CHAPTER.03: CURRENT ELECTRICITY

CDF:

1. **Resistor**: Resistor is device that opposes the flow of current through it.
2. **Ohm's law**: The strength of the current in a conductor (i) is directly proportional to the potential difference (V) applied across it at constant temperature.

   $i \alpha V,\ i = \frac{V}{R}$ $\Rightarrow$ V=iR

3. **Resistance**: R= $\frac{V}{i}$

   S.I unit of resistance is VA^{-1} or ohm (Ω)

   Dimensional formula:- $M^{1}L^{2}T^{-3}A^{-2}$
4. **Defination of Ohm** :- The Resistance of a conductor is one ohm(1Ω), if one ampere current flowing through the conductor when a potential difference of one volt is applied across its ends.

   $1\Omega = \frac{1V}{1A}$
5. Ohm's law is just an empirical relationship. It is not a fundamental physical principle.
6. **Ohmic device**:- The devices which obeys ohm's law are called ohmic devices. Ex: metals
7. **Non-Ohmic device**:- The devices which does not obeys ohm's law are called non-ohmic devices. Ex: diodes, Thermistor, vaccumtubes.. etc

8. The value of the resistance of the conductor depends on (i) nature of the material (ii) its dimensions (length, area of cross-section) (iii) its temperature
9. **Current density**:-

   Current per unit area (normal to the current) is called current density

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

   It is a vector quantity and SI unit is A/m^{2}

   and $J = \frac{1}{\rho}E = \sigma E$

   Where 'E' is electric field and σ is conductivity.
10. **Drift velocity** (V_d)

    Definition: The speed with which an electron gets drifted in a metallic conductor under the application of an external electric field is called "drift velocity" (V_d)

    $V_d = -\frac{eE}{m}\tau$

11. Mobility (μ)

The mobility of a charge carrier is the average drift velocity per unit electric field strength

$$\mu = \frac{|V_d|}{E}$$

12. The relation between Electric current and drift velocity

$$V_d = \frac{i}{neA}$$

When n ® The number of charge carriers per unit volume

e ® Charge of an electron

A ® The area of cross-section.

13. Variation of resistance with temperature

R_0 ® resistance of conductor at 0^0C

R_t ® resistance of conductor at t^0C

R_1 ® resistance of conductor at $t_1{}^0C$

R_2 ® resistance of conductor at $t_2{}^0C$

α ® temperature co-efficient of resistance

$$\alpha = \frac{R_t - R_0}{R_0 \Delta t} = \frac{R_2 - R_1}{R_1 t_2 - R_2 t_1}$$

14. Variation of resistivity with temperature

$\rho_0 \rightarrow$ resistivity of conductor at 0^0C

$\rho_t \rightarrow$ resistivity of conductor at t^0C

$\rho_1 \rightarrow$ resistivity of conductor at t_1^0C

$\rho_2 \rightarrow$ resistance of conductor at t_2^0C

$\alpha \rightarrow$ temperature co-efficient of resistivity

15. Resistivity of manganin and constantans are nearly independent of temperature then Manganine is widely used in making resistance boxes, standard resistances and wires used in metre bridge and potentiometer.

16. Resistivity of carbon decreases with increase in temperature and hence carbon has a negative temperature co-efficient of resistivity.

17. emf of a cell : It is defined as the workdone in carrying a unit positive charge through the complete circuit including the charge flow inside the cell (or) The potential difference between the terminals of a cell in open circuit is called emf of a cell.

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

Unit of emf = $J / coulomb = volt$

18. The magnitude of internal resistance depends on (i) The distance between the plates (ii) The area and size of the plates (iii) Strength of electrolyte (iv) Temperature (internal resistance decreases with increase of temperature)

19. **Kirchhoff's 1st Law (Junction Theorem)**

The sum of currents flowing in a junction is equal to the sum of currents flowing out of the junction or the algebraic sum of current meeting at a junction is zero .

Si =0

This law states the law of conservation of charge.

20. Kirchhoff's 2nd law (loop theorem)

The algebraic sum of changes in potential around any closed loop is zero

S $v = 0$ *or* Si ´ $R = 0$

This law is a consequence of law of conservation of energy.

21. Wheatstone Bridge

Wheatstone bridge is the application of Kirchhoff's law. If P,Q,R,S be the resistances of the four arms of Wheatstone Bridge then the balancing condition is P/Q=R/S.

22. Meter Bridge

$\frac{x}{R} = \frac{l_1}{(100 - l_1)}$ where $x \to$ unknown resistance of given wire

R $\to$ Resistance of resistance box, $l_1 \to$ balanching length from left end of the bridge to jockey

23. Potentiometer

Potentiometer is used to measure accurately the e.m.f of a source (or) the P.D across any part of an electric circuit, without drawing any current.

