DETERMINING THE ELECTROMOTIVE FORCE IN GALVANIC CELLS

Axunjonov Anvarjon Sobirovich
Andijan State Technical Institute
Senior Lecturer, Department of Materials Science

ahunjon.anvarjon@gmail.com

Abstract

This article investigates the methods used to measure the electromotive force (EMF) in galvanic cells, with a focus on the compensation method. Key principles, experimental setups, and equations for calculating EMF are presented. Using the Weston and Daniel-Jacobi cells as examples, the relationship between EMF, equilibrium constants, and potential differences is analyzed. Diagrams and tables are included to illustrate the findings and methods.

Keywords: galvanic cell, electromotive force, compensation method, Weston cell, Daniel-Jacobi cell.

Introduction

The electromotive force (EMF) of a galvanic cell represents the maximum potential difference between its electrodes. It is a critical parameter in electrochemistry, reflecting the cell's ability to drive an electric current. Accurate EMF measurements are essential for understanding the thermodynamic properties of electrochemical reactions. This paper outlines the theoretical principles and experimental procedures for determining the EMF of galvanic cells, emphasizing the compensation method.

Objectives

- To explain the theoretical foundation of EMF in galvanic cells.

- To describe the experimental setup and procedure for measuring EMF using the compensation method.
- To analyze the results using the Weston and Daniel-Jacobi cells as examples.

Methods

Principles of EMF Measurement

The EMF of a galvanic cell is the potential difference between its electrodes under equilibrium conditions. It is given by the Nernst equation:

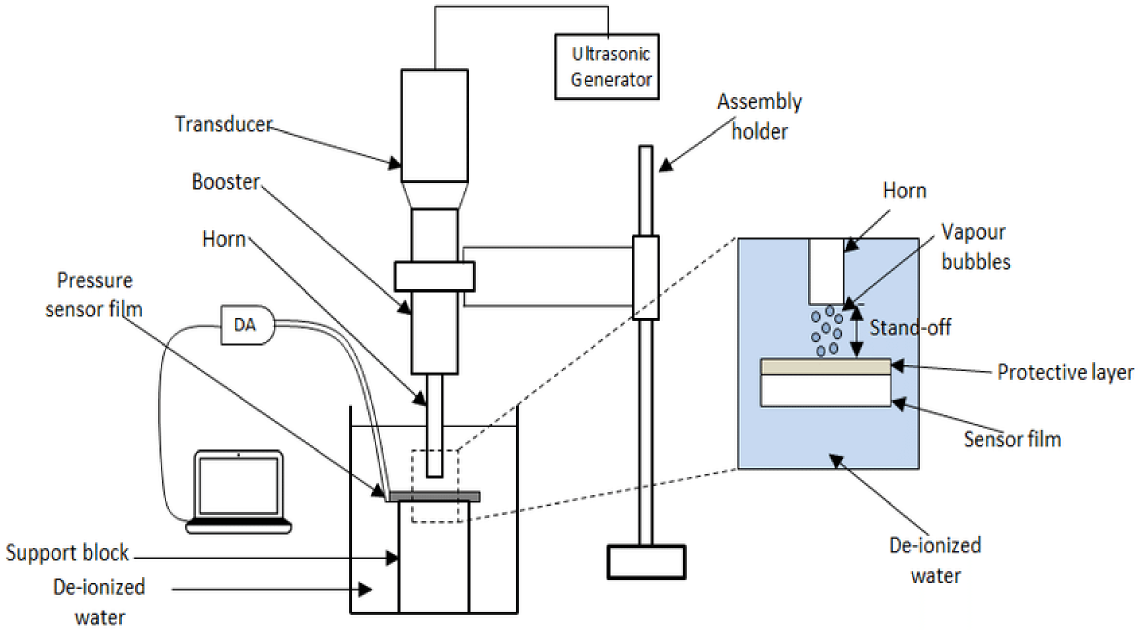
where:

- : Standard EMF of the cell.
- : Universal gas constant (8.314 J/mol·K).
- : Temperature in Kelvin.
- : Number of electrons transferred.
- : Faraday's constant (96485 C/mol).
- : Concentrations of species involved.

Experimental Setup

The compensation method involves the following components:

- A galvanic cell with unknown EMF.
- A Weston standard cell with known EMF.
- A resistance bridge (Wheatstone bridge).
- A galvanometer.
- A movable contact (slider).



The schematic of the setup is shown in **Figure 1**.

Procedure

1. Connect the Weston cell to one side of the resistance bridge.
2. Connect the galvanic cell to the opposite side.
3. Adjust the slider until the galvanometer shows zero current (compensation point).
4. Record the resistance values and calculate the EMF using the equation:

where is the EMF of the Weston cell.

Materials

- Weston standard cell.
- Daniel-Jacobi cell.
- Galvanometer.
- Resistance bridge.
- Slider and wires.

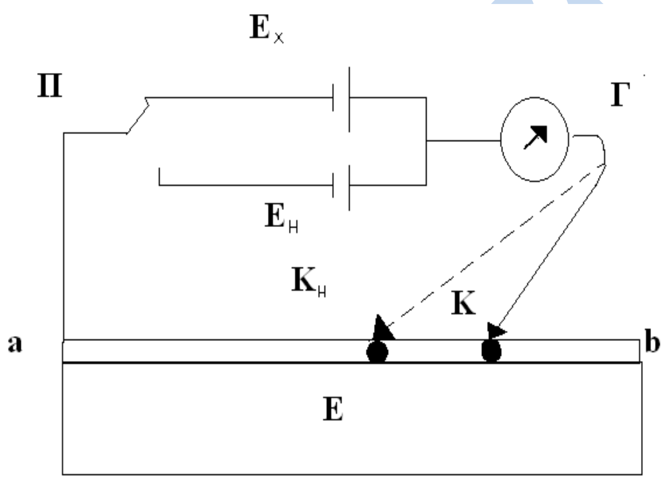
Results

Experimental Data

The EMF of the Daniel-Jacobi cell was measured under different conditions. Table 1 summarizes the results:

Table 1. EMF Measurements of the Daniel-Jacobi Cell

Temperature (°C)	Resistance ()	EMF () (V)
25	100	1.10
35	120	1.08
45	140	1.06



To measure the standard potential of zinc, a zinc plate is immersed in a 1 g·ion/l concentration solution of $ZnSO_4$. This electrode is connected to a calomel electrode, forming the following galvanic cell. **Figure 2.**

Discussion

The results demonstrate that the EMF decreases slightly with increasing temperature, consistent with the Nernst equation. The Weston cell provides a reliable reference, ensuring accurate compensation points. The method's precision highlights its suitability for determining the standard EMF of galvanic cells.

Limitations

- Variability in the Weston cell's EMF under non-standard conditions.
- Resistance fluctuations in the bridge.

Conclusion

The compensation method effectively measures the EMF of galvanic cells with high accuracy. The results align with theoretical predictions, showcasing the method's reliability for electrochemical studies.

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