

# ME Grad Assignment 2.2: H<sub>2</sub>-O<sub>2</sub> Fuel Cell Thermodynamics

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## 1 Introduction

This report analyzes the reversible potential of a hydrogen-oxygen fuel cell using variable specific heat models (NIST Shomate Equations)[1] and a constant  $C_p$  model for lower temperature regimes.

## 2 Thermodynamic Results

### 2.1 Potential vs. Temperature

Figure 1 shows the reversible potential  $E_{rev}$  as a function of temperature. We observe a decrease in potential as temperature increases due to the negative entropy of the reaction  $\Delta S_{rxn}$ .

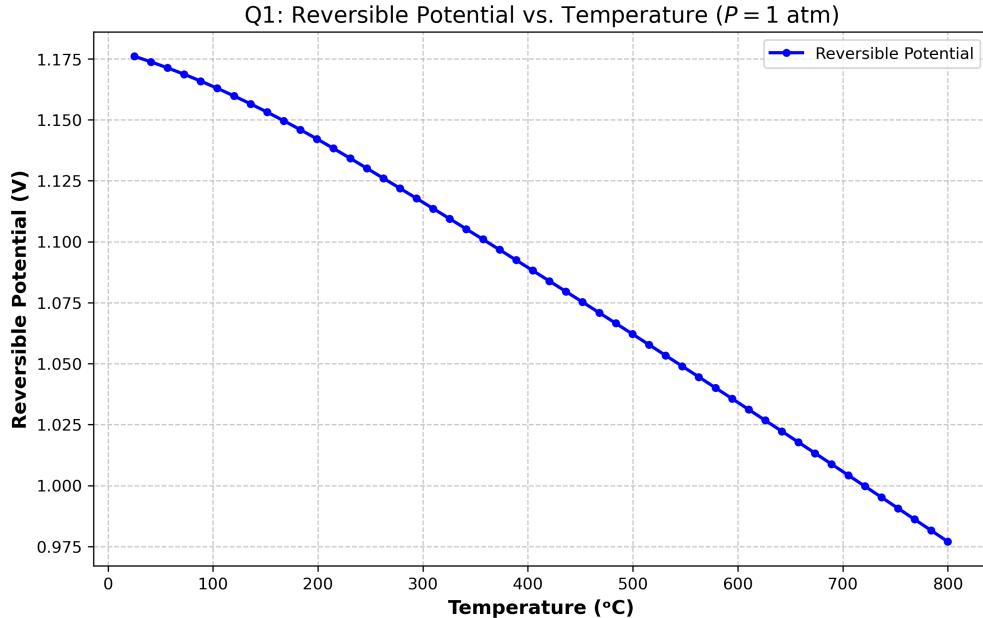


Figure 1: Reversible potential from 25°C to 800°C at  $P = 1$  atm.

### 2.2 Potential vs. Pressure

As shown in Figure 2, the potential increases logarithmically with pressure, consistent with the Nernst relationship.

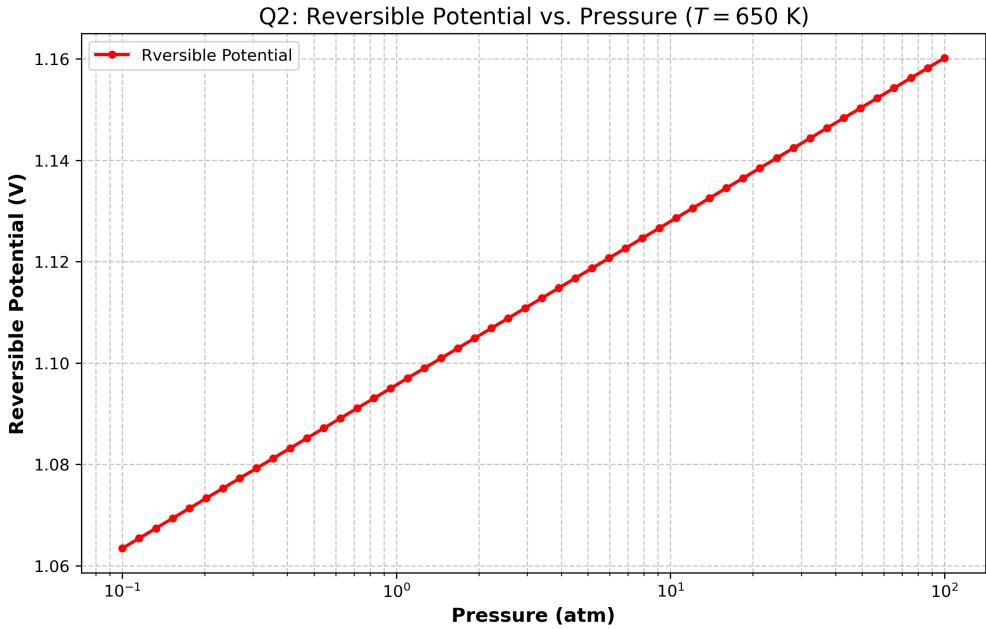


Figure 2: Reversible potential from 0.1 to 100 atm at  $T = 650$  K.

### 3 Mathematical Implementation

The potential was calculated using the Gibbs Free Energy relationship:

$$E_{rev} = -\frac{\Delta G_{rxn}}{nF} = -\frac{\Delta H - T\Delta S}{nF}. \quad (1)$$

The pressure dependence was incorporated using the Nernst equation:

$$E_{rev}(P) = E_{rev}^0 - \frac{RT}{nF} \ln \left( \frac{P_{H_2} P_{O_2}^{1/2}}{P_{H_2O}} \right). \quad (2)$$

### 4 Conclusion

The thermodynamic model successfully captures the voltage drop at higher temperatures and the logarithmic gains with pressure.

### 5 Code Availability

All Python scripts, thermodynamic coefficients, and diagnostic tools used for this analysis are available on GitHub at: <https://github.com/Ben-JaminRees/Fuel-Cell-Course-Spring-2026>.

## References

- [1] P. J. Linstrom and W. G. Mallard, Eds., *NIST Chemistry WebBook, NIST Standard Reference Database Number 69*. Gaithersburg, MD: National Institute of Standards and Technology. [Online]. Available: <https://webbook.nist.gov>