CURRENT ELECTRICITY

Important Questions & Answers

VERY SHORT ANSWER TYPE QUESTIONS (1 MARK)

1. **Two conducting wires *X* and *Y* of same diameter but different materials are joined in series across a battery. If the number density of electrons in *X* is twice that in *Y*, find the ratio of drift velocity of electrons in the two wires. [*AI 2010*]**
   Ans. Since the wires are connected in series, current *I* through both is same. Therefore ratio of drift velocities

$$\frac{v_X}{v_Y}=\frac{\frac{I}{n_X e A_X}}{\frac{I}{n_Y e A_Y}} \Rightarrow \frac{v_X}{v_Y}=\frac{n_Y}{n_X}=\frac{1}{2} \quad (Given \;\; A_X = A_Y, n_X = 2n_Y)$$

   where, n_X , n_Y = respective electron densities, A_X , A_Y = cross sectional Areas
   $\therefore v_X : v_Y = 1:2$

2. **Define the term 'Mobility' of charge carries in a conductor. Write its SI unit.**
   Ans. Mobility is defined as the magnitude of the drift velocity per unit electric field.

$$\mu=\frac{v_d}{E}=\frac{l\tau}{m}$$

   where τ is the average collision time for electrons.
   The SI unit of mobility is m^2/Vs or $m^2V^{-1}s^{-1}$.

3. **Define the term 'electrical conductivity' of a metallic wire. Write its S.I. unit.**
   Ans. The reciprocal of the resistivity of a material is called its conductivity and is denoted by σ.

$$\text{Conductivity}=\frac{1}{\text{Resistivity}}$$

   The SI unit of conductivity is $ohm^{-1}m^{-1}$ or Sm^{-1}.

4. **Define the term 'drift velocity' of charge carriers in a conductor and write its relationship with the current flowing through it.**
   Ans. Drift velocity is defined as the average velocity acquired by the free electrons in a conductor under the influence of an electric field applied across the conductor. It is denoted by v_d.
   Current, $I = neA.\, v_d$

5. **Why are the connections between the resistors in a meter bridge made of thick copper strips?**
   Ans. A thick copper strip offers a negligible resistance, so does not alter the value of resistances used in the meter bridge.

6. **Why is it generally preferred to obtain the balance point in the middle of the meter bridge wire?**

Ans. If the balance point is taken in the middle, it is done to minimise the percentage error in calculating the value of unknown resistance.

7. **Which material is used for the meter bridge wire and why?**

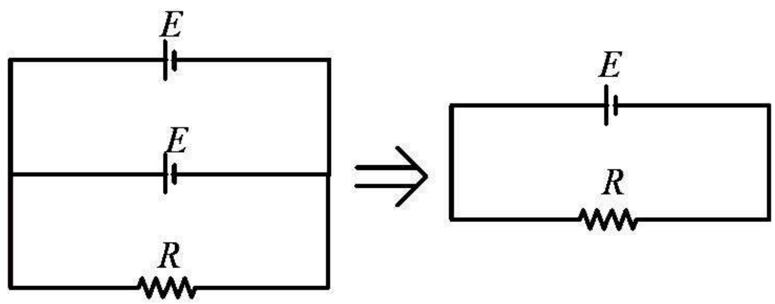
Ans. Generally alloys magnin/constantan/nichrome are used in meter bridge, because these materials have low temperature coefficient of resistivity.

8. **A resistance *R* is connected across a cell of emf ε and internal resistance *r*. A potentiometer now measures the potential difference between the terminals of the cell as *V*. Write the expression for *r* in terms of ε, *V* and *R*. [*AI 2011*]**
Ans. $\varepsilon = I(R+r) \;\; and \;\; V = IR$

$$\therefore \frac{\varepsilon}{V} = \frac{R+r}{R}$$

We get, $r = \left(\frac{\varepsilon}{V} - 1\right)R$

9. **Two identical cells, each of emf *E*, having negligible internal resistance, are connected in parallel with each other across an external resistance *R*. What is the current through this resistance?**
Ans.



$$So, \; current \;\; I = \frac{E}{R}$$

10. **Two wires of equal length, one of copper and the other of manganin have the same resistance. Which wire is thicker? [*AI 2012*]**
Ans. $R_{Cu} = R_m$

$$\rho_{Cu}\frac{\rho_{Cu}}{A_{Cu}} = \rho_m \frac{\rho_m}{A_m}$$

$$Here, \;\; \rho_{Cu} = \rho_m \;\; as \;\; \rho_m > \rho_{Cu}$$

$$\frac{\rho_{Cu}}{A_{Cu}} = \frac{\rho_m}{A_m}, \;\; \frac{\rho_m}{\rho_{Cu}} = \frac{A_m}{A_{Cu}} \qquad as, \rho_m > \rho_{Cu}$$

So, $A_m > A_{Cu}$
Manganin wire is thicker than copper wire.

SHORT ANSWER TYPE QUESTIONS (2 MARKS/3 MARKS)

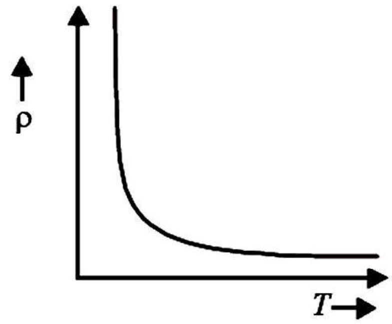
11. **Two metallic wires of the same material have the same length but cross sectional area is in the ratio 1 : 2. They are connected (i) in series and (ii) in parallel. Compare the drift velocities of electrons in the two wires in both the cases (i) and (ii). [*AI 2008*]**

Ans. (i) In series, current *I* through both the metallic wires is same, so $\frac{v_1}{v_2} = \frac{\frac{I}{neA_1}}{\frac{I}{neA_2}} \Rightarrow \frac{v_1}{v_2} = \frac{A_2}{A_1} = \frac{2}{1}$

(ii) In Parallel, potential difference *V* applied across both of them is same, so $\frac{v_1}{v_2} = \frac{\frac{eV_\tau}{ml}}{\frac{eV_\tau}{ml}} = \frac{1}{1}$

12. **Using the mathematical expression for the conductivity of a material, explain how it varies with temperature for (i) semiconductors, (ii) good conductors. [*AI 2008*]**

Ans. (i) Variation of resistivity in semiconductors
Resistivity of semiconductors decrease rapidly with increase in temperature. This is because more and more electrons becomes free in semiconductors and insulators on heating, there by increasing number density n of free electrons. So, in insulators and semiconductors, it is not the relaxation time t but the number density 'n' of free electrons that matters. An exponential relation exist between number of free electrons and temperature.



