The storage battery of a car has an emf of 12 V. If the internal resistance of the battery is 0.4 Ω , what is the maximum current that can be drawn from the battery?

Answer :

Given,

Emf of battery, E = 12 V

Internal resistance of battery, r = 0.4 Ω

Let I be the maximum current drawn from the battery.

We know, according to Ohm's law:

E = Ir

I = E/r = 12/0.4

$\Longrightarrow$ I = 30 A

Hence the maximum current drawn from the battery is 30 A.

3.2 A battery of emf 10 V and internal resistance 3 Ω is connected to a resistor. If the current in the circuit is 0.5 A, what is the resistance of the resistor? What is the terminal voltage of the battery when the circuit is closed?

Answer:

Given,

Emf of the battery, E = 10 V

The internal resistance of the battery, $r = 3\ \Omega$

Current in the circuit, $I = 0.5$ A

Let R be the resistance of the resistor.

Therefore, according to Ohm's law:

$E = IR' = I(R + r)$

$10 = 0.5(R + 3)$

$R = 20 - 3 = 17\ \Omega$

Also,

$V = IR$ (Across the resistor)

$= 0.5 \times 17 = 8.5$ V

Hence, terminal voltage across the resistor = 8.5 V

3.3 (a) Three resistors $1\ \Omega$, $2\ \Omega$, and $3\ \Omega$ are combined in series. What is the total resistance of the combination?

Answer:

We know that when resistors are combined in series, the effective resistance is the sum of that resistance.

Hence, total resistance of the three resistance combination $= 1 + 2 + 3 = 6\ \Omega$

3.3 (b) <u>If the combination is connected to a battery of emf 12 V and negligible internal resistance, obtain the potential drop across each resistor.</u>

Answer:

Since the resistances are in series, the current through each one of them will be equal to the current through the circuit but voltage/ potential drop will be different.

Total resistance, R = 6 Ω

Emf, V = 12 V

According to Ohm's law:

V = IR

$\Longrightarrow$ 12 = I x 6

$\Longrightarrow$ I = 12/6 = 2 A

Now, using the same relation, voltage through resistors:

1 Ω : V(1) = 2 x 1 = 2V

2 Ω : V(2) = 2 x 2 = 4V

3 Ω : V(3) = 2 x 3 = 6V

(Note: V(1) + V(2) + V(3) = 2 + 4 + 6 = 12 V)

3.4 (a) Three resistors 2 Ω, 4 Ω and 5 Ω are combined in parallel. What is the total resistance of the combination?

Answer:

We know that when resistances are in parallel combination, the total resistance R is given by:

$$\frac{1}{R} = \sum \frac{1}{R_i}$$

Therefore, total resistance of the given three resistances in parallel combination is

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\implies \frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5} = \frac{10+5+4}{20} = \frac{19}{20}$$

$$\implies R = \frac{20}{19} = 1.05\Omega$$

Hence, the total resistance is 1.05 Ω

3.4 (b) If the combination is connected to a battery of emf 20 V and negligible internal resistance, determine the current through each resistor, and the total current drawn from the battery.

Answer:

Since the resistances are in parallel, the voltage across each one of them will be equal.

Emf, V = 20 V

According to Ohm's law:

V = IR $\implies$ I = V/R

Therefore, current across each one of them is:

2 Ω : I = 20/2 = 10 A

4 Ω : I = 20/4 = 5 A

5 Ω : I = 20/5 = 4 A

3.5 At room temperature (27.0 °C) the resistance of a heating element is 100 Ω. What is the temperature of the element if the resistance is found to be 117 Ω, given that the temperature coefficient of the material of the resistor is $1.70 \times 10^{-4\circ} C^{-1}$.

Answer:

Given,

temperature coefficient of filament, $\alpha = 1.70 \times 10^{-4\circ} C^{-1}$

$T_1 = 27^\circ C$; $R_1 = 100\Omega$

Let T_2 be the temperature of element, $R_2 = 117\Omega$

(Positive α means that the resistance increases with temperature. Hence we can deduce that T_2 will be greater than T_1)

We know,

$R_2 = R_1[1 + \alpha \Delta T]$

$\Longrightarrow 117 = 100[1 + (1.70 \times 10^{-4})(T_2 - 27)]$

$$\Rightarrow T_2 - 27 = \frac{117 - 100}{1.7 \times 10^{-4}}$$
$$\Rightarrow T_2 - 27 = 1000$$
$$\Rightarrow T_2 = 1027°C$$

Hence, the temperature of the element is 1027 °C.

