CONTENTS

| METALLURGY DEFINED1.1General Definition11.2Extractive Metallurgy21.3Mechanical Metallurgy41.4Physical Metallurgy4HISTORICAL BACKGROUND71.5Ancient Times51.6The Industrial Revolution71.7The Modern Era7Exercise8Suggestions for Additional Reading8CHAPTER 2 Fundamental Concepts92.1Introduction92.2Atoms and Elements92.3The periodic Table102.4Bonding132.5The Electrovalent Bond142.6The Covalent Bond172.8Matter172.9The Kinetic Theory182.10Solution Chemistry192.11Heat ransfer242.13Temperature Measurement272.14The Solid State312.15Single Crystals Versus Aggregates452.16Single Crystals Versus Aggregates512.17Defects in Crystals462.18Graiti Size512.19Retrospect512.14The Solid State593.1Introduction553.2Equilibrina53CHAPTER 3 Phase Equilibria533.1Introduction553.2Equilibrina633.4Phases in the Solid State59 <t< th=""><th></th><th>Basic General Metallurgy</th><th></th></t<> | | Basic General Metallurgy | |
|--|------------|--------------------------------|----|
| 1.2Extractive Metallurgy21.3Mechanical Metallurgy41.4Physical Metallurgy4HISTORICAL BACKGROUND1.51.5Ancient Times51.6The Industrial Revolution71.7The Modern Era7Exercise8Suggestions for Additional Reading8CHAPTER 2Fundamental Concepts92.1Introduction92.3The periodic Table102.4Bonding132.5The Electrovalent Bond142.6The Covalent Bond172.8Matter172.9The Kinetic Theory182.10Solution Chemistry192.11Heat and Temperature222.12Heat Transfer242.13Temperature Measurement272.14The Solid State312.15Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect512.19Retrospect513.1Introduction553.2Equilibria633.1Lethaetier's Principle583.3Le Chatelier's Principle563.3Le Chatelier's Principle563.4Phase Rule613.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liqu | | | |
| 1.3Mechanical Metallurgy41.4Physical Metallurgy4HISTORICAL BACKGROUND********************************* | | | |
| 1.4 Physical Metallurgy 4 HISTORICAL BACKGROUND 5 1.5 Ancient Times 5 1.6 The Industrial Revolution 7 Exercise 8 8 Suggestions for Additional Reading 8 8 CHAPTER 2 Fundamental Concepts 9 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 Ovalent 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 and Temperature 22 2.13 Temperature Measurement 27 2.14 The Solid State 31 2.15 Crystals Versus Aggregates 45 2.17 Defects in Crystals 26 2.18 Grain Size 51 <td></td> <td></td> <td></td> | | | |
| 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 9 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 Crystallogrphy 35 2.16 Single Crystals Versus Aggregates 45 2.17 Defects in Crystals Versus Aggregates 51 2.18 Grain Size 51 2.19 Retrospect 51 Exercise 52 Suggestions for Additional Reading 53 CHAPTER 3 Phase Equilibria 61 3.1 Introduction 55 3.2 Equilibriua 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 63 3.7 The Hume-Rothery Solubility Rules 65 3.8 Compounds 63 3.1 Introduction 73 9 The Liquid State 82 3.10 Gibbs' Phase Rule 71 3.11 Pressure-Temperature-Composition Diagrams 71 3.12 Retrospect 71 3.11 Pressure-Temperature-Composition Diagrams 71 3.11 Pressure-Temperature-Com | | | 4 |
| 1.5Ancient Times51.6The Industrial Revolution71.7The Modern Era7Exercise8Suggestions for Additional Reading8CHAPTER 2Fundamental Concepts2.1Introduction92.2Atoms and Elements92.3The periodic Table102.4Bonding132.5The Electrovalent Bond142.6The Covalent Bond152.7The Metallic Bond172.8Matter172.9The Kinetic Theory182.10Solution Chemistry192.11Heat and Temperature222.12Heat Transfer242.13Temperature Measurement272.14The Solid State312.15Crystals Versus Aggregates452.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect512.19Retrospect513.1Introduction553.2Equilibria663.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase69 <t< td=""><td>1.4</td><td>Physical Metallurgy</td><td>4</td></t<> | 1.4 | Physical Metallurgy | 4 |
