

CONTENTS

	Page
CHAPTER 1 Basic General Metallurgy	
METALLURGY DEFINED	
1.1 General Definition	1
1.2 Extractive Metallurgy	2
1.3 Mechanical Metallurgy	4
1.4 Physical Metallurgy	4
HISTORICAL BACKGROUND	
1.5 Ancient Times	5
1.6 The Industrial Revolution	7
1.7 The Modern Era	7
Exercise	8
Suggestions for Additional Reading	8
CHAPTER 2 Fundamental Concepts	
2.1 Introduction	9
2.2 Atoms and Elements	9
2.3 The periodic Table	10
2.4 Bonding	13
2.5 The Electrovalent Bond	14
2.6 The Covalent Bond	15
2.7 The Metallic Bond	17
2.8 Matter	17
2.9 The Kinetic Theory	18
2.10 Solution Chemistry	19
2.11 Heat and Temperature	22
2.12 Heat Transfer	24
2.13 Temperature Measurement	27
2.14 The Solid State	31
2.15 Crystallography	35
2.16 Single Crystals Versus Aggregates	45
2.17 Defects in Crystals	46
2.18 Grain Size	51
2.19 Retrospect	51
Exercise	52
Suggestions for Additional Reading	53
CHAPTER 3 Phase Equilibria	
3.1 Introduction	55
3.2 Equilibrium Concept	56
3.3 Le Chatelier's Principle	58
3.4 Phases in the Solid State	59
3.5 Pure Metals	60
3.6 Solid Solutions	63
3.7 The Hume-Rothery Solubility Rules	65
3.8 Compounds	67
3.9 The Liquid State as a Metallurgical Phase	69
3.10 Gibbs' Phase Rule	71
3.11 Pressure-Temperature-Composition Diagrams	74
3.12 Retrospect	77
Exercises	77

Suggestions for Additional Reading	78
CHAPTER 4 Binary Equilibria	
4.1 Introduction	79
4.2 Reactions Involving Freezing	80
4.3 Solid Solutions	80
4.4 The Lever Rule	87
4.5 Solid-State Insolubility – The Eutectic Reaction	95
4.6 Eutectic Mixtures of Two Solid Solutions	98
4.7 Eutectic Mixtures Involving Intermediate Phases	102
4.8 The Peritectic Reaction	105
4.9 Limited Liquid Solubility – The Monotectic Reaction	109
4.10 The Syntectic Reaction	112
4.11 Solid-State Transformations	113
4.12 The Eutectoid Reaction	113
4.13 The Peritectoid Reaction	117
4.14 Allotropic Changes	120
4.15 Order-Disorder Reactions	123
4.16 Complex Binary Equilibrium Diagrams	126
4.17 Example Problem I	127
4.18 Example Problem II	133
4.19 Retrospect	136
Exercises	136
Suggestions for Additional Reading	139
CHAPTER 5 Equilibrium Microstructures in Binary Systems	
5.1 Introduction	140
5.2 Single-Phase Solid Structures	141
5.3 Two-Phase Structures Resulting from Solidification	145
5.4 Microstructures Resulting from solid-State Transformations	150
5.5 Retrospect	157
Exercises	158
Suggestions for Additional Reading	159
CHAPTER 6 Ternary Systems	
6.1 Introduction	160
6.2 Methods of Approach	161
6.3 Isothermal Ternary Equilibria; The Gibbs Triangle	161
6.4 The Phase Rule Applied to Ternary Equilibria	165
6.5 The Ternary Temperature-Composition Volume	166
6.6 Isothermal Sections	171
6.7 Some Industrially Important Ternary Systems	179
6.8 Retrospect	184
Exercises	185
Suggestions for Additional Reading	186
CHAPTER 7 Nonequilibrium Cooling	
7.1 Introduction	187
7.2 Coring and Homogenization	189
7.3 Solution-Treatment and Aging – Age Hardening	194
7.4 The Theory of Nonequilibrium Transformations	198
7.5 The Martensitic Transformation	202
7.6 The Mechanism of Quenching	208
7.7 The Mechanical Effects of Nonequilibrium Cooling	212
7.8 Retrospect	214
Exercises	215
Suggestions for Additional Reading	216