3.6 A negligibly small current is passed through a wire of length 15 m and uniform cross-section $6.0 \times 10^{-7}\ m^2$, and its resistance is measured to be 5.0 Ω. What is the resistivity of the material at the temperature of the experiment?

Answer:

Given,

Length of the wire, l = 15 m

The cross-sectional area of the wire, A = $6.0 \times 10^{-7}\ m^2$

The resistance of the wire, R = 5 Ω

We know,

$R = \rho l / A$, where ρ is the resistivity of the material

$$\implies \rho = RA/l = 5 \times 6 \times 10^{-7}/15$$

$$\implies \rho = 2 \times 10^{-7}$$

Hence, the resistivity of the material of wire is $\rho = 2 \times 10^{-7}\ m$

3.7 A silver wire has a resistance of 2.1 Ω at 27.5 °C, and a resistance of 2.7 Ω at 100 °C. Determine the temperature coefficient of resistivity of silver.

Answer:

Given,

$T_1 = 27.5^\circ C$; $R_1 = 2.1\Omega$

$T_2 = 100^\circ C$; $R_2 = 2.7\Omega$

We know,

$R_2 = R_1[1 + \alpha\Delta T]$

2.7 = 2.1[1 + α (100 - 27.5)]

α = (2.7 - 2.1) / 2.1(100 -27.5)

α = 0.0039 $^\circ C^{-1}$

Hence, the temperature coefficient of silver wire is 0.0039 $^\circ C^{-1}$

3.8 A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0 °C? Temperature coefficient of resistance of nichrome averaged over the temperature range involved is $1.70 \times 10^{-4}\ ^\circ C^{-1}$.

Answer:

For the given voltage, the two values of current will correspond to two different values of resistance which will correspond to two different temperature.

Given,

Voltage, V = 230 V

$I_1 = 3.2A$ and $I_2 = 2.8A$

Using Ohm's law:

$R_1 = 230/3.2 = 71.87\Omega$

and

$R_2 = 230/2.8 = 82.14\Omega$

Now, the temperature coefficient of filament,

$\alpha = 1.70 \times 10^{-4\circ} C^{-1}$

$T_1 = 27^\circ C$

Let T_2 be the steady temperature of the heating element.

We know,

$R_2 = R_1[1 + \alpha\Delta T]$

$\Longrightarrow$ 230/2.8 = 230/3.2[1 + (1.70×10^{-4}) (T_2 - 27)]

$\Longrightarrow$ 3.2/2.8 = 1 + (1.70×10^{-4}) (T_2 - 27)

$\Longrightarrow$ 1.14 - 1 = (1.70×10^{-4}) (T_2 - 27)

$\Longrightarrow$ T_2 - 27 = 0.14 / (1.70×10^{-4})

$\Longrightarrow$ T_2 = (840.5 + 27) °C

Hence, steady temperature of the element is 867.5 °C .

3.9 Determine the current in each branch of the network shown in Fig. 3.30:

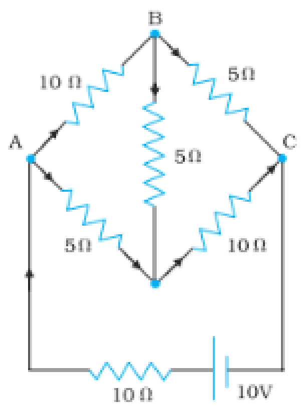
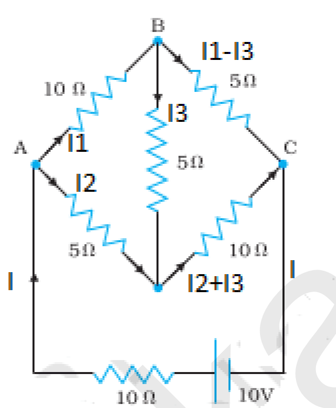


FIGURE 3.30

Answer:

Let current in the circuit is distributed like



where I1, I2, and I3 are the different current through shown branches.

