

The potentiometer

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Introduction :

G.R. :

The voltmeter reading is not accurate when measuring e.m.f of a cell or voltage drop across a resistor ?

When the voltmeter is connected between the terminals of a cell its reading V

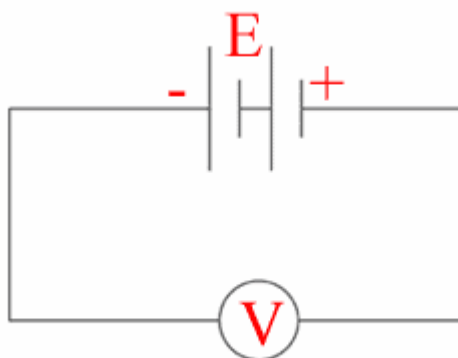
$$V = I R$$

$$\text{But } I = \frac{E}{R + r}$$

$$V = \frac{E}{R + r} \times R$$

$$V = E \times \frac{E}{R + r}$$

$$V = E \text{ when } \frac{E}{R + r} = 1$$



And takes place when $r = 0$ OR $R = \infty$

No current passes through it .

The e.m.f is the P.d between the two terminals of the cell when no current passes through it (when its circuit is open)

Answer :

E.m.f of a cell is defined as: “The external voltage across the two poles of the cell when there are no current passes through it (open circuit)” so when the voltmeter is joined between the two poles, a current passes through it and its reading represents the external voltage and not the E.m.f

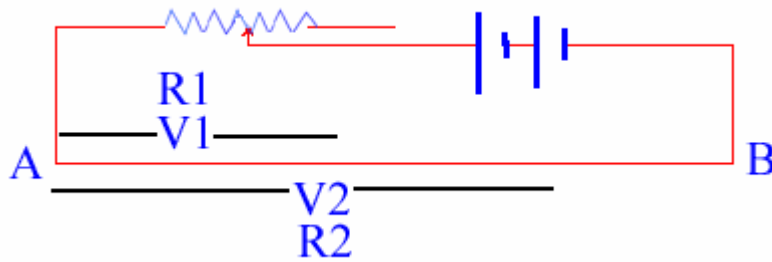
$$E = V (\text{ext.}) + V (\text{int}) = V (\text{ext.}) + 0 \quad \begin{array}{l} \text{r neglect} \\ \text{no current} \end{array}$$

- these conditions are impossible practically.
- when the voltmeter is joined across a resistor it withdraws a small current which affects the original V across the resistor.

• Advantages of potentiometer

- 1- It measures E.m.f or V in case of no current pass.
- 2- It has low resistance so it does not affect the resistance of the circuit measured.

Based on : How can you cancel a cell current in closed path
 $VaRaL$



Structure :

A long uniform wire with a small R stretched on a scale in “cm” its two ends are joined to a rheostat, a battery and a key in series.

Theory of the potent :

$$\frac{V_1}{V_2} = \frac{IR_1}{IR_2} = \frac{L_1}{L_2}$$

$$\therefore R \propto L \quad \therefore \frac{V_1}{V_2} = \frac{L_1}{L_2}$$

- The drop in voltage across any two points on the wire is direct. prop to the wire length of the two points.
- Total p.d is divided on the wire (due to lengths).

$$V \propto L$$

Precautions when using it to measure E.m.f of a cell

- (1) The positive pole of the battery is joined to the positive pole of the cell (to cancel the cell current).
- (2) V across the potentiometer wire must be greater than E.m.f of the cell. (to get balance point on the wire and not outside the wire).

(3) The connections must be tight to prevent the high Resistance of air gaps.

G.R. :

- One cannot be able to get the balance point ?
(The previous precautions are opposed).

comparison of two E.m.f of two cells by means of a potentiometer:

(write the precaution with the exp.)

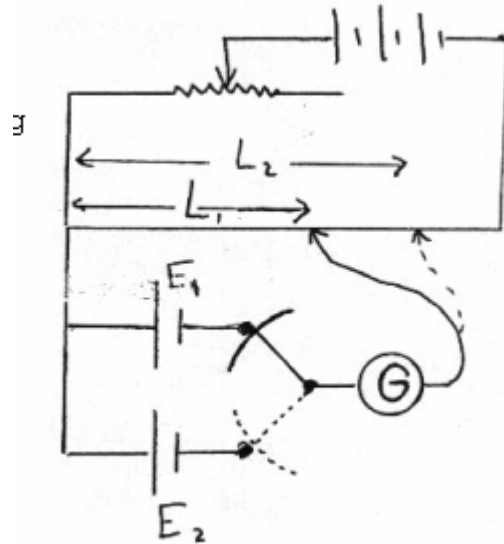
1- connect the circuit shown.

2- Join the key AB with E_1 and move the slider to get the balance length L_1 .

3-Repeat the previous steps by connecting the key CB with E_2 and measure L_2 .

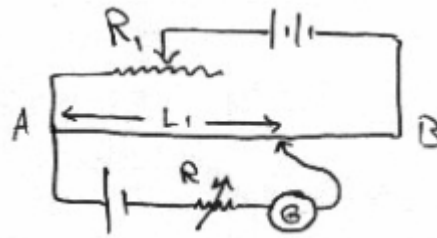
$$\frac{E_1}{E_2} = \frac{L_1}{L_2}$$

The ratio $\frac{E_1}{E_2}$ can be determined



Notes :-

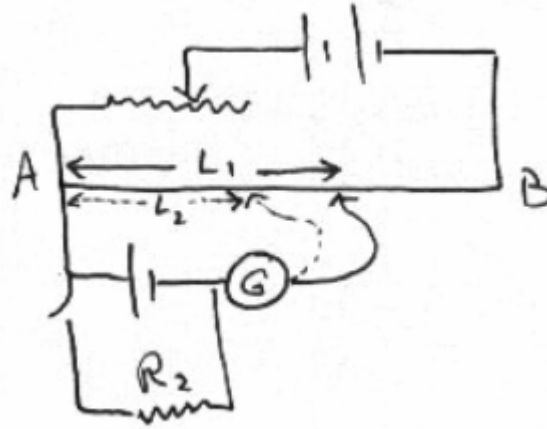
1- The connection of a resistance R in series with E does not affect balance length L_1 because no current goes out the cell E



2- Change the value of R or replace the galvanometer with another one has different resistance does not affect balance

3- E makes balance with L_1 from the potentiometer wire $E = V_1$ between terminals of L_1 But $V_1 = I R L_1$ When R_1 increases I decreases and V_1 decreases , so we must increase the length of the wire by moving the slider towards B to compensate the decreasing in current and return balance

4- E makes balance with L_1 when the key is closed a current goes out the cell E through R_2 producing P.d V which make balance with L_2 which must be less than L_1 where $V < E$



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