Resistance JEE Main PYQ - 1

Total Time: 50 Minute **Total Marks:** 80

Instructions

Instructions

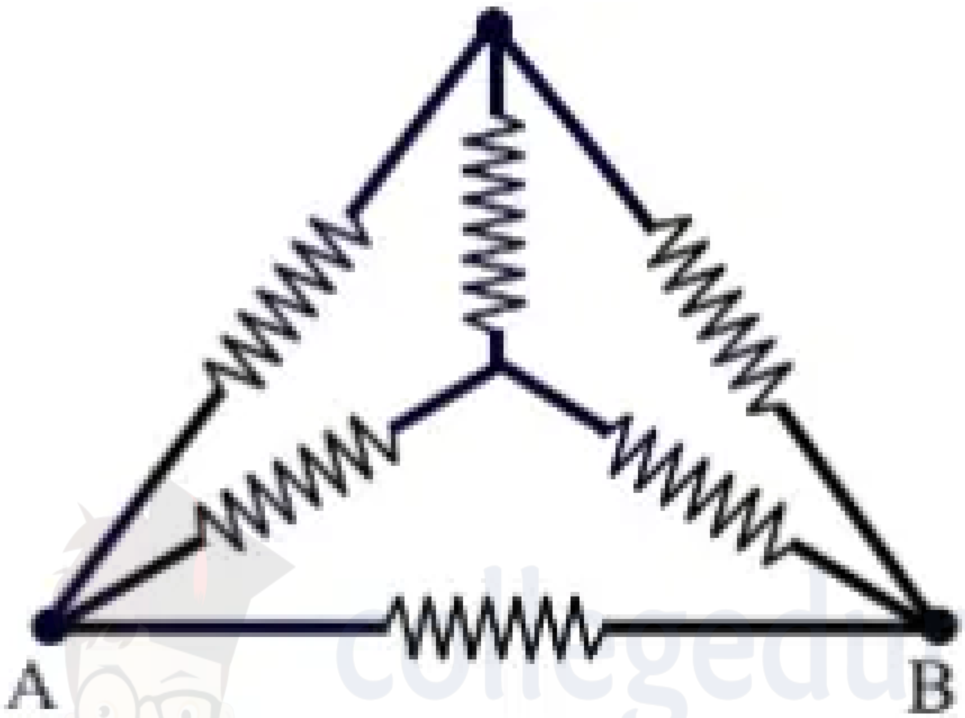
1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Resistance

1. **A wire of resistance R is bent into a triangular pyramid as shown in the figure, with each segment having the same length. The resistance between points A and B is $\frac{R}{n}$. The value of n is:** **(+4, -1)**



a. 16

b. 14

c. 10

d. 12

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2. Two wires A and B are made up of the same material and have the same mass. Wire A has radius $2.0\,\mathrm{mm}$ and wire B has radius $4.0\,\mathrm{mm}$. The resistance of wire B is $2\,\Omega$. The resistance of wire A is _____ Ω. **(+4, -1)**

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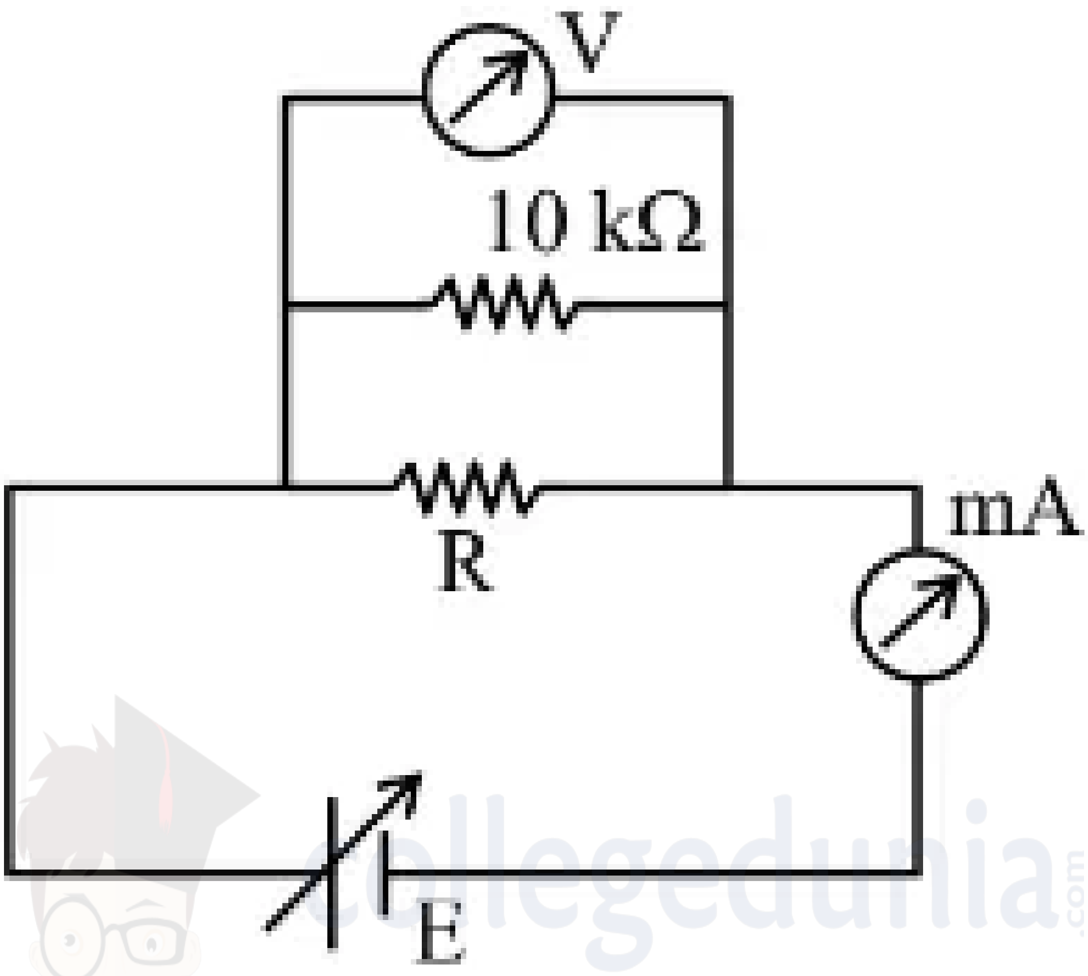
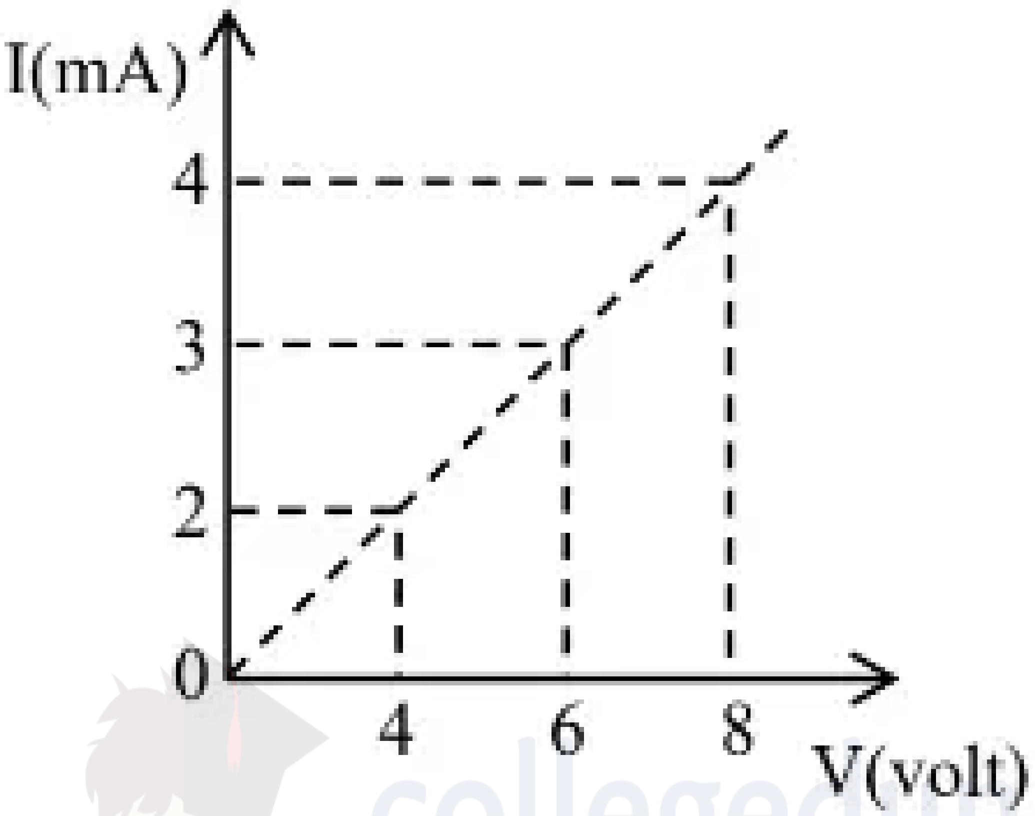
3. To determine the resistance R of a wire, a circuit is designed below. The V-I characteristic curve for this circuit is plotted for the voltmeter and the ammeter readings as shown in the figure. The value of R is $\ldots\ldots\ldots\,\Omega$. **(+4, -1)**


