

# Contents

<b>1</b>	<b>Chemical Bonding in Solids</b> .....	1
1.1	The Periodic Table of the Elements .....	1
1.2	Covalent Bonding .....	4
1.3	Ionic Bonding .....	9
1.4	Metallic Bonding .....	13
1.5	The Hydrogen Bond .....	15
1.6	The van der Waals Bond .....	15
	Problems .....	16
<b>2</b>	<b>Structure of Solid Matter</b> .....	21
2.1	The Crystal Lattice .....	22
2.2	Point Symmetry .....	25
2.3	The 32 Crystal Classes (Point Groups) .....	27
2.4	The Significance of Symmetry .....	28
2.5	Simple Crystal Structures .....	31
2.6	Phase Diagrams of Alloys .....	36
2.7	Defects in Solids .....	45
	Problems .....	48
<b>3</b>	<b>Diffraction from Periodic Structures</b> .....	51
3.1	General Theory of Diffraction .....	51
3.2	Periodic Structures and the Reciprocal Lattice .....	57
3.3	The Scattering Conditions for Periodic Structures .....	58
3.4	The Bragg Interpretation of the Laue Condition .....	60
3.5	Brillouin Zones .....	63
3.6	The Structure Factor .....	64
3.7	Methods of Structure Analysis .....	67
	Problems .....	70
	<b>Panel I:</b> Diffraction Experiments with Various Particles .....	72
	<b>Panel II:</b> X-Ray Interferometry and X-Ray Topography .....	79
<b>4</b>	<b>Dynamics of Atoms in Crystals</b> .....	85
4.1	The Potential .....	86
4.2	The Equation of Motion .....	87
4.3	The Diatomic Linear Chain .....	88
4.4	Scattering from Time-Varying Structures – Phonon Spectroscopy .....	93

4.5	Elastic Properties of Crystals	96
	Problems	106
	<b>Panel III: Raman Spectroscopy</b>	109
<b>5</b>	<b>Thermal Properties</b>	115
5.1	The Density of States	115
5.2	The Thermal Energy of a Harmonic Oscillator	118
5.3	The Specific Heat Capacity	120
5.4	Effects Due to Anharmonicity	122
5.5	Thermal Expansion	123
5.6	Heat Conduction by Phonons	127
	Problems	131
	<b>Panel IV: Experiments at Low Temperatures</b>	133
<b>6</b>	<b>“Free” Electrons in Solids</b>	137
6.1	The Free-Electron Gas in an Infinite Square-Well Potential	138
6.2	The Fermi Gas at $T=0\text{K}$	142
6.3	Fermi Statistics	144
6.4	The Specific Heat Capacity of Electrons in Metals	147
6.5	Electrostatic Screening in a Fermi Gas – The Mott Transition	152
6.6	Thermionic Emission of Electrons from Metals	154
	Problems	158
<b>7</b>	<b>The Electronic Bandstructure of Solids</b>	161
7.1	General Symmetry Properties	161
7.2	The Nearly Free-Electron Approximation	165
7.3	The Tight-Binding Approximation	169
7.4	Examples of Bandstructures	175
7.5	The Density of States	179
7.6	Density of States in Non-Crystalline Solids	181
	Problems	184
	<b>Panel V: Photoemission Spectroscopy</b>	186
<b>8</b>	<b>Magnetism</b>	191
8.1	Diamagnetism and Paramagnetism	191
8.2	The Exchange Interaction	196
8.3	Exchange Interaction Between Free Electrons	199
8.4	The Band Model of Ferromagnetism	201
8.5	The Temperature Behavior of a Ferromagnet in the Band Model	205
8.6	Ferromagnetic Coupling for Localized Electrons	209
8.7	Antiferromagnetism	211
8.8	Spin Waves	215
	Problems	219
	<b>Panel VI: Magnetostatic Spin Waves</b>	221
	<b>Panel VII: Surface Magnetism</b>	227

<b>9</b>	<b>Motion of Electrons and Transport Phenomena</b>	231
9.1	Motion of Electrons in Bands and the Effective Mass	231
9.2	Currents in Bands and Holes	235
9.3	Scattering of Electrons in Bands	237
9.4	The Boltzmann Equation and Relaxation Time	241
9.5	The Electrical Conductivity of Metals	245
9.6	Thermoelectric Effects	251
9.7	The Wiedemann-Franz Law	254
9.8	Electrical Conductivity of Localized Electrons	256
	Problems	258
	<b>Panel VIII: Quantum Oscillations and the Topology</b>	
	of Fermi Surfaces	260
<b>10</b>	<b>Superconductivity</b>	267
10.1	Some Fundamental Phenomena	
	Associated with Superconductivity	267
10.2	Phenomenological Description by Means	
	of the London Equations	272
10.3	Instability of the “Fermi Sea” and Cooper Pairs	275
10.4	The BCS Ground State	280
10.5	The Excitation Spectrum of a Superconductor	288
10.6	Consequences of the BCS Theory and Comparison	
	with Experimental Results	293
10.7	Supercurrents and Critical Currents	297
10.8	Coherence of the BCS Ground State	
	and the Meissner-Ochsenfeld Effect	300
10.9	Quantization of Magnetic Flux	305
10.10	Type II Superconductors	309
10.11	“High-Temperature” Superconductors	316
	Problems	325
	<b>Panel IX: One-Electron Tunneling in Superconductor Junctions</b>	328
	<b>Panel X: Cooper-Pair Tunneling – The Josephson Effect</b>	338
<b>11</b>	<b>Dielectric Properties of Materials</b>	347
11.1	The Dielectric Function	347
11.2	Absorption of Electromagnetic Radiation	350
11.3	The Dielectric Function for a Harmonic Oscillator	353
11.4	Longitudinal and Transverse Normal Modes	355
11.5	Surface Waves on a Dielectric	358
11.6	Reflectivity of a Dielectric Half-Space	360
11.7	The Local Field	361
11.8	The Polarization Catastrophe and Ferroelectrics	363
11.9	The Free-Electron Gas	365
11.10	Interband Transitions	367
11.11	Excitons	374
11.12	Dielectric Energy Losses of Electrons	376

Problems .....	379
<b>Panel XI: Spectroscopy with Photons and Electrons</b> .....	383
<b>Panel XII: Infrared Spectroscopy</b> .....	386
<b>Panel XIII: The Frustrated Total Reflection Method</b> .....	389
<b>12 Semiconductors</b> .....	391
12.1 Data for a Number of Important Semiconductors .....	392
12.2 Charge Carrier Density in Intrinsic Semiconductors .....	396
12.3 Doping of Semiconductors .....	400
12.4 Carrier Densities in Doped Semiconductors .....	404
12.5 Conductivity of Semiconductors .....	409
12.6 The $p$ - $n$ Junction and the Metal/Semiconductor Schottky Contact	415
12.7 Semiconductor Heterostructures and Superlattices .....	431
12.8 Important Semiconductor Devices .....	444
Problems .....	458
<b>Panel XIV: The Hall Effect</b> .....	461
<b>Panel XV: Cyclotron Resonance in Semiconductors</b> .....	464
<b>Panel XVI: Shubnikov-de Haas Oscillations and Quantum Hall Effect</b>	467
<b>Panel XVII: Semiconductor Epitaxy</b> .....	476
<b>References</b> .....	483
<b>Subject Index</b> .....	495
<b>Periodic Table of the Elements</b> (Inside front cover)	
<b>Table of Constants and Equivalent Values</b> (Inside back cover)	