S2} = R_3 + R_4$

- Finally, the net effective resistance is given by

$$\frac{1}{R_{total}} = \frac{1}{R_{S1}} + \frac{1}{R_{S2}}$$

2. Explain any three applications of heating effect.

Application of heating effect

1. Electric Heating Device:

- The heating effect of electric current is used in many home appliances such as electric iron, electric toaster, electric oven, electric heater, geyser, etc.

- In these appliances Nichrome, which is an alloy of **Nickel and Chromium** is used as the heating element.
- Because: (i) it has **high resistivity**, (ii) it has a **high melting point**, (iii) it is **not** easily **oxidized**.

2. Fuse Wire:

- The fuse wire is **connected in series**, in an electric circuit.
- 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**.
- The fuse wire is made up of a material **lead and tin** whose **melting point** is relatively **low**.

3. Filament in bulbs:

- In electric bulbs, a **small wire** is used, known as filament.
- The filament is made up of a material whose **melting point** is very **high**.
- When current passes through this wire, **heat is produced** in the filament.
- When the filament is heated, it **glows** and gives out light.
- **Tungsten** is the commonly used material to make the filament in bulbs.

IX. Numerical Problems:

1. Calculate the potential difference required across a conductor of resistance 5 Ω to pass a current of 1.5 A through it?

Given

$R = 5\ \Omega$

$I = 1.5\ A$

$V = ?$

Formula used: $V = IR$

From ohm's law $V = I \times R$

$\therefore$ Potential difference $V = 1.5 \times 5 = \mathbf{7.5\ V}$

2. Calculate the resistance of 1 km long copper wire of radius 1 mm. (specific resistance of copper is $1.72 \times 10^{-8}\ \Omega$ m) ★★

Given $l = 1\ km = 1000\ m$

$r = 1\ mm = 10^{-3}\ m$

$A = \pi r^2 = 3.14 \times (10^{-3})^2 = 3.14 \times 10^{-6}\ m^2$

$\rho = 1.72 \times 10^{-8}\ \Omega\ m$

Formula used: $R = \rho \frac{l}{A}$

$$R = \rho \frac{l}{A} = \frac{\left(1.72 \times 10^{-8}\right) \times 1000}{3.14 \times 10^{-6}} = \mathbf{5.5\ \Omega}$$

3. An electric heater of resistance 10 Ω uses 2 A current for 200 seconds. How much electrical energy converts into heat energy? ★

$H = I^2 R\, t = 2^2 \times 10 \times 200 = 8000\ J = \mathbf{8\ kJ}$

Formula used: $H = I^2Rt$

4. If three resistors 2 Ω, 3 Ω and 4 Ω are connected in parallel to a 6 V battery, what is the equivalent resistance of the circuit.

Given $R_1 = 2\Omega$; $R_2 = 3\ \Omega$; $R_3 = 4\ \Omega$

$$\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$$

$$=\frac{1}{2}+\frac{1}{3}+\frac{1}{4}$$

$$=\frac{6+4+3}{12}=\frac{13}{12}$$

$$R_p=\frac{12}{13}\ \Omega$$

Formula used:

Resistors in parallel

$$\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}.....+\frac{1}{R_n}$$

X. Higher Order Thinking Skills (HOTS)

1. A wire of uniform thickness with a resistance of 27 Ω is cut into three equal pieces and they are joined in parallel. Find the resistance of the parallel combination.

Resistance of each piece of wire = $\frac{27}{3}$ = 9 Ω

In parallel, $\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$

$$\frac{1}{R_p}=\frac{1}{9}+\frac{1}{9}+\frac{1}{9}=\frac{3}{9}$$

$$R_p = 3\ \Omega$$

Formula used:

$$\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}.....+\frac{1}{R_n}$$

2. Calculate the value of the resistance which must be connected to a 15 Ω resistance to provide an effective resistance of 6 Ω.

Since effective resistance is decreased. The two resistors are connected in parallel.

$$\frac{1}{15}+\frac{1}{R}=\frac{1}{6}$$

$$\frac{1}{R}=\frac{1}{6}-\frac{1}{15}=\frac{5-2}{30}=\frac{3}{30}=\frac{1}{10}$$

$$R = 10\ \Omega$$

3. Two fuse wires are rated 5 A and 20 A. Which of the two fuse wires are thicker and why?

- A fuse wire when carries current **more than its rating melts** and disconnects the electric circuit.
- Clearly a 20 A fuse has less resistance than a 5 A fuse and is thicker.

4. In a three pin plug why is the earth pin made longer and thicker than other two pins?

- The longer pin ensures the **initial earthing** of electrical appliances
- The **thicker pin differentiate** the earth pin with other two pins.

5. The current through a 12 V tungsten filament lamp connected to a 12 V accumulator of negligible resistance is 3.0 A. Calculate

(i) the resistance of the filament

(ii) the power of the lamp

(iii) the electrical energy in kWh consumed in 5 hours.

Formula used:

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

$P = V \times I$

$E = V\,I\,t$

Given

$V = 12\ V; \quad I = 3\ A; t = 5h$

(i) Resistance $R = \frac{V}{I} = \frac{12}{3} = 4\ \Omega$

(ii) Power $P = V \times I = 12 \times 3 = 36\ W$

(iii) Electrical energy $E = V\,I\,t$

$= 12 \times 3 \times 5 = 180\ Wh$

$= \mathbf{0.18\ kWh}$

Unit Test - 4

Electricity

Time : 1 hr | Marks : 30

I. Choose the most suitable answer and write the code with the corresponding answer. 5 × 1 = 5

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.
2. Kilowatt hour is the unit of
   a) resistivity b) conductivity
   c) electrical energy d) electrical power
3. The number of the free electrons constitute one coulomb of charge is
   a) 6.25×10^{10} electrons b) 100 electrons
   c) 1000 electrons d) 6.25×10^{18} electrons
4. When 2 V is the potential difference across a conductor, the current is 0.4 A, then the resistance is
   a) 5 Ω b) 50 Ω c) 0.8 Ω d) 2 Ω
5. A resistor of 18 Ω is connected to 9 V battery, the current in the circuit is
   a) 5 A b) 50 A c) 0.5 A d) 1 A

II. Answer the following questions in one or two lines. 5 × 2 = 10

1. Define the unit of current.
2. Name any two devices, which are working on the heating effect of the electric current.
3. How does the electric current pass in circuit?
4. Convert 1 kWh into joules.
5. State Ohm's law.

III. Answer the fllowing questions in brief: 2 × 4 = 8

1. Name any 5 components of a circuit. Write the uses and draw the symbols used.
2. i) An alloy of nickel and chromium is used as the heating element. Why?
   ii) How does a fues wire protect electrical appliances?

IV. Answer the fllowing questions in detail: 1 × 7 = 7

1. i) State Joule's law of heating.
   ii) 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.