XII - PHYSICS

Expt.No.
Date / /.

2. Current Electricity

II - Unit - 2, 3 and 5 marks Questions

1. Define: "Current"

" The rate of flow of charges through a given cross-sectional area A".

(or)

If a net charge Q passes through any cross section of a conductor in time t, then the currend is defined as $I = \frac{Q}{t}$ (or) $I = \frac{dQ}{dt}$ SI unit ampere (A).

2. Define - "One ampere"

" 1A of current is equivalent to 1 coulomb of charge passing through a perpendicular cross section in 1 second" $1A = \frac{1C}{1s}$

The electric current is a scalar.

3. Why current is a scalar?

The current I is defined as the scalar product of current density and area vector in which the charges cross.

$I = Q/t$ $I = \vec{J} \cdot \vec{A}$ ∵ current density $\vec{J} = I/\vec{A}$

4. What is called the drift velocity?

" The drift velocity is the average velocity acquired by the electrons inside the conductor when it is subjected to an electric field".

$\vec{v}_d = -\frac{e\vec{E}}{m}\tau$

Here,

$\tau \rightarrow$ mean free time

$-e\vec{E} \rightarrow$ force $\vec{F}$

SI unit ms^{-1}. $m \rightarrow$ mass

5. Define "Mobility".

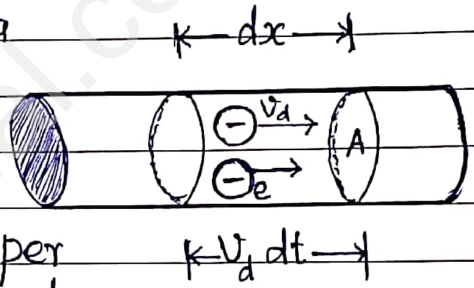
"The magnitude of the drift velocity per unit electric field"

$$\mu = \frac{v_d}{E} \quad . \quad \text{SI unit } m^2 V^{-1} s^{-1}$$

6. Explain the microscopic model of current

(or)

Obtain the relation betn current and drift velocity.



* Consider a conductor with area of cross section A & an electric field $\vec{E}$ applied from right to left.
* Suppose there are n electrons per unit volume in the conductor and assume that all the electrons move with the same drift velocity $\vec{v}_d$.
* The electrons move through a distance dx within a small interval of time dt.

$$v_d = \frac{dx}{dt} \Rightarrow dx = v_d\, dt$$

the electrons available in the volume of length dx is } = Volume × number per unit volume

$= A dx \times n$

$= A v_d dt \times n$

Total charge in volume element } = charge × number of electrons in the volume element

$$dQ = e \times A v_d dt\, n$$

$\therefore$ the Current, $I = \frac{dQ}{dt} = eAv_d n \frac{dt}{dt}$

$$\boxed{\therefore I = eAv_d n}$$

7. what is current density? obtain microscopic form of Ohm's law

Current density:

"the current per unit area of cross Section of the conductor"

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

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

$$\boxed{J = nev_d}$$

The above expression is valid only when the direction of the current is perpendicular to the area A $\therefore$ The current density is a vector quantity

$$\vec{J} = ne\vec{v}_d$$

where,

$$\vec{v}_d = -\frac{e\vec{E}}{m}\tau$$

$$\therefore \vec{J} = -\frac{ne^2\tau}{m}\vec{E}$$

$$\vec{J} = -\sigma\vec{E} \quad (\because \text{for } \bar{e})$$

But conventionally, the direction of current density as the direction of electric field.

$$\boxed{\therefore \vec{J} = \sigma\vec{E}}$$

where $\boxed{\sigma = \frac{ne^2\tau}{m}}$ is called conductivity

Expt.No.
Date / /.

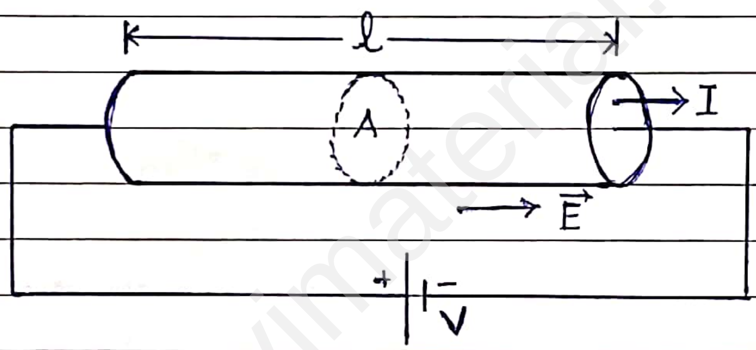
So, the inverse of conductivity is called resistivity ρ.

$$\therefore \rho = \frac{1}{\sigma} = \frac{m}{ne^2\tau}$$

Finally, $\boxed{\vec{J} = \frac{1}{\rho}\vec{E}}$

This is microscopic form of ohm's law.

