# Class: 10th

# Subject: Physics

# Unit 14: CURRENT ELECTRICITY

## Exercise MCQs:

**1. An electric current in conductors is due to the flow of:**

(a) positive ions

(b) negative ions

(c) positive charges

**(d)** free electrons ✅

**2. What is the voltage across a 6 Ω resistor when 3 A of current passes through it?**

(a) 2 V

(b) 9 V

**(c)** 18 V ✅

(d) 36 V

(V = I × R = 3 × 6 = 18V)

**3. What happens to the intensity or the brightness of the lamps connected in series as more and more lamps are added?**

(a) increases

(b) decreases ✅

(c) remains the same

(d) cannot be predicted

**4. Why should household appliances be connected in parallel with the voltage source?**

(a) to increase the resistance of the circuit

(b) to decrease the resistance of the circuit

(c) to provide each appliance the same voltage as the power source ✅

(d) to provide each appliance the same current as the power source

**5. Electric potential and e.m.f:**

(a) are the same terms

(b) are the different terms

(c) have different units

(**d**) both (b) and (c) ✅

**6. When we double the voltage in a simple electric circuit, we double the:**

(**a**) current ✅

(b) power

(c) resistance

(d) both (a) and (b)

**7. If we double both the current and the voltage in a circuit while keeping its resistance constant, the power:**

(a) remains unchanged

(b) halves

(c) doubles

(**d**) quadruples ✅

**8. What is the power rating of a lamp connected to a 12 V source when it carries 2.5 A?**

(a) 4.8 W

(b) 14.5 W

(c) 30 W ✅

(d) 60 W

(P = V × I = 12 × 2.5 = 30 W)

**9. The combined resistance of two identical resistors, connected in series is 8 Ω. Their combined resistance in a parallel arrangement will be:**

(a) 2 Ω ✅

(b) 4 Ω

(c) 8 Ω

(d) 12 Ω

(If $R_1 = R_2 = 4\ \Omega$, then in parallel: $1/R = 1/4 + 1/4 = 2/4 \Rightarrow R = 2\ \Omega$)