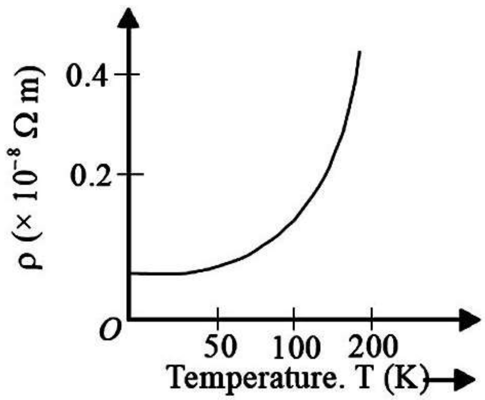
$$n(\tau) = n_0 e^{\frac{-E_g}{kT}}$$

Here E_g is the energy gap between valance and conduction band, n_0 is number of charge carriers at absolute zero temperature. So, the resistivity of insulators decreases exponentialy with increasing temperature.

$$\rho_\tau = \rho_0 e^{\frac{-E_g}{kT}}$$

Hence, temperature coefficient a of resistivity is negative in semiconductors and insulators.

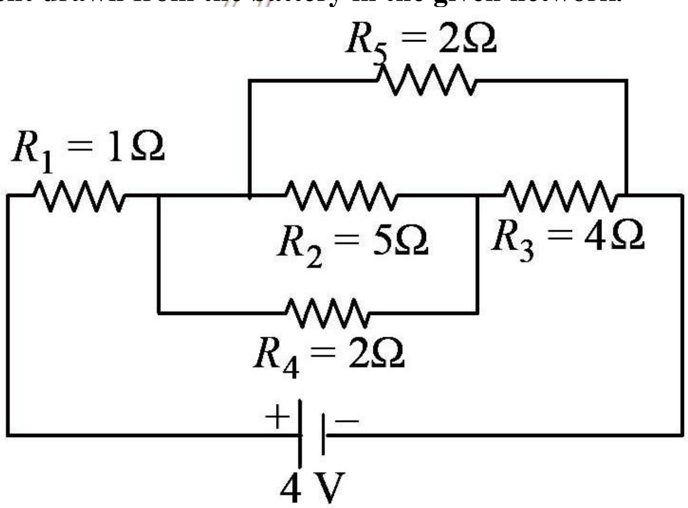
(ii) Variation of resistivity in conductors
On increasing the temperature of a conductor its resistivity and resistance increases. In metals, the number of free electron is fixed. As the temperature is increased, the atom/ions vibrates with increasing amplitude also the kinetic energy of free electrons increases. Thus now the electrons collide more frequently with atoms and hence the relaxation time t decreases.



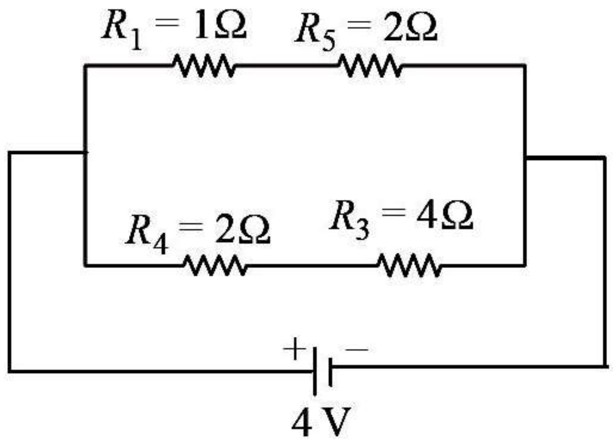
As resistivity of a conductor, $\rho = \frac{m}{ne^2\tau}$ or $\rho \propto \frac{1}{\tau}$

So the resistivity of a conductor increase, there by increasing the resistance of conductor. Resistivity increases non linearly in conductors. For example, variation of resistivity of copper is as shown in the graph.

13. Calculate the current drawn from the battery in the given network.



Ans. It is a balanced Wheatstone bridge, so it can be reduced to as shown below.



As R_1 and R_5 are in series, so their equivalent resistance is $R' = R_1 + R_5 = 1 + 2 = 3\,\Omega$
As R_4 and R_3 are in series, so their equivalent resistance is $R'' = R\,4 + R\,3 = 2 + 4 = 6\,\Omega$
So, net resistance of the network is

$$\frac{1}{R} = \frac{1}{R'} + \frac{1}{R"} = \frac{1}{3} + \frac{1}{6} = \frac{2+1}{6} = \frac{3}{6} = \frac{1}{2}$$

or $R = 2\,\Omega$
So, current drawn from the battery is

$$I = \frac{V}{R} \text{ or } I = 2 \text{ A.}$$

14. Derive an expression for the current density of a conductor in terms of the drift speed of electrons. [*AI 2008*]

Ans. Current density $\vec{J}$ is the current flowing through a conductor per unit are of cross section, it is a vector quantity and has the direction same as current.

$I = \vec{J}.\vec{A}$

Magnitude of current density

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

15. A wire of 15 Ω resistance is gradually stretched to double its original length. It is then cut into two equal parts. These parts are then connected in parallel across a 3.0 volt battery. Find the current drawn from the battery. [*AI 2009*]

Ans. When the wire of $15\,\Omega$ resistance is stretched to double its original length, then its resistance becomes

$R' = n^2 \times 15 = 2^2 \times 15 = 60\,\Omega$

When it cut into two equal parts, then resistance of each part becomes

$$R" = \frac{R'}{2} = \frac{60}{2} = 30\Omega$$

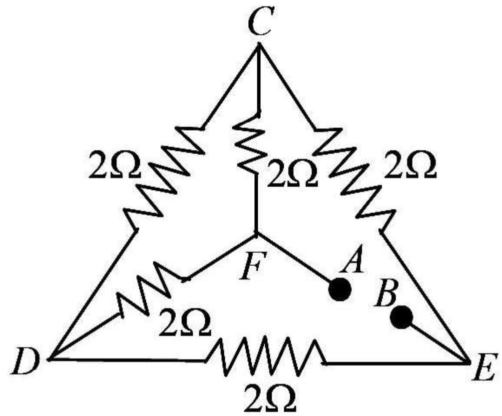
These parts are connected in parallel, then net resistance of their combination is