8. Obtain the macroscopic form of Ohm's law from its microscopic form and discuss its limitations.



The ohm's law can be derived from the eqn. $J = \sigma E$

* Consider a segment of wire of length l and cross sectional area A.
* when a pot^l difference V is applied across the wire, a net electric field is created in the wire which constitutes the current.
* assume that the electric field is uniform in the entire length of the wire.

The pot^l difference, $V = El \Rightarrow \boxed{E = \frac{V}{l}}$

The current density, $J = \sigma E$ (or) $J = \frac{I}{A}$

$$J = \sigma \frac{V}{l}$$

Expt.No.
Date / /.

$$\frac{I}{A} = \sigma \frac{V}{l} \Rightarrow \boxed{V = I\left(\frac{l}{\sigma A}\right)}$$

where, $\frac{l}{\sigma A} = R$, resistance of conductor.

∴ The macroscopic form of ohm's law, $\boxed{V = IR}$

<u>Limits:</u>

* the graph betn current Vs voltage is straight line.
* the slope of St. line is equal to $1/R$.

<u>ohmic materials:</u>

* Materials for which the current against voltage graph is a straight line through the origin, are said to obey Ohm's law and their behaviour is said to be ohmic.

<u>non-ohmic:</u>

* Materials or devices that do not follow ohm's law are said to be non-ohmic.

A plot of I & V for a non-ohmic material is non-linear and they do not have a constant resistance.

9. State Ohm's law.

"At a constant temperature, the steady current flowing through a conductor is directly proportional to the potl difference betn the two ends".

$$I \propto V$$

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

10. Define - "Resistance".

"The ratio of potential difference across the given conductor to the current passing through it".

SI unit of resistance, ohm (or) Ω. $\boxed{R = \frac{V}{I}}$

11. Define – "Resistivity".

The resistance, $R = \frac{1}{\sigma}\frac{l}{A}$

where, $\rho = 1/\sigma$ is resistivity

$\therefore R = \rho \frac{l}{A} \Rightarrow \boxed{\rho = R\frac{A}{l}}$

Def:

"The resistance offered to current flow by a conductor of unit length having unit area of cross section".

SI unit ohm-metre (or) Ωm.

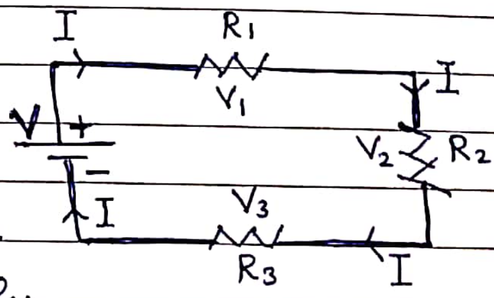
* Resistivity depends only on the type of the material used and not on its dimension.

12. "Repairing the electrical connection with the wet skin is always danger" – why?

* The human body dry skin has high resistance of around $500 k\Omega$.
* But when the skin is wet, the resistance is reduced to around $1 k\Omega$.
* So, it will be dangerous.

13. Calculate the equivalent resistance of a series resistor network.

* Three resistors R_1, R_2 & R_3 are connected in series with pot^l difference V.



* The current I passing through all the three resistors is same.
* Then the pot^l difference across each resistors must

Expt.No.
Date / /.

be different.

$\therefore$ total voltage, $V = V_1 + V_2 + V_3$

From Ohm's law, $V = IR$ and $V_1 = IR_1$; $V_2 = IR_2$; $V_3 = IR_3$.

$$\therefore IR_S = IR_1 + IR_2 + IR_3$$

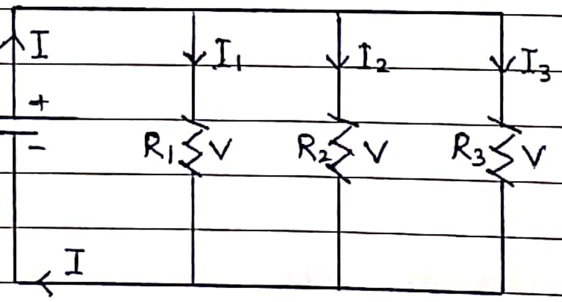
$$IR_S = I(R_1 + R_2 + R_3) \Rightarrow \boxed{R_S = R_1 + R_2 + R_3}$$

where,

* R_S is the equivalent resistance.
* The value of R_S will be greater than each individual resistance.