**10. Voltmeter is always connected:**

(a) in series

(b) in reverse

(c) parallel to the circuit component ✅

(d) nowhere in the circuit

## Important MCQs:

**1. The SI unit of electric current is:**

(a) Volt

(b) Ohm

(c) Ampere ✅

(d) Watt

**2. The formula for heat produced in a resistor is:**

(a) V = IR

(b) W = IRt ✅

(c) P = VI

(d) Q = It

**3. According to Ohm's Law, current is directly proportional to:**

(a) Resistance

(b) Power

(c) Potential difference ✅

(d) Energy

**4. The resistance of a conductor is measured in:**

(a) Ampere

(b) Watt

(c) Volt

(d) Ohm ✅

**5. The opposition offered to the flow of current is called:**

(a) Voltage

(b) Resistance ✅

(c) Power

(d) Current

**6. Materials in which electrons cannot move freely are called:**

(a) Conductors

(b) Semiconductors

(c) Resistors

(d) Insulators ✅

**7. The instrument used to measure current is called:**

(a) Voltmeter

(b) Galvanometer

(c) Ammeter ✅

(d) Resistor

**8. The instrument used to measure potential difference is:**

(a) Resistor

(b) Ammeter

(c) Voltmeter ✅

(d) Galvanometer

**9. In a series circuit, total resistance is equal to:**

(a) Product of all resistances

(b) Reciprocal sum of resistances

(c) Sum of all resistances ✅

(d) Zero

**10. The current which changes its direction after regular intervals is called:**

(a) Direct current

(b) Induced current

(c) Alternating current ✅

(d) Static current

**11. In metals, electric current is produced due to the flow of:**

(a) Positive ions

(b) Negative ions

(c) Free electrons ✅

(d) Bound electrons

**12. What is the SI unit of electric current?**

(a) Volt

(b) Coulomb

(c) Ampere ✅

(d) Ohm

**14. Electric current in an electrolyte is due to the flow of:**

(a) Only electrons

(b) Only protons

(c) Positive and negative ions ✅

(d) Neutrons

**15. The flow of current from the positive terminal to the negative terminal of a battery is called:**

(a) Real current

(b) Electron flow

(c) Negative current

(d) Conventional current ✅

**16. Which device is used to detect small currents in a circuit?**

(a) Voltmeter

(b) Thermometer

(c) Galvanometer ✅

(d) Barometer

**17. Which instrument is used to measure large currents in a circuit?**

(a) Ammeter ✅

(b) Multimeter

(c) Galvanometer

(d) Ohmmeter

**18. How is an ammeter connected in a circuit?**

(a) In parallel

(b) Diagonally

(c) In series ✅

(d) In reverse

**19. What causes the potential difference in a battery?**

(a) Magnetic force

(b) Electrochemical reaction ✅

(c) Frictional heating

(d) Gravitational force

**20. What remains constant when current flows**

**through a battery-powered circuit?**

(a) Potential energy

(b) Number of charge carriers ✅

(c) Heat energy

(d) Temperature

**21. What causes the flow of current in a conductor?**

(a) Resistance

(b) Electric field

(c) Potential difference ✅

(d) Magnetic field

**22. Which device provides potential difference for a steady flow of current?**

(a) Resistor

(b) Voltmeter

(c) Galvanometer

(d) Battery ✅

**23. What is the SI unit of potential difference?**

(a) Ampere

(b) Coulomb

(c) Joule

(d) Volt ✅

**24. A potential difference of 1 volt means:**

(a) 1 joule per ampere

(b) 1 joule per coulomb ✅

(c) 1 coulomb per joule

(d) 1 ampere per volt

**25. What happens to electrical energy when it flows through a conductor?**

(a) It disappears

(b) It reflects back

(c) It is converted into heat and light ✅

(d) It increases the charge

**26. Which instrument is used to measure potential difference?**

(a) Ammeter

(b) Voltmeter ✅

(c) Thermometer

(d) Galvanometer

**27. How is a voltmeter connected in a circuit?**

(a) In series

(b) In parallel ✅

(c) Diagonally

(d) Across the battery only

**28. An ideal voltmeter has:**

(a) Very low resistance

(b) Zero resistance

(c) Very high resistance ✅

(d) No resistance

**29. What is the function of a source of e.m.f.?**

(a) Converts electrical energy into heat

(b) Measures electric current

(c) Converts non-electrical energy into electrical energy ✅

(d) Increases circuit resistance

30. The formula for electromotive force (e.m.f.) is:

(a) E = W / Q ✅

(b) E = Q × W

(c) E = Q + W

(d) E = W − Q

31. According to Ohm's Law, current is directly proportional to:

(a) Resistance

(b) Voltage ✅

(c) Power

(d) Temperature

32. What is the formula for Ohm's Law?

(a) V = IR ✅

(b) V = I/R

(c) V = R/I

(d) V = $I^2R$

33. What is the SI unit of resistance?

(a) Ampere

(b) Volt

(c) Ohm ✅

(d) Watt

**34. When 60 V is applied and the current is 2 A, the resistance is:**

(a) 30 Ω ✅

(b) 120 Ω

(c) 62 Ω

(d) 58 Ω

**35. Which of the following is an Ohmic conductor?**

(a) Filament lamp

(b) Thermistor

(c) Metal wire ✅

(d) Diode

**36. Why are metals good conductors of electricity?**

(a) They have tightly bound electrons

(b) They reflect electric current

(c) They contain free electrons ✅

(d) They have high resistance

**37. What happens to the resistance of a metal wire as its temperature increases?**

(a) It decreases

(b) It remains the same

(c) It becomes zero

(**d**) It increases ✅

**38. A thermistor behaves in what way when heated?**

(a) Resistance increases

(**b**) Resistance decreases ✅

(c) No change in resistance

(d) Becomes an insulator

**39. Which device is used to plot the V–I graph to verify Ohm's Law?**

(a) Voltmeter

(b) Thermometer

(**c**) Ammeter and voltmeter ✅

(d) Galvanometer only

**40. Why can insulators not conduct electricity?**

(a) They have no electrons

(b) They are magnetic

(c) Their electrons are tightly bound and not free ✅

(d) They have high voltage

**41. In a series circuit, the current through each resistor is:**

(a) Different

(b) Maximum

(c) Same ✅

(d) Zero

**42. The total resistance in a series combination is:**

(a) Greater than the largest resistance ✅

(b) Less than the smallest resistance

(c) Equal to the smallest resistance

(d) Zero

**43. In a parallel circuit, the voltage across each**

**resistor is:**

(a) Zero

(b) Half of total voltage

(c) Different

(d) Same ✅

**44. In parallel combination, total current is:**

(a) Equal to current through one resistor

(b) Sum of currents through each resistor ✅

(c) Same in all resistors

(d) Zero

**45. The equivalent resistance of a parallel combination is:**

(a) Greater than the largest resistance

(b) Less than the smallest resistance ✅

(c) Sum of all resistances

(d) Same as in series

**46. Which of the following is an advantage of a parallel circuit?**

(a) Voltage drops across devices

(b) All devices share same current

(c) Devices work independently ✅

(d) More resistance is added

**47. What does Joule's law describe?**

(a) Increase in voltage

(b) Change in temperature

(c) Heat produced in a resistor ✅

(d) Magnetic field

**48. If a 6V battery supplies 0.5 A current for 20 seconds, what is the energy transferred?**

(a) 10 J

(b) 60 J

(c) 40 J ✅

(d) 30 J

**49. Which form of energy is mostly observed when current flows through a heater?**

(a) Light energy

(b) Mechanical energy

(c) Heat energy ✅

(d) Nuclear energy

**50. What is the formula for electric power when energy and time are known?**

(a) $P = V \times t$

(b) $P = W / t$ ✅

(c) $P = Q / t$

(d) $P = I / V$

**51. Which formula shows electric power in terms of current and resistance?**

(a) $P = IV$

(b) $P = V^2 / R$

(c) $P = I^2R$ ✅

(d) $P = V / I$

**52. What is the SI unit of electric power?**

(a) Volt

(b) Ohm

(c) Joule

(d) Watt ✅

**53. 1 kilowatt-hour is equal to:**

(a) 100 J

(b) 360 J

(c) 3600 J

(d) $3.6 \times 10^6$ J ✅

**54. What is the cost of using a 50 W bulb for 8 hours daily for 30 days, if the cost per unit is Rs. 12?**

(a) Rs. 120

(b) Rs. 144 ✅

(c) Rs. 96

(d) Rs. 160

**55. Which of the following is a unidirectional current?**

(a) A.C

(b) Voltage

(c) D.C ✅

(d) Resistance

**56. What is the frequency of alternating current in Pakistan?**

(a) 60 Hz

(b) 100 Hz

(c) 25 Hz

(**d**) 50 Hz ✅

**57. The wire that carries no electricity and is connected to a metal plate in the ground is called:**

(a) Neutral wire

(b) Live wire

(**c**) Ground wire ✅

(d) Positive wire

**58. What is the potential difference between the live and neutral wires in a house?**

(a) 110 V

(b) 250 V

(**c**) 220 V ✅

(d) 100 V

**59. Why are electrical appliances in a house connected in parallel?**

(a) To use less current

(b) To reduce voltage

(c) So all get same voltage ✅

(d) To increase resistance

**60. What is the major cause of insulation damage in electrical wires?**

(a) Moisture absorption

(b) Excess heat due to high voltage

(c) Overcurrent causing overheating ✅

(d) Dust accumulation

**61. What happens when the livewire and neutral wire come into direct contact?**

(a) The appliance stops working

(b) The fuse wire becomes cold

(c) A short circuit occurs ✅

(d) Resistance increases

**62. What is the resistance of dry human skin approximately?**

(a) 10 ohms

(b) 1000 ohms

(c) 10,000 ohms

(**d**) 100,000 ohms ✅

**63. Which safety device disconnects the circuit automatically if excessive current flows?**

(a) Fuse

(b) Switch

(c) Earthwire

(**d**) Circuit breaker ✅

**64. What is the function of the Earthwire in an electric appliance?**

(a) Increases current flow

(b) Prevents voltage drop

(**c**) Provides safe path for current in case of fault

✅

(d) Powers the appliance directly

## Important Short Questions:

**1. What is electric current?**

**Answer:**

The time rate of flow of electric charge through any cross-section is called electric current.

**2. What is conventional current?**

**Answer:**

Conventional current is the flow of positive charge, which is equivalent to the flow of negative charge in the opposite direction.

**3. What is the SI unit of electric current?**

**Answer:**

The SI unit of electric current is Ampere.

**4. Define e.m.f.**

**Answer:**

e.m.f. is the total energy supplied by a battery to move one coulomb of charge from the negative to the positive terminal.

**5. State Ohm's Law.**

**Answer:**

Ohm's Law states that current is directly proportional to the potential difference across a conductor, provided temperature and physical state remain unchanged.

**6. What is resistance?**

**Answer:**

Resistance is the opposition to the flow of current in a conductor. Its SI unit is ohm (Ω).

**7. What is the difference between conductors and insulators?**

**Answer:**

Conductors allow free movement of electrons to pass electricity, while insulators do not allow free electrons to flow.

**8. How is equivalent resistance calculated in series combination?**

**Answer:**

In series, the total resistance is the sum of all individual resistances:

$R = R_1 + R_2 + R_3 + ... + R_n$

**9. How is equivalent resistance calculated in parallel combination?**

**Answer:**

In parallel, the reciprocal of total resistance is equal to the sum of reciprocals of individual resistances:

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

**10. What is Joule's Law of heating?**

**Answer:**

Joule's law states that heat produced in a resistor is equal to the square of current multiplied by resistance and time:

$W = I^2Rt$

**11. What is electric current?**

**Answer:**

The rate of flow of electric charge through any cross-sectional area is called electric current.

**12. Which charge carriers are responsible for current in metals?**

**Answer:**

In metals, electric current is produced due to the flow of free electrons (negative charges).

**13. What is the SI unit of electric current?**

**Answer:**

The SI unit of electric current is ampere (A).

**14. Define 1 ampere of current.**

**Answer:**

If 1 coulomb of charge passes through a conductor in 1 second, the current is 1 ampere.

**15. What is conventional current?**

**Answer:**

Conventional current is the current that flows from the positive terminal to the negative terminal of a battery due to the flow of positive charges.

**16. What is the function of a galvanometer?**

**Answer:**

A galvanometer is a sensitive instrument used to detect small electric currents in a circuit.

