



# Contents

<b>Introduction</b> .....	1
<b>1. Translational Relaxation of Heavy Particles</b> .....	5
References .....	11
<b>2. Rotational Relaxation of Molecules</b> .....	13
References .....	21
<b>3. Vibrational Relaxation of Molecules</b> .....	23
3.1 Estimation of Vibrational Relaxation Times .....	23
3.2 Vibrational Kinetics of Harmonic Oscillators .....	26
3.2.1 Vibrational Relaxation of Diatomic Molecules in an Inert Gas: V-T Exchange .....	26
3.2.2 One-Component Systems: V-V Exchanges .....	29
3.2.3 Binary Mixture of Diatomic Molecules: V-T , V-V and V-V' Exchanges .....	31
3.2.4 Polyatomic Molecules .....	34
3.3 Vibrational Kinetics of Anharmonic Oscillators .....	36
3.3.1 V-T Relaxation in an Inert Gas .....	37
3.3.2 V-V Exchanges. The Treanor Distribution .....	38
3.3.3 V-V and V-T Exchanges. Moderate Deviation from Equilibrium .....	39
3.3.4 Resonant V-V Relaxation Under High Excitation Conditions .....	41
3.3.5 Time-Dependent Relaxation at High Excitation .....	45
3.4 Vibrational Kinetics in the Presence of Chemical Reactions of Vibrationally Excited Molecules .....	47
References .....	54
<b>4. Kinetics of Free Electrons</b> .....	59
4.1 The Boltzmann Equation .....	59
4.2 EEDF in Discharges Sustained by an Electric Field .....	66
4.3 EEDF in Discharges Excited by an Electron Beam .....	74
References .....	79

<b>5. Energetic and Spectroscopic Parameters of Atmospheric Species</b> .....	85
References .....	93
<b>6. Rates of Translational and Rotational Relaxation</b> .....	95
6.1 Translational Relaxation and Diffusion Coefficients .....	95
6.2 Rotational Relaxation .....	99
References .....	103
<b>7. Rate Coefficients for Vibrational Relaxation</b> .....	105
7.1 Rate Coefficients of V-T Relaxation .....	105
7.2 Rate Coefficients of V-V and V-V' Processes .....	112
References .....	116
<b>8. Electron Rate Coefficients</b> .....	119
8.1 Integral Scattering Cross-Sections .....	119
8.2 Electron Rate Coefficients and Power Balance in Plasmas Maintained by an Electric Field .....	123
8.3 Electron Loss Processes in the Plasma Bulk .....	139
8.4 Electron Rate Coefficients and Energy Balance in the Ionosphere Plasma .....	142
8.5 Excitation, Dissociation and Ionization of N <sub>2</sub> , O <sub>2</sub> and O Species by an Electron Beam .....	145
References .....	149
<b>9. Electronic State Relaxation Rates</b> .....	155
9.1 Radiative Lifetimes .....	155
9.2 Relaxation in Collisions with Atoms and Molecules .....	158
References .....	163
<b>10. Rate Coefficients of Chemical Reactions</b> .....	167
10.1 Reactions of Neutral Species .....	167
10.2 Ion-Molecule Reactions .....	178
10.3 Vibrational Excitation of Reaction Products .....	185
References .....	187
<b>11. Interactions of Gas Phase Species with Surfaces</b> .....	193
11.1 Balance Equations and Boundary Conditions at Walls .....	193
11.2 Wall Loss Probabilities $\gamma$ .....	196
11.3 Kinetic Model for Surface Processes .....	199
11.4 Molecular Dynamics Approach .....	206
References .....	207

<b>12. Discharges in Pure N<sub>2</sub> and O<sub>2</sub></b> .....	209
12.1 Discharge and Post-Discharge in N <sub>2</sub> .....	209
12.2 Discharge in O <sub>2</sub> .....	215
12.2.1 The Positive Column in Electronegative Gases .....	216
12.2.2 Chemical and Charge Kinetics in O <sub>2</sub> Discharges .....	221
References .....	224
<b>13. Discharges in N<sub>2</sub>–O<sub>2</sub> Mixtures</b> .....	229
13.1 Modelling of Low Pressure N <sub>2</sub> –O <sub>2</sub> Discharges .....	229
13.1.1 General Description of the Model .....	231
13.1.2 Kinetics of Free Electrons .....	231
13.1.3 Vibrational Kinetics .....	232
13.1.4 Kinetics of Electronic States and Chemical Kinetics ...	232
13.1.5 Interaction with the Wall .....	232
13.1.6 Gas and Wall Temperatures .....	233
13.2 Modelling of High Pressure N <sub>2</sub> –O <sub>2</sub> Discharges .....	241
13.2.1 Cleaning of Polluted Atmospheric Gases .....	241
13.2.2 N <sup>14</sup> and N <sup>15</sup> Isotope Separation .....	246
References .....	248
<b>14. Kinetic Processes in the Ionosphere</b> .....	251
14.1 Probabilities and Rates of Dissociation and Ionization .....	252
14.2 Chemical and Charge Kinetics .....	254
14.3 Vibrational Kinetics .....	257
References .....	264
<b>15. Interaction of Space Vehicles with Atmospheric Gases</b> ....	269
15.1 Free Molecular Regime .....	269
15.2 Hydrodynamic Regime. Vibrational and Chemical Kinetics During Space Shuttle Reentry .....	273
References .....	282
<b>16. Acoustic and Shock Waves in Non-equilibrium Gases</b> .....	287
16.1 Propagation of Small Perturbations in Non-equilibrium Gases	287
16.2 Nonlinear Hydrodynamic Waves in Non-equilibrium Gases ...	290
16.3 Propagation of Shock Waves in Non-equilibrium Gases .....	292
References .....	295
<b>Index</b> .....	299