

# Contents

PREFACE .....	ix
SYMBOLS USED .....	xii
UNITS USED .....	xiv
1. THE FIRST LAW .....	1
2. THERMODYNAMIC TERMINOLOGY .....	7
2.1 System, Surroundings & Boundary .....	8
2.2 Open, Closed & Isolated Systems .....	10
2.3 Property .....	11
2.4 State .....	13
2.5 Equilibrium State .....	13
2.6 Process .....	15
2.7 Simple Compressible System .....	17
2.8 State Postulate .....	18
2.9 Property Diagram .....	19
3. THE FIRST LAW APPLIED TO CLOSED SYSTEMS .....	21
3.1 Energy Balance for a Closed System .....	22
3.2 A Word of Caution .....	26
3.3 Worked Example .....	27
3.4 Summary .....	28
4. INTERNAL ENERGY & ENTHALPY .....	29
4.1 Internal Energy .....	30
4.2 Enthalpy .....	32
4.3 Summary .....	34
5. WORKING WITH IDEAL GAS .....	35
5.1 Definition of an Ideal Gas .....	36
5.2 Absolute Temperature Scale .....	37

5.3 Different Forms of the Ideal Gas Equation of State	37
5.4 Internal Energy and $C_v$	38
5.5 Enthalpy and $C_p$	41
5.6 Relating Ideal Gas Specific Heats	42
5.7 Data on Ideal Gas Specific Heats	43
5.8 Evaluation of $\Delta U$ for an Ideal Gas	46
5.9 Worked Examples	49
5.10 Summary	66
6. WORKING WITH REAL GASES & STEAM .....	69
6.1 Real Gas Behaviour	70
6.2 Phase Change: Gas to Liquid	71
6.3 $P$ - $v$ diagram for Phase Change	78
6.4 $P$ - $T$ diagram for Phase Change	80
6.5 The Steam Table	81
6.6 Worked Examples	96
6.7 Summary	108
7. BOUNDARY WORK .....	109
7.1 Boundary Work in Real Life	110
7.2 Evaluation of Boundary Work	110
7.3 Quasistatic Process	114
7.4 Boundary Work in Real Processes	116
7.5 Units for Boundary Work	117
7.6 Path Dependence of Boundary Work	117
7.7 Other Forms of Work	119
7.8 Worked Examples	120
7.9 Summary	158
8. ALL ABOUT HEAT .....	161
8.1 What is Heat?	162
8.2 Heat Supply and Common Sense	163

8.3 Heat Supplied to Increase the Temperature	164
8.4 Heat Supplied to Do Work	165
8.5 Temperature Increase without Heat Supply	166
8.6 Direct Evaluation of $Q_{in}$	167
8.7 Zeroth Law of Thermodynamics	168
8.8 Heat and Enthalpy	169
8.9 Heat and Internal Energy	170
8.10 Heat and Specific Heat	171
8.11 Worked Examples	172
8.12 Summary	188
9. THE FIRST LAW APPLIED TO OPEN SYSTEMS .....	189
9.1 Example of an Open System	190
9.2 Mass Balance for an Open System	192
9.3 Energy Balance for an Open System	193
9.4 Worked Examples	200
9.5 Summary	208
10. THE FIRST LAW APPLIED TO STEADY FLOW PROCESSES	211
10.1 What is Steady?	212
10.2 What is a Steady Flow Process?	212
10.3 Characteristics of a Steady Flow Process	213
10.4 Mass Balance for a Steady Flow Process	214
10.5 Energy Balance for a Steady Flow Process	215
10.6 Steady Flow Engineering Devices	217
10.7 Worked Examples	225
10.8 Summary	247
11. ENTROPY .....	249
11.1 Reversible Processes	250
11.2 Definition of Entropy	252
11.3 Evaluation of Entropy Change for any Process	253
11.4 Isentropic Process	255

11.5 Worked Examples	256
11.6 Summary	270
12. THERMODYNAMIC ANALYSES OF POWER PLANTS .....	273
12.1 Gas Turbine for Electric Power Generation	274
12.2 Gas Turbine for Jet Propulsion	281
12.3 Steam Turbine for Electric Power Generation	286
12.4 Gas Turbine - Steam Turbine Combined Power Plant	298
12.5 Minimizing the Heat Loss from Power Plants	303
13. INTRODUCTION TO THE SECOND LAW .....	305
13.1 The Second Law	306
13.2 Evaluation of Total Entropy Change	307
13.3 Worked Examples	309
13.4 Summary	332
INDEX .....	335