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عاصمة الثقافة الاسلامية
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Physics Lab 2

Student Name:

Student No.: **Sec:**

Day: **Date:**

Experiment No.:

Experiment Name:

Student Partners:

Lecturer:

Experiment No. 4
Potentiometer

Objective:

To calibrate a one meter slide wire potentiometer using a standard cell and then to use this potentiometer **to measure the emf of a test cell**. The terminal voltage of the same test cell is then measured as different load resistors are connected across the test cell and these data are used **to determine the internal resistance of the test cell**.

Equipment:

1. Standard Battery (power supply of fixed voltage of 5V).
2. Voltmeters.
3. Box resistance.
4. A test cell as unknown emf.
5. Connecting cables.

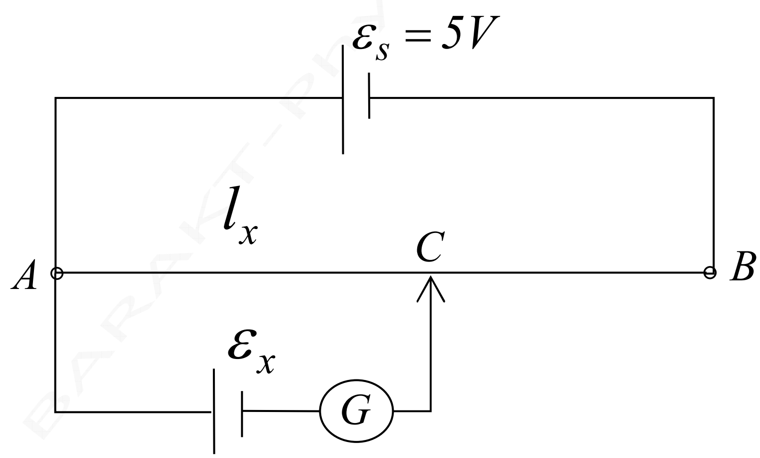

Figure 4-1.
Basic circuit diagram for a potentiometer. The point C is the sliding contact which can be adjusted for zero current deflection through the galvanometer.

Theory

The electromotive force (emf) of a cell is its terminal voltage when no current is flowing through it. The terminal voltage of a cell is the potential difference between its electrodes. A voltmeter cannot be used to measure the emf of a cell because a voltmeter draws some current from the cell. To measure a cell's emf a potentiometer is used since in a potentiometer measurement no current is flowing. It employs **a null method** of **measuring potential difference**, so that when a balance is reached and the reading is being taken, no current is drawn from the source to be measured.

In this method (refer to Figure 4.1) a uniform, bare slide wire AB is connected across the power supply. If you were to connect a voltmeter between the + power supply terminal and point A you would measure essentially zero volts. If you were to now connect the voltmeter between the + power supply and point B you would measure a voltage equal to the terminal voltage of the power supply which is approximately 5 volts. The potential relative to point A then varies from zero at A to approximately 5 volts at B.

The cell whose emf is to be determined is then connected so that its emf opposes the potential along the wire. **At some point C the potential difference between A and C** is **exactly equal to the <u>emf of the cell</u> so that if the other terminal of the cell is connected to the point C, no current will flow**. The calibration procedure is to locate this point C using a standard cell whose emf is accurately known (**emf = 5 volts**). You then know that at this point C the potential difference relative to point A is exactly 5 volts. **C is called Null point or balance point**

Since the wire is uniform, the length of wire spanned is proportional to the potential drop and the wire **<u>can now be calibrated in volts per cm</u>**. **The emf of an unknown cell is then found by finding a new point C whose potential is exactly equal to the emf of the unknown cell and multiplying this new distance AC times the calibration factor determined using the standard cell.**

Calibration factor: $f = \dfrac{\varepsilon_s}{L_{AB}}$,

$$V_{AC} = \varepsilon_x = l_{AC} \cdot f \qquad\qquad \varepsilon_x = \varepsilon_s \frac{L_x}{L_s} = \varepsilon_s \frac{L_{AC}}{L_{AB}}$$

It is crucial in this experiment that the current flowing through wire AB remain constant throughout the experiment. If the current varies then the potential at all points along the wire will vary and you cannot trust your calibration. An ammeter is included in series with wire AB so that you can monitor this current. (See Figure 4.2.) The circuits used in this experiment are shown below in Figures 4.2.

