

## Part 2: Statistical physics

### Preliminary questions

1. Explain in 5 to 10 lines what is a phonon.

### Adsorption

At the surface of a solid are  $A$  sites, each of which can adsorb at most one atom. The energy of an adsorbed atom is  $\epsilon_e$ .

The system is in contact with a reservoir (temperature  $T$  and chemical potential  $\mu$ ).

1. Justify which ensemble can be used to describe this system.
2. Calculate the grand-partition function of this system. Each of the sites can be treated as independent sub-systems.
3. Calculate the mean number of atoms adsorbed on the solid side.
4. Calculate the mean energy of the system.

The solid is actually the wall of a container of volume  $V$  in which we introduce  $N$  atoms of ideal gas at temperature  $T$ .

- 5 Calculate the temperature and the chemical potential of the ideal gas from the expression of the entropy.
- 6 From the previous answer, calculate the mean number of atoms adsorbed on the wall.

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We now consider that the adsorbed atoms, instead of being assigned on sites, behave as an two-dimensional ideal gas, free to explore the whole surface  $S$  (we assume a square to simplify).

- 7 We recall that the states for an ideal gas are quantized such that  $\vec{k} = p_x \frac{\pi}{L} \hat{e}_x + p_y \frac{\pi}{L} \hat{e}_y$ . Assume that the gas is made of fermions. Calculate the grand-partition function of each of the states of the 2D gas, then calculate the mean number of particles  $\bar{n}_k$  in for each state.
- 8 Calculate the density of states  $\rho(\epsilon_k)$ , using the fact that  $\epsilon_k = \frac{\hbar^2 k^2}{2m}$ .
- 9 Explain why the mean number of particles of the surface can be written as:

$$\bar{N} = g \int \rho(\epsilon) \bar{n}_k d\epsilon. \quad (6)$$

- 10 From previous results write the expression of the mean number of adsorbed atoms at high temperature.

# Statistical Physics Of Materials

**Elka Korutcheva**

## Statistical Physics Of Materials:

**Statistical Physics of Materials** Louis A. Girifalco,1973      **Statistical Mechanics for Chemistry and Materials Science** Biman Bagchi,2018-07-06 This book covers the broad subject of equilibrium statistical mechanics along with many advanced and modern topics such as nucleation spinodal decomposition inherent structures of liquids and liquid crystals Unlike other books on the market this comprehensive text not only deals with the primary fundamental ideas of statistical mechanics but also covers contemporary topics in this broad and rapidly developing area of chemistry and materials science

*Statistical Mechanics of Solids* Louis A. Girifalco,2003-07-31 This monograph suitable for use as an advanced text presents the statistical mechanics of solids from the perspective of the material properties of the solid state The statistical mechanics are developed as a tool for understanding properties and each chapter includes useful exercises to illustrate the topics covered Topics discussed include the theory of the harmonic crystal the theory of free electrons in metal and semiconductors electron transport alloy ordering surfaces and polymers      [Statistical Physics: Statics, Dynamics And Renormalization](#) Leo P Kadanoff,2000-05-05 The material presented in this invaluable textbook has been tested in two courses One of these is a graduate level survey of statistical physics the other a rather personal perspective on critical behavior Thus this book defines a progression starting at the book learning part of graduate education and ending in the midst of topics at the research level To supplement the research level side the book includes some research papers Several of these are classics in the field including a suite of six works on self organized criticality and complexity a pair on diffusion limited aggregation some papers on correlations near critical points a few of the basic sources on the development of the real space renormalization group and several papers on magnetic behavior in a plain geometry In addition the author has included a few of his own papers