24. P.D across 'l' is balanced by e.m.f of a cell $\in_0$

E_0 = potential gradient x balancing length.

$$E_0 = \frac{V}{L} l; E_0 = Emf\ in\ secondary\ circuit$$

V=P.D across the wire
L= total length of wire
l= balancing length

25. In comparison of E.M.F of 2 cells $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

26. Internal resistance of cell

$$r = \frac{R \times (l_1 - l_2)}{l_2}$$

where R is the shunt resistance connected to the battery of secondary

$l_1 \to$ *Balancing length without shunt*, $l_2 \to$ *Balancing length with Shunt.*

One Mark Questions with Answers :

1. Define an ampere.

Ans. When a charge of one coulomb flows across a cross-section of a conductor in one second, the current through the conductor is said to be one ampere.

2. How many electrons per second constitute a current of one ampere?

Ans. $6.25\times10^{18}\ electrons$

3. State Ohm's law and mention its mathematical form.

Ans. The current through a conductor is directly proportional to the potential difference across its ends provided temperature and other physical conditions remain the same.

$$I \propto V \Rightarrow V = IR$$

Where R= resistance

4. Define ohm.

Ans. The resistance of a conductor is said to be $1\ \Omega$ if a current of $1\ A$ flows through it when a potential difference of $1\,V$ is applied across its ends. $1\Omega = \frac{1A}{1V}$

5. What is the dimensional formula for resistance?

Ans. Dimensional formula for resistance is $\left[M^1 L^2 T^{-3} I^{-2}\right]$.

6. Mention the relation between the resistance and resistivity?

Ans. The resistance R of a conductor is given by $R = \frac{\rho l}{A}$,

7. What is drift velocity of conduction electrons?

Ans. It is the average velocity with which the conduction electrons get drifted in a conductor under the influence of electric field.

$$v_d = -\frac{e}{m}E\tau$$

8. How is current through a conductor related to drift velocity?

Ans. The current through a given conductor is directly proportional to the drift velocity.

$$\left(i = neAv_d\right)$$

9. Define relaxation time (or) mean free time.

Ans. The average time that elapses between two successive collisions of an electron with fixed atoms or ions in the conductor is called relaxation time.

10. Name two materials whose resistivity decreases with the rise of temperature.

Ans. Germanium and Silicon.

11. Name a material which exhibit very weak dependence of resistivity with temperature?

Ans. Nichrome , an alloy of nickel, iron and chromium exhibit very weak dependence of resistivity with temperature.

12. Define emf of a cell.

Ans. Emf of a cell is the work done by it in transferring unit quantity of charge once all round the circuit in which it is connected.

13. Define internal resistance of a cell.

Ans. The finite resistance offered by the electrolyte for the flow of current through it is called internal resistance.

14. What is the power output of a cell of emf $2\,V$ when it delivers $5\,A$ to an external load?

Ans. The power output $P = EI = 2 \times 5 = 10\,W$

15. Write the expression for equivalent emf when two cells of emf's ε_1 and ε_2 connected in series such that negative electrode of ε_1 to negative electrode of ε_2 $(\varepsilon_1 > \varepsilon_2)$

Ans. $\varepsilon_{equ} = \varepsilon_1 - \varepsilon_2$

16. What is a mesh or loop in an electric network?

Ans. A mesh or loop is a closed path with in the network for the flow of electric current.

17. What is the significance of junction rule?

Ans. Conservation of charge.

18. What is the significance of loop rule?

Ans. Conservation of energy.

19. What is a potentiometer?

Ans. It is an instrument consisting of long piece of uniform wire across which a standard cell is connected and is used to measure emf of a cell with an accuracy.

20. What is the principle of potentio meter?

Ans. When ever a steady current flows through a potentio meter wire, the potential difference between any two points on the wire is directly proportional to its length.

TWO (OR) THREE MARK QUESTIONS WITH ANSWERS:

21. Define electron mobility & Mention its SI unit.

Ans. Mobility (μ) is defined as the magnitude of drift velocity (v_d) per unit electric field (E). i.e., $\mu = \frac{v_d}{E}$

Its SI unit is $m^2 s^{-1} V^{-1}$ (or) $m s^{-1} N^{-1} C$

22. Define the term current density (j) & Mention its SI unit.

Ans. It is defined as the electric current (i) per unit area (A) taken normal to the direction of current. i.e., $j = \frac{i}{A}$

Its SI unit is Ampere / metre^2 (A/m^2)

23. Define electrical conductance & Mention its SI unit.

Ans. The reciprocal of resistance is called electrical conductance.

i.e., $G = \frac{1}{R}$

Its SI Unit is Siemen (s) or mho( ).

24. Define electrical conductivity & mention its SI unit .

Ans. The reciprocal of electrical resistivity of material of a conductor is called conductivity.

i.e., $\sigma = \frac{1}{\rho}$. its SI unit is $\Omega^{-1} m^{-1} (or) seimen / m$

25. Mention the limitations of Ohm's law.

Limitations of Ohm's law:

Ans. 1. Ohm's law is applicable only for good conductors.

