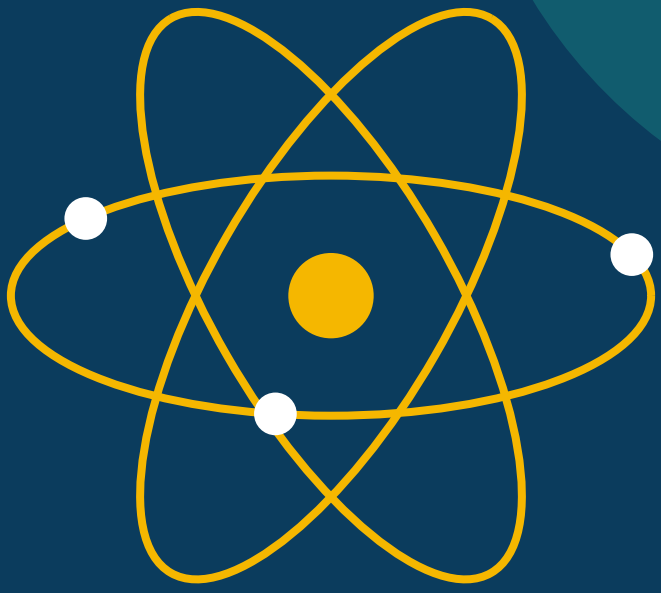


CHAPTER 14

CURRENT ELECTRICITY

10th Class Physics

Complete Exercise Solutions

MCQs • Review Questions
Conceptual Questions • Numericals

MULTIPLE CHOICE QUESTIONS

i. An electric current in conductors is due to the flow of

(a) positive ions

(b) negative ions

(c) positive charges

✓ **(d) free electrons**

Correct Answer: ✓ (d) free electrons

Explanation: In metallic conductors, atoms are packed in a lattice, and their outer (valence) electrons are loosely bound. These electrons can move freely throughout the metal. When a potential difference is applied, these “free electrons” drift in a specific direction, creating an electric current. Positive ions are fixed in the lattice and cannot move.

ii. 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

Correct Answer: ✓ (c) 18 V

Explanation: According to Ohm’s Law, V = I × R. Given Current (I) = 3 A and Resistance (R) = 6 Ω. Therefore, V = 3 A × 6 Ω = 18 V.

iii. 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

Correct Answer: ✓ (b) decreases

Explanation: Adding more lamps in a series circuit increases the total equivalent resistance. Because the voltage of the source remains constant, an increase in resistance causes the overall current to drop ($I = V/R$). Since the brightness of a bulb depends on the power it consumes ($P = I^2R$), a lower current results in a dimmer light for all bulbs.

iv. 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

Correct Answer: ✓ (c) to provide each appliance the same voltage as the power source

Explanation: In a parallel circuit, the voltage across each branch is equal to the source voltage. This ensures every appliance receives the exact voltage it is designed to operate on. Additionally, if one appliance turns off or breaks, the others continue to work independently.

v. 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)

Correct Answer: ✓ (b) are the different terms

Explanation: Electric potential is the work done per unit charge to bring a charge from infinity to a point. Electromotive force (e.m.f.) is the energy provided by a source (like a battery) per unit charge to drive it around the entire circuit. They are distinct concepts, but they share the **same unit**, which is the Volt (V). Therefore, option (c) and (d) are incorrect.

vi. When we double the voltage in a simple electric circuit, we double the

- ✓ **(a) current**
- (b) power
- (c) resistance
- (d) both (a) and (b)

Correct Answer: ✓ (a) current

Explanation: According to Ohm’s Law (I = V/R), if the resistance is constant, doubling the voltage will double the current. (Note: Power would actually quadruple because $P = V^2/R$, so option (d) is incorrect).

vii. 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**

Correct Answer: ✓ (d) quadruples

Explanation: Electric power is the product of voltage and current ($P = V \times I$). If you double both variables, the new power is $P_{new} = (2V) \times (2I) = 4VI$. Thus, the power increases by a factor of four (quadruples).

viii. 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

Correct Answer: ✓ (c) 30 W

Explanation: Using the power formula P = V × I. Given V = 12 V and I = 2.5 A. P = 12 × 2.5 = 30 W.

ix. 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

Correct Answer: ✓ (a) 2 Ω

Explanation: Let each resistor be R. In series, R + R = 8 Ω ⇒ 2R = 8 ⇒ R = 4 Ω. When these identical 4 Ω resistors are connected in parallel, the equivalent resistance R_p = (R × R) / (R + R) = (4 × 4) / (4 + 4) = 16 / 8 = 2 Ω.

REVIEW QUESTIONS

14.1. Define and explain the term electric current.

Electric current is defined as the rate of flow of electric charge through a conductor. It is measured in Amperes (A). Mathematically, **I = Q/t**. One ampere is the current produced when one coulomb of charge flows through a cross-section of a conductor in one second.