14. Calculate the equivalent resistance of a parallel resistor network.

* Resistors with resistance R_1, R_2, R_3 are connected in parallel with pot^l difference V.



* Since, the resistors are in parallel with V, they have a same pot^l.
* Let I_1, I_2 & I_3 be the current through the resistors R_1, R_2 & R_3 respectively.
* $\therefore$ the total current $I = I_1 + I_2 + I_3$

From Ohm's law, $I = \frac{V}{R_p}$ and $I_1 = \frac{V}{R_1}$; $I_2 = \frac{V}{R_2}$; $I_3 = \frac{V}{R_3}$

$$\therefore \frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

Expt.No.
Date / /.

$$\frac{V}{R_p} = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right] \Rightarrow \boxed{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Here, R_p is the equivalent resistance
The value of R_p is less than each individual resistance.

15. Define the temperature coefficient of resistivity.
" The ratio of increase in resistivity per degree rise in temperature to its resistivity at T_0.

$$\therefore \alpha = \frac{\rho_T - \rho_0}{\rho_0(T-T_0)} \rightarrow \boxed{\alpha = \frac{\Delta\rho}{\rho_0 \Delta T}}$$

Its unit is per °C.

16. what is superconductors ?
" The ability of certain metals to conduct electricity with zero resistance at very low temperature".

17. what is transition temperature (or) Critical temperature ?
"At which temperature, the electrical resistivity of the material suddenly drops to zero and becomes superconductor" is known as critical temp.
* The critical temp. of mercury is 4.2 K.

18. what is electric power and electric energy ?
* To move a charge from one point to other point some work is done.
* when the charge moves, it gains pot^l energy

$$dW = dU = V.dQ$$

$$\therefore \text{the electric power} = \frac{\text{work done}}{\text{time}}$$

Expt.No.
Date / /.

$$P = \frac{dW}{dt} = \frac{d}{dt}(V.dQ)$$

$$P = V\frac{dQ}{dt} \Rightarrow \boxed{P = VI}$$

From Ohm's law, $V = IR$

$$\therefore \boxed{P = I^2R} \text{ (or) } \boxed{P = \frac{V^2}{R}} \quad \because I = V/R$$

* The electrical power P is the rate at which the electrical pot^l energy is delivered.

Electric energy:
the capacity to do work.

The unit of power is watt ($1 \text{ watt} = 1\,Js^{-1}$)

The electrical energy is measured in kilowatt hour (kwh)
1 kwh is known as 1 unit of electrical energy.
$1\,kWh = 3.6 \times 10^6\,J$

19. Define "Watt".
"A current of 1A flowing through a pot^l difference of 1 Volt produces a power of 1 watt". $\because P = VI$.

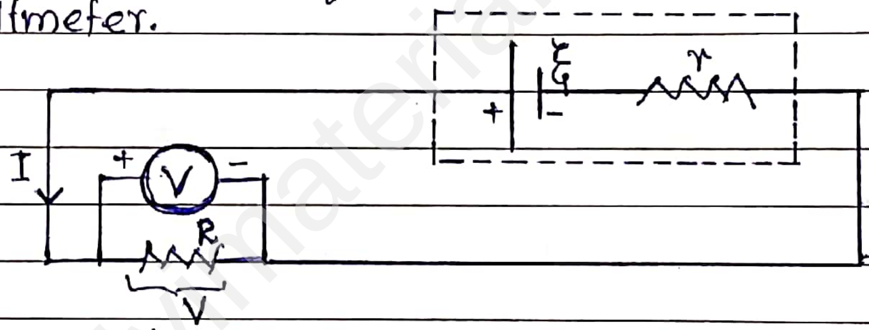
20. what is electric cell ?
"An electric cell converts chemical energy into electrical energy to produce electricity".

Expt.No.
Date / /.

21. What is internal resistance of the cell?

* Electromotive force (emf) determines the amount of work a cell does to move a certain amount of charge around the circuit.
* A real battery is made of electrodes and electrolyte, there is resistance to the flow of charges within the battery.
* This resistance is called internal resistance r.

