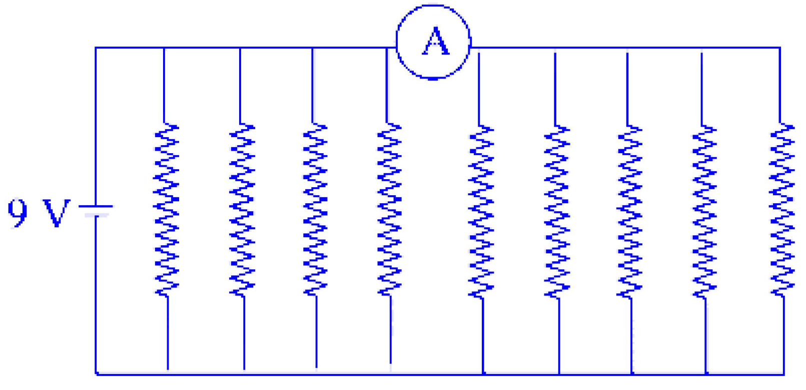
Current Electricity

Question1

If each resistance in the figure is 9Ω, then the reading of the ammeter (A) is



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Options:

A.

8 A

B.

5 A

C.

2 A

D.

9 A

Answer: B

Solution:

If R_{eq} be the equivalent resistance of the circuit, then

$$\frac{1}{R_{\text{eq}}} = \frac{1}{9} + \frac{1}{9} + \frac{1}{9} + \ldots \text{ nine times}$$
$$= \frac{9}{1} = 1$$
$$\Rightarrow R_{\text{eq}} = 1\Omega$$

$\therefore$ Current drawn from the 9 volt battery, i.e. main current

$I = \frac{V}{R_{\text{eq}}} = \frac{9}{1} = 9 \text{ A}$

From the circuit diagram, it is clear that current through each resistor will be 1 A and only 5 resistors on the right side of ammeter contributes for passing current through the ammeter.

Thus, reading of ammeter will be 5A.

Question2

The area of cross-section of a copper wire is $4 \times 10^{-7} \text{ m}^2$ and the electrons per cubic metre in copper is 8×10^{28}. If the wire carries a current of 6.4 A , then the drift velocity of the electrons ($\text{in} 10^{-3} \text{ ms}^{-1}$) is

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Options:

A.

0.25

B.

2.5

C.

0.125

D.

1.25

Answer: D

Solution:

Cross-sectional area, $A = 4 \times 10^{-7}\ \mathrm{m}^2$

Electron density, $n = 8 \times 10^{28}\ \mathrm{m}^{-3}$

Current, $I = 6.4\ \mathrm{A}$

Electron charge,

$e = 1.6 \times 10^{-19}\ \mathrm{C}$

Formula for drift velocity:

$I = neAv_d$

$\Rightarrow v_d = \frac{I}{neA}$

Substituting values:

$v_d = \frac{6.4}{(8\times10^{28})(1.6\times10^{-19})(4\times10^{-7})}$

Compute step-by-step:

1. $neA = 8 \times 10^{28} \times 1.6 \times 10^{-19} \times 4 \times 10^{-7}$

$= 8 \times 1.6 \times 4 \times 10^{28-19-7} = 51.2 \times 10^2 = 5.12 \times 10^3$

2. Therefore,

$v_d = \frac{6.4}{5.12\times10^3} = 1.25 \times 10^{-3}\ \mathrm{m/s}$

So, in units of 10^{-3} m/s:

$v_d = 1.25$

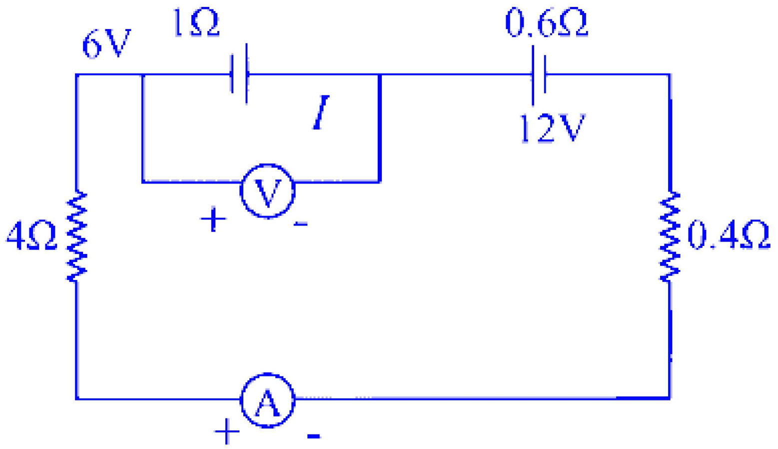
✅ **Final Answer:**

$\boxed{v_d = 1.25 \times 10^{-3}\ \mathrm{m/s}}$

Correct Option: D) 1.25

Question3

The readings of the voltmeter and ammeter in the circuit shown in the diagram are respectively



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Options:

A.

5 V, 3 A

B.

7 V, 3 A

C.

5 V, 1 A

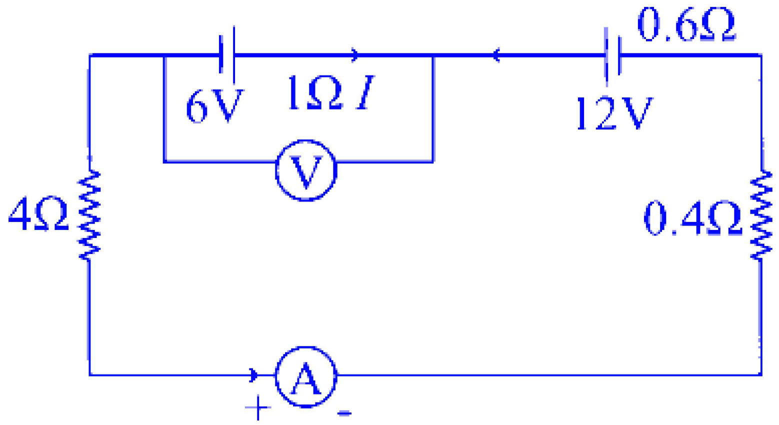
D.

7 V, 1 A

Answer: D

Solution:

By applying the KVL in loop



$$\begin{aligned}
& 12-I(0.6)-I(1)-6-4 I-0.4 I=0 \\
& \qquad 6=6 I \\
\Rightarrow & \quad I=1 \mathrm{~A}
\end{aligned}$$

So, reading of ammeter is 1 A and reading of voltmeter

$$\begin{aligned}
& =6+I \times 1 \\
& =6+1 \times 1=7 \mathrm{~V}
\end{aligned}$$

Question4

When two identical batteries of internal resistance 1Ω each are connected in series across a resistor R, the rate of heat produced in R is P_1. When the same batteries are connected in parallel across R, the rate of heat produced is P_2. If $P_1=2.25 P_2$, then the value of R is

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Options:

A.

2Ω

B.

4Ω

C.

10Ω

D.

12Ω

Answer: B

Solution:

Let emf of both batteries is E. When both are connected in series current through the circuit

$I = \frac{2E}{2+R}$

and power dissipated in R

$P_1 = I^2 R = \frac{4E^2 R}{(2+R)^2}$

When they are connected in parallel their equivalent emf will E and equivalent resistance $\frac{1}{2}$

$$\begin{aligned} So,\ I &= \frac{E}{\left(\frac{1}{2}+R\right)} \\ P_2 &= \frac{E^2}{\left(\frac{1}{2}+R\right)^2} \cdot R \end{aligned}$$

$$\begin{aligned} Now,\ & P_1 = 2.25 P_2 \\ & \frac{4E^2 R}{(2+R)^2} = \left(\frac{E^2 R}{\left(\frac{1}{2}+R\right)^2}\right)\left(\frac{9}{4}\right) \\ & \frac{4}{(2+R)^2} = \left(\frac{1}{\left(\frac{1}{2}+R\right)^2}\right)\left(\frac{9}{4}\right) \\ & 16\left(\frac{1}{2}+R\right)^2 = 9(2+R)^2 \\ & = 4\left(\frac{1}{2}+R\right) = 3(2+R) \\ & 2+4R = 6+3R \\ & R = 4\Omega \end{aligned}$$

Question5

The potential difference across a conducting wire of length 20 cm is 30 V . If the electron mobility is $2 \times 10^{-6}\ \mathrm{m}^2\ \mathrm{V}^{-1}\ \mathrm{s}^{-1}$, then the drift velocity of the electrons is

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Options:

A.

$3 \times 10^{-3}\ \mathrm{ms}^{-1}$

B.

$1.5 \times 10^{-3}\ \mathrm{ms}^{-1}$

C.

$1.5 \times 10^{-4}\ \mathrm{ms}^{-1}$

D.

$3 \times 10^{-4}\ \mathrm{ms}^{-1}$

Answer: D

Solution:

We know the electron mobility (μ) and want to find the drift velocity (v_d).

The formula is: $\mu = \frac{v_d}{E}$

Here, E stands for the electric field. For a wire, $E = \frac{V}{l}$, where V is the voltage and l is the length of the wire.

So, the drift velocity can be found as:

$v_d = E\mu = \frac{V}{l} \cdot \mu$

Plug in the values: $V = 30$ V, $l = 20$ cm $= 20 \times 10^{-2}$ m, and $\mu = 2 \times 10^{-6}\ \mathrm{m}^2\mathrm{V}^{-1}\mathrm{s}^{-1}$.

$v_d = \frac{30 \times 2 \times 10^{-6}}{20 \times 10^{-2}}$

Do the calculation step by step: $30 \times 2 = 60$, $20 \times 10^{-2} = 0.2$.

$v_d = \frac{60 \times 10^{-6}}{0.2} = 300 \times 10^{-6} = 3 \times 10^{-4}\ \mathrm{ms}^{-1}$

Question6

A maximum current of 0.5 mA can pass through a galvanometer of resistance 15Ω. The resistance to be connected in series to the galvanometer to convert it into a voltmeter of range $0 - 10$ V is

Options:

A.

9985Ω

B.

20015Ω

C.

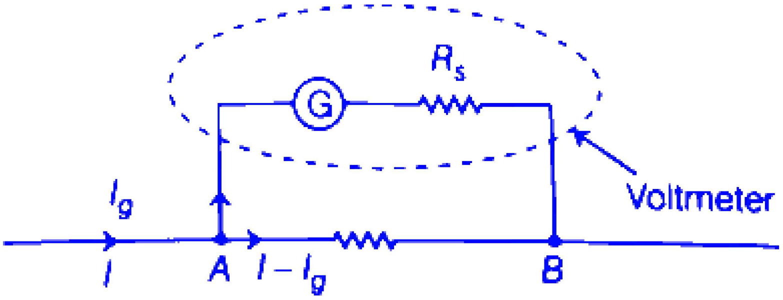
20000Ω

D.

19985Ω

Answer: D

Solution:



Here, $I_g = 0.5 \times 10^{-3}$ A

$V_{AB} = 10$ V, G $= 15\Omega$

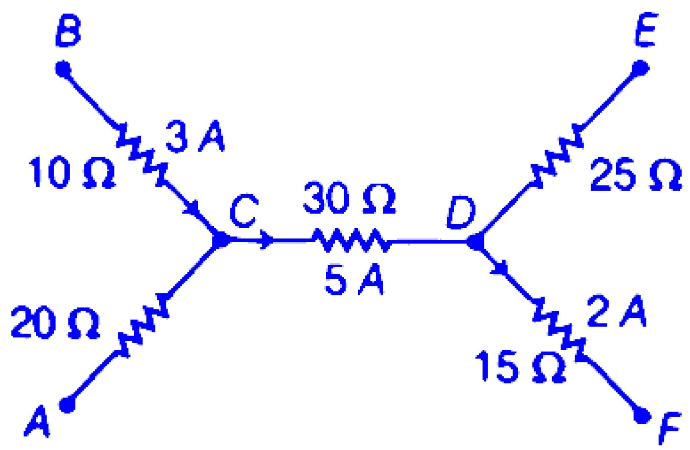
As, $\quad V_{AB} = I_g (G + R_s)$

$$\Rightarrow \quad 10 = 0.5 \times 10^{-3} (1.5 + R_s)$$

$$\Rightarrow \quad R_s = \frac{10}{0.5 \times 10^{-3}} - 15$$
$$= 20000 - 15 = 19985\Omega$$

Question7

A part of a circuit is shown in the figure. The ratio of the potential differences between the points A and C and the points D and E is



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Options:

A.