V
10 kΩ
R
mA
E



4. A 16Ω wire is bent to form a square loop. A 9 V battery with internal resistance 1Ω is connected across one of its sides. If a 4μF capacitor is connected across one of its diagonals, the energy stored by the capacitor will be $\frac{x}{2}$ μJ, where $x =$ _____. **(+4, -1)**

5. The resistance $R = \frac{V}{I}$ where $V = (200 \pm 5)\,\mathrm{V}$ and $I = (20 \pm 0.2)\,\mathrm{A}$. The percentage error in the measurement of R is: **(+4, -1)**

a. 3.5%

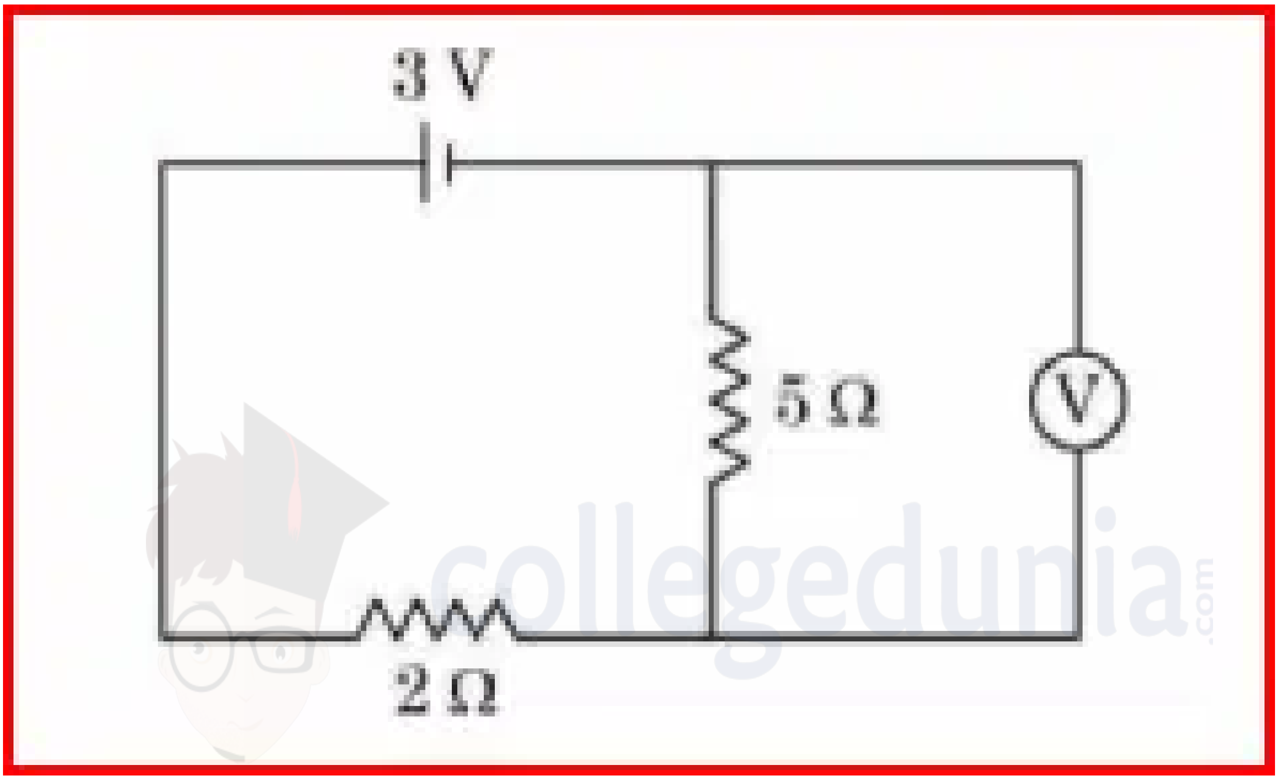
b. 7%

c. 3%

d. 5.5%

6. When a resistance of 5Ω is shunted with a moving coil galvanometer, it shows a full scale deflection for a current of 250 mA, however when 1050Ω resistance is connected with it in series, it gives full scale deflection for 25 volt. The resistance of galvanometer is _____Ω . **(+4, -1)**

