Potentiometer and It's principle explain?

Ans: Potentiometer:

=> A potentiometer is a sensitive electronic device used to measure e.m.f of cell, find internal resistance of cell and to compare the emf of two cells.

Principle:

=> When a constant current is passed through a wire of uniform area of cross-section, the potential drop across any position of wire is directly proportional to the length of that position.

i.e, $V = IR$ $\quad (\because R = \rho L/A)$

$V = I \times \rho \frac{L}{A}$ ——(i)

$\therefore V \propto L$ for constant 'A' and 'I'

This is the working principle of potentiometer.

Here, $V \Rightarrow$ potential difference (p.d)

$I \Rightarrow$ current.

$R \Rightarrow$ Resistance of wire.

$A \Rightarrow$ cross sectional area of wire.

$\rho \Rightarrow$ Resistivity.

=> Determination of the internal resistance 'r' of a cell.

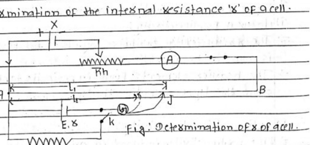


Fig: Determination of r of a cell.

=> The circuit diagram to determine the internal resistance of the given battery is as shown in Figure. A known external resistance 'R' is connected across parallel to cell

Comparison of the e.m.f. of two cells?

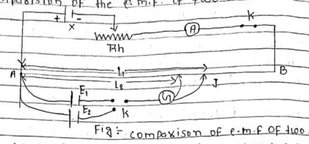


Fig: comparison of e.m.f of two cell.

=> The circuit diagram that is used to compare the emfs of two cells having emfs E_1 and E_2 is as shown in fig-ure.

=> The cell 'X' is driver cell whose e.m.f 'E' must be larger than p.d across the whole wire of potentiometer.

=> The positive terminal of E_1 and E_2 are connected on the same end 'A' where positive terminal of the driver cell 'X' is connected.

=> Negative terminals are connected by two way key 'K'. Galvanometer 'G' is connected in the common terminal

=> At first key 'K' is connected across terminal of cell E_1. the jokey 'J' is adjusted at the wire at a point where there is no deflection in galvanometer.

=> Suppose the balancing length of potentiometer wire is L_1 so,

$E_1 \propto L_1$ ——(i)

Similarly, $E_2 \propto L_2$ ——(ii)

From these two equation, we can write.

$\frac{E_1}{E_2} = \frac{L_1}{L_2}$ ——(iii)

=> If emf of one cell is know (say E_2), the emf of another cell (say E_1) can be calculate by using above relation.

$\therefore E_1 = \frac{L_1}{L_2} \times E_2$ ——(iv)

If 'm' is the mass of electron, the centripetal force acting on the electron is given by,

$F = \frac{m v_n^2}{r_n}$

Thus, $\frac{m v_n^2}{r_n} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Ze \cdot e}{r_n^2}$

$\therefore m v_n^2 r_n = \frac{1}{4\pi\varepsilon_0} \cdot Ze^2$ ——(i)

Applying Bohr's first postulate of atomic model we have,

$m v_n r_n = n \frac{h}{2\pi}$ $\quad (\because n = 1, 2, 3 \ldots)$

Squaring on both side, we get,

$m^2 v_n^2 r_n^2 = \frac{n^2 h^2}{4\pi^2}$ ——(ii)

On dividing equation (ii) by (i), we get,

$$\frac{m^2 v_n^2 r_n^2}{m v_n^2 r_n} = \frac{\frac{n^2 h^2}{4\pi^2}}{\frac{Ze^2}{4\pi\varepsilon_0}}$$

$m r_n = \frac{n^2 \varepsilon_0 h^2}{\pi Z e^2}$

$r_n = \frac{n^2 h^2 \varepsilon_0}{\pi m Z e^2}$ ——(iii)

For a hydrogen atom we have,

$Z = 1$, $\varepsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$.

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

$h = 6.62 \times 10^{-34} Js$

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

radius of first orbit, $r_1 = \frac{\varepsilon_0 h^2}{\pi m Z e^2} = 0.53 \times 10^{-10} m$.