4 : 5

B.

2 : 3

C.

8 : 15

D.

11 : 15

Answer: C

Solution:

$$\begin{aligned} V_{AC} &= I_{AC} \times 20 \\ &= (5-3) \times 20 = 40 \text{Volt} \\ V_{DE} &= I_{AD} \times 25 = (5-2) \times 25 = 75 \text{ V} \end{aligned}$$

$$\therefore \frac{V_{AC}}{V_{AD}} = \frac{40}{75} = \frac{8}{15}$$

$$\therefore V_{AC} : V_{AD} = 8 : 15$$

Question8

A DC supply of 160 V is used to charge a battery of emf 10 V and internal resistance 1Ω by connecting a series resistance of 24Ω. The terminal voltage of the battery during charging is

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Options:

A.

8 V

B.

12 V

C.

16 V

D.

4 V

Answer: C

Solution:

Terminal voltage of the battery during charging,

$V = E + Ir \qquad\qquad \ldots(i)$

Here, $E = 10$ volt

Net emf in the circuit

$$\begin{aligned} E' &= V_{\text{supply}} - E = 160 - 10 \\ &= 150 \text{ V} \end{aligned}$$

$$\therefore \quad I = \frac{E'}{R+r} = \frac{150}{24+1} = \frac{150}{25} = 6 \text{ A}$$

$\therefore$ From eqn (i)

$$\begin{aligned} V &= E + Ir \\ &= 10 + 6 \times 1 \\ &= 16 \text{ V} \end{aligned}$$

Question9

A wire of resistance ' R ' is bent in the form of a circular loop. Two points on the circle seperated by a quarter circumference are connected to a battery of emf ' E ' and negligible internal resistance. The heat generated in the wire per second is

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Options:

A.

$\frac{E^2}{4R}$

B.

$\frac{16E^2}{3R}$

C.

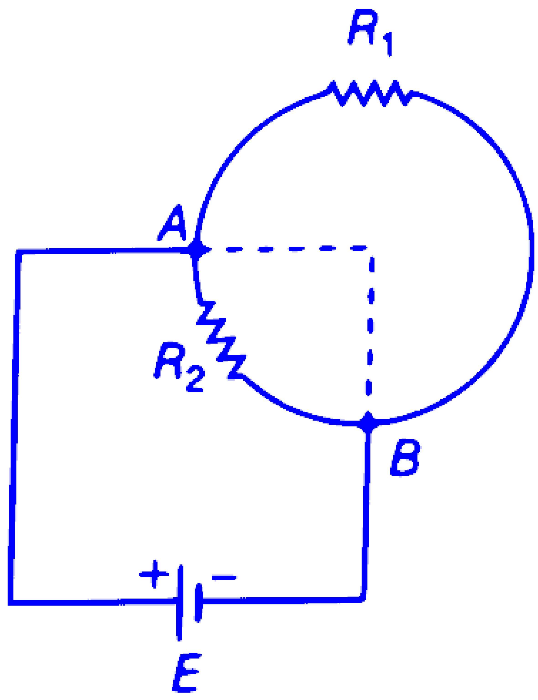
$\frac{E^2}{R}$

D.

$\frac{2E^2}{3R}$

Answer: B

Solution:



$$R_1 = \frac{3R}{4} \text{ and } R_2 = \frac{R}{4}$$

$$\therefore \quad \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{\frac{3R}{4}} + \frac{1}{\frac{R}{4}}$$

$$\frac{1}{R_{eq}} = \frac{4}{3R} + \frac{4}{R} = \frac{16}{3R} \Rightarrow R_{eq} = \frac{3R}{16}$$

Heat generated in the wire per second

$$P = \frac{H}{t} = \frac{E^2}{R_{eq} \cdot t} = \frac{E^2}{\left(\frac{3R}{16}\right) \times 1} \quad [t = 1s]$$

$$= \frac{16E^2}{3R}$$

Question10

When a wire is connected in the left gap of a metre bridge, the balancing point is at 40 cm from the left end of the bridge wire. If the wire in the left gap is stretched so that its length is doubled and again connected in the same gap, then the balancing point from the left end of the bridge wire is

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Options:

A.

$\frac{300}{11}$ cm

B.

$\frac{800}{11}$ cm

C.

$\frac{400}{11}$ cm

D.

$\frac{700}{11}$ cm

Answer: B

Solution:

Let R_1 be the initial resistance of the wire in the left gap.

R_2 be the resistance in the right gap l_1 be the initial balancing length (40 cm)

Let l_2 be the remaining length $(100 - 40 = 60 \text{ cm})$

The initial ratio is $\frac{R_1}{R_2} = \frac{40}{60} = \frac{2}{3}$

When the wire is stretched to double its length, its resistance becomes $4R_1$

Let l_1 " be the new balancing length l_2 'be the new remaining length $(100 - l_1)$

The new ratio is $\frac{4R_1}{R_2} = \frac{l_1{}'}{100 - l_1{}'}$

$$4 \cdot \left(\frac{2}{3}\right) = \frac{l_1'}{100 - l_1'}$$
$$8\left(100 - l_1'\right) = 3l_1'$$
$$800 - 8l_1' = 3l_1'$$
$$11l_1' = 800$$
$$l_1' = \frac{800}{11}$$

The new balancing point is approximately $\left(\frac{800}{11}\right)$cm from the left end.

Question11

The length and area of cross-section of a copper wire are respectively 30 m and $6 \times 10^{-7}\ \mathrm{m}^2$. If the resistivity of copper is $1.7 \times 10^{-8} \Omega\ \mathrm{m}$, then the resistance of the wire is

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Options:

A.

0.51Ω

B.

0.68Ω

C.

0.85Ω

D.

0.75Ω

Answer: C

Solution:

Given:

- Length $L = 30\,\mathrm{m}$
- Area of cross-section $A = 6 \times 10^{-7}\,\mathrm{m}^2$
- Resistivity $\rho = 1.7 \times 10^{-8}\,\Omega\mathrm{m}$

Formula:

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

Substitution:

$R = (1.7 \times 10^{-8}) \times \frac{30}{6\times10^{-7}}$

Simplify:

$\frac{30}{6\times10^{-7}} = 5 \times 10^{7}$

So,

$R = 1.7 \times 10^{-8} \times 5 \times 10^{7}$

$R = (1.7 \times 5) \times 10^{-1}$

$R = 8.5 \times 10^{-1} = 0.85\,\Omega$

✅ **Final Answer:**

Option C: $0.85\,\Omega$

Question12

If current of 80 A is passing through a straight conductor of length 10 m , then the total momentum of electrons in the conductor is

(mass of electron $= 9.1 \times 10^{-31}$ kg and charge of electron $= 1.6 \times 10^{-19}\mathrm{C}$)

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Options:

A.

$910 \times 10^{-9}\mathrm{Ns}$

B.

$910 \times 10^{-11}\mathrm{Ns}$

C.

$455 \times 10^{-9}\mathrm{Ns}$

D.

$455 \times 10^{-11}\mathrm{Ns}$

Answer: D

Solution:

Given Data:

The current $I = 80$ A, and the length of the conductor $L = 10$ m.

Expression for Current:

Current can be written as $I = neAV_d$, where n is the number of electrons per unit volume, e is the charge of an electron, A is the cross-sectional area, and V_d is the drift velocity of electrons.

Total Number of Electrons:

Let N be the total number of free electrons in the length L of the conductor. $N = nAL$.

Total Momentum:

The total momentum of all free electrons is $P_{\text{total}} = N(m_e V_d)$, where m_e is the mass of an electron.

Substitute N:

So, $P_{\text{total}} = (nAL)(m_e V_d)$.

Rewrite with Current Expression:

Since $I = neAV_d$, we can replace nAV_d with $\frac{I}{e}$.

Therefore, $P_{\text{total}} = (I/e)Lm_e$.

Simplified Formula:

So, $P_{\text{total}} = I\dfrac{Lm_e}{e}$.

Plug in the Values:

$$P_{\text{total}} = 80 \times \frac{10 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19}}$$

First, multiply $80 \times 10 = 800$.

Now $800 \times 9.1 = 7280$.

So, numerator is 7280×10^{-31} and denominator is 1.6×10^{-19}.

Divide 7280 by 1.6 to get 4550.

Power of ten: $10^{-31}/10^{-19} = 10^{-12}$

Final Answer:

$P_{\text{total}} = 4550 \times 10^{-12}\,\mathrm{N-s} = 4.55 \times 10^{-9}\,\mathrm{N-s} = 455 \times 10^{-11}\,\mathrm{N-s}$

Question13

Charge ' Q ' (in coulomb) flowing through a conductor in terms of time ' t ' (in second) is given by the equation $Q=3t^2+t$. The current in the conductor at time $t=3$ s is

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Options:

A.

3 A

B.

7 A

C.

19 A

D.

21 A

Answer: C

Solution:

We are given:

$Q=3t^2+t$

and we know that **current** $I=\frac{dQ}{dt}$.

Differentiate Q with respect to t:

$I=\frac{dQ}{dt}=\frac{d}{dt}(3t^2+t)=6t+1$

Now, at $t=3$ s:

$I=6(3)+1=18+1=19$ A

✅ **Answer: Option C (19 A)**

Question14

In a metal, the charge carrier density is $9.1 \times 10^{28}\ \mathrm{m}^{-3}$ and its electrical conductivity is $6.4 \times 10^{7}\ \mathrm{S\ m}^{-1}$. When an electric field of $10\mathrm{NC}^{-1}$ is applied to the metal, then the average time between two successive collisions of electrons in the metal is

(Mass of electron $= 9.1 \times 10^{-31}$ kg, charge of electron $= 1.6 \times 10^{-19}\mathrm{C}$)

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Options:

A.

4.6×10^{-14} s

B.

2.5×10^{-13} s

C.

4.6×10^{-13} s

D.

2.5×10^{-14} s

Answer: D

Solution:

Given data:

$n = 9.1 \times 10^{28}\ \mathrm{m}^{-3}$

$\sigma = 6.4 \times 10^{7}\ \mathrm{S/m}$

$E = 10\ \mathrm{N/C}$

$e = 1.6 \times 10^{-19}\ \mathrm{C}$

$m = 9.1 \times 10^{-31}$ kg

Step 1. Relation between conductivity and relaxation time (Drude model)

$\sigma = \frac{ne^2\tau}{m}$

$\Rightarrow \tau = \frac{m\sigma}{ne^2}$

Step 2. Substitute values

$\tau = \frac{(9.1\times10^{-31})(6.4\times10^{7})}{(9.1\times10^{28})(1.6\times10^{-19})^2}$

Compute step by step:

Denominator:

$ne^2 = 9.1 \times 10^{28} \times (1.6 \times 10^{-19})^2$

$= 9.1 \times 10^{28} \times 2.56 \times 10^{-38}$

$= 2.33 \times 10^{-9}$

Numerator:

$m\sigma = 9.1 \times 10^{-31} \times 6.4 \times 10^{7} = 5.82 \times 10^{-23}$

Now divide:

$\tau = \frac{5.82\times10^{-23}}{2.33\times10^{-9}} = 2.5 \times 10^{-14}$ s

✅ **Answer:**

$\tau = 2.5 \times 10^{-14}$ s

Step 3 (check options)

Option D: 2.5×10^{-14} s

✔ **Correct option: D**

Question15

A straight wire of resistance 18Ω is bent in the form of an equilateral triangular loop. The effective resistance between any two vertices of the triangle is

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Options:

A.

6Ω

B.

3Ω

C.

1Ω

D.

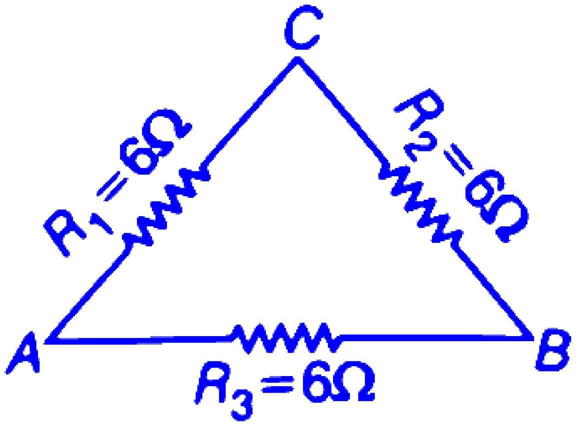
4Ω

Answer: D

Solution:

Resistance of each side of triangle,

$$R_1 = R_2 = R_3 = \frac{18}{3} = 6\Omega$$



$$\begin{aligned} \therefore R_{AB} &= (R_1 + R_2) \| (R_3) \\ &= (6+6) \| 6 = 12 \| 6 \\ &= \frac{12 \times 6}{12+6} = \frac{72}{18} = 4\Omega \end{aligned}$$

Question16

The power dissipated by a uniform wire of resistance 100Ω when a potential difference of 120 V is applied across its ends is

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Options:

A.