**17. How is an ammeter connected in a circuit?**

**Answer:**

An ammeter is connected in series in the circuit so that the current flows through it.

**18. What is the function of a battery in a circuit?**

**Answer:**

A battery provides a potential difference between its terminals, which pushes the charges to flow in the circuit.

**19. What is meant by potential difference?**

**Answer:**

Potential difference is the work done to move a unit

charge from one point to another in an electric field.

**20. What is the unit of potential difference and what does 1 volt mean?**

**Answer:**

- The SI unit is volt (V).
- 1 volt means 1 joule of energy is used to move 1 coulomb of charge.

**21. What is electromotive force (e.m.f)?**

**Answer:**

e.m.f is the energy supplied by a source to one coulomb of positive charge to move it through the complete circuit.

**22. What are the common sources of e.m.f?**

**Answer:**

Batteries, thermocouples, and generators are common sources of e.m.f.

**23. How is e.m.f mathematically expressed?**

**Answer:**

e.m.f = Energy / Charge ’n  E = W / Q

**24. How is e.m.f measured?**

**Answer:**

e.m.f is measured using a voltmeter connected directly across the battery terminals without current flowing in the external circuit.

**25. What is Ohm's Law?**

**Answer:**

Ohm's law states that current through a conductor is directly proportional to the potential difference across its ends, provided temperature and physical conditions remain unchanged.

**26. Write the formula of Ohm's Law.**

**Answer:**

V = IR, where V is voltage, I is current, and R is resistance.

**27. Define resistance.**

**Answer:**

Resistance is the opposition offered by a substance to the flow of electric current through it.

**28. What is the SI unit of resistance?**

**Answer:**

The SI unit of resistance is ohm (Ω).

**29. What are Ohmic and Non-ohmic conductors?**

**Answer:**

Ohmic conductors obey Ohm's Law and have constant resistance, while non-ohmic conductors do not follow Ohm's Law and their resistance changes with voltage or temperature.

**30. Name three factors affecting the resistance of a conductor.**

**Answer:**

1. Length of the conductor ($R \propto L$)

2. Cross-sectional area ($R \propto 1/A$)

3. Nature of material and temperature

**31. Why are metals used as conductors of electricity?**

**Answer:**

Because metals have free electrons which allow

current to flow easily.

**32. Why does the resistance of a conductor increase with temperature?**

Answer: Due to increased collisions of electrons with atoms and with each other.

**33. Why is rubber an insulator?**

**Answer:**

Because its electrons are tightly bound and cannot move freely.

**34. Give any three examples of insulating materials.**

**Answer:**

Glass, wood, plastic.

**35. What is meant by series combination of resistors?**

**Answer:**

A connection where resistors are connected end to end and current has only one path.

**36. What is the formula for equivalent resistance in a series circuit?**

Answer:

**37. What is meant by parallel combination of resistors?**

**Answer:**

A connection where one end of each resistor is connected to the same potential difference.

**38. State Joule's law of electrical energy.**

**Answer:**

Heat produced

**39. What is kilowatt-hour?**

**Answer:**

- The energy used when 1 kW power is consumed in 1 hour.
- 1 kWh = $3.6 \times 10^6$ joules

**40. What is the difference between direct current (DC) and alternating current (AC)?**

**Answer:**

Direct current (DC) flows in one direction and has constant polarity, whereas alternating current (AC)

changes its direction and polarity periodically.

**41. Why is alternating current (AC) used in homes instead of direct current (DC)?**

**Answer:**

AC is used in homes because it is more practical for transferring electrical energy over long distances and can be easily generated and transformed.

**42. What is the function of a fuse in house wiring?**

**Answer:**

A fuse is a safety device that melts and breaks the circuit if excess current flows, thus protecting electrical appliances from damage.

**43. What happens during a short circuit and why is it dangerous?**

**Answer:**

A short circuit occurs when current flows through a low-resistance path, causing excessive current that can melt wires, damage appliances, or start a fire.

**44. How does earthing protect us from electric**

**shocks?**

**Answer:**

Earthing provides a low-resistance path for the current to flow safely into the ground if the livewire touches the metal casing of an appliance, preventing electric shocks.

## Important Long Questions:

🌟 **Q1: What is electric current? Explain the flow of electric current in metals and electrolytes.**

❖ **Definition of Electric Current:**

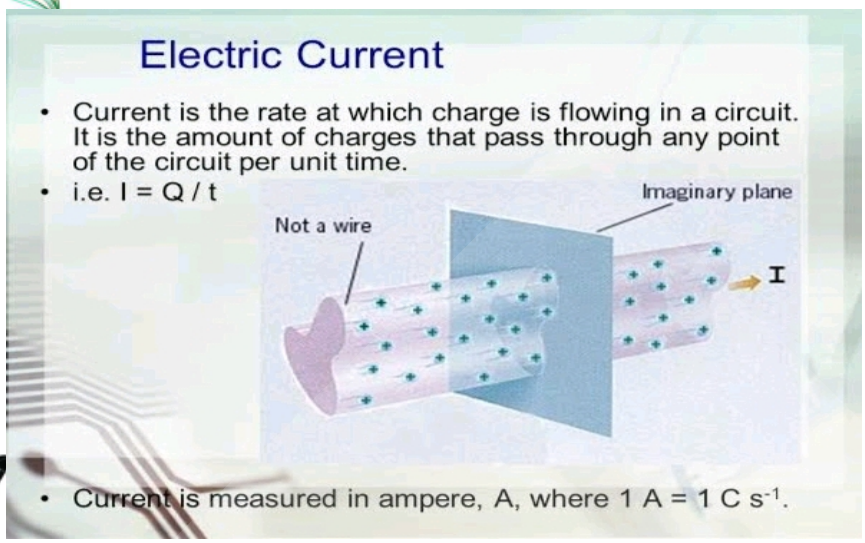
Electric current is defined as the rate of flow of electric charge through any cross-sectional area of a conductor.

**Formula:**

$I = Q / t$

(Where I = current, Q = charge, t = time)

If 1 coulomb of charge passes through a point in 1 second, the current is said to be 1 ampere.




## Flow of Electric Current in Metals

### Role of Free Electrons:

- Metals have loosely bound free electrons.
- In the absence of electric field, these electrons move randomly.
- When a battery is connected, it creates a potential difference.
- The free electrons start moving in a specific direction, opposite to the electric field.
- This directed flow of free electrons is called electric current in metals.
- In metals, only negative charges (electrons) are responsible for the current.

- Flow of Electric Current in Electrolytes

## Dissociation of Molecules in Electrolyte:

Electrolytes (like salt or acid in water) dissociate into positive and negative ions.

**Example**: $NaCl \Rightarrow Na^+ + Cl^-$

These ions are charge carriers in liquids.

## Flow of Charges:

## When an electric field is applied:

- Positive ions (cations) move toward the negative terminal.
- Negative ions (anions) move toward the positive terminal.
- Hence, in electrolytes, current flows due to the movement of both positive and negative charges.

## ✅ Explanation:

- **In metals**, current flows due to free electrons, which are negatively charged.
- **In electrolytes**, current is carried by both

positive (cations) and negative (anions) ions.

