CONTENTS

	PREFACE	xiii
1.	INTRODUCTION	1
1.1.	The nature and the goals of kinetic theory. Summary and related books.	1
1.2.	Some concepts from probability theory.	4
1.3.	Some properties of the Dirac delta function.	6
1.4.	Phase spaces, conservation of probability and the Liouville equation.	9
1.5	Microscopic and macroscopic quantities.	12
1.6.	Exercises.	13
2.	BALANCE EQUATIONS	15
2.1.	Conservation of particles.	15
2.2.	Momentum equation.	17
2.2.1	Short range interaction forces.	20
2.2.2	Long range interaction forces.	21
2.2.3	Approximations: Boltzmann gas, Landau gas and electron plasma.	24
2.3.	Energy equation.	25
2.4.	Exercises.	30
3.	KLIMONTOVICH EQUATION, B.B.G.K.Y.–HIERARCHY AND VLASOV–MAXWELL EQUATIONS	33
3.2.	Densities in μ–space.	33
3.2.	Klimontovich equation.	35
3.3.	Vlasov–Maxwell equations.	38
3.4.	The first equation of the B.B.G.K.Y.–hierarchy.	41
3.5.	The complete hierarchy.	42
3.6.	Derivation of the B.B.G.K.Y.–hierarchy.	45
3.7.	Exercises.	47
4.	DERIVATION AND PROPERTIES OF THE BOLTZMANN EQUATION	51
4.1.	The small parameter of the Boltzmann gas.	51
4.2.	Multiple–time–scales formalism.	55

4.2.1	The Van de Pol oscillator.	55
4.3.	Derivation of the Boltzmann equation.	58
4.3.1	First order theory and Bogoliubov boundary condition.	59
4.3.2	Discussion of the kinetic equation. Limitations of Bogoliubov's approach.	62
4.3.3	Bogoliubov's cylindrical integration.	64
4.4.	Dynamics of binary collisions.	66
4.4.1	An explicit form of the Boltzmann equation.	69
4.4.2	Cross–sections	70
4.5.	Boltzmann equation and Markov processes.	71
4.6.	Properties of the Boltzmann equation.	74
4.6.1	Positivity of the distribution function and invariance under time reversal.	74
4.6.2	H–theorem for a uniform gas.	75
4.6.3	H–theorem for a non–uniform gas	78
4.6.4	The pair distribution function in equilibrium.	84
4.7.	Discussion of irreversibility.	86
4.8.	Exercises.	88
5.	CHAPMAN–ENSKOG THEORY: ASYMPTOTIC SOLUTION TO THE BOLTZMANN EQUATION; TRANSPORT COEFFICIENTS	92
5.1.	Introduction and table of characteristic quantities.	92
5.2.	Balance equations.	93
5.3.	Power series in the Knudsen number and the multiple time scale formalism revisited.	95
5.3.1	Zeroth and first order theory, the Euler equations of hydrodynamics and the Chapman–Enskog integral equation.	96
5.3.2	Derivation of the Navier–Stokes equations and the constitutive equations.	102
5.4.	The role of entropy and the thermodynamic identity.	107
5.5.	The eigenvalues of the linearized collision operator and transport coefficients.	110
5.5.1	Properties of irreducible tensors.	115
5.6.	The Maxwell gas.	116
5.7.	Non–Maxwellian intermolecular interaction.	124
5.8.	Exercises.	128
6.	KINETIC THEORY OF PLASMAS IN THE BINARY COLLISION APPROXIMATION.	133
6.1.	Kinetic theory of gas mixtures. Lorentz gas.	133
6.1.1	Expansion of the collision integral J_{12} in powers of the square root of the mass ratio.	134
6.1.2	Expansion in powers of the Knudsen number. Zeroth and first order theory.	138
6.1.3	Second order theory. Diffusion, thermodiffusion, thermal conductivity and Dufour effect. Onsager symmetry.	142
6.2.	The electrons in a very weakly ionized gas.	149
6.2.1	Transport properties.	150

6.2.2	The isotropic part of the distribution function. The Davydov distribution.	151
6.2.3	Relaxation towards the Davydov distribution.	153
6.3.	The Landau equation for a fully ionized plasma.	154
6.3.1	Derivation from the Boltzmann equation. Impulse approximation.	155
6.3.2	Discussion of the validity of the Landau equation for a plasma.	158
6.3.3	The Landau equations for electrons and ions.	161
6.4.	Calculation of the electrical conductivity.	163
6.4.1	Simplifying assumptions.	163
6.4.2	Electrical conductivity and velocity dependent collision frequency.	165
6.4.3	DC–conductivity and conductivity at rather high frequencies.	167
6.4.4	Validity of the Lorentz approximation.	169
6.4.5	DC–conductivity and electron–electron collisions	170
6.5.	Exercises.	174
7.	B.G.K.–MODELS AND THE SLIP PROBLEM.	179
7.1.	Linear B.G.K.–model. Its relation to the Boltzmann equation.	179
7.2.	The non–linear B.G.K.–model. Linearization.	182
7.3.	The slip problem of Kramers.	184
7.4.	Solution to the B.G.K. integro–differential equation.	186
7.5.	The singular integral equation and hydrodynamic slip.	189
7.6.	The microscopic slip velocity.	196
7.7.	Exercises.	200
8.	KINETIC THEORY OF PLASMAS, INCLUDING DYNAMICAL SCREENING.	204
8.1.	Collisions and screening in plasmas. The Lenard approach.	204
8.1.1	Equations for the distribution function and the binary correlation function.	204
8.1.2.	Derivation of the Lenard–Balescu equation.	208
8.2.	The interaction between two charged particles in a dielectric medium.	212
8.2.1	The dynamically screened interaction and the impulse approximation.	213
8.2.2	Heuristic derivation of the Lenard–Balescu equation.	214
8.3.	Properties of the Lenard–Balescu equation.	215
8.4.	The Landau equation as an approximation to the Lenard–Balescu equation.	217
8.5.	Completely convergent collision integrals.	219
8.5.1	The quantum–mechanical version of the Lenard–Balescu equation.	220
8.5.2	Completely convergent classical collision integral.	223
8.6.	The electrical conductivity at rather high frequencies.	223
8.6.1	Calculation of the quantum–mechanical conductivity.	224
8.6.2	Calculation of the completely convergent classical conductivity.	227
8.7.	Excercises.	228