122 W

B.

144 W

C.

160 W

D.

200 W

Answer: B

Solution:

$$\begin{aligned} P &= \frac{V^2}{R} = \frac{120^2}{100} \\ &= \frac{120 \times 120}{100} = 144 \text{ W} \end{aligned}$$

Question17

A wire of resistance 100Ω is stretched, so that its length increases by 20%. The stretched wire is then bent in the form of a rectangle whose length and breadth are in the ratio $3:2$. The effective resistance between the ends of any diagonal of the rectangle is

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Options:

A.

36Ω

B.

72Ω

C.

28.8Ω

D.

432Ω

Answer: A

Solution:

$R_1 = 100\Omega l_1 = l$

$$\begin{aligned} R_2 &= ?, l_2 = l_1 + 20\% \text{ of } l_1 \\ &= l + 0.2l = 1.2l \\ \therefore \quad R' &= n^2 R = (1.2)^2 R \\ &= 1.44R = 1.44 \times 100 = 144\Omega \end{aligned}$$

The wire of resistance 144Ω is bent into a rectangle with sides in the ratio $3:2$. Let the side be $3x$ and $2x$.

Total length, $l = 2(3x + 2x) = 10x$

$$\begin{aligned} \therefore \quad R_{\text{length}} &= \frac{3x}{10x} \times 144 = 43.2\Omega \\ R_{\text{width}} &= \frac{2x}{10x} \times 144 = 28.8\Omega \end{aligned}$$

The effective resistance across the diagonal is the equivalent resistance of two parallel branches. On branch consists of the other two sides of the same resistance. Each branch has a resistance of

$$\begin{aligned} R_{\text{length}} + R_{\text{width}} &= 43.2 + 28.8 = 72\Omega \\ \therefore \quad \frac{1}{R_{\text{eq}}} &= \frac{1}{72} + \frac{1}{72} = \frac{1}{36} \\ \Rightarrow \quad R_{\text{eq}} &= 36\Omega \end{aligned}$$

Question18

In a potentiometer experiment, when two cells of emfs E_1 and E_2 $(E_2 > E_1)$ are connected in series, the balancing length is 160 cm

. If one of the cells is reversed, the balancing length decreases by 75%. If $E_1 = 1.2$ V, then $E_2 =$

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Options:

A.

2 V

B.

2.4 V

C.

1.8 V

D.

1.5 V

Answer: A

Solution:

Initially $E_1 + E_2 = K160 \qquad \ldots(i)$

On reversing polarity of E_1

and $E_1 + E_2 = K160 \times 0.25 \qquad \ldots(ii)$

Dividing, we get

$$\frac{1.2 + E_2}{-1.2 + E_2} = 4$$
$$\Rightarrow \quad 1.2 + E_2 = -4.8 + 4E_2$$
$$3E_2 = 6$$
$$E_2 = \frac{6}{3} = 2 \text{ V}$$

Question19

The emf of a cell of internal resistance 2Ω is measured using a voltmeter of resistance 998Ω. The error in the emf measured is

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Options:

A. 0.4%

B. 4%

C. 2%

D. 0.2%

Answer: D

Solution:

The percentage error in measuring the electromotive force (emf) of a cell with an internal resistance of $2\,\Omega$ when using a voltmeter with a resistance of $998\,\Omega$ is calculated as follows:

Percentage error $= \left(1 - \frac{R_V}{R_V + r}\right) \times 100$

Where:

R_V is the resistance of the voltmeter ($998\,\Omega$)

r is the internal resistance of the cell ($2\,\Omega$)

Substitute the given values:

Percentage error $= \left(1 - \frac{998}{998+2}\right) \times 100\%$

$= (1 - 0.998) \times 100\%$

$= 0.002 \times 100\% = 0.2\%$

Therefore, the error in the emf measured is 0.2% of the actual emf of the cell.

Question20

In a meter bridge experiment, a resistance of 9Ω is connected in the left gap and an unknown resistance greater than 9Ω is connected in right gap. If the resistance in the gaps are interchanged, the balancing point shifts by 10 cm . The unknown resistance is

Options:

A. 18Ω

B. 22Ω

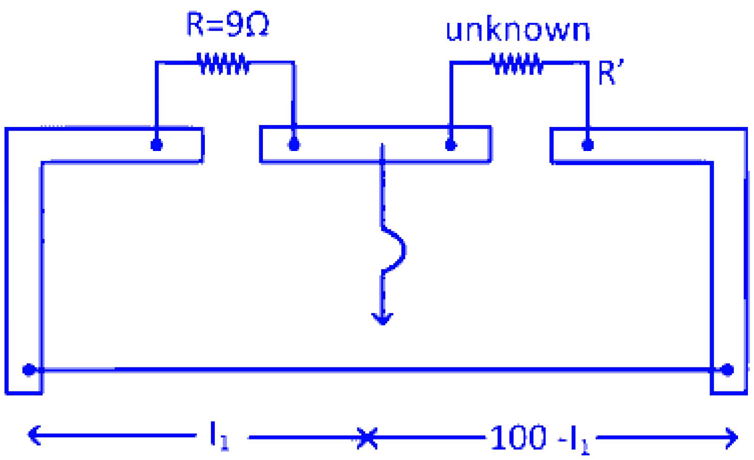
C. 11Ω

D. 36Ω

Answer: C

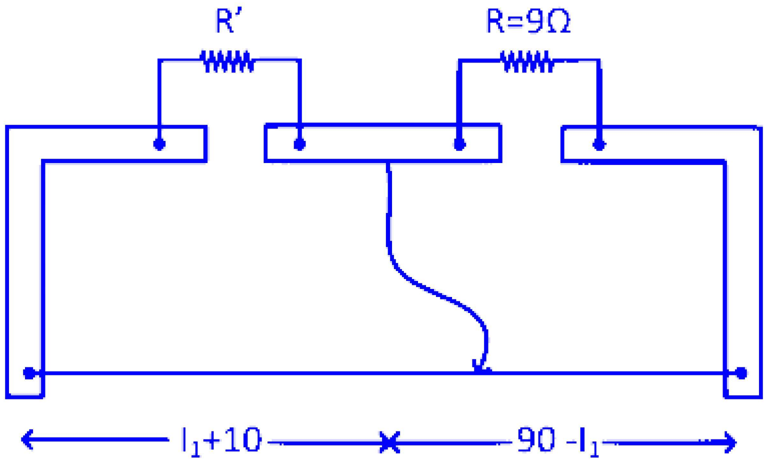
Solution:

Case-1



$\frac{R}{R'} = \frac{l_1}{100-l_1} \Rightarrow \frac{9}{R'} = \frac{l_1}{100-l_1} \qquad \ldots(i)$

Case-2



$\therefore \quad \frac{R'}{9} = \frac{l_1+100}{90-l_1}$

$\Rightarrow \quad \frac{9}{R'} = \frac{90-l_1}{l_1+10} \qquad \ldots(ii)$

From Eqs. (i) and (ii), we get

$$\frac{l_1}{100-l_1} = \frac{90-l_1}{l_1+10}$$

$$\Rightarrow \quad l_1^2 + 10l_1 = 9000 - 90l_1 - 100l_1 + l_1^2$$

$$\Rightarrow \quad 200l_1 = 9000$$

$$\Rightarrow \quad l_1 = 45 \text{ cm}$$

$\therefore$ From Eq. (i), $\frac{9}{R'} = \frac{45}{100-45}$

$\Rightarrow \quad R' = 11\Omega$

Question21

Current sensitivities of two galvanometers G_1 and G_2 of resistances 100Ω and 50Ω are $10^8 \mathrm{div/A}$ and $0.5 \times 10^5 \mathrm{div/A}$ respectively. The galvanometer in which the voltage sensitivity is more is 100Ω

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Options:

A. same in both galvanometers

B. more in G_2

C. zero

D. more in G_1

Answer: D

Solution:

Let S_I be the current sensitivity (divisions per ampere) and S_V the voltage sensitivity (divisions per volt). Since for a galvanometer of resistance R,

$S_V = \frac{S_I}{R}$,

we get:

• For G_1:

$S_I = 10^8$ div/A, $R = 100\ \Omega$

$S_V^{(1)} = \frac{10^8}{100} = 10^6\ \mathrm{div/V}.$

• For G_2:

$S_I = 0.5 \times 10^5 = 5 \times 10^4\ \mathrm{div/A},\ R = 50\ \Omega$

$S_V^{(2)} = \frac{5 \times 10^4}{50} = 10^3\ \mathrm{div/V}.$

Since $10^6 > 10^3$, the voltage sensitivity is greater for G_1.

Answer: more in G_1.

Question22

A battery of emf 8 V and internal resistance 0.5Ω is being charged by a 120 V DC supply using a series resister of 15.5Ω. The terminal voltage of 8 V batter) during charging is

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Options:

A. 11.5 V

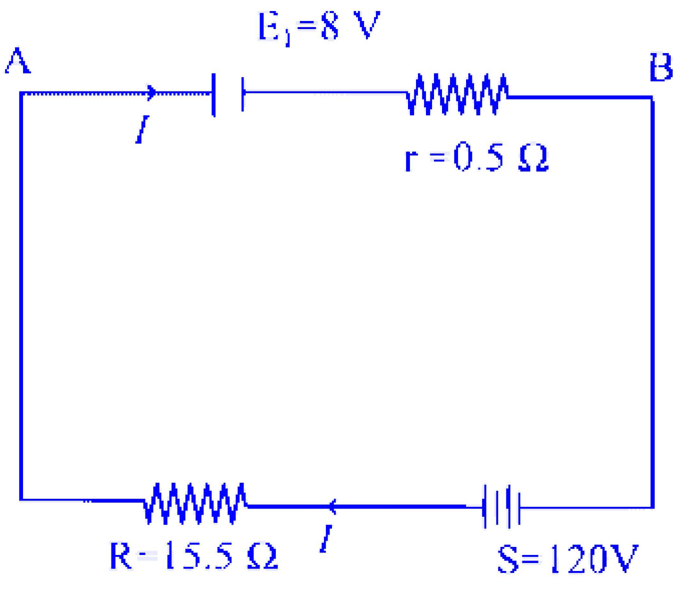
B. 1.15 V

C. 115 V

D. 0.5 V

Answer: A

Solution:



$$\begin{aligned}
E_{\text{eff}} & =E_{\text{source}}-E_{\text{battery}} \\
& =120-8=112 \mathrm{~V} \\
R_{\text{eq}} & =R+r=15.5+0.5=16 \Omega \\
I & =\frac{E_{\text{eff}}}{R_{\text{eq}}}=\frac{112}{16}=7 \mathrm{~A}
\end{aligned}$$

Terminal voltage of battery $=V_A-V_B$

$$\begin{aligned}
& V_A-E_{\text{battery}}-I r=V_B \\
& V_A-V_B=E_{\text{battery}}+I r \\
& =8+7 \times 0.5=8+3.5 \\
& V_A-V_B=11.5 \mathrm{~V}
\end{aligned}$$

Question23

Resistance of a wire is 8Ω. It is drawn in such a way that it experiences a longitudinal strain of 400%. The final resistance of the wire is

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Options:

A. 100Ω

B. 200Ω

C. 300Ω

D. 400Ω

Answer: B

Solution:

To find the final resistance of the wire, we start with the basic formula for resistance:

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

Here, R is the resistance, ρ is the resistivity, L is the length, and A is the cross-sectional area.

Given that the resistance of the wire is $8\,\Omega$ and it experiences a longitudinal strain of 400%, the length of the wire increases as follows:

$L' = L + \frac{L \times 400}{100} = L + 4L = 5L$

This implies the new length L' is 5 times the original length L.

