

Ferroelectric Crystals

A ferroelectric crystal is defined as a crystal which exhibits a spontaneous electric dipole moment; in other words, a crystal for which even in the absence of an applied electric field the center of positive charge does not coincide with the center of negative charge. It can be shown that it is a necessary, but not sufficient, condition for ferroelectricity that the crystal lack a center of symmetry. All ferroelectrics will be piezoelectric, but not all piezoelectrics will be ferroelectric (e.g., quartz). The occurrence of ferroelectricity is generally interpreted to be the result of a polarization catastrophe as treated in the preceding chapter; we discuss this at greater length below.

After a ferroelectric crystal is polarized in a given direction, the action of the polarization outside the crystal is gradually neutralized by the collection on the crystal surface of free charges from the atmosphere and by conduction within the crystal. In a number of substances the polarization appears to have a very high coercive force—the direction of the spontaneous polarization may not be changed by an electric field of the maximum intensity which it is possible to apply without causing electrical breakdown of the crystal. We are often able to observe the spontaneous moment in these substances only when they are heated, as raising the temperature changes the value of the polarization. Thus crystals, such as tourmaline, which develop an observable spontaneous electric moment only on heating are called *pyroelectric*, while crystals with a lower coercive force, such that the direction of the spontaneous moment can be altered by an electric field, are called *ferroelectric* and often have very high dielectric constants.

ELECTRETS

There is another class of substances known as *electrets*, discovered by Eguchi in 1923, which may display "permanent" electric moments. Electrets are produced by the solidification of mixtures of certain organic waxes in a strong electric field. Some of the wax molecules

carry permanent dipole moments; they are oriented by the electric field, and frozen in their orientation by the solidification. The moments produced in this way may persist for several years, yet it is generally believed that the polarized state of an electret is only metastable, and that the stable state would be unpolarized. We shall not consider electrets here; for a review of their properties the reader is referred to a paper by Gutmann.¹

CLASSIFICATION OF FERROELECTRIC CRYSTALS

We list in Table 8.1 some of the crystals which are commonly considered ferroelectric, along with the transition (Curie) temperature T_c , at which the crystal changes from the low temperature polarized state to the high temperature unpolarized state. Rochelle salt has both an upper and a lower Curie point, between which the crystal is ferroelectric. The maximum value of the spontaneous polarization P_s is listed where known. It is useful in converting units to recall that $P(\text{esu})$ is obtained by multiplying $P(\mu\text{rcoul}/\text{cm}^2)$ by 3×10^4 and by multiplying $P(\text{coul}/\text{m}^2)$ by 3×10^5 .

The crystals considered in the table may be classified into several quite natural groups. First there is Rochelle salt² and the associated isomorphous salts. Rochelle salt is a quite complicated crystal, and little progress has been made toward understanding its behavior on a microscopic basis, although Mueller³ and others have formulated a phenomenological theory which correlates a number of experimental facts. It seems possible that the ferroelectric behavior of Rochelle salt is connected intimately with the action of the molecules of water of hydration in the crystal. This is suggested by the observation that the substitution of D_2O for H_2O changes the range in which the crystal is ferroelectric from 41.7°C for the ordinary Rochelle salt to 37°C for the deuterated salt,⁴ which is quite a large effect. It may be noted, however, that the observed spontaneous polarization 800 esu is considerably less than the polarization which would result from the parallel orientation of all the water molecules; there are 1.52×10^{22} of these per cubic centimeter, and the moment per molecule is 1.85×10^{-18} esu (in the vapor), corresponding to a polarization of 28,000 esu, while the observed spontaneous polarization is only 800 esu.

¹ F. Gutmann, *Revs. Modern Phys.* **30**, 437 (1958).

² Discovered by J. Valasek, *Phys. Rev.* **12**, 475 (1921); for summary of properties see R. Mueller, *Ann. N.Y. Acad. Sci.* **46**, 321 (1946).

³ R. Mueller, *Phys. Rev.* **47**, 829 (1940); **55**, 565 (1946).

⁴ Riddon, Kolman, Mason, and Morgan, *Phys. Rev.* **84**, 378 (1952); J. Riddihill, *Helv. Phys. Acta*, **22**, 480 (1950).