🔍 **Summary:**

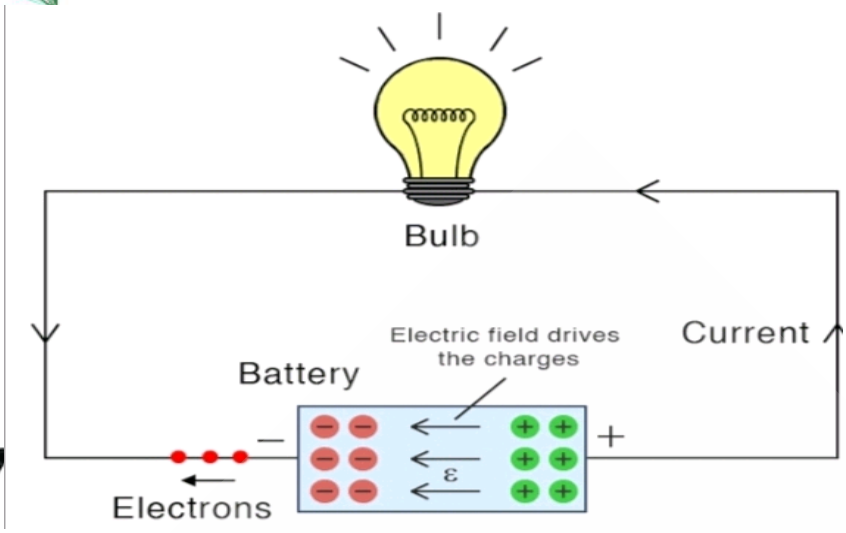
- Electric current is the flow of electric charge.
- In metals, current is caused by the movement of free electrons only.
- In electrolytes, current results from the movement of both positive and negative ions, which are produced due to dissociation of molecules.
- The potential difference provided by a battery or source causes the charges to move in a specific direction, creating current.

🌟 **Q2: What is Electromotive Force (e.m.f.)?**

❖ **Definition of e.m.f.**

Electromotive force (e.m.f.) is the total energy supplied by a battery or cell to move one coulomb of positive charge from its negative terminal to the positive terminal inside the battery.

🧪 It is not a force, but a kind of energy per unit charge.




## 🔸 Explanation:

- A battery converts chemical energy into electrical energy.
- Inside the battery, this energy is used to push the positive charges from the negative terminal to the positive terminal.
- This buildup of energy allows charges to flow in an external circuit when connected.
- The e.m.f. creates the potential difference required for current to flow.

## 📘 Mathematical Formula:

e.m.f (E) = W / Q

**Where:**

E = Electromotive force (in volts)

W = Work done or energy supplied (in joules)

Q = Charge (in coulombs)

### 🧮 Numerical Example:

Let's say a 2V battery moves 10 coulombs of charge:

E = W / Q

W = E × Q

W = 2 V × 10 C = 20 joules

✅ This means the battery supplies 20 joules of energy to move 10 coulombs of charge.

### ⚠ Unit of e.m.f.:

The SI unit of e.m.f. is the volt (V).

1 volt = 1 joule per coulomb.

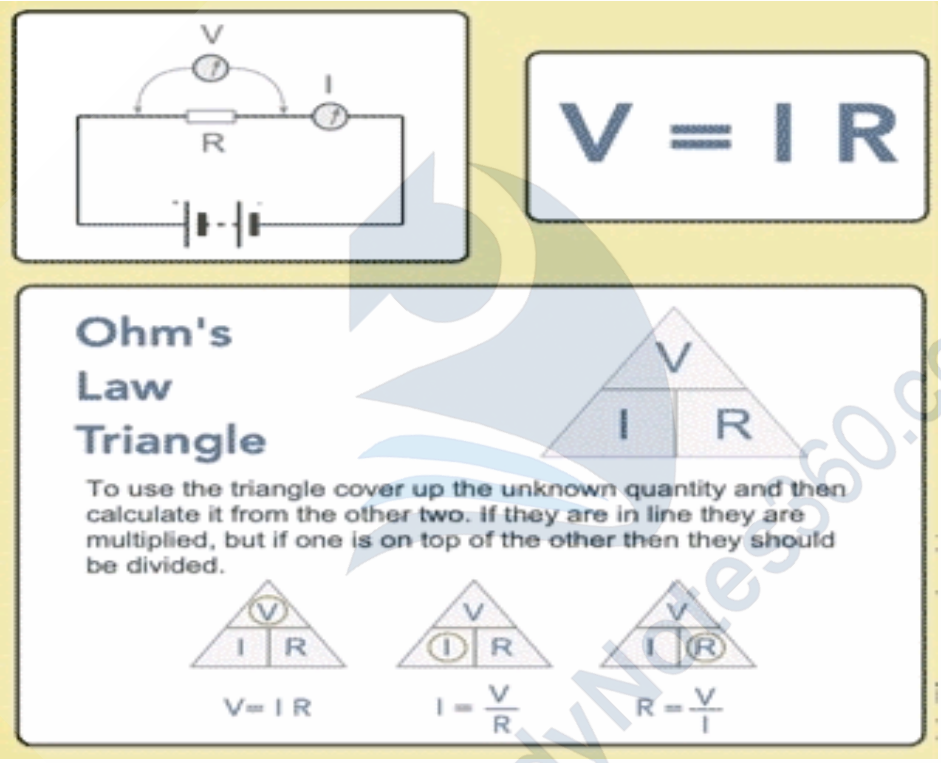
### 🔍 Summary:

Electromotive force (e.m.f.) is the energy provided by a cell or battery to move one coulomb of charge through the internal and external circuit. It is measured in volts, and calculated by the formula E

= W/Q. It explains how a battery performs work to create current by moving charges from low to high potential.

### 🌟 Q3: State and Explain Ohm's Law.

#### 🔹 Statement of Ohm's Law:




**Ohm's Law states that:**

> "The current (I) passing through a conductor is directly proportional to the potential difference (V) across its ends, provided the temperature and physical state of the conductor remain constant."

#### 🔹 Mathematical Form:

$$V \propto I \quad \text{or} \quad V = IR$$

Where:

- $V$ = Potential difference (in volts
- $I$ = Current (in amperes)
- $R$ = Resistance of the conductor ohms, $\Omega$)

---

## Explanation of Terms:

**Potential Difference (V):**

The energy provided by the battery per unit charge to move electrons through the conductor.

**Current (I):**

The rate of flow of electric charge (electrons) in the conductor.

**Resistance (R):**

The property of a conductor that resists or opposes the flow of electric current. Resistance depends on material, length, cross-sectional area, and temperature.

## 🔹 Conditions for Validity of Ohm's Law:

**Ohm's Law is valid only when:**

1. The temperature of the conductor remains constant.

2. The physical state (like length, area, material) of the conductor does not change.

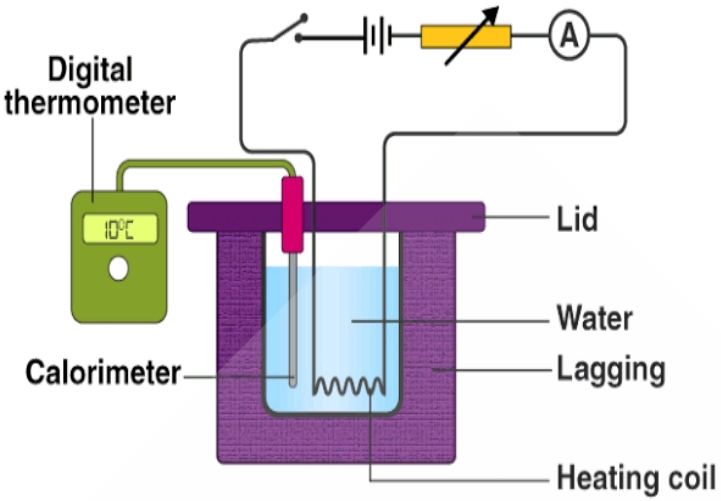
3. The conductor used is ohmic (obeys Ohm's law, e.g., metals like copper, nichrome).