Since the volume of the wire remains constant, we have:

$V = V' \Rightarrow AL = A'L'$

$AL = A' \times 5L$

$A' = \frac{A}{5}$

Now, to find the new resistance R', we use the resistance formula with the new dimensions:

$R' = \rho \frac{L'}{A'} = \rho \frac{5L}{\frac{A}{5}} = 25 \rho \frac{L}{A}$

From the original equation, we know:

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

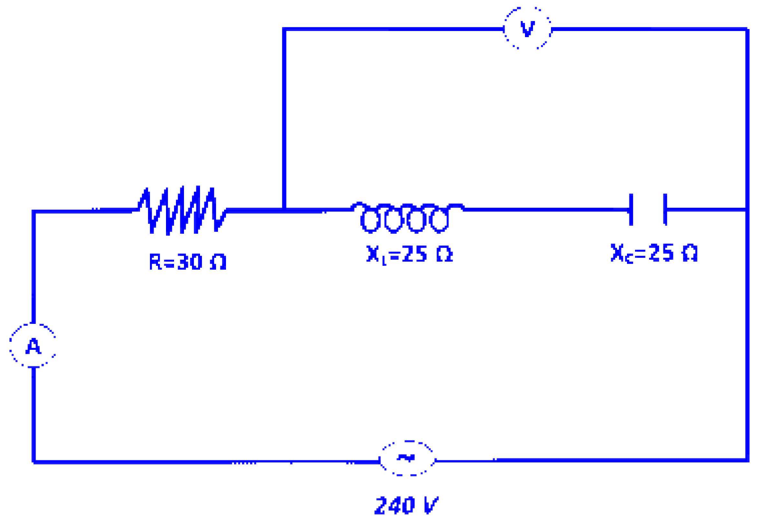
Thus, substituting, we get:

$R' = 25 \times R = 25 \times 8 = 200\,\Omega$

Therefore, the final resistance of the wire is $200\,\Omega$.

Question24

In the circuit shown in the figure, neglecting the source resistance, the voltmeter and ammeter readings respectively are



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Options:

A. $0 \mathrm{~V}, 8 \mathrm{~A}$

B. $150 \mathrm{~V}, 3 \mathrm{~A}$

C. $150 \mathrm{~V}, 6 \mathrm{~A}$

D. $0 \mathrm{~V}, 3 \mathrm{~A}$

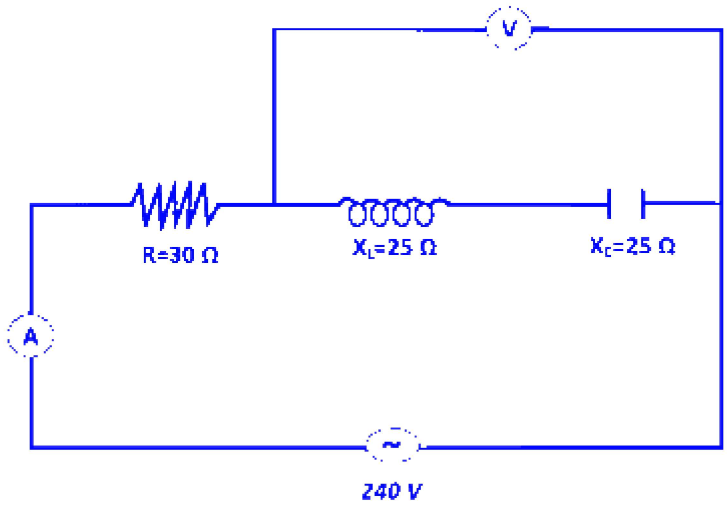
Answer: A

Solution:

Given, $R=30 \Omega$

$X_L=25 \Omega \Rightarrow X_C=25 \Omega$

Source voltage, $V_s=240 \mathrm{~V}$



Since, $X_L = X_C = 25\Omega$

So, V_L and V_C are equal in magnitude but opposite in phase, i.e

Voltmeter reading $= 0$ V

Where, V_L and V_C are voltage across inductor and capacitor respectively.

For ammeter reading,

$$I = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}}$$
$$I = \frac{240}{\sqrt{(30)^2 + (25 - 25)^2}}$$
$$I = \frac{240}{30} = 8 \text{ A}$$

Question25

The potential difference across the ends of conductor is $\beta 0 \pm 03)$V and the current through the conductor is (5 ± 0.10) A. The error in the determination of the resistance of the conductor is

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Options:

A. 1%

B. 2%

C. 3%

D. 4%

Answer: C

Solution:

Given the following measurements:

Voltage, V: 30 V

Error in voltage, ΔV: 0.3 V

Current, I: 5 A

Error in current, ΔI: ±0.1 A

The resistance, R, is calculated using Ohm's Law:

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

To find the percentage error in the resistance, we use the formula for the propagation of uncertainty for division:

$\frac{\Delta R}{R} \times 100 = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$

Plugging in the given values:

$\frac{\Delta V}{V} \times 100 = \frac{0.3}{30} \times 100$

$\frac{\Delta I}{I} \times 100 = \frac{0.1}{5} \times 100$

Calculating these:

$\frac{0.3}{30} \times 100 = 1\%$

$\frac{0.1}{5} \times 100 = 2\%$

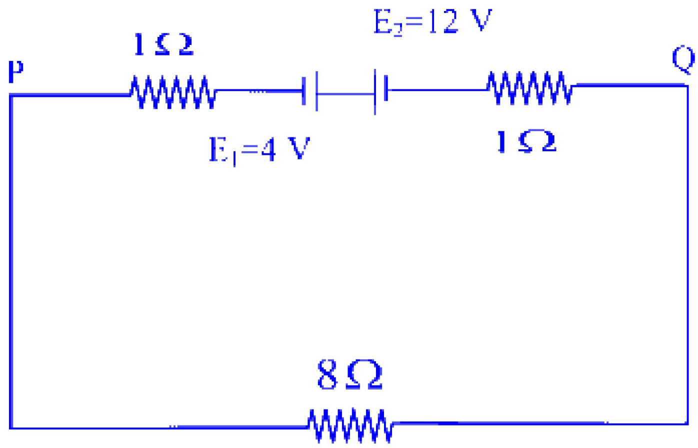
Adding these percentage errors together gives:

$\frac{\Delta R}{R} \times 100 = 1\% + 2\% = 3\%$

Therefore, the percentage error in the resistance is ±3%.

Question26

If $E_1 = 4$ V and $E_2 = 12$ V, the current in the circuit and potential difference between the points P and Q respectively are



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Options:

A. 1 A, 8 V

B. 1 A, 6 V

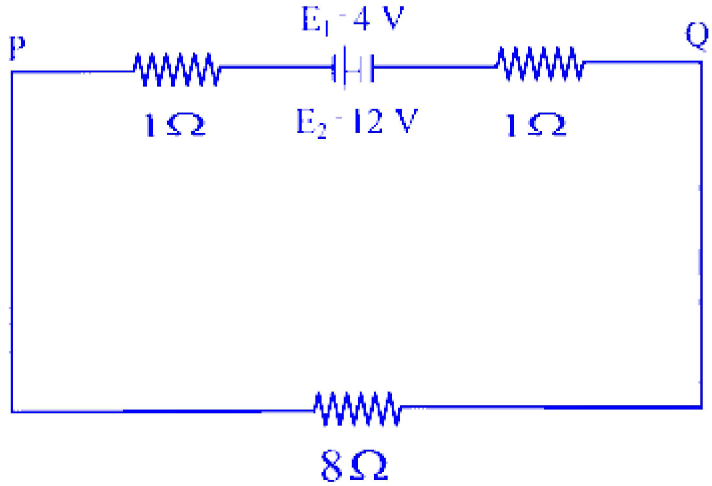
C. 0.8 A, 6.4 V

D. 0.8 A, 8 V

Answer: C

Solution:

As, the batteries are connected inverse polarities,



The net potential applied to the circuit

$= 12\text{ V} - 4\text{ V} = 8\text{ V}$

The net resistance in the circuit,

$R = r_1 + r_2 + r_3 = 1 + 1 + 8 = 10\Omega$

Thus, According to Ohm's law,

$V = \frac{I}{R} \Rightarrow I = \frac{V}{R} = \frac{8}{10} = 0.8 \text{ A}$

and potential difference across P and Q

$V = I \times R = 0.8 \times 8 = 6.4 \text{ V}$

Question27

Two identical cells gave the same current through an external resistance of 2Ω regardless whether the cells are grouped in series or parallel. The internal resistance of the cells is

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Options:

A. 1Ω

B. 0.5Ω

C. 1.5Ω

D. 2.0Ω

Answer: D

Solution:

Series Arrangement

For cells in series, the total electromotive force (EMF) is doubled, and the total internal resistance is also doubled. The current I_1 in this setup is given by:

$I_1 = \frac{2E}{2+2r}$

where E is the electromotive force of each cell and r is the internal resistance of each cell.

Parallel Arrangement

For cells in parallel, the EMF remains the same, but the internal resistance is halved. The current I_2 in this setup is given by:

$I_2 = \frac{E}{2+\frac{r}{2}} = \frac{2E}{4+r}$

Equating the Currents

Since the problem states $I_1 = I_2$, we set the equations equal:

$\frac{2E}{4+r} - \frac{2E}{2+2r} = 0$

Solving this equation:

$\frac{2E(2+2r) - 2E(4+r)}{(4+r)(2+2r)} = 0$

Simplifying further:

$2E(2 + 2r) - 2E(4 + r) = 0$

$4E + 4Er - 8E - 2Er = 0$

$2Er - 4E = 0$

Factoring out common terms:

$Er - 2E = 0$

Divide by E (assuming $E \neq 0$):

$r - 2 = 0$

Hence, solving this gives:

$r = 2$

Thus, the internal resistance of each cell is $2\,\Omega$.

Question28

The charge q (in coulomb) passing through a 10Ω resistor as a function of time t (in second) is given by $q = 3t^2 - 2t + 6$. The potential difference across the ends of the resistor at time $t = 5$ s is

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Options:

A. 120 V

B. 240 V

C. 140 V

D. 280 V

Answer: D

Solution:

Given that the charge q passing through a $10\,\Omega$ resistor as a function of time t is expressed by the equation $q = 3t^2 - 2t + 6$, we can determine the potential difference across the resistor.

To find the current I as a function of time, we differentiate the charge function with respect to time:

$I = \frac{dq}{dt} = \frac{d}{dt}(3t^2 - 2t + 6)$

Solving for the derivative:

$I = 6t - 2$

Next, we calculate the current at $t = 5$ s:

$I = 6(5) - 2 = 30 - 2 = 28\,\mathrm{A}$

The voltage V across the resistor, using Ohm's Law, is given by:

$V = IR$

With the resistance $R = 10\,\Omega$, the potential difference is:

$V = 28 \times 10 = 280\,\mathrm{V}$

Thus, the potential difference across the resistor at $t = 5$ s is $280\,\mathrm{V}$.

Question29

A cell of emf 1.2 V and internal resistance 2Ω is connected in parallel to another cell of emf 1.5 V and internal resistance 1Ω. If the like poles of the cells are connected together, the emf of the combination of the two cells is

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Options:

A. 0.8 V

B. 3.9 V

C. 2.7 V

D. 1.4 V

Answer: D

Solution:

Given the following values:

$E_1 = 1.2\,\mathrm{V}$ with an internal resistance $r_1 = 2\,\Omega$

$E_2 = 1.5\,\mathrm{V}$ with an internal resistance $r_2 = 1\,\Omega$

To find the equivalent emf of the cells connected in parallel with like poles together, we first calculate the equivalent resistance as follows:

$$r_{\text{eq}} = \frac{r_1 r_2}{r_1 + r_2} = \frac{2\times1}{2+1} = \frac{2}{3}\,\Omega$$

Next, we calculate the equivalent emf using the formula:

$$\text{Emf (equivalent)} = \left[\frac{E_1}{r_1} + \frac{E_2}{r_2}\right] \times r_{\text{eq}}$$

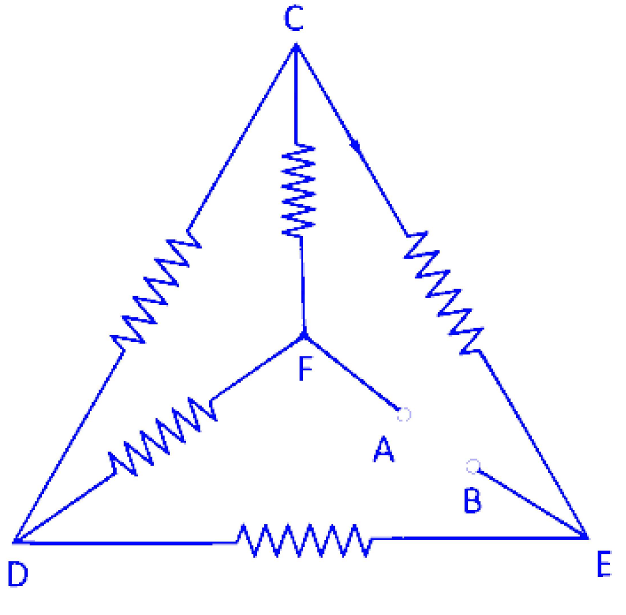
Substituting the given values, we have:

$$\begin{aligned}\text{Emf (equivalent)} &= \left[\frac{1.2}{2} + \frac{1.5}{1}\right] \times \frac{2}{3} \\ &= [0.6 + 1.5] \times \frac{2}{3} \\ &= 2.1 \times \frac{2}{3} \\ &= 1.4\,\mathrm{V}\end{aligned}$$

Thus, the equivalent emf of the combination of the two cells is $1.4\,\mathrm{V}$.