$$R = \frac{R"}{2} = \frac{30}{2} = 15\Omega$$

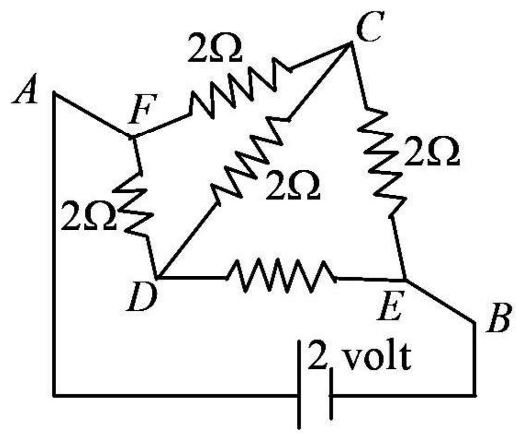
So, the current drawn from the battery

$$I = \frac{V}{R} = \frac{3}{15} = \frac{1}{5} \text{ or } I = 0.2 \text{ A.}$$

16. A potential difference of 2 Volts is applied between the points *A* and *B* as shown in the network drawn in figure. Calculate (i) equivalent resistance of the network, across the point *A* and *B*, the (ii) the magnitudes of currents flowing in the arms *AFCEB* and *AFDEB*. (iii) current through *CD* and *ACB*, if a 10V d.c. source is connected between *A* and *B*. [*AI 2008*]



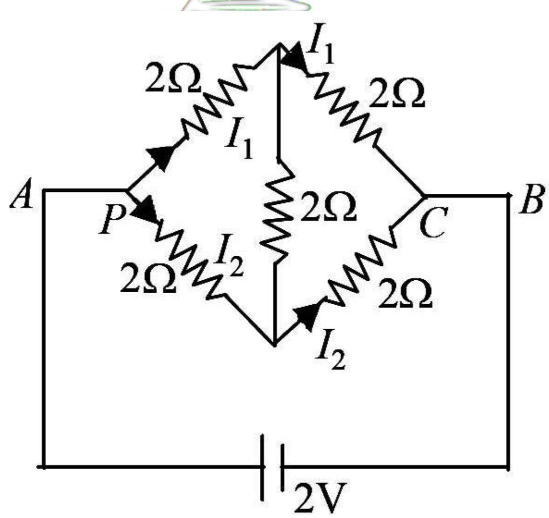
Ans. The given circuit, can also be opened up by stretching *A* and *B* as shown below.



Now it is a balanced wheatstone bridge. The potential at point *C* and *D* is the same. No current flows between *C* and *D*.

(i) The equivalent resistance is $R_{eq} = 2\ \Omega$

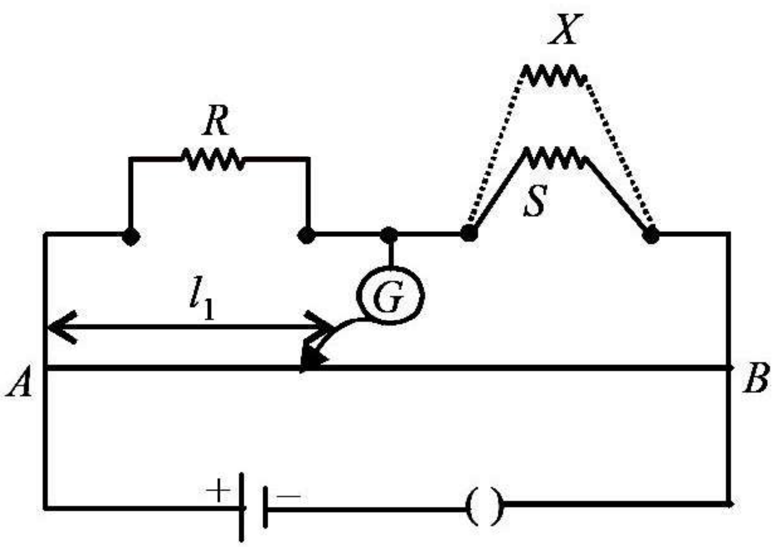
(ii) $2 = 4I_1 = 4I_2$



$I_1 = I_2 = 0.5$ A

Current through both the arms is 0.5 A.

17. (i)State the principle of working of a meter bridge. (ii) In a meter bridge balance point is found at a distance l_1 with resistances *R* and *S* as shown in the figure. When an unknown resistance *X* is connected in parallel with the resistance *S*, the balance point shifts to a distance l_2 . Find the expression for *X* in terms of l_1 , l_2 and *S*. [*AI 2009*]



Ans.

(i) Meter bridge works on the principle of Wheatstone bridge.

(ii) In first case, $\frac{R}{S} = \frac{l_1}{100 - l_1} \Rightarrow R = \frac{S.l_1}{100 - l_1}$ ----------------- (i)

In second case, $\frac{R}{\left(\frac{XS}{X+S}\right)} = \frac{l_2}{100 - l_s} \Rightarrow R = \frac{l_2 \times XS}{(100 - l_s)(X + S)}$ -------------- (ii)

By equations (i) and (ii), we get

$$\frac{S.l_1}{100 - l_1} = \frac{l_2 \times XS}{(100 - l_2)(X + S)}$$

$$\Rightarrow l_1(100 - l_2)(X + S) = Xl_2(100 - l_1)$$

$$\Rightarrow (100l_1 - l_1l_2)(X + S) = 100Xl_2 - Xl_1l_2$$

$$\Rightarrow 100Xl_1 - Xl_1l_2 + 100Sl_1 - Sl_1l_2 = 100Xl_2 - Xl_1l_2$$

$$\Rightarrow 100Xl_1 - 100Xl_2 = Sl_1l_2 - 100Sl_1$$

$$\Rightarrow 100X(l_1 - l_2) = Sl_1(l_2 - 100)$$

$$\Rightarrow X = \frac{Sl_1(l_2 - 100)}{100(l_1 - l_2)}$$

18. Write any two factors on which internal resistance of a cell depends. The reading on a high resistance voltmeter, when a cell is connected across it, is 2.2 V. When the terminals of the cell are also connected to a resistance of 5Ω as shown in the circuit, the voltmeter reading drops to 1.8 V. Find the internal resistance of the cell.

Ans. Internal resistance of a cell depends upon

(i) surface area of each electrode.