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Steven H. Simon



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The Scientification of the "Jewish Question" in Nazi Germany Horst Junginger, 2017-03-20 The Scientification of the Jewish Question in Nazi Germany describes the attempt of a considerable number of German scholars to counter the vanishing influence of religious prejudices against the Jews with a new antisemitic rationale As anti Jewish stereotypes of an old fashioned soteriological kind had become dysfunctional under the pressure of secularization a new more objective explanation was needed to justify the age old danger of Judaism in the present In the 1930s a new research field called Judenforschung Jew research emerged Its leading figures amalgamated racial and religious features to verify the existence of an everlasting Jewish problem Along with that they offered scholarly concepts for its solution **Atomistic Spin Dynamics** Olle Eriksson, Anders Bergman, Lars Bergqvist, Johan Hellsvik, 2017-02-10 The purpose of this book is to provide a theoretical foundation and an understanding of atomistic spin dynamics ASD and to give examples of where the atomistic Landau Lifshitz Gilbert equation can and should be used As argued in the text a description of magnetism in an atomistic way is very natural and allows for an interpretation of experimental results in a clear and deep way This description also allows for calculations from first principles of all parameters needed to perform the spin dynamics simulations without using experimental results as input to the simulations As shown in the book we are now at a very exciting situation where it is possible to perform accurate and efficient atomistic simulations on a length and time scale which is balancing on the edge of what is experimentally possible In this way ASD simulations can both validate and be validated by state of the art experiments and ASD simulations also have the possibility to act as a predictive tool that is able to explain the magnetization dynamics in experimentally inaccessible situations The purpose of this book has been to communicate technically relevant concepts An even larger motivation is to communicate an inspiration to magnetism and magnetization dynamics and the emerging technological fields that one may foresee e g in magnonics solitonics and skyrmionics **Phase Transitions in Materials** Brent Fultz, 2014-08-14 Offering a fresh viewpoint on phase changes and the thermodynamics of materials this textbook covers the thermodynamics and kinetics of the most important phase transitions in materials science spanning classical metallurgy through to nanoscience and quantum phase transitions Clear concise and complete explanations rigorously address transitions from the atomic scale up providing the quantitative concepts analytical tools and methods needed to understand modern research in materials science Topics are grouped according to complexity ensuring that students have a solid grounding in core topics before they begin to tackle more advanced material and are accompanied by numerous end of chapter problems With explanations firmly rooted in the context of modern advances in electronic structure and statistical mechanics and developed from classroom teaching this book is the ideal companion for graduate students and researchers in materials science condensed matter physics solid state science and physical chemistry **The Oxford Solid State Basics** Steven H. Simon, 2013-06-21 The study of solids is one of the richest most exciting and most successful

branches of physics While the subject of solid state physics is often viewed as dry and tedious this new book presents the topic instead as an exciting exposition of fundamental principles and great intellectual breakthroughs Beginning with a discussion of how the study of heat capacity of solids ushered in the quantum revolution the author presents the key ideas of the field while emphasizing the deep underlying concepts The book begins with a discussion of the Einstein Debye model of specific heat and the Drude Sommerfeld theories of electrons in solids which can all be understood without reference to any underlying crystal structure The failures of these theories force a more serious investigation of microscopics Many of the key ideas about waves in solids are then introduced using one dimensional models in order to convey concepts without getting bogged down with details Only then does the book turn to consider real materials Chemical bonding is introduced and then atoms can be bonded together to crystal structures and reciprocal space results Diffraction experiments as the central application of these ideas are discussed in great detail From there the connection is made to electron wave diffraction in solids and how it results in electronic band structure The natural culmination of this thread is the triumph of semiconductor physics and devices The final section of the book considers magnetism in order to discuss a range of deeper concepts The failures of band theory due to electron interaction spontaneous magnetic orders and mean field theories are presented well Finally the book gives a brief exposition of the Hubbard model that undergraduates can understand The book presents all of this material in a clear fashion dense with explanatory or just plain entertaining footnotes This may be the best introductory book for learning solid state physics It is certainly the most fun to read

The Hormone Connection Gale Maleskey, Mary S. Kittel, 2001-01-01 Explains how a hormonal imbalance can contribute to dozens of physical and emotional ailments including fatigue diabetes osteoporosis and depression and furnishes a number of self help strategies for relieving more than forty different conditions

Fundamentals of Micro-Optics Hans Zappe, 2010-09-30 From optical fundamentals to advanced applications this comprehensive guide to micro optics covers all the key areas for those who need an in depth introduction to micro optic devices technologies and applications Topics covered range from basic optics optical materials refraction and diffraction to micro mirrors micro lenses diffractive optics optoelectronics and fabrication Advanced topics such as tunable and nano optics are also discussed Real world case studies and numerous worked examples are provided throughout making complex concepts easier to follow whilst an extensive bibliography provides a valuable resource for further study With exercises provided at the end of each chapter to aid and test understanding this is an ideal textbook for graduate and advanced undergraduate students taking courses in optics photonics micro optics microsystems and MEMs It is also a useful self study guide for research engineers working on optics development