**Statistical Physics** Roberto Piazza,2016-10-21 This book provides a general introduction to the ideas and methods of statistical mechanics with the principal aim of meeting the needs of Master s students in chemical mechanical and materials science engineering Extensive introductory information is presented on many general physics topics in which students in engineering are inadequately trained ranging from the Hamiltonian formulation of classical mechanics to basic quantum mechanics electromagnetic fields in matter intermolecular forces and transport phenomena Since engineers should be able to apply physical concepts the book also focuses on the practical applications of statistical physics to material science and to cutting edge technologies with brief but informative sections on for example interfacial properties disperse systems nucleation magnetic materials superfluidity and ultralow temperature technologies The book adopts a graded approach to learning the opening four basic level chapters being followed by advanced starred sections in which special topics are discussed Its relatively informal style including the use of musical metaphors to guide the reader through the text will aid self learning      *Statistical Physics I* Morikazu Toda,Ryogo Kubo,Nobuhiko Saito,2011-09-27 Statistical Physics I discusses the fundamentals of equilibrium statistical mechanics focussing on basic physical aspects No

previous knowledge of thermodynamics or the molecular theory of gases is assumed Illustrative examples based on simple materials and photon systems elucidate the central ideas and methods *Equilibrium Statistical Physics* Michael Plischke,Birger Bergersen,2006 This third edition of one of the most important and best selling textbooks in statistical physics is a graduate level text suitable for students in physics chemistry and materials science The discussion of strongly interacting condensed matter systems has been expanded A chapter on stochastic processes has also been added with emphasis on applications of the Fokker Planck equation The modern theory of phase transitions occupies a central place The chapter devoted to the renormalization group approach is largely rewritten and includes a detailed discussion of the basic concepts and examples of both exact and approximate calculations The development of the basic tools includes a chapter on computer simulations in which both Monte Carlo method and molecular dynamics are introduced and a section on Brownian dynamics added The theories are applied to a number of important systems such as liquids liquid crystals polymers membranes Bose condensation superfluidity and superconductivity There is also an extensive treatment of interacting Fermi and Bose systems percolation theory and disordered systems in general Statistical Thermodynamics Of Surfaces, Interfaces, And Membranes Samuel Safran,2018-03-08

Understanding the structural and thermodynamic properties of surfaces interfaces and membranes is important for both fundamental and practical reasons Important applications include coatings dispersants encapsulating agents and biological materials Soft materials important in the development of new materials and the basis of many biological systems cannot be designed using trial and error methods due to the multiplicity of components and parameters While these systems can sometimes be analyzed in terms of microscopic mixtures it is often conceptually simpler to regard them as dispersions and to focus on the properties of the internal interfaces found in these systems The basic physics centers on the properties of quasi two dimensional systems embedded in the three dimensional world thus exhibiting phenomena that do not exist in bulk materials This approach is the basis behind the theoretical presentation of Statistical Thermodynamics of Surfaces Interfaces and Membranes The approach adapted allows one to treat the rich diversity of phenomena investigated in the field of soft matter physics including both colloid interface science as well as the materials and macromolecular aspects of biological physics such as interfacial tension the roughening transition wetting interactions between surfaces membrane elasticity and self assembly Presented as a set of lecture notes this book is aimed at physicists physical chemists biological physicists chemical engineers and materials scientists who are interested in the statistical mechanics that underlie the macroscopic thermodynamic properties of surfaces interfaces and membranes This paperback edition contains all the material published in the original hard cover edition as well as additional clarifications and explanations **Advances in Condensed Matter and Statistical Physics** Elka Korutcheva,2004 This book collects recent results in systems whose evolutions are dominated by fluctuations driven systems in which the way to dissipate driving forces is relevant and systems in which disorder induces highly non trivial dynamics leading naturally to

