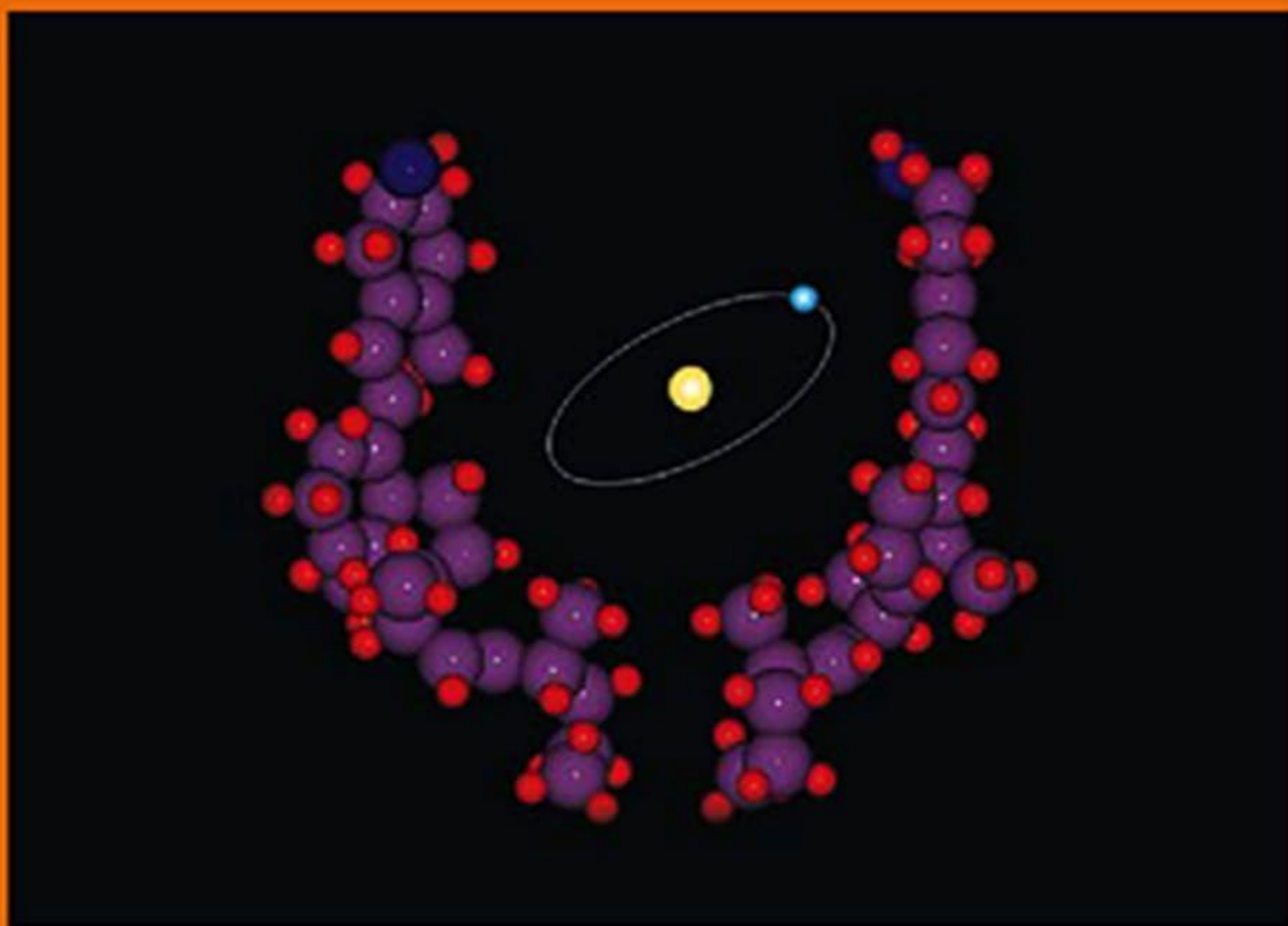




Physics for Chemists

Ruslan P. Ozerov and Anatoli A. Vorobyev



Colour for textiles

A user's handbook

Wilfred Ingamells PhD MSc CText FTI CCol FSDC

School of Home Economics and Institutional Management, University of Wales, Cardiff, UK