2. Ohm's law is applicable only, when the physical conditions like temperature, pressure and tension remains constant.

3. Ohm's law is not applicable at very low temperature and very high temperature.

4. Ohm's law is not applicable for semiconductors, thermistors, vaccum tubes, discharge tubes.

26. What are Ohmic devices? Give examples.

Ans. A device that obey ohm's law through out its range is known as ohmic device.

Ex: Linear conductors.

27. What are non-ohmic devices? Give two examples.

Ans. A device that does not obey Ohm's law throughout its range is known as non-ohmic device.

E.g: Semiconductors and electron tubes are non-ohmic.

28. Define temperature co-efficient of resistance of the material of a conductor.

Ans. The temperature coefficient of resistance of a material is the ratio of increase in its resistance of a resistor per $1\,^{o}C$ rise in temperature to its resistance at $0^{o}C$.

$$\alpha = \frac{R_t - R_0}{R_0 \times t}$$

29. What is the resistance of a $60\,W, 220\,V$ electric lamp?

Ans. $R = \frac{V^2}{P} = \frac{(220)^2}{60} = 807\ \Omega$

30. On what factors does internal resistance of a cell depend?

Ans. Internal resistance of a cell depends on

(i) surface area of its electrodes

(ii) the separation between the electrodes

(iii) the nature, concentration and temperature of the electrolyte.

31. State Kirchhoff's rules in electrical network.

Ans. **Kirchhoff's 1st law (KCL):** At any junction in an electric network the sum of the currents entering the junction is equal to sum of the currents leaving the junction. i.e., $\sum I = 0$

Kirchhoff's 2nd law (KVL): The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero.i.e., $\sum \varepsilon = 0$

32. Write the applications of potentiometer.

A. Potentiometer is used

i) To measure the emf of a cell accurately $\varepsilon(l) = \phi l$, where ϕ is the potential drop per unit length

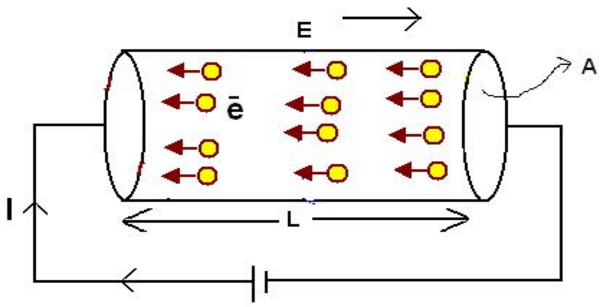
ii) To compare the emf's of two cells , $\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$

iii) To determine internal resistance of a cell, $r = R\left(\frac{l_1}{l_2} - 1\right)$

FIVE MARKS QUESTIONS WITH ANSWERS

33. Define relaxation time. Derive the expression for electrical conductivity of a material in terms of relaxation time.

Ans : **Relaxation time :** The averege time that elapses between two successive collisions of an electron with fixed atoms or ions in the conductor is called relaxation time.



Consider a conductor of length of 'L' and cross sectional area 'A'. When electric field 'E' is applied across it, the electrons are drifted opposite to the applied field. Let 'V_d' be the drift velocity of electrons.

$\therefore$ Volume of a conductor = LA

Let 'n' be the number of free electrons per unit volume of conductor.

$\therefore$ Total number of e- in unit volume = n x volume = nLA

$\therefore$ Total charge on all the electrons in the conductor q = nLAe

But current $I = \frac{q}{t} = \frac{n\,e\,A\,L}{t}$

We know $I = neAV_d$ ------- (1) $\qquad \because \left(V_d = \frac{L}{t}\right)$

Current density $J = \frac{I}{A} = n\,e\,V_d$ --------(2)

But $V_d = \frac{eE}{m}\tau$

$\therefore J = ne\left(\frac{eE}{m}\right)\tau$

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

$J = \sigma E$

where $\sigma =$ conductivity $= \frac{ne^2}{m}\tau$, and $\tau =$ relaxation time

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

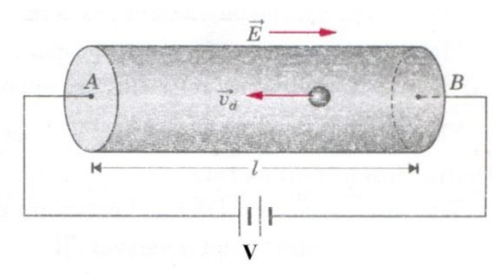
34. What is drift velocity and mobility of free electrons and deduce the expressions for them.

Ans. The average velocity with which electrons in a conductor get drifted in a direction opposite to the applied field is called Drift velocity.

