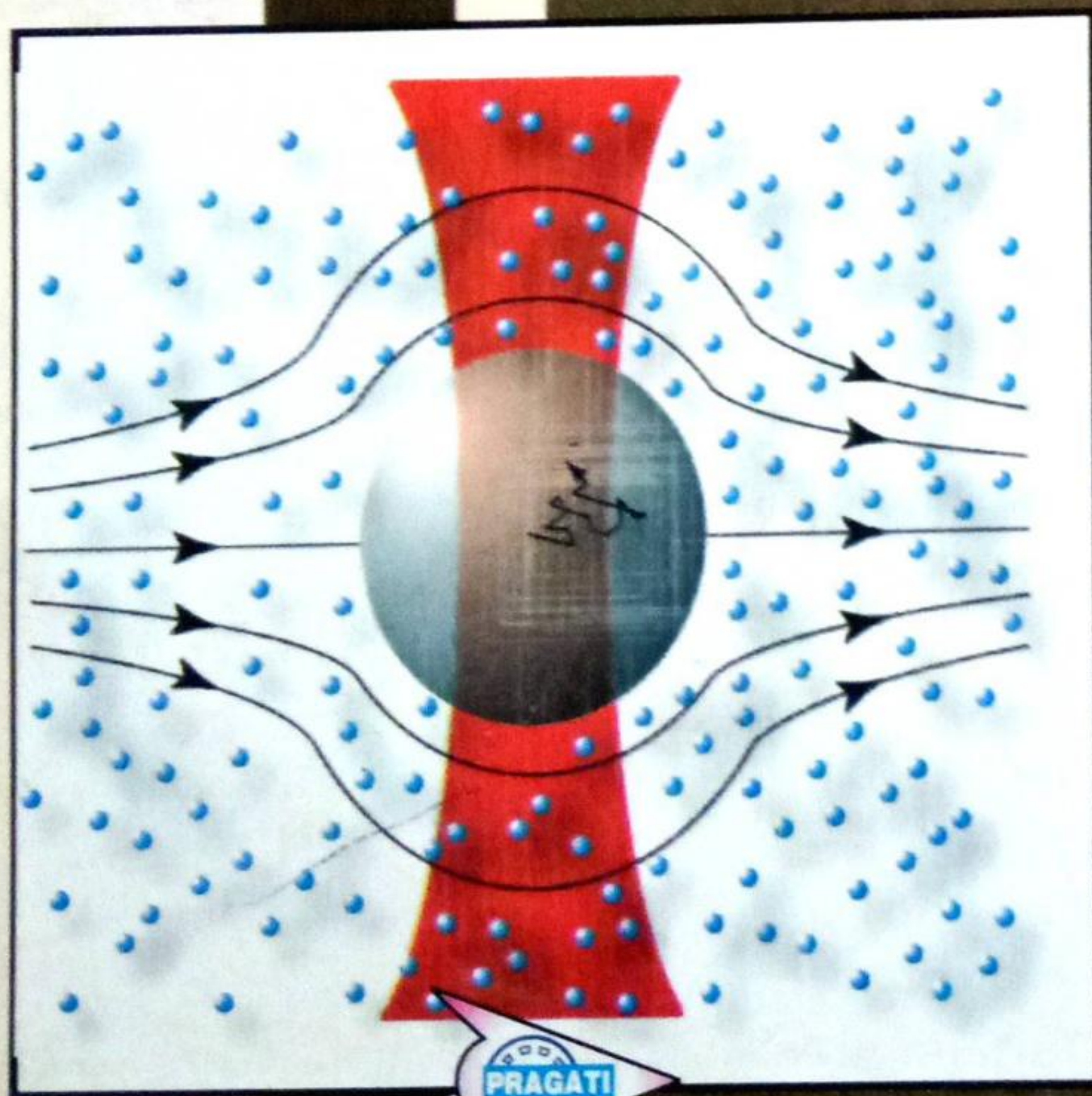




GUPTA • KUMAR

ELEMENTARY STATISTICAL MECHANICS



A Pragati Edition

Contents

REVIEW OF THERMODYNAMICS AND KINETIC THEORY OF GASES

3-74

A. THERMODYNAMICS

- Second law of thermodynamics 3
- Entropy and second law of thermodynamics 4
- Entropy and disorder 9
- Thermodynamic potentials and the reciprocity relations 13
- Thermodynamic equilibria 18
- Nernst's heat theorem 19
- Chemical potential 22