7. As shown in the figure, the voltmeter reads 2V across 5Ω resistor. The resistance of the voltmeter is_____Ω. **(+4, -1)**



8. A wire of resistance 160 Ω is melted and drawn in wire of one-fourth of its length. The new resistance of the wire will be **(+4, -1)**

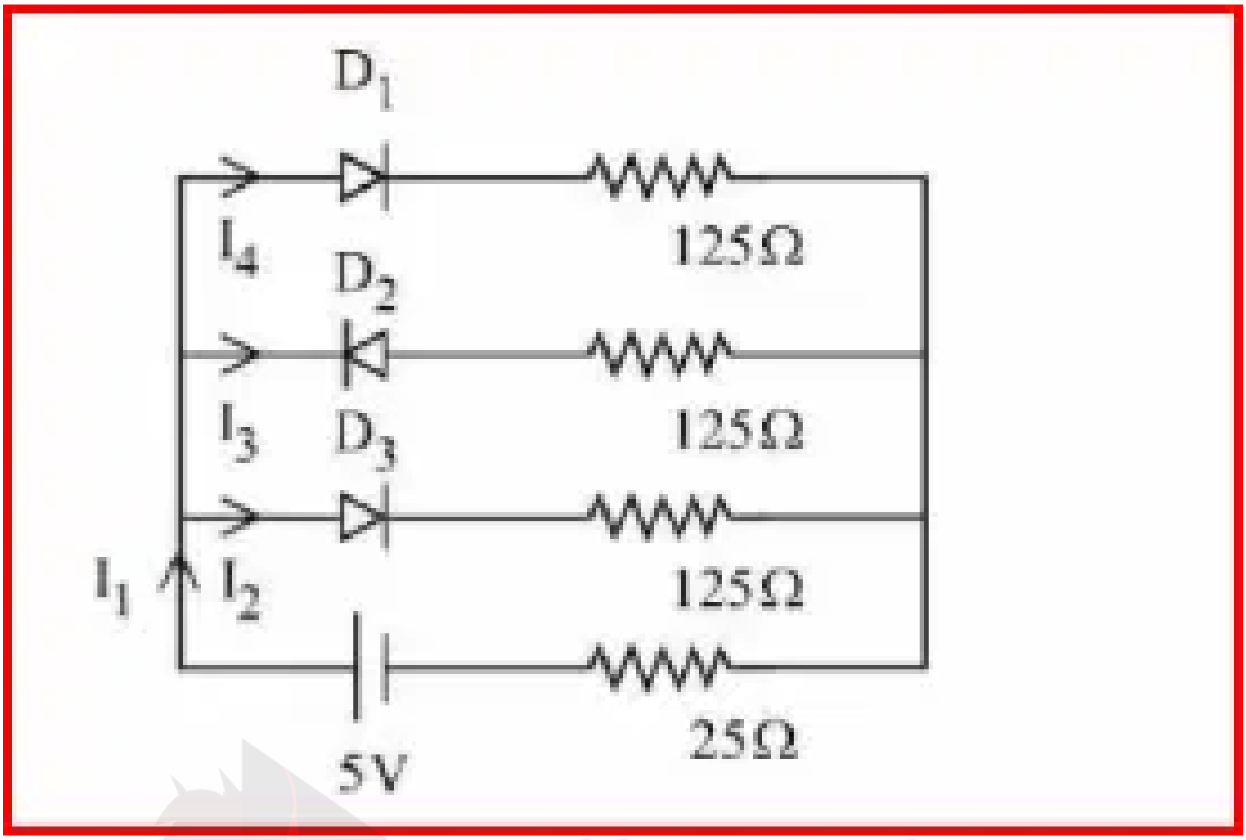
a. 10 Ω

b. 16 Ω

c. 40 Ω

d. 640 Ω

9. If each diode has a forward bias resistance of 25Ω in the below circuit, Which of the following options is correct: **(+4, -1)**



a. $\frac{I_1}{I_2}=1$

b. $\frac{I_2}{I_3}=1$

c. $\frac{I_3}{I_4}=1$

d. $\frac{I_1}{I_2}=2$

---

10. A wire of resistance 160 Ω is melted and drawn in wire of one-fourth of its length. The new resistance of the wire will be **(+4, -1)**

a. 10 Ω

b. 16 Ω

c. 40 Ω

d. 640 Ω

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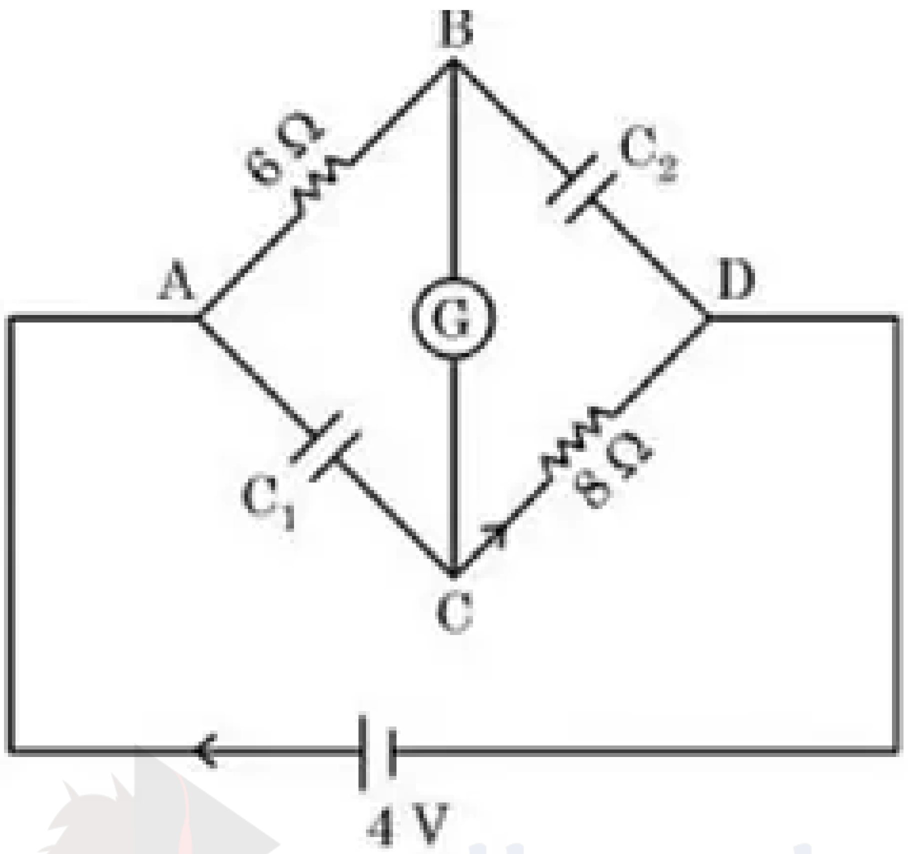
11. In this figure the resistance of the coil of galvanometer G is 2Ω. The emf of the cell is 4 V. The ratio of potential difference across C_1 and C_2 is **(+4, -1)**



