530 BER V.5

Contents

Preface to the Berkeley Physics Course v Preface to Volume V vii Acknowledgments ix Teaching and Study Notes xi

Chapter 1 Characteristic Features of Macroscopic Systems 1

- 1.1 Fluctuations in Equilibrium 4
- 1.2 Irreversibility and the Approach to Equilibrium 15
- 1.3 Further Illustrations 29
- 1.4 Properties of the Equilibrium Situation 31
- 1.5 Heat and Temperature 35
- 1.6 Typical Magnitudes 39
- I.7 Important Problems of Macroscopic Physics 45 Summary of Definitions 50 Suggestions for Supplementary Reading 51 Problems 51

Chapter 2 Basic Probability Concepts 55

- 2.1 Statistical Ensembles 56
- 2.2 Elementary Relations among Probabilities 64
- 2.3 The Binomial Distribution 67
- 2.4 Mean Values 75
- 2.5 Calculation of Mean Values for a Spin System 80
- 2.6 Continuous Probability Distributions 86 Summary of Definitions 90 Important Relations 90 Suggestions for Supplementary Reading 91 Problems 91

xviii Contents

Chapter 3 Statistical Description of Systems of Particles 99

- **3.1** Specification of the State of a System 101
- 3.2 Statistical Ensemble 108
- 3.3 Statistical Postulates 111
- 3.4 Probability Calculations 116
- 3.5 Number of States Accessible to a Macroscopic System 118
- 3.6 Constraints, Equilibrium, and Irreversibility 124
- 3.7 Interaction between Systems 129 Summary of Definitions 135 Important Relations 136 Suggestions for Supplementary Reading 136 Problems 136

Chapter 4 Thermal Interaction 141

- 4.1 Distribution of Energy between Macroscopic Systems 142
- 4.2 The Approach to Thermal Equilibrium 147
- 4.3 Temperature 149
- 4.4 Small Heat Transfer 155
- 4.5 System in Contact with a Heat Reservoir 157
- 4.6 Paramagnetism 163
- 4.7 Mean Energy of an Ideal Gas 166
- 4.8 Mean Pressure of an Ideal Gas 172 Summary of Definitions 176 Important Relations 177 Suggestions for Supplementary Reading 177 Problems 178

Contents

Chapter 5 Microscopic Theory and Macroscopic Measurements 191

- 5.1 Determination of the Absolute Temperature 192
- 5.2 High and Low Absolute Temperatures 196
- 5.3 Work, Internal Energy, and Heat 200
- 5.4 Heat Capacity 206
- 5.5 Entropy 209
- 5.6 Intensive and Extensive Parameters 211
 Summary of Definitions 213
 Important Relations 213
 Suggestions for Supplementary Reading 213
 Problems 214

Chapter 6 Canonical Distribution in the Classical Approximation 223

- 6.1 The Classical Approximation 224
- 6.2 Maxwell Velocity Distribution 231
- 6.3 Discussion of the Maxwell Distribution 235
- 6.4 Effusion and Molecular Beams 240
- 6.5 The Equipartition Theorem 246
- 6.6 Applications of the Equipartition Theorem 248
- 6.7 The Specific Heat of Solids 250 Summary of Definitions 256 Important Relations 256 Suggestions for Supplementary Reading 256 Problems 257

Chapter 7 General Thermodynamic Interaction 265

- 7.1 Dependence of the Number of States on the External Parameters 266
- 7.2 General Relations Valid in Equilibrium 271
- 7.3 Applications to an Ideal Gas 276
- 7.4 Basic Statements of Statistical Thermodynamics 281
- 7.5 Equilibrium Conditions 286
- 7.6 Equilibrium between Phases 292
- 7.7 The Transformation of Randomness into Order 299 Summary of Definitions 307 Important Relations 307 Suggestions for Supplementary Reading 308 Problems 308

Chapter 8 Elementary Kinetic Theory of Transport Processes 317

- 8.1 Mean Free Path 319
- 8.2 Viscosity and Transport of Momentum 323
- 8.3 Thermal Conductivity and Transport of Energy 331
- 8.4 Self-diffusion and Transport of Molecules 335
- 8.5 Electrical Conductivity and Transport of Charge 339 Summary of Definitions 342 Important Relations 342 Suggestions for Supplementary Reading 343 Problems 343

Contents

Appendix 349

- A.1 Gaussian Distribution 350
- A.2 Poisson Distribution 355
- A.3 Magnitude of Energy Fluctuations 357
- A.4 Molecular Impacts and Pressure in a Gas 360

Mathematical Notes 363

- M.1 The Summation Notation 364
- M.2 Sum of a Geometric Series 364
- M.3 Derivative of $\ln n!$ for large n = 365
- M.4 Value of $\ln n!$ for large n = 366
- **M.5** The Inequality $\ln x \le x 1$ 367
- **M.6** Evaluation of the Integral $\int_{-\infty}^{\infty} e^{-x^2} dx$ 367
- **M.7** Evaluation of Integrals of the Form $\int_{-\infty}^{\infty} e^{-\alpha x^2} x^n dx$ 369

Supplementary Problems 371 Mathematical Symbols 377 Greek Alphabet 379 Numerical Constants 381 Answers to Problems 383 Index 393