22. Explain the determination of the internal resistance of a cell using voltmeter.



* The emf of cell is measured by connecting a high resistance voltmeter across it without connecting the external resistance R. That is $\xi = V$
* Now, the external resistance R is included in the circuit and current I is established in the circuit.
* The pot^{l} drop across the resistor R is $\boxed{V = IR}$
* Due to internal resistance r of the cell, the voltmeter reads a value V, which is less than the emf of cell ξ.

$$\therefore V = \xi - Ir$$

where,

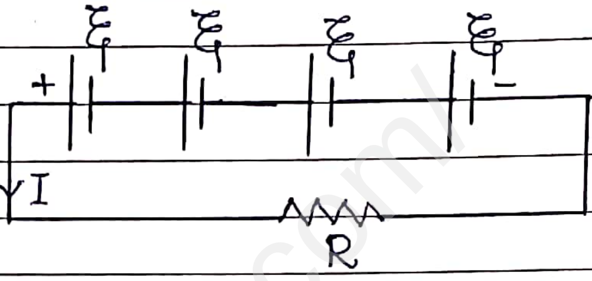
Ir is the voltaged dropped across the internal resistance r.

$$\therefore \boxed{\xi - V = Ir}$$

Expt.No.
Date / /.

$$\frac{Ir}{IR} = \frac{\mathcal{E}-V}{V} \Rightarrow \boxed{r = \left[\frac{\mathcal{E}-V}{V}\right]R}$$

23. Determine the resultant current when the cells are in the series connection.



* Suppose n cells, each of emf $\mathcal{E}$ volts and internal resistance r ohms are connected in series with an external resistance R.

$\therefore$ The total emf of the battery $= n\mathcal{E}$

$\therefore$ The total resistance in the circuit $= nr+R$

By Ohm's law,

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

$$I = \frac{\text{total emf}}{\text{total resistance}} \Rightarrow \boxed{I = \frac{n\mathcal{E}}{nr+R}}$$

Case: (i)

If $r << R$, then $(nr+R) \simeq R$

$$I = \frac{n\mathcal{E}}{R} \sim nI_1$$

where, $I_1 = \mathcal{E}/R$ is the current due to a single cell.

Thus, if $r << R$, the current supplied by the battery is n times that supplied by a single cell.

Case: (ii)

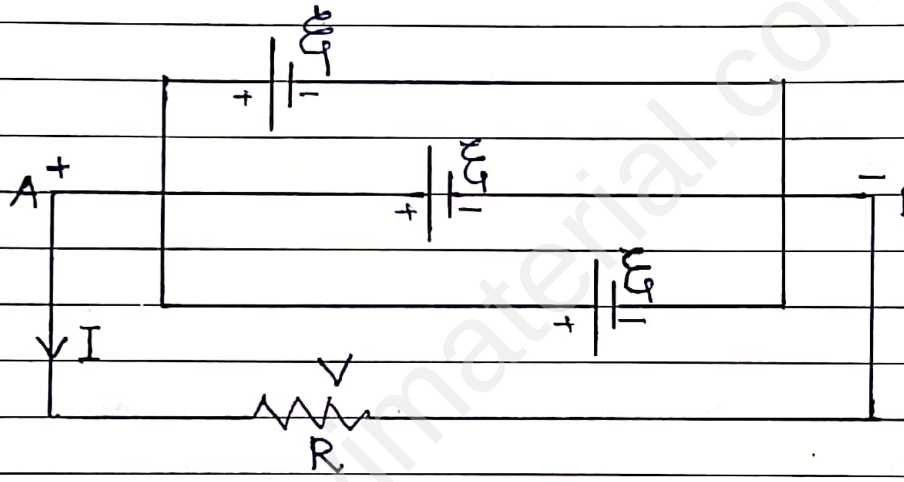
If $r >> R$, then $(nr+R) \simeq nr$

$$I = \frac{n\mathcal{E}}{nr} = \frac{\mathcal{E}}{r}$$

It is the current due to a single cell.

That is current due to the whole battery is the same as that due to a single cell.
Hence there is no advantage in connecting several cells.

24. Determine the resultant current when the cells are in the parallel connection.



* Let n cells be connected in parallel betn the points A and B and a resistance R is connected betn the points A & B.
* Let ε be the emf and r, the internal resistance of each cell.
* the equivalent internal resistance is

$$\frac{1}{r_{eq}} = \frac{1}{r} + \frac{1}{r} + \frac{1}{r} + \dots + \frac{n}{r} = \frac{n}{r}$$

$\therefore r_{eq} = \frac{r}{n}$

* this equivalent resistance connected with R in series.