14.2. What is the difference between electronic current and conventional current?

Electronic current is the actual flow of negatively charged electrons from the negative terminal to the positive terminal of a source. Conventional current is a historical convention that assumes current flows from the positive terminal to the negative terminal (opposite to the actual electron flow).

14.3. What do we mean by the term e.m.f? Is it really a force? Explain.

e.m.f stands for electromotive force. It is the energy supplied by a source (like a battery) per unit charge to move a charge around a complete circuit. It is **not** a force; rather, it is a potential difference measured in Volts.

14.4. How can we differentiate between e.m.f. and potential difference?

e.m.f. is the energy provided *by a source* per unit charge to move it through the entire circuit. Potential difference (p.d.) is the energy *converted* from electrical to other forms (like heat or light) per unit charge between two specific points in a circuit. e.m.f. exists even when the circuit is open, whereas p.d. only exists when current is flowing.

14.5. Explain Ohm's law. What are its limitations?

Ohm’s law states that the current through a conductor between two points is directly proportional to the voltage across the two points, provided the temperature remains constant (**V = IR**).

Limitations: It only applies to “ohmic” materials (like metals). It does not apply to non-linear devices like semiconductors, diodes, transistors, or electrolytes, as their resistance changes with voltage or temperature.

14.6. Define resistance and its units.

Resistance is the property of a material that opposes the flow of electric current through it. Its SI unit is the Ohm (Ω). One Ohm is the resistance of a conductor when a potential difference of one volt causes a current of one ampere to flow through it.

14.7. What is the difference between conductors and insulators?

Conductors (like copper, silver) have a large number of free electrons that allow electric current to flow easily. Insulators (like rubber, glass, wood) have tightly bound electrons with no free charge carriers, thus preventing the flow of current.

14.8. Explain the energy dissipation in a resistance. What is Joule's law?

When current flows through a resistor, the electrons collide with the atoms of the material, producing heat. This means electrical energy is dissipated as thermal energy. Joule’s law states that the heat (H) produced is directly proportional to the square of the current (I^2), the resistance (R), and the time (t) for which it flows: $\mathbf{H = I^2Rt}$.

14.9. What is difference between D.C and A.C?

Direct Current (D.C.) flows continuously in one single direction (e.g., from a battery). Alternating Current (A.C.) periodically reverses its direction of flow (e.g., household mains electricity).

14.10. Discuss the main features of parallel combination of resistors.

1. The potential difference (voltage) across each resistor is the same.
2. The total current is the sum of the currents through individual branches.
3. The equivalent resistance is always less than the smallest individual resistance.
4. If one branch breaks, the others continue to function.

14.11. Determine the equivalent resistance of series combination of resistors.

In a series circuit, the same current (I) flows through all resistors, and the total voltage (V) is the sum of individual voltages: $V = V_1 + V_2 + V_3$. Using Ohm's law ($V = IR$), $IR_{eq} = IR_1 + IR_2 + IR_3$. Dividing by I gives: $\mathbf{R_{eq} = R_1 + R_2 + R_3}$.

14.12. Describe briefly the hazards of household electricity.

Hazards include:

1. **Electric shock:** Can cause severe burns or cardiac arrest.
2. **Fires:** Overloaded circuits or short circuits can generate intense heat, sparking fires.
3. **Appliance damage:** Voltage fluctuations or short circuits can ruin expensive electronics.

14.13. Describe four safety measures that should be taken in connection with the household circuit.

1. Installing fuses or circuit breakers to prevent overloading.
2. Proper earthing of metallic appliances to prevent shocks.
3. Using three-pin plugs for heavy appliances.
4. Ensuring wires are properly insulated and kept away from water.

14.14. Design a circuit diagram for a studyroom that needs the following equipments in parallel:
(a) One 100 W lamp operated by one switch.
(b) One reading lamp fitted with a 40 W bulb which can be switched ON and OFF from two points.
(c) What is the advantage of connecting the equipments in parallel instead of series?

(a & b) Conceptual Design: Draw a main parallel circuit connected to a voltage source. Branch 1 contains the 100 W bulb in series with a standard one-way switch. Branch 2 contains the 40 W bulb connected in a “staircase wiring” setup using two two-way switches.

(c) Advantage: In a parallel setup, each appliance receives the full source voltage, ensuring optimal performance. Also, each appliance can be operated independently without affecting the others.

CONCEPTUAL QUESTIONS

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

In solid conductors, the atoms are fixed in a lattice. The positively charged protons are locked deep inside the atomic nuclei and cannot move. However, the outer electrons are loosely bound and can move freely throughout the metal. Therefore, charge transfer happens via free electrons.