An Introduction To Statistical Thermodynamics Robert P H Gasser, Richards W Graham, 1995-09-26 Statistical thermodynamics plays a vital linking role between quantum theory and chemical thermodynamics yet students often find the subject unpalatable In this updated version of a popular text the authors overcome this by emphasising the concepts involved in particular demystifying the

partition function They do not get bogged down in the mathematical niceties that are essential for a profound study of the subject but which can confuse the beginner Strong emphasis is placed on the physical basis of statistical thermodynamics and the relations with experiment After a clear exposition of the distribution laws partition functions heat capacities chemical equilibria and kinetics the subject is further illuminated by a discussion of low temperature phenomena and spectroscopy The coverage is brought right up to date with a chapter on computer simulation and a final section which ranges beyond the narrow limits usually associated with student texts to emphasise the common dependence of macroscopic behaviour on the properties of constituent atoms and molecules Since first published in 1974 as *Entropy and Energy Levels* the book has been very popular with students This revised and updated version will no doubt serve the same needs **ASP.NET 2.0**

Cookbook Michael A Kittel, Geoffrey T. LeBlond, 2005-12-16 Completely revised for ASP NET 2 0 this new edition of the best selling ASP NET Cookbook has everything you need to go from beginning to advanced Windows based web site development using Microsoft s popular Visual Studio 2005 and ASP NET 2 0 developer tools Written for the impatient professional ASP NET 2 0 Cookbook contains more than 125 recipes for solving common and not so common problems you are likely to encounter when building ASP NET based web applications The recipes in this book which run the gamut from simple coding techniques to more comprehensive development strategies are presented in the popular Problem Solution Discussion format of the O Reilly Cookbook series As with the first edition every solution is coded in both C and Visual Basic 2005 Among the additions and revisions to this new edition are Three new chapters including 25 new recipes for Master and Content pages Personalization using Profiles and Themes Custom Web Parts and more New code for every solution rewritten to take advantage of features and techniques new to ASP NET 2 0 and available for download The ASP NET 2 0 Cookbook continues to provide the most comprehensive coverage you ll find anywhere of Tabular controls including the new GridView control Data validation including the new ASP NET 2 0 validation controls as well as techniques for performing your own validation programmatically User and custom controls Error handling performance tuning and caching Whether you re new to ASP NET or an experienced Microsoft developer with ASP NET 2 0 Cookbook deliverance from a long day or night at your computer could be just one recipe away **Solvents and Solutions: Structure and Properties** Keshra Sangwal, 2021-08-06 A

UNIQUE BOOK ON THE PRESENT STATUS OF SOLVENTS AND SOLUTIONS WITH IMPORTANT PROBLEMS RELATED TO THEIR STRUCTURE AND PROPERTIES The literature on the properties of solvents and solutions used in academic research and in a wide range of industries has grown enormously during the last four decades and is scattered in different specialized journals *Solvents and Solutions* is a groundbreaking text that offers a systematic compilation of important problems related to selected properties of solvents and solutions based on the literature published so far The author places emphasis on explaining the basic concepts involved in understanding the properties and behavior of various solvents and solutions of electrolytes and nonelectrolytes in a consistent manner After a description of the general characteristics of structure of

solvents and solutions and the solubility of electrolytes and nonelectrolytes under normal temperature and pressure conditions the book first deals with different aspects of the density and the refractive index of solvents and dilute as well as concentrated solutions and finally with the transport i e viscosity and electric conductivity and thermal properties of solvents and solutions Solvents and solutions is the first text devoted to the description and discussion of their properties since the publication of a monograph on the physical properties of aqueous electrolyte solutions more than three decades ago The main features of this book are Reflects developments in the investigation of solvents and solutions during the last three decades Outlines basic concepts involved in understanding the properties and behavior of solvents and solutions Describes and discusses different properties of ionic liquids as solvents and the behavior of their mixtures with other commonly used solvents Contents of different chapters are not only self contained but the contents are practically independent of each other Written as a practical guide for researchers who are looking for an uptodate overview of the physical and transport properties of solvents and solutions and as a reference source for workers in chemical industries and related fields and for graduate students of chemical engineering and physical chemistry

A Course on Many-body Theory Applied to Solid-state Physics Charles Paul Enz, 1992 The main aim of this book is to give a self contained and representative cross section through present day research in solid state physics This covers metallic and mesoscopic transport localization by disorder and superconductivity including questions related to high temperature superconductors and to heavy fermion systems An important part of the book is devoted to itinerant electron magnetism discussing paramagnons strong correlation magnetization fluctuations and spin density waves All the formal tools used in these chapters are developed in the first part of the book which contains a thorough discussion of second quantization and of perturbation theory for an arbitrary complex time path and also describes the functional approach to Feynman diagrams including general ward identities Each chapter contains an extensive list of the relevant literature and a series of problems with detailed solutions which complement the main text The book is meant both as a course and a research tool