$\therefore$ Total resistance $= R + \frac{r}{n}$

Expt.No.
Date / /.

The total emf across the points A and B = $\mathcal{E}$

From Ohm's law

$$V = IR \Rightarrow I = \frac{V}{R} = \mathcal{E} \Big/ \frac{r}{n} + R$$

$$= \mathcal{E} \Big/ \frac{nR + r}{n}$$

$$\boxed{I = \frac{n\mathcal{E}}{nR + r}}$$

Case(i): If $r >> R$, then $(nR + r) \simeq r$

$$I = n\frac{\mathcal{E}}{r} = nI_1$$

where I_1 is the current due to a single cell.

Thus, the current through the external resistance R, due to the whole battery is n times the current due to a single cell.

Case(ii):

If $r << R$, then, $(nR + r) \simeq nR$

$$I = \frac{n\mathcal{E}}{nR} = \mathcal{E}/R$$

Thus, the current due to the whole battery is the same as that due to a single cell.

25 State "Kirchhoff's first rule" (Current rule)

" The algebraic sum of the currents at any junction of a circuit is zero".

It is a statement of conservation of electric charges.

Expt.No.
Date / /.

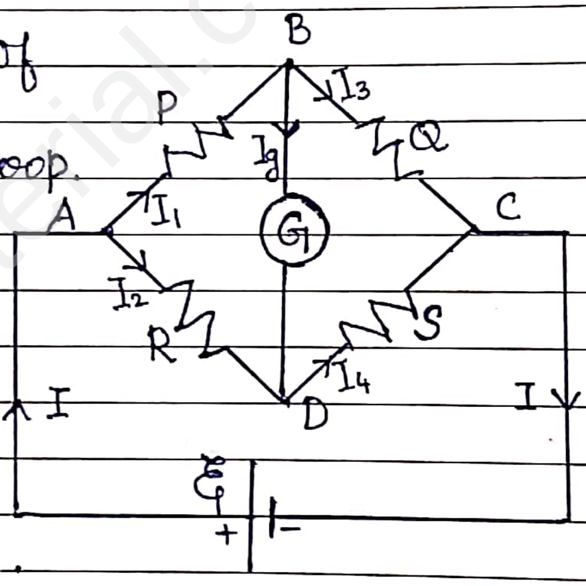
26. State the Kirchhoff's Second Rule. (Voltage Rule).

"In a closed circuit the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the circuit".

This rule, on the basis of law of conservation of energy.

27. Obtain the ~~condition~~ balancing condition for the Wheatstone's Bridge.

* The network consists of resistance P, Q, R & S connected to form a loop.
* A galvanometer G is connected betn B & D.
* The battery is connec-ted betn A & C.
* The current through the galvanometer is I_g and its resistance is G.



* Current rule at junction B, $I_1 - I_g - I_3 = 0$
* Current rule at junction D, $I_2 + I_g - I_4 = 0$
* Voltage rule to loop ABDA, $I_1P + I_gG - I_2R = 0$
* Voltage rule to loop ABCDA, $I_1P + I_3Q - I_4S - I_2R = 0$

When the points B and D are at the same potential, the bridge is said to be balanced. ie) $\boxed{I_g = 0}$

Expt.No.
Date / /.