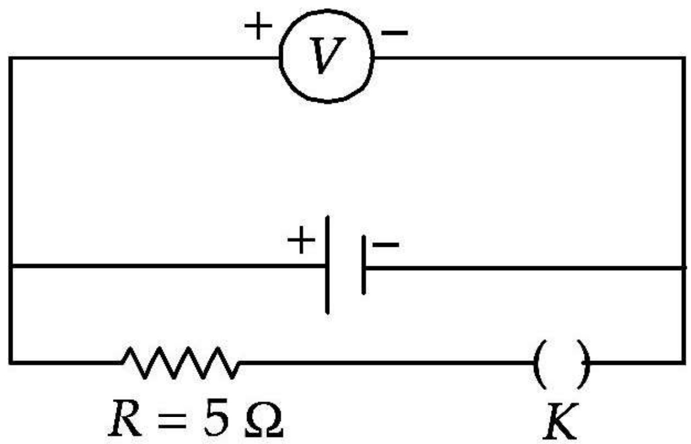
(ii) distance between the two electrodes.

(iii) nature, temperature and concentration of electrolyte.

Let internal resistance of cell be *r*.

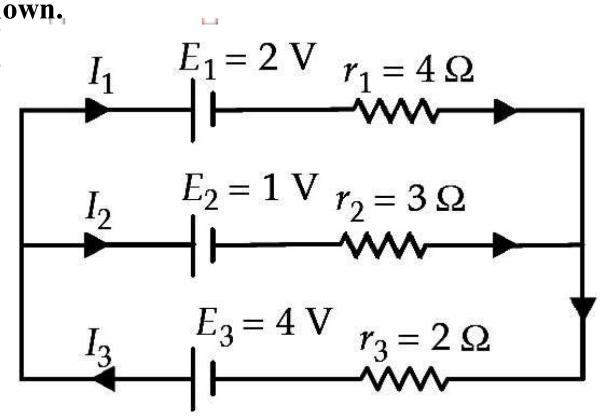
Initially when *K* is open, voltmeter reads 2.2 V.

i.e. emf of the cell, $\varepsilon = 2.2$ V

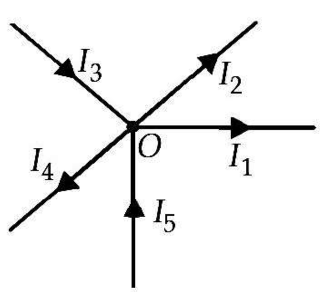


Later when K is closed, voltmeter reads 1.8 V which is actually the terminal potential difference, V.
i.e. if I is the current flowing, then $\varepsilon = I(R + r)$
$\Rightarrow 2.2 = I(5 + r)$ ------------------- (i)
and $V = \varepsilon - Ir$
$1.8 = 2.2 - Ir$ ------------------- (ii)
Solving (i) and (ii),
$I = 0.36$ A
Substituting in (ii)
$r = \frac{0.4}{0.36} = \frac{10}{9}\Omega$

19. State Kirchhoff's rules. Use these rules to write the expressions for the currents I_1 , I_2 and I_3 in the circuit diagram shown.



Ans. Kirchhoff's first law of electrical network or junction rule states that at any junction of electrical network, sum of incoming currents is equal to the sum of outgoing currents *i.e.*,
$I_1 + I_2 + I_4 = I_3 + I_5$



Kirchhoff's second law of electrical network or loop rule states that in any closed loop, the algebraic sum of the applied emf's is equal to the algebraic sum of potential drops across the resistors of the loop *i.e.*, $\sum \varepsilon = \sum IR$

To find I_1 , I_2 , I_3 in the given diagram.
For loop *ABCFA*
$E_1 + I_1 r_1 - I_2 r_2 - E_2 = 0$
$\Rightarrow 2 + 4I_1 - 3I_2 - 1 = 0$
$\Rightarrow 4I_1 - 3I_2 + 1 = 0$ ---------------------- (i)
Using loop *FCDEF*
$E_2 + I_2 r_2 + I_3 r_3 - E_3 = 0$
$\Rightarrow 1 + 3I_2 + 2I_3 - 4 = 0$
$\Rightarrow 3I_2 + 2I_3 - 3 = 0$ ---------------------- (ii)
Also using junction rule $I_3 = I_1 + I_2$ ---------------------- (iii)
Using (ii) and (iii)
$3I_2 + 2I_1 + 2I_2 - 3 = 0$
$\Rightarrow 2I_1 + 5I_2 - 3 = 0$ ...(iv)
Solving (i) and (iv)

$$\begin{array}{r} 4I_1 - 3I_2 + 1 = 0 \\ -2\times(2I_1 + 5I_2 - 3) = 0I_1 \\ \hline 0 - 13I_2 + 7 \;=\; 0 \\ \hline \end{array}$$

$$\Rightarrow I_2 = \frac{7}{13}A$$

$$4I_1 - 3\times\frac{7}{13} + 1 = 0$$

$$\Rightarrow 4I_1 = \frac{8}{13} \Rightarrow I_1 = \frac{2}{13}A$$

$$\Rightarrow I_3 = I_1 + I_2 = \frac{2}{13} + \frac{7}{13} = \frac{9}{13}A$$

20. Define the terms (i) drift velocity, (ii) relaxation time. A conductor of length *L* is connected to a dc source of emf e. If this conductor is replaced by another conductor of same material and same area of cross section but of length 3*L*, how will the drift velocity change? [*AI 2011*]

Ans. (i) **Drift velocity :** It is defined as the average velocity of electrons with which they move along the length of the conductor when an electric field is applied across the conductor and is given by

$$v_d = \frac{e}{m}\left(\frac{V}{L}\right)\tau$$

where, *V* is potential difference across the conductor, *L* is length of conductor and τ is relaxation time *m* is the mass of the electron.

