

Contents

Preface — V

List of principal symbols — XII

1 Introduction — 1

- 1.1 What do we mean by 'environment'? — 1
- 1.2 What is chemistry? — 2

2 Chemistry under environmental conditions — 7

- 2.1 General remarks — 7
- 2.2 States of matter — 12
 - 2.2.1 Atoms, elements, molecules, compounds and substances — 13
 - 2.2.2 Pure substances and mixtures — 14
 - 2.2.3 Concentration measures — 15
- 2.3 Air and gases — 20
 - 2.3.1 Composition of the atmosphere — 21
 - 2.3.2 Properties of gases: The ideal gas — 23
- 2.4 Water and waters — 32
 - 2.4.1 Cycling and chemical composition of waters — 33
 - 2.4.2 Physical and chemical properties of water — 39
 - 2.4.3 Properties of aqueous solutions — 44
 - 2.4.4 Water vapour — 46
- 2.5 Solid matter — 47
 - 2.5.1 General remarks — 47
 - 2.5.2 Soils — 49
 - 2.5.3 Dust — 50

3 Fundamentals of physical chemistry — 53

- 3.1 Chemical thermodynamics — 53
 - 3.1.1 First law of thermodynamics and its applications — 54
 - 3.1.2 Second law of thermodynamics and its applications — 59
- 3.2 Equilibrium — 67
 - 3.2.1 Phase equilibrium — 68
 - 3.2.2 Chemical equilibrium — 76
 - 3.2.3 Dynamic equilibrium and steady state — 87
- 3.3 Theory of chemical reactions — 90
 - 3.3.1 Chemical bonding — 90
 - 3.3.2 Types of chemical reactions — 96
 - 3.3.3 Chemical kinetics: Reaction rate constant — 99

3.3.4	Catalysis —	105
3.3.5	Electrochemistry —	106
3.3.6	Photochemistry —	115
3.3.7	Heterogeneous chemistry —	128
3.3.8	Radicals, groups, and nomenclature —	128
4	Chemistry of elements and its compounds in the environment —	132
4.1	General remarks —	133
4.2	Hydrogen —	137
4.2.1	Natural occurrence —	137
4.2.2	Compounds of hydrogen —	138
4.2.3	Chemistry —	139
4.3	Oxygen —	141
4.3.1	Natural occurrence —	143
4.3.2	Gas-phase chemistry —	144
4.3.3	Aqueous-phase chemistry —	148
4.4	Nitrogen —	159
4.4.1	Natural occurrence and sources —	162
4.4.2	Thermal dissociation of dinitrogen (N_2) —	163
4.4.3	Ammonia (NH_3) —	164
4.4.4	Dinitrogen monoxide (N_2O) —	167
4.4.5	Nitrogen oxides (NO_x) and oxoacids (HNO_x) —	168
4.4.6	Organic nitrogen compounds —	181
4.5	Sulphur —	187
4.5.1	Natural occurrence and sources —	189
4.5.2	Reduced sulphur: H_2S , COS, CS_2 , and DMS —	191
4.5.3	Oxides and oxoacids: SO_2 , H_2SO_3 , SO_3 , and H_2SO_4 —	194
4.6	Carbon —	202
4.6.1	Elemental carbon —	203
4.6.2	Inorganic C_1 Chemistry: CO, CO_2 , and H_2CO_3 —	206
4.6.3	Organic carbon —	212
4.7	Halogens —	235
4.7.1	Chlorine in the environment —	237
4.7.2	Formation of sea salt and HCl degassing —	239
4.7.3	Gas-phase chemistry —	242
4.7.4	Aqueous and interfacial chemistry —	245
4.8	Phosphorous —	250
4.9	Metals and metalloids —	253
4.9.1	General remarks —	253
4.9.2	Alkali and alkaline earth like metals: Na, K, Mg, and Ca —	256
4.9.3	Iron: Fe —	257
4.9.4	Mercury: Hg —	258

4.9.5	Cadmium: Cd —	260
4.9.6	Lead: Pb —	261
4.9.7	Arsenic: As —	262
4.9.8	Silicon (Si) and aluminium (Al) —	262
5	Chemical processes in the environment —	264
5.1	Chemical evolution —	266
5.1.1	Origin of elements and molecules —	267
5.1.2	Formation of the Earth —	271
5.1.3	Degassing the Earth and formation of the atmosphere —	275
5.1.4	Evolution of life and atmospheric oxygen —	282
5.1.5	Volcanism and weathering: Inorganic CO ₂ cycling —	288
5.2	Biogeochemistry and biogeochemical cycling —	291
5.2.1	General remarks —	291
5.2.2	Principles of photosynthesis —	295
5.2.3	Carbon cycle —	299
5.2.4	Nitrogen cycle —	303
5.2.5	Sulphur cycle —	308
5.3	Atmospheric chemistry and air pollution —	311
5.3.1	The ozone problem —	314
5.3.2	Atmospheric acidification —	327
5.3.3	Atmospheric removal: Deposition processes —	334
5.3.4	Radioactivity —	338
A	List of acronyms and abbreviations in environmental sciences found in the literature —	342
B	Quantities, units and some useful numerical values —	346
C	List of the elements (alphabetically) —	350
Bibliography —		353
Author index —		358
Subject index —		361