questions of computational complexity Topics of the 14 papers include multiplicative noise in non equilibrium phase transitions the stochastic population dynamics of spiking neurons anomalous velocity distributions in elastic Maxwell gases universality issues in surface kinetic roughening of thin solid films and multi state neural networks based upon spin glasses Some of the chapters have appeared in the arXiv org database No information is given about the authors Annotation 2004 Book News Inc Portland OR booknews.com *Equilibrium Statistical Physics (3rd Edition)* Michael Plischke, Birger Bergersen, 2006-04-25 This third edition of one of the most important and best selling textbooks in statistical physics is a graduate level text suitable for students in physics chemistry and materials science The discussion of strongly interacting condensed matter systems has been expanded A chapter on stochastic processes has also been added with emphasis on applications of the Fokker Planck equation The modern theory of phase transitions occupies a central place The chapter devoted to the renormalization group approach is largely rewritten and includes a detailed discussion of the basic concepts and examples of both exact and approximate calculations The development of the basic tools includes a chapter on computer simulations in which both Monte Carlo method and molecular dynamics are introduced and a section on Brownian dynamics added The theories are applied to a number of important systems such as liquids liquid crystals polymers membranes Bose condensation superfluidity and superconductivity There is also an extensive treatment of interacting Fermi and Bose systems percolation theory and disordered systems in general **Glassy Materials and Disordered Solids** Kurt Binder, Walter Kob, 2005 The physics of glassy materials and disordered solids presents a challenging area of study This book provides an introduction to important concepts such as percolation fractals spin glasses and glasses It is useful for researchers on amorphous materials and is also intended for theorists and experimentalists **Statistical Mechanics Made Simple: A Guide For Students And Researchers** Daniel C Mattis, 2003-04-08 This book is an elaboration of the author's lecture notes in a graduate course in statistical physics and thermodynamics augmented by some material suitable for self teaching as well as for undergraduate study The first 4 or 5 chapters are suitable for an undergraduate course for engineers and physicists in Thermodynamics and Statistical Physics and include detailed study of the various ensembles and their connections to applied thermodynamics The Debye law of specific heats and reasons for deviations from the Debye formulas are covered as are the Einstein theories of Brownian motion black body radiation and specific heat of solids Van der Waals gases and the reason for the apparent failure of his Law of Corresponding States are discussed The last 5 chapters treat topics of recent interest to researchers including the Ising and Potts models spin waves in ferromagnetic and anti ferromagnetic media sound propagation in non ideal gases and the decay of sound waves introduction to the understanding of glasses and spin glasses superfluidity and superconductivity The selection of material is wide ranging and the mathematics for handling it completely self contained ranging from counting probability theory to quantum field theory as used in the study of fermions bosons and as an adjunct in the solutions of the equations of classical diffusion reaction theory In addition to the standard material found

in most recent books on statistical physics the constellation of topics covered in this text includes numerous original items Generalization of negative temperature to interacting spins Derivation of Gibbs factor from first principles Exact free energy of interacting particles in 1D e g classical and quantum Tonks gas Introduction to virial expansions Equations of State Correlation Functions and critical exponents Superfluidity in ideal and non ideal fluids both Bogolubov and Feynman theories Superconductivity thermodynamical approach and the BCS theory Derivation of Central Limit Theorem and its applications Boltzmann's H Theorem and the nonlinear Boltzmann equation Exact solution of nonlinear Boltzmann Equation for electrons in time dependent electric field and the derivation of Joule heating transport parameters in crossed electric and magnetic fields etc Frequency spectrum and decay of sound waves in gases Exact evaluation of free energy and thermodynamic properties of the two dimensional Ising model in regular and fully frustrated spin glass like lattices The zipper model of crystal fracture or polymer coagulation calculation of  $T_c$  Potts model in 2D duality and  $T_c$  Doi's theory of diffusion limited chemical reactions with some exact results including the evaluation of statistical fluctuations in radioactive decay Thermodynamic Green Functions and their applications to fermions and bosons with an example drawn from random matrix theory and much more *The Physics of Metals and Metallography*, 1984 *Computational Statistical Physics* K.-H. Hoffmann, Michael Schreiber, 2013-03-14

In recent years statistical physics has made significant progress as a result of advances in numerical techniques While good textbooks exist on the general aspects of statistical physics the numerical methods and the new developments based on large scale computing are not usually adequately presented In this book 16 experts describe the application of methods of statistical physics to various areas in physics such as disordered materials quasicrystals semiconductors and also to other areas beyond physics such as financial markets game theory evolution and traffic planning in which statistical physics has recently become significant In this way the universality of the underlying concepts and methods such as fractals random matrix theory time series neural networks evolutionary algorithms becomes clear The topics are covered by introductory tutorial presentations