### 🔍 Summary:

- Ohm's Law shows the linear relationship between voltage and current.
- The formula  is used in almost all electric circuit calculations.
- It helps define resistance and explains how current changes with voltage.
- The law is only applicable if temperature and physical conditions are unchanged.

### 🌟 Q4: State and explain Joule's Law of Heating.

## 🔹 Statement of the Law:




**Joule's Law of Heating states that:**

> "The heat produced (or electrical energy converted into heat) in a resistor is directly proportional to the square of the current, the resistance, and the time for which current flows."

- **Mathematical Expression:**

$$W = I^2 \times R \times t$$

- **W – Heat Energy**
  - It is the total heat produced when electric current flows through a conductor.
  - This heat is generated due to the resistance in the wire.

- It depends on current (I), resistance (R), and time (t).
- **Formula**: $W = I^2Rt$
- Unit: Joules (J)

### I – Electric Current

- It is the flow of electric charge per unit time.
- Higher current means more charge is flowing through the circuit.
- It is a fundamental quantity in electricity.
- **Unit**: Amperes (A)

### R – Resistance

- It is the opposition a material offers to the flow of electric current.
- More resistance means less current flows.
- Materials like copper have low resistance, while rubber has high resistance.
- **Unit**: Ohms (Ω)

### t – Time

- It is the duration for which the electric current flows in the circuit.
- The longer the time, the more heat is produced.
- Time plays a key role in calculating total heat.
- Unit: Seconds (s)

### Units of Energy:

- SI Unit of W (Energy): Joule (J)
- 1 Joule = Energy used when 1 Ampere of current flows through 1 Ohm of resistance for 1 second.

### Explanation:

When an electric current passes through a resistor, the free electrons collide with atoms, converting electrical energy into heat energy.

**The amount of heat produced depends on:**

- How strong the current is ($I^2$)
- How high the resistance is (R)
- How long the current flows (t)

### Practical Examples:

### 1. Electric Bulb:

The filament of the bulb gets hot due to resistance and produces light + heat.

### 2. Electric Heater / Iron:

These appliances use high resistance coils to convert electrical energy into heat energy for warming.

### 3. Electric Kettle:

Uses Joule heating to boil water by passing current through a resistive heating element.

### 🔍 Summary:

**Joule's Law tells us that the heat produced in a resistor increases:**

- More rapidly with higher current ($I^2$)
- Directly with resistance (R)
- Linearly with time (t)

This law is the basis of all electrical heating devices like irons, heaters, toasters, etc.

# Exercise Questions:

## REVIEW QUESTIONS

🌟 **Q14.1: Define and explain the term Electric Current.**

❖ **Definition:**

Electric current is the rate at which electric charge flows through a point in a conductor.

✅ **Explanation:**

When a battery or any source of voltage is applied across a conductor, electrons start moving through it. This movement of electrons in a specific direction is called electric current. Current always flows from higher potential to lower potential in the external circuit.

✅ **Formula:**

$I = Q / t$

**Where:**

- I = Current (ampere, A)

- Q = Charge (coulombs, C)
- t = Time (seconds, s)

✅ **Unit:**

- The SI unit of current is ampere (A).
- 1 A = 1 C / 1 s

✅ **Example:**

- If 12 coulombs of charge flow in 3 seconds,
- then current I = Q / t = 12 / 3 = 4 A

🔍 **Summary:**

Electric current is the flow of charge per unit time. It is measured in amperes. The direction of flow is from higher to lower potential, and its formula is I = Q / t.

🌟 **Q14.2: What is the difference between Electronic Current and Conventional Current?**

❖ **Electronic Current:**

This is the actual flow of electrons in a conductor. Electrons move from the negative terminal to the positive terminal of a battery.

## Conventional Current:

This is the assumed flow of current from the positive terminal to the negative terminal. It was defined before the discovery of electrons and is still widely used in circuit diagrams.

## Electronic Current:

- Direction: Flows from Negative to Positive terminal.
- Based on: Actual flow of electrons.
- Used in: Modern physics and real-world electron flow explanations.
- Nature: Electrons (which are negatively charged) move from the negative terminal to the positive terminal.

## Conventional Current:

- **Direction**: Flows from Positive to Negative terminal.
- **Based on:** Historical assumption made before electron discovery.

- **Used in**: Circuit diagrams, textbooks, and theoretical analysis.
- **Nature**: Imaginary flow of positive charge used for ease of calculation.

🔍 **Summary:**

Electronic current flows from negative to positive due to electron movement, while conventional current flows from positive to negative by assumption. Both are opposite in direction but used in different contexts.

🌟 **Q14.3: What do we mean by the term e.m.f.? Is it really a force? Explain.**

❖ **Definition of e.m.f.:**

e.m.f. stands for electromotive force. It is the energy provided by a source (like a battery or cell) to move 1 coulomb of charge through the entire circuit (external + internal).

🔹 **Explanation:**

Although the word "force" is used in the name, e.m.f. is not a force in the mechanical sense. It is actually

the energy per unit charge supplied by a source to move charges around a circuit.

**Formula:**

e.m.f. (E) = W / Q

**Where:**

E = e.m.f. in volts (V)

W = Work done or energy supplied (Joules)

Q = Charge (Coulombs)

🔸 **Units:**

Volt (V) — 1 Volt = 1 Joule / 1 Coulomb

**Example:**

- If a battery does 6 joules of work to move 2 coulombs of charge,
- then e.m.f. = 6 / 2 = 3 volts

🔍 **Summary:**

e.m.f. (electromotive force) is the energy per unit charge supplied by a source, not an actual force. It is measured in volts and determines how much energy is given to charges in a circuit.

🌟 **Q14.4: How can we differentiate between e.m.f. and potential difference?**

❖ **Definition:**

**1. e.m.f.:**

The total energy supplied by the source (e.g., battery) to move one coulomb of charge around the complete circuit.

**Potential Difference (P.D.):**

The energy used by one coulomb of charge to move between two points in a circuit (like across a resistor).

**2. Where it is measured:**

- **e.m.f.:** Measured across the terminals of a source (like battery or generator) when no current is drawn.
- **P.D.:** Measured between two points in a circuit (usually across a component).

**3. Energy role:**

- **e.m.f.:** Represents total energy supplied by the

source.

- **P.D.:** Represents energy consumed by components like bulbs or resistors.

## 4. Mathematical Form:

- e.m.f. (E) = W / Q
- P.D. (V) = W / Q

👉 Both have the same unit (Volt), but they apply to different parts of the circuit.

✅ Example: If a battery supplies 12V (e.m.f.) but a bulb in the circuit only gets 10V (P.D.), it means 2V was lost inside the battery due to internal resistance.

