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 ϵ_ℓ.

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

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 $\mathcal{V}$ in which we introduce N atoms of ideal gas at temperature T.

5. Calculate the temperature and the kemical 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.

2

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 $\vec{k} = p_x \frac{\pi}{L} \vec{e}_x + p_y \frac{\pi}{L} \vec{e}_y$. 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 $\bar{n}_{\vec{k}}$ in for each state.

8. Calculate the density of states $\rho(\epsilon_{\vec{k}})$, using the fact that $\epsilon_{\vec{k}} = \frac{\hbar^2 k^2}{2m}$.

9. Explain why the mean number of particles of the surface can be written as:

$$\bar{N} = g \int \rho(\epsilon)\, \bar{n}_{\vec{k}}\, d\epsilon. \tag{6}$$

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

Statistical Physics Of Materials

Hung-the Diep

Statistical Physics Of Materials:

<u>Statistical Physics of Materials</u> 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,2000-09-21 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 <u>Statistical Physics</u> A.M. Guenault,1995-02-28 In this revised and enlarged second edition Tony Gu nault provides a clear and refreshingly readable introduction to statistical physics The treatment itself is self contained and concentrates on an understanding of the physical ideas without requiring a high level of mathematical sophistication The book adopts a straightforward quantum approach to statistical averaging from the outset The initial part of the book is geared towards explaining the equilibrium properties of a simple isolated assembly of particles The treatment of gases gives full coverage to Maxwell Boltzmann Fermi Dirac and Bose Einstein statistics

Statistical Physics Franz Mandl,1991-01-08 The Manchester Physics Series General Editors D J Sandiford F Mandl A C Phillips Department of Physics and Astronomy University of Manchester Properties of Matter B H Flowers and E Mendoza Optics Second Edition F G Smith and J H Thomson Statistical Physics Second Edition E Mandl Electromagnetism Second Edition I S Grant and W R Phillips Statistics R J Barlow Solid State Physics Second Edition J R Hook and H E Hall Quantum Mechanics F Mandl Particle Physics Second Edition B R Martin and G Shaw The Physics of Stars Second Edition A C Phillips Computing for Scientists R J Barlow and A R Barnett Statistical Physics Second Edition develops a unified treatment of statistical mechanics and thermodynamics which emphasises the statistical nature of the laws of thermodynamics and the atomic nature of matter Prominence is given to the Gibbs distribution leading to a simple treatment of quantum statistics and of chemical reactions Undergraduate students of physics and related sciences will find this a stimulating account of the basic physics and its applications Only an elementary knowledge of kinetic theory and atomic physics as well as the rudiments of quantum theory are presupposed for an understanding of this book Statistical Physics Second Edition features A fully integrated treatment of thermodynamics and statistical mechanics A flow diagram allowing topics to be studied in different orders or omitted altogether Optional starred and highlighted sections containing more advanced and specialised material for the more ambitious reader Sets of problems at the end of each chapter to help student understanding Hints for solving

the problems are given in an Appendix   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
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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 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 Tonk s 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 Tc Potts model in 2D duality and Tc 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 **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

Fundamentals of Statistical and Thermal Physics F. Reif,2009-01-05 All macroscopic systems consist ultimately of atoms obeying the laws of quantum mechanics That premise forms the basis for this comprehensive text intended for a first upper level course in statistical and thermal physics Reif emphasizes that the combination of microscopic concepts with some statistical postulates leads readily to conclusions on a purely macroscopic level The authors writing style and penchant for description energize interest in condensed matter physics as well as provide a conceptual grounding with information that is crystal clear and memorable Reif first introduces basic probability concepts and statistical methods used throughout all of physics Statistical ideas are then applied to systems of particles in equilibrium to enhance an understanding of the basic notions of statistical mechanics from which derive the purely macroscopic general statements of thermodynamics Next he turns to the more complicated equilibrium situations such as phase transformations and quantum gases before discussing nonequilibrium situations in which he treats transport theory and dilute gases at varying levels of sophistication In the last chapter he addresses some general questions involving irreversible processes and fluctuations A large amount of material is presented to facilitate students later access to more advanced works to allow those with higher levels of curiosity to read beyond the minimum given on a topic and to enhance understanding by presenting several ways of looking at a particular question Formatting within the text either signals material that instructors can assign at their own discretion or highlights important results for easy reference to them Additionally by solving many of the 230 problems contained in the text students activate and embed their knowledge of the subject matter 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 *Statistical Mechanics* D H Trevena,2001-11-01 Thirty years teaching experience have been condensed into this concise introductory book on Statistical Mechanics Ideal for second and third year undergraduates in physics applied mathematics physical chemistry chemical engineering metallurgy materials science and polymer science Provides a concise introduction to statistical mechanics Ideal for second and third year undergraduates in physics applied mathematics physical chemistry chemical engineering metallurgy materials science and polymer science *Statistical Physics of Disordered Systems: from Real Materials to Optimization and Codes* ,2003 *Statistical Thermodynamics* Lukong Cornelius Fai,Gary Matthew Wysin,2012-10-19 Statistical thermodynamics and the related domains of statistical physics and quantum mechanics are very important in many fields of research including plasmas rarefied gas dynamics nuclear systems lasers semiconductors superconductivity ortho and para hydrogen liquid helium and so on Statistical Thermodynamics Understanding the Properties of Macroscopic Systems provides a detailed overview of how to apply statistical principles to obtain the physical and thermodynamic properties of macroscopic systems Intended for physics chemistry and other science students at the graduate level the book starts with fundamental principles of statistical physics before diving into thermodynamics Going further than many advanced textbooks it includes Bose Einstein Fermi Dirac statistics and Lattice dynamics as well as applications in polaron theory electronic gas in a magnetic field thermodynamics of dielectrics and magnetic materials in a magnetic field The book concludes with an examination of statistical thermodynamics using functional integration and Feynman path integrals and includes a wide range of problems with solutions that explain the theory **Monte Carlo Methods in Statistical Physics** Kurt Binder,2012-12-06 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

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Computational Statistical Physics K. -H Hoffmann,Michael Schreiber,2014-01-15

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