

## CONTENTS

PREFACE . . . . .	vii
TABLE OF CONTENTS . . . . .	ix
LIST OF SYMBOLS . . . . .	xiii
I. INTRODUCTION . . . . .	1
§ 1. On the theories of irreversible processes . . . . .	1
§ 2. Onsager's theory . . . . .	5
§ 3. Non-equilibrium thermodynamical functions . . . . .	9
II. THE ONSAGER RECIPROCAL RELATIONS . . . . .	13
§ 4*. Method of treatment . . . . .	13
§ 5*. Fluctuation theory . . . . .	13
§ 6*. Microscopic reversibility . . . . .	15
§ 7*. Regression of fluctuations . . . . .	17
§ 8*. Derivation of the Onsager relations . . . . .	18
III. SYSTEMS OF A SINGLE COMPONENT . . . . .	20
§ 9. Thermomolecular pressure difference and thermo- mechanical effect . . . . .	20
§ 10. On a different choice of fluxes and forces . . . . .	27
§ 11*. On a third choice of fluxes and forces . . . . .	30
§ 12*. Reduction of the phenomenological coefficient matrix to a diagonal form . . . . .	32
§ 13*. Shift of the energy zero point . . . . .	33
§ 14*. Derivation of the heat of transfer in a Knudsen gas . . . . .	35
IV. HEAT CONDUCTION, ELECTRICAL CONDUCTION AND RELAXATION PHENOMENA IN CONTINUOUS SINGLE COMPONENT SYSTEMS . . . . .	37
§ 15. Introduction . . . . .	37
§ 16. Heat transfer from one system to another . . . . .	38
§ 17. One-dimensional heat conduction . . . . .	39
§ 18*. Three-dimensional heat conduction . . . . .	41
§ 19*. Heat conduction in an external magnetic field . . . . .	46
§ 20*. Electrical conduction . . . . .	47
§ 21*. Electrical conduction in an external magnetic field . . . . .	50
§ 22. Relaxation phenomena . . . . .	51

V.	DISCONTINUOUS SYSTEMS WITHOUT CHEMICAL REACTIONS . . . . .	54
	§ 23. Introduction . . . . .	54
	§ 24. The fundamental equations . . . . .	55
	§ 25. The entropy balance and the phenomenological equations . . . . .	58
	§ 26. The energies of transfer . . . . .	60
	§ 27. The stationary state. The thermomolecular pressure effect and the thermal effusion effect . . . . .	61
	§ 28. Stationary states of first and second order. The mechano-caloric effect . . . . .	63
	§ 29*. Linear transformations of fluxes and forces . . . . .	66
VI.	DISCONTINUOUS SYSTEMS WITH CHEMICAL REACTIONS . . . . .	73
	§ 30*. Introduction . . . . .	73
	§ 31*. The fundamental equations . . . . .	74
	§ 32*. The entropy balance and the phenomenological equations . . . . .	76
	§ 33*. The stationary states . . . . .	79
	§ 34*. Stationary state of first order . . . . .	79
	§ 35*. Stationary state of second order and energies of transfer . . . . .	82
	§ 36*. The thermomolecular pressure effect . . . . .	85
	§ 37*. The thermal effusion effect . . . . .	86
	§ 38*. The chemical effect . . . . .	87
	§ 39*. The mechano-caloric effect and heats of transfer . . . . .	87
	§ 40*. Energy and heat conduction in the first order stationary state . . . . .	89
	§ 41*. Liquid helium II . . . . .	90
VII.	CONTINUOUS SYSTEMS (ORDINARY DIFFUSION, THERMAL DIFFUSION, VISCOSITY, ORDINARY AND THERMAL DIFFUSION POTENTIALS, ETC.) . . . . .	94
	§ 42. Introduction . . . . .	94
	§ 43. The fundamental equations . . . . .	94
	§ 44. The entropy balance . . . . .	97
	§ 45. The phenomenological equations . . . . .	100
	§ 46. Ordinary diffusion . . . . .	101
	§ 47. Mechanical equilibrium . . . . .	106
	§ 48*. Ordinary diffusion, molecular and barycentric . . . . .	108
	§ 49. Thermal diffusion (Soret effect) . . . . .	111
	§ 50. Dufour-effect . . . . .	118
	§ 51. Viscosity . . . . .	120
	§ 52*. Linear transformations of fluxes and forces . . . . .	123

§ 53. Linear transformations in connection with electrical phenomena . . . . .	127
§ 54*. The stationary state in systems with electrical charges (thermal diffusion and electrical potential) . . . . .	133
§ 55*. The non-stationary state in systems with electrical charges (thermal diffusion, ordinary and thermal diffusion potential) . . . . .	136
<b>VIII. THERMO-ELECTRICITY . . . . .</b>	<b>141</b>
§ 56. Introduction . . . . .	141
§ 57. Direct method . . . . .	142
§ 58. Discussion of the direct method . . . . .	145
§ 59*. Method using energies of transfer . . . . .	147
§ 60*. Method using entropies of transfer . . . . .	153
§ 61. Thermomagnetic and galvanomagnetic effects . . . . .	159
<b>IX. CHEMISTRY . . . . .</b>	<b>163</b>
§ 62. Introduction . . . . .	163
§ 63. Chemical reactions in closed systems . . . . .	163
§ 64*. Discussion on the principle of detailed balance . . . . .	169
§ 65. Chemical reactions in open systems . . . . .	171
§ 66*. Reaction rates and degrees of advancement of chemical reactions . . . . .	174
§ 67. Electrochemistry . . . . .	181
§ 68. Electrokinetic effects . . . . .	185
§ 69. Interference of a chemical reaction and a relaxation phenomenon . . . . .	189
<b>X. THE STATIONARY STATES . . . . .</b>	<b>195</b>
§ 70. Two descriptions . . . . .	195
§ 71. States of minimum entropy production . . . . .	196
§ 72. Extension of Le Chatelier's principle . . . . .	197
§ 73. Stationary states of various order . . . . .	199
§ 74*. Stationary state of the zeroth order . . . . .	201
§ 75. Stationary states of the first and second order . . . . .	201
§ 76*. Examples of Le Chatelier's principle applied to stationary states of the first order . . . . .	205
§ 77*. Application in biology . . . . .	206
<b>XI. FURTHER DISCUSSION ON FOUNDATIONS . . . . .</b>	<b>208</b>
§ 78. Transformation properties of the Onsager relations . . . . .	208

§ 79*.	The influence of odd and even variables on the Onsager relations . . . . .	212
§ 80*.	Generalizations of Onsager's theorem . . . . .	217
§ 81*.	Non-equilibrium thermodynamical functions . . . . .	220
§ 82*.	Other thermodynamical theories of irreversible phenomena . . . . .	224
INDEXES . . . . .		229
§ 83.	Bibliography . . . . .	229
§ 84.	References . . . . .	235
§ 85.	Subject and name index . . . . .	236