a. $\frac{4}{5}$

b. 1

c. $\frac{5}{4}$

d. $\frac{3}{4}$

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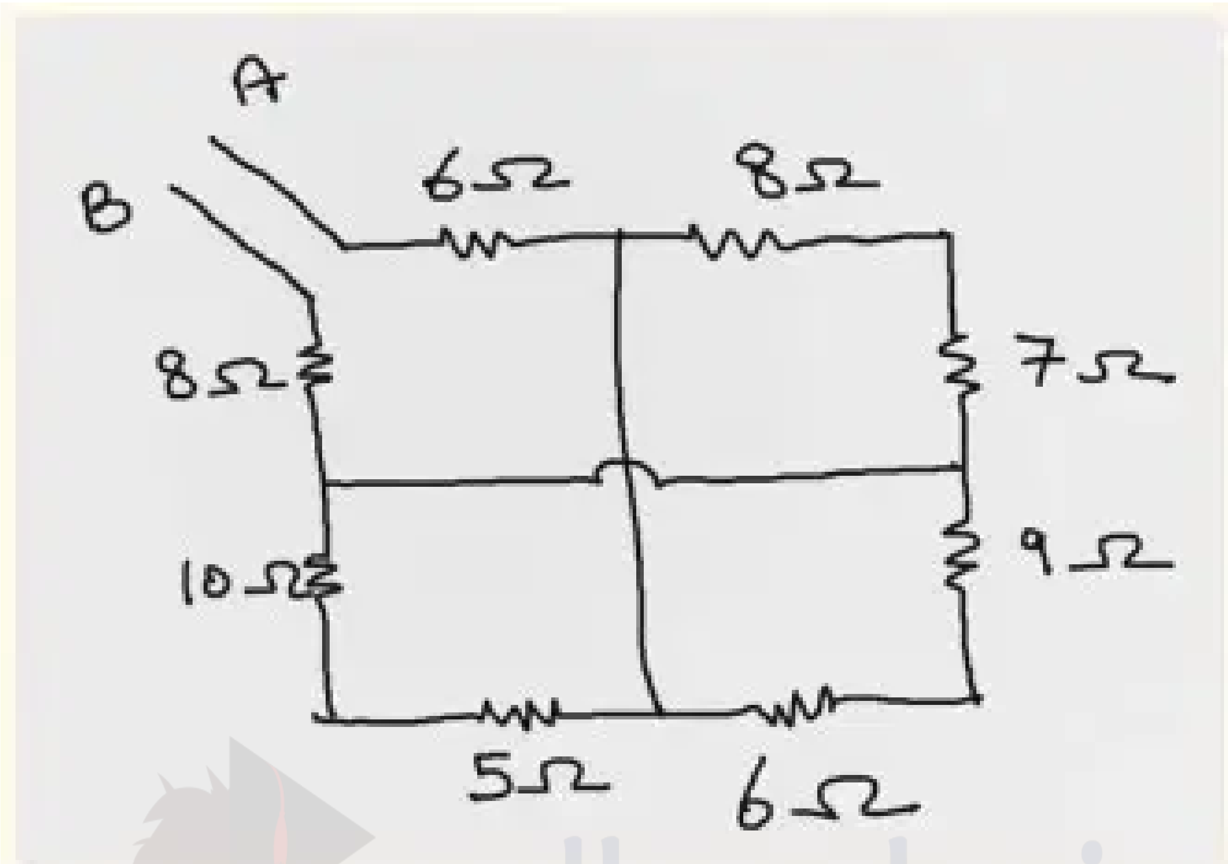
12. Find the equivalent resistance between terminal A and B for the given network. **(+4, -1)**



a. 16 Ω

b. 20 Ω

c. 15 Ω

d. 19 Ω

---

13. 20R resistance wire is cut into 10 equal parts. Now each part first is connected in series and then in parallel. Find ratio of equivalent resistance in both cases (Rseries : Rparallel) **(+4, -1)**

a. 100 : 1

b. 50 : 1

c. 25 : 1

d. 5 : 1

14. Given below are two statements: **(+4, -1)**

Statement I : The equivalent resistance of resistors in a series combination is smaller than least resistance used in the combination.

Statement II : The resistivity of the material is independent of temperature.

In the light of the above statements, choose the correct answer from the options given below :