| 1.6The Industrial Revolution71.7The Modern Era7Exercise8Suggestions for Additional Reading8CHAPTER 2Fundamental Concepts2.1Introduction92.3The periodic Table102.4Bonding132.5The Electrovalent Bond142.6The Covalent Bond152.7The Metallic Bond172.8Matter172.9The Kinetic Theory182.10Solution Chemistry192.11Heat and Temperature222.12Heat and Temperature222.13Temperature Measurement272.14The Solid State312.15Crystallogrphy352.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading553.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules633.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Introduction55< | HISTORICAL | LBACKGROUND | |
| 1.7The Modern Era7Exercise8Suggestions for Additional Reading8CHAPTER 2Fundamental Concepts2.1Introduction92.2Atoms and Elements92.3The periodic Table102.4Bonding132.5The Electrovalent Bond142.6The Covalent Bond152.7The Metallic Bond172.8Matter172.9The Kinetic Theory182.10Solution Chemistry192.11Heat Transfer242.13Temperature Measurement272.14The Solid State312.15Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3Phase Equilibria563.1Introduction553.2Equilibriand Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules633.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams74 <td>1.5</td> <td>Ancient Times</td> <td>5</td> | 1.5 | Ancient Times | 5 |
| Exercise8Suggestions for Additional Reading8CHAPTER 2Fundamental Concepts2.1Introduction92.2Atoms and Elements92.3The periodic Table102.4Bonding132.5The Electrovalent Bond142.6The Covalent Bond172.8Matter172.9The Kinetic Theory182.10Solution Chemistry192.11Heat Transfer222.12Heat Transfer242.13Temperature222.14The Solid State312.15Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading553.2Equilibria563.3Le Chatelier's Principle583.4Phase Equilibria593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect71 | 1.6 | The Industrial Revolution | 7 |
| Suggestions for Additional Reading 8 CHAPTER 2 Fundamental Concepts 9 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 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 Crystallogrphy 35 2.16 Single Crystals Versus Aggregates 45 2.17 Defects in Crystals 46 2.18 Grain Size 51 2.19 Retrospect 51 2.18 Grain Size 52 Suggestions for Additional Reading 52 3.1 Introduction 55 3.2 Equilibria 58 3.4 Phases in the Solid State 59 3.5 Pure Metals 60 | 1.7 | The Modern Era | 7 |
| Suggestions for Additional Reading 8 CHAPTER 2 Fundamental Concepts 9 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 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 Crystallogrphy 35 2.16 Single Crystals Versus Aggregates 45 2.17 Defects in Crystals 46 2.18 Grain Size 51 2.19 Retrospect 51 2.18 Grain Size 52 Suggestions for Additional Reading 52 3.1 Introduction 55 3.2 Equilibria 58 3.4 Phases in the Solid State 59 3.5 Pure Metals 60 | Exer | cise | 8 |
| 2.1 Introduction 9 2.2 Atoms and Elements 9 2.3 The periodic Table 10 0.4 Bonding 13 2.5 The Electrovalent Bond 14 2.6 The Covalent 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 Crystallogrphy 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 58 3.1 <t< td=""><td>Sugg</td><td>estions for Additional Reading</td><td></td></t<> | Sugg | estions for Additional Reading | |
| 2.1 Introduction 9 2.2 Atoms and Elements 9 2.3 The periodic Table 10 0.4 Bonding 13 2.5 The Electrovalent Bond 14 2.6 The Covalent 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 Crystallogrphy 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 58 3.1 <t< td=""><td>CHAPTER 2</td><td>Fundamental Concepts</td><td></td></t<> | CHAPTER 2 | Fundamental Concepts | |
| 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 Crystallogrphy 35 2.16 Single Crystals Versus Aggregates 45 2.17 Defects in Crystals 46 2.18 Grain Size 51 2.19 Retrospect 51 2.19 Retrospect 51 2.11 Introduction 55 3.1 Introduction 55 3.2 Equilibria 58 3.4 Phases in the Solid State 59 | | - | 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 Crystallogrphy 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 CHAPTER 3 Phase Equilibria 56 3.1 Introduction 55 3.2 Equilibrium Concept 56 3.3 Le Chatelier's Principle 58 3.4 Phases | 2.2 | Atoms and Elements | |
