Date 29/06/21

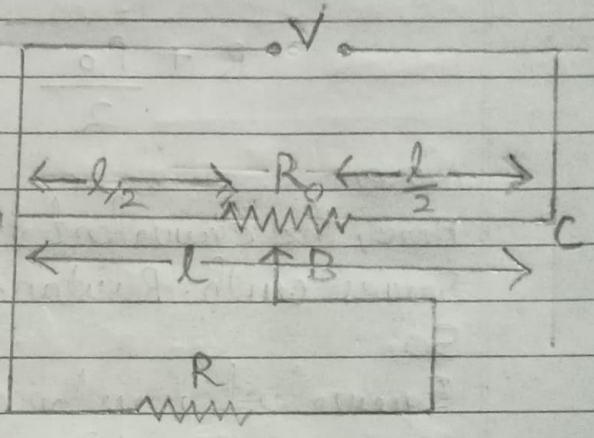
Chapter-3

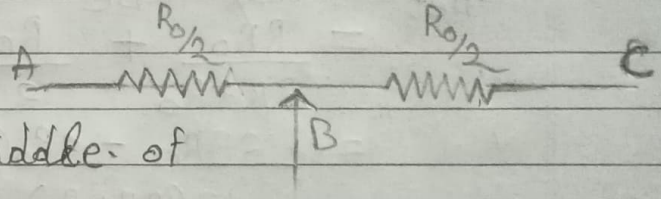
Current Electricity:-

Home Assignment-13

Q.1 A resistance R draws current from a potentiometer of resistance R_0 as shown. Derive an expression for the voltage across R when the sliding contact is in the middle of the potentiometer wire.

Ans- Here,
Given that,
The sliding contact is in the middle of the potentiometer wire.
& So,
Lets consider the length of the wire to be l.
So, as the sliding contant is in the middle of the wire.
the length will be $AB = BC = \frac{l}{2}$.





Now,
As the Resistance is directly proportional to the length i.e.,

$$R = \rho \frac{l}{A} \quad \Rightarrow R \propto l.$$

So, According to the length, the corresponding resistance will be

$$R_{AB} = \frac{R_0}{2} \quad \& \quad R_{BC} = \frac{R_0}{2}.$$

Here,
the resistance R is in parallel with resistance

R_{AB} of the potentiometer.

So,

Equivalent resistance of R & R_{AB} is

$$R_{eq} = \frac{R \times R_{AB}}{R + R_{AB}}$$

$$= \frac{R \times \frac{R_0}{2}}{R + \frac{R_0}{2}} = \frac{\frac{RR_0}{2}}{\frac{2R+R_0}{2}} = \frac{RR_0}{2R+R_0}$$

Now,

Here, the equivalent resistance R_{eq} will be in Series with Resistance R_{BC}.

So,

Equivalent resistance of R_{eq} & R_{BC} is.

$$R_{net} = R_{eq} + R_{BC}$$

$$= \frac{RR_0}{2R+R_0} + \frac{R_0}{2}$$

$$= \frac{2RR_0 + R_0(2R+R_0)}{2(2R+R_0)}$$

$$= \frac{2RR_0 + 2RR_0 + R_0^2}{2(2R+R_0)}$$

$$= \frac{4RR_0 + R_0^2}{2(2R+R_0)}$$

∴ The Expression for the current will be.

$$I = \frac{V}{R_0}$$

$$\Rightarrow I = \frac{V}{\frac{4RR_0 + R_0^2}{2(2R+R_0)}} = \frac{2V(2R+R_0)}{4RR_0 + R_0^2}$$

Now,

Here, Current flowing through the potentiometer is obtained.

Hence,
the expression for Voltage across R will be

~~$V_0 = I R_{net}$~~

$V_0 = I R_{eq}$

$= \frac{2V(2R+R_0)}{4RR_0 + R_0^2} \times \frac{RR_0}{2R+R_0}$

$= \frac{2V}{R_0(4R+R_0)} \times RR_0$

$\Rightarrow V_0 = \frac{2V \cdot R}{4R+R_0}$.

Q.2. Two students X and Y perform an experiment on potentiometer separately using the circuit given below. Keeping other parameters unchanged, how will the position of the null point be affected if,

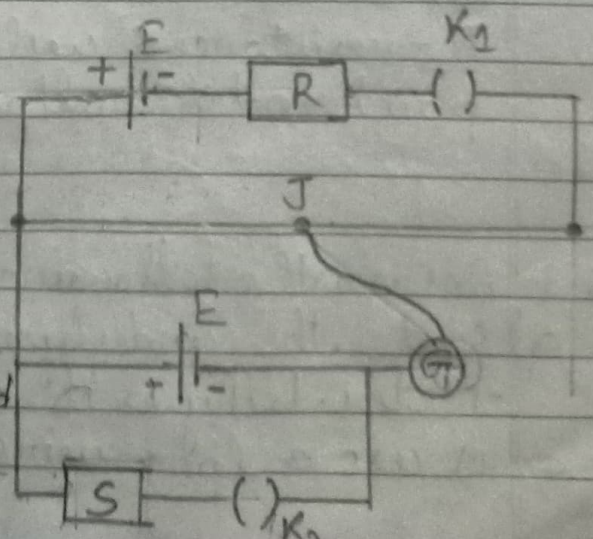
(a.) X increases the value of resistance R in the setup by keeping the key K_1 closed and the key K_2 open?