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

A cell is a single electrochemical unit that generates electrical energy. A battery is a collection of two or more such cells connected together in series or parallel to provide a higher voltage or current.

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

No. A potential difference (voltage) acts as the “push” or driving force that causes charges to move. Without a potential difference, free electrons move randomly, resulting in zero net current.

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

If the object is an insulator, charge will not flow easily despite the potential difference because there are no free charge carriers. If it is a conductor, charge will flow until the potential difference is neutralized.

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

An ammeter is designed with extremely low resistance. It is connected in series so that all the current in the circuit passes through it to be measured. If connected in parallel, its low resistance would create a short circuit and potentially damage the meter.

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

A voltmeter has very high resistance. It is connected in parallel across the component whose voltage is to be measured. Because of its high resistance, it draws negligible current and does not alter the circuit's behavior while measuring the potential difference.

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

Since 1 hour = 3600 seconds, 1 Watt-hour = 1 Watt × 3600 seconds = 3600 Joules. Therefore, 1000 Joules = 1000 / 3600 Wh = **0.2778 Wh** (or approx 0.28 Wh).

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

Automobile headlamps are connected in **parallel**. This ensures both lamps get the full battery voltage for maximum brightness, and if one bulb burns out, the other remains functional.

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?

The **5 ohm bulb** will produce brighter light. Since $P = V^2/R$, lower resistance draws more current, resulting in higher power (brightness). The 5 ohm bulb will discharge the battery faster because it draws a higher current.

14.10. It is impossible to connect an electric bulb and an electric heater in series. Why?

Heaters require very high current (low resistance), while bulbs require much lower current (high resistance). If connected in series, the total resistance becomes very high, reducing the current drastically. The heater will not get enough current to work, and the bulb might also glow very dimly.

14.11. Does a fuse in a circuit control the potential difference or the current?

A fuse controls the **current**. It is a thin wire that melts and breaks the circuit if the current exceeds a safe maximum limit, preventing overheating and fires.

NUMERICAL PROBLEMS

14.1. A current of 3 mA is flowing through a wire for 1 minute. What is the charge flowing through the wire?

Given: I = 3 mA = 3×10^{-3} A, t = 1 minute = 60 s

Formula: Q = I × t

Solution: Q = (3×10^{-3} A) × 60 s = 180×10^{-3} C

Answer: 180×10^{-3} C (or 0.18 C)

14.2. At 100,000 Ω, how much current flows through your body if you touch the terminals of a 12 V battery? If your skin is wet, so that your resistance is only 1000 Ω, how much current would you receive from the same battery?

Part 1 (Dry skin):

- R = 100,000 Ω, V = 12 V
- I = V/R = 12 / 100,000 = 1.2×10^{-4} A

Part 2 (Wet skin):

- R = 1000 Ω, V = 12 V
- I = V/R = 12 / 1000 = 1.2×10^{-2} A

Answer: Dry: 1.2×10^{-4} A, Wet: 1.2×10^{-2} A

14.3. The resistance of a conductor wire is 10 MΩ. If a potential difference of 100 volts is applied across its ends, then find the value of current passing through it in mA.

Given: R = 10 MΩ = 10×10^6 Ω, V = 100 V

Formula: I = V/R

Solution: I = 100 / (10^7) = 10^{-5} A

Convert to mA: $10^{-5} \times 10^3$ mA = 10^{-2} mA

Answer: 0.01 mA

14.4. By applying a potential difference of 10 V across a conductor, a current of 1.5 A passes through it. How much energy would be obtained from the current in 2 minutes?

Given: V = 10 V, I = 1.5 A, t = 2 minutes = 120 s

Formula: Energy E = P × t = V × I × t

Solution: E = 10 × 1.5 × 120 = 15 × 120 = 1800 J

Answer: 1800 J

14.5. Two resistances of 2 kΩ and 8 kΩ are joined in series, if a 10 V battery is connected across the ends of this combination, find the following quantities:
(a) The equivalent resistance of the series combination.
(b) Current passing through each of the resistances.
(c) The potential difference across each resistance.

Given: $R_1 = 2000\ \Omega$, $R_2 = 8000\ \Omega$, $V = 10$ V
(a) Equivalent Resistance: $R_s = R_1 + R_2 = 2000 + 8000 = 10{,}000\ \Omega = 10\ k\Omega$
(b) Current: In series, I is the same. $I = V / R_s = 10 / 10000 = 0.001$ A $= 1$ mA
(c) Potential Difference:
- $V_1 = I \times R_1 = 0.001 \times 2000 = 2$ V
- $V_2 = I \times R_2 = 0.001 \times 8000 = 8$ V

Answer: (a) 10 kΩ (b) 1 mA (c) 2 V, 8 V

14.6. Two resistances of 6 kΩ and 12 kΩ are connected in parallel. A 6 V battery is connected across its ends, find the values of the following quantities:
(a) Equivalent resistance of the parallel combination.
(b) Current passing through each of the resistances.
(c) Potential difference across each of the resistance.

