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Viva Date: 30 May 2022

Level of Study: MSc by Research

Decision: Decision suspended pending re-examination following re-submission within 12 months

Joint Examiner Comments and Requirements for Resubmission (Addendum to Report and Results form).

The thesis presents an experimental study of temperature-dependent battery characteristics and claims that the results validate the theories developed by Joseph Newman in regard to his energy machine. These theories are open to debate, have not been independently validated in a scientifically rigorous manner, and are not accepted by the mainstream research community. Any evidence presented to support these theories must therefore be extensive, accurate, repeatable and clearly related to the specific claims made. The work presented does not meet these requirements. The experiment data has limited accuracy and the format of the investigations allows multiple interpretations of the results. Various scientific theories are presented but then applied in error to unrelated phenomena.

In its present form the thesis is scientifically incorrect and does not meet the MSc by Research standard. A complete re-writing of the thesis is required.

The examiners believe that a focused report, limited to presentation and explanation of the temperature-dependent battery performance could potentially meet the requirements of an MSc and will therefore consider a resubmission if made within a 12 month period.

The re-submitted thesis MUST meet all of the requirements listed below:

1. The thesis title is: **An Investigation of the Photoelectric Effect to the Endothermic Electric Effect during the Electric Field Charge**. This is misleading and must be changed. The photoelectric effect has not been studied.

2. A chapter on the relevant standard models of battery operation (what happens at the anode and cathode during a charge or discharge), how a battery generates heat as irreversible and reversible heat and the temperature effects, should be presented so that the experimental data can be assessed in reference to accepted knowledge of the device under study.

3. The above chapter must include a section explaining the battery entropy coefficient and how it plays a part as a reversible heat source term behaving either as an exothermic or endothermic heat source term (based on the state-of-charge the battery is at).

4. The limitations and inaccuracies of the experiment must be discussed. These include the resolution of the temperature measurement, calibration of multiple sensors to ensure cross-sensor accuracy, experimental error in relation to repeated measurement and the possibility of thermocouple hysteresis.

5. The design of the experiments means that multiple processes influence the battery characteristics: heating/cooling following heat pre-treatment, battery relaxation effects, temperature dependent battery open-circuit voltage. All of these factors must be considered and taken into account when interpreting the observed behaviour (see points 6 and 7 below).

6. In the USW data (Chapter 9, figure 27) why are the three starting cell temperatures different and what is the ambient temperature? If the ambient temperature is lower than the initial cell temperature, the cell can cool down to ambient despite the battery being charged. The temperature gradient, between ambient and cell temperature, can outweigh the heat generated (by both irreversible and reversible heat) in the cell. To determine if the cell cooling is truly the endothermic heat generation of the cell (rather than cooling to ambient), the cell temperature must be at equilibrium with the ambient before charging commences.

7. In the home experiments (Chapter 11) the cell voltage should be at equilibrium before the experiments are conducted. If not, the measured voltage is the relaxation voltage (OCV + over potentials of the cell due to the discharge that the cell has undergone prior to the experiment) which then appears as "air charge". The cell could be still relaxing since the over potentials in the cell have not reached to zero from the discharge step it has undergone. No details of how long the cell was kept in the oven or how long the cell was allowed to relax (after fully discharging the cell is given). The results are therefore inconclusive, and the voltage could simply be the relaxation voltage appearing as a “charging effect” (there is no current applied in this chapter, and voltage relaxation is not a charging phenomenon).

8. When interpreting the measurements established models, that have been validated by peer review should be presented. In particular, the literature relating to endothermic effects and entropic changes within the battery should be thoroughly assessed and considered when interpreting the results.

   See for example:
   - Richardson, Giles, and Ivan Korotkin. "Heat generation and a conservation law for chemical energy in Li-ion batteries." Electrochimica Acta 392 (2021): 138909. https://doi.org/10.1016/j.electacta.2021.138909
   - Viswanathan, Vilayanur V., et al. "Effect of entropy change of lithium intercalation in cathodes and anodes on Li-ion battery thermal management." Journal of Power Sources 195.11 (2010): 3720-3729. https://doi.org/10.1016/j.jpowsour.2009.11.103
   - Geng, Zeyang, Jens Groot, and Torbjörn Thiringer. "A time-and cost-effective method for entropic coefficient determination of a large commercial battery cell." IEEE Transactions on Transportation Electrification 6.1 (2020): 257-266. https://doi.org/10.1109/TTE.2020.2971454
   - Mercer, Michael P., et al. "The influence of point defects on the entropy profiles of Lithium Ion Battery cathodes: a lattice-gas Monte Carlo study." Electrochimica Acta 241 (2017): 141-152. https://doi.org/10.1016/j.electacta.2017.04.115
   - Schmidt, Jan Philipp, André Weber, and Ellen Ivers-Tiffée. "A novel and precise measuring method for the entropy of lithium-ion cells: ΔS via electrothermal impedance spectroscopy." Electrochimica Acta 137 (2014): 311-319. http://dx.doi.org/10.1016/j.electacta.2014.05.153
   - He, Tengfei, et al. "A comprehensive numerical study on electrochemical-thermal models of a cylindrical lithium-ion battery during discharge process." Applied Energy 313 (2022): 118797. https://doi.org/10.1016/j.apenergy.2022.118797

9. Any hypotheses presented must be referenced to existing refereed, scientific literature, or justified by detailed evidence from experiment. The experiments presented do not provide proof of the electric field charge theories of Joseph Newman and no such claim should be made in the thesis. Discussion of Newman's work should be limited to its presentation as an alternative explanation of the observed phenomena, which cannot be proven due to the limited scope and accuracy of the measurements.

10. Where scientific theories are presented the link and relevance of the theory to the measurement data must be more clearly made. Where equations are stated, each term should be specified and applied to the experimental observations. Explanations must be given on how the equation links to measured variables and any prediction be corroborated by the experiment. Why weren't any prediction of the cell temperature and voltage made with the equations that were presented? Where well established theories are presented, they need to be interpreted in the standard way, as understood by the scientific community.

11. The purpose of the thesis is to present the student's work. Where other work is referred to it should be referenced, instances of full reproduction of other reports and papers should be removed from the thesis.

12. Any material in the thesis relating to other areas of science, unrelated to endothermic properties of batteries must be removed.

13. The formatting and presentation quality of the thesis needs to improve. Avoid one-page chapters (Chapter 13, 14 and 15). Why does the Glossary come before the Reflections and recommendations chapter (move it to the end)? Citations must be appropriately formatted with the relevant information, authors, date of publication, title, publisher etc. Equations should be numbered (some were numbered as letters, avoid copying equations as images), the variables in them defined and used within the main text of the body.

14. Equation (1) needs to be corrected.

15. 2. Equation (2) cannot be used for explaining the special case presented in the experiment, i.e. the endothermic effect at the start of charging process.

16. The image quality of all experimental figures needs to be improved. All experimental figures need to be added error bars.

17. Figures 52 and 53 are not correct, electrons don't flow in air circling a conductor.