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Class	10th	Chapter	16
Subject	Physics	Board	Federal

CHAPTER 16: CURRENT ELECTRICITY

MULTIPLE CHOICE QUESTIONS

1. Ampere-hour (Ah) is the unit of:

A. electric current **B. charge** C. energy D. resistance

2. Which of the following is a non-ohmic device?

A. Copper wire B. Carbon resistor **C. Diode** D. all of these

3. Electric current is measured using:

A. ammeter B. voltmeter C. ohmmeter D. meter rod

4. Voltmeter measures:

A. Potential difference B. electric current C. resistance D. resistivity

5. If 3 A of current flows for 2 minutes, the amount of charge crosses the cross-section of a conductor will be:

A. 3 C B. 6 C C. 60 C **D. 360 C**

6. A current of 1 mA is passing through a wire. Number of electrons passing through a point in the wire in 10 seconds is:

A. 6.25×10^{15} **B.** 6.25×10^{16} C. 6.25×10^{17} D. 6.25×10^{18}

7. Resistance of a material always decreases when:

A. Its temperature increases **B. Its temperature decreases** C. Number of free electrons increases D. Number of free electrons decreases

8. The resistance of a metallic conductor varies inversely as:

A. area of cross section B. length C. temperature D. all of these

9. Directions of actual current and conventional current are:

A. same **B. opposite to each other** C. perpendicular to each other D. none of these

10. As temperature of a semiconductor increases, its resistance:

A. Increases **B. Decreases** C. remains constant D. becomes zero

11. The SI unit of temperature coefficient of resistance (α) is:

A. K **B. K^{-1}** C. $\Omega \cdot K$ D. Ω/K

12. By increasing temperature, the resistivity of semiconductors:

A. Increases **B. Decreases** C. remains constant D. first increases then decreases

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CONSTRUCTED RESPONSE QUESTIONS

Question 1:

Draw connections so that the emf sources given in figure become in series and parallel.

1. Series Connection:

To connect four cells (E_1, E_2, E_3, E_4) in **series**:

- Connect the **positive terminal (+)** of E_1 to the circuit's positive end.
- Connect the **negative terminal (-)** of E_1 to the **positive terminal (+)** of E_2.
- Connect the **negative terminal (-)** of E_2 to the **positive terminal (+)** of E_3.
- Connect the **negative terminal (-)** of E_3 to the **positive terminal (+)** of E_4.
- Connect the **negative terminal (-)** of E_4 to the circuit's negative end.
- **Total EMF:** $E_{\text{total}} = E_1 + E_2 + E_3 + E_4$

2. Parallel Connection:

To connect four cells (E_1, E_2, E_3, E_4) in **parallel**:

- Connect all **positive terminals (+)** of E_1, E_2, E_3, and E_4 together to a common positive node.
- Connect all **negative terminals (-)** of E_1, E_2, E_3, and E_4 together to a common negative node.
- **Total EMF:** $E_{\text{total}} = E$ *(assuming identical cells)*

Question 2:

Compare and contrast the roles of ammeters and voltmeters in electrical circuits. Include a discussion on how each instrument measures different electrical properties.

Comparison & Contrast Table:

Feature / Property	**Ammeter**	**Voltmeter**
Quantity Measured	Electric Current (I) in Amperes (A)	Electric Potential Difference (V) in Volts (V)
Circuit Connection	Connected in **Series** with the circuit component	Connected in **Parallel** across the component
Internal Resistance	**Very low** (Ideally zero)	**Very high** (Ideally infinite)
Reason for Resistance	To allow maximum current to pass through without altering the circuit current.	To draw negligible current from the circuit so potential difference remains unchanged.

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Feature / Property	Ammeter	Voltmeter
Galvanometer Conversion	Low resistance (Shunt resistance, R_s) connected in **parallel** with galvanometer.	High resistance (R_h) connected in **series** with galvanometer.