Now, applying KVL in Loop

$$10 - I10 - I_2 5 - (I_2 + I_3)10 = 0$$

Also, we have $I = I_1 + I_2$

so putting it in kvl equation

$$10-(I_1+I_2)10-I_2 5-(I_2+I_3)10=0$$

$$10-10I_1-10I_2-5I_2-10I_2-10I_3=0$$

$10-10I_1-25I_2-10I_3=0$ ....(1)

Now let's apply kvl in the loop involving I1 I2 AND I3

$5I_2-10I_1-5I_3=0$ ....(2)

now, the third equation of KVL

$$5I_3-5(I_1-I_3)+10(I_2+I_3)=0$$

$-5I_1+10I_2+20I_3=0$ ....(3)

Now we have 3 equation and 3 variable, on solving we get

$$I_1=\frac{4}{17}A$$

$$I_2=\frac{6}{17}A$$

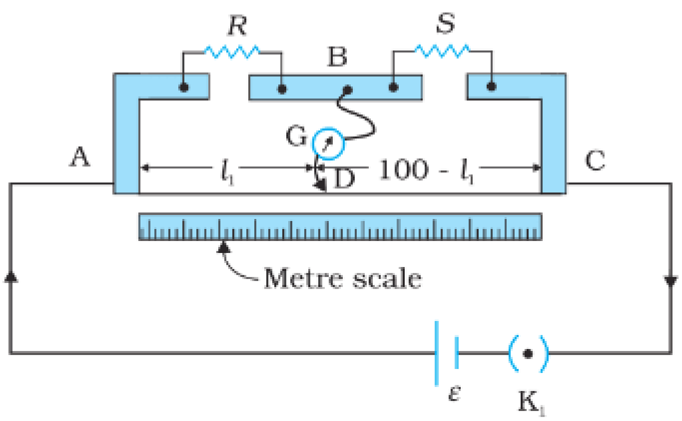
$$I_3=\frac{-2}{17}A$$

Now the total current

$$I=I_1+I_2=\frac{4}{17}+\frac{6}{17}=\frac{10}{17}$$

3.10 (a) In a meter bridge [Fig. 3.27], the balance point is found to be at 39.5 cm from the end A, when the resistor Y is Determine the current in each branch of the network shown in Fig. 3.30:of

12.5 Ω. Determine the resistance of X. Why are the connections between resistors in a Wheatstone or meter bridge made of thick copper strips?



Answer:

Balance point from the end A, l_1 = 39.5 cm

Resistance of Y = 12.5 Ω

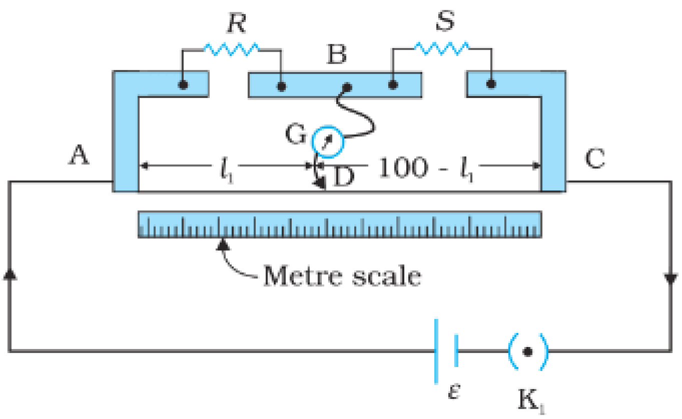
We know, for a meter bridge, balance condition is:

$$\frac{X}{Y} = \frac{l_1}{l_2} = \frac{l_1}{100 - l_1}$$

$$\Longrightarrow \quad X = \frac{39.5}{100 - 39.5} \times 12.5 = 8.2\Omega$$

The connections between resistors in a Wheatstone or meter bridge made of thick copper strips to minimise the resistance of the connection which is not accounted for in the bridge formula.

3.10 (b) In a meter bridge [Fig. 3.27], the balance point is found to be at 39.5 cm from the end A, when the resistor Y is of 12.5 Ω. Determine the resistance of X. Why are the connections between resistors in a Wheatstone or meter bridge made of thick copper strips?



(b) Determine the balance point of the bridge above if X and Y are interchanged.

Answer:

If X and Y are interchanged.

Then, X = 12.5 Ω , Y = 8.2 Ω

We know, for a meter bridge, balance condition is:

$$\frac{X}{Y} = \frac{l_1}{l_2} = \frac{l_1}{100 - l_1}$$

$$\implies \frac{12.5}{8.16} = \frac{l_1}{100 - l_1}$$

$$\implies 1.53(100 - l_1) = l_1$$
$$\implies 2.53 l_1 = 153$$

$$\therefore l_1 = 60.5cm(from\ point\ A)$$

3.10 (c) What happens if the galvanometer and cell are interchanged at the balance point of the bridge? Would the galvanometer show any current?