$r_1 = \frac{(8.85 \times 10^{-12}) \times (6.63 \times 10^{-34})^2}{\pi \times (9.1 \times 10^{-31}) \times (1 \times 1.6 \times 10^{-19})^2}$

=> Suppose 's' be the monochromatic source of light. A and B are two final slits which act as the coherent source of light, 'd' be the distance between them. Suppose the screen is placed at a distance 'D' from the current sources. 'c' is the centre of screen which is equidistance from two slits A and B. The path diffrence of the wave reaching at point c from A & B is zero.

Hence, a bright fringe of maximum intensity is observed at point 'c' suppose a point 'p' which lies at distance 'x' from point 'c'.

Here, $PR = \left(x - \frac{d}{2}\right)$

and, $PQ = \left(x + \frac{d}{2}\right)$

Now, $AP^2 = \left(x - \frac{d}{2}\right)^2 + D^2$

and, $BP^2 = \left(x + \frac{d}{2}\right)^2 + D^2$

So, $BP^2 - AP^2 = \left(x + \frac{d}{2}\right)^2 + D^2 - \left(x + \frac{d}{2}\right)^2 - D^2$

$= \left(x + \frac{d}{2}\right)^2 - \left(x + \frac{d}{2}\right)^2$

$\therefore BP^2 - AP^2 = 2xd$.

$\therefore BP - AP = \frac{2xd}{BP + AP}$

As, the point p lies very near to point c, then,

$BP \approx AP \approx D$.

$BP - AP = \frac{2xd}{2D} = \frac{xd}{D}$

i.e, path difference $= xd/D$

Since, (the phase difference) $= \frac{2\pi}{\lambda} \times$ (Path difference)

$\therefore \phi = \frac{2\pi}{\lambda} \times \frac{xd}{D}$.

Energy stored on a charge capacitor?

=> Suppose an unchared capacitor of capacitance 'c' is to be charged with an electric charged 'q' so that its potential differen becomes 'V'

So, $\therefore V = q/C$

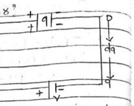


Fig. A charged capacitor

=> Suppose the uncharged capacitor is started to be charged. At any instant, let the electric charges on plate of capacitor is 'dq' and p.d across the plate is 'V' the small workdone to deposited the electric charge 'dq' is,

$dw = V dq$

$\therefore dw = \frac{q}{C} dq$

=> When the capacitor is charged to final charge 'q' the total workdone in charging of capacitor from charge '0' to 'q' is given by.

$W = \int_0^q dw$

or, $W = \int_0^q \frac{q}{C} dq$

$= \frac{1}{C} \int_0^q q\, dq$

$= \frac{1}{C} \left[\frac{q^{1+1}}{1+1}\right]_0^q = \frac{1}{C} \left[\frac{q^2}{2}\right]_0^q$

$= \frac{1}{C} \left(\frac{q^2}{2}\right)$

$\therefore W = \frac{q^2}{2C}$ ——(i)

This workdone is stored as (electric potential) energy on the charged capacitor, thus, the energy stored on the charged capacitor is given by,

Reduce an expression for parallel plate capacitor?

=> Two metal plates are placed parallel to each other separated by dielectric material forms a parallel plate capacitor.

let, two parallel plates having area 'A', each separated by 'd' forms a parallel plate capacitor. If Q charge is given by on upper plate and surface density of the charged plate is σ then,

Charge density $(\sigma) = \frac{Q}{A}$ ——(i)

$\therefore E = \frac{\sigma}{\varepsilon_0}$ ——(ii)

From equations (1) and (2); we get.

$E = \frac{Q}{A\varepsilon_0}$ ——(iii)

If 'V' is the potential difference between the plates; then,

$E = \frac{V}{d}$ ——(iv)

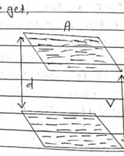
Now, equation (3) and (4); we get,

$\frac{V}{d} = \frac{Q}{A\varepsilon_0}$

or, $\frac{d}{V} = \frac{A\varepsilon_0}{Q}$

or, $\frac{Q}{V} = \frac{A\varepsilon_0}{d}$

i.e, $C = \frac{\varepsilon_0 A}{d}$ $\quad (\because C = Q/V)$



Hence, the capacitance of parallel plate capacitor is, $\frac{\varepsilon_0 A}{d}$.