Question30

Five equal resistances each $2R$ connected as shown in figure. A battery of V volts connected between A and B. Then, current through FC is



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Options:

A. $\frac{V}{4R}$

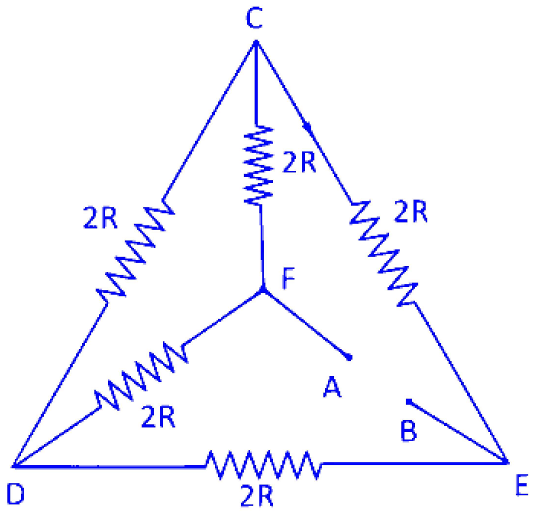
B. $\frac{V}{8R}$

C. $\frac{V}{R}$

D. $\frac{V}{2R}$

Answer: A

Solution:



Given, Voltage across battery $= V$

Each resistor have resistance $= 2R$

$i_{FC} = \ ?$

According to figure, it is a balanced Wheatstone bridge.

$$\begin{aligned} So, R_1 &= R_{FC} + R_{CE} = 2R + 2R = 4R \\ R_2 &= R_{FD} + R_{DE} = 2R + 2R = 4R \\ R_{\text{eq}} &= \frac{R_1 \times R_2}{R_1 + R_2} = \frac{4R \times 4R}{4R + 4R} = \frac{16RR}{8R} = 2R \end{aligned}$$

We know that, voltage will be same in parallel combination. So, R_1 will have voltage V.

Current will be same in series combination. So R_{FC} and R_{CE} will have current same as R_1

So, $i_{FC} = \frac{V}{R_1} \Rightarrow i_{FC} = \frac{V}{4R}$

Question31

A lamp is rated at 240 V, 60 W. When in use the resistance of the filament of the lamp is 20 times that of cold filament. The resistance of the lamp when not in use is

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Options:

A. 54Ω

B. 60Ω

C. 50Ω

D. 48Ω

Answer: D

Solution:

Given the specifications for the lamp:

Voltage, $V = 240\text{ V}$

Power, $P = 60\text{ W}$

The problem states that when the lamp is in use, the resistance of the filament (hot resistance, R_{Hot}) is 20 times that of when it is not in use (cold resistance, R_{Cold}).

Calculating Hot Resistance

Using the power formula from Joule's law of heating:

$P = \frac{V^2}{R}$

Solve for R_{Hot} :

$R_{\text{Hot}} = \frac{V^2}{P} = \frac{240 \times 240}{60} = 960\,\Omega$

Relating Hot and Cold Resistance

According to the problem, the hot resistance is 20 times the cold resistance:

$R_{\text{Hot}} = 20 \times R_{\text{Cold}}$

Solving for R_{Cold} :

$R_{\text{Cold}} = \frac{R_{\text{Hot}}}{20} = \frac{960}{20} = 48\,\Omega$

Thus, the resistance of the lamp when not in use is $48\,\Omega$.

Question32

A straight wire of resistance R is bent in the shape of f_d square. A cell of emf 12 V is connected between two adjacent corners of the square. The potential difference across any diagonal of the square is

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Options:

A. 8 V

B. 18 V

C. 6 V

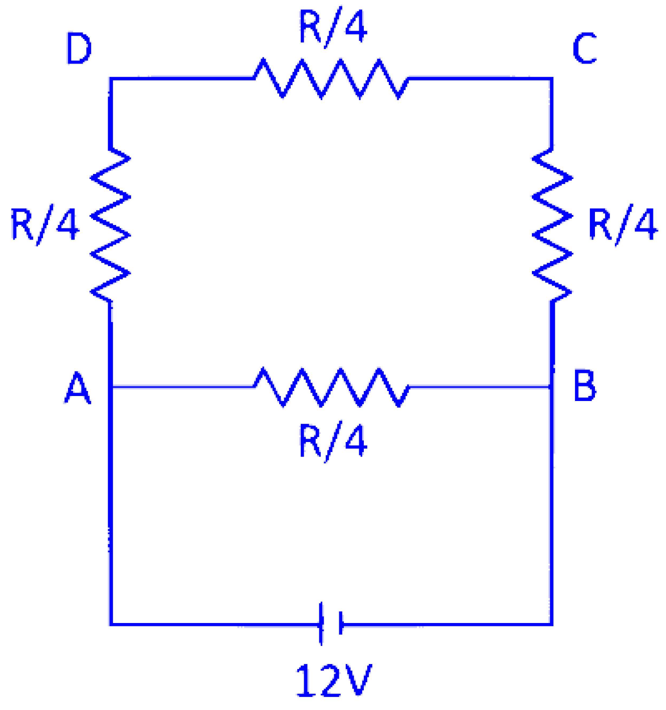
D. 12 V

Answer: A

Solution:

Since, wire is bent into form of a square so each side will have resistance,

$r = \frac{R}{4}$



Here, AD, DC and CB are in series and AB will be parallel,

$\therefore R_{\text{eq}} = \frac{3R}{4} \| \frac{R}{4} = \frac{\frac{3R}{4} \times \frac{R}{4}}{\frac{3R}{4} + \frac{R}{4}} = \frac{\frac{3R^2}{16}}{R} = \frac{3R}{16}$

Current in the circuit, $I = \frac{V}{R_{\text{eq}}} = \frac{12}{\frac{3R}{16}} = \frac{4}{4}$

So, potential difference between end A and B

$= \frac{V}{R/4} = \frac{48}{R}$

$\therefore$ Current in the branch

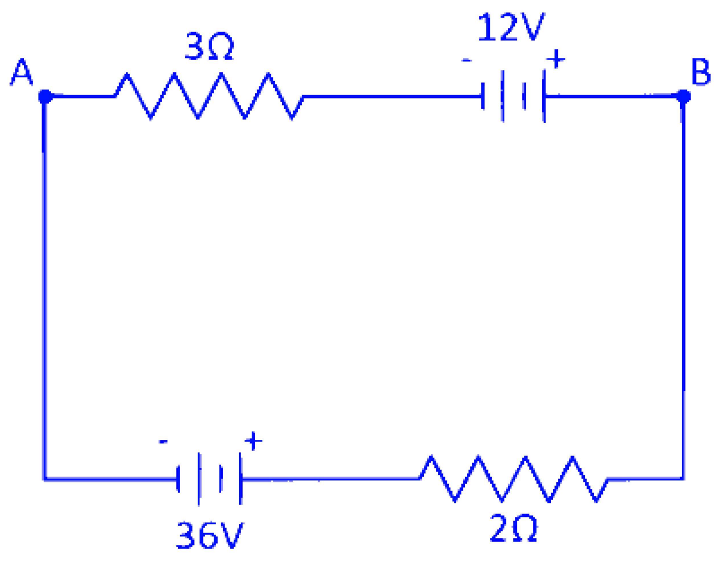
$ADC = \frac{64}{R} - \frac{48}{R} = \frac{16}{R}$

$\therefore$ Potential dropp across any diagnal AC or BD)

$= \frac{16}{R} \times \frac{R}{2} = 8 \mathrm{~V}$

Question33

In the given circuit, if the potential at point B is 24 V , the potential at point A is



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Options:

A. -4.8 V

B. -2.4 V

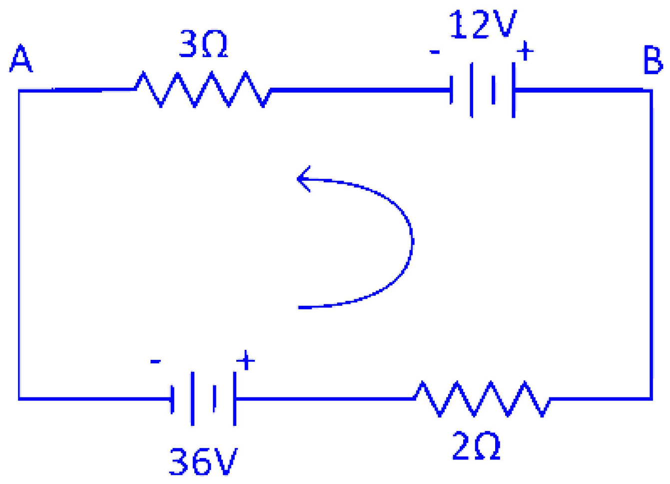
C. -12 V

D. -14.4 V

Answer: B

Solution:

Applying KVL in the loop considering current in anti-clockwise direction.



$$-36+2i+12+3i=0$$
$$5i=24$$
$$i=\frac{24}{5}\text{ A}$$

Now; $V_B-V_A=12+3\times i$

$$24-V_A=12+3\times\frac{24}{5}$$
$$\Rightarrow\quad V_A=24-12-\frac{72}{5}=12-\frac{72}{5}$$
$$=-\frac{12}{5}=-2.4\text{ V}$$

Question34

A block has dimensions $1\text{ cm}, 2\text{ cm}$ and 3 cm . Ratio of the maximum resistance to minimum resistance between any palr of opposite faces of the block is

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Options:

A. 9 : 1

B. 1 : 9

C. 18 : 1

D. 6 : 1

Answer: A

Solution:

Given the block dimensions of 1 cm, 2 cm, and 3 cm, we need to determine the ratio of the maximum to minimum resistance between any pair of opposite faces of the block.

The resistance R of a conductor is given by the formula:

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

where:

ρ is the resistivity of the material,

A is the area of cross-section,

l is the length.

Calculating Maximum Resistance:

The resistance is maximum when:

$l = 3\,\text{cm} = 3 \times 10^{-2}\,\text{m}$

$A = 1 \times 10^{-2} \times 2 \times 10^{-2} = 2 \times 10^{-4}\,\text{m}^2$

Thus, the maximum resistance R_{max} is:

$R_{\text{max}} = \rho \times \frac{3\times10^{-2}}{2\times10^{-4}} = \frac{3}{2} \times 10^2 \rho$

Calculating Minimum Resistance:

The resistance is minimum when:

$l = 1\,\text{cm} = 10^{-2}\,\text{m}$

$A = 2 \times 10^{-2} \times 3 \times 10^{-2} = 6 \times 10^{-4}\,\text{m}^2$

Thus, the minimum resistance R_{min} is:

$R_{\text{min}} = \rho \times \frac{10^{-2}}{6\times10^{-4}} = \frac{10^2 \rho}{6}$

Calculating the Ratio:

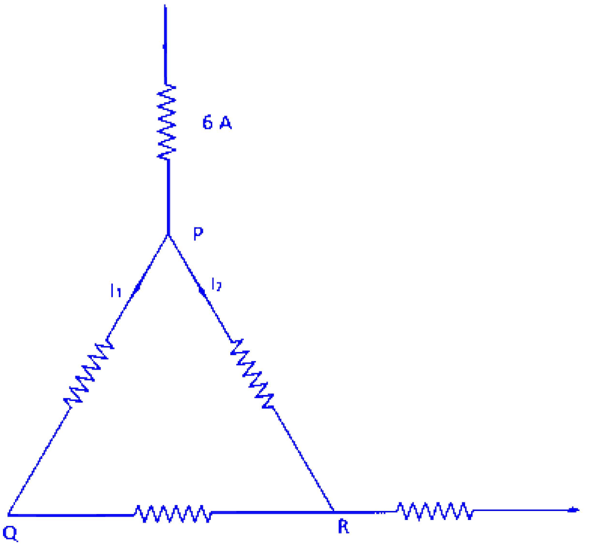
The ratio of the maximum resistance to the minimum resistance is:

$\frac{R_{\text{max}}}{R_{\text{min}}} = \frac{\frac{3\times10^2\rho}{2}}{\frac{10^2\rho}{6}} = \frac{3}{2} \times 6 = \frac{9}{1}$

Therefore, the ratio is 9 : 1.