a. Statement I is false but Statement II is true

b. Both Statement I and Statement II are false

c. Statement I is true but Statement II is false

d. Both Statement I and Statement II are true

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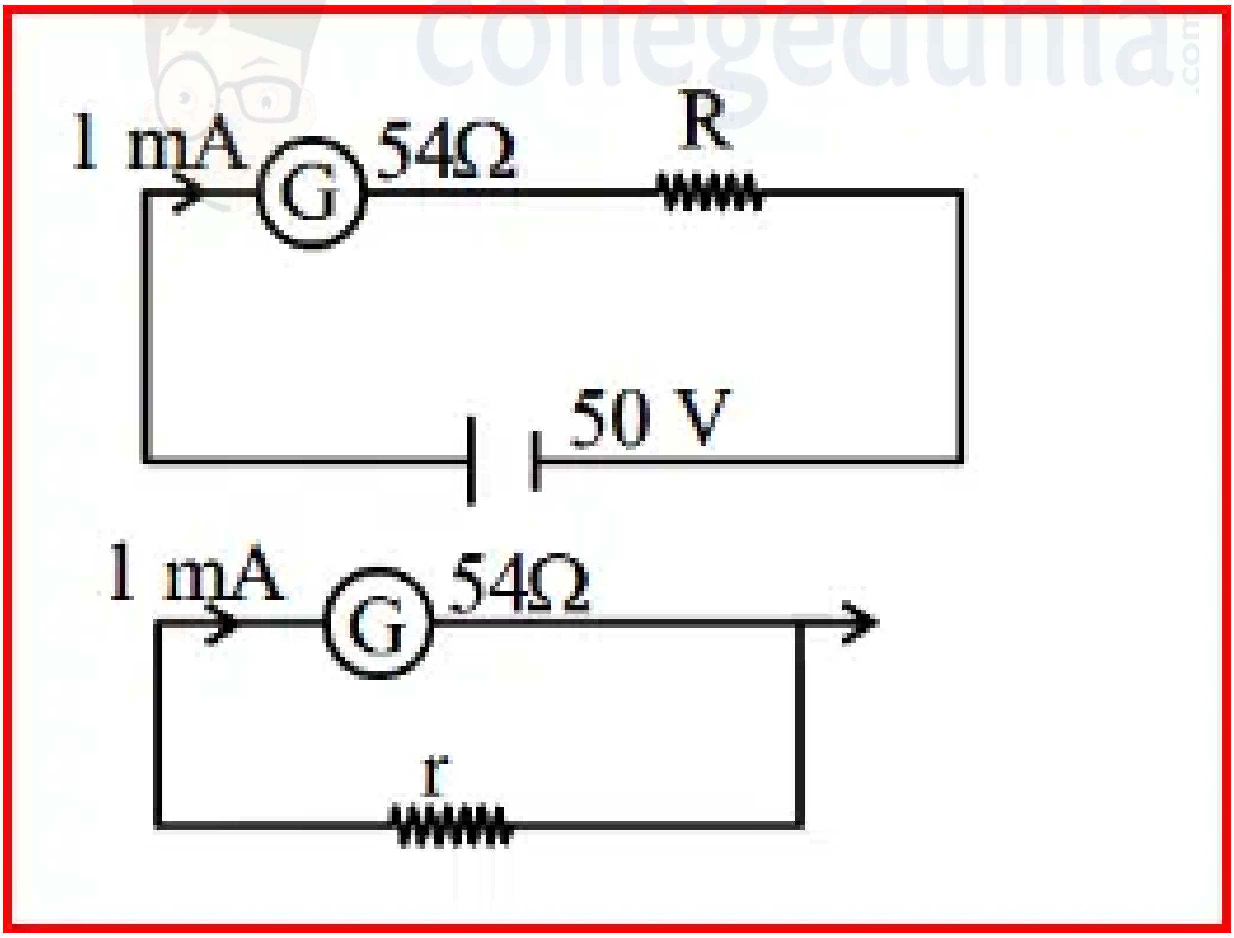
15. For designing a voltmeter of range 50 V and an ammeter of range 10 mA using a galvanometer which has a coil of resistance 54Ω showing a full scale deflection for 1 mA as in figure. **(+4, -1)**



(A) for voltmeter R ≈ 50 kΩ

(B) for ammeter r ≈ 0.2Ω
(C) for ammeter r ≈ 6Ω
(D) for voltmeter R ≈ 5 kΩ (E) for voltmeter R ≈ 500Ω
Choose the correct answer from the options given below :

a. (A) and (C)

b. (A) and (B)

c. (C) and (D)

d. (C) and (E)

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16. A 12V battery connected to a coil of resistance 6Ω through a switch, drives a constant current in the circuit. The switch is opened in 1ms. The emf induced across the coil is 20V. The inductance of the coil is: **(+4, -1)**

a. 5mH

b. 8mH

c. 10mH

d. 12mH

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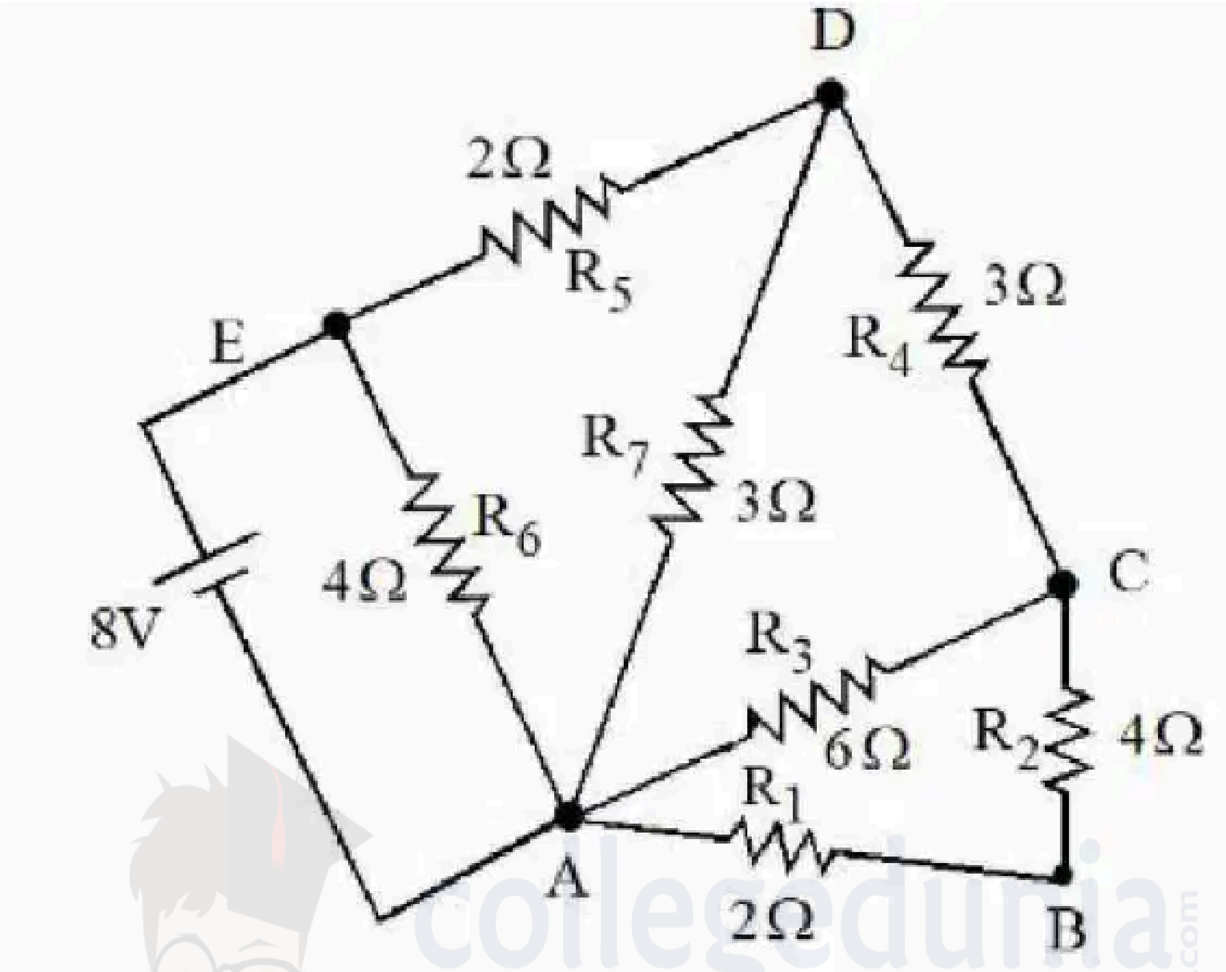
17. Two identical cells each of emf 1.5 V are connected in series across a 10Ω resistance. An ideal voltmeter connected across 10 resistance reads 1.5 V. The internal resistance of each cell is ______Ω. **(+4, -1)**



