Contents

Introduction 1

Chapter 1 **Elementary Concepts of Specific Heats**

1.1. Definitions 5
1.2. Thermodynamics of Simple Systems..... 6
1.3. Difference Between C_p and C_v 7
1.4. Variation of Specific Heats with Temperature and Pressure..... 10
1.5. Statistical Calculation of Specific Heats 11
1.6. Different Modes of Thermal Energy 12
1.7. Calorimetry 16

Chapter 2 **Lattice Heat Capacity**

2.1. Dulong and Petit's Law 20
2.2. Equipartition Law 21
2.3. Quantum Theory of Specific Heats 22
2.4. Einstein's Model 25
2.5. Debye's Model 28
2.6. Comparison of Debye's Theory with Experiments 31
2.7. Shortcomings of the Debye Model..... 35
2.8. The Born–Von Kármán Model 36
2.9. Calculation of $g(\nu)$ 40
2.10. Comparison of Lattice Theory with Experiments 43
2.11. Debye θ in Other Properties of Solids 47

2.11.1. θ-Values from Elastic Properties 49
2.11.2. θ-Values from Compressibility and Melting Point 50
2.11.3. θ-Values from Thermal Expansion 50
2.11.4. θ-Values from Infrared Data 51
2.11.5. θ-Values from Electrical Resistivity..... 52
2.11.6. Scattering of X-Rays, γ-Rays, and Neutrons.. 52

Chapter 3 **Electronic Specific Heat**

3.1. Specific Heat of Metals 55
3.2. Quantum Statistics of an Electron Gas 56
3.3. Specific Heat of Electrons in Metals 58
3.4. Electronic Specific Heat at Low Temperatures 61
3.5. Specific Heat and Band Structure of Metals 64
3.6. Specific Heat of Alloys 68
3.7. Specific Heat of Semiconductors 72
3.8. Phenomenon of Superconductivity 74
3.9. Specific Heat of Superconductors 76
3.10. Recent Studies 80

Chapter 4 **Magnetic Contribution to Specific Heats**

4.1. Thermodynamics of Magnetic Materials 84
4.2. Types of Magnetic Behavior 86
4.3. Spin Waves—Magnons 87
4.4. Spin Wave Specific Heats 89
4.5. The Weiss Model for Magnetic Ordering 93
4.6. The Heisenberg and Ising Models 95
4.7. Specific Heats Near the Transition Temperature 98
4.8. Paramagnetic Relaxation 100
4.9. Schottky Effect 102
4.10. Specific Heat of Paramagnetic Salts 105
4.11. Nuclear Schottky Effects 109

Chapter 5 **Heat Capacity of Liquids**

5.1. Nature of the Liquid State 112
5.2. Specific Heat of Ordinary Liquids and Liquid Mixtures 113
5.3. Liquid ^{4}He at Low Temperatures 114
5.4. Phonon and Roton Specific Heats 116
5.5. Transition in Liquid ^{4}He 120

5.6. Specific Heat of Liquid ^{3}He 123
5.7. Liquid ^{3}He as a Fermi Liquid 127
5.8. Mixtures of ^{4}He and ^{3}He 129
5.9. Supercooled Liquids—Glasses 129

Chapter 6 **Specific Heats of Gases**
6.1. C_p and C_v of a Gas 135
6.2. Classical Theory of C_v of Gases 136
6.3. Quantum Theory of C_v of Gases 138
6.4. Rotational Partition Function 140
6.5. Homonuclear Molecules—Isotopes of Hydrogen 142
6.6. Vibrational and Electronic Specific Heats 147
6.7. Calorimetric and Statistical Entropies —Disorder in Solid State 148
6.8. Hindered Rotation 152
6.9. Entropy of Hydrogen 154

Chapter 7 **Specific-Heat Anomalies**
7.1. Spurious and Genuine Anomalies 158
7.2. Cooperative and Noncooperative Anomalies 161
7.3. Order–Disorder Transitions 163
7.4. Onset of Molecular Rotation 166
7.5. Ferroelectricity 167
7.6. Transitions in Rare-Earth Metals 170
7.7. Liquid–Gas Critical Points 175
7.8. Models of Cooperative Transitions 177

Chapter 8 **Miscellaneous Problems in Specific Heats**
8.1. Specific Heat Near Phase Transitions 181
8.2. Specific Heat at Saturated Vapor Pressure 185
8.3. Relaxation of Rotational and Vibrational Specific Heats 186
8.4. Defects in Solids 187
8.5. Surface Effects 190
8.6. Compilations of Specific-Heat Data 192
8.7. Tabulations of Specific-Heat Functions 194

Appendix (Six-Figure Tables of Einstein and Debye Internal-Energy and Specific-Heat Functions) ... 197

Author Index 227

Subject Index 234