$\therefore I_1 = I_3$

$I_2 = I_4 \qquad \therefore \boxed{I_1 P = I_2 R}$

$\therefore I_1 P + I_1 Q - I_2 S - I_2 R = 0$

$I_1 P + I_1 Q = I_2 S + I_2 R$

$$\boxed{I_1 (P+Q) = I_2 (S+R)}$$

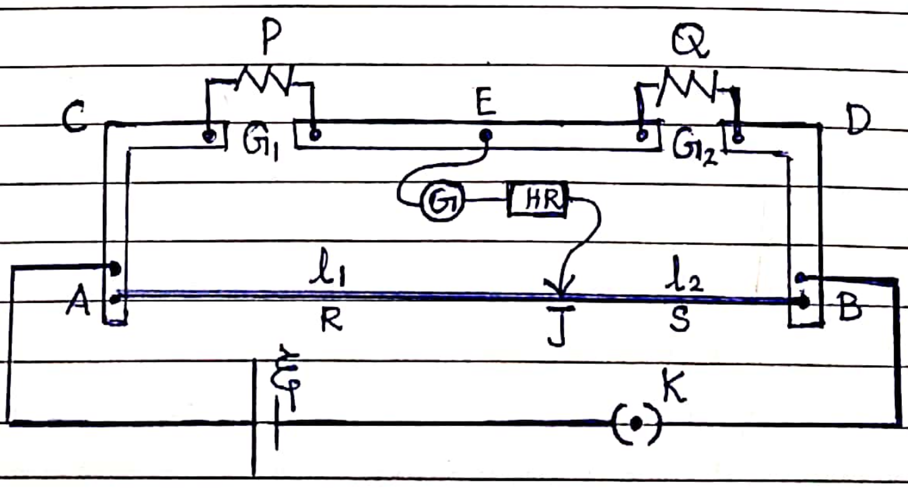
$$\frac{I_1 (P+Q)}{I_1 P} = \frac{I_2 (S+R)}{I_2 R} \rightarrow \frac{P+Q}{P} = \frac{S+R}{R}$$

$$\frac{P}{P} + \frac{Q}{P} = \frac{S}{R} + \frac{R}{R}$$

$$1 + \frac{Q}{P} = \frac{S}{R} + 1$$

$$\boxed{\frac{Q}{P} = \frac{S}{R}} \text{ (or) } \boxed{\frac{P}{Q} = \frac{R}{S}}$$

28. Calculate the unknown resistance using Meter Bridge.



Expt.No.
Date / /.

* Construction:
    * The meter bridge is another form of wheatstone's bridge.
    * It consists of a uniform manganin wire AB of one meter length.
    * An unknown resistance P is connected in G_1 and a standard resistance Q is connected in G_2.
    * A jockey J, Galvanometer G and high resistance HR are connected in series with terminal E.
    * A Lechlanche cell and a key are connected across the ends of the bridge wire.

working:

* The position of the J on the wire is adjusted so that the galvanometer shows zero deflection.
* Let $AJ = l_1 = R$

$JB = l_2 = S$

Then,

$$\frac{P}{Q} = \frac{R}{S} = \frac{R'.AJ}{R'.JB}$$

where, R' is the resistance per unit length of wire.

$$\frac{P}{Q} = \frac{AJ}{JB} = \frac{l_1}{l_2} \Rightarrow \frac{P}{Q} = \frac{l_1}{l_2}$$

$$\therefore P = Q\frac{l_1}{l_2}$$

Note: The bridge wire is soldered at the ends of the copper strips. Due to this there is some error in P. To avoid this, we interchange P & Q and do the same procedure. Now the average value of P is found.

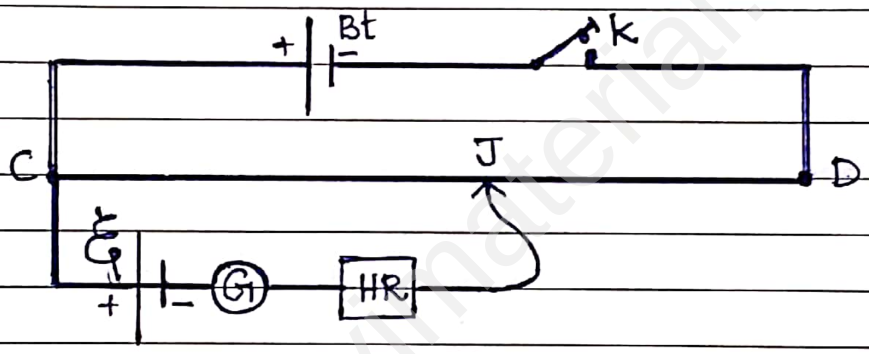
Expt.No.
Date / /.

∴ The specific resistance of the coil is

$$\rho = \frac{PA}{l} \Rightarrow \boxed{\rho = \frac{P\pi r^2}{l}}$$

where, P – resistance of the wire
l – length of the wire
r – radius of the wire.

29. Explain the Principle of the Potentiometer.



Construction:

* Potentiometer is used for the accurate measurement of pot^n differences, current & resistances.
* It consists of ten meter long uniform wire of manganin or constantan stretched in parallel rows each of 1 meter length, on a wooden board.
* A meter scale is fixed parallel to the wire.
* A jockey is provided for making contact.
* The battery, key, potentiometer wire are connected in series, forms the primary circuit.
* A primary cell, jockey, galvanometer G, high resistance HR are connected in series, forms the secondary circuit.