| 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 Crystallogrphy 35 2.16 Single Crystals Versus Aggregates 45 2.17 Defects in Crystals 46 2.18 Grain Size 51 2.19 Retrospect 51 Suggestions for Additional Reading 53 CHAPTER 3 Phase Equilibria 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 | | | |
| 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 Crystallogrphy 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 CHAPTER 3 3.1 Introduction 55 3.2 Equilibria 50 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 | | · | |
| 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 Crystallogrphy 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 CHAPTER 3 Phase Equilibria 55 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 Th | | | |
| 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 Crystallogrphy 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 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 Compoun | | | |
| 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 Crystallogrphy 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 CHAPTER 3 Phase Equilibria 3.1 Introduction 55 3.2 Equilibria 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' | | | |
| 2.9The Kinetic Theory182.10Solution Chemistry192.11Heat and Temperature222.12Heat Transfer242.13Temperature Measurement272.14The Solid State312.15Crystallogrphy352.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3Phase Equilibria3.1Introduction553.2Equilibria563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 2.10Solution Chemistry192.11Heat and Temperature222.12Heat Transfer242.13Temperature Measurement272.14The Solid State312.15Crystallogrphy352.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3Phase Equilibria3.1Introduction553.2Equilibria563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 2.11Heat and Temperature222.12Heat Transfer242.13Temperature Measurement272.14The Solid State312.15Crystallogrphy352.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3Phase Equilibria3.1Introduction553.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | • | |
| 2.12Heat Transfer242.13Temperature Measurement272.14The Solid State312.15Crystallogrphy352.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3 Phase Equilibria3.1Introduction553.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules633.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | • | |
| 2.13Temperature Measurement272.14The Solid State312.15Crystallogrphy352.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3Phase Equilibria3.1Introduction553.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules633.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 2.14The Solid State312.15Crystallogrphy352.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3 Phase Equilibria3.1Introduction3.2Equilibrium Concept3.3Le Chatelier's Principle3.4Phases in the Solid State3.5Pure Metals3.6Solid Solutions3.7The Hume-Rothery Solubility Rules3.8Compounds3.9The Liquid State as a Metallurgical Phase3.10Gibbs' Phase Rule3.11Pressure-Temperature-Composition Diagrams3.12Retrospect77 | | | |
| 2.15Crystallogrphy352.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3 Phase Equilibria3.1Introduction3.2Equilibrium Concept3.3Le Chatelier's Principle3.4Phases in the Solid State3.5Pure Metals3.6Solid Solutions3.7The Hume-Rothery Solubility Rules3.8Compounds3.9The Liquid State as a Metallurgical Phase3.10Gibbs' Phase Rule3.11Pressure-Temperature-Composition Diagrams3.12Retrospect77 | 2.14 | • | |
