To Determine the Internal Resistance Of a Given Primary Cell Using Potentiometer

Aim

To determine the internal resistance of given primary cell using potentiometer.

Apparatus

A potentiometer, a battery (or battery eliminator), two one-way keys, a rheostat of low resistance, a galvanometer, a high resistance box, a fractional resistance box, an ammeter, a voltmeter, a cell (say Leclanche cell), a jockey, a set square, connecting wires and a piece of sand paper.

Theory

The internal resistance of a cell is given by

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

where and l_2 are the balancing lengths without shunt and with shunt, respectively, and R is the shunt resistance in parallel with the given cell.

Circuit diagram

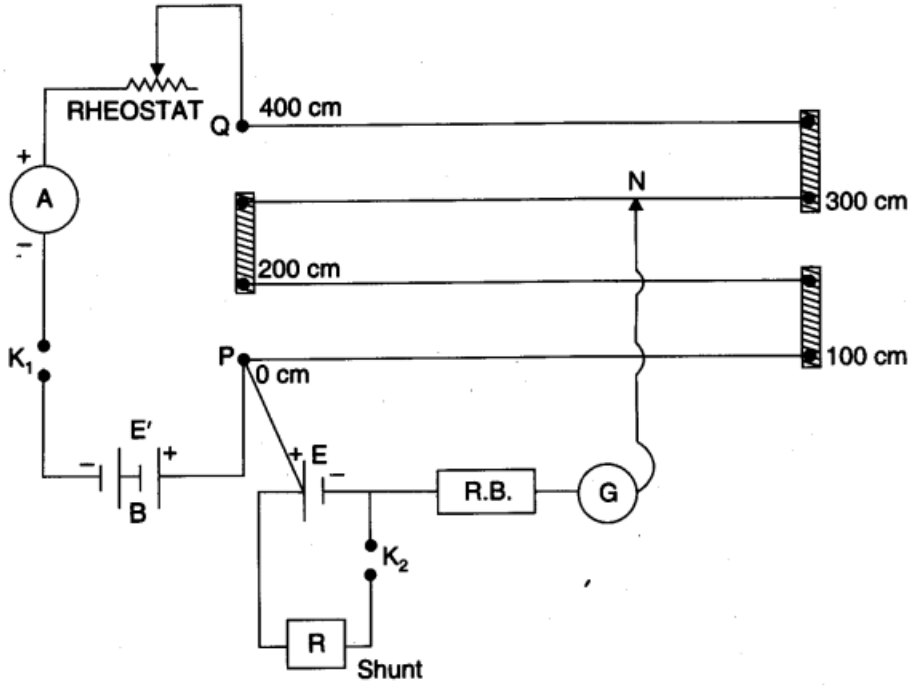

Fig. Internal resistance of a cell.

Procedure

1. Make the connections accordingly, as shown in circuit diagram.
2. Clean the ends of the connecting wires with sand paper and make tight connections according to the circuit diagram.
3. Tight the plugs of the resistance box.
4. Check the e.m.f. of the battery and cell and see that e.m.f. of the battery is more than that of the given cell, otherwise null or balance point will not be obtained (E' > E).
5. Take maximum current from the battery, making rheostat resistance small.
6. To test the correctness of the connections. (Insert the plug in the key K_1 and note the ammeter reading. Take out 2000 Ω resistance plug from the resistance box. Place the jockey first at the end P of the wire and then at the end Q. If the galvanometer shows deflection in opposite directions in the two cases, the connections are correct).
7. Without inserting the plug in the key K_2 adjust the rheostat so that a null point is obtained on the fourth wire of potentiometer.
8. Insert the 2000 ohm plug back in its position in resistance box and by slightly adjusting the jockey near the previously obtained position of null point, obtain the null point position accurately, using a set square.
9. Measure the balancing length l_1 between this point and the end P of the wire.
10. Take out the 2000 ohms plug again from the resistance box R.B. Introduce the plugs in key K_1, as well as in key K_2. Take out a small resistance (1-5 Ω) from the resistance box R connected in parallel with the cell.
11. Slide the jockey along the potentiometer wire and obtain null point.
12. Insert 2000 ohms plug back in its position in R.B. and if necessary make further adjustment for sharp null point.
13. Measure the balancing length l_1 from end P.
14. Remove the plug keys at K_1 and K_2. Wait for some time and for the same value of current (as shown by the ammeter), repeat the steps 7 to 13.
15. Repeat the observations for different values of R repeating each observation twice.
16. Record your observations as given below.