Detailed Discussion on Measurement:

1. **How an Ammeter Measures Current:**
   - An ammeter measures the **rate of flow of charge** through a circuit element. Since it is connected in **series**, the full current flowing through the branch passes through the ammeter. Its extremely low internal resistance ensures that it does not drop significant potential or restrict current flow, giving an accurate current reading.
2. **How a Voltmeter Measures Potential Difference:**
   - A voltmeter measures the **energy difference per unit charge** between two distinct points in a circuit. Since it is connected in **parallel**, it samples the voltage drop across the component. Its extremely high internal resistance prevents current from diverting into the voltmeter, leaving the main circuit operation unaffected while providing an accurate voltage measurement.

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QIII. SHORT RESPONSE QUESTIONS

1. Why is copper preferred over silver for household wiring, considering cost, conductivity, and durability?

Although silver has slightly higher electrical conductivity than copper, copper is drastically cheaper and far more abundant. Additionally, copper offers excellent mechanical durability, flexibility, and resistance to corrosion, making it the most cost-effective and practical choice for household wiring.

2. Why free electrons in metals don't create a current without a potential difference?

Without an external potential difference, free electrons undergo rapid, random thermal motion in all directions, causing their net displacement to equal zero. When a potential difference is applied, an electric field directs these electrons to drift toward the positive terminal, producing a net electric current.

3. How conventional and actual current directions affect circuit behavior, and why conventional current is important in diagrams and calculations?

Conventional current flows from positive to negative, while actual electron current flows from negative to positive; however, both yield identical circuit energy transfer and behavior. Conventional current remains the universal standard across circuit diagrams, laws (like Kirchhoff's laws), and mathematical calculations to ensure global consistency.

4. Compare emf and potential difference, and why this distinction matters in circuit analysis.

Electromotive force (emf) is the non-electrical energy converted per unit charge by a source to maintain current, while potential difference (PD) is the electrical energy dissipated per unit charge between two points in a circuit. Distinguishing them is vital because internal battery resistance makes terminal PD lower than total emf.

5. How is a current-carrying wire electrically neutral?

A current-carrying wire remains electrically neutral because the rate at which electrons enter one end equals the rate at which they exit the other end. Since the total number of negative electrons continuously equals the total number of positive fixed metal ions, there is no net charge accumulation inside the conductor.

6. Would the lights still work if a car battery's positive and negative terminals were interchanged?

Yes, standard incandescent car bulbs would still light up because simple resistive heating elements operate independently of current direction. However, modern vehicle circuits containing polarity-sensitive components like LEDs, diodes, or electronic control units (ECUs) would fail to function or suffer permanent electrical damage.

7. Evaluate the limits of Ohm's law for different materials, especially under extreme conditions.

Ohm's law ($V = IR$) applies strictly to ohmic conductors (e.g., metals) at constant temperatures. It fails for non-ohmic devices like diodes and transistors, and breaks down under extreme

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conditions like high temperatures, strong electric fields, or cryogenic states where resistivity changes drastically due to thermal agitation or superconductivity.

8. How does a wire's shape affect its resistance, whether bending changes it?

Resistance depends on physical dimensions, given by $R = \rho\frac{L}{A}$, where longer length (L) increases resistance and larger cross-sectional area (A) decreases it. Smoothly bending a wire does not alter its total length or cross-sectional area, so its electrical resistance remains completely unchanged.

9. The temperature coefficient of copper is $0.004\ \mathrm{C}^{-1}$. How does this affect copper's performance in electrical systems under varying temperatures?

A positive temperature coefficient ($\alpha = 0.004\ \mathrm{K}^{-1}$) means copper's resistance increases linearly as temperature rises. In high-temperature electrical systems, increased resistance causes greater energy loss as heat (I^2R losses), reduces operational current efficiency, and requires thermal management to prevent overheating.

10. How would you define fluid resistance for a water-carrying pipe?

Fluid resistance is the opposition faced by a flowing fluid due to internal viscous friction and friction against the inner walls of a pipe. It depends directly on pipe length, fluid viscosity, and flow speed, and inversely on the pipe's radius (proportional to $1/r^4$ according to Poiseuille's Law).

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QIV. LONG RESPONSE QUESTIONS

1. Explain electric current and its unit (ampere) by exploring charge flow. Discuss the difference between conventional and actual current and when this distinction matters.

Definition and Equation of Electric Current

Electric current (I) is defined as the net rate of flow of electric charge through any cross-sectional area of a conductor per unit time:

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

Where:

- ΔQ is the net charge in Coulombs (C).
- Δt is the time interval in seconds (s).