B. APPLICATION OF THERMODYNAMICS TO SPECIAL SYSTEMS : RADIATION

- Radiation and thermodynamics 23
- Radiation pressure 24
- Prevost's theory of exchanges 26
- Kirchhoff's law 27
- Black body radiation 28
- Stefan Boltzmann law 29
- Wien's displacement law 31
- Planck's radiation law 36
- Rayleigh Jean's law 39
- Experimental verification of Planck's radiation law and comparison with other laws 41

KINETIC THEORY OF GASES

- Maxwell Boltzmann distribution law of velocities 44
- Experimental proof of Maxwell's distribution law from the finite breadths of spectral line 48
- Mean free path 52
- Viscosity 58
- Heat conduction 63
- Wiedemann and Franz law 65
- Brownian motion 68
- Problems 72

CLASSICAL STATISTICS

75-216

1. BASIC CONCEPTS

77-104

- Phase space 80
- Volume in phase space 81
- Number of phase cells in given energy range of harmonic oscillator 82
- Number of phase cells in the given energy range of three dimensional free particle 83
- More about phase space, ensemble and ensemble averages 83
- Ensembles 85
- Uses of ensembles 87
- Density distribution in phase space 88
- General discussion of mean values 89
- Liouville's theorem 92
- Density of phase points in classical ensemble 97
- Postulate of equal a priori probabilities 98

- Statistical equilibrium 98
- Thermal equilibrium 99
- Mechanical equilibrium 100
- Particle equilibrium 102
- Connection between statistical and thermodynamic quantities 102

2. CLASSICAL DISTRIBUTION LAW

105-141

- Microstates and Macrostates 105
- Stirling's approximation 107
- Thermodynamical probability 107
- General statistical distribution law 108
- Most probable distribution 109
- Division of phase space into cells 110
- Classical Maxwell-Boltzmann distribution law 111
- Maxwell-Boltzmann distribution for molecules of more than a single kind 113
- Evaluation of constants in the Maxwell-Boltzmann distribution law 114
- Maxwell's law of distribution of velocities 119
- Doppler Broadening of Spectral lines 121
- Principle of equipartition of energy 122
- Calculation of gas pressure 125
- Connection between partition function and thermodynamic quantities 126
- Mean values obtained from distribution law 127
- Probability of Boltzmann's entropy relation 129
- Magnetic moment distribution of independent atoms 133
- Solved examples 134

3. METHOD OF ENSEMBLES-I

142-203

- Microcanonical ensemble 142
- Implications of microcanonical ensemble in practical use 143
- Perfect gas in microcanonical ensemble 144
- Gibbs paradox 148
- Partition function and its correlation with thermodynamic quantities 149
- Gibbs canonical ensemble 154
- Canonical ensemble as an approximation to microcanonical ensemble—Probability density for canonical ensemble 155
- Nature of probability function—Partition function for canonical ensemble 158
- Thermodynamic functions for canonical ensemble 160
- Partition function and properties 163
- Perfect monatomic gas in canonical ensemble 170
- Grand canonical ensemble 174
- Partition function and thermodynamic functions for grand canonical ensemble 174
- Perfect gas in grand canonical ensemble 177
- Comparison of ensembles 181
- Maxwellian distribution from canonical distribution 182, 185
- Equipartition theorem from canonical distribution 187
- Internal degrees of freedom of gas molecules and their contribution to thermodynamic properties of gas 193
- Thermodynamic properties of diatomic molecules 195