Working:

* The position of the jockey on the wire is adjusted So that the G shows zero deflection.
* Now the pot^l difference across CJ is equal to the emf of primary cell ξ_1. that is $V = \xi_1$
* CJ is the balancing length l.

* V across CJ is $V = Irl$ (or) $\xi_1 = Irl$ (or) $\xi_1 \propto l$

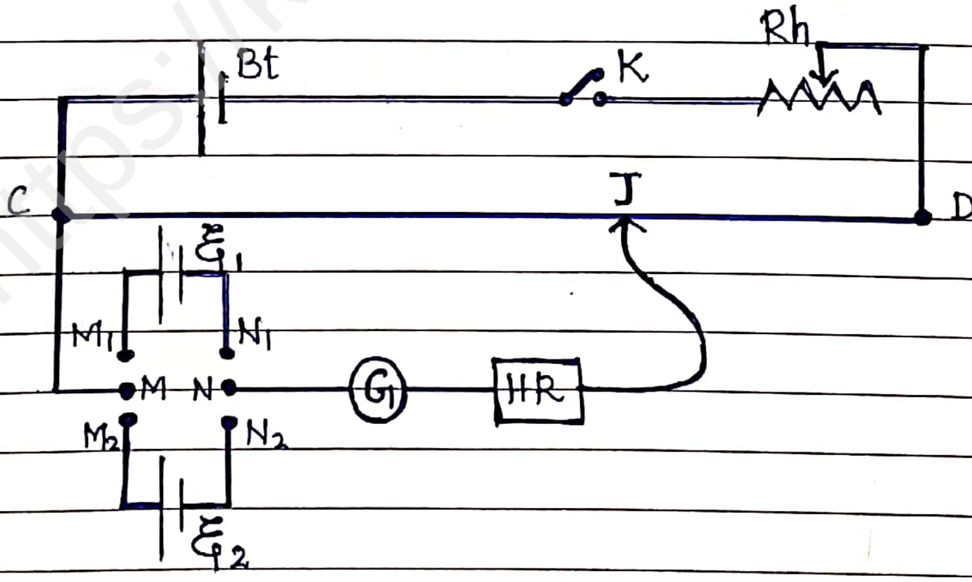
where,

I – current flow through the wire
r – is resistance per unit length of wire.

Since, I and r are constant,

∴ "The emf of the cell is directly proportional to the balancing length". ∴

30 How the emf of two cells are compared using potentiometer? Explain.



Construction:

* In primary circuit, the battery, key and

Expt.No.
Date / /.

Rheostat (Rh) are connected in series with the wire CD

* In the Secondary circuit,
  - two primary cells with emf ξ_1 & ξ_2 are connected with DPDT Switch.
  - the DPDT switch, G, HR, J are connected in series in the secondary circuit.

Working:

* The DPDT Switch make the connection with the first primary cell ξ_1 and findout the balancing length l_1

$\therefore$ the emf $\boxed{\xi_1 = Irl_1}$

where,

I – current flow through the wire
r – resistance per unit length

* Similarly the second cell ξ_2 is included in the circuit and the balancing length l_2 is determined.

$\therefore$ the emf $\boxed{\xi_2 = Irl_2}$

The Comparison of emf

$$\frac{\xi_1}{\xi_2} = \frac{Irl_1}{Irl_2} \Rightarrow \boxed{\frac{\xi_1}{\xi_2} = \frac{l_1}{l_2}}$$

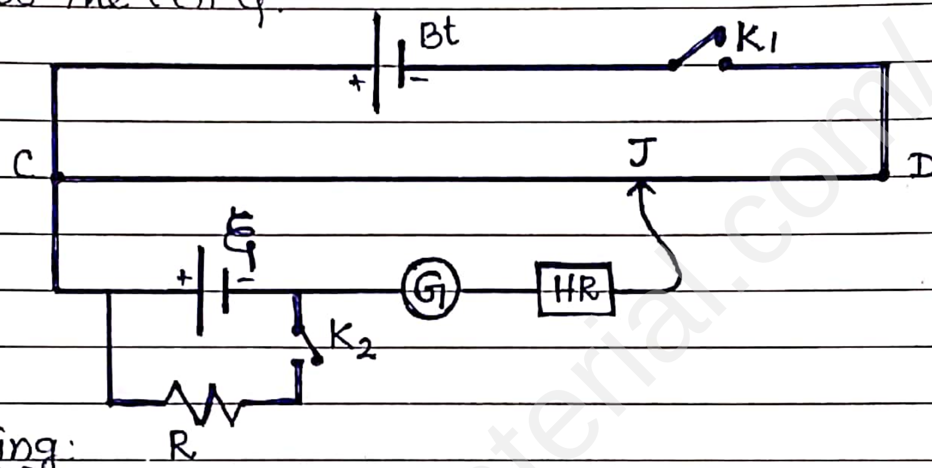
Using Rh in the primary circuit, the expt. can be repeated by changing the current flow thro' it.