(b.) Y decreases the value of resistance S in the setup, while the key K_2 remains open and then K_1 closed?

Ans-Q) Here,

X increases the value of resistance R in the setup by keeping the key K_1 closed.

So, as the resistance R in the circuit is increased the potential gradient



decreases. Throughout the circuit So, in turn the potential across AB also decreases.
Hence,
A greater length of wire is needed in order to have the balancing point for same potential on the ~~driving cell and~~ standard cell and across AB. wire.
~~So,~~
~~The resistance~~.
So, as the potential $V_{AJ} = E$ should be the condition to meet.
The length AJ should be increased as.

$$V_{AJ} \propto l.$$

Hence,
The null point J will shift towards B.

b) Here,
Y decreases the resistance S. But ~~as~~ as the resistance S is along the ~~stand~~ standard cell, it will have no effect on the potential across AB.
And also as K_2 is open, no current will ~~flow~~ pass through resistance S.
Hence,
The resistance S will have no effect on the null point and the null point will remain unchanged.

Q.3 Answer the following
a) State the underlying principle of a potentiometer. Why is it necessary to.
i) use a long wire.

ii) have uniform area of cross-section of the wire and.

iii) use a driving cell whose emf is taken to be greater than the emf of the primary cell?

Ans- Principle of potentiometer states that the potential difference across any length of wire of uniform cross-section and uniform composition is directly proportional to the length of the wire when a constant current flows through it.

Now,

i) It is necessary to have a long wire because it decreases the potential gradient throughout the potentiometer which increases the sensitivity of the potentiometer.

Now,

ii) The area of crossection should be uniform because, as per the principle, the potential difference is directly proportional to the length of the wire. So, if the area is not uniform, the principle of the potentiometer is not satisfied.

Now,

iii) It is necessary to use a driving cell whose emf is taken to be greater than the emf of the primary cell because if the potential across the potentiometer wire becomes less than primary cell, no balance point would be obtained. So, to have a greater potential drop across the wire, we have to use a greater emf driving cell.

b) In a potentiometer experiment, if the area of cross-section of the wire increases uniformly from one end to the other, draw a graph showing how potential gradient would vary as the length of the wire increases from one end.

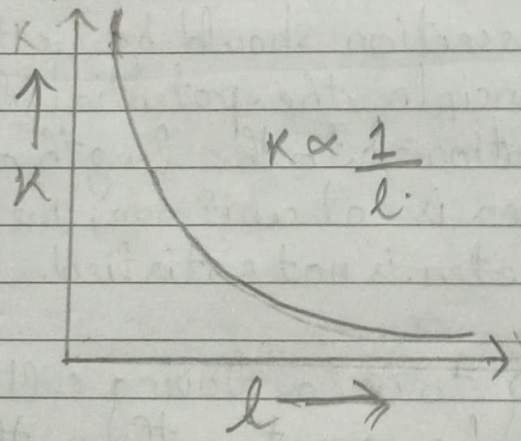
Ans- According to the principle of potentiometer.

$$V \propto l$$
$$\Rightarrow V = Kl.$$
$$\Rightarrow K = \frac{V}{l}.$$

Hence, the potential gradient is inversely proportional to the length of the wire. $K \propto \frac{1}{l}$.

So,

Graph will be $K \sim l$.



Q.4 Below figure shows the circuit diagram of a potentiometer for determining the emf E of the cell of negligible internal resistance.

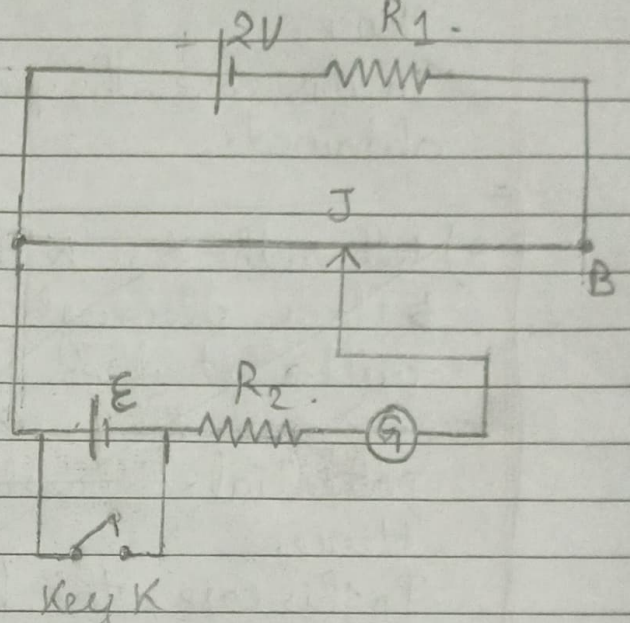
a) What is the purpose of using high resistance R_2?