Question35

A current of 6 A enters one corner P of an equilateral triangle PQR having three wires of resistance 2Ω each and leaves by the corner R as shown in figure. Then the currents I_1 and I_2 are respectively



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Options:

A. 4 A, 2 A

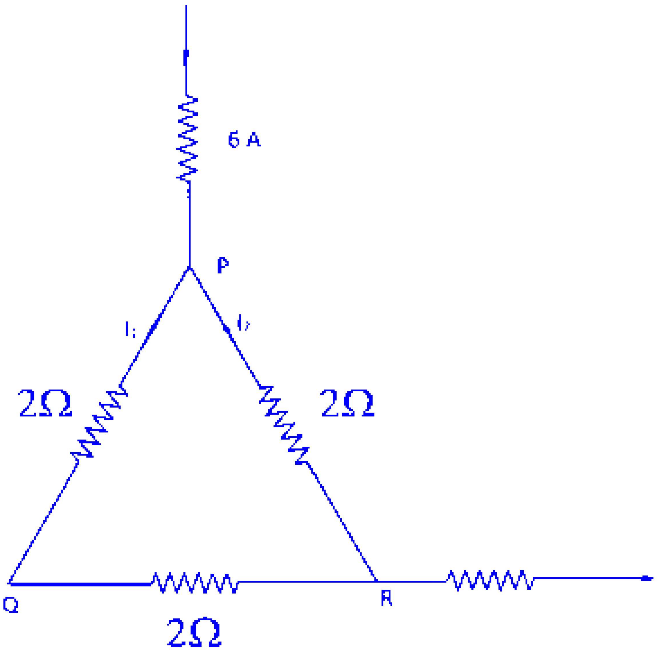
B. $2A, 3A$

C. 6 A, 0

D. 2 A, 4 A

Answer: D

Solution:



Using Kirchhoff's current law at point P,

$I_1 + I_2 = 6$

Using Krichhoff's voltage law to the closed circuit $PQRP$,

$$\begin{aligned} \Rightarrow \quad -2I_1 - 2I_1 + 2I_2 &= 0 \\ \Rightarrow \quad -4I_1 + 2I_2 &= 0 \\ \Rightarrow \quad 2I_1 - I_2 &= 0 \end{aligned}$$

On adding Eqs. (i) and (ii), we get

$$\begin{aligned} \Rightarrow \quad I_1 + I_2 + 2I_1 - I_2 &= 6 + 0 \\ \Rightarrow \quad 3I_1 &= 6 \\ \Rightarrow \quad I_1 &= 2 \text{ A} \end{aligned}$$

Substitute the value of I_1 in Eq. (i)

$$\Rightarrow \quad I_2 = 6 - I_1 = 6 - 2 = 4 \text{ A}$$

Question36

The value of shunt resistance that allows only 10% of main current through the galvanometer of resistance 99Ω is

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Options:

A. 9Ω

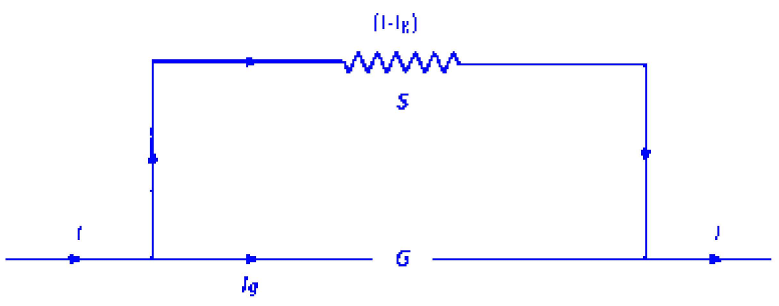
B. 4Ω

C. 2Ω

D. 11Ω

Answer: D

Solution:



Given, Galvanometer resistance, $G=99 \Omega$

Let I be the current passes through main circuit.

$\therefore \quad I_g=\left(\frac{10}{100}\right) I=0.1 I$

Using the formula for shunt resistance,

$S=\frac{I_g G}{\left(I-I_g\right)}$

$$\Rightarrow \quad S=\frac{0.1 I \times 99}{(I-0.1 I)}=\frac{0.1 \times 99}{0.9}$$

$$\therefore \quad S=11 \Omega$$

Question37

A steady current is flowing in a metallic conductor of non-uniform cross-section. The physical quantity which remains constant is

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Options:

A. electricity current density

B. drift velocity

C. electricity current density and drift velocity

D. electric current

Answer: D

Solution:

In a steady current flowing through a conductor, the quantity that remains constant is the electric current. Here's why:

For any section of the conductor, the electric current I is defined as the net charge per unit time passing through that section. In a steady state (no accumulation of charge), charge conservation requires that I is constant along the length of the conductor.

The current density J is given by

$J = \frac{I}{A}$,

where A is the local cross-sectional area. If the conductor has a non-uniform cross-section, the area A changes, causing J to vary.

Similarly, the drift velocity v_d of the charge carriers is related to the current by

$I = nev_dA$,

where n is the carrier density and e is the elementary charge. Again, if A varies, v_d must adjust accordingly to keep I constant.

Thus, it is only the electric current I that remains unchanged along a conductor with non-uniform cross-section.

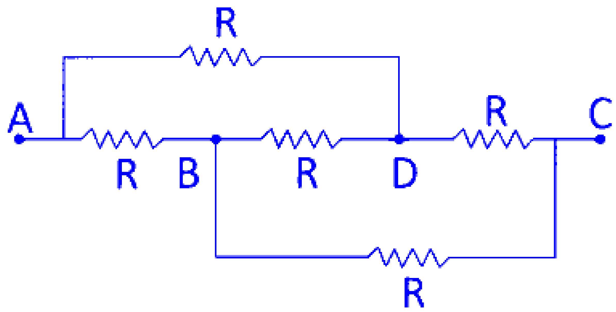
The correct answer is:

Option D

electric current

Question38

The resistance between points A and C in the given network is



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Options:

A. $\frac{R}{4}$

B. $\frac{R}{2}$

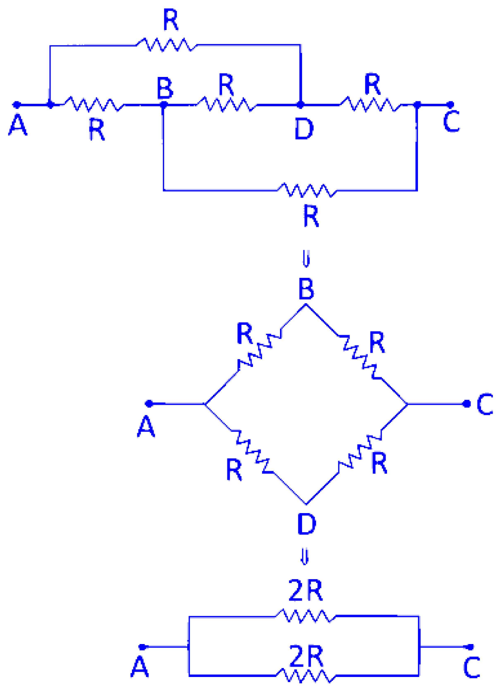
C. $2R$

D. R

Answer: D

Solution:

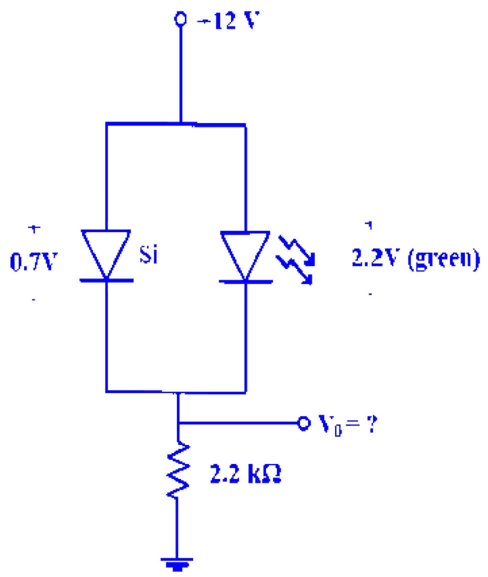
The circuit diagram given below represents balanced Wheatstone bridge.



$$\therefore \quad R_{AC} = \frac{2R \times 2R}{2R + 2R} = \frac{4R^2}{4R} = R$$

Question39

The voltage V_0 in the network shown is



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Options:

A. $V_0 = 11.3 \text{ V}$

B. $V_0 = 9.8 \text{ V}$

C. $V_0 = 12.0 \text{ V}$

D. $V_0 = 0.7 \text{ V}$

Answer: A

Solution:

Since, potential barrier in Si diode is less (0.7 V) than green, and both are forward biased. Therefore, for conduction, minimum potential difference across the junction diode $= 0.7 \text{ V}$.

$\therefore \quad V_0 = 12 - 0.7 = 11.3 \text{ V}$

Question40

In a potentiometer, the area of cross-section of the wire is $4 \mathrm{~cm}^2$. The current flowing in the circuit is 1 A and the potential gradient is $7.5 \mathrm{Vm}^{-1}$. Then, the resistivity of the potentiometer wire is

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Options:

A. $3 \times 10^{-3} \mathbf{q}-\mathrm{m}$

B. $2 \times 10^{-6} \mathrm{Q}-\mathrm{m}$

C. $4 \times 10^{-2} \mathbf{Q}$-m

D. $5 \times 10^{-4} \Omega$-m

Answer: A

Solution:

To find the resistivity of the potentiometer wire, we are provided with the following information:

Area of cross-section (A): $4 \mathrm{~cm}^2=4 \times 10^{-4} \mathrm{~m}^2$

Current (i): $1 \mathrm{~A}$

Potential Gradient $\left(\frac{V}{l}\right)$**:** $7.5 \mathrm{~V} / \mathrm{m}$

We need to calculate the resistivity (ρ) of the wire.

Calculation:

From Ohm's law, we know the following relationship:

$V=i \cdot R$

The resistance R for a wire can be expressed in terms of its resistivity:

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

Thus, substituting R in the equation for V:

$V=i \cdot \frac{\rho l}{A}$

Rearranging this equation to solve for resistivity (ρ):

$\rho=\frac{V}{l} \cdot \frac{A}{i}$

Substitute the known values:

$\rho=(7.5 \mathrm{~V} / \mathrm{m}) \cdot\left(\frac{4 \times 10^{-4} \mathrm{~m}^2}{1 \mathrm{~A}}\right)$

Calculate ρ:

$\rho = \frac{7.5 \times 4 \times 10^{-4}}{1}$

$\rho = 30 \times 10^{-4}$

$\rho = 3 \times 10^{-3}\,\Omega\text{-m}$

Therefore, the resistivity of the potentiometer wire is $3 \times 10^{-3}\,\Omega\text{-m}$.

Question41

Drift speed v varies with the intensity of electric field E as per the relation.

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Options:

A. $v = E$

B. $v \propto \frac{1}{E}$

C. $v = E^2$

D. $v = E^{-2}$

Answer: A

Solution:

Drift velocity is the average velocity acquired by charged particles, such as electrons, within a material when influenced by an electric field.