Unit of Electric Current (Ampere)

The SI unit of electric current is the **Ampere (**A**)**.

- **1 Ampere Definition:** One ampere of current flows through a conductor when one coulomb of charge passes through a given cross-section in one second ($1\ \text{A} = 1\ \text{C/s}$).

Conventional Current vs. Actual Current

- **Conventional Current:** Historical convention established by Benjamin Franklin assumes current is the flow of **positive charges** from the positive (higher potential) terminal to the negative (lower potential) terminal.
- **Actual (Electron) Current:** Physical reality in metallic conductors where negatively charged free electrons move from the **negative terminal** toward the **positive terminal**.

When the Distinction Matters

1. **Semiconductor Devices:** In p-n junctions, transistors, and electrolytes, both positive charge carriers (holes) and negative charge carriers (electrons/ions) move simultaneously; distinguishing carrier flow direction is crucial for device modeling.
2. **Magnetic Field Forces (Right-Hand Rule):** Determining force direction on moving charges ($\vec{F} = q(\vec{v} \times \vec{B})$) requires knowing the sign of the charge carrier.
3. **Electrolysis & Particle Accelerators:** Chemical reactions at anodes/cathodes depend directly on the true direction of ionic drift.

2. Analyse electrical conduction in metals and how external factors like temperature and magnetic fields affect electron movement and conduction efficiency.

Electrical Conduction Mechanism in Metals

Metals consist of a rigid lattice of positive ions surrounded by a cloud of free conduction electrons (Drude free-electron model).

- In the absence of an electric field, electrons move randomly at high speeds ($\approx 10^6$ m/s) due to thermal energy, resulting in zero net displacement.
- When an electric field ($\vec{E}$) is applied across the metal, an electrostatic force ($\vec{F} = -e\vec{E}$) accelerates electrons, establishing a small net **drift velocity** ($v_d \approx 10^{-4}$ m/s) towards the positive terminal.

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Effect of External Factors

1. **Temperature:**
   - **Mechanism:** Increasing temperature causes lattice ions to vibrate with larger amplitudes.
   - **Impact on Efficiency:** Conduction electrons collide more frequently with vibrating ions, reducing mean free path (λ) and relaxation time (τ). This causes an increase in resistance and a drop in conduction efficiency.
2. **Magnetic Fields (Hall Effect & Magnetoresistance):**
   - **Mechanism:** When a magnetic field ($\vec{B}$) is applied perpendicular to electron flow, electrons experience a magnetic Lorentz force ($\vec{F}_B = -e(\vec{v}_d \times \vec{B})$).
   - **Impact on Efficiency:** The Lorentz force deflects electrons toward one side of the conductor, creating a transverse potential difference (Hall Voltage) and increasing path trajectory lengths (magnetoresistance), which slightly degrades standard longitudinal conduction.

3. Compare DC and AC in terms of their behaviour in circuit elements. Discuss the pros and cons of each in applications like power transmission and electronics.

Behavior in Circuit Elements

Circuit Element	Direct Current (DC) Behavior	Alternating Current (AC) Behavior
Resistor (R)	Dissipates power ($P = I^2R$); current and voltage are constant.	Dissipates power ($P = I_{\text{rms}}^2 R$); current and voltage oscillate in phase.
Capacitor (C)	Blocks steady DC after fully charging ($X_C = \infty$).	Conducts AC by continuously charging and discharging ($X_C = \frac{1}{2\pi f C}$).
Inductor (L)	Acts as a simple low-resistance wire once steady state is reached ($X_L = 0$).	Opposes AC flow via self-induced back emf ($X_L = 2\pi f L$).

Pros and Cons of DC and AC

- **Direct Current (DC):**
  - **Pros:** Highly stable; essential for digital electronics, microprocessors, battery storage, and electric vehicles.
  - **Cons:** Difficult to step up or step down voltages efficiently without complex power electronics; higher transmission losses at low voltages over long distances.

- **Alternating Current (AC):**
  - **Pros:** Voltages can easily be stepped up or down using **transformers**, enabling high-voltage, low-current long-distance power distribution with minimal I^2R losses.
  - **Cons:** Cannot be stored directly in batteries; produces electromagnetic interference (EMI); skin effect increases effective wire resistance at high frequencies.