Application:

1. Capacitor is widely used in radio and television tuners, in the starting circuit of electric motors in automobile ighition system etc.
2) They can be used as device for storing charge.

Conversion of a Galvanometer into an ammeter?

=> If a low resistance is connected in parallel (i.e shunt) with a galvanometer into an ammeter. thus the ammeter is a galvanometer with a low resistance parallel to it.

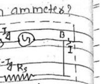


Fig: Symbol.

=> Let, $R_s \Rightarrow$ shunt resistance.

$G \Rightarrow$ Galvanometer resistance.

$I_g \Rightarrow$ current flowing through the galvanometer.

$(I - I_g) = I_s \Rightarrow$ shunt current.

Then form the figure,

p.d across 'R_s' = p.d across 'G'

$I_s R_s = I_g G$ $\quad (\because V = IR)$

$R_s = \frac{I_g G}{I_s}$ $\quad (\because I_s = I - I_g)$

$\therefore R_s = \frac{I_g G}{I - I_g}$ | This is the required value of shunt resistance.

Conversion of a Galvanometer into an voltmeter?

=> If a high resistance is connected in series with a galvanometer, it can be connected into a voltmeter as shown in figure.

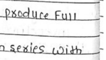


Fig:- Symbol.

let, G = resistance of galvanometer coil.

I_g = Galvanometer current. to produce Full scale deflection.

$R \Rightarrow$ external high resistance in series with galvanometer.

As both 'G' and 'R' in series; then,

$V = I_g(R + G)$

$\frac{V}{I_g} = R + G$

$\therefore R = \frac{V}{I_g} - G$

This relaction gives high resistance chosen to convert galvanometer into voltmeter in required range.

Faraday's law of electrolysis?

a) Faraday's First law of electrolysis:

=> The mass of a substance liberated or deposited in electrolysis is directly proportional the electric charge that passes through the electrolyte.

i.e, $m \propto q$

$m = Zq$ ——(i)

where, Z is the constant is called electrochemical equivalent (E.C.E).

$\therefore m = ZIt$ ——(ii) $\quad (\because q = It)$.

b) Faraday's Second law of electrolysis:

=> The mass of different substance liberated in electrolysis by the passes of same quantity of electric charge, is directly proportional to their respective chemical equivalent." $\frac{m}{E}$ = constant ——(iii).

Faraday's law of electromagnetic Induction:

i) First law:

=> "Whenever magnetic flux linked with a circuit changes induced e.m.f is produced. the induced e.m.f lasts as long as the change in the magnetic flux contineues".

=> So. first law of electromagnetic induction gives the condition in which the induced e.m.f is obtained.

ii) Second law:

=> "The magnitude of induced e.m.f in a coil (or a conductor) is directly proportional to the rate of change of magnetic flux."

=> Suppose 'ϕ_1' and ϕ_2 are the magnetic fluxes linked with a coil (or a conductor) intially and after time 't' respectively. thus, the rate of change of magnetic flux is,

$e = \frac{\phi_1 - \phi_2}{t_2} = -\frac{d\phi}{dt}$.

Calculate the force experienced by a charge moving inside magnetic field.

=> Suppose a charge 'q' is moving with velocity 'v' inside a magnetic field 'B'

=> Suppose 'B' acts along z-axis while the charge 'q' moves with velocity 'v' in yz plane making an angle 'α' with the direction of magnetic field 'B' as shown in figure.

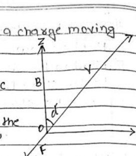


Fig:- Force on moving charge in magnetic field.

Now, the force expreinced by charge 'q' is directly proportional to:

a) The magnitude of the charge 'q'

i.e, $F \propto q$

b) The speed 'v' with which the charge is moving;

i.e, $F \propto v$

c) The applied magnetic field 'B'.

i.e, $F \propto B$.

d) The sine of the angle between direction of 'v' and 'B'.

i.e, $F \propto \sin\alpha$.

On combaining these two equation we get,

$F \propto Bqv\sin\alpha$.

$\therefore F = kBqv\sin\alpha$ ——(i).

where, k is a proportional constant (k = 1).

So, $F = Bqv\sin\alpha$.

It is the required equation.

In the vector form equation (i) becomes.

$\vec{F} = q(\vec{v} \times \vec{B})$