

CONTENTS

I. PHONONS

1.1.	Solid matter as a gas of excitations	1
1.2.	The crystal lattice	3
1.3.	Dynamics of a linear lattice	6
1.4.	Dynamics of space lattices	16
1.5.	The reciprocal lattice	22
1.6.	Normal coordinates in three dimensions	27
1.7.	General properties of lattice waves	31
1.8.	Calculation and observation of the dispersion of lattice waves	38
1.9.	Lattice specific heat, and the frequency spectrum	43
1.10.	Vibrations of an elastic continuum	49
1.11.	The Debye theory, and similar approximations	52

II. ELECTRONS

2.1.	The free electron model	62
2.2.	The effect of the periodic lattice	66
2.3.	Brillouin zones	69
2.4.	Band structure and the Fermi surface	73
2.5.	Coulomb interaction	80
2.6.	The tight-binding method	82
2.7.	The cellular method	85
2.8.	Plane-wave methods	88
2.9.	Dynamical properties of electrons	92
2.10.	Fermi-Dirac statistics	100
2.11.	Experimental study of the Fermi surface	105
2.12.	The electronic structure of the elements	109

III. PHONON-PHONON INTERACTION

3.1.	General theory of transition probabilities	128
3.2.	Anharmonic lattice forces	130
3.3.	Effects of the selection rules	134
3.4.	Interaction with optical modes	144
3.5.	Four-phonon processes	146
3.6.	Elastic anharmonicity	147
3.7.	Thermal expansion	152
3.8.	The absorption of sound in solids	156

IV. ELECTRON-ELECTRON INTERACTION

4.1.	Screening	159
4.2.	Plasma oscillations	161

CONTENTS

4.3. Collective coordinates	162
4.4. The short-range interaction	166
4.5. Screening in real solids	168
4.6. Electron-electron scattering	170
4.7. Scattering by bound electrons	172
V. ELECTRON-PHONON INTERACTION	
5.1. The adiabatic principle	174
5.2. Interaction terms	179
5.3. Matrix element for electron-phonon scattering	181
5.4. Rigid ion approximation	183
5.5. The deformable ion	188
5.6. The deformation potential	191
5.7. Bardeen's self-consistent calculation	197
5.8. Electron-lattice interaction in metals	202
5.9. Deformation potentials in semiconductors	205
5.10. Interaction of carriers with optical modes	206
5.11. Interaction with polar modes	209
5.12. When does the adiabatic principle fail?	212
VI. SCATTERING BY LATTICE IMPERFECTIONS	
6.1. The types of imperfection	220
6.2. Point imperfections and phonons	221
6.3. Point imperfections and electrons	223
6.4. Dislocations and phonons	228
6.5. Dislocations and electrons	235
6.6. Stacking faults and twin boundaries	239
6.7. Grain boundaries	244
6.8. Disordered alloys	246
6.9. Amorphous structures	248
VII. FORMAL TRANSPORT THEORY	
7.1. The kinetic method	257
7.2. Distribution functions	261
7.3. The Boltzmann equation	264
7.4. The elementary solution	267
7.5. The macroscopic transport coefficients	270
7.6. The Kelvin-Onsager relations	273
7.7. The variational principle	275
7.8. Thermodynamic formulation of the variational principle	280
7.9. The general variational principle applied	283
7.10. Matthiessen's rule	285

VIII. LATTICE CONDUCTION

8.1.	Thermal conduction in insulators	288
8.2.	Calculation of Umklapp resistance	292
8.3.	The problem of long longitudinal waves	298
8.4.	Experimental study of Umklapp resistance	302
8.5.	Theory of imperfection resistance	306
8.6.	Isotopes and other point imperfections	310
8.7.	Imperfect crystals and glasses	316
8.8.	Other heat conduction mechanisms in insulators	319
8.9.	Lattice conduction in metals	319
8.10.	Lattice conduction in semi-metals and semiconductors	326

IX. ELECTRONIC CONDUCTION IN METALS

9.1.	Transport properties of metals	334
9.2.	Residual resistance in alloys	337
9.3.	The resistance-minimum phenomenon	344
9.4.	Residual resistance from crystal imperfections	350
9.5.	Lattice resistance: the Bloch theory	357
9.6.	Temperature variation of lattice resistance: amendment of the Bloch formula	367
9.7.	The magnitude of the lattice resistivity	370
9.8.	The electrical resistivity of the transition metals	376
9.9.	Thermal conductivity: the Wiedemann-Franz law	382
9.10.	Thermal conductivity: lattice scattering	385
9.11.	Thermopower	398
9.12.	Thermopower at low temperatures	403
9.13.	Phonon drag	407
9.14.	Electron-electron scattering	412
9.15.	High temperatures and pressures	418

X. MOBILITY IN SEMICONDUCTORS

10.1.	Scope of the investigation	421
10.2.	Spherical energy surfaces	423
10.3.	Scattering by impurities and imperfections	428
10.4.	Lattice scattering	431
10.5.	Scattering by optical modes: polar crystals	434
10.6.	Scattering by optical modes: covalent semiconductors	439
10.7.	The many-valley model	440
10.8.	Piezo-resistance	444
10.9.	Phonon drag	447

XI. SIZE AND SURFACE EFFECTS

11.1.	Limitation of the mean free path	450
11.2.	General theory	452

11.3. Rough and smooth	456
11.4. Boundary scattering of phonons	460
11.5. Electrical conductivity of thin wires and films	465
11.6. The galvanomagnetomorphic effect	469
11.7. The anomalous skin effect	474
XII. TRANSPORT PHENOMENA IN A MAGNETIC FIELD	
12.1. Elementary theory	483
12.2. The Hall effect	486
12.3. Magnetoresistance	490
12.4. Thermomagnetic phenomena	495
12.5. The method of Jones & Zener	501
12.6. The variational principle in a magnetic field	508
12.7. Effects in strong fields	512
12.8. Quantization of electron orbits	521
AUTHOR INDEX AND BIBLIOGRAPHY	
SUBJECT INDEX	
INDEX OF SYMBOLS	551