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FACTORS AFFECTING INTERNAL RESISTANCE/EMF OF A

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INDEX

CERTIFICATE

This is to certify that

AYUSHI SHAKYA, a student of class XII

has successfully completed the research project on the topic

"**FACTORS AFFECTING INTERNAL RESISTANCE/EMF OF A CELL**"

under the guidance of Mrs. Manjusha Rawat (Subject teacher).

This project is absolutely genuine and does not indulge in plagiarism of any kind. The references taken in making this project have been declared at the end of this report.

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Ayushi Shakya

XII A

INTRODUCTION

ELECTROCHEMICAL CELLS

An electrochemical cell is a device by which electric energy is generated at the cost of chemical energy due to chemical action taking place in the cell. They are of two types:

1. Primary Cells
2. Secondary Cells

PRIMARY CELL: It is the cell in which electrical energy is produced due to chemical energy. The chemical reaction in the cell is irreversible.
E.g. Daniel cell, Leclanche cell.

SECONDARY CELL: It is that cell in which the electrical energy is first stored up as chemical energy and when the outside circuit is closed to draw the current from the cell the stored chemical energy is reconverted into electrical energy. The chemical reactions in this case are reversible.
E.g. lead acid accumulator, Edison cell.

DANIEL CELL

The Daniel cell was invented by a British chemist, John Frederic Daniel. In the Daniel cell, copper and zinc electrodes are immersed in a solution of copper (II) sulphate ($CuSO_4$ (aq)) and zinc (II) sulphate ($ZnSO_4$ (aq)) respectively. The two half cells are connected through a salt bridge. Here zinc acts as anode and copper acts as cathode.

At the anode, zinc undergoes oxidation to form zinc ions and electrons. The zinc ions pass into the solution. If the two electrodes are connected using an external wire, the electrons produced by the oxidation of zinc travel through the wire and enter into the copper cathode, where they reduce the copper ions present in the solution and form copper atoms that are deposited on the cathode.

The anodic reaction is represented as:

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$
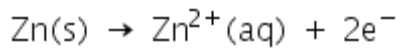
The cathodic reaction is represented as:
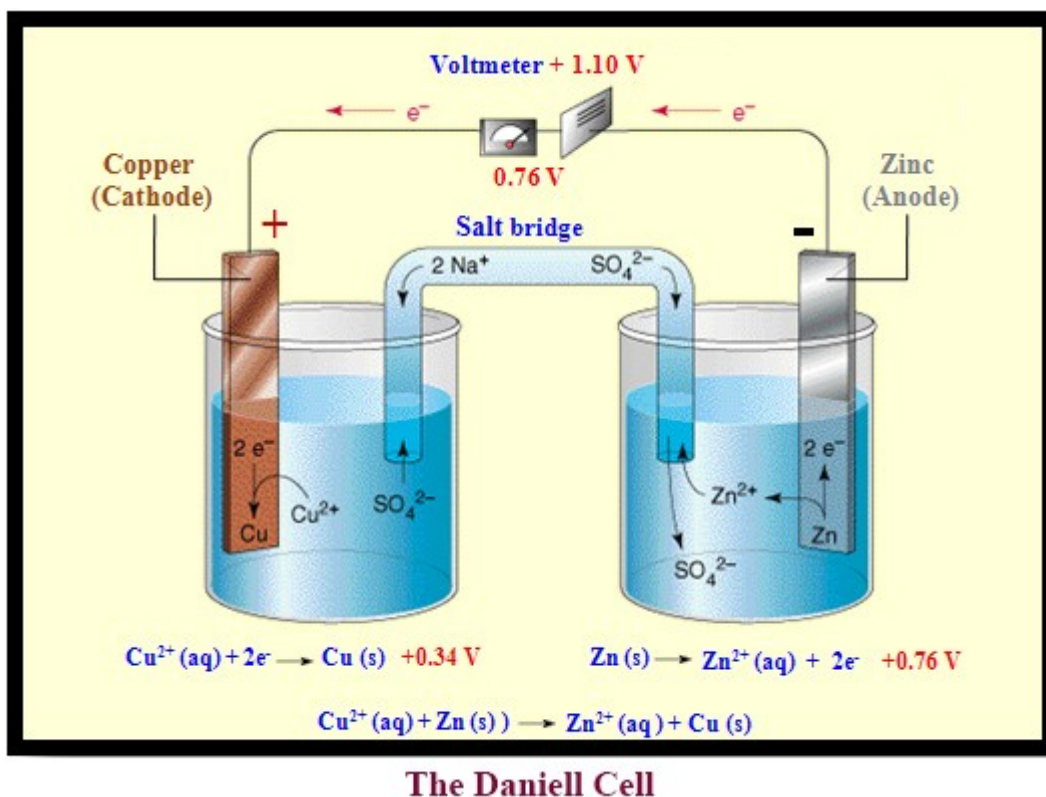
$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$
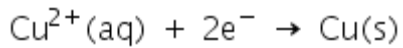
The difference of excess electrons on the anode and deficit of electrons on the cathode creates an electrical potential between the two electrodes.