Answer:

if the galvanometer and cell are interchanged the galvanometer will show no current and hence no deflection.

3.11 A storage battery of emf 8.0 V and internal resistance 0.5 Ω is being charged by a 120 V dc supply using a series resistor of 15.5 Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

Answer:

Given,

Emf of battery, E = 8 V

Internal resistance of battery, r = 0.5 Ω

Supply Voltage, V = 120 V

The resistance of the resistor, R = 15.5 Ω

Let V' be the effective voltage in the circuit.

Now, V' = V - E

V' = 120 - 8 = 112 V

Now, current flowing in the circuit is:

I = V' / (R + r)

$$\implies I = \frac{112}{15.5 + 0.5} = 7A$$

Now, using Ohm 's Law:

Voltage across resistor R is v = IR

v = 7 x 15.5 = 108.5 V

Now, the voltage supplied, V = Terminal voltage of battery + v

∴ Terminal voltage of battery = 120 -108.5 = 11.5 V

The purpose of having a series resistor is to limit the current drawn from the supply.

3.12 In a potentiometer arrangement, a cell of emf 1.25 V gives a balance point at 35.0 cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 63.0 cm, what is the emf of the second cell?

Answer:

Given,

E_1 = 1.25 V , l_1 = 35 cm

And, l_2 = 63 cm

Let E_2 be the voltage in the second case.

Now, the balance condition is given by :

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\implies E_2 = \frac{l_2}{l_1} \times E_1 = \frac{63}{35} \times 1.25$$

$$\implies E_2 = 2.25V$$

Therefore, the emf of the second cell = 2.25 V

3.13 The number density of free electrons in a copper conductor estimated in Example 3.1 is $8.5 \times 10^{28} m^{-3}$. How long does an electron take to drift from one end of a wire 3.0 m long to its other end? The area of cross-section of the wire is $2.0 \times 10^{-6} m^2$ and it is carrying a current of 3.0 A.

Answer:

We know,

$$I = neAv_d$$

V_d :drift Velocity = length of wire(l) / time taken to cover

$$I = neA\frac{l}{t}$$

by substituting the given values

$\Longrightarrow$ t = 2.7 x 10^4 s

Therefore, the time required by an electron to drift from one end of a wire to its other end is 2.7×10^4s.

NCERT Solutions for Class 12 Physics Chapter 3 Current Electricity Additional Exercises

3.14 The earth's surface has a negative surface charge density of 10 $^{-9}$ C m $^{-2}$. The potential difference of 400 kV between the top of the atmosphere and the surface results (due to the low conductivity of the lower atmosphere) in a current of only 1800 A cover the entire globe. If there were no mechanism of sustaining atmospheric electric field, how much time (roughly) would be required to neutralise the earth's surface? (This never happens in practice because there is a mechanism to replenish electric charges, namely the continual thunderstorms and lightning in different parts of the globe). (Radius of earth = 6.37 × 10 6 m.)

Answer:

Given,

The surface charge density of earth $\rho = 10^{-9} Cm^{-2}$

Current over the entire globe = 1800 A

Radius of earth, r = 6.37 x 10^6 m

∴ The surface area of earth A = $4\pi r^2$

$= 4\pi(6.37 \times 10^6)^2 = 5.09 \times 10^{14} m^2$

Now, charge on the earth surface, $q = \rho \times A$

Therefore,

$q = 1005.09 \times 10^5 C$

Let the time taken to neutralize earth surface be t

∴ Current I = q / t

$\Longrightarrow$ t = 282.78 s.

Therefore, time take to neutralize the Earth's surface is 282.78 s

3.15 (a) Six lead-acid type of secondary cells each of emf 2.0 V and internal resistance 0.015 Ω are joined in series to provide a supply to a resistance of 8.5 Ω. What are the current drawn from the supply and its terminal voltage?

Answer:

Given,

There are 6 secondary cells.

Emf of each cell, E = 2 V (In series)

The internal resistance of each cell, r = 0.015 Ω (In series)

And the resistance of the resistor, R = 8.5 Ω

Let I be the current drawn in the circuit.

$$I = \frac{nE}{R + nr}$$

$$\implies I = \frac{6(2)}{8.5 + 6(0.015)} = \frac{12}{8.59}$$

$\implies$ I = 1.4 A

Hence current drawn from the supply is 1.4 A

Therefore, terminal voltage, V = IR = 1.4 x 8.5 = 11.9 V

3.15 (b) A secondary cell after long use has an emf of 1.9 V and a large internal resistance of 380 Ω. What maximum current can be drawn from the cell? Could the cell drive the starting motor of a car?