Drift velocity per unit electric field is called Mobility.

Expression for Drift velocity:

Let a potential difference V is applied across a conductor of length l.



The electric field in the conductor $= E = \frac{V}{l}$

The force on each electron $= F = -\,e\,E$

(Negative sign indicates that F and E are directed opposite)

The acceleration of electron $= a = \frac{F}{m} = -\frac{e\,E}{m}$

Where, m is the mass of the electron.

Let τ be the average time between two successive collisions of the electron (relaxation time). i.e. the electron accelerates for average time interval .

We have,

Here,

$v = v_d$, $u = 0$ and $t = \tau$

$\therefore v_d = u + a\,\tau$

$$v_d = 0 - \frac{e\,E}{m}\,\tau$$

$$v_d = -\frac{e\,E}{m}\,\tau$$

$$|v_d| = \frac{e\,E}{m}\,\tau$$

Mobility $= \mu = \frac{|v_d|}{E} = \frac{e\,E}{m\,E}\,\tau = \frac{e\,\tau}{m}$

35. State and deduce ohm's law. Mention the limitations of ohm's law.

Ans : Statement : At a constant temparature, the steady current flowing through a conductor is directly proportional to the potential difference betweeen the ends of the conductor.

$$I\,\alpha\,V$$

$I = \frac{1}{R}V$ where $\frac{1}{R} =$ conductance.

The current flowing through a conductor is

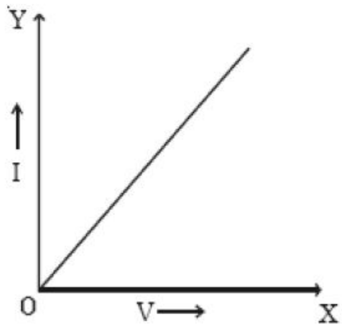
$I = nAeV_d$ But $v_d = \frac{eE}{m}\tau$

$\Rightarrow I = nAe\left(\frac{eE}{m}\right)\tau$ $\Rightarrow I = \frac{ne^2A\tau V}{mL}$ $\left(E = \frac{V}{L}\right)$

The quantity $\left(\frac{mL}{nAe^2\tau}\right)$ i.e a constant for a given conductor called electrical resistance.

$I\,\alpha\,V$

$$I = \frac{1}{R} V \Rightarrow V = IR$$



Resistance

Resistance of a conductor is defined as the ratio of potential defference across the conductor to the current flowing through it.

Limitations of ohm's law:

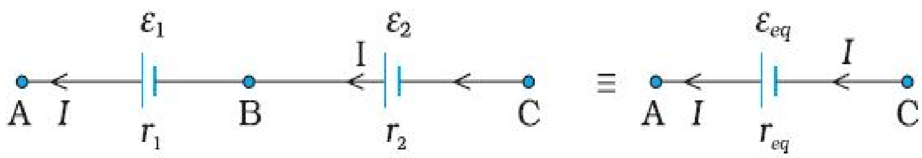
1. Ohm's law applicable only for good conductores.

2. it is applicable only when the physical conditions like temporature, pressure and tension remains constant.

3. This law is not applicable for semiconductors, thermistors, vaccum tubes.

36. Obtain expressions for effective emf and effective internal resistance when two different cells are connected in series.

Ans : Consider two cells connected in series, with negative terminal of one cell is connected to the positive terminal of the other.



Let $\varepsilon_1, \varepsilon_2$ are the emf's of the two cells. r_1, r_2 are the internal resistances of the cells. I be the current sent by the cells. Let V_A, V_B, V_C be the potentials at points A, B and C respectively. The potential difference between the positive and negative terminals of the first cell is

$$V_{AB} = V_A - V_B = \varepsilon_1 - Ir_1$$

The potential difference between the positive and negative terminals of the second cell is

$$V_{BC} = V_B - V_C = \varepsilon_2 - Ir_2$$

The potential difference between the terminals A and C of the combination is

$$V_{AC} = V_A - V_C$$

$$= (V_A - V_B) + (V_B - V_C)$$

$$= \varepsilon_1 - Ir_1 + \varepsilon_2 - Ir_2$$

$$V_{AC} = \varepsilon_1 + \varepsilon_2 - I(r_1 + r_2) ---------- (1)$$

The series combination of two cells can be replaced by a single cell between 'A' and 'C'

of emf ε_{eq} and internal resistance r_{eq}.

$$V_{AC} = \varepsilon_{eq} - Ir_{eq} --------- (2)$$

from equations (1) and (2)

$$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$$

$$r_{eq} = r_1 + r_2$$

for 'n' identical cells.