🔍 **Summary:**

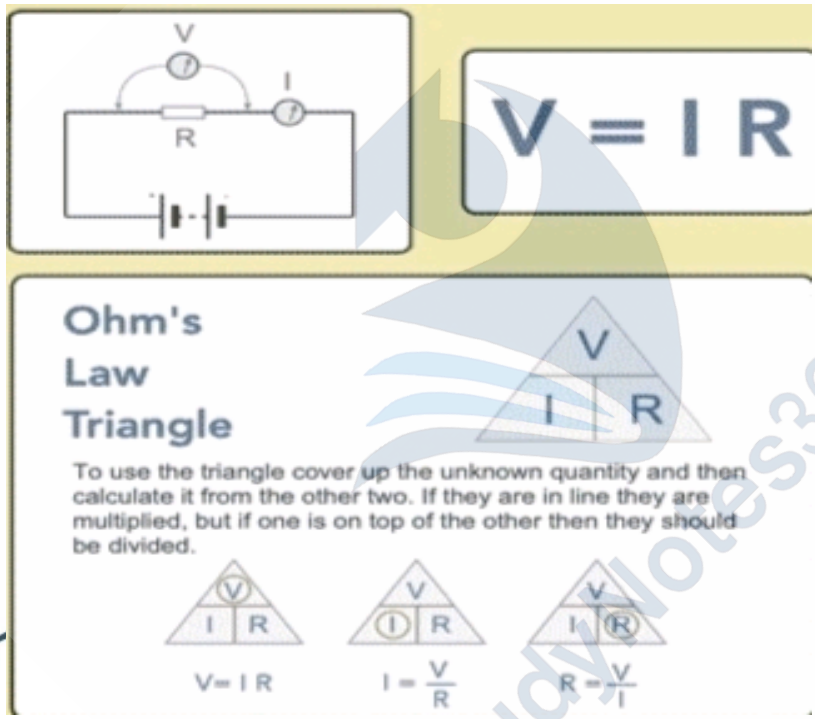
e.m.f. is the total energy supplied by a source, while potential difference is the energy used by components in the circuit. Both are measured in volts but apply to different locations and meanings.

🌟 **Q14.5: Explain Ohm's Law. What are its limitations?**

## ❖ Definition of Ohm's Law:

**Ohm's law states that:**

> "The current (I) passing through a conductor is directly proportional to the potential difference (V) across its ends, provided the temperature and physical conditions remain constant."




## Mathematical Form:

V = IR

V = potential difference (volts)

I = current (amperes)

R = resistance (ohms, Ω)

## ⚠ Limitations of Ohm's Law:

### 1. Not applicable to non-linear (non-ohmic) devices:

Devices like diodes, transistors, vacuum tubes do not obey Ohm's law because the V-I graph is not a straight line.

### 2. Temperature dependency:

Ohm's law is valid only when temperature remains constant. In real devices like bulbs or wires, temperature affects resistance.

### 3. Doesn't apply to semiconductors:

Semiconducting materials (e.g., silicon, germanium) do not follow Ohm's Law due to their special electrical properties.

### 🔍 Summary:

Ohm's law relates voltage, current, and resistance using the formula . It holds true for conductors at constant temperature but fails for devices like diodes, transistors, and semiconductors.

### 🌟 Q14.6: Define resistance and its units.

❖ **Definition of Resistance:**

"Resistance is the opposition offered by a conductor to the flow of electric current through it."

**It depends on:**

- Material of conductor
- Length and cross-sectional area
- Temperature

✅ **Formula:**

R = V/I

R = resistance (ohms)

V = potential difference (volts)

I = current (amperes)

**SI Unit of Resistance:**

Ohm (Ω)

> 1 Ohm = 1 Volt / 1 Ampere

🔹 **Explanation:**

A conductor has a resistance of 1 ohm if a potential difference of 1 volt produces a current of 1 ampere.

🔍 **Summary:**

Resistance is the opposition to the flow of current. Its unit is ohm (Ω), and it depends on the conductor's material, dimensions, and temperature.

🌟 **Q14.7: What is the difference between conductors and insulators?**

❖ **Answer:**

- **Conductors** are materials that allow electric current to pass through them easily because they have a large number of free electrons. These free electrons move when potential difference is applied, resulting in current flow.
- **Insulators** are materials that do not allow electric current to pass through them because they lack free electrons. Their electrons are tightly bound and cannot move freely.

**Explanation:**

In **conductors**, current flows easily due to availability of mobile charge carriers (free electrons).

In **insulators**, electrons are not free to move, so they block electric current.

**Examples of Conductors:** Copper, aluminum, silver, gold.

**Examples of Insulators:** Rubber, plastic, wood, glass.

🔍 **Summary:**

**Conductors** allow electric current to flow due to the presence of free electrons (e.g. copper), **while insulators** resist current due to the absence of free electrons (e.g. rubber). Both are essential for making safe electric circuits.

🌟 **Q14.8: Explain the energy dissipation in a resistance. What is Joule's Law?**

❖ **Energy Dissipation in Resistance:**

When electric current passes through a resistor or any resistive element, electrical energy is converted into heat. This loss or conversion of energy is called energy dissipation.

**Joule's Law (Statement):**

**The amount of heat produced in a conductor is directly proportional to:**

- The square of the current ($I^2$),
- The resistance of the conductor (R), and
- The time (t) during which current flows.

**Mathematical Expression:**

$W = I^2 \times R \times t$

Where:

W = heat energy in joules (J)

I = current in amperes (A)

R = resistance in ohms (Ω)

t = time in seconds (s)

**Alternate form using voltage (from Ohm's Law V = IR):**

$W = V^2 \times t / R$

**Units:**

The unit of electrical energy or heat is Joule (J).

**Practical Applications of Joule's Law:**

- In electric heaters and irons, the electric current produces heat for useful purposes.
- In electric bulbs, part of the energy is converted to heat and part to light.
- Fans use electrical energy to create mechanical motion.

🔍 **Summary:**

Joule's Law explains that heat produced in a resistor is proportional to $I^2$, R, and t. It is used in many daily-life appliances like heaters, irons, and electric bulbs. Formula: W = I^2 × R × t

🌟 **Q14.9: What is the difference between D.C and A.C?**

❖ **Answer:**

**D.C (Direct Current):**

Direct Current is the type of current that flows only in one direction. It has a constant magnitude and does not change with time.

**A.C (Alternating Current):**

Alternating Current is the type of current that changes direction periodically. Its magnitude also varies with time in the form of a sine wave.

## Differences:

### Direction:

- D.C flows in one direction.
- A.C reverses direction regularly.

### Source:

- D.C is produced by batteries and solar cells.
- A.C is produced by generators and supplied by power stations.

### Graph:

- D.C is represented as a straight line.
- A.C is represented as a sine wave.

### Use:

- D.C is used in electronic devices like mobiles, calculators.
- A.C is used for domestic and industrial electricity supply.

🔍 **Summary:**

D.C flows in one constant direction (used in batteries), while A.C changes direction periodically (used in home electricity). Both are important forms of electric current used in different applications.

🌟 **Q14.10: Discuss the main features of parallel combination of resistors.**

❖ **Answer:**

**Parallel Combination:**

In a parallel combination, resistors are connected in such a way that one end of all resistors is joined together and the other ends are also connected together. The current divides across the branches, but the voltage remains the same across all resistors.