1993

Society of Dyers and Colourists

Physics for Chemists

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Contents

Preface	iv
CHAPTER ONE	
Introduction and the role of testing	1
CHAPTER TWO	
The colourist and colour quality	15
CHAPTER THREE	
The chemical principles of coloration	27
CHAPTER FOUR	
The attributes of fibres	44
CHAPTER FIVE	
The selection, classification and application of dyes	76
CHAPTER SIX	
Industrial coloration methods	112
CHAPTER SEVEN	
The modern approach to coloration	138
CHAPTER EIGHT	
Practical notes	158
APPENDICES	
1 Some examples of commercial dyes	166
2 Generic names of synthetic fibres	171

Physics for Chemists

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Preface

For many years the Society of Dyers and Colourists has been aware of the need for a book covering the basic science and technology of textile coloration for the benefit of readers without a detailed scientific background. In the mid-1980s the late Dr Frank Jones of the University of Leeds started to write such a book, but sadly he died before he could complete this worthwhile task. The torch was then passed to me, with the brief to prepare a work for those who probably lack science qualifications at A-level but who nevertheless need to become familiar to some extent with the work of the professional colourist. The target readership included people working in nontechnical capacities in industry, and students of home economics, textile design and management. The aim is to introduce such readers to the relevant technological background and the basic principles of coloration, and show how colour is assessed objectively in modern industry.

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Contents

<i>Preface</i>	xiii
<i>Acknowledgments</i>	xv
<i>Recommendations to the Solution of the Physical Problems</i>	xvii
1 Mechanics	1
1.1 Introduction	1
1.2 Kinematics	1
1.2.1 Kinematics of a material point	1
1.2.2 Kinematics of translational movement of a rigid body	12
1.2.3 Kinematics of the rotational motion	12
1.3 Dynamics	16
1.3.1 Newton's first law of motion: inertial reference systems	16
1.3.2 Galileo's relativity principle: Galileo transformations	18
1.3.3 Newton's second law of motion: Momentum	20
1.3.4 The third Newtonian law	29
1.3.5 Forces classification in physics	29
1.3.6 Noninertial reference systems. An inertia force: D'Alembert principle	33
1.3.7 A system of material points: internal and external forces	35
1.3.8 Specification of a material points system	39
1.3.9 The dynamics of rotational motion	40
1.4 Work, Energy and Power	51
1.4.1 Elementary work of a force and a torque	51
1.4.2 Power	53
1.4.3 Kinetic energy	54
1.4.4 A force field	58
1.4.5 Potential energy	61
1.5 Conservation Laws in Mechanics	67
1.5.1 Conservation law of mechanical energy	67
1.5.2 Momentum conservation law	69
1.5.3 Angular momentum conservation law	71
1.5.4 Potential curves	74
1.5.5 Particle collisions	79
1.6 Einstein's Special Relativistic Theory (STR) (Short Review)	90
Problems/Tasks	97
Answers	101
2 Oscillations and Waves	105
2.1 Definitions	105
2.2 Kinematics of Harmonic Oscillations	106
2.3 Summation of Oscillations	113

2.3.1	Summation of codirectional oscillations	113
2.3.2	Summing up two codirectional oscillations with slightly different frequencies: beatings	117
2.4	Dynamics of the Harmonic Oscillation	118
2.4.1	Differential equations of harmonic oscillations	118
2.4.2	Spring pendulum	118
2.4.3	The mathematical pendulum	119
2.4.4	A physical pendulum	121
2.4.5	Diatomic molecule as a linear harmonic oscillator	129
2.5	Energy of Harmonic Oscillations	131
2.6	Damped Oscillations	133
2.7	Forced Oscillations	138
2.8	Waves	145
2.8.1	Introductory remarks	145
2.8.2	An equation of a plane traveling wave	147
2.8.3	Wave energy	151
2.8.4	Acoustic Doppler effect	154
2.9	Summation of Waves	156
2.9.1	Superposition of waves	156
2.9.2	Standing waves	157
2.9.3	String oscillations	160
2.9.4	Group velocity of waves: wave package	163
	Problems/Tasks	165
	Answers	166
3	Molecular Physics	169
3.1	Kinetic Theory of Ideal Gases	169
3.1.1	Introductory remarks	169
3.1.2	Distribution function	172
3.1.3	An ideal gas model	174
3.1.4	General equation of an ideal gas	175
3.1.5	Absolute temperature	177
3.2	Distribution of Molecules of an Ideal Gas in a Force Field (Boltzmann Distribution)	178
3.2.1	An ideal gas in a force field: Boltzmann distribution	178
3.2.2	Barometric height formula	180
3.2.3	Centrifugation	183
3.2.4	Boltzmann factor	185
3.3	Distribution of the Kinetic Parameters of an Ideal Gas' Particles (Maxwell Distribution)	186
3.3.1	The Maxwellian distribution of the absolute values of molecule velocities	186
3.3.2	The kinetic energies Maxwellian distribution of molecules	193
3.4	First Law of Thermodynamics	194
3.4.1	Equipartition of energy over degrees of freedom	194
3.4.2	First laws of thermodynamics	195
3.4.3	Heat capacity of an ideal gas: the work of a gas in isoprocesses	197
3.4.4	Heat capacity: theory versus experiment	204
3.5	The Second Law of Thermodynamics	205
3.5.1	Heat engines	206