$$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 + ... + \varepsilon_n$$

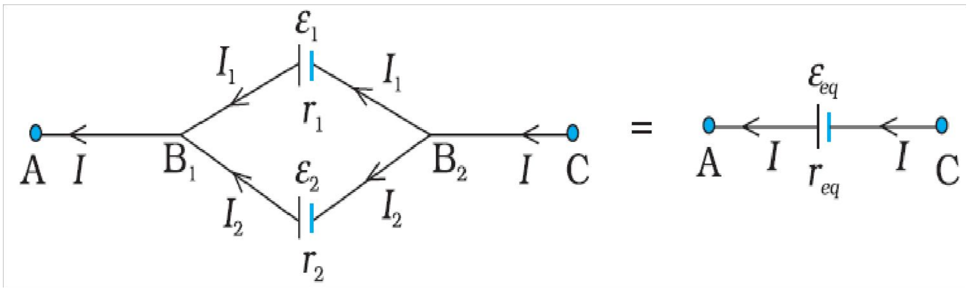
$$= \varepsilon + \varepsilon + ... + \varepsilon$$

$$\varepsilon_{eq} = n\varepsilon.$$

$$r_{eq} = r_1 + r_2 + ... + r_n$$

$$r_{eq} = nr \, .$$

37. Obtain expression for effective emf and effective internal resistance when two different cells are connected in parallel.



Consider two cells connected in parallel, Let $\varepsilon_1, \varepsilon_2$ are the emf's of two cells, r_1 *and* r_2 are the internal resistance of the cells are connected in parallel across points B_1 *and* B_2.

I_1 *and* I_2 are the currents leaving the positive electrodes of the cells. At the point. B_1, I_1 *and* I_2 flow in whereas the current I leave out.

$$I = I_1 + I_2 ------(1)$$

Let $V(B_1)$ *and* $V(B_2)$ be the potentials at B_1 *and* B_2 respectively.

for the first cell.

$$V = V(B_1) - V(B_2)$$

$$V = \varepsilon_1 - I_1 r_1$$

$$\Rightarrow I_1 = \frac{\varepsilon_1 - V}{r_1} ------(2)$$

Similarly for the second cell

$$I_2 = \frac{\varepsilon_2 - V}{r_2} ------(3)$$

substituting (2) and (3) in (1)

$$I = \frac{\varepsilon_1 - V}{r_1} + \frac{\varepsilon_2 - V}{r_2}$$

$$I = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

$$\Rightarrow V=\left(\frac{\varepsilon_1 r_2+\varepsilon_2 r_1}{r_1+r_2}\right)-I\left(\frac{r_1 r_2}{r_1+r_2}\right)-----(4)$$

If the parallel combination of cells is replaced by a single cell of emf ε_{eq} and internal resistance r_{eq} between B_1 *and* B_2

$$V_{AC}=\varepsilon_{eq}-I\,r_{eq}-----(5)$$

Comparing equations (4) & (5)

$$\varepsilon_{eq}=\frac{\varepsilon_1 r_2+\varepsilon_2 r_1}{r_1+r_2} \quad and \quad r_{eq}=\frac{r_1 r_2}{r_1+r_2}$$

38. State Kirchhoff's rules for electrical networks. Deduce the condition for balance of wheat stone's network using Kirchhoff's law. (M2014, J2014, M2011)

Ans : **First law :** at any junction the sum of the currents entering the junction is equal to the sum of the currents leaving the junction.

This law is a consequence of conservation of charges.

Second law: The algebraic sum of changes in potential around any closed loop involving resistors and cells is zero.

This law is a consequence of conservation of energy :

Condition for balance of wheat stone bridge:

Wheatstone bridge is based on the application of Kirchhoff's rules.

The bridge has four resistors R_1, R_2, R_3 *and* R_4. Across one pair of diogonally opposite points 'A' and 'C' a source is connected. Between the other two vertices 'B' and 'D', a galvanometer of resistance 'G' is connected.

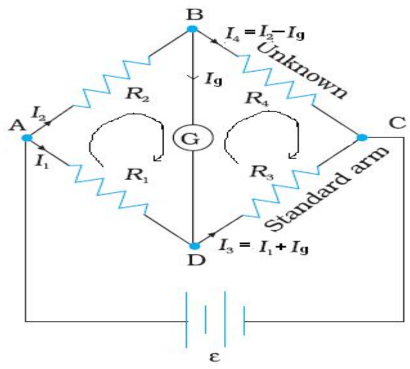
Let I_g be the current in the galvanometer. The branch currents and their directions are as shown in fig.