CHAPTER 8	Some Industrially Important Nonferrous Binary and Ternary Systems	
8.1	Introduction	217
8.2	The Lead-Tin Binary System	218
8.3	The Lead-Antimony System	221
8.4	The Lead-Tin-antimony System	223
8.5	The Copper-Zinc System	225
8.6	The Copper-Tin System	231
8.7	The Aluminum-Magnesium System	232
8.8	Zinc and the Zinc-Aluminum System	238
8.9	Titanium and Titanium Alloys	242
8.10	The Production of Nonferrous Alloys	245
8.11	Retrospect	247
	Exercises	248
	Suggestions for Additional Reading	248
CHAPTER 9	Ferrous Metallurgy – The Iron-Iron Carbide System	
9.1	Introduction	249
9.2	The Iron-Iron Carbide System	250
9.3	Some Notes on Nomenclature	252
9.4	The Iron-Iron Carbide Eutectoid Reaction	253
9.5	Nonequilibrium Transformations in the Iron-Iron Carbide System	257
9.6	Isothermal Transformation Curves in Ferrous Metallurgy	258
9.7	Continuous Cooling Curves	261
9.8	Austenite Stabilization	264
9.9	The Effect of Carbon Content on Transformations in Steels	265
9.10	Hardenability	265
9.11	Common Heat-Treating Methods Applied to Steel	270
9.12	Austenitizing as a Heat-Treating Operation	271
9.13	Annealing	272
9.14	Normalizing	274
9.15	Spheroidizing	275
9.16	Hardening Operations – General	276
9.17	Martempering	276
9.18	The Quench – Temper Cycle	278
9.19	Akustempering	280
9.20	Hardening Operations Involving Chemical Change	282
9.21	Retrospect	286
	Exercises	287
	Suggestions for Additional Reading	288
CHAPTER 10	Ferrous Metallurgy – The Cast Irons, Alloy Steels, and Alloy Cast Irons	
10.1	Introduction	289
10.2	The Iron-graphite Equilibrium Diagram	289
10.3	White Cast Iron	292
10.4	Gray Cast Iron	295
10.5	Malleable Iron	299
10.6	Nodular or Ductile Iron	303
10.7	The Effects of Alloying Ingredients on Ferrous Alloys	304
10.8	Some Specific Types of Alloy Steels	312
10.9	The Effects of Alloying Ingredients on the Cast Irons	317
10.10	Retrospect	318
	Exercises	319
	Suggestions for Additional Reading	320
CHAPTER 11	The Deformation of Metals	
11.1	Introduction	321
11.2	Crystallographic Principles of Deformation	322
11.3	Close-Packed Crystal Planes	322
11.4	Mechanical Concepts in Deformation	326
11.5	Elastic Versus Plastic Deformation, or Strain	326

11.6	Yielding	329
11.7	The Crystalline Nature of Mechanical Phenomena	330
11.8	Slip	333
11.9	Twining	334
11.10	Failure Versus Fracture	336
11.11	Hot-Working versus Cold-Working	337
11.12	Retrospect	341
	Exercises	341
	Suggestions for Additional Reading	342
CHAPTER 12	The Corrosion of Metallic Materials	
12.1	Introduction	343
12.2	Physical and Chemical Principles Underlying Corrosion	344
12.3	Oxidation and Reduction	344
12.4	Reversibility and Chemical Equilibrium	347
12.5	Electrochemistry	349
12.6	The Mechanisms of Corrosion	351
12.7	Continual Attack by a Corrosive Medium	351
12.8	Intimate Contact – A Requirement for Protection	351
12.9	Concentration Cells	353
12.10	Galvanic Corrosion	355
12.11	Internal Corrosion	356
12.12	The Prevention and Utilization of Corrosion	358
12.13	Alloying Ingredients as an Influence on Corrosion	359
12.14	Protective Coatings	360
12.15	Passivation	360
12.16	Nonmetallic Coatings	363
12.17	Metallic Coatings	363
12.18	Organic Coatings	366
12.19	Substitutional Corrosion	366
12.20	Retrospect	368
	Exercises	368
	Suggestions for Additional Reading	370
	Index	371