Module 7: Thermodynamics

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Overview

This module covers reaction spontaneity, entropy, microstates, and Gibbs free energy. This module helps students to classify spontaneous and nonspontaneous reactions based on entropy and ultimately, Gibbs Free Energy. Students apply their knowledge of previously learned material (enthalpy and equilibrium, for example) to lead into more advanced topics covered in this module which include predicting the sign of ΔS for physical and chemical processes, calculating standard entropy changes for a system from standard molar entropies, calculating the Gibbs free energy from the enthalpy change and the entropy change at a given temperature, and relating this to the equilibrium constant, K.

Student Learning Outcomes for the Course

- #4: Apply the principles of thermodynamics and kinetics to analyze chemical transformations.
- #8: Apply problem solving and mathematical analysis to chemical systems.

Keywords

Spontaneous, entropy, Gibbs free energy, equilibrium constant

Teaching Tip

The content in this module is a combination of qualitative and quantitative material. Some of the information such as enthalpy and equilibrium should have been covered earlier in the course, students will need to apply their knowledge of these topics to more advanced topics such as reaction spontaneity and Gibbs free energy. Each module contains Google slides which can be edited for inclusion in either an online or face-to-face course. A study guide is presented in each module which may help students to take notes and keep their focus on specific material while listening to lectures and/or watching the videos of demos and/or example problems. While some of the videos provide background information on the topics, others contain examples of mathematical calculations to emphasize the skills needed for students who may struggle with the calculations. These videos may be helpful as students work through the problems provided on the suggested end-of-chapter problems, worksheets, and other types of problems which might be included with these items.

Diversity, Equity and Inclusion (see more resources)

The Digital Enhancement Group encourages UNC system faculty to enhance Diversity, Equity, and Inclusion of all types in all STEM courses. Within the Chem II modules, we have included some examples with which to possibly start. Our materials are not comprehensive, but rather specific to the topics within each module.

- Biography of Alfonso Ortega, Ph.D.
    - Description: In this biography, Dr. Ortega describes his childhood as the son of parents who migrated to the United States from Durango, Mexico. With degrees from the University of Texas at El Paso and Stanford University, Dr. Ortega studied heat transfer, thermodynamics, and fluid mechanics. He is currently the James R. Birle Professor of Energy Technology in the Department of Mechanical Engineering at Villanova University. Additional profiles for scientists in other areas are linked on the SACNAS Biography Project website and are available here.
- Norbert Rillieaux, Thermodynamics and Chemical Engineering
    - Description: This landmark lesson plan available from the American Chemical Society describes the life and influence of Norbert Rillieaux. This lesson plan showcases Rillieux's understanding of basic thermodynamic principles which was pivotal to his invention of the multiple effect evaporator. In fact, Rillieaux's multiple effect evaporator relied on what we know today as the First and Second Laws of Thermodynamics. His invention provided a safer and more efficient way

to evaporate sugar cane juice and this technology is still used today to produce sugar and other products such as condensed milk and freeze-dried foods.