Apply Kirchhoff's loop rule to closed loop ADBA

$$I_2R_2+I_gG-I_1R_1=0-----(1)$$

Apply Kirchhoff's loop rule to closed loop BCDB

$$\left(I_2-I_g\right)R_4-\left(I_1+I_g\right)R_3-I_gG=0----(2)$$



The bridge is said to be balanced, when the galvanometer show zero deflection. i.e $I_g = 0$

The equations (1) and (2) becomes

$$I_2R_2 - I_1R_1 = 0$$

$$\Rightarrow I_2R_2 = I_1R_1 ----(3) \text{ and}$$

$$I_2 R_4 - I_1 R_3 = 0 \Rightarrow I_2R_4 = I_1R_3 ------(4)$$

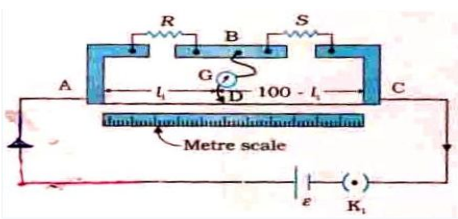
$$\left(\frac{3}{4}\right) \qquad \frac{I_2R_2}{I_2R_4} = \frac{I_1R_1}{I_1R_3}$$

$$\frac{R_2}{R_4} = \frac{R_1}{R_3}$$

This is the balancing condition of wheatstone network.

39. Explain how meter bridge is used to determine unknown resistance.

Ans : Meter bridge works on the principle of wheatstone bridge. The meter bridge consists of a wire of length 1 m and of uniform cross sectional area stretched taut and clamped between two thick metallic strips bent at right angles, as shown.



The metallic strip has two gaps across which resistors can be connected. The end points where the wire is clamped are connected to a cell through a key. One end of a galvanometer is connected to the metallic strip midway between the two gaps. The other end of the galvanometer is connected to a 'jockey'.

Let R is an unknown resistance connected across one of the gaps. Across the other gap, we connect a standard knwon resistance S.

The four arms AB, BC, AD and DC form a wheatstone bridge with AC as the battery arm and BD the galvanometer arm. let the distance of the jockey from the end A at the balance point be $l = l_1$. The four resistances of the bridge at the balance point then are R, S, R_{cm} and $R_{cm}(100-l_1)$. The balance condition, gives

$$\frac{R}{S} = \frac{R_{cm}\, l_1}{R_{cm}\left(100 - l_1\right)} = \frac{l_1}{100 - l_1}$$

$\therefore$ The unknown resistance R is known in terms of the standard known resistance S by

$$R = S\,\frac{l_1}{100 - l_1}$$

40. Three equal resistors connected in series across a source of emf of negligible intenal resistance together dissipate 10 watts of power .What would be the power dissipated if the resistors are connected in parallel across the same source of emf .

Ans. Given; P_1=10W

When the resistors are connected in series ,

Power dissipated , $P_1 = \frac{V^2}{R_s} = \frac{V^2}{3R}$ -------- (1)

When the resistors are connected in parallel ,

Power dissipated , $P_2 = \frac{V^2}{R_p} = \frac{V^2}{(R/3)} = \frac{3V^2}{R}$ --------(2)

From equations (1)& (2) , we get

$$\frac{P_2}{P_1} = \frac{3V^2}{R} \times \frac{3R}{V^2} = 9$$

$P_2 = 9P_1 = 9\times10 = 90W$

Power dissipated is 90 W

41. Two cells A and B are conneted in series, each having an emf of 1.5V.The internal resistances of A and B are 0.5 ohm and 0.25Ω respectively .The combination is connected across a resistance of 2.25ohm .
Calculate (i) The current in the circuit (ii) The potential difference across the terminal of each cell

Ans. Emf of the battery E=1.5+1.5=3V

Internal resistance of battery , r=0.5+0.25=0.75 ohms

Total resistance in the circuit , R=2.25+0.75=3 ohms

(i) Current in the circuit , $I = \frac{E}{R} = \frac{3}{3} = 1A$

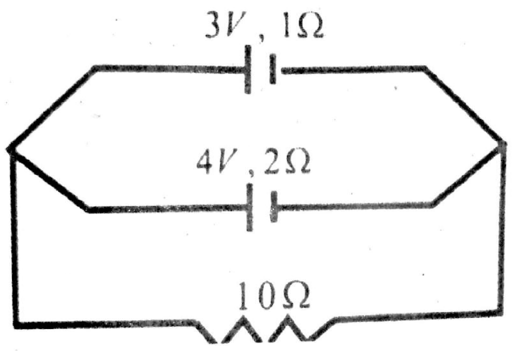
(ii) P.d. across the terminals of cell A is