Observations

1. Range of voltmeter =……
   Least count of voltmeter = ……
   E.M.F. of battery (or battery eliminator) = ……
   E.M.F. of cell = ……

2. **Table for Lengths**

Serial No. of Obs.	Corrected ammeter reading (A)	Balance point when E_1 (Leclanche cell) in the circuit l_1 (cm)			Balance point when E_2 (Daniel cell) in the circuit l_2 (cm)			$\frac{E_1}{E_2} = \frac{l_1}{l_2}$
(1)	(2)	1 (3a)	2 (3b)	Mean l_1 (3c)	1 (4a)	2 (4b)	Mean l_2 (4c)	(5)
1.	.....	.....	.....	.....	.....	.....	.....	.....
2.	.....	.....	.....	.....	.....	.....	.....	.....
3.	.....	.....	.....	.....	.....	.....	.....	.....

Calculations

1. For each set of observation find mean and l_2 and write in column 3c and 3f.
2. Calculate value of r for each set and write it in column 5.
3. Take mean of values of r recorded in column 5.

Result

The internal resistance of the given cell is……

Precautions

Same as in Experiment 4 and other precautions are as:

1. The e.m.f. of the battery should be greater than that of the cell.
2. For one set of observation the ammeter reading should remain constant.
3. Current should be passed for short time only, while finding the null point.
4. Rheostat should be adjusted so that initial null point lies on last wire of the potentiometer.
5. Cell should not be disturbed during experiment.
6. Jockey should not be rubbed against the potentiometer wire.

Viva Voce

Question. 1. What do you understand by the e.m.f. of a cell?
Answer. Electromotive force i.e., e.m.f. of a cell is the potential difference across the terminals of the cell when the cell is in an open circuit i.e., when no current is drawn from the cell.

Question. 2. What is a potentiometer?
Answer. It is an instrument used to measure potential difference or e.m.f. of a cell.

Question. 3. Why is it called a potentiometer? ,
Answer. Because it measures potential difference between any two points of electric circuits.

Question. 4. What is the principle of a potentiometer?
Answer. It works On the principle that for a constant current, fall of potential along a uniform wire is directly proportional to its length.

Question. 5. What is potential gradient?
Answer. It is the fall of potential per unit length of the potentiometer wire. K =V/l.

Question. 6. How does the potential gradient vary along the length of the wire from end P to end Q?
Answer. Potential gradient is same throughout if the wire has uniform cross-section and material density.

Question. 7. What kind of source of e.m.f. should be used as auxiliary battery?
Answer. The e.m.f. of the source must be steady. A freshly charged accumulator should be used for this purpose.

Question. 8. What should be the order of magnitude of the e.m.f. of the auxiliary battery?
Answer. The e.m.f. of the auxiliary battery should be slightly greater than the e.m.f. of the individual cells. (With battery of lesser e.m.f., null point will not be obtained on the potentiometer wire).

Question. 9. Why do we use a rheostat in the battery circuit?
Answer. To vary the potential gradient.

Question. 10. What purpose is served by varying the potential gradient?
Answer. A lower potential gradient gives more length of wire upto null point. Accuracy becomes more.

Question. 11. On what factors does the potential gradient depend?
Answer. Potential gradient depends directly on the strength of the current and resistance per cm of the wire. K = Ip/A.