31. Determine the internal resistance of a cell using potentiometer.

Construction: * In the primary circuit, the battery and key are connected in series with CD.

Expt.No.
Date / /.

* In the secondary circuit, the cell ξ whose internal resistance is to be determined, G, HR are connected in series.
* A resistance box R and key K_2 are connected across the cell ξ.



Working:

* with K_2 is open the balancing point J is obtained.
∴ the balancing length, $CJ = l_1$

Since, K_2 is open
the emf of the cell $\boxed{\xi \propto l_1}$

* Put a suitable value in the box R and key K_2 closed.
* Let r be the internal resistance of the cell.
* r and R are in series connection, then the current passing through the cell and the resistance R is given by,

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

The pot^l difference across R is,

$$\boxed{V = \frac{\xi R}{R+r}}$$

$\because V = IR$

Expt.No.
Date / /.

* determine the balancing length due to this pot difference is l_2. Then,

$$\boxed{\frac{\xi R}{R+r} \propto l_2}$$

Here, $\xi = l_1$

$$\therefore \frac{l_1 R}{R+r} = l_2$$

$$\frac{R}{R+r} = \frac{l_2}{l_1} \Rightarrow \frac{R+r}{R} = \frac{l_1}{l_2}$$

$$1+\frac{r}{R} = \frac{l_1}{l_2}$$

$$\frac{r}{R} = \frac{l_1}{l_2} - 1$$

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

(or)

$\therefore$ The internal resistance of the cell is

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

32. what is Joule's heating effect?

"when current flows through a resistor, some of the electrical energy delivered to the resistor is converted into heat energy and it is dissipated". This is known as Joule's heating effect.

33. what are the uses of Joule's heating effect?

* used in electric heater
* used in electric iron box
* used in electric fuses wire
* used in electric Toaster.
* used in electric (bulb) lamp
* used in electric furnace

Expt.No.
Date / /.

34. what is thermoelectric effect ?

"Conversion of temperature differences into electrical voltage and vice versa" is known as thermoelectric effect.

35. State Joule's law.

* The amount of heat (H) produced in the conductor is

$$H = VIt$$

* For a resistance R,

$$\boxed{H = I^2Rt}$$

law :

the heat developed in an electrical circuit due to the flow of current varies directly as
(i) the square of the current
(ii) the resistance of the circuit and
(iii) the time of flow.

36. what are the reasons to use Nichrome as the heating element in electric heating devices ?

* it has high specific resistance.
* it has high melting point
* it is not easily oxidized.

37 what is Seebeck effect ?

"In a circuit consisting of two dissimilar metals, an emf is developed when the junctions are at different temperature".

38. what are the applications of Seebeck effect ?

(i) is used in thermoelectric generators.

(ii) is used in automobiles for increasing fuel efficiency.
(iii) is used in thermocouples and thermopiles.

39. What is Peltier effect ?
" When electric current is pass through a circuit consisting of two dissimilar metals, heat is evolved at one junction where as heat absorbed at other junction". Peltier effect is reversible.

40 Define "Thomson effect".
" If two points in a conductor are at different temperatures, the density of electrons at these points will differ and as a result the potential difference is created betn these points".
Thomson effect is also reversible.

41. What is positive Thomson effect ?
* In Thomson effect, the heat is transferred due to the current flow in the direction of the current", is called positive Thomson effect.
+ve Thomson metals: Copper, Silver, Zinc, Cadmium.

42. What is negative Thomson effect ?
* In Thomson effect, the heat is transferred due to the current flow in the direction opposite to the direction of current", is called negative Thomson effect.
-ve Thomson metals: iron, platinum, nickel, cobalt and mercury.

Expt.No.
Date / /.

43. Differentiate Peltier effect and Joule effect.

Peltier	Joule
(i) It is reversible	(i) It is irreversible
(ii) It is done only at the junctions of two metals.	(ii) It is done throughout the metal.
(iii) Heat energy, $H = \pi I t$	(iii) Here, $H = I^2 R t$.