Answer:

Given,

Emf , E = 1.9 V

Internal resistance, r =380 Ω

The maximum current that can drawn is I = E/r = 1.9/380 = 0.005 A

The motor requires a large value of current to start and hence this cell cannot be used for a motor of a car.

3.16 Two wires of equal length, one of aluminium and the other of copper have the same resistance. Which of the two wires is lighter? Hence explain why aluminium wires are preferred for overhead power cables. ($\rho_{Al} = 2.63 \times 10^{-8} \Omega m$, $\rho_{Cul} = 1.73 \times 10^{-8} \Omega m$ relative density of Al = 2.7, of Cu = 8.9.)

Answer:

We know,

R = ρ 1 / A

The wires have the same resistance and also are of the same length.

Hence,

$$\frac{\rho_{Al}}{A_{Al}} = \frac{\rho_{Cu}}{A_{Cu}}$$

$$\implies \frac{A_{Al}}{A_{Cu}} = \frac{\rho_{Al}}{\rho_{Cu}} = \frac{2.63}{1.73}$$

Now, mass = Density x Volume = Density x Area x length

Taking the ratio of their masses for the same length

$$\implies \frac{m_{Al}}{m_{Cu}} = \frac{d_{AL} A_{Al}}{d_{Cu} A_{Cu}} = \frac{2.7 \times 2.63}{8.9 \times 1.73} < 1$$

Hence, $m_{Al} < m_{Cu}$

Therefore, for the same resistance and length, the aluminium wire is lighter.

Since aluminium wire is lighter, it is used as power cables.

3.17 <u>What conclusion can you draw from the following observations on a resistor made of alloy manganin?</u>

Current A	Voltage V	Current A	Voltage V
0.2	3.94	3.0	59.2
0.4	7.87	4.0	78.8
0.6	11.8	5.0	98.6
0.8	15.7	6.0	118.5
1.0	19.7	7.0	138.2

Current A	Voltage V	Current A	Voltage V
2.0	39.4	8.0	158.0

Answer:

The ratio of Voltage to current for the various values comes out to be nearly constant which is around 19.7.

Hence the resistor made of alloy manganin follows Ohm's law.

Answer the following questions:

3.18 (a) A steady current flows in a metallic conductor of non-uniform cross-section. Which of these quantities is constant along the conductor: current, current density, electric field, drift speed?

Answer:

The current flowing through the conductor is constant for a steady current flow.

Also, current density, electric field, and drift speed are inversely proportional to the area of cross-section. Hence, not constant.

Answer the following questions:

3.18 (b) Is Ohm’s law universally applicable for all conducting elements? If not, give examples of elements which do not obey Ohm’s law.

Answer:

No. Ohm's law is not universally applicable for all conducting elements.

A semiconductor diode is such an example.

Answer the following questions

3.18 (c) A low voltage supply from which one needs high currents must have very low internal resistance. Why?

Answer:

Ohm's law states that: V = I x R

Hence for a low voltage V, resistance R must be very low for a high value of current.

Answer the following questions:

3.18 (d) A high tension (HT) supply of, say, 6 kV must have a very large internal resistance. Why?

Answer:

A very high internal resistance is required for a high tension supply to limit the current drawn for safety purposes.

3.19 Choose the correct alternative:

(a) Alloys of metals usually have (greater/less) resistivity than that of their constituent metals.

(b) Alloys usually have much (lower/higher) temperature coefficients of resistance than pure metals.

(c) The resistivity of the alloy manganin is nearly independent of/ increases rapidly with increase of temperature.

(d) The resistivity of a typical insulator (e.g., amber) is greater than that of a metal by a factor of the order of ($10^{22}/10^{23}$).

Answer:

(a) Alloys of metals usually have greater resistivity than that of their constituent metals.

(b) Alloys usually have much lower temperature coefficients of resistance than pure metals.

(c) The resistivity of the alloy manganin is nearly independent of temperature.

(d) The resistivity of a typical insulator (e.g., amber) is greater than that of a metal by a factor of the order of 10^{22} .