**Main Features:**

**1. Same Voltage:**

Voltage across each resistor is equal to the total voltage of the circuit.

$\Rightarrow V_1 = V_2 = V_3 = V$

### 2. Current Divides:

The total current divides among the resistors depending on their resistance.

$\Rightarrow I = I_1 + I_2 + I_3$

### 3. Reciprocal of Resistance:

The total or equivalent resistance (R) in parallel is given by:

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

### 4. Reduced Resistance:

The equivalent resistance in parallel is always less than the smallest resistor in the circuit.

### 5. Useful in Homes:

Parallel combination is used in household wiring. Each device works independently without affecting the others.

### 🔍 Summary:

In parallel combination, all resistors get equal voltage, but the current divides. It is used in house wiring due to safety and independent control of

appliances. Total resistance is calculated using reciprocal formula and is always less than individual resistors.

🌟 **Q14.11: Determine the equivalent resistance of series combination of resistors.**

❖ **Answer:**

**Series Combination:**

In a series combination, resistors are connected end-to-end, so that the same current passes through each resistor. The total resistance increases in this arrangement.

**Key Features:**

**1. Same Current:**

Current remains the same through each resistor.

$\Rightarrow I = I_1 = I_2 = I_3$

**2. Total Voltage:**

Total voltage across the series is the sum of voltages across each resistor.

$\Rightarrow V = V_1 + V_2 + V_3$

### 3. Total or Equivalent Resistance:

The equivalent resistance (R) of resistors connected in series is the sum of their individual resistances.

$\Rightarrow R = R_1 + R_2 + R_3$

**Example:**

**If three resistors of 2Ω, 3Ω and 5Ω are connected in series:**

$R = 2\Omega + 3\Omega + 5\Omega = 10\Omega$

🔍 **Summary:**

In a series combination, the total resistance is equal to the sum of all individual resistances. Current remains the same, but voltage divides. Total resistance increases in series.

🌟 **Q14.12: Describe briefly the hazards of household electricity.**

❖ **Answer:**

**Household Electricity Hazards:**

Electricity is very useful, but can be dangerous if not

handled properly. Some common hazards include:

**1. Electric Shock:**

If a person touches a live wire or exposed metal part, the current can pass through the body, causing severe shock or even death.

**2. Fire Risk:**

Short circuits due to faulty wiring or overloading can cause sparks that may lead to fire.

**3. Damaged Appliances:**

Voltage fluctuations or using poor-quality wiring can damage household appliances.

**4. Wet Conditions:**

Using electrical devices with wet hands or in wet areas increases the risk of electric shock.

**5. Overloading:**

Plugging too many devices into a single socket can cause overheating and melting of wires, resulting in fire.

**Safety Measures:**

- Use circuit breakers (MCBs) and fuses.
- Do not overload sockets.
- Keep appliances away from water.
- Use proper insulation and earthing.

🔍 **Summary:**

Household electricity can be hazardous if misused. Risks include electric shock, fire, and appliance damage. Always follow safety precautions to avoid such dangers.

🌟 **Q14.13: Describe four safety measures that should be taken in connection with the household circuit.**

❖ **Answer:**

Electrical safety is essential to prevent accidents, fires, or electric shocks in the home. Here are four important safety measures:

**1. Use of Circuit Breakers (MCB) and Fuses:**

- These protect the household wiring from overloading or short circuits.

- When the current exceeds a safe limit, they automatically disconnect the circuit, preventing damage.

## 2. Proper Earthing (Grounding):

- Earthing provides a safe path for stray current to flow into the ground.
- It prevents electric shocks from faulty appliances or exposed wires.

## 3. Avoid Overloading Sockets:

- Plugging too many appliances into one socket can cause overheating.
- This may melt wires or cause fires, so use appropriate extensions or multi-plug systems with surge protection.

## 4. Use of Quality Wiring and Insulated Equipment:

- Always use standard, high-quality wires and properly insulated switches.
- Avoid using damaged wires or plugs, and replace them when needed.

🔍 **Summary:**

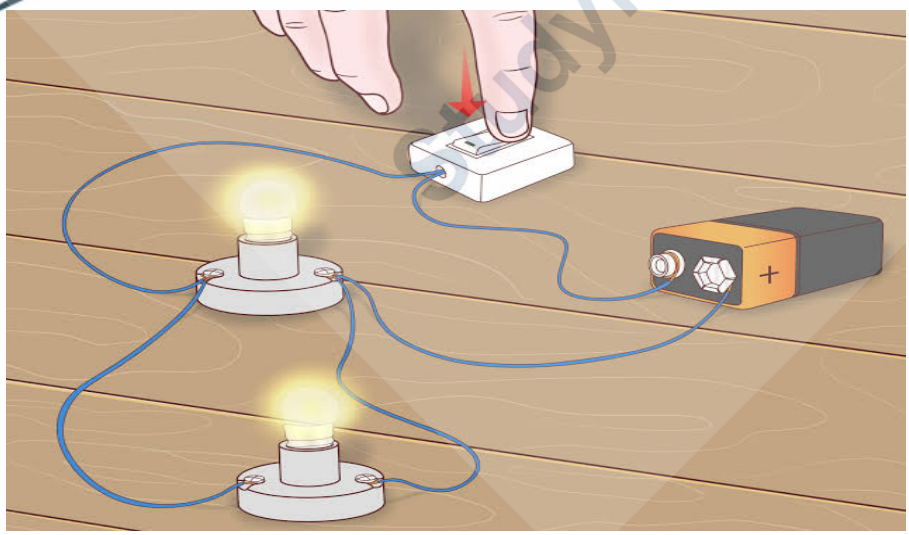
To ensure safety in household circuits, always use fuses/MCBs, proper earthing, avoid overloading, and ensure quality wiring. These steps help prevent shocks, fires, and equipment damage.

🌟 **Q14.14: Design a circuit diagram for a study room that needs the following equipment in parallel:**

(a) One 100 W lamp operated by one switch.

(b) One 40 W reading lamp operated by two-way switches.

(c) What is the advantage of connecting the equipment in parallel instead of series?




🔹 **Explanation of Circuit Design:**

## 1. Parallel Connection:

Both lamps (100 W and 40 W) are connected in parallel, meaning each has its own path to the power supply.

## 2. Switch Control:

- The 100 W lamp is controlled by one switch near the entrance.
- The 40 W reading lamp is controlled using two-way switches, allowing you to turn it ON or OFF from two locations (e.g., door and study table).

### Why Parallel Connection is Better than Series?

Advantages:

- Each appliance receives full voltage (e.g., 220 V).
- **Independent control**: One lamp can be switched ON while the other remains OFF.
- **Equal brightness**: Devices operate at rated power without dimming.

- **Easy troubleshooting**: If one device fails, others continue to work.

🔍 **Summary:**

In a study room circuit, connecting lamps in parallel allows independent control and full voltage supply. The 100 W lamp uses a single switch, while the 40 W reading lamp uses two-way switches. Parallel circuits are more efficient and safer than series circuits.

## CONCEPTUAL QUESTIONS

🌟 **14.1. Why in conductors charge is transferred by free electrons rather than by positive charges?**

🔹 **Explanation:**

- In conductors like copper or aluminum, free electrons are loosely bound and can move easily from one atom to another.
- These electrons are negatively charged and are responsible for the flow of electric current.