3.5.2	The Carnot cycle	207
3.5.3	Refrigerators and heat pumps	210
3.5.4	Reduced amount of heat: entropy	211
3.5.5	Clausius inequality and the change of entropy for nonequilibrium processes . . .	214
3.5.6	Statistical explanation of the second law of thermodynamics	219
3.5.7	Entropy and disorder	220
3.6	A Real Gas Approximation: van der Waals Equation	221
3.6.1	An equation of state of a van der Waals gas	221
3.6.2	Internal energy of the van der Waals gas	226
3.6.3	A Joule–Thomson effect	227
3.7	Elements of Physical Kinetic	230
3.7.1	Introduction	230
3.7.2	Transport processes: relaxation	230
3.7.3	Transport phenomena in ideal gases	231
3.7.4	A macroscopic representation of a transport coefficient	233
3.7.5	Diffusion in gases	235
3.7.6	Heat transfer	237
3.7.7	Viscosity or internal friction	238
3.7.8	A transport phenomena in a vacuum condition	243
	Problems/Tasks	245
	Answers	247
4	Dielectric Properties of Substances	251
4.1	Electrostatic Field	251
4.1.1	General laws of electrostatics	251
4.1.2	Strength of an electrostatic field	252
4.1.3	The Gauss law	259
4.1.4	Work of an electrostatic field force and potential of an electrostatic field	273
4.1.5	Electrical field of an electric dipole	276
4.2	Dielectric Properties of Substances	280
4.2.1	Conductors and dielectrics: a general view	280
4.2.2	Macroscopic (phenomenological) properties of dielectrics	282
4.2.3	Microscopic properties of dielectrics	284
4.2.4	Three types of polarization mechanisms	286
4.2.5	Dependence of the polarization on an alternative electric field frequency	293
4.2.6	A local electric field in dielectrics. Lorentz field	294
4.2.7	Clausius–Mossoti formula	296
4.2.8	An experimental determination of the polarization and molecular electric dipole moments	298
	Problems/Tasks	301
	Answers	303
5	Magnetics	305
5.1	General Characteristics of the Magnetic Field	305
5.1.1	A permanent (direct) electric current	305
5.1.2	A magnetic field induction	309

5.1.3	The law of a total current (ampere law)	318
5.1.4	Action of the magnetic field on the current, on the moving charge	320
5.1.5	A magnetic dipole moment in a magnetic field.	327
5.1.6	Electromagnetic induction	328
5.2	Magnetic Properties of Chemical Substances	331
5.2.1	Atomic magnetism	332
5.2.2	Macroscopic properties of magnetics	333
5.2.3	An internal magnetic field in magnetics	334
5.2.4	Microscopic mechanism of magnetization	336
5.3	Magnetically Ordered State	344
5.3.1	Ferromagnetism	344
5.3.2	Domains: magnetization of ferromagnetics.	347
5.3.3	Antiferro- and ferrimagnetics	349
5.4	Displacement Current: Maxwell's Equations	350
	Problems/Tasks	358
	Answers.	360
6	Wave Optics and Quantum–Optical Phenomena	361
6.1	Physics of Electromagnetic Optical Waves.	361
6.2	An Interference	369
6.2.1	Superposition of two colinear light waves of the same frequencies	369
6.2.2	Interference in thin films	370
6.3	Diffraction	377
6.3.1	Huygens–Fresnel principle: Fresnel zones	378
6.3.2	Diffraction on one rectangular slit	379
6.3.3	Diffraction grating	381
6.3.4	Diffraction grating as a spectral instrument	383
6.3.5	X-ray diffraction	385
6.4	Polarization	386
6.4.1	Polarized light: definitions	386
6.4.2	Malus law	387
6.4.3	Polarization at reflection: Brewster's law	388
6.4.4	Rotation of the polarization plane.	389
6.4.5	Birefringence: a Nichol prism	391
6.5	Dispersion of Light	395
6.6	The Quantum-Optical Phenomena	398
6.6.1	Experimental laws of an ideal black body radiation	398
6.6.2	Theory of radiation of an ideal black body from the point of view of wave theory: Rayleigh–Jeans formula	402
6.6.3	Planck's formula: a hypothesis of quanta—intensity of light from wave and quantum points of view	404
6.6.4	Another quantum-optical phenomena	407
6.7	The Bohr Model of a Hydrogen Atom	416
	Problems/Tasks	421
	Answers.	422

