

Table of Contents

Introduction	xii
Chemical Glossary	xvii
Chapter 1. From the Chemical Element to Solids.	1
1.1. Carbon on Earth.	1
1.2. A brief history of the chemistry of carbon	5
1.2.1. The first discoveries: fire, heat and metals.	9
1.2.2. Exploitation of mined resources	11
1.2.3. Uses of dispersed carbons	13
1.3. Presentation of carbon solids.	14
1.3.1. Comparison of natural and artificial evolution	16
1.3.2. Production and development of carbonaceous products	17
1.4. Conclusion and perspectives	18
1.5. Bibliography	19
Chapter 2. The Polymorphism of Carbon.	23
2.1. The carbon atom and its chemical bonds	24
2.1.1. Chemical bonds and solid phases	24
2.1.2. Carbon isotopes	26
2.2. A thermodynamic approach	27
2.2.1. Some reminders about phenomenological thermodynamics	27

2.2.2. Diagram of equilibrium states of carbon	28
2.3. New molecular phases	30
2.4. Non-crystalline carbons	32
2.4.1. Principal processes	33
2.4.2. Evolution and structural characterizations	35
2.4.3. Homogeneous massive carbons	40
2.4.4. Porous and dispersed carbons	42
2.5. From solids to materials	44
2.6. Bibliography	45
Chapter 3. Natural Carbons: Energy Source and Carbochemistry	47
3.1. Primary energy sources	48
3.1.1. The various forms of energy	48
3.1.2. Combustion of natural coals	53
3.1.3. Manufacturing cements	57
3.1.4. Gasification and liquefaction procedures	57
3.2. Carbochemistry	58
3.2.1. Intermediary products: coal tar and pitch	60
3.2.2. Solid primary materials: cokes and artificial graphites	63
3.3. Use of coal resources	64
3.3.1. Primary energy source	64
3.3.2. The future of carbochemistry and carbonaceous materials	67
3.4. Summation and essential points	68
3.5. Bibliography	68
Chapter 4. The Role of Carbon in Metallurgy	71
4.1. Principles and evolution of the steel industry	72
4.1.1. Industrial manufacturing for cast iron and steel	75
4.1.2. Carbons in the steel industry	77
4.2. The manufacturing of aluminum	78
4.2.1. Electrolysis tank	78
4.2.2. Carbons for the aluminum industry	79
4.3. Silicon production	80
4.3.1. Obtaining metallurgical silicon	80

4.3.2. Carbon electrodes	81
4.4. Metallic carbides	81
4.4.1. Synthesis of acetylene	82
4.4.2. Refractory carbides	82
4.5. Summary and essential points	83
4.6. Bibliography	84
Chapter 5. Black and White Ceramics	85
5.1. Graphites and isotropic carbons	86
5.1.1. Manufacturing artificial graphites	86
5.1.2. General physical properties	88
5.1.3. Glassy carbons	91
5.1.4. Major areas of application	92
5.2. Pyrocarbons and pyrographites	94
5.2.1. Pyrocarbons (Pyc) obtained via vapor-phase chemical deposit	95
5.2.2. Textural and physical characteristics	96
5.2.3. Pyrographites and analogs	99
5.3. Films of diamond	100
5.3.1. Thin layer processes	100
5.3.2. Properties and fields of application	102
5.4. Summary and essential points	103
5.5. Bibliography	104
Chapter 6. Dispersed and Porous Carbons	107
6.1. Carbon blacks	108
6.1.1. Formation mechanisms and industrial processes	108
6.1.2. Classification and characteristics	110
6.1.3. Other carbon particles	112
6.2. Shaping and fields of application	113
6.2.1. Reminder on heterogeneous media	113
6.2.2. Main domains of exploitation	116
6.3. Porous and adsorbent carbons	119
6.3.1. General definitions	119
6.3.2. Activated carbons	123
6.3.3. Purification and transport in the gaseous phase	125
6.3.4. Uses in the liquid phase	126

6.4. Summary and essential points.	128
6.5. Bibliography	129
Chapter 7. Fibers and Composites	131
7.1. Carbon filaments	132
7.1.1. Historic overview of the main families	132
7.1.2. Textural characteristics and physical properties	136
7.2. Composite materials.	139
7.2.1. Fiber-matrix interface	139
7.2.2. Main categories of composites and nanocomposites	143
7.2.3. Manufacture of carbon-carbon composites	145
7.2.4. Applications of carbon-carbon composites	148
7.3. Summary and essential points.	151
7.4. Bibliography	152
Chapter 8. Molecular Carbons and Nanocarbons	155
8.1. Synthesis and production.	156
8.1.1. Synthesis and characterization of fullerenes	156
8.1.2. Formation and identification of nanotubes	157
8.1.3. Manufacture and stabilization of graphene ribbons	160
8.2. Transport and nanoelectronic properties	162
8.2.1. Electronic transport in single-wall nanotubes and graphene ribbons.	165
8.2.2. Molecular transistors and logic circuits	166
8.2.3. Associated quantum phenomena	168
8.3. Physical chemistry of interface and sensors	169
8.3.1. Chemical functionalization of surfaces	170
8.3.2. Sensors, biosensors and actuators	173
8.3.3. Comments on biological compatibility.	175
8.4. Conclusion and prospective	176
8.5. Bibliography	176
Chapter 9. Carbon Techniques and Innovation	179
9.1. Evolution of carbon materials.	180
9.1.1. Different generations of carbonaceous materials . . .	180

Table of Contents ix

9.1.2. Classification by purpose and areas of activity	182
9.1.3. Role in energy problems	183
9.2. Socio-economic aspects	186
9.2.1. Economic assessments	186
9.2.2. Economic transitions and cycles	188
9.3. Epilogue	191
9.4. Bibliography	192
Index	195