(ii) **Relaxation time :**

$$\text{Relaxation time} = \frac{\text{mean free path of electron}}{\text{drift speed of electron}}$$

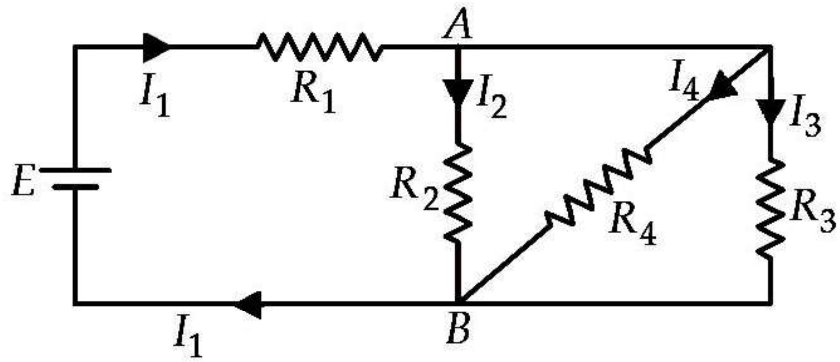
$$\text{Drift velocity, } v_d = \frac{I}{neA} = \frac{V}{neAR}\left(\because V = IR\right)$$

$$\Rightarrow v_d = \frac{V}{neA\left(\frac{\rho L}{A}\right)}\left(\because R = \frac{\rho L}{A}\right)$$

$$\Rightarrow v_d = \frac{V}{nAeL} \quad or \quad v_d \propto \frac{1}{L}$$

$$\therefore \frac{v'_d}{v_d} = \frac{L}{3L} \Rightarrow v'_d = \frac{v_d}{3}$$

21. In the circuit shown, R_1 = 4Ω, R_2 = R_3 = 15Ω, R_4 = 30Ω and E = 10 V. Calculate the equivalent resistance of the circuit and the current in each resistor.



Ans. From figure, R_2 , R_3 and R_4 are connected in parallel.

∴ Effective resistance R_p

$$\frac{1}{R_p}=\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}=\frac{1}{15}+\frac{1}{15}+\frac{1}{30}=\frac{5}{30}$$

$$\Rightarrow R_p=6\Omega$$

Now, equivalent resistance of circuit,

$R = R_1 + R_p = 4 + 6 = 10\ \Omega$

Current, $I_1=\frac{10}{10}=1$ A

Potential drop across R_1 , = I_1 R_1 = 1 × 4 = 4 V

Potential drop across all other resistances = 10 – 4 = 6 V

Current through R_2 or R_3 ;

$$I_2=\frac{6}{15}A, I_3=\frac{6}{15}A$$

Current through R4, $I_4=\frac{6}{30}A$

22. Define relaxation time of the free electrons drifting in a conductor. How is it related to the drift velocity of free electrons? Use this relation to deduce the expression for the electrical resistivity of the material. [*AI 2012*]

Ans. Relaxation time (τ): The average time interval between two successive collisions. For the free electrons drifting within a conductor (due to the action of the applied electric field), is called relaxation time.

$$v_d=\left(\frac{-eV\tau}{ml}\right)$$

Relation for drift velocity,

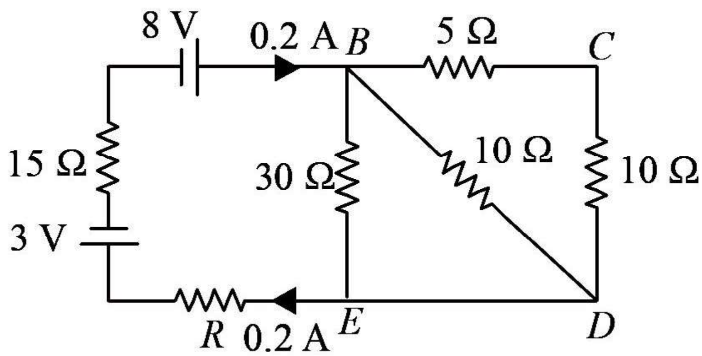
Since $I=-neAv_d$

$$\Rightarrow I=-neA\left(\frac{-eV\tau}{ml}\right)=\frac{ne^2A\tau V}{ml}$$

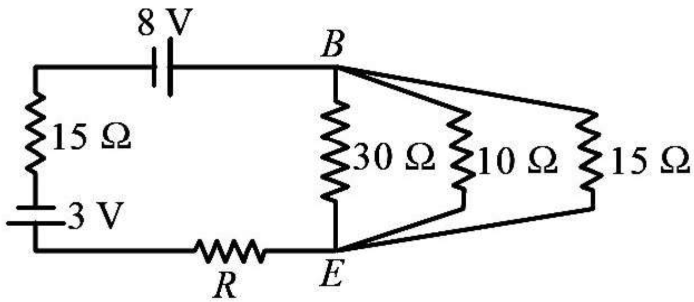
$$\therefore \frac{V}{I}=\frac{ml}{ne^2A\tau}=\frac{\rho l}{A}\left(\because \frac{V}{I}=R=\frac{\rho L}{A}\right)$$

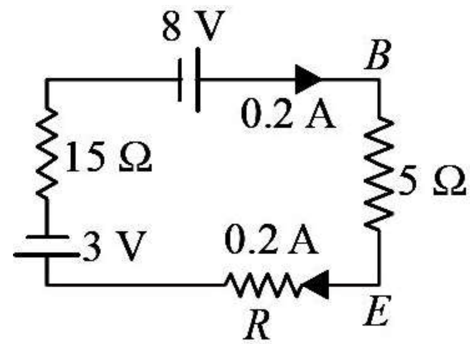
$$\therefore \rho=\frac{m}{ne^2\tau}$$

23. Calculate the value of the resistance *R* in the circuit shown in the figure so that the current in the circuit is 0.2 A. What would be the potential difference between points *B* and *E*? [*AI 2012*]



Ans. The given circuit can be simplified





In the given circuit

$$I = 0.2 = \frac{8-3}{5+15+R}$$

$$\Rightarrow 0.2 = \frac{5}{20+R} \Rightarrow 20 + R = 25$$

$$\Rightarrow R = 5\Omega$$

$$V_{BE} = I(5) = 0.2 \times 5 = 1.0V$$

24. Explain the term 'drift velocity' of electrons in a conductor. Hence obtain the expression for the current through a conductor in terms of 'drift velocity'.

Ans. Drift velocity : It is the average velocity acquired by the free electrons superimposed over the random motion in the direction opposite to electric field and along the length of the metallic conductor.

Let n = number of free electrons per unit volume, v_d = Drift velocity of electrons

Total number of free electrons passing through a cross section in unit time

$$\frac{N}{t} = Anv_d$$

So, total charge passing through a cross section in unit time

i.e., current, $I = \frac{Q}{t} = \frac{Ne}{t} = Anev_d$

25. A potentiometer wire of length 1 m has a resistance of 10 Ω. It is connected to a 6 V battery in series with a resistance of 5 Ω. Determine the emf of the primary cell which gives a balance point at 40 cm.