7	Elements of Quantum Mechanics	423
7.1	Particle-Wave Duality	423
7.1.1	De Broglie hypothesis	423
7.1.2	Electron and neutron diffraction	424
7.2	Heisenberg's Uncertainty Principle	428
7.3	Wavefunction and the Schrödinger Equation	432
7.3.1	A wavefunction	432
7.3.2	The Schrödinger equation	433
7.3.3	Standard requirements that the wavefunction should obey	434
7.4	Most General Problems of a Single-Particle Quantum Mechanics	435
7.4.1	A free particle	435
7.4.2	A particle in a potential box	436
7.4.3	A potential step	441
7.4.4	A potential barrier: a tunnel effect	442
7.4.5	Tunnel effect in chemistry	445
7.5	The Hydrogen Atom	447
7.5.1	The Schrödinger equation for the hydrogen atom	448
7.5.2	The eigenvalues of the electron angular momentum projection L_z	451
7.5.3	Angular momentum and magnetic moment of a one-electron atom	452
7.5.4	A Schrödinger equation for the radial part of the wave function; electron energy quantization	457
7.5.5	Spin of an electron	460
7.5.6	Atomic orbits: hydrogen atom quantum numbers	461
7.5.7	Atomic orbits	462
7.5.8	A spin-orbit interaction (fine interaction)	467
7.6	A Many-Electron Atom	468
7.6.1	Types of electron's coupling in many-electron atoms	469
7.6.2	Magnetic moments and a vector model of a many-electron atom. The Lande factor	470
7.6.3	The atomic terms	473
7.6.4	Characteristic X-rays: Moseley's law	473
7.7	An Atom in the Magnetic Field: The Zeeman Effect	477
7.8	A Quantum Oscillator and a Quantum Rotator	480
7.8.1	Definitions	480
7.8.2	Quantum oscillators: harmonic and anharmonic	481
7.8.3	A rigid quantum rotator	486
7.8.4	Principles of molecular spectroscopy	491
	Problems/Tasks	494
	Answers	495
8	Physical Principles of Resonance Methods in Chemistry	497
8.1	Selected Atomic Nuclei Characteristics	497
8.1.1	A nucleon model of nuclei	497
8.1.2	Nuclear energy levels	499

8.1.3	Nuclear charge and mass distribution	500
8.1.4	Nuclear quadrupole electrical moment	501
8.2	Intraatomic Electron–Nuclear Interactions	502
8.2.1	General considerations	502
8.2.2	Coulomb Interaction of an electron shell with dimensionless nucleus	504
8.2.3	Coulomb Interaction of an electron shell with a nucleus of finite size: the chemical shift	504
8.2.4	The nuclear quadrupole moment and the electric field gradient interaction . . .	506
8.2.5	Interaction of a nuclear magnetic moment with an electron shell	507
8.2.6	Atomic level energy and the scale of electromagnetic waves	507
8.3	γ -Resonance (Mössbauer) Spectroscopy	508
8.3.1	Principles of resonance absorption	508
8.3.2	Resonance absorption of γ -rays: Mössbauer effect	510
8.3.3	γ -Resonance (Mössbauer) spectroscopy in chemistry	513
8.3.4	Superfine interactions of a magnetic nature	515
8.4	Nuclear Magnetic Resonance (NMR)	516
8.4.1	Introduction	516
8.4.2	Use of nuclear magnetic resonance in chemistry	517
8.5	Abilities of Nuclear Quadrupole Resonance.	525
8.6	Electron Paramagnetic Resonance (EPR).	526
	Problems/Tasks	528
	Answers.	529
9	Solid State Physics	531
9.1	Crystal Structure, Crystal Lattice.	531
9.2	Electrons in Crystals	537
9.2.1	Energy band formation.	537
9.2.2	Elements of quantum statistics	540
9.2.3	Band theory of solids	544
9.3	Lattice Dynamics and Heat Capacity of Crystals	545
9.3.1	The Born–Karman model and dispersion curves.	545
9.3.2	The heat capacity of crystals	550
9.4	Crystal Defects	561
9.4.1	Point defects	561
9.4.2	Dislocations	563
9.5	Transport Phenomena in Liquids and Solids	567
9.6	Some Technically Important Electric Properties of Substances.	571
	Problems/Tasks	577
	Answers.	578
	Appendix 1	581
	Appendix 2	589
	Appendix 3	591

