Contents

- A. Wint Air Pollution in Perspective 1
- P. Fabian Halogenated Hydrocarbons in the Atmosphere 23
- H. Güsten Formation, Transport and Control of Photochemical Smog 53
- H. van Dop Atmospheric Distribution of Pollutants and Modelling of Air Pollution Dispersion 107
- J. M. Hales The Mathematical Characterization of Precipitation Scavenging and Precipitation Chemistry 149

Subject Index 219

Air Pollution in Perspective

A. Wint

Chemical Engineering Department, University of Nottingham Nottingham, NG7 2RD, England

Introduction
A Brief History of Air Pollution
Early Problems and Control Measures
Problems of Recent Years
Classification of Air Pollution Problems
Global Air Pollution Problems
Regional Air Pollution Problems
Local Air Pollution Problems
Effects of Atmospheric Pollution on Health
Epidemiology
Animal Toxicology
Controlled Clinical Studies
Air Quality Standards
Air Pollution as a Cause of Lung Cancer
Research Methods
Results
Economics of Air Pollution
Strategy and Costs of Air Pollution Control.
Costs of Damage
Perspective
References

Halogenated Hydrocarbons in the Atmosphere

P. Fabian

Max-Planck-Institut für Aeronomie D-3411 Katlenburg-Lindau 3 Federal Republic of Germany

Introduction
The Major Halocarbons: Sources, Sinks, Tropospheric Distribution and
Trends
Methyl Chloride (CH_3Cl)
$CFCl_3$ (CFC-11) and CF_2Cl_2 (CFC-12)
Carbon Tetrachloride (CCl ₄) \ldots 30
Methyl Chloroform (CH_3CCl_3)
$CHF_2Cl (CFC-22)$
The Stratospheric Distribution of the Major Halocarbons
Methyl Chloride (CH ₃ Cl)
CFCl ₃ (CFC-11)
CF_2Cl_2 (CFC-12)
Carbon Tetrachloride (CCl ₄)
Methyl Chloroform (CH_3CCl_3)
$CHF_2CI (CFC-22)$
Sources, Budgets and Distribution of Other Atmospheric Halocarbons . 41
CF_4 (CFC-14)
$C_2 F_6$ (CFC-116)
$C_2F_3Cl_3$ (CFC-113) and $C_2F_4Cl_2$ (CFC-114)
C_2F_5Cl (CFC-115) and CF ₃ Cl (CFC-13)
Methyl Bromide (CH ₃ Br) and CF ₃ Br (CFC-13 B1)
Methyl Iodide (CH_3I)
Concluding Remarks
Acknowledgements
References

Summary

This report reviews the present knowledge about all halocarbon species that contribute to the stratospheric halogen budget. Since review articles published in earlier volumes of this handbook [13, 14] cover topics such as production processes, use patterns, the distribution in waters and biological systems, this chapter focuses on the atmospheric aspects, on budgets and the global distribution in the troposphere and stratosphere.

Formation, Transport and Control of Photochemical Smog

Hans Güsten

Kernforschungszentrum Karlsruhe, Institut für Radiochemie D-7500 Karlsruhe, Federal Republic of Germany

Introduction					54
Historical Background					54
Photochemical Smog Chemistry					56
Basic Photochemical Cycle of NO, NO ₂ , and Ozone .					57
Catalytic Cycle of $NO \rightarrow NO_2$ Conversion					59
Sources of OH and HO ₂ Radicals					60
Significance of the Hydrocarbon/NO, Ratio					63
Computer Modelling of the Photochemical Smog					65
The Reactivity of the OH Radical					68
General Mechanism of the Oxidation of Hydrocarbons					70
Products of the Photochemical Smog					71
Ozone					71
Ambient Air Concentrations of Ozone in Europe					76
Peroxyacetyl Nitrate (PAN)					79
Hydrogen Peroxide (H_2O_2)					81
Nitrate Radical (NO_3)					82
Nitric Acid (HNO ₃) $\tilde{.}$					84
Nitrous Acid (HNO_2)					84
Aldehydes and Ketones					86
Miscellaneous Compounds					87
Long-Range Transport of Photochemical Smog.					88
Mathematical Models Describing Long-Range Transpo	rt				90
Control of Photochemical Smog					92
Ambient Air Quality Criteria for Ozone					92
Air Pollution Control Principles					95
Chemical Control of Photochemical Smog					96
Final Remarks					97
Acknowledgements					98
References.					98

Atmospheric Distribution of Pollutants and Modelling of Air Pollution Dispersion

H. van Dop

Royal Netherlands Meteorological Institute P.O. Box 201, NL-3730 AE De Bilt, The Netherlands

Introduction	08
Atmospheric Physics	08
Atmospheric Radiation	08
Thermodynamics	
Atmospheric Dynamics	
The Fluid Dynamics Equations	
The Ekman Layer	
Turbulence	
The Convective Boundary Layer	20
The Stable Boundary Layer	
Transport and Dispersion	21
Analytical Solutions	23
Statistical Dispersion Theory	25
Random Walk Dispersion Theory	27
Numerical Methods	28
Air Pollution Models	
Urban Dispersion Models	31
Dispersion Coefficients.	
Plume Rise	134
Air Pollution Statistics.	135
The Validation of Urban Air Pollution Models	135
Medium Range Transport Models	36
Turbulence Data	137
Deposition Processes	138
The Wind Field \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots	139
Long Range Transport Models	40
Acknowledgement	45
References	45
Notations	.46

The Mathematical Characterization of Precipitation Scavenging and Precipitation Chemistry

J. M. Hales

Battelle Pacific Northwest Laboratories, Richland, WA 99352, USA

Introduction	150
Spatial and Temporal Variability: A Qualitative Overview	
Precipitation-Scavenging Modeling: Formulation of Governing Equations	162
Introduction	162
Material Balances	164
Energy Balances.	168
Momentum Balances.	170
Precipitation-Scavenging Modeling: Description of Physicochemical	
Microprocesses	170
Introduction	
Elementary Raindrop Statistics	171
Below-Cloud Scavenging of Nonreactive Aerosols: Homogeneous	
Aerosols	172
Below-Cloud Scavenging of Aerosols: Enhancement by Water	
Condensation	176
Below-Cloud Scavenging of Aerosols: Collection by Snow	178
Below-Cloud Scavenging of Nonreactive Gases	179
Below-Cloud Scavenging of Reactive Gases	183
In Cloud Scavenging of Gases and Aerosols	185
Combination of Governing Equations and Microprocess Descriptions:	
Example Model Integrations	187
Introduction	187
Differential Material Balances and Below-Cloud Scavenging	
Integral Material Balances	194
Integral Material Balances and Statistical Models	199
Model Selection Techniques	200
Introduction	200
Model Uses.	201
Model Scales, Domains, and Averaging Times	201
Input Information	202
Final Model Selection	202
Model-Measurement Comparisons	205
	205
Within-Event Variability of a Single Storm	206
Long-Term Variability of Regional Precipitation Chemistry	207
total turnomely of regional troup	

Spatial '	Vai	ria	bil	ity	Ν	ea	r ł	20	int	S	ou	rc	es								208
Spatial '	Vai	rial	bil	ity	01	n t	he	R	eg	io	na	1 S	ica	le							210
Conclusion																					
References.		•	•																•		212