Decision Making for Sports Officials Ian Cunningham, Aden Kittel, Duncan Mascarenhas, Clare MacMahon, Paul Larkin, 2025-06-09 This essential guidebook provides a comprehensive holistic and evidence based account for improving the decision making of sports officials across different sports and levels By combining cutting edge research with practical strategies this book provides fundamental frameworks for developing decision making skills that support the needs of officials themselves officiating educators sport organizations and academics This cross disciplinary collaboration ensures the book stays grounded in both theory and practice offering readers a well rounded state of the art understanding of the subject Divided into three key sections the book first explores the unique demands and types of decisions faced by officials in different sports Next fundamental cognitive and mental factors that influence decision making are explained emphasizing the creation of knowledge the influences on decision processes and the role of mental health and psychological management on decision making performance Finally the book

outlines pragmatic and innovative strategies for supporting assessing and training decision making and creating effective development climates for sports officials Future trends in the evolution of technology use for training and assessing officials spanning grassroots to elite levels are also discussed including artificial intelligence AI virtual reality VR and other immersive learning tools Each chapter is enriched by Knowledge in Practice boxes which bring the experiences and perspectives of sports officials officiating educators and administrators and sports scientists from around the globe to light These provide real world examples and lessons for how decision making can be improved in various sporting contexts Decision Making for Sports Officials Training and Assessment Perspectives is a core resource for enhancing decision making in the high stakes world of sports officiating

Transmission Electron Microscopy David B. Williams, C. Barry Carter, 2009-08-05 This profusely illustrated text on Transmission Electron Microscopy provides the necessary instructions for successful hands on application of this versatile materials characterization technique The new edition also includes an extensive collection of questions for the student providing approximately 800 self assessment questions and over 400 questions suitable for homework assignment

Electrode And Corrosion Physics Anthony Paxton, 2024-05-28 The cost to the world's economy due to corrosion was said to be two and a half trillion dollars or 3.4% of global GDP in 2013 Electrochemistry as a discipline is of even greater relevance ten years on in view of the world's desperate attempts to prevent catastrophic climate change by moving from fossil fuel to e mobility among other measures This means that whereas electrochemistry in all its mystery and complexity was formerly the domain of the physical chemist alone today it is an essential skill for the materials scientist the engineer and indeed the physicist This textbook fills a gap in providing a course of learning from first principles for the student researcher and industrialist who has an undergraduate level education in physics but only high school chemistry The author will take you through simple electrochemical cells and the rigorous description of the many confusing potentials that arise across their interfaces to what can and cannot be measured in an experiment The first three quarters of the book are rather general highlights being the electrochemical series and the Nernst and Butler Volmer equations This all lies at the heart of the science of corrosion fuel cells and batteries The last quarter of the book is dedicated solely to corrosion applying the thermodynamic and kinetic groundwork laid earlier to help the reader clearly understand the two principal tools of corrosion scientists and engineers the Evans and Pourbaix diagrams

The Foundations of Quantum Theory Sol Wieder, 2012-12-02 The Foundations of Quantum Theory discusses the correspondence between the classical and quantum theories through the Poisson bracket commutator analogy The book is organized into three parts encompassing 12 chapters that cover topics on one and many particle systems and relativistic quantum mechanics and field theory The first part of the book discusses the developments that formed the basis for the old quantum theory and the use of classical mechanics to develop the theory of quantum mechanics This part includes considerable chapters on the formal theory of quantum mechanics and the wave mechanics in one and three dimension with an emphasis

on Coulomb problem or the hydrogen atom The second part deals with the interacting particles and noninteracting indistinguishable particles and the material covered is fundamental to almost all branches of physics The third part presents the pertinent equations used to illustrate the relativistic quantum mechanics and quantum field theory This book is of value to undergraduate physics students and to students who have background in mechanics electricity and magnetism and modern physics

Polymer Science and Engineering II Katsuyuki Kida,2021-06-09 Selected peer reviewed full text papers from the 4th International Conference on Composite Material Polymer Science and Engineering 4th CMPSE Selected peer reviewed papers from the 4th International Conference on Composite Material Polymer Science and Engineering CMPSE2020 December 06 07 2020 virtual South Korea