4. Examine electromotive force (emf) and its role in maintaining current.

Definition and Concept of EMF

Electromotive force ($\mathcal{E}$) is the maximum potential difference supplied by a source (like a battery, generator, or solar cell) when no current is being drawn from it. Mathematically, it is the work done (W) per unit charge (q) by non-electrical forces inside the source:

$$\mathcal{E} = \frac{W}{q}$$

Role of EMF in Maintaining Current

1. **Energy Supply:** In a closed circuit, electric current flows through resistors, converting electrical energy into heat, light, or mechanical work. Without a source, potential differences dissipate rapidly.
2. **Pumping Action:** The source of emf acts as a chemical/mechanical "pump" that pushes positive charges from low potential (negative terminal) to high potential (positive terminal) *inside* the battery against the internal electric field.
3. **Maintaining Steady State:** By continuously restoring electrostatic potential energy to passing charges, the emf source maintains a steady potential difference across the external circuit, driving continuous current flow.

5. Distinguish between emf and potential difference, using real-world examples like batteries.

Comparison Between EMF and Potential Difference

Property	Electromotive Force (EMF)	Potential Difference (PD)
Definition	Work done per unit charge by a non-electrical source to move charge inside the supply.	Energy dissipated per unit charge as it moves between two points in a circuit.
Cause vs. Effect	Cause (it generates electrical current).	Effect (it is the result of current flowing through resistance).
Open vs. Closed Circuit	Exists even when the circuit is open ($I = 0$).	Zero across passive elements in an open circuit.

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Property	Electromotive Force (EMF)	Potential Difference (PD)
Magnitude	Always greater than terminal voltage during battery discharge ($\mathcal{E} = V + Ir$).	Lower than emf during battery discharge ($V = \mathcal{E} - Ir$).

Real-World Example: Automobile Battery

Consider a standard 12.0 V car battery with an internal resistance $r = 0.05\ \Omega$:

- **Open Circuit Condition:** When no load is connected ($I = 0$), a voltmeter across the battery terminals reads its full **emf** ($\mathcal{E} = 12.0$ V).
- **Closed Circuit Condition (Engine Start):** When starting the engine, a large current $I = 100$ A is drawn. The internal voltage drop across r is $V_{\text{internal}} = Ir = 100 \times 0.05 = 5$ V.
- The measured **terminal potential difference** drops to:

$$V = \mathcal{E} - Ir = 12.0 - 5.0 = 7.0 \text{ V}$$

6. Critically analyse Ohm's law and its limitations for non-ohmic devices. Discuss the importance of I-V graphs and propose experiments to explore non-linear materials.

Critical Analysis of Ohm's Law

Ohm's law states that the current (I) flowing through a conductor is directly proportional to the potential difference (V) applied across it, provided physical conditions such as temperature remain constant ($V \propto I \Longrightarrow V = IR$).

Limitations and Non-Ohmic Devices

Ohm's law is not a fundamental law of physics, but an empirical relationship valid only for specific materials (metals at moderate temperatures).

- **Filament Bulb:** As current increases, thermal heating increases resistance; I-V graph curves downward.
- **Semiconductor Diode:** Allows current in only one direction (forward bias) after reaching a knee voltage (≈ 0.7 V for Si); completely non-linear.
- **Thermistor:** Resistance decreases as temperature increases (negative temperature coefficient).

Importance of I-V Graphs

I-V characteristic curves provide a dynamic visual representation of component behavior. The dynamic resistance at any point is given by the inverse slope of the I-V graph:

$$R_{\text{dynamic}} = \frac{\Delta V}{\Delta I}$$

Proposed Experiment to Explore Non-Linear Materials (e.g., Semiconductor Diode)

1. **Apparatus:** Variable DC power supply, ammeter (mA), voltmeter, 1 kΩ resistor (current limiter), and a semiconductor diode (1N4007).
2. **Procedure:**
    - Connect the diode in series with the resistor and ammeter across the power supply.

- Connect the voltmeter in parallel across the diode.
- Increase supply voltage in steps of 0.1 V and record terminal voltage V_D and current I_D.

