



MECHANICAL ENGINEERING MSc SEMINAR (30 min.)

Wednesday, July 13 2026 at 16:00-16:30, Lady Davis Building, Room 641

Development of the Fundamental Redlich Kwong Equation for Hydrogen

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Due to its inherent potential as a clean and renewable energy source, there has been an increasing interest during the last decades in the use of hydrogen in a variety of energy processes. While modern fundamental equations provide highly accurate results (Leachman et al., 2009), they lack the analytical simplicity. Contrariwise, simpler cubic models like the Redlich Kwong equation are mathematically practical but thermodynamically incomplete, as they require additional empirical data to derive properties such as internal energy and entropy. The derivation of a complete fundamental equation based on the Redlich Kwong model has historically been unattainable due to the equation's implicit temperature dependence. The present work focuses on overcoming this obstacle to develop a simple, explicit fundamental equation for hydrogen. To achieve an analytical solution, a first order Taylor expansion was applied to the nonlinear temperature term of the Redlich Kwong equation, using the critical point of normal hydrogen as the expansion point. This approach successfully resolved the necessary partial differential equations, yielding a continuous mathematical relationship between specific entropy, internal energy, and molar volume. The derived fundamental equation was strictly evaluated and validated against the fundamental postulates of thermodynamics (Callen, 1985), and was verified by calculating the specific volume, compressibility factor, internal energy, and entropy of hydrogen across a reduced temperature range of 0.7 to 1.3. The thermodynamic properties derived from the Redlich-Kwong Taylor expansion were compared with NIST database and against predictions from the fundamental equations of the ideal gas and Van der Waals models. The developed fundamental equation demonstrated a very good agreement with the NIST reference data, particularly at supercritical conditions. Ultimately, the study illustrates the superiority of the Redlich Kwong Taylor expansion over the ideal gas and Van der Waals fundamental equations in predicting the thermodynamic behavior of real gases.