Statistical Physics for Electrical Engineering Neri Merhav,2017-08-16 The main body of this book is devoted to statistical physics whereas much less emphasis is given to thermodynamics In particular the idea is to present the most important outcomes of thermodynamics most notably the laws of thermodynamics as conclusions from derivations in statistical physics Special emphasis is on subjects that are vital to engineering education These include first of all quantum statistics like the Fermi Dirac distribution as well as diffusion processes both of which are fundamental to a sound understanding of semiconductor devices Another important issue for electrical engineering students is understanding of the mechanisms of noise generation and stochastic dynamics in physical systems most notably in electric circuitry Accordingly the fluctuation dissipation theorem of statistical mechanics which is the theoretical basis for understanding thermal noise processes in systems is presented from a signals and systems point of view in a way that is readily accessible for engineering students and in relation with other courses in the electrical engineering curriculum like courses on random processes

Textual and Literary Criticism of the Books of Kings Julio Treballe Barrera,2020-06-08 This volume contains a collection of the author's life long study along with some new research written specifically for this book of the text of 1 2 Kings some of them translated into English for the first time Julio Treballe's career has focused on the history of these biblical books from the triple angle of a combined textual literary and source compositional criticism His usage of the Septuagint and its secondary versions like the Old Latin as a basis for the reconstruction of the history of the text is an invaluable contribution to the panorama of textual pluralism in the Bible during the Second Temple period which has emerged after the discoveries of the Dead Sea

Flight 427 Gerry Byrne,2013-03-14 Boeing's 737 is indisputably the most popular and arguably the safest commercial airliner in the world But the plane had a lethal flaw and only after several disastrous crashes and years of painstaking investigation was the mystery of its rudder failure solved This book tells the story of how engineers and scientists finally uncovered the defect that had been engineered into the plane

Inorganic Chemistry James E. House,2025-01-27 Inorganic Chemistry Fourth Edition provides essential information for students of inorganic chemistry and is updated throughout The presentation of topics is made with an effort to be clear and concise so that the book is portable and user friendly The text emphasizes fundamental principles including

molecular structure acid base chemistry coordination chemistry ligand field theory and solid state chemistry It is organized into five major themes structure condensed phases solution chemistry main group and coordination compounds with several chapters in each There is a logical progression from atomic structure to molecular structure to properties of substances based on molecular structures to behavior of solids etc The textbook contains a balance of topics in theoretical and descriptive chemistry For example the hard soft interaction principle is used to explain hydrogen bond strengths strengths of acids and bases stability of coordination compounds etc Discussion of elements begins with survey chapters focused on the main groups while later chapters cover the elements in greater detail Each chapter opens with narrative introductions and includes figures tables and end of chapter problem sets This new edition features updates throughout with an emphasis on bioinorganic chemistry and a new chapter on nanostructures and graphene More in text worked out examples encourage active learning and prepare students for their exams This text is ideal for advanced undergraduate and graduate level students enrolled in the Inorganic Chemistry course This core course serves Chemistry and other science majors The book may also be suitable for biochemistry medicinal chemistry and other professionals who wish to learn more about this subject area Physical chemistry is incorporated to show the relevant principles from bonding theory and thermodynamics while also emphasizing the chemical characteristics of main group elements and coordination chemistry An extensive revision to the bioinorganic chemistry chapter brings the student up to date on cutting edge research Discussion of elements begins with survey chapters focused on the main groups while later chapters cover the elements in greater detail Each chapter opens with narrative introductions and includes figures tables and end of chapter problem sets New to this edition More descriptive language sentences flow more logically than they do in numerous chemistry books Additional coverage on topics as photovoltaic compounds metal oxide catalysts superconductivity flame fusion synthesis splitting water nanoparticles synthesis and use high temperature syntheses Updated end of chapter exercises

Frontiers in Magnetism of Reduced Dimension Systems Victor G. Bar'yakhtar, P.E. Wigen, 2012-12-06 Frontiers in Magnetism of Reduced Dimension Systems presents a definitive statement of our current knowledge and the state of the art in a field that has yet to achieve maturity even though there are a number of potential applications of thin magnetic films and multilayers such as magnetic sensors data storage retrieval media actuators etc The book is organized into 13 chapters each including a lecture and contributed papers on a similar subject Five chapters deal with theoretical descriptions of electron transport phenomena relaxation processes nonlinear paramagnetic interactions phase transitions and macroscopic quantum effects in magnetic films and particles The description of different characterization techniques occupies an important place in the book Separate chapters are dedicated to magnetic resonances FMR SWR NMR magneto optical spectroscopy controlling chaos magnetoelastic phenomena and magnetic resonance force microscopy A further chapter gives a detailed review spread over a number of papers of materials in current use in information storage devices

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