
C O N T E N T S

SECTION A THE LITHOSPHERE

Chapter 1	FOSSIL FUELS	9
1.1	Energy and Power	9
1.2	Total Energy Consumption	13
1.3	Fossil Energy	17
1.3.1	Petroleum and Gas	17
1.3.2	Oil Shale	21
1.3.3	Coal	23
1.3.4	Tar Sands	28
1.4	Resources Models	29
1.4.1	Macroscopic Approach by King Hubbert	29
1.4.2	McKelvey's Microanalytical Model	34
1.4.3	Dynamic Model of Meadows	35
1.4.4	Odum Ecological Model	38
1.5	Energy Conservation and its Chemical Perspective	40
1.5.1	Intra, Inter and Combined Fuel Conversions	41
1.5.2	Enhanced Oil Recovery (EOR) and Ultimate Oil Recovery (UOR)	42
1.5.3	Substitution Technology	43
1.5.4	Environmentally-Benign Processing (Green Process)	44
Chapter 2	ALTERNATIVE ENERGY SOURCES	51
2.1	Waste Heat	52
2.2	Plank's Law and Absorption	59
2.3	Stefan-Boltzmann Law and Emissivity	63
2.4	Solar Technology	66
2.4.1	Solar Thermal Electric Conversion	67
2.4.2	Photovoltaic Devices	72
2.5	Miscellaneous Energy Sources	78
2.5.1	Wind Power	78
2.5.2	Tidal Power	81

2.5.3	Geothermal Power	82
2.5.4	Hydrogen Fuel – “Eco-energy”	84
2.5.5	Fuel Cell	86
Chapter 3 NUCLEAR POWER		91
3.1	Radioactivity	92
3.1.1	Nuclear Binding Energy	94
3.1.2	Nuclear Reactions	94
3.1.3	Radioactive Decay	97
3.1.4	Units of Radioactivity	100
3.1.5	Natural Radiation	102
3.1.6	Nuclear Fission	105
3.1.7	Nuclear Fusion	106
3.2	Nuclear Reactors	107
3.2.1	Thermal Reactors	108
3.2.2	Breeder Reactors	110
3.3	Nuclear Fuel Cycle	111
3.3.1	Nuclear Accidents	114
3.4	Radioactive Nuclear Waste	116
3.4.1	Nuclear Waste and Waste Types	119
3.4.2	Biological Concentration of Radioactive Elements	120
3.5	Nuclear Waste Disposal and Treatment Technology	121
3.5.1	Transmutation	122
3.5.2	Polymer Extraction	124
3.5.3	Aqueous Extraction for Separation	124
 SECTION B THE ATMOSPHERE		
Chapter 4 GLOBAL ISSUES AND UPPER ATMOSPHERE		135
4.1	Greenhouse Effect	135
4.1.1	Carbon Dioxide Cycle	138
4.1.2	Global Warming and Ice Periods	141
4.2	Ozone Layer	148
4.2.1	Beer-Lambert Law and Chapman Layers	148
4.2.2	Depletion of the Ozone Layer	152
4.2.3	Fate of Halomethanes	154
4.3	Stratospheric Chemistry	157
4.3.1	Photochemistry	157
4.3.2	Term Symbols	160
4.4	Thermosphere and Ionosphere	163

Chapter 5	TROPOSPHERE: AIR POLLUTION	167
5.1	Particulates	168
5.2	Sulfur Oxides	174
5.2.1	Desulfurization	175
5.2.2	Removal of Sulfur Dioxide	178
5.2.3	Fate of Sulfur Dioxide	179
5.3	Automotive Emissions	184
5.3.1	Carbon Monoxide	185
5.3.2	Nitrogen Oxides	187
5.3.3	Photochemical Smog	194
5.3.4	Antiknocking Agents	197
5.3.5	Catalytic Converters	200
5.4	Tropospheric Chemistry	201
5.5	Meteorology Influenced by Pollution	205
5.5.1	Dispersion of Pollutants	207
5.5.2	Gaussian Model	210

