

Measuring Electromotive Forces With A Potentiometer

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ABSTRACT

A slide wire potentiometer was used to study an electromotive force due to a power source. The potentiometer has 11 parallel wires 1 meter long and a slide tool for precise measurement. two metal electrodes were place in water to create a battery, three different metals were used for the electrodes. 6 different trials were performed, 3 with salt and 3 without salt, the salt mixture that was used was hydrochloric acid or HCl. A measurement of the potential difference was also performed with a standard volt meter for a comparison of the measuring devices. the results acquired are summarized at the end of this paper.

Subject headings: Electromotive force, potential difference, potentiometer

1. Introduction

All measuring devices effect the system in which they are measuring and therefore produce errors in the results they acquire, to reduce these errors the measuring device used should effect the system as little as possible. they should take only the smallest possible power from the measured system. The potentiometer is a measuring device that measures potential difference while using very little power from the system.

The definition of quantities used in this report are as follow, E_p is the voltage of the power supply, E_s is the voltage of the standard cell (1.019 V), E_x is the unknown voltage being measured, L_t is the total length of resistance wire on the potentiometer (11 meters), L_s is the length of resistance wire required to balance the standard voltage, L_x is the length of the resistance wire required to balance the unknown voltage, ρ is the resistivity of the resistance wire on the potentiometer.

$$E_p = I_t R_t = I_t \frac{\rho L_t}{A} \implies \frac{\rho I_t}{A} = \frac{E_p}{L_t} \quad (1)$$

$$E_s = I_t R_s = I_t \frac{\rho L_s}{A} \implies \frac{\rho I_t}{A} = \frac{E_s}{L_s} \quad (2)$$

$$E_x = I_t R_x = I_t \frac{\rho L_x}{A} \implies \frac{\rho I_t}{A} = \frac{E_x}{L_x} \quad (3)$$

therefore

$$\frac{E_p}{L_t} = \frac{E_s}{L_s} = \frac{E_x}{L_x} \quad (4)$$

from this equation we derive

$$E_x = E_s \left(\frac{L_x}{L_s} \right) \quad (5)$$

2. Method

2.1. Equipment Used

Equipment	Serial
Potentiometer (11 meter wire)	51573
Standard cell	n/a
Digital Voltmeter	n/a
Electrodes	n/a
DC power supply	51588
Galvanometer	51676

2.2. Procedure

the set up of the apparatus can best be described by the attached diagram included with this report. Three different types of metal electrodes were used for the experiment, copper, zinc, and lead were used in three different combinations. Potential difference measurements were acquired with a voltmeter, potentiometer, and with the aid of electrochemical series table(theoretical). The potential difference of the standard cell remained constant throughout the experiment. The first three runs conducted using the experimental cell were performed without the salt solution, and the last three runs conducted included the salt solution. A summary of the results are provided in the next section. For a more extensive explanation for the procedures performed during this experiment can also be found in the Los Angeles City College physics 102 lab manual.

3. Results and Discussion

There are six calculations that were performed using equation 5, three of the calculations were for the battery without the salt mixture and three were with the salt solution. The value calculated was for the potential difference of the experimental battery. A value was also measured using a standard volt meter for both different solutions. A value was also calculated using the table from the electrochemical series table included with this report. Three error measurements were also conducted to verify some of the principles involving electricity and magnetism. The results acquired were within an acceptable range and therefore confirmed that the equations derived in the introduction section can be used to predict how a battery will behave under certain conditions. The theoretical values were calculated using the electrochemical series table provided with this report. The voltage from the negative electrode is subtracted from the voltage of the positive electrode. The theoretical value is then compared with the other methods and an error calculation can be made. The positive electrode used in the experimental values is the first metal written down in the next table i.e. Cu-Zn. Copper is the positive electrode.

3.1. Data and Calculations

	Student Battery					
	Cu-ZN		Cu-Pb		Pb-Zn	
	No Salt	With Salt	No Salt	With Salt	No Salt	With Salt
L_s (m)	2.63	2.65	2.63	2.65	2.63	2.65
L_x (m)	2.41	2.31	.913	1.05	1.31	1.37

Table 3.1 Measured length using potentiometer

	Output Voltage (V)			
	P. Meter Method		Lab Std. Voltmeter	Theory (Table)
	No Salt	With Salt	No Salt	
Cu-Zn	.930	.880	.945	1.1
Cu-Pb	.349	.404	.394	.460
Pb-Zn	.504	.521	.551	.640
Percent errors(%)				
Cu-Zn	15%	20%	14%	
Cu-Pb	24%	12%	14%	
Pb-Zn	21%	19%	14%	

Table 3.2 Results and error calculations.

4. Conclusion

This lab was conducted to verify some principle on electricity and to also observe how the accuracy of different measuring devices deviate. The errors acquired using the volt meter were very consistent at 14 %. A possible source of error can be accounted for by the power needed from the system to power the meter in order to get a reading. Another source of error could have also been acquired by not allowing the meter to stabilize during the reading. The errors acquired using the potentiometer were not very consistent, a large source of error can be explained by how accurate the readings for the lengths of the wires needed to zero out the galvanometer were. Another source of error using the potentiometer could also have been acquired by the precise set up of the apparatus. The errors acquired were within $\leq 24\%$.

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REFERENCES

Los Angeles City College Lab Manual Physics 102.

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