

## **AIM**

*To study the variation in potential drop with length of a wire for a steady current.*

## **MATERIALS REQUIRED**

*A battery eliminator of range of (0-6 V) or a freshly charged accumulator, one way key, an ammeter, a rheostat, a voltmeter, a potentiometer, connecting wires and sand paper.*

## **THEORY**

*Let  $V$  be potential difference across a portion of wire whose resistance is  $R$ .*

*According to Ohm's law, potential difference across wire,*

$$V = IR$$

*where  $I$  is the current passing through the wire of resistance  $R$ .*

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

*where  $\rho$  is the resistivity of material of the wire,  $l$  is the length of the portion of the wire and  $A$  is the area of cross-section of wire.*

$$\text{Therefore, } V = I \frac{\rho l}{A}$$

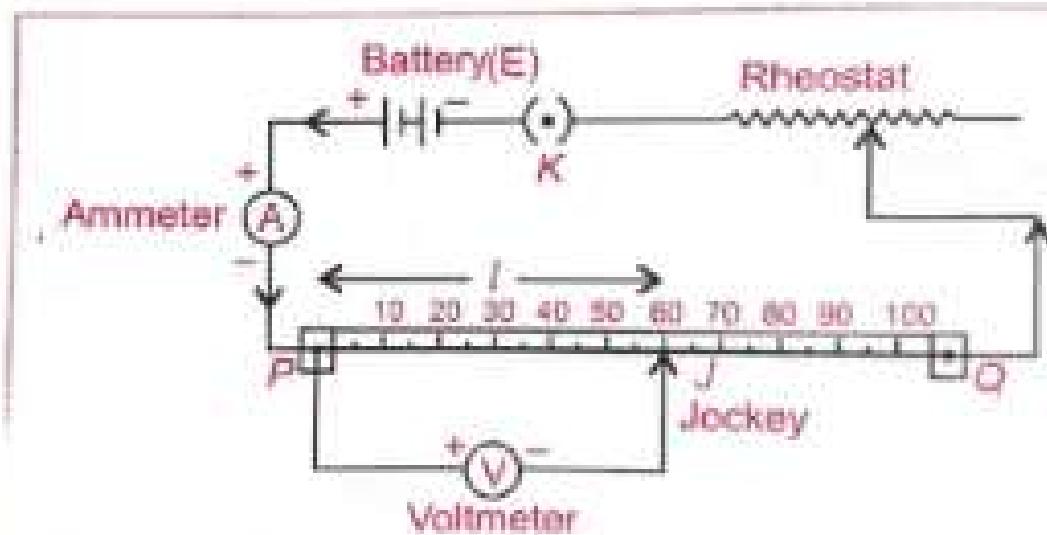
$$\text{Or } \frac{V}{I} = \frac{\rho l}{A} = \text{constant (say } k\text{)}$$

$$\text{i.e., } V = kl, \text{ where } k \text{ is called potential gradient}$$

Potential gradient is defined as the fall of potential per unit length of a wire of uniform cross-section. It remains same for the entire length of the given wire.

## **PROCEDURE**

1. Drew a circuit diagram for experimental arrangement and connected all the components like a battery ( $E$ ), a rheostat, a voltmeter, an ammeter, and one way key to terminal P and Q of a potentiometer wire as showed in figure.



2. Observed that the positive terminal of voltmeter is connected to the positive terminal of potentiometer.
3. Pressed the jockey at a point P, i.e., at the zero cm marked of wire where the positive terminal of battery is connected. Recorded the voltmeter reading. This reading must be zero but

*if it is not so then the zero correction to the voltmeter must be noted.*

*4. Now pressed jockey at different lengths of wire away from its first end P and recorded the corresponding readings of voltmeter.*