**Statistical and Thermal Physics: Probabilities and statistics, thermodynamics, and classical statistical mechanics** Shigeji Fujita, 1986 *Theoretical Physics 8*

Wolfgang Nolting, 2018-03-02 Der Grundkurs Theoretische Physik deckt in 7 Bänden alle für das Diplom und für Bachelor Master Studiengänge maßgeblichen Gebiete ab Jeder Band vermittelt das im jeweiligen Semester notwendige theoretisch physikalische Repertoire bungsaufgaben mit ausführlichen Lösungen dienen der Vertiefung des Stoffs Der 6. Band zur Statistischen Physik wurde für die Neuauflage grundlegend bearbeitet und um aktuelle Entwicklungen ergänzt Durch die zweifarbige Gestaltung ist der Stoff jetzt noch übersichtlicher gegliedert

**Statistical Physics: Fundamentals And Application To Condensed Matter** Hung-the Diep, 2015-06-29 The aim of this book is to provide the fundamentals of statistical physics and its application to condensed matter The combination of statistical mechanics and quantum mechanics has provided an understanding of properties of matter leading to spectacular technological innovations and discoveries in

condensed matter which have radically changed our daily life The book gives the steps to follow to understand fundamental theories and to apply these to real materials Functional Methods in Quantum Field Theory and Statistical Physics A.N. Vasiliev, 2019-01-22 Providing a systematic introduction to the techniques which are fundamental to quantum field theory this book pays special attention to the use of these techniques in a wide variety of areas including ordinary quantum mechanics quantum mechanics in the second quantized formulation relativistic quantum field theory Euclidean field theory quant

**Monte Carlo Methods in Statistical Physics** Kurt Binder, 1986-03-01 In the seven years since this volume first appeared there has been an enormous expansion of the range of problems to which Monte Carlo computer simulation methods have been applied This fact has already led to the addition of a companion volume Applications of the Monte Carlo Method in Statistical Physics Topics in Current Physics Vol 36 edited in 1984 to this book But the field continues to develop further rapid progress is being made with respect to the implementation of Monte Carlo algorithms the construction of special purpose computers dedicated to execute Monte Carlo programs and new methods to analyze the data generated by these programs Brief descriptions of these and other developments together with numerous additional references are included in a new chapter Recent Trends in Monte Carlo Simulations which has been written for this second edition

Typographical corrections have been made and fuller references given where appropriate but otherwise the layout and contents of the other chapters are left unchanged Thus this book together with its companion volume mentioned above gives a fairly complete and up to date review of the field It is hoped that the reduced price of this paperback edition will make it accessible to a wide range of scientists and students in the fields to which it is relevant theoretical physics and physical chemistry condensed matter physics and materials science computational physics and applied mathematics etc

**Thermal Physics** Robert Floyd Sekerka, 2015-08-19 In Thermal Physics Thermodynamics and Statistical Mechanics for Scientists and Engineers the fundamental laws of thermodynamics are stated precisely as postulates and subsequently connected to

historical context and developed mathematically These laws are applied systematically to topics such as phase equilibria chemical reactions external forces fluid fluid surfaces and interfaces and anisotropic crystal fluid interfaces Statistical mechanics is presented in the context of information theory to quantify entropy followed by development of the most important ensembles microcanonical canonical and grand canonical A unified treatment of ideal classical Fermi and Bose gases is presented including Bose condensation degenerate Fermi gases and classical gases with internal structure

Additional topics include paramagnetism adsorption on dilute sites point defects in crystals thermal aspects of intrinsic and extrinsic semiconductors density matrix formalism the Ising model and an introduction to Monte Carlo simulation

Throughout the book problems are posed and solved to illustrate specific results and problem solving techniques Includes applications of interest to physicists physical chemists and materials scientists as well as materials chemical and mechanical engineers Suitable as a textbook for advanced undergraduates graduate students and practicing researchers Develops

content systematically with increasing order of complexity Self contained including nine appendices to handle necessary background and technical details

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