3. **Analysis:** Plot I_D (y-axis) vs. V_D (x-axis). The resulting exponential non-linear curve illustrates non-ohmic behavior.

7. Investigate the relationship between resistance and resistivity and design an experiment to measure resistance. Discuss factors affecting accuracy, such as temperature.

Relationship Between Resistance and Resistivity

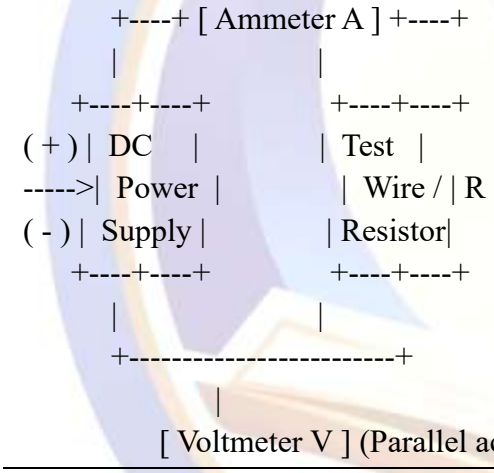
Resistance (R) is an extrinsic property dependent on dimensions, whereas resistivity (ρ) is an intrinsic property dependent only on material composition and temperature. They are related by:

$$R = \rho \frac{L}{A}$$

Where:

- L = length of conductor (m)
- A = cross-sectional area (m^2)

Experimental Design to Measure Resistance (Four-Probe / Voltmeter-Ammeter Method)



1. **Setup:** Connect a test wire of length L in series with a DC power supply, a rheostat, and a digital ammeter. Connect a digital voltmeter in parallel across the test wire.
2. **Measurement:** Vary the rheostat to record 5 sets of voltage (V) and current (I).
3. **Calculation:** Calculate $R = \frac{V}{I}$ for each trial and take the average slope of the V-I graph.

Factors Affecting Accuracy

1. **Temperature Fluctuations:** Current flow causes Joule heating (I^2R), increasing resistivity ($\rho(T) = \rho_0(1 + \alpha\Delta T)$). **Mitigation:** Use low currents and take readings quickly.
2. **Contact Resistance:** Resistance at terminal connection points can add systematic error. **Mitigation:** Use four-wire sensing (Kelvin connection).
3. **Parallax/Meter Resistance:** Voltmeter drawing small current or ammeter internal voltage drop.

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8. Analyse how factors like temperature, material, length, and area affect resistance. Discuss practical applications, such as wiring or heating elements, and ways to optimize resistance.

Factors Affecting Resistance ($R = \rho\frac{L}{A}$)

1. **Length (L):** $R \propto L$. Longer paths present more collisions for electrons.
2. **Cross-Sectional Area (A):** $R \propto \frac{1}{A}$. Wider cross-sections provide more parallel paths for electrons.
3. **Material (ρ):** Governed by free electron density (n). Metals ($n \approx 10^{28}\ \mathrm{m}^{-3}$) have low resistance; insulators have high resistance.
4. **Temperature (T):** Increases lattice vibrations in metals, raising R.

Practical Applications

- **Household Wiring:** Requires minimal energy loss ($P = I^2R$). Optimized using thick copper/aluminum wires (large A, low ρ).
- **Heating Elements (Nichrome):** Requires high heat generation. Optimized using high-resistivity material (Nichrome) formed into long thin coils (large L, small A).

Optimization Strategies

- Minimize unwanted circuit resistance by selecting materials with high conductivity (Cu, Ag) and increasing wire diameter.
- Maximize heat production in appliances by selecting high-resistivity alloys (Nichrome) designed to handle high operating temperatures without oxidizing.

9. How does temperature influence the resistance of materials, and what implications does this have for electrical components in different environments?

Temperature Influence by Material Class

1. **Metals (Conductors):** Positive Temperature Coefficient ($\alpha > 0$). Higher temperature increases thermal lattice vibrations, leading to more electron collisions and increased resistance:

$$R(T) = R_0[1 + \alpha(T - T_0)]$$

2. **Semiconductors (Silicon, Germanium):** Negative Temperature Coefficient ($\alpha < 0$). Thermal energy breaks covalent bonds, releasing more electron-hole charge carriers, which significantly decreases resistance.
3. **Superconductors:** Below a critical threshold temperature (T_c), electrical resistance drops abruptly to absolute zero ($R = 0$).