The ions pass through the salt bridge to maintain charge balance until such a time as the anode and cathode reach electrical equilibrium of zero volts as chemical equilibrium is reached in the cell.

The so-called "salt bridge" is not made of salt but could be made of material able to wick the cations and anions (salts) in the solutions, where the flow of positively charged cations along the "bridge" amounts to the same number of negative charges flowing in the opposite direction.

ELECTROMOTIVE FORCE

Electromotive force, also called **emf** (denoted and measured in volt), is the voltage developed by any source of electrical energy such as a battery or dynamo. It is generally defined as the electrical potential for a source in a circuit.

Voltmeter + 1.10 V

Copper (Cathode)

0.76 V

Zinc (Anode)

Salt bridge

2 Na⁺ SO_4^{2-}

$2\,e^-$ Cu²⁺ SO_4^{2-} Cu

$2\,e^-$ Zn²⁺   Zn SO_4^{2-}

$Cu^{2+}(aq) + 2e^- \longrightarrow Cu\ (s) \quad +0.34\ V$ $Zn\ (s) \longrightarrow Zn^{2+}(aq) + 2e^- \quad +0.76\ V$

$$Cu^{2+}(aq) + Zn\ (s)) \longrightarrow Zn^{2+}(aq) + Cu\ (s)$$

The Daniell Cell

OBJECTIVE

To study the various factors on which the internal resistance/emf of a cell depends.

APPARATUS

A Potentiometer , a battery (battery eliminator) , two way keys , a rheostat of low resistance , a galvanometer , a high resistance , an ammeter , a cell , a Jockey , a set square , connecting wires , water bath , thermometer(0-100°C) , burner , tripod stand , wire gauge .