3.20 (a)

(i) Given n resistors each of resistance R , how will you combine them to get the (i) maximum effective resistance?

Answer:

To get maximum effective resistance, combine them in series. The effective resistance will be nR.

3.20 (a)

(ii) Given n resistors each of resistance R, how will you combine them to get the (ii) minimum effective resistance?

Answer:

To get minimum effective resistance, combine them in parallel. The effective resistance will be R/n.

3.20 (a)

(iii) What is the ratio of the maximum to minimum resistance?

Answer:

The ratio is nR/(R/n) = n^2

3.20 (b)

(i) Given the resistances of 1 Ω, 2 Ω, 3 Ω, how will be combine them to get an equivalent resistance of (i) $\frac{11}{3}\Omega$

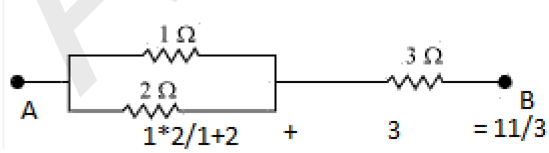
Answer:

We have, equivalent resistance = 11/3

Let's break this algebraically so that we can represent it in terms of 1, 2 and 3

$$\frac{11}{3} = \frac{9+2}{3} = 3 + \frac{2}{3} = 3 + \frac{1*2}{1+2}$$

this expression is expressed in terms of 1, 2 and 3. and hence we can make a circuit which consist only of 1 ohm, 2 ohms and 3 ohms and whose equivalent resistance is 11/3. that is :



3.20 (b)

(ii) Given the resistances of 1 Ω, 2 Ω, 3 Ω, how will be combine the to get an equivalent resistance of (ii) $\frac{11}{5}\Omega$

Answer:

Connect 2 Ω and 3 Ω resistor in parallel and 1 Ω resistor in series to it

Equivalent Resistance R = {1/(1/2 + 1/3)} + 1 = 6/5 + 1

R = 11/5 Ω

3.20 (b)

(iii) Given the resistances of 1 Ω, 2 Ω, 3 Ω, how will be combine them to get an equivalent resistance of (iii) 6 Ω

Answer:

1 Ω+2 Ω+ 3 Ω= 6 Ω, so we will combine the resistance in series.

3.20 (b)

(iv) Given the resistances of 1 Ω, 2 Ω, 3 Ω, how will be combine them to get an equivalent resistance of (iv) $\frac{6}{11}\Omega$

Answer:

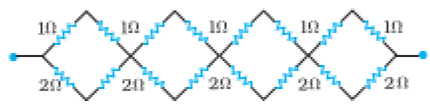
Connect all three resistors in parallel.

Equivalent resistance is R = 1/(1/1 + 1/2 + 1/3) = (1x 2 x 3)/(6 + 3 + 2)

R = 6/11 Ω

3.20 (c)

(a) Determine the equivalent resistance of networks shown in Fig. 3.31.



(a)

Answer:

It can be seen that in every small loop resistor 1 ohm is in series with another 1 ohm resistor and two 2 ohms are also in series and we have 4 loops,

so equivalent resistance of one loop is equal to the parallel combination of 2 ohms and 4 ohm that is

$$Equivalent\ R_{loop} = \frac{2*4}{2+4} = \frac{8}{6} = \frac{4}{3}$$

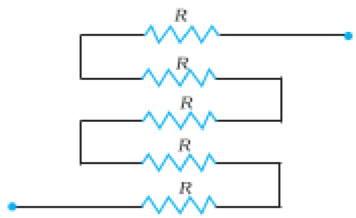
now we have 4 such loops in series so,

$$Total\ Equivalent\ R_{loop} = \frac{4}{3} + \frac{4}{3} + \frac{4}{3} + \frac{4}{3} = \frac{16}{3}$$

Hence equivalent resistance of the circuit is 16/3 ohm.

3.20 (c)

(b) Determine the equivalent resistance of networks shown in Fig. 3.31.



(b)

Answer:

It can be seen that all 5 resistors are in series, so

Equivalent Resistance = R + R + R + R + R = 5R

Hence equivalent resistance is 5R.

3.21 Determine the current drawn from a 12V supply with internal resistance 0.5Ω by the infinite network shown in Fig. 3.32. Each resistor has 1Ω resistance.