18. (+4, -1)

The current flowing through R_2 is

a. $\frac{1}{3}A$

b. $\frac{1}{2}A$

c. $\frac{2}{3}A$

d. $\frac{1}{4}A$

---

19. A rectangular parallelopiped is measured as 1 cm × 1 cm × 100 cm. If its specific resistance is 3 × 10^{-7} Ωm, then the resistance between its two opposite rectangular faces will be _____ ×10^{-7} Ω. (+4, -1)

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20. The distance between two plates of a capacitor is d and its capacitance is C_1, when air is the medium between the plates. If a metal sheet of thickness $\frac{2d}{3}$ and of the same area as plate is introduced between the plates, the capacitance of the capacitor becomes C_2. The ratio $\frac{C_2}{C_1}$ is (+4, -1)

a. 4:1

b. 2:1

c. 3:1

d. 1:1

Answers

1. **Answer: d**

Explanation:

We are given a triangular pyramid formed by a wire with resistance R, and each segment has the same length.
The wire is bent into a pyramid, and we are asked to find the resistance between points A and B.
Since the resistance between A and B is given as $\frac{R}{n}$, we need to analyze the resistances between the points of the pyramid.
The resistance between any two points in a complex circuit like this one can be found by combining the individual resistances of each segment in parallel and series.
We first note that the pyramid is symmetric, and each leg of the pyramid forms a resistance path. Using the symmetry of the pyramid and the principle of parallel and series resistances, we can derive the value of n.
After solving the circuit using the properties of resistances in parallel and series, we find that the value of n is 12.
Thus, the resistance between points A and B is $\frac{R}{12}$. %
Final Answer n = 12

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2. **Answer: 32 - 32**

Explanation:

Since both wires are made of the same material and have the same mass, they also have the same volume. Let ρ be the resistivity, A the cross-sectional area, V the volume, and ℓ the length.

The resistance R of a wire is given by:

$$R = \frac{\rho \ell}{A} = \frac{\rho V}{A^2}.$$

Since V is constant for both wires, we can write:

$$\frac{R_A}{R_B} = \frac{A_B^2}{A_A^2} = \frac{r_B^4}{r_A^4}.$$

Given $R_B = 2\,\Omega$, $r_B = 4\,\text{mm}$, and $r_A = 2\,\text{mm}$, we substitute these values:

$$\frac{R_A}{2} = \left(\frac{4 \times 10^{-3}}{2 \times 10^{-3}}\right)^4.$$

Simplifying this, we get:

$$\frac{R_A}{2} = 16,$$

which gives:

$$R_A = 32\,\Omega.$$

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3. Answer: 2500 - 2500

Explanation:

To determine the resistance R of the wire, we use Ohm's Law: $V = IR$, where V is the voltage, I is the current, and R is the resistance.
The circuit shows that a 10 kΩ resistor is in parallel with R. The total resistance (R_t) for resistors in parallel is given by:
$\frac{1}{R_t} = \frac{1}{R} + \frac{1}{10000}$.

From the graph, at 8 V:
$I = 4$ mA $= 0.004$ A.
Using Ohm's law for 8 V, $R_t = \frac{8}{0.004} = 2000\,\Omega$.

Substituting $R_t = 2000\,\Omega$ into the parallel formula:
$\frac{1}{2000} = \frac{1}{R} + \frac{1}{10000}$
Solving for R:
$\frac{1}{R} = \frac{1}{2000} - \frac{1}{10000} = \frac{5}{10000} - \frac{1}{10000} = \frac{4}{10000}$
$R = \frac{10000}{4} = 2500\,\Omega$.

The calculated resistance $R = 2500\,\Omega$ fits within the expected range (2500,2500).

4. **Answer: 81 - 81**

Explanation:

Step 1: Calculate Equivalent Resistance:

- The square loop consists of four $4\,\Omega$ resistors, each forming the sides of the square.
- The equivalent resistance R_{eq} between points A and B (opposite sides of the square) is:

$$R_{eq} = \frac{12 \times 4}{12 + 4} = 3\,\Omega$$

- Including the internal resistance of the battery, the total resistance is $R = 3 + 1 = 4\,\Omega$
.

Step 2: Calculate the Current I:

$$I = \frac{V}{R} = \frac{9}{4} = 2.25\,A$$

Step 3: Determine Current Through Each Side:

- Due to symmetry, the current through each $4\,\Omega$ resistor in parallel with the capacitor is I_1:

$$I_1 = \frac{9}{16} = 0.5625\,A$$

Step 4: Calculate Voltage Across the Capacitor:

$$V_{AB} = I_1 \times 8 = 4.5\,V$$

Step 5: Calculate Energy Stored in the Capacitor:

- Energy stored in a capacitor is given by:

$$U = \frac{1}{2} C V_{AB}^2$$

- Substitute values:

$$U = \frac{1}{2} \times 4 \times (4.5)^2 = \frac{81}{2}\,\mu J$$

Step 6: Determine x:

- Since $U = \frac{x}{2}\mu J$, we find $x = 81$.

