

# Contents

ACKNOWLEDGEMENTS	v
NOMENCLATURE	xi–xiv
LIST OF EQUATIONS	xv–xviii
LIST OF EXAMPLES	xix–xxii
GLOSSARY	xxiii–xxviii
AN INTRODUCTION	1
Uses of Material and Energy Balances	1
Prerequisites	2
Dealing with Complex Problems	2
Further Reading	3
CHAPTER ONE: THE GENERAL BALANCE EQUATION	5
The General Balance	6
Conserved and Changing Quantities	7
Material and Energy Balances	8
Forms of the General Balance Equation	13
Class of Problem	14
Summary	21
Further Reading	22
CHAPTER TWO: PROCESS VARIABLES AND THEIR RELATIONSHIPS	23
Units and Calculations	24
Consistency of Units	24
Conversion of Units	28
Significant Figures in Calculations	29
Process Variables	31
Equations of State	38
Multi-Species, Multi-Phase Equilibria	44
Chemical Equations and Stoichiometry	51
Thermochemistry	58
Mixing	69
Thermodynamic Tables and Reference States	71
Thermodynamic Diagrams	75
Summary	80
Further Reading	84

CHAPTER THREE: MATERIAL AND ENERGY BALANCES IN PROCESS ENGINEERING	85
Significance of Material and Energy Balances	86
Flowsheets	86
Process Units	86
Streams and Stream Tables	91
Process Economics	92
Summary	94
Further Reading	95
CHAPTER FOUR: MATERIAL BALANCES	97
General Material Balance	98
Closed Systems (Batch Processes)	100
Open Systems (Continuous Processes)	103
Continuous Processes at Steady-State	104
Single process units	104
Subsidiary relations	113
Closure of material balances	118
Simultaneous equations	119
Specification of material balance problems	122
Multiple process units	126
Recycling, accumulation and purging	131
Material balance calculations by computer (spreadsheet)	138
Summary	154
Further Reading	157
CHAPTER FIVE: ENERGY BALANCES	159
General Energy Balance	160
Closed Systems (Batch Processes)	162
Open Systems (Continuous Processes)	166
Continuous Processes at Steady-State	168
Mechanical energy balance	169
Enthalpy balance	171
Heat and work	174
Specification of energy balance problems	176
Energy balance calculations by computer (spreadsheet)	178
Energy balances with the heat of combustion	180
Single process units	183
Multiple process units	183
Summary	207
Further Reading	210

CHAPTER SIX: SIMULTANEOUS MATERIAL AND ENERGY BALANCES	211
Simultaneous Balances	212
Specification of Simultaneous Material and Energy Balances	212
Closed Systems (Batch Processes)	213
Open Systems (Continuous Processes)	215
Single process units	215
Multiple process units	215
Summary	234
Further Reading	234
CHAPTER SEVEN: UNSTEADY-STATE MATERIAL AND ENERGY BALANCES	235
Differential Material and Energy Balances with Accumulation	236
Closed Systems (Batch Processes)	239
Open Systems (Continuous Processes)	243
Summary	252
Further Reading	253
EPILOGUE	255
INDEX	257