

# CONTENTS

<b>Preface</b> . . . . .	<b>vii</b>
<b>List of Symbols</b> . . . . .	<b>xiii</b>
<b>Chapter 1. The System</b> . . . . .	<b>1</b>
1-1. Introduction . . . . .	1
1-2. Field Quantities . . . . .	3
1-3. Mass Flow . . . . .	5
1-4. Chemical Reactions . . . . .	6
<b>Chapter 2. The Hydrodynamic Equations.</b> . . . . .	<b>9</b>
2-1. General Conservation Equation . . . . .	9
2-2. Equation of Continuity of Matter . . . . .	10
2-3. Stress Tensor . . . . .	12
2-4. Equation of Motion . . . . .	13
2-5. Energy Transport Equation . . . . .	16
2-6. Summary . . . . .	18
<i>Problems</i> . . . . .	19
<i>References</i> . . . . .	20
<i>Suggestions for Further Reading</i> . . . . .	20
<b>Chapter 3. The Assumption of Local Equilibrium</b> . . . . .	<b>21</b>
3-1. Postulate I . . . . .	21
3-2. Validity of Postulate I . . . . .	22
3-3. Partial Specific Quantities . . . . .	24

3-4. Diffusion Current Density $j_i^{\circ}$ . . . . .	25
3-5. Energy Transport Equation . . . . .	26
3-6. Second-law Heat Flux . . . . .	28
3-7. Entropy Equation . . . . .	29
3-8. Fluxes and Forces . . . . .	32
<i>References</i> . . . . .	33
<i>Suggestions for Further Reading</i> . . . . .	33
<b>Chapter 4. The Phenomenological Relations.</b> . . . . .	<b>34</b>
4-1. Postulate II . . . . .	34
4-2. Curie's Theorem . . . . .	35
4-3. Postulate III . . . . .	36
4-4. Newtonian Stress Tensor . . . . .	40
4-5. Navier-Stokes Equation . . . . .	43
4-6. Mechanical Equilibrium . . . . .	43
4-7. Diffusion and Heat Flow . . . . .	44
4-8. Other Fluxes and Forces for Diffusion and Heat Flow . . . . .	47
<i>Problems</i> . . . . .	49
<i>References</i> . . . . .	50
<i>Suggestions for Further Reading</i> . . . . .	50
<b>Chapter 5. The Transport Equations</b> . . . . .	<b>51</b>
5-1. Two Thermodynamic Relations for the Entropy. . . . .	51
5-2. Equations of Transport . . . . .	53
<b>Chapter 6. The Transport of Heat</b> . . . . .	<b>56</b>
6-1. Pure Heat Conduction . . . . .	56
6-2. Rate of Cooling in an External Magnetic Field . . . . .	58
6-3. Inversion of the Linear Relations . . . . .	62
6-4. Heats of Transport . . . . .	62
6-5. Heats of Transport with Respect to Solvent . . . . .	65
<i>Problems</i> . . . . .	68
<i>References</i> . . . . .	68
<i>Suggestions for Further Reading</i> . . . . .	68
<b>Chapter 7. Electrochemical Systems</b> . . . . .	<b>69</b>
7-1. Specific Charge of an Ionic Species . . . . .	69
7-2. Linear Relations . . . . .	70
7-3. Electric Current Density . . . . .	73
7-4. Liquid Junction Potential . . . . .	75
<i>References</i> . . . . .	77
<i>Suggestions for Further Reading</i> . . . . .	77
<b>Chapter 8. Diffusion in Isothermal Systems</b> . . . . .	<b>78</b>
8-1. Diffusion Relative to the Local Center of Mass . . . . .	78
8-2. Diffusion Relative to the Solvent . . . . .	80
8-3. Diffusion Relative to the Local Center of Volume . . . . .	81
8-4. Fick's Second Law . . . . .	82
8-5. Some Thermodynamic Relationships . . . . .	84

8-6. Diffusion in Binary Systems . . . . .	90
8-7. Diffusion in Ternary Systems . . . . .	92
8-8. The System NaCl-KCl-Water . . . . .	94
<i>Problems</i> . . . . .	99
<i>References</i> . . . . .	99
<i>Suggestions for Further Reading</i> . . . . .	100
<b>Chapter 9. Thermal Diffusion</b> . . . . .	<b>101</b>
9-1. Soret Effect . . . . .	101
9-2. Thermal Diffusion in Terms of $\bar{Q}_1$ . . . . .	104
9-3. Composition in Terms of Molalities . . . . .	105
9-4. Composition in Terms of Weight Fractions . . . . .	107
9-5. Experimental Soret Coefficients for Binary Systems . . . . .	109
9-6. Soret Coefficient for Electrolytic Solutions in an External Electric Field . . . . .	113
9-7. Thermal Conductivity . . . . .	115
9-8. Dufour Effect. . . . .	116
<i>Problems</i> . . . . .	117
<i>References</i> . . . . .	117
<i>Suggestions for Further Reading</i> . . . . .	117
<b>Chapter 10. Sedimentation and Centrifugation</b> . . . . .	<b>119</b>
10-1. Gravitational Fields . . . . .	119
10-2. Vanishing Volume Flow . . . . .	121
10-3. Entropy Production . . . . .	122
10-4. Sedimentation Potential and Electrophoresis . . . . .	123
10-5. Potential of a Galvanic Cell . . . . .	125
10-6. Equilibrium Sedimentation . . . . .	127
<i>Problems</i> . . . . .	131
<i>References</i> . . . . .	131
<i>Suggestions for Further Reading</i> . . . . .	131
<b>Chapter 11. Chemical Reactions</b> . . . . .	<b>132</b>
11-1. Ideal Gas Reactions . . . . .	132
11-2. Monomolecular Triangular Reaction . . . . .	135
11-3. Method of Kirkwood and Crawford . . . . .	138
<i>References</i> . . . . .	141
<i>Suggestions for Further Reading</i> . . . . .	141
<b>Appendix A. Dyadics</b> . . . . .	<b>143</b>
A-1. Tensor Quantities . . . . .	143
A-2. Definition of a Dyadic . . . . .	144
A-3. Multiplication by a Dyadic . . . . .	145
A-4. An Example . . . . .	148
A-5. Dyadics with Differential Operators . . . . .	148
A-6. Unit Dyadic . . . . .	149
A-7. Trace of a Dyadic . . . . .	150
A-8. Symmetric and Antisymmetric Dyadics . . . . .	150
<i>Problems</i> . . . . .	151

**xii**      **CONTENTS**

<b>Appendix B. The Onsager Theory</b> . . . . .	<b>152</b>
<i>References</i> . . . . .	154
<b>Appendix C. Relaxation in Viscoelastic Media</b> . . . . .	<b>155</b>
C-1. Stress-Strain Relation . . . . .	155
C-2. Isotropic Medium . . . . .	159
C-3. Newtonian Fluid . . . . .	160
<i>Reference</i> . . . . .	161
<b>Appendix D. Inertial Forces and Viscous Stresses</b> . . . . .	<b>162</b>
D-1. Inertial and Viscous Terms . . . . .	162
D-2. Linear Relations for Diffusion Relative to Solvent . . . . .	163
D-3. Neglect of Inertial and Viscous Terms . . . . .	164
D-4. Linear Relations for a System in a Rapidly Varying External Electric Field . . . . .	165
<i>References</i> . . . . .	166
<b>Name Index</b> . . . . .	<b>167</b>
<b>Subject Index.</b> . . . . .	<b>169</b>