$V_A = E - Ir_A = 1.5 - 1 \times 0.5 = 1V$

P.d. across the terminals of cell B is

$V_B = E - Ir_B = 1.5 - 1 \times 0.25 = 1.25V$

42. Calculate the power dissipated in 10 ohms resistor in the given circuit



Ans. Applyig KCL to the node B, $I_1 + I_2 = I_3$

Applying KVL to the mesh ABEFA we get

$$-2I_2 + I_1 = -4 + 3$$

$$-2I_2 + (I_3 - I_2) = -1$$

$$-3I_2 + I_3 = -1 \qquad \text{----------(1)}$$

Applying KVL to the mesh BCDEB we get

$$10I_3 + 2I_2 = 4$$

$$I_2 + 5I_3 = 2 \qquad \text{----------(2)}$$

Equation (2)×3, $\quad 3I_2 + 15I_3 = 6$

From equation (1), $\quad -3I_2 + I_3 = -1$

$$16I_3 = 5$$

$$\therefore \quad I_3 = \frac{5}{16} A$$

Power dissipated in 10 ohm is

$$P = I_3^2 R = \frac{25}{256} \times 10 = \frac{250}{256} = 0.9766W$$

Power dissipated in 10Ω resistor is 0.9766W

43. A copper wire of $10^{-6}\,m^2$ area of cross section, carries a current of 2A. If the number of electrons per cubic metre is 8×10^{28}, calculate the current density and average drift velocity.

[Given $e = 1.6\times10^{-19} C$)

Data : $A = 10^{-6} m^2$; Current flowing $I = 2A; n = 8\times10^{28}$ **(1M)**

$e = 1.6\times10^{-19} C;\ J = ?;\ v_d = ?$ **(1M)**

Solution : Current density, $J = \frac{I}{A} = \frac{2}{10^{-6}} = 2\times10^{6}\ A/m^2$ **(1M)**

$\boxed{J = n e v_d}$ **(1M)**

or $v_d = \frac{J}{ne} = \frac{2\times10^{6}}{8\times10^{28}\times1.6\times10^{-19}} = 15.6\times10^{-5}\ ms^{-1}$ **(1M)**

44. The resistance of a nichrome wire at 0^0C is 10Ω. If its temperature coefficient of resistance is $0.004/^0C$, find its resistance at boiling point of water. Comment on the result.

Data : At $0^0C, R_0 = 10\Omega; \alpha = 0.004/^0C; t = 100^0C;$ **(1M)**

$At\ t^0C, R_t = ?$ **(1M)**

Solution : $\boxed{R_t = R_0(1+\alpha t)}$ **(1M)**

$= 10(1+(0.004\times100))$ **(1M)**

$R_t = 14\Omega$

As temperature increases the resistance of wire also increases. **(1M)**

45. a) Three resistance of resistance $2\Omega, 3\Omega$ and 4Ω are combined in series. What is the total resistance of the combination?

b) If this combination is connected to a battery of emf 10V and negligible internal resistance, obtain the potential drop across each resistor.

Ans. a) $R_{eq} = R_1 + R_2 + R_3 = 2+3+4 = 9\Omega$

b) $V = IR_{eq}, I = \frac{V}{R_{eq}} = \frac{10}{9} = 1.11A$

finding potential drop across $R_1, V_1 = IR_1 = 2.22V$

finding potential drop across $R_2, V_2 = IR_2 = 3.33V$

finding potential drop across $R_3, V_3 = IR_3 = 4.44V$

46. When two resistors are connected in series with a cell of emf 2 V and negligible internal resistance, a current of $\frac{2}{5}$ A flows in the circuit. When the resistors are connected in parallel the main current is $\frac{5}{3}$ A. Calculate the resistances. (MARCH 2017)

Given that E= 2V $I_s = \frac{2}{5}A$**,** $I_p = \frac{5}{3}A$

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

For series $R_s = \frac{2}{2/5} = 5\Omega$

$R_p = \frac{2}{5/3} = \frac{6}{5}\Omega$

$R_1 + R_2 = 5 \rightarrow (1)$

$\frac{R_1 R_2}{R_1 + R_2} = \frac{6}{5} \rightarrow (2)$

simplyfing both eq than $R_1 = 3/L,\ R_2 = 2/L$

47. 100 mg mass of nichrome metal is drawn into a wire of area of cross-section 0.05 mm^2. Calculate the resistance of this wire. Given density of nichrome 8.4 x 10^3 kgm^{-3} and resistivity of the material as 1.2 x 10$^{-6}\Omega$ m.

(5M) 2018 MARCH QP

Given:

Mass = 100×10^{-3} g

A = $0.05 \times (10^{-3})^2 m^2$

Density = 8.4×10^3 kgm^{-3}

$\rho = 1.2 \times 10^{-6}\Omega m$

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

R = $\frac{1.2 \times 10^{-6} \times 0.238}{0.05 \times 10^{-6}}$

R = 5.714 Ω

$\text{Density} = \frac{\text{mass}}{\text{volume}}$

$Volume = \frac{mass}{Density} = \frac{100 \times 10^{-6}}{8.4 \times 10^3}$

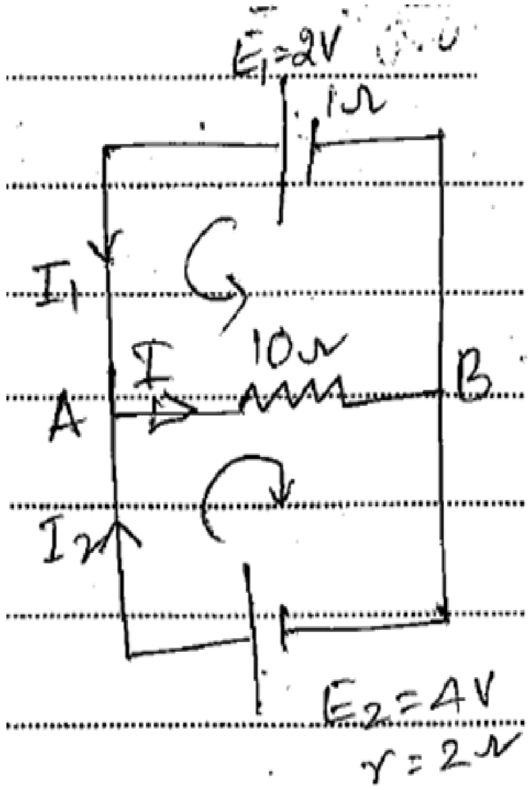
V = $11.904 \times 10^{-9} m^3$

Volume = $\ell \times$ A

$\ell = \frac{V}{A} = \frac{11.904 \times 10^{-9}}{0.05 \times 10^{-6}}$

ℓ = 0.23808 m

48. Two cells of emf 2V and 4V and internal resistabce 1Ω and 2Ω respctively are connected in parallel so as to send the current in the same direction through an external resistanve of 10Ω. Fine the potential diffecnece across 10Ω resistor. (5M) MARCH 2015 QP



KVL to mesh E_1ABE_1

$11I_1 + 10I_2 = 2$

KVL to mesh E_2ABE_2

$10I_1 + 12I_2 = 4$

$I_1 = -0.5A$

$I_2 = 3/4\ A$

Potential drop across 10Ω is

$V = (I_1 + I_2)R$

$= 2.5\ V$

49.A Wire having length 2.0 m diameter 1.0 mm and resistivity $1.963X10^{-8}\Omega m$ is connected in series with a battery of emf 3V and internal resistance 1Ω. Calculate the resistance of the wire and current in the circuit. (5M) JULY 2016 QP

Ans. Given

$l=2m$, $D=1.0mm$, $\rho=1.963X10^{-8}\Omega m$ $e=3V$, $r=1\Omega$, $R=?$, $1=?$

$$A=\frac{\pi D^2}{4}=\frac{3.14X\left(1X10^{-3}\right)}{4}=0.785X10^{-6}m^2$$

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

$$R=\frac{1.963X10^{-8}X2}{0.785X10^{-6}}$$

$$R=5X10^{-2}\Omega$$

$$\boxed{R=0.05\Omega}$$

$$l=\frac{\varepsilon}{R+r}=\frac{3}{0.05+1}$$

$$\boxed{I=2.85A}$$

50. Define electrical resistivity of material of a conductor.

(1M) (MARCH 2019)

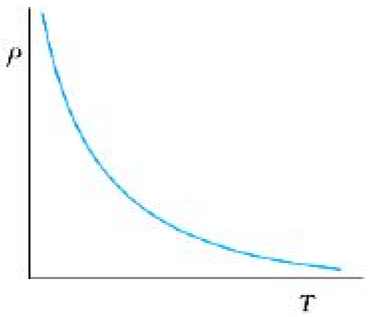
Ans: The resistance of the conductor per unit length and per unit area of cross section.

51. Write the expression for drift velocity interms of current, explain the term used. (2M) (MARCH 2019)

$$V_d=\frac{I}{n\,A\,e}$$

I – current in conductor, A- area of cross section, n – number of electrons per unit volume or free electron density, e – charge on electron

52. Graphically represent the variation of resistivity of a semiconductor with absolute temperature.



53. a) Three resistors $3\Omega, 4\Omega$ and 12Ω are connected in parallel. What is the effective resistance of the combination?

b) If the combination is connected to a battery of emf 6V and internal resistance 0.5Ω, find the current drawn from the battery and terminal potential difference across the battery. (5M) (MARCH 2020)

a) Effective resistance R_P is given by $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Substituting, $\frac{1}{R_P} = \frac{1}{3} + \frac{1}{4} + \frac{1}{12} \Rightarrow \frac{1}{R_P} = \frac{4+3+1}{12} = \frac{8}{12} = \frac{2}{3}$

Effective resistance of the combination: $R_p = 3/2\ \Omega = 1.5\ \Omega$

b) Current drawn from the battery is, $I = \frac{\varepsilon}{R_P + r}$

$$I = \frac{6}{1.5 + 0.5} = 3\ A$$

Terminal potential difference: $V = \varepsilon - I r = 6 - 3(0.5) = 4.5\ V$

OR Terminal potential difference: $V = I R_p = 3\ (1.5) = 4.5V$