SECTION C THE HYDROSPHERE

Chapter 6	WATER PROPERTIES AND GROUNDWATER	219
6.1	Chemistry of Runoff	219
6.2	Chemical Properties of Natural Waters	224
6.3	Acidity and Hardness	226
6.3.1	Hardness	226
6.3.2	Acid Rain	228
6.4	Groundwater	232
6.4.1	Aquifer	233
6.4.2	Darcy's Law and Groundwater Movement	234
6.4.3	Stream Function and Turbulent Flow	243
6.4.4	Hydrodynamic Control for Contaminant Plume	260
6.4.5	Chemical Restoration of Contaminated Aquifers	269
Chapter 7	NATURAL WATER AND POLLUTION	275
7.1	Chemical Oceanography	276
7.1.1	Oil Pollution	282
7.1.2	Tributyltin in a Marine Environment	287
7.2	Rivers and Streams	294
7.3	Chemical Limnology	301
7.4	Eutrophication	305
7.4.1	Photosynthesis and Respiration	307
7.4.2	Eutrophication and Its Control	309

Chapter 8	WATER TREATMENT	321
8.1	Water Quality Criteria	322
8.1.1	Chemistry of Dissolved Oxygen (DO)	328
8.1.2	Biochemical Oxygen Demand (BOD)	330
8.1.3	Chemical Oxygen Demand (COD)	332
8.1.4	Theoretical Oxygen Demand (ThOD) and Other Tests	333
8.2	Staged Wastewater Treatment	336
8.2.1	Primary and Intermediate Treatment	338
8.2.2	Secondary Treatment	338
8.2.3	Tertiary Treatment	340
8.2.4	Quaternary Treatment	340
8.3	Olfaction and Taste in Water	340
8.4	Industrial Wastewater	345
8.4.1	Chemical Perspective of Industrial Wastewater	345
8.4.2	Chemistry Associated with Synfuel Wastewaters	354
 SECTION D THE PEDOSPHERE		
Chapter 9	SOIL CHEMISTRY	375
9.1	Soil Formation and Soil Properties	375
9.1.1	Soil Organic Matter	382
9.1.2	Chemical and Physical Weathering	387
9.1.3	Agricultural Applications	393
9.1.4	Geotechnical Applications	397
9.1.5	Biodegradation in Soil	405
9.2	Global Soil Pollution	406
9.2.1	DDT and PCB	414
9.3	Pesticides and Stockpile Wastes	421
9.3.1	The Third Generation Insecticides	425
9.3.2	Neurotoxin and Stockpile Waste	430
Chapter 10	HAZARDOUS WASTE AND REMEDIATION	437
10.1	Solid Waste Chemistry	438
10.1.1	Recycling and Conversion	445
10.1.2	Disposal: Landfill and Leachate	452
10.2	Plastic Wastes	458
10.3	Heavy Metals	466
10.3.1	Mercury	468
10.3.2	Lead	474
10.3.3	Cadmium	477
10.4	Hazardous Waste	478
10.5	Remediation Technology	483

10.5.1	Bioaccumulation	483
10.5.2	Soil Vapor Extraction	485
10.5.3	Encapsulation and Vitrification	490
10.5.4	In-Situ and On Site Soil Remediation Methods	490
SECTION E THE BIOSPHERE		
Chapter 11	GEOCHEMICAL ASPECTS OF BIOSPHERE	501
11.1	Exosphere	501
11.2	Radioactive Dating	508
11.3	Biochemistry	510
11.3.1	Biopolymer	519
11.3.2	Chemical Evolution	526
11.3.3	Chemical Autopoiesis	532
11.4	Environmental Geochemistry	537
11.4.1	Geochemical Biomarkers	542
11.4.2	Long-Range Geochemical Cycles	549
Chapter 12	TOXICOLOGY AND RISKS	563
12.1	The Quality of Life	563
12.1.1	Optimization for the Infrastructure	566
12.2	Chemical Toxicology	569
12.2.1	Food Safety	572
12.2.2	Carcinogenesis and Mutagenesis	577
12.2.3	Radon	584
12.3	Risk Assessment and Occupational Toxicology	587
12.4	Sound, Microwave and Other Electromagnetic Exposure	591
12.4.1	Noise Pollution	593
Appendix		605
Index		613