So, the correct answer is: $x = 81$

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5. **Answer: a**

Explanation:

Step 1: Express R in Terms of V and I

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

Step 2: Calculate the Percentage Error Using Error Analysis

The relative error in R is given by:

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

Substitute the values:

$$\frac{\Delta R}{R} = \frac{5}{200} + \frac{0.2}{20}$$

Step 3: Simplify the Expression

$$\frac{\Delta R}{R} = \frac{5}{200} + \frac{0.2}{20} = \frac{5}{200} + \frac{2}{200} = \frac{7}{200}$$

Step 4: Calculate the Percentage Error

$$\text{Percentage Error} = \frac{\Delta R}{R} \times 100 = \frac{7}{200} \times 100 = 3.5\%$$

So, the correct answer is: 3.5%

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6. **Answer: 50 - 50**

Explanation:

Solution:

Let G be the resistance of the galvanometer. For the shunted circuit, the total current I is given by:

$$I = 250\,\text{mA} = 0.25\,\text{A}.$$

The current through the galvanometer is:

$$I_G = \frac{I \times S}{G + S}.$$

Substituting $S = 5\,\Omega$ and $I_G = 0.25\,\text{A}$:

$$0.25 = \frac{0.25 \times 5}{G + 5}.$$

Simplifying:

$$G + 5 = 5 \quad \Rightarrow \quad G = 0\,\Omega.$$

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7. **Answer: 20 - 20**

Explanation:

Method-I: The equivalent resistance for the given circuit is:

$$R_{eq} = 2 + \frac{5R}{5 + R}$$

Using Ohm's law:

$$i = \frac{3}{R_{eq}} = \frac{3}{5 + R}$$

The current in the circuit is:

$$i = 3 \times \frac{5R}{5 + R}$$

From the voltage readings, we calculate $R = 20\,\Omega$.

Method-II: Given potential across 5 Ω and voltmeter is 2V, to find the resistance R of the voltmeter:

$$i = \frac{2}{5} = \frac{1}{2}$$

Using junction law:

$$i = i_1 + i_2$$

Hence, $R = 20\,\Omega$.

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8. **Answer: a**

Explanation:

The correct option is(A): 10 Ω

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9. **Answer: d**

Explanation:

Analyzing the circuit.
From the given circuit, we see that Diodes D_1 and D_3 are conducting, while D_2 is reverse biased. Hence, current I_1 will be split between I_3 and I_4, and $I_2 = 0$. Using Kirchhoff's Current Law (KCL), we have:

$$I_1 = I_2 + I_4 + I_3 = 2I_2$$

Thus, the ratio $\frac{I_1}{I_2}$ is:

$$\frac{I_1}{I_2} = 2$$

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10. **Answer: a**

Explanation:

Given that the volume of the wire remains constant, we use the relation:

$$A_1 L_1 = A_2 L_2$$

Where: - A_1 and L_1 are the area and length of the original wire, - A_2 and L_2 are the area and length of the new wire. The volume of the wire is constant, so the area of cross-section A_2 and the length L_2 change according to the new dimensions. Since the length of the new wire is one-fourth of the original, we have:

$$A_1 L_1 = A_2 L_2 \quad \Rightarrow \quad A_2 = 4A_1$$

For resistance R, we know:

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

Thus, for the new wire:

$$R_2 = \rho \frac{L_2}{A_2} = \rho \frac{L/4}{4A} = \rho \frac{L}{16A} = \frac{1}{16} R_1$$

Substituting $R_1 = 160\Omega$:

$$R_2 = \frac{1}{16} \times 160 = 10\Omega$$

Thus, the new resistance is $\boxed{10}\Omega$.

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11. Answer: a

Explanation:

Step 1: Apply Kirchhoff's laws.- Using the given circuit, calculate the currents and potential drops across C1 and C2.- The ratio is determined as:

$\frac{V_{C1}}{V_{C2}} = \frac{4}{5}$.

Final Answer: The ratio of potential differences is $\frac{4}{5}$

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12. Answer: d

Explanation:

The Correct answer is option is (D) : 19 Ω

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13. **Answer: a**

Explanation:

The Correct answer is option is (A) : 100 : 1

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14. **Answer: b**

Explanation:

The correct option is(B): Both Statement I and Statement II are false

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15. **Answer: a**

Explanation:

Understanding the Problem

We are given a galvanometer with a resistance of 54 Ω and a full-scale deflection current of 1 mA. We need to find the resistance R to convert it into a voltmeter reading 50 V, and the shunt resistance r to convert it into an ammeter reading 10 A.

Solution

For Voltmeter:

1. **Current Through Voltmeter:**

The current flowing through the voltmeter is given by $I = \frac{V}{R+G}$, where G is the galvanometer resistance.

2. **Substitute Values:**

We are given $V = 50\,\text{V}$, $G = 54\,\Omega$, and $I = 1\,\text{mA} = 0.001\,\text{A}$.

$0.001 = \frac{50}{R+54}$

3. **Solve for R:**

$R + 54 = \frac{50}{0.001} = 50000$

$R = 50000 - 54 = 49946\,\Omega$

$R \approx 50\,\mathrm{k\Omega}$

For Ammeter:

1. **Shunt Current:**

The total current is $I = 10\,\mathrm{A}$. The galvanometer current is $I_g = 1\,\mathrm{mA} = 0.001\,\mathrm{A}$. The shunt current is $I_s = I - I_g$.

$I_s = 10 - 0.001 \approx 10\,\mathrm{A}$

2. **Voltage Across Galvanometer and Shunt:**

The voltage across the galvanometer and the shunt resistor is the same.

$I_g G = I_s r$

3. **Substitute Values and Solve for r:**

$(0.001)(54) = (10)r$

$r = \frac{0.001 \times 54}{10} = 0.0054\,\Omega$

$r = 5.4\,\mathrm{m\Omega}$

Corrected Answers:

The resistance R is approximately $50\,\mathrm{k\Omega}$.

The shunt resistance r is approximately $5.4\,\mathrm{m\Omega}$.

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16. Answer: c

Explanation:

Understanding the Problem

We are given the induced emf in a coil and the rate of change of current, and we need to find the inductance of the coil.

Solution

1. **Formula for Induced EMF:**

The induced emf in a coil is given by:

$e = -L\frac{di}{dt}$

where:

- e is the emf induced across the coil
- L is the inductance
- $\frac{di}{dt}$ is the rate of change of current

2. **Given Values:**

- $e = 20\,\text{V}$
- $R = 6\,\Omega$ (not needed for this calculation)
- $i = 2\,\text{A}$ (initial current)
- $\frac{di}{dt} = \frac{0-2}{10^{-3}} = -2 \times 10^3\ \text{A/s}$

3. **Substitute Values into the Formula:**

$20 = -L \times (-2 \times 10^3)$

4. **Solve for Inductance (L):**

$L = \frac{20}{2\times10^3}$

$L = 10 \times 10^{-3}\,\text{H}$

$L = 10\,\text{mH}$

Final Answer

The inductance of the coil is $10\,\text{mH}$.