Given: $R_1 = 6000\ \Omega$, $R_2 = 12000\ \Omega$, $V = 6\ V$

(a) Equivalent Resistance: $1/R_p = 1/6000 + 1/12000 = 3/12000 \Rightarrow R_p = 12000/3 = 4000\ \Omega = 4\ k\Omega$

(b) Current through each: In parallel, voltage is the same.

- $I_1 = V / R_1 = 6 / 6000 = 0.001\ A = 1\ mA$
- $I_2 = V / R_2 = 6 / 12000 = 0.0005\ A = 0.5\ mA$

(c) Potential Difference: In parallel, $V_1 = V_2 = V = 6\ V$

Answer: (a) 4 kΩ, (b) 1 mA, 0.5 mA, (c) 6 V

14.7. An electric bulb is marked with 220 V, 100 W. Find the resistance of the filament of the bulb. If the bulb is used 5 hours daily, find the energy in kilowatt-hour consumed by the bulb in one month (30 days).

Given: V = 220 V, P = 100 W = 0.1 kW, Time = 5 h/day × 30 days = 150 h

Resistance: $P = V^2/R \Rightarrow R = V^2/P = (220)^2 / 100 = 48400 / 100 = 484\ \Omega$

Energy consumed: E = P × t = 0.1 kW × 150 h = 15 kWh

Answer: 484 Ω, 15 kWh

14.8. An incandescent light bulb with an operating resistance of 95 Ω is labelled “150 W”. Is this bulb designed for use in a 120V circuit or a 220 V circuit?

Given: R = 95 Ω, P = 150 W

Formula: $P = V^2/R \Rightarrow V = \sqrt{(P \times R)}$

Solution: $V = \sqrt{(150 \times 95)} = \sqrt{14250} \approx 119.37$ V

Answer: Since the value is approx 120 V, **it has been designed for a 120 V circuit**.

14.9. A house is installed with (a) 10 bulbs of 60 W each which are used 5 hours daily. (b) 4 fans of 75 W each which run 10 hours daily. (c) One TV of 100 W which is used for 5 hours daily. (d) One electric iron of 1000 W which is used for 2 hours daily. If the cost of one unit of electricity is Rs. 4. Find the monthly expenditure of electricity (one month = 30 days).

Daily Energy Calculation:

- Bulbs: 10 × 60 W = 600 W = 0.6 kW ⇒ Energy = 0.6 × 5 = 3 kWh
- Fans: 4 × 75 W = 300 W = 0.3 kW ⇒ Energy = 0.3 × 10 = 3 kWh
- TV: 100 W = 0.1 kW ⇒ Energy = 0.1 × 5 = 0.5 kWh
- Iron: 1000 W = 1 kW ⇒ Energy = 1 × 2 = 2 kWh
- *Total Daily Energy* = 3 + 3 + 0.5 + 2 = 8.5 kWh

Monthly Energy: 8.5 × 30 = 255 kWh (units)

Cost: 255 × 4 = Rs. 1020

Answer: Rs. 1020/-

14.10. A 100 W lamp bulb and a 4 kW water heater are connected to a 250 V supply. Calculate (a) the current which flows in each appliance (b) the resistance of each appliance when in use.

Given: V = 250 V, P_{bulb} = 100 W, P_{heater} = 4000 W

(a) Current: I = P/V

- I_{bulb} = 100 / 250 = 0.4 A
- I_{heater} = 4000 / 250 = 16 A

(b) Resistance: R = V/I

- R_{bulb} = 250 / 0.4 = 625 Ω
- R_{heater} = 250 / 16 = 15.625 Ω

Answer: (a) 0.4 A, 16 A (b) 625 Ω, 15.62 Ω

14.11. A resistor of resistance 5.6 Ω is connected across a battery of 3.0 V by means of a wire of negligible resistance. A current of 0.5 A passes through the resistor. Calculate:
(a) Power dissipated in the resistor.
(b) Total power produced by the battery.
(c) Give reason of difference between these two quantities.

Given: R = 5.6 Ω, V = 3.0 V, I = 0.5 A

(a) Power dissipated in resistor: $P = I^2R = (0.5)^2 \times 5.6 = 0.25 \times 5.6 = 1.4$ W

(b) Total power produced by battery: $P = V \times I = 3.0 \times 0.5 = 1.5$ W

(c) Reason: The difference of 0.1 W is because some power is lost by the **internal resistance** of the battery itself.

Answer: (a) 1.4 W (b) 1.5 W (c) Some power is lost by the internal resistance of the battery.

CHAPTER 14 COMPLETED

Thank You!

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