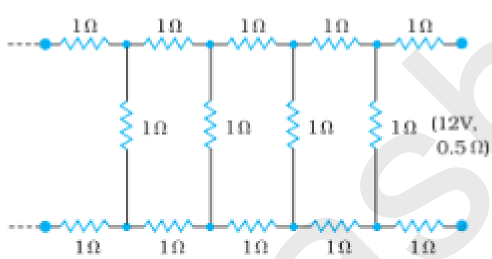
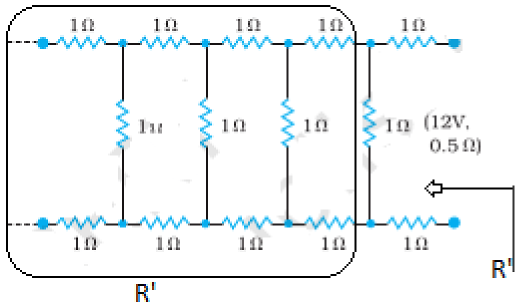


FIGURE 3.32

Answer:

First, let us find the equivalent of the infinite network,

let equivalent resistance = R'



Here from the figure, We can consider the box as a resistance of R'

Now, we can write,

equivalent resistance = R'

' =[(R')Parallel with (1)] + 1 + 1

$$\frac{R' * 1}{R' + 1} + 2 = R'$$

$$R' + 2R' + 2 = R'^2 + R'$$

$$R'^2 - 2R' - 2 = 0$$

$$R' = 1 + \sqrt{3}, or 1 - \sqrt{3}$$

Since resistance can never be negative we accept

$$R' = 1 + \sqrt{3}$$

, We have calculated the equivalent resistance of infinite network,

Now

Total equivalent resistance = internal resistance of battery+ equivalent resistance of the infinite network

= 0.5+1+1.73

=3.23 ohm

$$V = IR$$
$$I = \frac{V}{R} = \frac{12}{3.23} = 3.72A$$

Hence current drawn from the 12V battery is 3.72 Ampere.

3.22 (a) Figure 3.33 shows a potentiometer with a cell of 2.0 V and internal resistance 0.40 Ω maintaining a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents up to a few mA) gives a balance point at 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf ε and the balance point found similarly, turns out to be at 82.3 cm length of the wire.

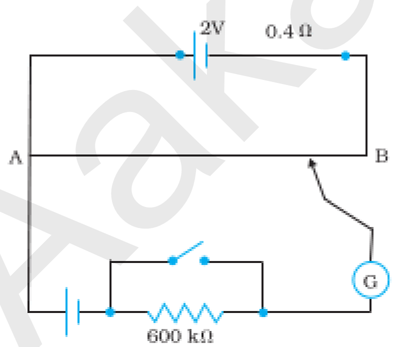


FIGURE 3.33

(a) What is the value of ϵ

Answer:

Given

maintained constant emf of standard cell = 1.02V, balanced point of this cell = 67.3cm

Now when the standard cell is replaced by another cell with emf = ε . balanced point for this cell = 82.3cm

Now as we know the relation

$$\frac{\varepsilon}{l} = \frac{E}{L}$$

$$\varepsilon = \frac{E}{L} * l = \frac{1.02}{67.3} * 82.3 = 1.247V$$

hence emf of another cell is 1.247V.

3.22 (b) Figure 3.33 shows a potentiometer with a cell of 2.0 V and internal resistance 0.40 Ω maintaining a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balance point at 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf ε and the balance point found similarly, turns out to be at 82.3 cm length of the wire.

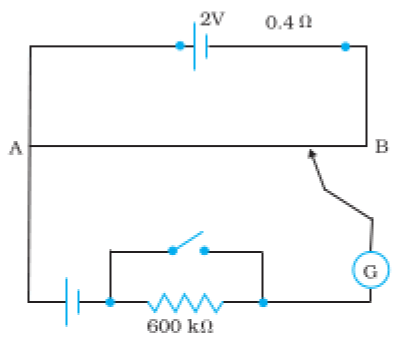


FIGURE 3.33

(b) What purpose does the high resistance of 600 kΩ have?

Answer:

If a sufficiently high current passes through galvanometer then it can get damaged. So we limit the current by adding a high resistance of 600 kΩ .

3.22 (c) Figure 3.33 shows a potentiometer with a cell of 2.0 V and internal resistance 0.40 Ω maintaining a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balance point at 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf ε and the balance point found similarly, turns out to be at 82.3 cm length of the wire.

