INTRODUCTION to ATMOSPHERIC CHEMISTRY

Peter V. (Jobbs

Contents

| Preface | | | | | |
|---------|--|--|----|--|--|
| 1 | Evolution of the Earth's atmosphere | | | | |
| | 1.1 | The primitive atmosphere | 2 | | |
| | 1.2 | Prebiotic atmosphere and the origins of life | 3 | | |
| | 1.3 | Rise of oxygen and ozone | 5 | | |
| | 1.4 | Oxygen and carbon budgets | 6 | | |
| | 1.5 | Some other atmospheric constituents | 9 | | |
| | 1.6 | The Gaia hypothesis | 10 | | |
| | 1.7 | Summary | 10 | | |
| 2 | Half-life, residence time, and renewal time of chemicals | | | | |
| | in tl | he atmosphere | 13 | | |
| | 2.1 | Half-life | 13 | | |
| | 2.2 | Residence time and renewal time | 15 | | |
| | 2.3 | Spatial and temporal scales of variability | 20 | | |
| 3 | Present chemical composition of the atmosphere | | 21 | | |
| | 3.1 | Units for chemical abundance | 21 | | |
| | 3.2 | Composition of air close to the Earth's surface | 23 | | |
| | 3.3 | Change in atmospheric composition with height | 26 | | |
| 4 | Interactions of solar and terrestrial radiation with | | | | |
| | atmospheric trace gases and aerosols | | | | |
| | 4.1 | Some basic concepts and definitions | 34 | | |
| | 4.2 | Attenuation of solar radiation by gases | 41 | | |
| | 4.3 | Vertical profile of absorption of solar radiation in | | | |
| | | the atmosphere | 43 | | |
| | | | | | |

| | 4.4 | Heating of the atmosphere due to gaseous | 45 | | | | |
|---|------------------------------|---|----------|--|--|--|--|
| | | absorption of solar radiation | 45 50 | | | | |
| | 4.5 | Attenuation of solar radiation by aerosols | 50 51 | | | | |
| | 4.6 4.7 | Absorption and emission of longwave radiation | J.L | | | | |
| | 4.7 | The greenhouse effect, radiative forcing, and | 54 | | | | |
| | 4.0 | global warming | 57 | | | | |
| | 4.8 | Photochemical reactions | 31 | | | | |
| 5 | Sou | Sources, transformations, transport, and sinks of | | | | | |
| | chemicals in the troposphere | | | | | | |
| | 5.1 | Sources | 63 | | | | |
| | 5.2 | Transformations by homogeneous gas-phase | | | | | |
| | | reactions | 72 | | | | |
| | 5.3 | Transformations by other processes | 78 | | | | |
| | 5.4 | Transport and distributions of chemicals | 79 | | | | |
| | 5.5 | Sinks of chemicals | 80 | | | | |
| 6 | Atn | nospheric aerosols | 82 | | | | |
| • | 6.1 | Aerosol concentrations and size distributions | 82 | | | | |
| | 6.2 | | 91 | | | | |
| | 6.3 | Transformations of aerosols | 95 | | | | |
| | 6.4 | | 97 | | | | |
| | 6.5 | Transport of aerosols | 99 | | | | |
| | 6.6 | Sinks of aerosols | 100 | | | | |
| | 6.7 | | 102 | | | | |
| | 6.8 | Geographical distribution of aerosols | 104 | | | | |
| | 6.9 | Atmospheric effects of aerosols | 104 | | | | |
| 7 | Cla | ud and precipitation chemistry | 111 | | | | |
| , | | Overview | 111 | | | | |
| | 7.1 | Cloud condensation nuclei and nucleation | 111 | | | | |
| | 1.2 | scavenging | 113 | | | | |
| | 7.3 | Dissolution of gases in cloud droplets | 121 | | | | |
| | 7.3 | - | 125 | | | | |
| | 7.4 | Aqueous-phase chemical reactions | 131 | | | | |
| | | Precipitation scavenging | 131 | | | | |
| | 7.6 | Sources of sulfate in precipitation | 134 | | | | |
| | 7.7 | Chemical composition of rainwater | | | | | |
| | 7.8 | Production of aerosols by clouds | 137 | | | | |

| | | | vii | | |
|------------|------------------------------|--|-----|--|--|
| 8 | Tropospheric chemical cycles | | | | |
| | 8.1 | Carbon cycle | 143 | | |
| | 8.2 | Nitrogen cycle | 149 | | |
| | 8.3 | Sulfur cycle | 151 | | |
| 9 | Air pollution | | | | |
| | 9.1 | Sources of anthropogenic pollutants | 153 | | |
| | 9.2 | Some atmospheric effects of air pollution | 156 | | |
| 10 | Stratospheric chemistry | | | | |
| | 10.1 | Unperturbed stratospheric ozone | 165 | | |
| | 10.2 | Anthropogenic perturbations to stratospheric ozone | 171 | | |
| | | Stratospheric aerosols; sulfur in the stratosphere | 179 | | |
| App | endix I | Exercises | 185 | | |
| App | endix I | I Answers to exercises in Appendix I and hints | | | |
| • • | | and solutions to the more difficult exercises | 206 | | |
| App | endix 1 | II Atomic weights | 235 | | |
| | endix 1 | | 238 | | |
| Appendix V | | · , , | 240 | | |
| | endix V | | 241 | | |
| Inde | ex | | 242 | | |