Ans. Here, l = 1 m, R_1 = 10Ω, V = 6 V, R_2 = 5 Ω

Current flowing in potentiometer wire,

$$I = \frac{V}{R_1 + R_2} = \frac{6}{10+5} = \frac{6}{15} = 0.4A$$

Potential drop across the potentiometer wire

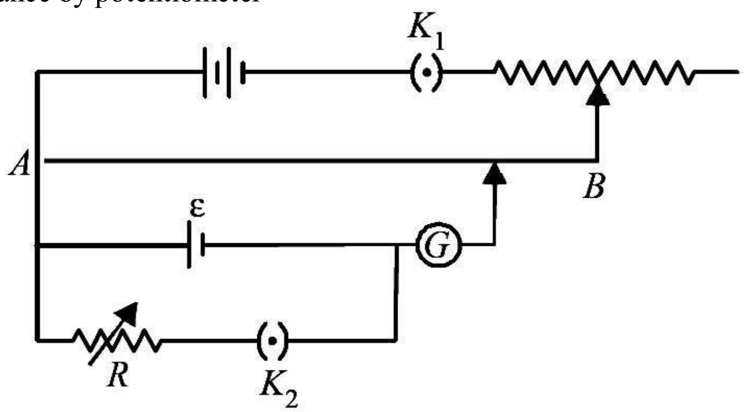
$V' = IR = 0.4 \times 10 = 4V$

Potential gradient, K = $\frac{V'}{l} = \frac{4}{1}$ = 4 V/m

Emf of the primary cell = $KI = 4 \times 0.4 = 1.6$ V

26. Describe briefly, with the help of a circuit diagram, how a potentiometer is used to determine the internal resistance of a cell. [*AI 2013*]

Ans. Internal resistance by potentiometer



Initially key K_2 is off

Then at balancing length l_1

$e = Kl_1$ ------------------ (i)

Now key K_2 is made on

At balancing length l_2

$V = Kl_2$ --------------- (ii)

So, $\frac{\varepsilon}{V} = \frac{l_1}{l_2}$ --------------- (iii)

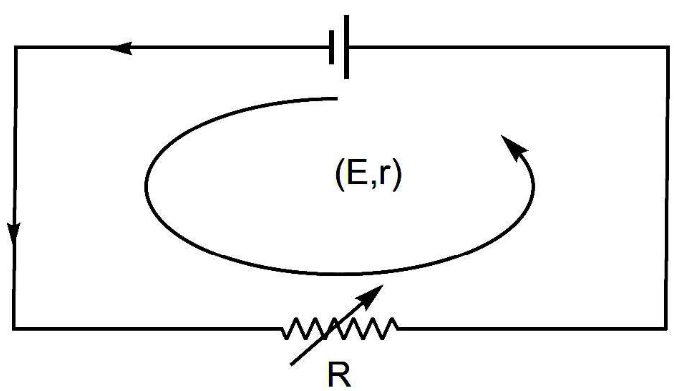
where internal resistance r is

$$r = \left(\frac{\varepsilon}{V} - 1\right)R$$

$$\Rightarrow r = \left(\frac{l_1}{l_2} - 1\right)R$$

27. A cell of emf '*E*' and internal resistance '*r*' is connected across a variable resistor '*R*'. Plot a graph showing variation of terminal voltage '*V*' of the cell versus the current '*I*'. Using the plot, show how the emf of the cell and its internal resistance can be determined.

Ans.



Suppose a current I flows through the circuit and using loop rule

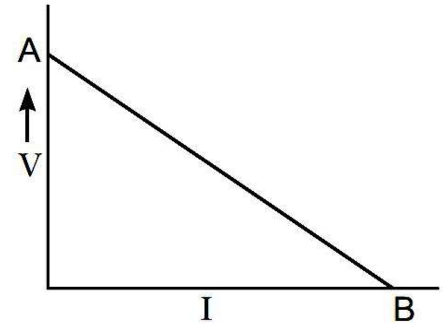
$E - IR - Ir = 0$

$\Rightarrow E - Ir = V\ [V = IR]$

$\Rightarrow V = E - Ir$ ……… (i)

If terminal voltage V is the function of current I, Reason – Equation of straight line, $y = -mx + c = c - mx$

Then,



Using the graph

For point A, $I = 0$ and on using equation (i)

$V = E - 0 \times r = E$

Hence voltage intercept (intercept on the vertical axis) measures emf of the cell.

For point B, $V = 0$, from equation (i)

$O = E - Ir$

$$\Rightarrow r = \frac{E}{I}$$

i.e., negative of the slope if V - I graph measures the internal resistance r.

28. Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area 1.0 × 10^{-7} m^2 carrying a current of 1.5 A. Assume the density of conduction electrons to be 9 × 10^{28} m^{-3}.

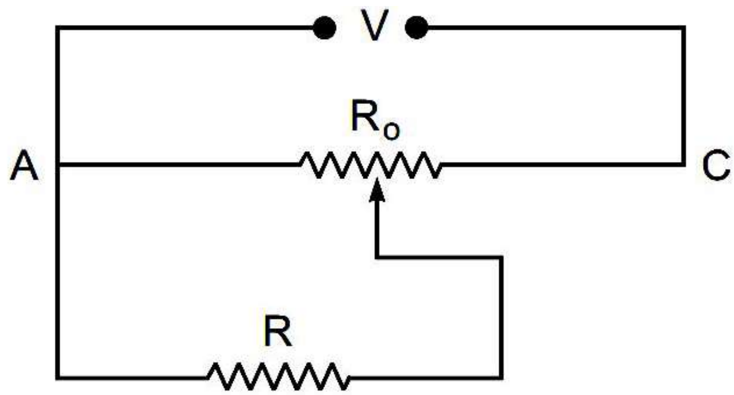
Ans. Flow of current in the conductor due to drift velocity of the free electrons is given by

$I = neAv_d$

$$v_d = \frac{I}{neA} = \frac{15}{9\times10^{28}\times1.6\times10^{-19}\times1.0\times10^{-7}}$$

$$\Rightarrow v_d = 1.048\times10^{-3}\, m/s \approx 1mm/s$$

29. A resistance of RΩ draws current from a potentiometer as shown in the figure. The potentiometer has a total resistance *Ro* Ω. A voltage V is supplied to the potentiometer. Derive an expression for the voltage across R when the sliding contact is in the middle of the potentiometer.