b) How does the position of balance point (J)

change when the resistance R_1 is increased?

c) Why cannot the point be obtained.
1) When the emf $\mathcal{E}$ is greater than 2V, and.
2) When the Key K is closed.

Ans-a) The purpose of using high resistance R_2 along the standard cell is to protect the galvanometer by ensuring low current flowing through it when the balanced point is achived.



b) When the resistance R_1 is increased, the potential drop across the Resistance R_1 is also increased, so, the potential supplied to the potentiometer is decreased. Hence,
the Potential across the wire AB becomes less than that of the standard cell of emf $\mathcal{E}$ provided.
Therefore,
In order to get a potential greater than the emf $\mathcal{E}$ so that the balance point is obtained, the length of the wire is to be increased.
So,
For increasing the length, the balance point is shifted towards the point B.

c) 1) When, the emf $\mathcal{E}$ is greater than, ~~the~~ RV, the potential drop across the wire AB supplied, will be less than emf $\mathcal{E}$.
But to achive the balance point, the potential across AB should be equal to emf $\mathcal{E}$.
Hence,
In this case, the ~~pai~~ balance point cannot be obtained.

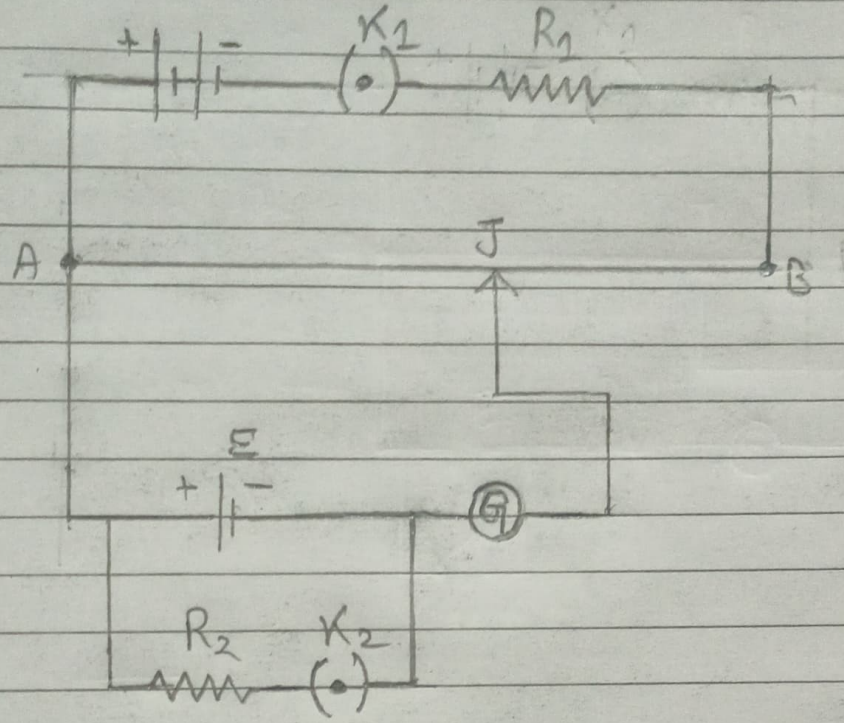
~~2) When the Key K is closed, the current will flow through the resistance R_2, which will affect the potential across the wire AB and, they will not bear the same potential. It will also affect the.~~
~~Hence,~~
~~In this case, the balance point cannot be obtained.~~

2) When the Key K is closed, the current will flow through the resistance R_2 which will affect the standard cell containg emf $\mathcal{E}$ and so, they will not bear the same potential as potential across AB.
Hence,
In this case, the balance point cannot be obtained.

Q.5 For the circuit shown in the bellow figure would the balancing length increases, decrease or remain the same if.
a) R_1 is decreased.

b) R_2 is increased without any change (in each case) in the rest of the circuit? Justify your answer in each case.

Ans



Ans a) If R_1 is decreased, the balancing length 'l' decreases.
Because it will decrease the potential drop across R_1 resistance, so, that the potential drop across potentiometer wire AB becomes more than the emf of standard cell.

b) If R_2 is increased, the balancing length of this potentiometer increases.
because, it will increase the terminal voltage across the standard cell and it will be more than potential across AB. So, in order to increase it the balancing length will increase.