The magnitude of drift velocity per unit electric field is defined as mobility. This relationship is given by:

$m = \frac{|v_d|}{E} \Rightarrow |v_d| = m \cdot E$

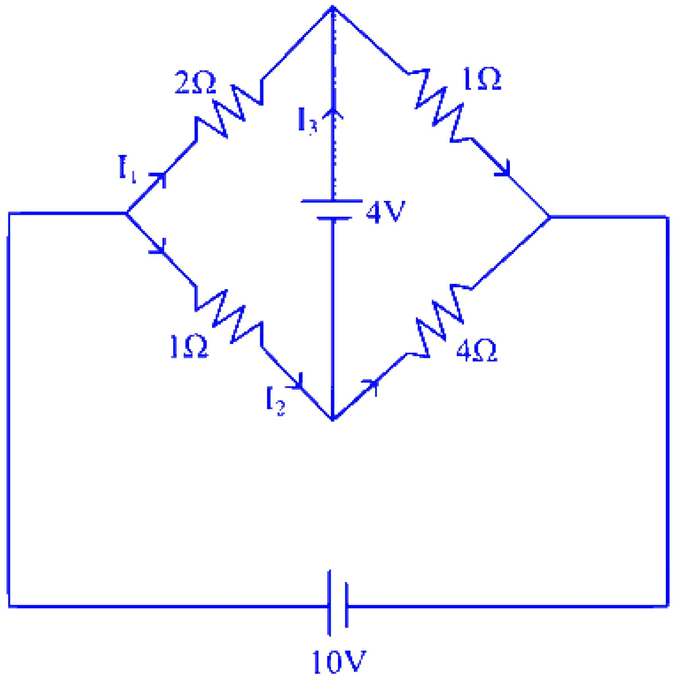
From this, we understand that:

$v_d \propto E$

Thus, the drift velocity is directly proportional to the electric field E. Therefore, the correct relationship is represented by $v \propto E$.

Question42

In the given circuit values of I_1, I_2, I_3 are respectively



AP EAPCET 2022 - 5th July Morning Shift

Options:

A. 1.364 A, 6.278 A, 5.91 A

B. $1.97 \mathrm{~A}, 3.56 \mathrm{~A}, 2.784 \mathrm{~A}$

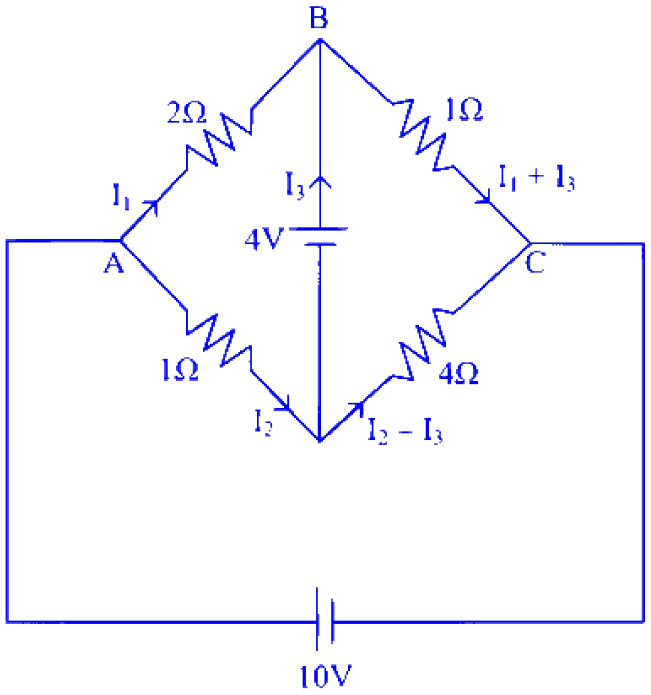
C. $-0.327 \mathrm{~A}, 5.28 \mathrm{~A}, 3.197 \mathrm{~A}$

D. $1.523 \mathrm{~A}, 4.396 \mathrm{~A}, 1.63 \mathrm{~A}$

Answer: A

Solution:

The given circuit diagram is shown as :



Applying KVL in loop $ABDA$, we get

$$2I_1 + 4 - I_2 = 0$$
$$I_2 = 2I_1 + 4 \quad \text{... (i)}$$

Applying KVL in loop $BCDB$, we get

$$1(I_1 + I_3) - 4(I_2 - I_3) - 4 = 0$$
$$\Rightarrow \quad I_1 + I_3 - 4I_2 + 4I_3 - 4 = 0$$
$$\Rightarrow \quad I_1 + 5I_3 - 4(2I_1 + 4) - 4 = 0$$
$$\Rightarrow \quad -7I_1 + 5I_3 = 20$$
$$\Rightarrow \quad I_3 = \frac{20+7I_1}{5} \quad \text{... (ii)}$$

By applying KVL in loop $ADCA$, we get

$$I_2 + 4(I_2 - I_3) - 10 = 0$$
$$\Rightarrow \quad 5I_2 - 4I_3 = 10$$
$$\Rightarrow \quad 5(2I_1 + 4) - 4\left(\frac{20 + 7I_1}{5}\right) = 10 \quad \text{[From Eqs. (i) and (ii)]}$$

$$\Rightarrow \quad I_1 = 1.364 \text{ A}$$

From Eq. (i), $I_2 = 2 \times 1.364 + 4 = 6.278$ A

From Eq (ii), $I_3 = \frac{20+7\times1.364}{5} = 5.91$ A

Question43

The resistance of wire at $0^{\circ}\mathrm{C}$ is 20Ω. If the temperature coefficient of the resistance is $5 \times 10^{-3\circ}\mathrm{C}^{-1}$. The temperature at which the resistance will be double of that at $0^{\circ}\mathrm{C}$ is

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Options:

A. $10^{\circ}\mathrm{C}$

B. $200^{\circ}\mathrm{C}$

C. $250^{\circ}\mathrm{C}$

D. $300^{\circ}\mathrm{C}$

Answer: B

Solution:

Resistance of wire at $0^{\circ}\mathrm{C}$, $R_0 = 20\Omega$

Temperature coefficient,

$\alpha = 5 \times 10^{-3\circ}\mathrm{C}^{-1}$
$R_t = 2R_0 = 2 \times 20 = 40\Omega$

we know that,

$R_t = R_0(1 + \alpha t)$
$40 = 20\left(1 + 5 \times 10^{-3}t\right) \Rightarrow 2 = 1 + 5 \times 10^{-3}t$

$\Rightarrow \quad t = \frac{1}{5\times10^{-3}} = \frac{1000}{5} = 200^{\circ}\mathrm{C}$

Question44

The electrons take 40×10^{3} s to dirift from one end of a metal wire of length 2 m to its other end. The area of cross-section of the wire is $4\ \mathrm{mm}^{2}$ and it is carrying a current of 1.6 A. The number density of free electrons in the metal wire is

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Options:

A. $8 \times 10^{28} \mathrm{~m}^{-3}$

B. $6 \times 10^{28} \mathrm{~m}^{-3}$

C. $4 \times 10^{28} \mathrm{~m}^{-3}$

D. $5 \times 10^{28} \mathrm{~m}^{-3}$

Answer: D

Solution:

Given, length of wire, $l=2 \mathrm{~m}$

Time taken to drift electron, $t=40 \times 10^3 \mathrm{~s}$

Current, $I=1.6 \mathrm{~A}, A=4 \mathrm{~mm}^2=4 \times 10^{-6} \mathrm{~m}^2$

$\therefore$ Drift velocity, $v_d=\frac{l}{t}$

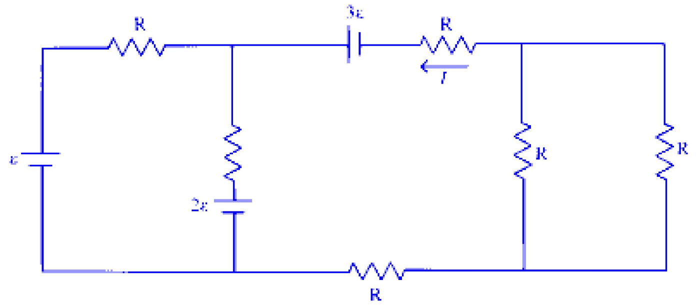
$=\frac{2}{40 \times 10^3}=5 \times 10^{-5} \mathrm{~m} / \mathrm{s}$

We know that,

$$
\begin{aligned}
& I=n e A v_d \\
\Rightarrow \quad & n=\frac{I}{e A v_d} \\
& =\frac{1.6}{1.6 \times 10^{-19}} \times 4 \times 10^{-6} \times 5 \times 10^{-5} \\
& =0.5 \times 10^{29} \\
& =5 \times 10^{28} \text { electrons } / \mathrm{m}^3
\end{aligned}
$$

Question45

The current 'I' in the circuit shown in the figure is



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Options:

A. ε / R

B. $-\varepsilon / R$

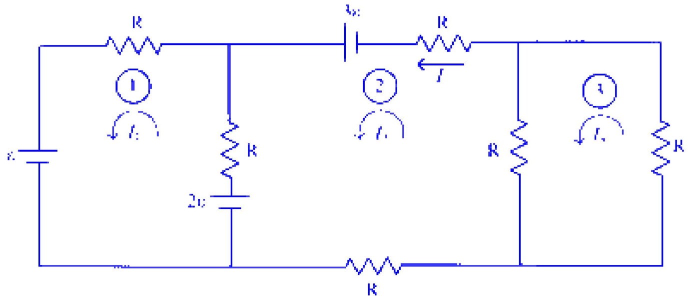
C. $2 \varepsilon / R$

D. $-2 \varepsilon / R$

Answer: A

Solution:

The circuit diagram is shown as,



Applying KVL in loop 3, we get

$I_3 R+R\left(I_3-I_2\right)=0$

$2 I_3 R-R I_2=0$

$$I_3=\frac{I_2}{2} \quad \ldots \text{(i)}$$

Applying KVL in loop 2, we get

Applying KVL in

$$RI_2 - 3\varepsilon + R(I_2 - I_1) + 2\varepsilon + RI_2 - R(I_2 - I_3) = 0$$

$$\Rightarrow 2RI_2 - RI_1 + RI_3 - \varepsilon = 0$$

$$\Rightarrow 2RI_2 - RI_1 + R\frac{I_2}{2} - \varepsilon = 0$$

$$\Rightarrow \quad 5RI_2 - 2RI_1 - 2\varepsilon = 0 \quad \text{... (ii)}$$

By applying KVL in loop 1, we get

$$RI_1 + \varepsilon - 2\varepsilon + R(I_1 - I_2) = 0$$

$$2RI_1 - RI_2 - \varepsilon = 0$$

$$I = \frac{RI_2 + \varepsilon}{2R} \quad \text{... (iii)}$$

From Eqs. (ii) and(iii), we get

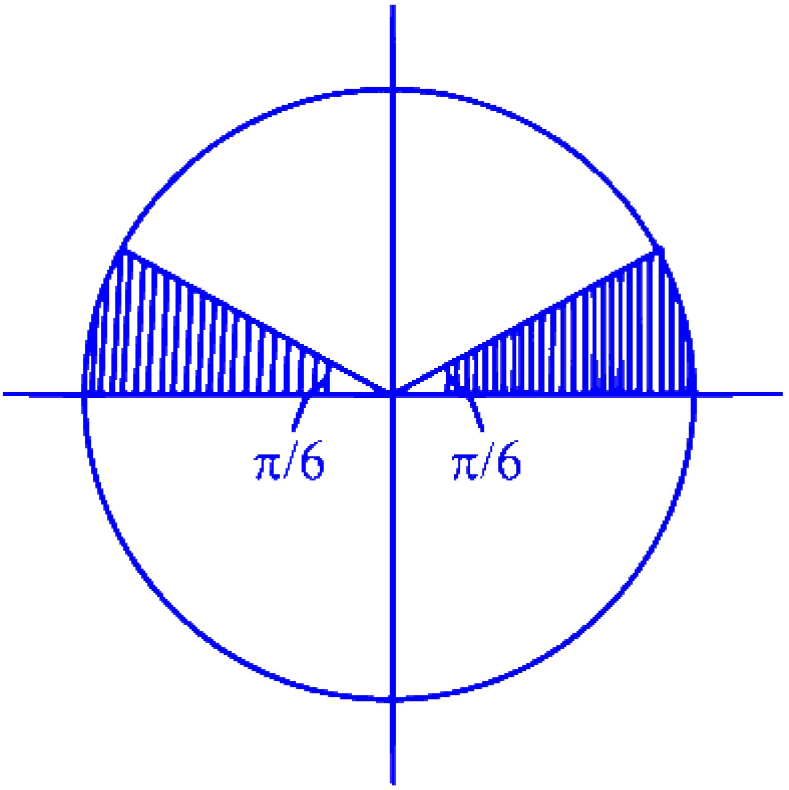
$$5RI_2 - 2R\frac{(RI_2 + \varepsilon)}{2R} - 2\varepsilon = 0$$

$$5RI_2 - RI_2 - \varepsilon - 2\varepsilon = 0$$

$$\Rightarrow \quad I_2 = \frac{3\varepsilon}{4R}$$

Question46

Current density in a cylindrical wire of radius R varies with radial distance as $\beta(r + r_0)^2$. The current through the section of the wire shown in the figure is