Environmental & Practical Implications

- **High-Temperature Environments:** Industrial machinery and transformers experience higher internal resistance, leading to thermal runaway risks and reduced efficiency.
- **Cryogenic & Computing Environments:** High-performance computers and MRI magnets use liquid helium cooling to lower conductor resistance to near zero, eliminating heat dissipation and maximizing operational speeds.

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10. Examine the placement of ammeters and voltmeters in circuits and how misconnection affects measurement. Propose strategies to avoid errors.

Correct Placement and Ideal Characteristics

Instrument	Circuit Connection	Ideal Internal Resistance	Reason
Ammeter	**In Series**	Zero ($r_A \to 0$)	Measures total loop current without adding extra resistance.
Voltmeter	**In Parallel**	Infinite ($r_V \to \infty$)	Measures potential difference without drawing current from the circuit.

Consequences of Misconnection

1. **Voltmeter connected in Series:**
   - High internal resistance ($r_V \approx$ MΩ) drops total circuit current to nearly zero ($I \approx 0$).
   - The circuit stops functioning, and the voltmeter simply reads the supply emf.
2. **Ammeter connected in Parallel:**
   - Extremely low internal resistance ($r_A \approx 0$) creates a direct short circuit across the component.
   - A massive surge of current flows through the ammeter, which can blow its internal fuse or permanently damage the instrument.

Strategies to Avoid Errors

- Double-check circuit topology before switching on power: **"Ammeters in line, Voltmeters across"**.
- Select digital meters with ultra-high input impedance (> 10 MΩ) for voltage measurements.
- Always begin measurements using the highest current/voltage scale to prevent overload.

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QV. NUMERICAL RESPONSE QUESTIONS

1. How much time will it take to charge a 200 Ah battery when it is connected to a current of 25 A?

Given:

- Battery Capacity (Q) = 200 Ah
- Charging Current (I) = 25 A

Formula:

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

Calculation:

$$t = \frac{200\ \text{A} \cdot \text{h}}{25\ \text{A}} = 8\ \text{hours}$$

Answer:

8 hr

2. A 12.0 V emf source is connected to a purely resistive electrical appliance (a light bulb). An electric current of 2.0 A flows through it. Consider the conducting wires to be resistance-free, calculate the resistance offered by the electrical appliance.

Given:

- Electromotive Force / Voltage (V) = 12.0 V
- Current (I) = 2.0 A

Formula (Ohm's Law):

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

Calculation:

$$R = \frac{12.0\ \text{V}}{2.0\ \text{A}} = 6.0\ \Omega$$

Answer:

6.0 Ω

3. The potential difference across the two ends of the component decreases to one fourth of its initial value while its resistance remains constant. What change will occur in the current through it?

Given:

- Initial Potential Difference = V_1
- Final Potential Difference (V_2) = $\frac{1}{4}V_1$
- Resistance (R) = Constant

Formula:

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

Calculation:

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$$I_1 = \frac{V_1}{R}$$

$$I_2 = \frac{V_2}{R} = \frac{\frac{1}{4}V_1}{R} = \frac{1}{4}\left(\frac{V_1}{R}\right) = \frac{1}{4}I_1$$

Answer:

The current decreases to $\mathbf{\frac{1}{4}}$ of its initial value (1/4)

4. What voltage is necessary to pass a current of 50 amperes through a resistance of 100 Ω?

Given:

- Current (I) = 50 A
- Resistance (R) = 100 Ω

Formula:

$$V = I \times R$$

Calculation:

$$V = 50\ \text{A} \times 100\ \Omega = 5000\ \text{V}$$

Answer:

$$\mathbf{5,000}\ \text{V}$$

5. The current passing through a resistor in a circuit is 0.5 A when the voltage across it is 6.0 V. What current will pass through the same resistor when the voltage across it is 9.0 V?