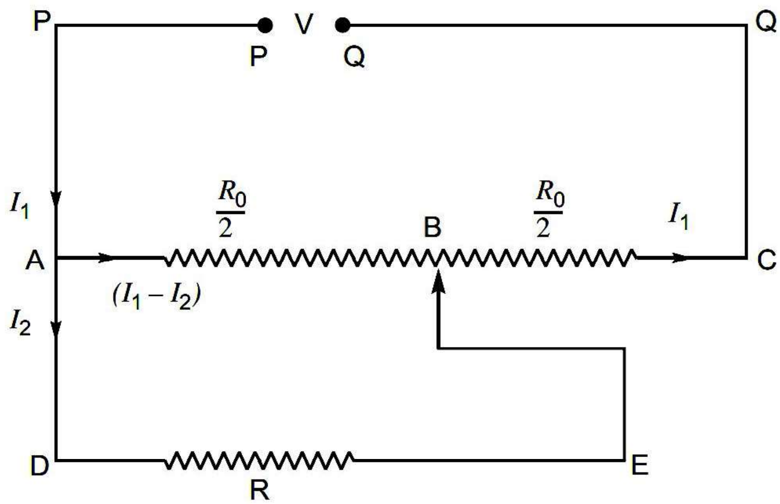


Ans. In loop *ABEDA*

$$(I_1 - I_2)\frac{R_0}{2} - I_2 R = 0$$

$$\Rightarrow I_1\frac{R_0}{2} = I_2\left(R + \frac{R_0}{2}\right) = \frac{I_2}{2}(R_0 + 2R)$$

$$\Rightarrow I_1 R_0 = I_2(R_0 + 2R) \qquad -------(i)$$



In Loop *PABCQP*

$$V = (I_1 - I_2) \times \frac{R_0}{2} + I_1 \frac{R_0}{2} = I_1 \frac{R_0}{2} - I_2 \frac{R_0}{2} + I_1 \frac{R_0}{2}$$

$$\Rightarrow V = I_1 R_0 - I_2 \frac{R_0}{2} \qquad ----------(ii)$$

From equation (*i*) and (*ii*)

$$V = R_0 \times \frac{I_2(R_0 + 2R)}{R} - I_2 \frac{R_0}{2}$$

$$\Rightarrow V = I_2 \left(\frac{R_0(R_0 + 2R)}{R} - \frac{R_0}{2} \right)$$

$$\Rightarrow V = \frac{I_2 R_0}{2R}(2(R_0 + 2R) - R) = I_2 \times \frac{R_0}{2R}(R_0 + 2R)$$

$$\Rightarrow I_2 = \frac{2VR}{R_0(R_0 + 2R)}$$

30. State the principle of a potentiometer. Define potential gradient. Obtain an expression for potential gradient in terms of resistivity of the potentiometer wire.

Ans. It is based on the fact that the fall of potential across any segment of the wire is directly proportional to the length of the segment of the wire, provided wire is of uniform area of cross-section and a constant current is flowing through it.

$$V \propto l$$

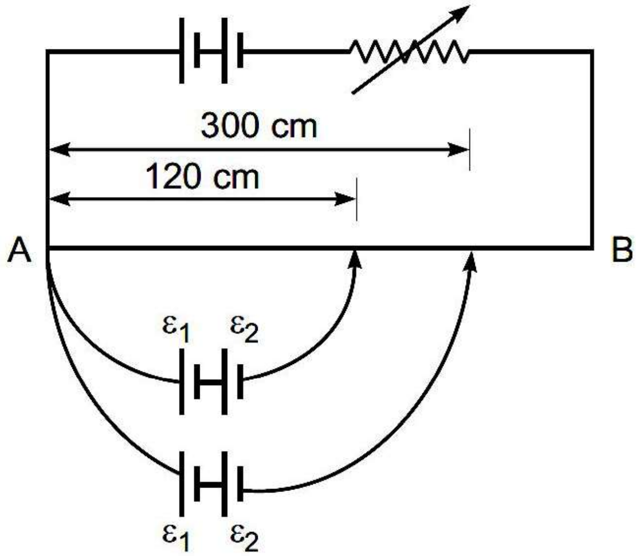
Potential gradient is the fall of potential per unit length of potentiometer wire.

Potential gradient $K = \frac{V}{l} = \frac{IR}{l} \qquad (\because V = IR)$

$$\Rightarrow K = \frac{I \frac{\rho l}{A}}{l} \qquad \left(\because R = \frac{\rho l}{A} \right)$$

$$\Rightarrow K = \frac{I\rho}{A}$$

31. Figure shows a long potentiometer wire *AB* having a constant potential gradient. The null points for the two primary cells of emfs ε_1 and ε_2 connected in the manner shown are obtained at a distance of l_1 = 120 cm and l_2 = 300 cm from the end *A*. Determine (*i*) $\varepsilon_1/\varepsilon_2$ and (*ii*) position of null point for the cell ε_1 only.



Ans. Let k = potential gradient in V/cm

$\varepsilon_1 + \varepsilon_2 = 300k$ ...(i)

$\varepsilon_1 - \varepsilon_2 = 120k$ ...(ii)

Adding (i) and (ii), we get $2\,\varepsilon_1 = 420k$

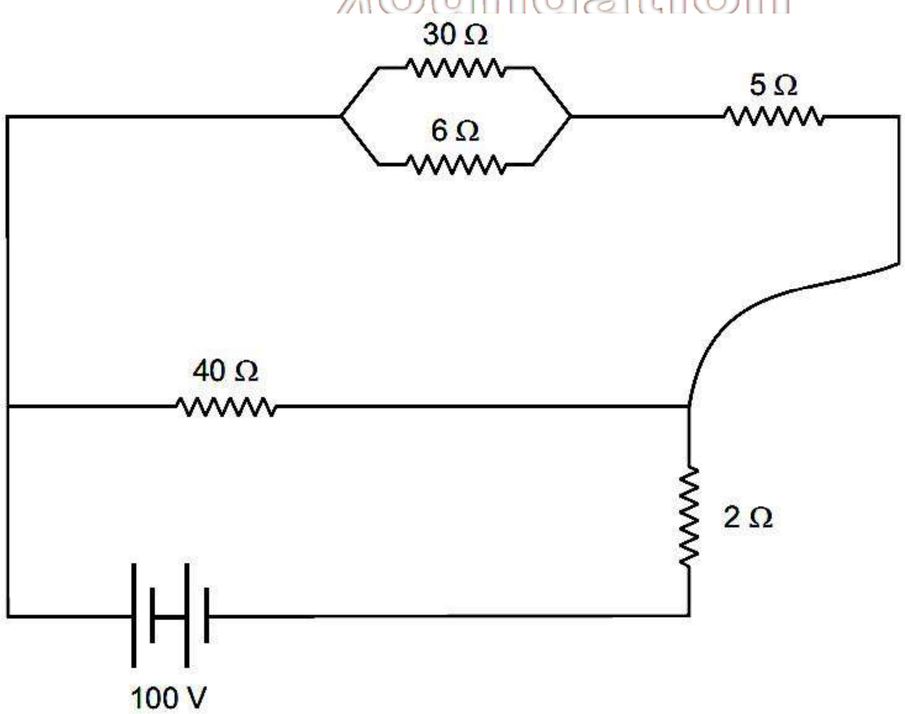
$\Rightarrow \varepsilon_1 = 210k$

Substituting the value of ε_1 in equation (i), we get $\varepsilon_2 = 90k$

Therefore, $\frac{\varepsilon_1}{\varepsilon_2} = \frac{210}{90} = \frac{7}{3}$

Balancing length for cell ε_1 is 210 cm.

