CONTENTS

PREFACE xi

NOTE ON SYMBOLS USED FOR PHYSICAL QUANTITIES xv

I. GENERAL INTRODUCTION

1. Classification of Transformations 1
2. Characteristics of Nucleation and Growth Transformations 11
3. Characteristics of Martensitic Transformations 13
4. Isothermal Transformation Curves 16

II. FORMAL GEOMETRY OF CRYSTAL LATTICES

5. Description of the Ideal Crystal 23
6. Linear Transformations of the Co-ordinate System 31
7. Affine Transformations: Homogeneous Deformation 40
8. Twin Crystals 49
9. Relations between Different Lattices 56
10. Infinitesimal Deformations 63
11. Stress–Strain Relations: Theory of Elasticity 69

III. THE THEORY OF REACTION RATES

12. Chemical Kinetics and Activation Energy 80
13. The Reaction Rate Theory 87

IV. THE THERMODYNAMICS OF IRREVERSIBLE PROCESSES

14. Microscopical Reversibility: the Onsager Reciprocal Relations 95
15. Entropy Production in Natural Processes 100

V. THE STRUCTURE OF REAL METALS

16. Metallic Structures: Polymorphism 107
17. Point Defects in Crystals 125
18. Crystal Surfaces: the Equilibrium Structure of a Step 137

19. The Structure of Close-packed Surfaces 143
20. The Equilibrium Shape of a Crystal: Wulff's Theorem 146
21. Liquid Metals: the Solid–Liquid Interface 152

VI. Solid Solutions

22. Pair Probability Functions: Thermodynamic Properties 161
23. The Nearest Neighbour Model: Regular Solutions 172
24. The Quasi-chemical Theory: Other Statistical Theories 178
25. Misfit Energy in Solid Solutions: Sub-regular Solutions 188
26. Ordered Structures in Alloys 198
27. Fluctuations in Solid Solutions: Short-range Order and Clustering 217

VII. The Theory of Dislocations

28. Introduction: Edge and Screw Dislocations 224
29. Geometrical Properties of Dislocations 234
30. Dislocations in an Elastic Medium 245
31. Formation and Properties of Crystal Dislocations 260
32. Imperfect Dislocations, Twinning Dislocations, and Transformation Dislocations 269
33. The Stable Dislocations of the Common Metallic Structures 277
34. Distributions of Dislocations 293

VIII. Polycrystalline Aggregates

35. Macroscopic Theory 306
36. Dislocation Models of Grain Boundaries 314
37. Grain Boundary Energies 326
38. Interphase Boundaries: Surface Dislocations 331

IX. Diffusion in the Solid State

39. Mechanism of Atomic Migration 339
40. Statistical Basis of Diffusion: Fick's Law 345
41. Phenomenological Theory of Diffusion 352
42. Uphill Diffusion 358
43. Kinetic Theory of Vacancy Diffusion 359
44. The Theory of Diffusion Coefficients 365
45. Structure Sensitive Diffusion Processes 369

X. The Classical Theory of Nucleation

46. The Formation of Nuclei of a New Phase 377
47. Heterophase Fluctuations: Volmer's Theory of Nucleation 382
48. The Becker–Döring Theory of Nucleation 389
49. Nucleation of the Solid from the Vapour or the Liquid 394
50. Time-dependent Nucleation 399
51. Heterogeneous Nucleation and Nucleation on Grain Boundaries 405
52. Nucleation in the Solid State 415

XI. Theory of Thermally Activated Growth

53. Growth Controlled by Processes at the Interface 433
54. Diffusion-controlled Growth 440
55. Linear Growth of Duplex Regions 454

XII. Formal Theory of Transformation Kinetics

56. Transformations Nucleated on Grain Boundaries 471
57. Analysis of Isothermal Transformation Curves 475
58. Transformations with Parabolic Growth Laws 481
59. Effects of Temperature: Non-isothermal Transformations 489

XIII. The Growth of Crystals From the Vapour

60. The Rate of Growth of a Perfect Crystal 496
61. Real Crystals: Frank's Theory of Crystal Growth 511
62. Shape and Interaction of Growth Spirals 517
63. Whisker Growth 519

XIV. Solidification and Melting

64. The Solidification of Pure Metals 527
65. Nucleation of the Liquid–Solid Change in Alloys 537
66. The Growth of Crystals from the Melt 547
67. Growth from a Liquid Alloy 566
68. The Structure of Cast Ingots 582
69. Melting 587

XV. Polymorphic Changes

70. Solid State Reactions at Constant Composition 594
71. Massive Transformations 601

XVI. Precipitation From Solid Solution

72. Types of Precipitation: Spinodal Decomposition 606
73. Segregation and Nucleation in Solid Solutions 617
74. Continuous Precipitation 625
75. Discontinuous Precipitation 643
76. Guinier–Preston Zone Formation, and other Low Temperature Changes 649

XVII. Eutectoidal Transformations

77. Eutectoidal Decomposition and T—T—T Diagrams 670
78. The Austenite–Pearlite Transformation in Steels 677
79. The Formation of Austenite from Two-phase Mixtures of Ferrite and Iron Carbide 691

XVIII. Order–Disorder Transformations

80. The Formation of a Superlattice 697
81. Ordering as a Homogeneous Reaction: Changes in Long-range Order 703

XIX. Recovery, Recrystallization and Grain Growth

82. Annealing of Cold-worked Metals 710
83. Primary Recrystallization 717
84. Grain Growth, Secondary Recrystallization and Twin Formation 734

XX. Mechanical Twinning

85. Crystallography of Twinning 743
86. Operative Twinning Modes in Metallic Structures 765
87. Nucleation and Growth of Mechanical Twins 777

XXI. Characteristics of Martensitic Transformations

88. Atomic Movements in the Transformation 802
89. Kinetics of Martensitic Transformations 812
90. Bainitic Transformations and Related Phenomena 824

XXII. Crystallography of Martensitic Transformations

91. General Description of Formal Theories 834
92. The Martensitic Transformation in Steels 861
93. Body-centred Cubic to Orthorhombic Transformations 880
94. Other Applications of the Formal Theory 894
95. The Martensite Interface and the Fine Structure of Martensite 900

XXIII. Kinetics of Martensitic Transformations

96. The Nucleation of Martensite 913
97. Formal Kinetics of Martensite Formation 925

Index of Symbols 932

Subject Index 945

Author Index 965

Other Titles in the Series 975