Question. 12. What is the preferred material used for making potentiometer wires?
Answer. Manganin. It is characterised by a low temperature coefficient of resistance and a high resistivity.

Question. 13. Why do we want the material of the potentiometer wire to have a low temperature coefficient of resistance?
Answer. There is invariably some heating of the potentiometer wire when a current flows through it. A material with a low temperature coefficient ensures that its resistance does not change much because of this heating.

Question. 14. Why don't we use a copper wire as a potentiometer wire?
Answer. Copper has a high temperature coefficient of resistance and low resistivity and hence a copper wire will have a low resistance. There would then be no appreciable potential drop across the ends of the potentiometer wire.

Question. 15. Which materials can be used for making potentiometer wire?
Answer. The alloys like manganin, constantan etc.

Question. 16. What do you mean with sensitivity of a potentiometer?
Answer. Sensitivity of a potentiometer is the smallest potential difference that it can measure.

Question. 17. Why is a ten-wire potentiometer more sensitive than a four-wire one?
Answer. The potential gradient, under same conditions, decreases with an increase in the length of the potentiometer wire. Hence, a 10-wire potentiometer (having a smaller potential gradient) is more sensitive than a 4-wire one.

Question. 18. How will you know that the apparatus can give a null point?
Answer. The jockey is put at the two ends of the potentiometer wire. The deflection in the galvanometer must be in opposite directions.

Question. 19. What will you conclude if the deflection of the galvanometer is in same direction at both the ends?
Answer. The reasons may be

1. the positive terminals of all the cells are not connected at one point.
2. the potential difference between the ends of the wire is less than the e.m.f. of the cell which is to be measured.
3. the e.m.f. of driving cell is less than the e.m.f. of each cells whose e.m.f. to be compared or measured.

Question. 20. How are above situations corrected?
Answer.

1. Connections of positive terminals are checked.
2. Current in potentiometer wire is increased.

3. $E > E_1$ or $E > E_2$.

Question. 21. Under what conditions galvanometer will give no deflection when jockey is put on the wire?
Answer. The reason may be

1. the cell whose e.m.f. is being measured, is totally damaged to have infinite internal resistance.
2. connecting wire in the galvanometer circuit may be broken.

Question. 22. Under what conditions deflection in the galvanometer is shaky?
Answer. The reason may be

1. The e.m.f. of the battery or the cells may be fluctuating.
2. The circuit has a loose contact somewhere.

Question. 23. Why should we use a sensitive galvanometer?
Answer. A sensitive galvanometer will respond to even a small departure from the exact balance point and will hence enable us to locate the balance point with greater precision.

Question. 24. Why do we need a protective series resistance/shunt along with a sensitive galvanometer?
Answer. To prevent it from damage from the flow of excessive currents that may exist when the jockey is far from the balance point.

Question. 25. Does the use of a series protective resistance/shunt effect the location of the balance point?
Answer. No; however, it makes the galvanometer less sensitive. We therefore, remove it once we are near the balance point.

Question. 26. Why do we not want the balance point to be on the first wire, say?
Answer. The smaller is the balancing length, the greater is the relative uncertainty in its location.

Question. 27. What is the merit of a potentiometer over a voltmeter in measurement of e.m.f. of a cell?
Answer. E.M.F. measured by potentiometer is more accurate because the cell is in open circuit, giving no current.

Question. 28. How will you determine specific resistance of potentiometer wire material?
Answer. We measure V across a known length l of the wire. We measure diameter D of wire and

current I through it. Then $R = \frac{\rho l}{\pi D^2/4} = \frac{V}{I}$. From which ρ can be calculated.

Question. 29. What do you mean by internal resistance of a cell?
Answer. It is the resistance offered by the electrolyte to the flow of ions to their respective electrodes.

Question. 30.Is there any change in the internal resistance of cell in open and closed circuit?
Answer.