- Positive charges (protons) are located in the nucleus of atoms, and they are fixed in place — they cannot move freely.
- Hence, when a potential difference is applied, it is the free electrons that drift through the conductor and transfer charge.

🔸 **Reason:**

Positive charges are immobile in solids, while free electrons can move and carry current efficiently.

🔍 **Summary:**

In conductors, only free electrons move and carry electric current because positive charges are bound inside atomic nuclei and cannot move.

🌟 **14.2. What is the difference between a cell and a battery?**

🔹 **Explanation:**

A cell is a single unit that converts chemical energy into electrical energy.

**Example**: Dry cell (1.5 V)

- A battery is a combination of two or more cells connected together to provide a higher voltage or current.
- **Example**: A battery with 3 cells may provide 4.5 V.

### Cell

- **Definition**: A single electrochemical unit that converts chemical energy into electrical energy.
- **Voltage**: Usually around 1.5 volts (in dry cells).
- **Example**: AA cell, dry cell, pencil cell.
- **Use**: Used in small electronic devices like remotes, clocks, toys.
- **Size**: Smaller in size, limited power.

### Battery

- **Definition**: A combination of two or more cells connected together.
- **Voltage**: Higher voltage — the total is the sum of individual cell voltages.
- **Example**: Car battery, mobile phone battery,

laptop battery.

- **Use**: Powers larger devices requiring more energy.
- **Size**: Bigger than a single cell, provides more power.

🔍 **Summary:**

A cell is a single source of electrical energy, while a battery is made up of multiple cells connected together to provide greater power.

🌟 **14.3. Can current flow in a circuit without potential difference?**

🔹 **Explanation:**

- No, current cannot flow in a circuit without a potential difference.
- Electric current is the flow of charges (usually electrons), and this flow requires a driving force.
- The potential difference (voltage) provides the force that pushes charges through the circuit.
- If both ends of the conductor are at the same

potential, there is no reason for electrons to move — so, no current flows.

🔋 **Analogy:** Like water doesn't flow between two containers at the same height, charges won't flow without a difference in potential.

🔍 **Summary:**

Current cannot flow without potential difference, because a voltage is needed to push the charges through the circuit.

🌟 **14.4. Two points on an object are at different electric potentials. Does charge necessarily flow between them?**

🔹 **Explanation:**

- Not always. Although a potential difference exists, charge will only flow if there is a conducting path between the two points.
- If the material between the two points is an insulator, or the circuit is incomplete, charges cannot move despite the potential difference.
- In order for charge to flow, the circuit must be

closed, and the material must allow conduction.

💡 **Important Note:**

Potential difference is a necessary condition, but not a sufficient condition for current to flow.

🔍 **Summary:**

Charge will not necessarily flow just because there is a potential difference. A conducting path is also required.

🌟 **14.5. In order to measure current in a circuit, why is ammeter always connected in series?**

🔹 **Explanation:**

- An ammeter is a device used to measure the current flowing through a circuit.
- Current is the same at all points in a series circuit, so to measure the actual current, the ammeter must be placed in the same path as the current.
- If we connect the ammeter in parallel, the entire current may not pass through it, or the low resistance of the ammeter could damage it or

the circuit.

- Hence, to get the accurate value of current, ammeters are always connected in series with the circuit.

🔹 **Key Point:**

An ammeter has very low resistance to avoid affecting the current in the circuit.

🔍 **Summary:**

An ammeter is connected in series so that all the current flows through it for accurate measurement. It must not be connected in parallel.

🌟 **14.6. In order to measure voltage in a circuit, voltmeter is always connected in parallel. Discuss.**

🔹 **Explanation:**

- A voltmeter is used to measure the potential difference (voltage) between two points in a circuit.
- To measure this difference, the voltmeter must be connected across (in parallel with) the component or section where the voltage is to

be measured.

- When connected in parallel, it compares the potential of both points and shows the difference.
- A voltmeter has a very high resistance, so it does not allow much current to flow through it, avoiding disturbance in the circuit.

💡 **Important Note:**

If connected in series, the voltmeter would block the current flow due to its high resistance.

🔍 **Summary:**

A voltmeter is connected in parallel to measure the potential difference accurately, as it compares the voltage between two points without affecting circuit current.

🌟 **14.7. How many watt-hours are there in 1000 joules?**

🔹 **Explanation:**

A watt-hour (Wh) is a unit of energy.

1 watt-hour = 3600 joules, because:

$$1\ \text{watt} = 1\text{joule per second}, \quad 1\text{hour} = 3600\text{seconds}$$

So,

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

To convert 1000 joules to watt-hours:

$$\frac{1000\ \text{J}}{3600\ \text{J/Wh}} = 0.278\ \text{Wh (approximately)}$$

📌 **Answer:**
1000 joules = **0.278 watt-hours**

🔍 **Summary:**

1000 joules is equal to about 0.278 watt-hours. This is calculated using the conversion:

1 Wh = 3600 J.

🌟 14.8. From your experience in watching cars on the roads at night, are automobile headlamps connected in series or in parallel?

🔹 **Explanation:**

- Automobile headlamps are connected in

parallel.

- In a parallel circuit, each lamp gets the same voltage from the battery.
- If one lamp fails or burns out, the other still works, because each has its own independent path.
- If headlamps were in series, and one failed, the entire circuit would break, and both would stop working.

🔸 **Real-Life Example:**

When one car headlamp stops working, the other usually stays on, which confirms they are connected in parallel.

🔍 **Summary:**

Car headlamps are connected in parallel so that each lamp works independently and continues working even if the other fails.

🌟 14.9. A certain flash-light can use a 10-ohm bulb or a 5-ohm bulb. Which bulb should be used to get the brighter light? Which bulb will discharge the

battery first?

🔹 **Explanation:**

- According to **Joule's Law of Heating:**

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

**So:**

- The 5-ohm bulb will be brighter than the 10-ohm bulb.
- Since it uses more power, it will also discharge the battery faster.

❖ **Answer:**

- Use the 5-ohm bulb for brighter light.
- The 5-ohm bulb will discharge the battery faster.

🔍 **Summary:**

Lower resistance (5 ohms) = more brightness, but battery drains faster.

🌟 **14.10. It is impracticable to connect an electric bulb and an electric heater in series. Why?**

🔹 **Explanation:**

- In a series circuit, the same current flows through all devices.
- A bulb and a heater are designed for different power and current requirements.

**If connected in series:**

- The heater may not get enough current, so it may not heat properly.
- Or, the bulb may burn out if current exceeds its rating.
- This setup will not work efficiently or safely.

❖ Answer:

It is impractical because both devices need different current, and in series, the same current passes through all, causing malfunction.

🔍 **Summary:**

Devices with different power needs (bulb and heater) cannot work properly in series due to shared current.

🌟 **14.11. Does a fuse in a circuit control the**

potential difference or the current?

🔹 **Explanation:**

- A fuse is a safety device that protects appliances from excess current.
- It is made of a thin wire that melts when current exceeds a safe limit.
- It does not affect potential difference (voltage).
- Its main job is to interrupt the circuit when too much current flows.

❖ **Answer:**

A fuse controls the current, not the potential difference.

🔍 **Summary:**

Fuse protects appliances by breaking the circuit when excess current flows. It does not control voltage.

## Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

## Author: Muhammad Asghar

**Purpose**: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

## Copyright & Usage Policy