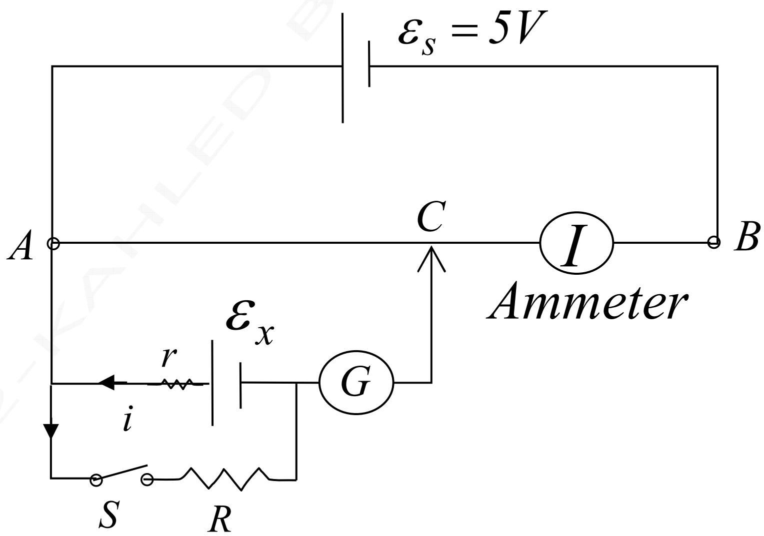

Figure 4-2.
The load resistance R is not external to the test cell, but it is used to determine the voltage across the load resistor *R* and finding the internal resistance *r*.

Here ε_s is the standard cell (emf = 5 volts), and ε_x is the unknown cell whose emf is to be measured. G is the galvanometer which has an internal resistor R_1 in series with the meter to decrease its sensitivity. Once the potentiometer is balanced by adjusting point C until there is no deflection of G, switch S (a pushbutton on top of the galvanometer) is closed to increase the sensitivity of G by shorting out R_1. Point C is then further adjusted with S closed until there is no deflection of G.

Since the electromotive force of the standard cell is equal to the potential drop in the length of wire spanned (measured from A) for a condition of balance and the same is true for the unknown cell, the emf of each cell is proportional to the lengths of wire spanned.

Thus, where ε_x is the unknown emf and, ε_s is the emf of the standard cell, L_x is the length of wire (AC) used for balancing the unknown cell, and L_s is the length of wire used for balancing with the standard cell.

If we have a test cell of emf, ε and internal resistance r supplying current to a variable load resistor R (see figure 4.2), then we will measure a terminal voltage V which is a function of the load resistance R.

Since $V = \varepsilon - Ir$, if you **plot V versus I** the **negative of the slope** of the graph will be the internal resistance of the cell r, the V-intercept gives the value of ε_X**.**

PROCEDURE

- **<u>Calibration</u>**

Use the experimental arrangement shown in Figure 4.2 for the calibration of the potentiometer wire, using the standard cell ε_s. Start with your sliding contact C near the center of the bridge. Press the contact C. The galvanometer will probably deflect. Find a point C where there is no deflection. Again adjust C **for half deflection at the center of the wire**. Find the point for full or double deflection as read for the midpoint, this point should be B. Record the final setting of the contact point C and known value of the emf of the standard cell. <u>Compute</u> the calibration factor f in volts/cm.

- **<u>Electromotive force (emf) of a test cell</u>**

Connect the test cell ε_x into the circuit as shown in Figure 4.1. Determine the emf of this cell by again locating a point C **where no galvanometer deflection occurs when contact C is pressed**.. When **no galvanometer deflection** occurs, the potential drop along the wire from A to C exactly **equals the emf of the test cell**. Record the final balance position of the contact C and the emf of the test cell.

- **<u>Terminal Voltage of the test cell in use</u>**

Now adjust the load resistor R to 100 ohms. You must hold switch S down (closed) in order for the circuit connecting R across the test cell to be complete. While holding S down again balance the bridge as described above. When balanced, again record the distance AC and compute the terminal voltage of the test cell. Repeat this procedure for *R* = 60, 30, 15, 10, 8, 6, and 4 ohms. Using your measured value for the terminal voltage *V* and the resistance *R*, compute the current *I* being supplied by the test cell for each value of *R* used.

Plot a graph with terminal voltage *V* on the vertical axis and current I on the horizontal axis. Draw the best straight line through your data points. **Determine the value of the internal resistance** of the test cell from this graph.

Experiment No. 4

The potentiometer

Name: ………………………………,,,,,. Day and Date: …..…………………

Student's No.: …………………….. Sec: ……………..……………………..

Partners Names: …………………………………………………………..............

Data and Calculation:

(1) Calibration:

ε_s = ……..........................V

Balance point C for standard cell ε_s = ……………………………..cm

Calibration factor f = ε_s / L_{AB} =……………………V/cm

(2) Electromotive force (emf) of test cell ε_X

Balance point C for ε_X (the test cell) =L_{AC} =L_x=…………………..cm

Emf of test cell = ε_X =…………………….. V

(3) Internal resistance of test cell **r** from graph:

R (Ω) (Load Resistance)	**L_{AC}** (cm) (slide position)	**V_{AC}** (V) (terminal Voltage) $V_{AC} = \varepsilon_s \frac{L_{AC}}{L_{AB}}$	**I** (A) (V_{AC}/R)

Plot V_{AC} *vs. I. from the graph determine.* ($V_{AC}=\varepsilon_x - ir$)

(1) The slope = - r = ……………………………………

(2) the internal resistance r = …………………………….

(3) the V-intercept = ε_x *……………………….*