CIRCUIT DIAGRAM
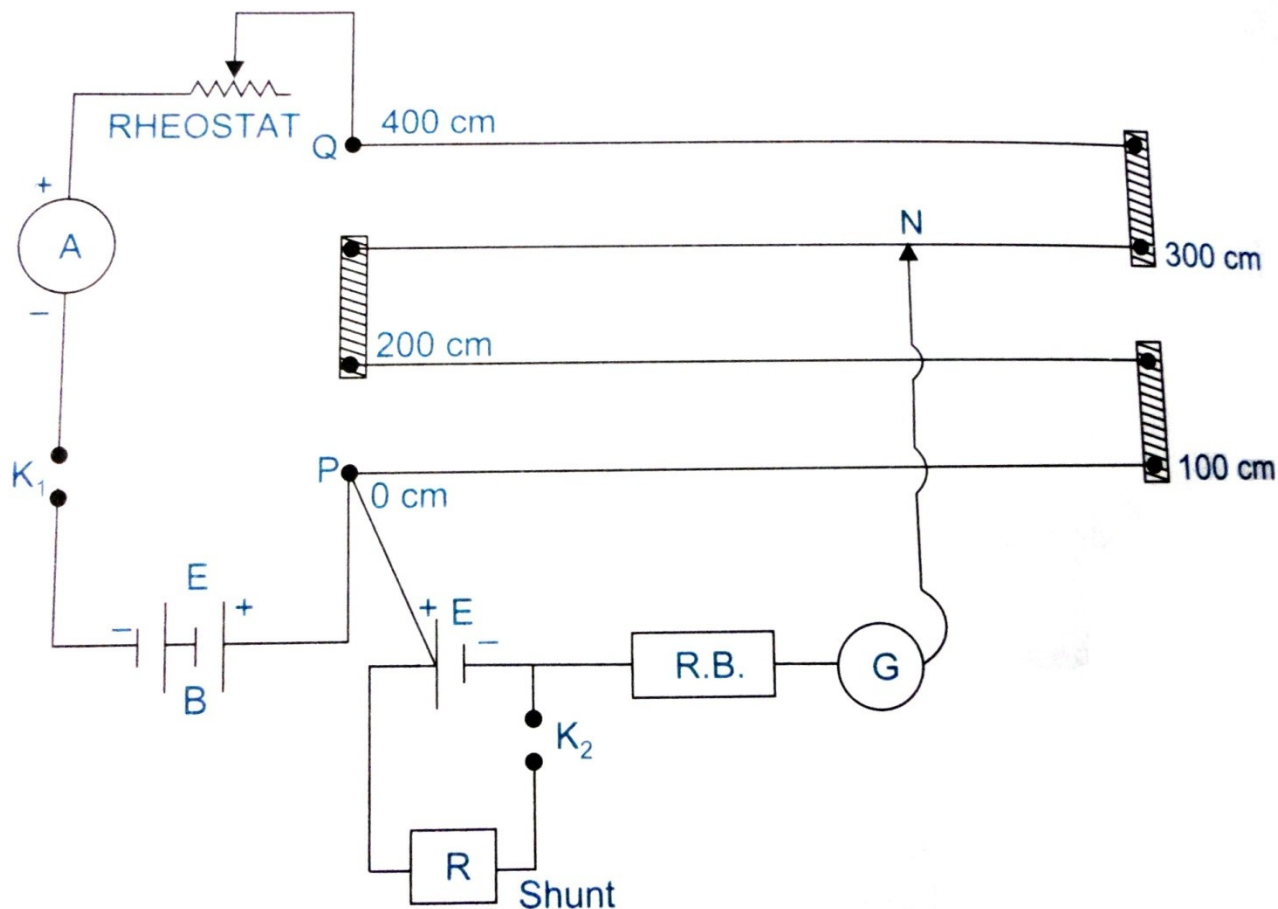
Figure: Circuit diagram for internal resistance of a cell

THEORY

The internal resistance of a cell is the resistance offered by its electrolyte to the flow of ions. The internal resistance of a cell

   i.   Is directly proportional to the distance between the electrodes.
  ii.   Is inversely proportional to facing surface area of the electrodes in electrolyte.
 iii.   Decrease with increase in temperature of electrolyte.
 iv.   Is inversely proportional to concentration of electrolyte.

The internal resistance of a cell is given by

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

Where l_1 , l_2 are the balancing lengths without resistance and with resistance (shunt) , respectively and R is the shunt resistance in parallel with the given cell.

