

12 Solutions: fundamentals

12.1 Ideal solutions

Solutions are among the most important kinds of systems in the chemical and biochemical sciences and technologies, spanning an enormous range of different phenomena and scales. The simplest model of a solution is the so-called ideal one.

An **ideal solution** is defined by the following properties.

- (1) Components are non-interacting. In other words, there are no explicit energetic interactions between molecules of different species.
- (2) At constant temperature and pressure, an **ideal entropy of mixing** contributes to the total entropy due to the presence of different species.
- (3) Ideal solutions are usually excellent approximations to real ones in the near-pure limit, in which there is one major component (e.g., a solvent) and the concentrations of all other species (solutes) are very small.

To develop a thermodynamic model of ideal solutions, we first evaluate the entropy of mixing using a simple model. Figure 12.1 illustrates a lattice mixing model for a binary system. Though the lattice certainly does not represent molecular-structural features of actual liquids, the final behavior of the mixing entropy is surprisingly insensitive to its use. Prior to mixing the particles are completely separated into different regions of the system volume. One configuration exists for this state, and thus the entropy is zero. If the particles are then allowed to mix randomly, the number of arrangements of N_A A particles and N_B B particles in the $N = N_A + N_B$ sites is given by the combinations formula

$$\begin{aligned}\Omega_{\text{mix}}(N_A, N_B) &= \frac{(N_A + N_B)!}{N_A! N_B!} \approx \frac{(N_A + N_B)^{N_A + N_B}}{N_A^{N_A} N_B^{N_B}} \\ &= \left(\frac{N_A}{N_A + N_B} \right)^{-N_A} \left(\frac{N_B}{N_A + N_B} \right)^{-N_B}\end{aligned}\quad (12.1)$$

In the second line, we applied Stirling's approximation. By taking the logarithm to obtain the entropy, we find

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Sergio Carrà



Thermodynamics Cambridge University Press Solution Manual:

Solved Problems in Thermodynamics and Statistical Physics Gregor Skačej, Primož Ziherl, 2019-11-09 This book contains a modern selection of about 200 solved problems and examples arranged in a didactic way for hands on experience with course work in a standard advanced undergraduate first year graduate class in thermodynamics and statistical physics The principles of thermodynamics and equilibrium statistical physics are few and simple but their application often proves more involved than it may seem at first sight This book is a comprehensive complement to any textbook in the field emphasizing the analogies between the different systems and paves the way for an in depth study of solid state physics soft matter physics and field theory Fundamentals of Solidification 5th edition with Solutions Manual Wilfried Kurz, David J. Fisher, Michel Rappaz, 2023-08-23 Since the 4th 1998 edition there have been numerous crucial advances to the modelling and the basic understanding of solidification phenomena and with its linking to experimental results These topics have been incorporated into this 5th Fully Revised Edition as well as a new final chapter on microstructure selection which explains how to combine the concepts of the preceding chapters for modelling real microstructures in complex processes such as additive manufacturing This new 5th edition is of high interest to undergraduate and graduate levels and professionals With its numerous new topics also borne out by the new authorship students and teachers scientists and engineers will greatly benefit from this new book The topics are presented in the same praised manner as in previous editions readable at three levels an initial feel for the subject is obtained by consulting the figures and their detailed captions a deeper understanding of the underlying physics is found by working through the main text 15 appendices offer a detailed analysis of the various theories by providing detailed derivations of the relevant equations Particularly Novel the final chapter 8 on microstructure selection explains how to combine the concepts of the preceding chapters to model the real microstructures formed during complex processes such as additive manufacturing and the new detailed phase field appendix which opens the door to the accurate computer modelling of growth forms This edition goes with a companion Solutions Manual offering model solutions to 133 problems exercises Biochemical Thermodynamics Robert A. Alberty, 2006-03-31 Navigate the complexities of biochemical thermodynamics with Mathematica r Chemical reactions are studied under the constraints of constant temperature and constant pressure biochemical reactions are studied under the additional constraints of pH and perhaps pMg or free concentrations of other metal ions As more intensive variables are specified more thermodynamic properties of a system are defined and the equations that represent thermodynamic properties as a function of independent variables become more complicated This sequel to Robert Alberty s popular Thermodynamics of Biochemical Reactions describes how researchers will find Mathematica r a simple and elegant tool which makes it possible to perform complex calculations that would previously have been impractical Biochemical Thermodynamics Applications of Mathematica r provides a comprehensive and rigorous treatment of biochemical thermodynamics using Mathematica r to practically resolve

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Table of Contents Thermodynamics Cambridge University Press Solution Manual

1. Understanding the eBook Thermodynamics Cambridge University Press Solution Manual
 - The Rise of Digital Reading Thermodynamics Cambridge University Press Solution Manual
 - Advantages of eBooks Over Traditional Books
2. Identifying Thermodynamics Cambridge University Press Solution Manual
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Thermodynamics Cambridge University Press Solution Manual
 - User-Friendly Interface
4. Exploring eBook Recommendations from Thermodynamics Cambridge University Press Solution Manual
 - Personalized Recommendations
 - Thermodynamics Cambridge University Press Solution Manual User Reviews and Ratings

- Thermodynamics Cambridge University Press Solution Manual and Bestseller Lists
- 5. Accessing Thermodynamics Cambridge University Press Solution Manual Free and Paid eBooks
 - Thermodynamics Cambridge University Press Solution Manual Public Domain eBooks
 - Thermodynamics Cambridge University Press Solution Manual eBook Subscription Services
 - Thermodynamics Cambridge University Press Solution Manual Budget-Friendly Options
- 6. Navigating Thermodynamics Cambridge University Press Solution Manual eBook Formats
 - ePub, PDF, MOBI, and More
 - Thermodynamics Cambridge University Press Solution Manual Compatibility with Devices
 - Thermodynamics Cambridge University Press Solution Manual Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Thermodynamics Cambridge University Press Solution Manual
 - Highlighting and Note-Taking Thermodynamics Cambridge University Press Solution Manual
 - Interactive Elements Thermodynamics Cambridge University Press Solution Manual
- 8. Staying Engaged with Thermodynamics Cambridge University Press Solution Manual
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Thermodynamics Cambridge University Press Solution Manual
- 9. Balancing eBooks and Physical Books Thermodynamics Cambridge University Press Solution Manual
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Thermodynamics Cambridge University Press Solution Manual
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Thermodynamics Cambridge University Press Solution Manual
 - Setting Reading Goals Thermodynamics Cambridge University Press Solution Manual
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Thermodynamics Cambridge University Press Solution Manual
 - Fact-Checking eBook Content of Thermodynamics Cambridge University Press Solution Manual
 - Distinguishing Credible Sources

13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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