Contents	xi
Appendix 4	595
Appendix 5	599
Glossary of Symbols and Abbreviations.	605
Index	609

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All miracles of nature, no matter how extraordinary they are, have always found their explanation in the laws of physics

Jules Verne
Journey to the Center of the Earth

Preface

In this new century, the development of science, technology, industry, etc., will require new materials and devices, which will in many respects differ from those of the past. Even now, there are many such examples. Certainly, the main foundation of these achievements is science, primarily physics, which enables the solid building of chemical, biological and atomic technologies, etc.

In general, this book is a textbook on physics, but takes the above circumstances into account. It is aimed at students and scientists in the field of technology (chemical, biological and other branches of sciences), who will be working in the times ahead. The book differs substantially from standard physics textbooks in its choice of subjects, the manner of its presentation, selection of examples and illustrations as well as problems to be solved by the reader. The book contains problems important for chemists such as the language of potential curves and the essence of the theory of molecular collisions, and a large part is devoted to molecular physics with classical Boltzmann and Maxwell statistics, transport phenomena, etc. In a special part, the dielectric and magnetic properties of molecules are considered from the point of view of their structure. Optics is also covered in order to give the reader some idea of how its laws can be used for molecular structure analysis. Quantum mechanics is presented in an adapted form, aimed at a description of atomic and molecular spectroscopy. A special chapter describes tunneling both as a general phenomenon and as a mechanism of chemical reactions. Special attention is paid, also in an adapted form, to inter-atomic fine and superfine interactions, which are the basis of many modern and productive physical methods in the field of atomic and molecular structural investigations. Solid-state theory is presented on the basis of quantum statistics in order to form a bridge to their properties. A new technological field—nano-scale technology—is touched on here. In our opinion, no other textbook covers the sophisticated modern subjects mentioned above in such an acceptable form.

Physics always operates with certain models—simplified representations of real systems. The ideal gas model is one such example. Despite its variety of real gas properties, this simple model assists in understanding the behavior of more complex systems using more complex factors permitted within the model, and it provides numerical results. For example, the introduction of additional interactions leads to van der Waals's gas and allows further inclusion of virial factors, which in turn make the model more universally applicable to all gases. When using the model, the level of required accuracy has to be defined and on that basis, an appropriate model can be selected.

The authors have aimed to make the subject matter easy to master; therefore many theoretical approaches in the text have been presented in an adapted manner, while the more strict proofs are given separately throughout each chapter in the *Examples*, in the *Problems/Tasks* at the end of each chapter, and particularly in the *Appendices*. A set of important constants is given in *Appendix A1* to facilitate the solution of the problems. Units of measurement of physical values are also listed there.

The text is further enhanced by the illustrative material, including selected drawings, graphs and tables, which are an inseparable part of the book and greatly simplify understanding of the text. The book will be particularly useful for students, not only in the narrow area of their future profession but also in allowing them a broader glimpse of the surrounding world. In our opinion, this is necessary to encourage in the young people of the twenty-first century a firm perception of the world as an objective reality. The book pays a good deal of attention to the laws they need to learn in order to acquire new knowledge and to use it to expand human possibilities both in industrial and spiritual spheres of activity.