9.	LINEAR RESPONSE THEORY	234
9.1.	Linearized Liouville equation.	234
9.2.	Kubo formulae.	238
9.2.1	Derivation.	238
9.2.2	Symmetries.	238
9.2.3	Time reversal.	239
9.3.	Electrical conductivity.	242
9.3.1	The Kubo–formula.	242
9.3.2	Fluctuation–dissipation theorem, Nyquist theorem.	245
9.4.	Internal agencies.	253
9.4.1	Mori method: linearization in small gradients.	254
9.4.2	Fluctuations and entropy.	258
9.5.	Longtime tail of autocorrelation functions.	265
9.5.1	Kinetic approximation to the velocity autocorrelation function.	266
9.5.2	Asymptotic behaviour for large time.	267
9.6.	Exercises.	270
10.	BROWNIAN MOTION	278
10.1.	Statistical description. Markov processes.	278
10.1.1	Fokker–Planck equation for the position. Diffusion.	279
10.1.2	Rayleigh particle. Fokker–Planck equation for the velocity.	281
10.1.3	Autocorrelation functions of velocity and position.	283
10.1.4	Langevin equation.	285
10.2.	Generalized theory of the velocity autocorrelation function.	286
10.2.1	Hydrodynamical forces on a Brownian particle.	286
10.2.2	An equation for the velocity autocorrelation function derived from linear response theory, and its solution.	292
10.2.3	Long time tales.	296
10.3.	Hydrodynamic fluctuations and the generalized Langevin equation.	297
10.3.1	Induced forces.	298
10.3.2	The generalized Faxén theorem.	301
10.3.3	Stochastic hydrodynamic equations.	302
10.3.4	Generalized Langevin equation and a fluctuation–dissipation theorem.	303
10.4.	Discussion of the velocity autocorrelation function.	308
10.4.1	Solution to the generalized Langevin equation.	308
10.4.2	Long time tails.	310
10.4.3	Some remaining difficulties.	311
10.5.	Exercises.	311
	Appendix.	318
11.	DENSE GASES, RENORMALIZED KINETIC THEORY	320
11.1.	The Enskog equation for hard sphere dense gases.	320
11.1.1	Determination of $Y(n)$.	323
11.1.2	Transport coefficients.	325
11.1.3	Self–diffusion. Lorentz–Enskog equation.	327
11.2.	Limitations of Bogoliubov approach revisited. Hard–sphere gases.	331

11.2.1	The binary collision expansion.	332
11.2.2	Hard–sphere dynamics. Pseudo–Liouville Equation and –Hierarchy.	333
11.3.	Renormalization of collisional effects.	338
11.3.1	The Choh–Uhlenbeck collision term. The ring operator.	339
11.3.2	The diffusion coefficient of a Lorentz gas.	342
11.3.3	Self–diffusion.	344
11.4.	Memory effects in hard–sphere gases and self–diffusion.	345
11.4.1	Dynamic cluster expansion.	346
11.4.2	Independent particle approximation. Non–Markovian kinetic equation.	349
11.4.3	Some results obtainable from the Non–Markovian kinetic equation.	351
11.5.	Exercises.	353
12.	THEORY OF (SLIGHTLY) NONIDEAL PLASMAS	359
12.1.	The Klimontovich equation revisited.	360
12.1.1	Fourier transforms	360
12.2.	The expansion scheme.	361
12.2.1	Initial conditions.	362
12.2.2	Derivation of the Lenard–Balescu equation.	364
12.2.3	Corrections to the Lenard–Balescu equation.	367
12.3.	The electrical conductivity at frequencies much lower than the plasma frequency.	369
12.3.1	Outline of the method.	369
12.3.2	Calculation of the conductivity by means of a completely convergent collision integral.	371
12.3.3	Discussion of the results.	374
12.4.	The electrical conducitivity at high frequencies	377
12.4.1	The zeroth and first order conductivity.	378
12.4.2	Second order conductivity.	380
12.4.3	The conductivity in case of a homogeneous electric field.	382
12.4.4	Comparison with Kubo's formalism.	388
12.5.	The dispersion relation for plasma waves.	390
12.5.1	The dispersion relation in zeroth order.	390
12.5.2	The dispersion relation in second order.	391
12.6.	Remarks about strongly non–ideal plasmas.	393
12.6.1	Classification of plasmas, n–T diagram.	394
12.6.2	Quantum–statistical methods.	396
12.6.3	Some results for thermodynamic equilibrium.	498
12.6.4	Some results for the electrical conductivity.	400
12.7.	Exercises.	402
References.		409
Index.		415