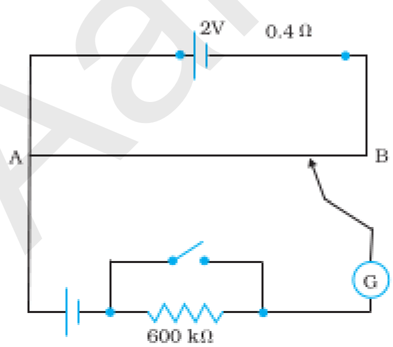


FIGURE 3.33

(c) Is the balance point affected by this high resistance?

Answer:

No, the Balance point is not affected by high resistance. High resistance limits the current to galvanometer wire. The balance point is obtained by moving the joe key on the potentiometer wire and current through potentiometer wire is constant. The balance point is the point when the current through galvanometer becomes zero. The only duty of high resistance is to supply limited constant current to potentiometer wire.

3.22 (d) Figure 3.33 shows a potentiometer with a cell of 2.0 V and internal resistance 0.40 Ω maintaining a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balance point at 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf ε and the balance point found similarly, turns out to be at 82.3 cm length of the wire.

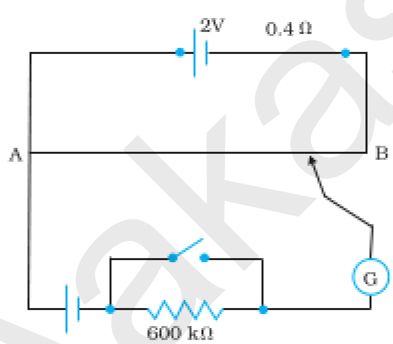


FIGURE 3.33

(d) Would the method work in the above situation if the driver cell of the potentiometer had an emf of 1.0V instead of 2.0V?

Answer:

No, the method would not have worked if the driver cell of the potentiometer had an emf of 1.0V instead of 2, because when emf of the driving point is less than the other cell, their won't be any balance point in the wire

3.22 (e) Figure 3.33 shows a potentiometer with a cell of 2.0 V and internal resistance 0.40 Ω maintaining a potential drop across the resistor wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents upto a few mA) gives a balance point at 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf ε and the balance point found similarly, turns out to be at 82.3 cm length of the wire.

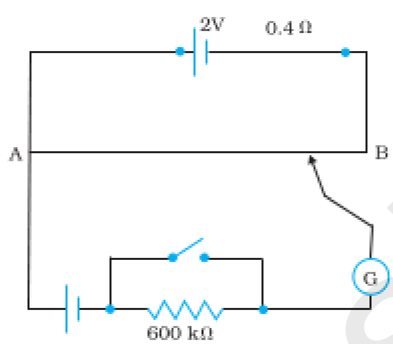


FIGURE 3.33

(e) Would the circuit work well for determining an extremely small emf, say of the order of a few mV (such as the typical emf of a thermo-couple)? If not, how will you modify the circuit?

Answer:

No, the circuit would not work properly for very low order of Voltage because the balance points would be near point A and there will be more percentage error in measuring it. If we add series resistance with wire AB. It will increase the potential difference of wire AB which will lead to a decrease in percentage error.

3.23 Figure 3.34 shows a 2.0 V potentiometer used for the determination of internal resistance of a 1.5 V cell. The balance point of the cell in open circuit is 76.3 cm. When a resistor of 9.5 Ω is used in the external circuit of the cell, the balance point shifts to 64.8 cm length of the potentiometer wire. Determine the internal resistance of the cell.

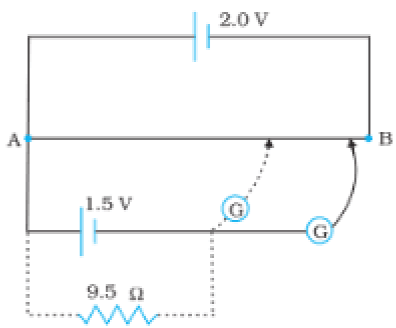


FIGURE 3.35

Answer:

Given,

the balance point of cell in open circuit = $l_1 = 76.3cm$

value of external resistance added = $R = 9.5\Omega$

new balance point = $l_2 = 64.8cm$

let the internal resistance of the cell be r .

Now as we know, in a potentiometer,

$$r = \frac{l_1 - l_2}{l_2} * R$$

$$r = \frac{76.3 - 64.8}{64.8} * 9.5 = 1.68\Omega$$

hence the internal resistance of the cell will be 1.68 Ω