

Title: Gibbsian Surface Thermodynamics

Gibbsian composite-system thermodynamics is the framework governing equilibrium of composite systems, including systems that at equilibrium have more than one value of pressure because of the action of surface tension, semipermeable membranes, or fields, and thus cannot be treated as simple systems. J. W. Gibbs's paper that lays out composite-system thermodynamics, "On the Equilibrium of Heterogeneous Substances", communicated in two parts in 1876 and 1878, is widely regarded as one of the most important pieces of scientific literature of its century. In a 2020 Feature Article in the *Journal of Physical Chemistry B* entitled, "Gibbsian Surface Thermodynamics", I described the framework of Gibbsian composite-system thermodynamics including in detail the treatment of systems with interface effects and with nonideal, multicomponent phases. This work lays out the relationships between important equilibrium equations including: the Gibbs–Duhem equation, the Gibbs adsorption equation, the Young–Laplace equation, the Young equation, the Cassie–Baxter equation, the Wenzel equation, the Kelvin equation, the Gibbs–Thompson equation, and the Ostwald–Freundlich equation, including nonideal and multicomponent forms. In order to make quantitative predictions using the Gibbsian composite-system framework, equations of state for individual phases must be separately added. D.-Y. Peng and D. B. Robinson's paper, "A New Two-Constant Equation of State", published in 1976, 100 years after Gibbs's paper, is among the top 0.0005% most cited engineering papers on any topic ever. One of the strengths of the Peng–Robinson equation of state is its semi-empirical nature where insight from thermodynamic principles was used to find a robust functional form that was then fit to experimental data to obtain very accurate parameter correlations. We have combined the Peng–Robinson equation of state with Gibbsian surface thermodynamics to make quantitative predictions; we have also developed other semi-empirical equations of state for water and aqueous solutions. Our work has led to new equations for such things as the curvature-induced depression of the eutectic temperature or the removal of azeotropes by nanoscale fluid interface curvature.

Speaker: Janet A. W. Elliott

Dr. Janet A. W. Elliott is a University of Alberta Distinguished Professor and Engineering Research Chair in Thermodynamics in the Department of Chemical and Materials Engineering. Dr. Elliott obtained her BSc in Engineering Science (Engineering Physics Option of which she was the first female graduate), and her MSc and PhD in Mechanical Engineering, from the University of Toronto. Dr. Elliott has been a Visiting Professor at the Massachusetts Institute of Technology, the University of Oxford Centre for Collaborative Applied Mathematics, and the Norwegian University of Science and Technology. Dr. Elliott currently serves as Editor-in-Chief of the journal *Cryobiology*, on the Editorial Advisory Board of *Langmuir*, and on the Editorial Board of *Advances in Colloid and Interface Science*. She has previously served on the Editorial Advisory Board of *The Journal of Physical Chemistry*, the Physical Sciences Advisory Committee of the Canadian Space Agency, the Board of Directors of the Canadian Society for Chemical Engineering, and the Executive Committee of the American Chemical Society Division of Colloid and Surface Chemistry. Dr. Elliott's research has been recognized nationally and internationally in science and engineering by the Pioneers in Applied and Fundamental Interfacial Chemistry Award of the journal *Langmuir* (2023); the American Chemical Society Langmuir Lectureship Award (2022); Fellowship in: the Canadian Academy of Engineering (2023), the Royal Society of Canada (2022), the American Institute for Medical and Biological Engineering (2019), the Society for Cryobiology (2018), the Chemical Institute of Canada (2015), and Engineers Canada (2023); the Canadian Society for Chemical Engineering Syncrude Canada Innovation Award (2008); the Natural Sciences and Engineering Research Council Doctoral Prize (1998); the Canadian Council of Professional Engineers Young Engineer Achievement Award (2001); the Canadian Institute for Advanced Research Young Explorer's Prize (2002); and Time Magazine's Canadians Who Define the New Frontiers of Science (2002). Dr. Elliott has also received many provincial and University awards including the APEGA Summit Excellence in Education Award (2017), the University of Alberta Teaching Unit Award (2004, 2016), the Faculty of Engineering Undergraduate Teaching Award (2021), the Faculty of Engineering Graduate Teaching Award (2023), and the Faculty of Graduate Studies and Research Great Supervisor Award (2019). As one student put it, "*She could convince rocks to study thermodynamics.*"