4. METHODS OF ENSEMBLES-II

204-216

- Total energy of imperfect gas 204
- Theory of imperfect gases, Cluster expansion 205
- Partition function 208
- Equation of state and virial coefficients 211
- vander Waal equation 212
- *Problems on Classical Statistics 214

QUANTUM STATISTICS**219-398****219-246****5. BASIC CONCEPTS**

- Postulatory foundations of quantum mechanics 219
- Transition from classical statistical mechanics to quantum statistical mechanics 222
- Indistinguishability and quantum statistics 222
- Exchange symmetry of wavefunctions 223
- Exchange degeneracy 224
- Construction of symmetric and antisymmetric wavefunctions 225
- Average value and quantum statistics 226
- Statistical weight or a priori probability 227
- Matrices 227
- The density matrix 229
- Postulate on the form of the density matrix 232
- Condition for statistical equilibrium 240
- Darwin-Fowler method 241

6. DISTRIBUTION LAW**247-267**

- Identical particles and symmetry requirement 248
- Bose-Einstein statistics 250
- Fermi-Dirac statistics 252
- Maxwell-Boltzmann statistics 255
- Evaluation of constants α and β 257
- Result of three statistics 258
- Thermodynamic interpretation of the parameters α and β 259
- Number of Eigen states in an energy range 261
- Eigen states and Maxwell Boltzmann equation 262
- Blackbody radiation and the Plancks radiation 263
- Grand canonical ensemble and the quantum statistics 265

7. DIATOMIC MOLECULES**268-283**

- Thermodynamic properties of diatomic molecules 268
- Nuclear spin effects in diatomic molecules 274
- Specific heat of solids 276
- Einstein theory 277
- Debye theory 279

8. IDEAL BOSE EINSTEIN GAS**284-305**

- Energy and pressure of gas 284
- Gas degeneracy 287
- Bose Einstein condensation 290
- Thermal properties of Bose-Einstein gas 293
- Liquid Helium 296
- London theory 297
- Tisza two fluid model 298
- Second Sound 299
- Landau theory 302

9. IDEAL FERMI DIRAC GAS**306-328**

- Energy and pressure of the gas 306
- Slight degeneracy 307
- Strong degeneracy 309
- Thermodynamic function of degenerate Fermi Dirac gas 314
- Compressibility of Fermi Gas 316
- Electron gas 317

- Free electron model and electronic emission 320
- Pauli's theory of paramagnetism 322
- White dwarfs 325

10. TRANSPORT PROPERTIES

329-349

- Boltzmann transport equation 330
- Boltzmann transport equation for electrons and Lorentz solution 333
- Chambers equation 335
- Sommerfeld theory of electrical conductivity 336
- Thermal conductivity of metals 339
- Magnetoresistance 341
- Viscosity from Boltzmann equation 344
- Isothermal Hall effect 346

11. IRREVERSIBLE PROCESS : ONSAGER RELATIONS AND APPLICATIONS

350-357

- Onsager relations 350
- Proof of Onsager reciprocal relations 352
- Applications of Onsager relations 354

12. FLUCTUATIONS IN THERMODYNAMIC QUANTITIES

358-374

- Fluctuations in energy 359
- Fluctuations in pressure 361
- Fluctuations in volume 362
- Fluctuations in enthalpy 363
- Probability of one dimensional random work 363
- Brownian movement 365
- Fokker-Planck equation 366
- Solution of Fokker-Planck equation 368
- Fourier analysis of Random function, Wiener Khintchine theorem 370
- Electrical noise, Nyquist's theorem 373

13. PHASE TRANSITION

375-386

- Phase transition 375
- Phase transition of first and second kind 375
- Critical exponent 377
- Yang and Lee Theory 379
- Phase transitions of the second kind; The Ising Model 381
- Bragg Williams approximation 382
- One dimensional Ising model 385

14. PRODUCTION AND MEASUREMENT OF LOW TEMPERATURE

387-399

- Production of low temperature 387
- Approach to absolute zero by adiabatic demagnetisation 388
- Measurement of low temperature 393
- *Problems on Quantum Statistics 394

SELF TEST QUESTIONS

400-402