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17. **Answer: 5 - 5**

Explanation:

Given:

- EMF of each cell (ε) = $1.5\,\mathrm{V}$
- External resistance (R) = $10\,\Omega$
- Voltmeter reading across R: $V_R = 1.5\,\mathrm{V}$.

Step 1: Calculate the Current in the Circuit

The cells are connected in series, so:

- Total EMF: $2\varepsilon = 2 \times 1.5 = 3\,\mathrm{V}$
- Total internal resistance: $2r$ (where r is the internal resistance of each cell).

The current I in the circuit is given by:

$$I = \frac{2\varepsilon}{R + 2r}.$$

The voltmeter measures the potential difference across the external resistance R:

$$V_R = I \cdot R.$$

Rearranging to find I:

$$I = \frac{V_R}{R}.$$

Substitute $V_R = 1.5\,\mathrm{V}$ and $R = 10\,\Omega$:

$$I = \frac{1.5}{10} = 0.15\,\mathrm{A}.$$

Step 2: Solve for the Internal Resistance

Using the formula for current in the circuit:

$$I = \frac{2\varepsilon}{R + 2r}.$$

Substitute $I = 0.15\,\mathrm{A}$, $2\varepsilon = 3\,\mathrm{V}$, and $R = 10\,\Omega$:

$$0.15 = \frac{3}{10 + 2r}.$$

Rearranging for $10 + 2r$:

$$10 + 2r = \frac{3}{0.15} = 20.$$

Simplify for $2r$:

$$2r = 20 - 10 = 10.$$

Finally, solve for r:

$$r = \frac{10}{2} = 5\,\Omega.$$

Final Answer:

The internal resistance of each cell is $5\,\Omega$.

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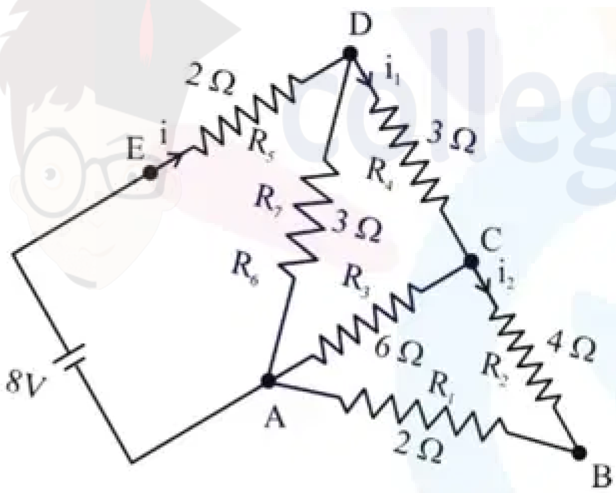
18. Answer: a

Explanation:



Step 1: Determine the Equivalent Resistance (R_{eq})

The total resistance in the circuit is given as:

$$R_{\text{eq}} = 4\,\Omega.$$

Step 2: Calculate the Total Current (i)

Using Ohm's law:

$$i = \frac{V}{R_{\text{eq}}}.$$

Substitute the given values ($V = 8\,\text{V}$, $R_{\text{eq}} = 4\,\Omega$):

$$i = \frac{8}{4} = 2\,\text{A}.$$

Step 3: Calculate i_1

The current i_1 is determined using the current division rule:

$$i_1 = i \cdot \frac{R_2}{R_1 + R_2},$$

where $R_1 = 6\,\Omega$ and $R_2 = 3\,\Omega$. Substituting the values:

$$i_1 = 2 \cdot \frac{3}{3+6} = 2 \cdot \frac{3}{9} = \frac{6}{9} = \frac{2}{3}\,\text{A}.$$

Step 4: Calculate i_2

The current i_2 is given by:

$$i_2 = \frac{i_1}{2}.$$

Substitute $i_1 = \frac{2}{3}$:

$$i_2 = \frac{\frac{2}{3}}{2} = \frac{2}{3} \cdot \frac{1}{2} = \frac{1}{3}\,\text{A}.$$

Final Answer:

The calculated currents are:

- $i = 2\,\text{A}$
- $i_1 = \frac{2}{3}\,\text{A}$
- $i_2 = \frac{1}{3}\,\text{A}$

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19. **Answer: 3 - 3**

Explanation:

Step 1: Understanding the formula for resistance.
The resistance R between two opposite faces of a rectangular parallelepiped is

given by the formula:

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

Where:
$\rho = 3 \times 10^{-7}\,\Omega$-cm is the specific resistance,
$l = 1\,\text{cm}$ is the length of the parallelepiped,
$A = 1\,\text{cm} \times 100\,\text{cm} = 100\,\text{cm}^2$ is the cross-sectional area.
Step 2: Calculating the resistance.
Substituting the given values:

$$R = \frac{3 \times 10^{-7} \times 1}{100\,\text{cm}^2} = 3 \times 10^{-7} \times \frac{1}{100 \times 10^{-4}} = 3 \times 10^{-5}\,\Omega$$

Thus, the resistance between the two opposite faces is $3 \times 10^{-5}\,\Omega$.

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20. Answer: c

Explanation:

The capacitance C of a parallel plate capacitor is given by the formula:

$$C = \frac{\epsilon_0 A}{d}$$

where ϵ_0 is the permittivity of free space, A is the area of the plates, and d is the distance between the plates. For the initial configuration, the capacitance is C_1 with air as the dielectric, so:

$$C_1 = \frac{\epsilon_0 A}{d}$$

When a metal sheet of thickness $\frac{2d}{3}$ is introduced between the plates, the effective distance between the plates becomes $d - \frac{2d}{3} = \frac{d}{3}$, and the capacitance becomes C_2. The formula for C_2 becomes:

$$C_2 = \frac{\epsilon_0 A}{d - t + \frac{t}{K}}$$

where $t = \frac{2d}{3}$ and $K = \infty$ for metals. Substituting these values:

$$C_2 = \frac{\epsilon_0 A}{\frac{d}{3}} = 3 \times \frac{\epsilon_0 A}{d} = 3C_1$$

Thus, the ratio $\frac{C_2}{C_1} = 3 : 1$.