Options:

A. $\pi\beta\left[\frac{R^4}{12}+\frac{r_0^2R^2}{6}+\frac{2r_0R^3}{9}\right]$

B. $\pi\beta\left[\frac{R^4}{6}+\frac{r_0^2R^2}{12}+\frac{r_0R^3}{9}\right]$

C. $\pi\beta\left[\frac{R^4}{12}+\frac{r_0^2R^2}{12}+\frac{r_0R^3}{9}\right]$

D. $\pi\beta\left[\frac{R^4}{8}+\frac{r_0^2R^2}{6}+\frac{r_0R^3}{12}\right]$

Answer: A

Solution:

Given, current density,

$J=\beta(r+r_0)^2=\beta\left(r^2+2\pi\pi_0+r_0^2\right)$

We know that, current density, $J=\frac{\text{Current}(I)}{\text{Area}(A)}$

$\Rightarrow$ Current, $I=J\cdot A$

or $dI=J\cdot dA$

$$\begin{aligned}\Rightarrow \quad & \int dI=\int J\cdot dA\\ \Rightarrow \quad & I=\int\beta\left(r^2+2\pi_0+r_0^2\right)\cdot dA\end{aligned}$$

Where, dA is area element in cartesian coordinate.

In polar coordinates $dA=rdrd\theta$

$$\therefore \quad I=2\beta\int_0^{\pi/6} d\theta \int_0^R \left(r^2+2\pi_0+r_0^2\right) r dr$$

($\because$ for θ, 0 to $\pi\backslash 6$ and $5\pi\backslash 6$ to π is symmetric)

$$=2\beta[\theta]_0^{\pi/6}\left[\int_0^R r^3 dr+2r_0\int_0^R r^2 dr+r_0^2\int_0^R r dr\right]$$

$$2\beta\left(\frac{\pi}{6}\right)\left[\left(\frac{r^4}{4}\right)_0^R+2r_0\left(\frac{r_3}{3}\right)_0^R+r_0^2\left(\frac{r^2}{2}\right)_0^R\right]$$

$$=\beta\frac{\pi}{3}\left[\frac{R^4}{4}+2r_0\frac{R^3}{3}+\frac{r_0^2R^2}{2}\right]$$

$$=\pi\beta\left[\frac{R^4}{12}+\frac{2r_0R^3}{9}+\frac{r_0^2R^2}{6}\right]$$

Question47

A cell can supply currents of 1 A and 0.5 A via resistances of 2.5Ω and 10Ω, respectively. The internal resistance of the cell is

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Options:

A. 2Ω

B. 3Ω

C. 4Ω

D. 5Ω

Answer: D

Solution:

Let r be the internal resistance of the cell.

for case -1

$I=1$ A, $R=25\Omega$, then

$$I=\frac{E}{r+R}$$

$$\Rightarrow \quad E=I(r+R)=1(r+25)$$

$$\Rightarrow \quad E=r+25 \quad \ldots \text{(i)}$$

For the second condition,

$$I' = 0.5 \text{ A}, R' = 10\Omega$$
$$I' = \frac{E}{R' + r}$$
$$\Rightarrow \quad E = I'\left(R' + r\right)$$
$$= 0.5(10 + r)$$
$$\Rightarrow \quad E = 5 + 0.5r \quad \text{... (ii)}$$

Now, from Eqs. (i) and (ii), we get

$$\Rightarrow \quad r + 25 = 5 + 0.5r$$
$$\Rightarrow \quad r - 0.5r = 5 - 25 \Rightarrow 0.5r = 25$$
$$\Rightarrow \quad r = \frac{25}{0.5} = 5\Omega$$

Question48

The conductivity of a conductor decreaseswith temperature because, on heating

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Options:

A. atoms vibrates vigorously

B. conductor expands

C. electrons gain energy

D. electrons vibrate vigorously

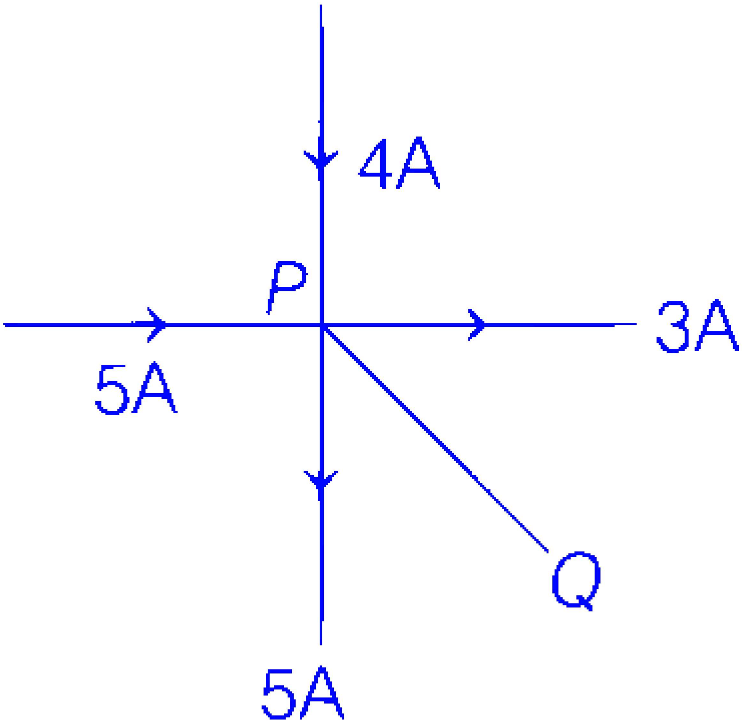
Answer: C

Solution:

Since, conductors are material which canconduct electricity at room temperature due topresence of valence electrons in their outermostshell and on heating valence electrons gainenergy, get excited and leave the conduction band.Now, due to absence / lack of free electrons inconduction band, on heating conductors do notconduct electricity.

Question49

Five current carrying conductors meet at apoint P. What is the magnitude and directionof the current in the fifth conductor?



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Options:

A. 1A from Q to P

B. 1A from P to Q

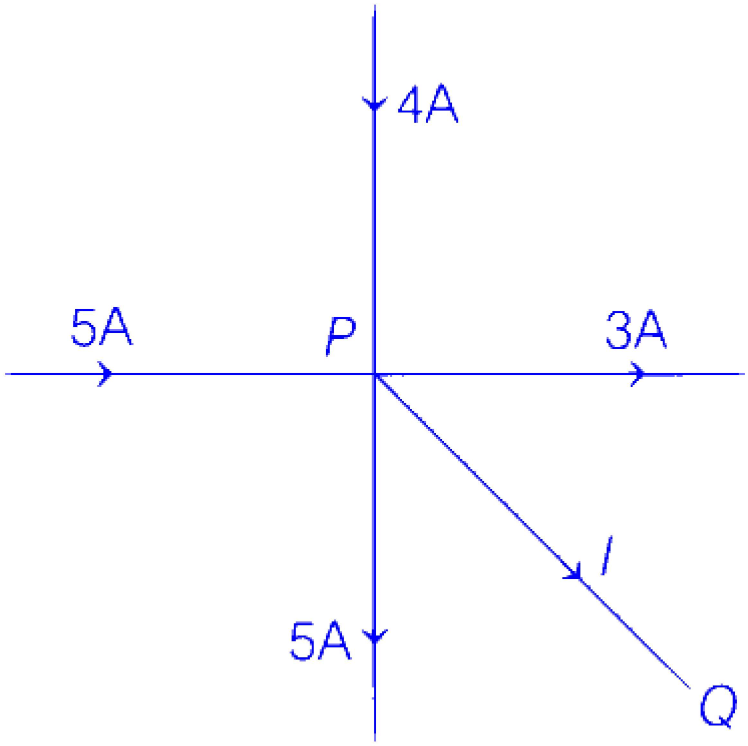
C. 3A from P to Q

D. 2A to Q to P

Answer: B

Solution:

According to given figure and by usingKirchhoff's current law,



Input current at P = Output current from P

$\therefore 4+5=I+3+5$

$\Rightarrow 9=8+I$

$\Rightarrow I=9-8$

= 1A from P to Q

Question50

In a potentiometer of 10 wires, the balancepoint is obtained on the 6th wire. To shift thebalance point to 8th wire, we should

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Options:

A. increase resistance in the main circuit

B. decrease resistance in the main circuit

C. increase resistance in series with the cell whose emf is to be measured

D. decrease resistance in series with the cell whose emf is to be measured

Answer: A

Solution:

Let length of each wire be l.

$\therefore$ Total length $= 10l$

At, Ist balance point, $l_1 : l_2 = 6l : 4l$

and as in case of potentiometer, $\frac{\text{emf}_1}{\text{emf}_2} = \frac{l_1}{l_2}$

i.e. $\varepsilon \propto l$

If l increases, emf also increases and emf is only increased by increasing resistance (R) in main circuit.

Question51

The length of germanium rod is 0.925 cm and its area of cross-section is $1\ \text{mm}^2$. If for germanium $n_i = 2.5 \times 10^{19}\ \text{m}^{-3}, \propto_n = 0.19\ \text{m}^2/\text{V} - \text{s}, \propto_e = 0.39\ \text{m}^2/\text{V}$-s, then the resistance of the rod is

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Options:

A. 2.5Ω

B. 4.0Ω

C. 5.0Ω

D. 10.0Ω

Answer: A

Solution:

Given, length of germanium, $l = 0.925\ \text{cm} = 0.925 \times 10^{-2}\ \text{m}$

Area of cross-section,

$$A = 1\ \mathrm{mm}^2$$
$$= \left(10^{-3}\ \mathrm{m}\right)^2$$
$$= 10^{-6}\ \mathrm{m}^2$$
$$n_i = 2.5 \times 10^{19}\ \mathrm{m}^{-3}$$
$$\mu_n = 0.19\ \mathrm{m}^2/\mathrm{V} - \mathrm{s}$$
$$\mu_e = 0.39\ \mathrm{m}^2/\mathrm{V} - \mathrm{s}$$

$$\begin{aligned} & \sigma = n_i e\left(\mu_e + \mu_n\right) \\ \text{Conductivity,} \quad & = 2.5 \times 10^{19} \times 1.6 \times 10^{-19}(0.39 + 0.19) \\ & = 2.32\ \mathrm{mho}\ \mathrm{m}^{-1} \end{aligned}$$

Resistivity, $\rho = \frac{1}{\sigma} = 0.431 \Omega - \mathrm{m}$

$$\begin{aligned} R & = \frac{\rho l}{A} \\ \text{and resistance,} \quad & = \frac{0.431 \times 0.925 \times 10^{-2}}{10^{-6}} \\ & = 0.3986 \times 10^4 = 3.9 \times 10^3 \\ & = 4 \times 10^3 \Omega = 4 \mathrm{k}\Omega \end{aligned}$$

Question52

A cell of emf 1.8 V gives a current of 17 A when directly connected to an ammeter of resistance 0.06 Ω. Internal resistance of the cell is

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Options:

A. 0.046 Ω

B. 0.066 Ω

C. 0.10 Ω

D. 10 Ω

Answer: A

Solution:

Given, emf of cell $= 1.8$ V

Current, $I = 17$ A

Resistance of ammeter, $R = 0.06\Omega$

Let internal resistance be r.

$$\begin{aligned}
&\text{Since, emf} = I(R + r) \\
&\therefore \quad 1.8 = 17(0.06 + r) \\
&\Rightarrow \quad \frac{1.8}{17} = 0.06 + r \\
&\Rightarrow \quad r = \frac{1.8}{17} - 0.06 = 0.046\Omega
\end{aligned}$$