The book's nine chapters provide a description of the main laws of mechanics, statistical physics, thermodynamics, physics of dielectrics and magnetics, wave optics, quantum mechanics and physics of electronic shell of atoms, solid-state physics, physics of electromagnetic waves and physical methods of investigation. It contains a large amount of comprehensive information, useful for everybody in all stages of tutorial, practical and scientific activity.

For successfully understanding the book, the reader should have a knowledge of the mathematical laws of, and some experience regarding, operation with vectors, differentiation and integration of elementary functions and others. Mathematics is the language of physics: the faults in mathematics must be considered as the faults in physics.

The book is the fruit of our long experience at the Mendeleev University of Chemical Technology (MUCHT) in Moscow. The results we have achieved have had a great influence on the content of the book and the problems chosen. One of us (RO) participated in publishing a textbook on physics under the auspices of the "State Program of Education and Science Integration" ("Physics in Chemical Technology" in collaboration with Professor E.F. Makarov from the Institute of Chemical Physics of Russian Academy of Sciences). Although it appeared in a very limited edition, which meant that the book wasn't available for purchase, it has nevertheless greatly influenced the publication of this new work. One of the authors (RO) has spent a relatively long time at The University of Western Australia (UWA) in Perth, and this too has had a significant influence on the content and style of the book.

R.P. Ozerov
A.A. Vorobjev

Acknowledgments

It happens that both co-authors of this book, learning together in the same institute (Moscow Institute of Physical Engineering) and working thereafter for a very long period of time in the same department of the Moscow University of Chemical Technology have now been separated by long distance, corresponding only by telephone and e-mail. Therefore this part of the acknowledgment is expressed mostly by one of us, namely RPO.

Firstly I would like to give my thanks the late Professor Edvard N. (Ted) Maslen, my colleague on the commission on Electron Density of the International Union of Crystallography; he strongly supported an acceptance of my previous student Dr. Victor A. Streltsov to a postdoctoral position at the Crystallography Centre of the University of Western Australia, which has resulted in an profitable collaboration with the D.I. Mendeleev Institute of Chemical Technology in Moscow.

Ted and Professor Sid Hall made provision for a very favorable and productive investigation into X-ray crystallography. I greatly appreciate the initiative that Professor Sid Hall showed when he undertook on the position to assist me, especially considering the unusual circumstances.

Dr. Alexandre N. Sobolev jointed the project a little latter; though the skill he has acquired in UWA made him a high-class specialist in X-ray crystallography. His skill and determination are extremely valued and his endless commitment enabled me to complete this book.

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Professor Ruslan P. Ozerov
Professor Anatoli Vorobyev

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Recommendations to the Solution of the Physical Problems

Readers are recommended to begin solving the problems by writing down the given data in the normal way. On the left-hand side, all the data should be written in a column as accurately as possible. At this point, it is useful to translate all the given data to the SI system of units in order to avoid confusion at the end. In the majority of cases, it is also very useful to make a competent analysis of the task, choose a reference system, and make the drawing indicating all the details correctly; with the proper indication of all details; it can be said that a reliable drawing is 50% of the solution.

The solution should be carried out, as a rule, in a general form, i.e., without intermediate numerical calculations down to the final answer; this means that the symbol for the physical value sought should remain on the left-hand side of the answer, while the symbols for the physical values of the given conditions and the necessary physical constants should be on the right-hand side. The values of physical constants are listed in *Appendix 1*.

It is also useful to accompany the decision with a brief explanation, both physical and mathematical, to state the physical ideas behind the solution. Moreover, the mathematical treatment should also be explained: if the definite integral is treated, the limits should be explained. In square root calculations it is desirable to explain whether both roots should proceed or one root should be rejected and why? The final answer in a general form should be marked by any way. We especially want to emphasize that a general solution is of greater significance and value: it means that not just the particular problem has been solved, but a real task. The results can then always be used to solve similar problems without starting the treatment again from the very beginning.

The analysis of the dimension of the result is one of the important stages of the solution; it permits one to be confident of the result. It is necessary to carry out calculations keeping the desired accuracy in mind; more often three significant figures will be sufficient. The numerical answer should be written down as a number increased to the proper power of 10 or using multiple prefixes, e.g., $A = 2.56 \times 10^7 \text{ J}$ and/or 25.6 MJ.

It is important that one should be certain that a reasonable result has been achieved, i.e., the speed of a body does not exceed the speed of light, or its size does not exceed the size of the universe, etc.

We wish our readers all success!

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