| 2.16Single Crystals Versus Aggregates452.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3Phase Equilibria553.1Introduction553.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 2.17Defects in Crystals462.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3 Phase Equilibria3.1Introduction3.2Equilibrium Concept3.3Le Chatelier's Principle3.4Phases in the Solid State3.5Pure Metals3.6Solid Solutions3.7The Hume-Rothery Solubility Rules3.8Compounds3.9The Liquid State as a Metallurgical Phase3.10Gibbs' Phase Rule3.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 2.18Grain Size512.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3 Phase Equilibria3.1Introduction3.2Equilibrium Concept3.3Le Chatelier's Principle3.4Phases in the Solid State3.5Pure Metals3.6Solid Solutions3.7The Hume-Rothery Solubility Rules3.8Compounds3.9The Liquid State as a Metallurgical Phase3.10Gibbs' Phase Rule3.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 2.19Retrospect51Exercise52Suggestions for Additional Reading53CHAPTER 3 Phase Equilibria3.1Introduction553.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| Exercise52Suggestions for Additional Reading53CHAPTER 3 Phase Equilibria553.1 Introduction553.2 Equilibrium Concept563.3 Le Chatelier's Principle583.4 Phases in the Solid State593.5 Pure Metals603.6 Solid Solutions633.7 The Hume-Rothery Solubility Rules653.8 Compounds673.9 The Liquid State as a Metallurgical Phase693.10 Gibbs' Phase Rule713.11 Pressure-Temperature-Composition Diagrams743.12 Retrospect77 | | | |
| Suggestions for Additional Reading53CHAPTER 3Phase Equilibria3.1Introduction3.2Equilibrium Concept3.3Le Chatelier's Principle3.4Phases in the Solid State3.5Pure Metals3.6Solid Solutions3.7The Hume-Rothery Solubility Rules3.8Compounds3.9The Liquid State as a Metallurgical Phase3.10Gibbs' Phase Rule3.11Pressure-Temperature-Composition Diagrams3.12Retrospect | | | |
| 3.1Introduction553.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.1Introduction553.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | CHAPTER 3 | Phase Equilibria | |
| 3.2Equilibrium Concept563.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | 55 |
| 3.3Le Chatelier's Principle583.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.4Phases in the Solid State593.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.5Pure Metals603.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.6Solid Solutions633.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.7The Hume-Rothery Solubility Rules653.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.8Compounds673.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.9The Liquid State as a Metallurgical Phase693.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.10Gibbs' Phase Rule713.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.11Pressure-Temperature-Composition Diagrams743.12Retrospect77 | | | |
| 3.12 Retrospect 77 | | | |
| 1 | | · · · · | |
| | | • | |

| 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 |
| Exer | | 136 |
| | estions 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 | 150 |
| Exer | | 157 |
| | estions for Additional Reading | 150 |
| | The second se | |
| | Ternary Systems | 1.00 |
| 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 |
| Exerc | | 185 |
| Sugg | estions 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 |
| Exerc | cises | 215 |
| Sugg | estions for Additional Reading | 216 |
| | | |

78

| 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 |
| Exer | - | 248 |
| | estions 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 Nomenelature | 252 |
| 9.4 | The Iron-Iron Carbide Eutectoid Reaction | 253 |
| 9.5 | Nonequilibrium Transformations in the Iron-Iron Carbide System | 255 |
| 9.6 | Isothermal Transformation Curves in Ferrous Metallurgy | 258 |
| 9.0 9.7 | Continuous Cooling Curves | 238 261 |
| 9.7 9.8 | Austenite Stalibization | |
| | | 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 |
| Exerc | cises | 287 |
| Sugg | estions 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 | | 318 |
| Exer | The second se | 319 |
| | estions for Additional Reading | 320 |
| CHAPTER 1 | 1 The Deformation of Metals | |
| 11.1 | Introduction | 321 |
| 11.2 | Crystallographic Principles of Deformation | 322 |
| 11.2 | Close-Packed Crystal Planes | 322 |
| 11.5 | Mechanical Concepts in Deformation | 326 |
| 11.4 | Elastic Versus Plastic Deformation, or Strain | 320 |
| 11.3 | Liustic versus i fastic Deformation, of Stralli | 520 |

| 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 |