PROCEDURE

Step 1

1. Draw the circuit diagram showing the scheme of connections.
2. Clean the ends of the connecting wires with sand paper and make tight connections according to the circuit diagrams.
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. and see that e.m.f. of the battery is more than that of 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 corrections of the connections.**(insert the plug in the key K_1 and note the ammeter reading .Take out 2000 ohm resistance plug from resistance box. Place the jokey first at the end P of the wire and then at the end Q. If the galvanometer shows deflection in opposite direction 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 4th wire of potentiometer.
8. Insert the 2000 ohm plug back in the position in resistance box and by slightly adjusting the jockey near the previous obtained position of null point, obtain null point position accurately, using a set square.
9. Measure the balancing length l_1 between the point and the end P of the wire.
10. Take out the 2000 ohm plug again from the resistance box R.B. introduce plugs in the key K_1 ,as well as in key K_2 . Take out 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_2 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 ammeter) repeat the steps 7 to 13.
15. Repeat the observations for different values of R repeating each observation twice.
16. Calculate the internal resistance of cell by using the above relation for r.

Step 2
   To see the effect of distance between the electrodes on internal resistances keeping the other factors constant ,vary separation between electrodes and measure

internal resistance in each case.

Step 3

To see the effect of the temperature of electrolyte on internal resistance by keeping other factors constant.
Keep primary cells in water bath to heat the electrolyte. Determine the internal resistance at various temperatures.

Step 4

To see the effect of concentration (nature) of electrolyte on internal resistance by :-
Keeping the other factors constant , decrease concentration of electrolyte by adding the distilled water and determine internal resistance of cell in each case .

OBSERVATIONS

(A)Internal resistance of cell

1. Table for internal resistance:-

S.No.	Ammeter Reading (A)	Pos. of null point (cm)		Shunt Resistance R (Ω)	$r=(\dfrac{(l_1-l_2)/l_1}{})R$ Ω
		With R (l_1)	Without R (l_2)		
1.	0.3	660.5	35.5	1	0.94
2.	0.3	660.5	77.2	2	1.77
3.	0.3	660.5	108.3	3	2.51

(B) To study the effect of separation between the electrodes

2. Table for effect of separation between electrodes:-

S.No.	Separation between Electrodes-d (cm)	Balancing length (cm) (l_1)	Balancing length (cm) (l_2)	$r=(\dfrac{(l_1-l_2)/l_1}{})R$ (Ω)	r/d
1.	1.2	326.6	276.9	0.456	0.38
2.	2.5	320.7	219.1	0.95	0.38
3.	3.7	660.5	350.9	1.406	0.38

(c) Effect of temperature of electrolyte on the internal resistance

3. Table for effect of temperature:-

S.No.	Temperature (T) °C	l_1 (cm)	l_2 (cm)	Resistance R (Ω)	$r=(\dfrac{l_1-l_2}{l_1})R$ (Ω)	Tr (ΩK)
1.	40	325	12	1	0.96	301.44
2.	32	552	23.6	1	0.95	291.96
3.	27	660.5	35.5	1	0.94	283.87

CONCLUSIONS

1. The Electromotive Force of the cell is constant and is equal to E = 0.98 Volt
2. The internal resistance of a cell is directly proportional to the separation between the electrodes.
3. The internal resistance of a cell is inversely proportional to the area of the electrodes dipped in electrolyte.
4. The internal resistance of a cell is inversely proportional to the temperature of electrolytes.
5. The internal resistance of a cell is inversely proportional to the concentration of the electrolyte.

PRECAUTIONS

1. The connections should be neat , clean and tight.
2. The plugs should be introduced in the keys only when the observations are to be taken.
3. The positive polls of the battery E and cells E1 and E2 should , all be connected to the terminal at the zero of the wires.
4. The jockey key should not be rubbed along the wire. It should touch the wire gently.
5. The ammeter reading should remain constant for a particular set of observation. If necessary , adjust the rheostat for this purpose.
6. The e.m.f. of the battery should be greater than the e.m.f.'s of the either of the two cells.
7. Some high resistance plug should always be taken out from resistance box before the jockey is moved along the wire.

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

SOURCES OF ERROR

1. The auxiliary battery may not be fully charged.
2. The potentiometer wire may not be of uniform cross-section and material density throughout its length.
3. End resistances may not be zero.

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