Given:

- Initial Voltage (V_1) = 6.0 V
- Initial Current (I_1) = 0.5 A
- New Voltage (V_2) = 9.0 V

Step 1: Find Resistance (R)

$$R = \frac{V_1}{I_1} = \frac{6.0\ \text{V}}{0.5\ \text{A}} = 12\ \Omega$$

Step 2: Find New Current (I_2)

$$I_2 = \frac{V_2}{R} = \frac{9.0\ \text{V}}{12\ \Omega} = 0.75\ \text{A}$$

Answer:

$$\mathbf{0.75}\ \text{A}$$

6. The length and area of wire are given as 2 m and 0.4 mm^2 respectively. The resistance of that wire is 0.085 Ω, calculate the resistivity?

Given:

- Length (L) = 2 m
- Area (A) = 0.4 mm^2 = 0.4×10^{-6} m^2
- Resistance (R) = 0.085 Ω

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Formula:

$$R = \rho \frac{L}{A} \Longrightarrow \rho = \frac{R \times A}{L}$$

Calculation:

$$\rho = \frac{0.085\ \Omega \times 0.4 \times 10^{-6}\ \text{m}^2}{2\ \text{m}}$$

$$\rho = \frac{0.034 \times 10^{-6}}{2} = 0.017 \times 10^{-6} = 1.7 \times 10^{-8}\ \Omega \cdot \text{m}$$

Answer:

$$\mathbf{1.7 \times 10^{-8}\ \Omega} \cdot \text{m}$$

7. Resistivity of a given copper wire of length 2 m is $\mathbf{1.7 \times 10^{-8}\ \Omega \cdot m}$.
(a) If the wire is stretched to double of its length, what will be the new resistivity?
(b) If its temperature is increased by 20 K**, find the new resistivity. (Take** $\alpha = 3.9 \times 10^{-3}\ \text{K}^{-1}$**)**

Part (a):

- **Concept:** Resistivity (ρ) is an intrinsic intensive material property. It depends only on the material and temperature, independent of dimensions (length or area).
- **Answer (a):**

$$\mathbf{1.7 \times 10^{-8}\ \Omega} \cdot \text{m}$$

Part (b):

- **Given:**
  - Initial Resistivity (ρ_0) = $1.7 \times 10^{-8}\ \Omega \cdot \text{m}$
  - Temperature Change (ΔT) = 20 K
  - Temperature Coefficient (α) = $3.9 \times 10^{-3}\ \text{K}^{-1}$
- **Formula:**

$$\rho_{\text{new}} = \rho_0(1 + \alpha \Delta T)$$

- **Calculation:**

$$\rho_{\text{new}} = 1.7 \times 10^{-8} \times \left(1 + (3.9 \times 10^{-3} \times 20)\right)$$

$$\rho_{\text{new}} = 1.7 \times 10^{-8} \times (1 + 0.078)$$

$$\rho_{\text{new}} = 1.7 \times 10^{-8} \times 1.078 = 1.8326 \times 10^{-8}\ \Omega \cdot \text{m}$$

- **Answer (b):**

$$\mathbf{1.83 \times 10^{-8}\ \Omega} \cdot \text{m}$$

8. At some temperature T_o, the resistivity of a metallic conductor is $\mathbf{1.7 \times 10^{-8}\ \Omega \cdot m}$. If the temperature is increased by 50 K, find the new resistivity by taking temperature coefficient of resistivity as 0.004.

Given:

- Initial Resistivity (ρ_0) = $1.7 \times 10^{-8}\ \Omega \cdot \text{m}$
- Temperature Change (ΔT) = 50 K
- Temperature Coefficient (α) = $0.004\ \text{K}^{-1}$

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Formula:

$$\rho_{\text{new}} = \rho_0(1 + \alpha\Delta T)$$

Calculation:

$$\rho_{\text{new}} = 1.7 \times 10^{-8} \times \left(1 + (0.004 \times 50)\right)$$

$$\rho_{\text{new}} = 1.7 \times 10^{-8} \times (1 + 0.20)$$

$$\rho_{\text{new}} = 1.7 \times 10^{-8} \times 1.20 = 2.04 \times 10^{-8}\ \Omega \cdot \text{m}$$

Answer:

$$\mathbf{2.04 \times 10^{-8}\ \Omega} \cdot \text{m}$$

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