32. A 100 V battery is connected to the electric network as shown. If the power consumed in the 2Ω resistor is 200 W, determine the power dissipated in the 5Ω resistor.



Ans. We know that Power, $P = I^2R$

$\Rightarrow 200 = I^2 \times 2$

$I^2 = \frac{200}{2} = 100$

$\Rightarrow I = \sqrt{100} = 10A$

$\therefore$ Current flowing through 2Ω resistor = 10 A

Potential drop across 2Ω resistor, $V = IR$

= 10 × 2 = 20 V

Equivalent resistance of 30Ω and 6Ω

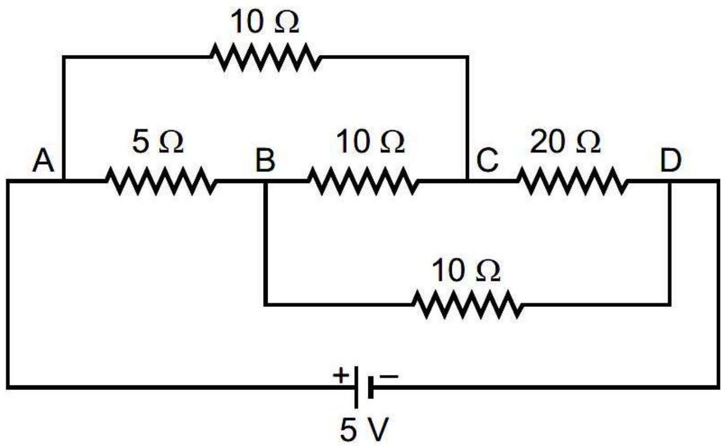
$\frac{30 \times 6}{30 + 6} = \frac{180}{36} = 5\Omega$

$\therefore$ Therefore, potential across parallel combination of 40Ω and 10Ω = 10 × 8 = 80 V

$\therefore$ Current through 5Ω resistor, $I = \frac{80}{10} = 8A$

$\therefore$ Power dissipated in 5Ω resistor = I^2R = 82 × 5 = 320 W

33. Calculate the value of the current drawn from a 5 V battery in the circuit as shown.



Ans.

In case of balanced Wheatstone bridge, no current flows through the resistor 10Ω between points B and C.

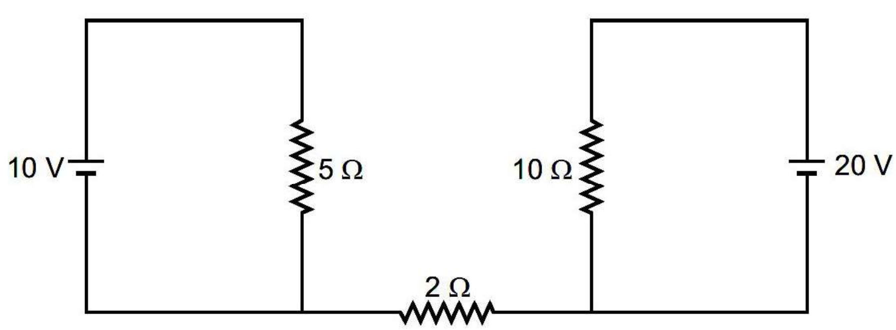
The resistance of arm ACD, R_1 =10 + 20 =30Ω

The resistance of arm ABD, R_2 = 5 +10 =15Ω

Equivalent resistance $R_{eq} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{30 \times 15}{30 + 15} = \frac{450}{45} = 10\Omega$

Current drawn from the source, $I = \frac{V}{R_{eq}} = \frac{5}{10} = 0.5A$

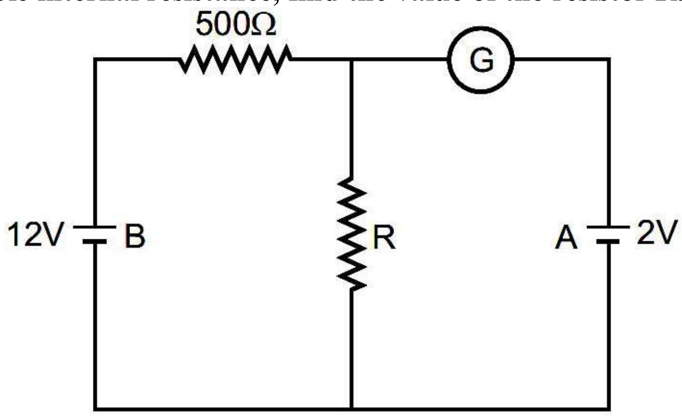
34. What will be the value of current through the 2Ω resistance for the circuit shown in the figure? Give reason to support your answer.



Ans. No current will flow through 2Ω resistor, because in a closed loop, total p.d. must be zero. So

$10\ V - 5I_1 = 0 \ldots (1)$
$20\ V - 10I_2 = 0 \ldots (2)$
Equation (1) and (2) have no solutions and resistor 2Ω is not part of any loop ABCD and EFGH.

35. In the circuit shown in the figure, the galvanometer 'G' gives zero deflection. If the batteries A and B have negligible internal resistance, find the value of the resistor R.



Ans. If galvanometer G gives zero deflection, than current of source of 12V flows through R, and voltage across R becomes 2V.

Current in the circuit, $I = \dfrac{\varepsilon}{R_1 + R_2} = \dfrac{12.0V}{500 + R}$

and V = IR = 2.0V

$\left(\dfrac{12.0V}{500+R}\right)R = 2.0$

⇒ 12R = 1000 + 2R
⇒ 10R = 1000
⇒ R = 100 Ω