Question. 31. On what factors does the internal resistance of a cell depend?
Answer. Internal resistance of a cell depends upon :

1. Distance between electrodes and is directly proportional to its
2. Facing surface area of the electrodes in electrolyte and is inversely proportional to it
3. Nature of electrolyte and is inversely proportional to its specific conductivity
4. Temperature increases, the internal resistance decreases and vice-versa.
5. Internal resistance increases with the use of cell.

Question. 32. Does the internal resistance depend on the current drawn from the cell?
Answer. Yes, the internal resistance usually increases as more current is drawn from the cell.

Question. 33.Can we find the internal resistance of an accumulator or secondary cell?
Answer. No. the internal resistance of an accumulator is so small (= 0.01 Q) that this method cannot be used.

Question. 34.Why a cell should not be disturbed during experiment?
Answer. Disturbing of the cell may change the factors (Q. 31 above) on which the internal resistance of the cell depends.

Question. 35.What other measurements can be made by a potentiometer?
Answer. A potentiometer can be used for measuring small thermo e.m.f. It can also be used for calibrating voltmeter and ammeter. It can be used to measure and control stress, temperature, radiation, pH, frequency etc.

Question. 36. Can you measure e.m.f. by a voltmeter?
Answer. No. The voltmeter measure the terminal potential difference of a cell because it draw some current
V = E -Ir, when I≠0, then V < E.

Question. 37.Which voltmeters can be used to measure the e.m.f. of the cells?
Answer. Electric voltmeter. Vacuum tube volt meter (VTVM) after nearly infinite resistance. So the current drawn is minimum, nearly zero. These two voltmeter are act as ideal voltmeter.

Question. 38. Is the terminal potential difference (V) and e.m.f. (E) of a cell different? Explain.

Answer.
Yes.

(*i*) When the Cell is discharged (current is taken)

$$V = E - Ir, (V < E)$$

(*ii*) When the cell is charged

$$V = E + Ir, (V > E)$$

(*iii*) When the $I = 0$, or $r = 0$ or $R \to \infty$, then $V = E$.

Question. 39. Does the at position of balance point (null point) mean no current through the potentiometer?
Answer. No. the current always flow in potentiometer wire. These is no current in galvanometer f because there is no current drawn from the cell whose e.m.f. is to be measured or compared.

Question. 40. Does the potentiometer is used to determine the internal resistance of (i) primary cell (ii) secondary cell?
Answer. The potentiometer is used to determine the internal resistance of primary cell only but not secondary cell because of very small resistance (0.02 Q).

Question. 41. What are the factors on which the e.m.f. of a cell depends?
Answer.

1. Nature of electrodes,
2. Nature of electrolyte,
3. concentration of electrolyte,
4. Temperature of electrolyte.

Question. 42. Why is a potentiometer preferred over a voltmeter for measuring the e.m.f. of cell?
Answer. A potentiometer draws no current from the cell whose e.m.f. is to be measured. On the other hand, the voltmeter always some current. Thus e.m.f. measured by voltmeter will be slightly less than the e.m.f. measured by potentiometer.
V = E -Ir

Question. 43. Why do we prefer a potentiometer with a longer bridge wire?
Answer. When the bridge wire is longer, the potential gradient is smaller. Smaller the potential gradient, more is the sensitivity of potentiometer wire.

Question. 44. What are the factors on which internal resistance of a cell depends.
Answer.

1. Nature of electrodes
2. Nature of electrolyte
3. Concentration of electrolyte
4. Temperature of electrolyte
5. Distance between the electrodes
6. The area of electrodes immersed in electrolyte.

Question. 45. Can we consider the potentiometer as an ideal voltmeter?
Answer. Yes. At null point, the potentiometer does not draw any current. Hence it measure the emf. The potentiometer is equivalent to an ideal voltmeter.

$$V = E - Ir$$

Let $I = 0$, then

$$V = E.$$