*5. Calculated potential gradient every time.*

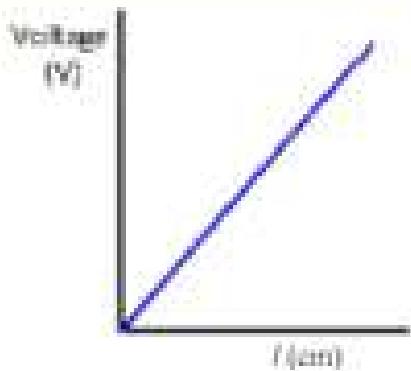
## **OBSERVATIONS**

S.No. of observations	Length( $l$ ) of wire through which P.D is measured (cm)	Potential difference measured by voltmeter V (volt)	Potential gradient $K = V/l$ (volt per cm)
1.	0	0	
2.	50	0.2	0.004
3.	100	0.6	0.006
4.	150	0.8	0.005
5.	200	1.2	0.006

*Reading of constant current flowing through the potentiometer wire = V*

## CALCULATION AND GRAPH

Plot a graph between  $V$  and  $I$ . This will be a straight line as showed in figure . The slop of the line gives potential gradient.



## RESULT

1. Within the experimental error, it is observed that the potential gradient for the given wire carrying a current is nearly constant throughout the wire.
2. The  $V$  vs  $I$  graph is a straight line showing that potential drop increases with the increases in length of the wire.
3. Mean value of potential gradient ( $k$ ) =  $\text{V cm}^{-1}$

## **PRECAUTIONS**

1. All the connections should be clean and tight.
2. The reading of current through ammeter should be unchanged throughout the experiment.
3. Plug should be inserted in the key only when the observations are being taken.

## **SOURCES OF ERROR**

1. The potentiometer wire used may not be of uniform area of cross-section.
2. Voltmeter/ammeter may not be connected correctly in the circuit.

### **Q (i) Why is the current kept constant in this experiment?**

The current ( $I$ ) must be kept constant to ensure a **linear relationship** between the potential difference ( $V$ ) and the length ( $l$ ) of the wire, and to calculate the potential gradient ( $k$ ) accurately.

- The **potential gradient ( $k$ )** is defined as  $k = \frac{I\rho}{A}$ . If the current  $I$  varies,  $k$  would not be constant, and the  $V$  vs.  $l$  graph would not be a straight line, making the calculation of a single, meaningful potential gradient impossible.
- This constancy also ensures that the **specific resistance ( $\rho$ )** calculation remains valid, as  $\rho$  is determined from the constant slope  $k$  and the constant current  $I$ .

### **Q (ii) How can you increase the sensitivity of the potentiometer?**

The **sensitivity** of a potentiometer is its ability to measure a very small potential difference or detect a small change in potential difference. High sensitivity is achieved by having a **smaller potential gradient ( $k$ )**.

$$k = \frac{\text{Emf of Driver Cell}(E)}{\text{Total Length of Potentiometer Wire}(L)}$$

To decrease the potential gradient ( $k$ ):

- **Increase the total length ( $L$ ) of the potentiometer wire:** This is the most effective method, as it spreads the total potential drop over a greater distance, hence decreasing  $k$ .
- **Decrease the current ( $I$ ) flowing through the potentiometer wire:** This is typically done by **decreasing the voltage of the driver cell ( $E$ )** or by **increasing the series resistance** (e.g., using a rheostat) in the driver circuit.

### **Q (iii) How can you use the above results and measure the emf of a cell?**

You can use the constant **potential gradient ( $k$ )** determined from your  $V$  vs.  $l$  graph to find the **electromotive force (emf,  $E_{cell}$ )** of an unknown cell.

1. **Set up the circuit** to compare the unknown cell's emf with a portion of the potentiometer wire's potential drop. The positive terminal of the unknown cell is connected to the high-potential end (terminal A), and the negative terminal is connected to a galvanometer and then to the jockey.
2. **Find the balancing length ( $l_{bal}$ ):** Slide the jockey along the potentiometer wire until the **galvanometer shows zero deflection**. At this point, the cell draws no current, and the potential difference across the length  $l_{bal}$  of the wire is exactly equal to the emf of the cell.
3. **Calculate the emf:** Since the potential drop across the length  $l_{bal}$  is equal to the product of the potential gradient ( $k$ ) and the balancing length ( $l_{bal}$ ), the emf of the cell is:

$$E_{cell} = k \times l_{bal}$$