CONTENTS

Preface		xv
Acknowled	gements	xix
	PART ONE Introduction	
1. Intro	oduction—The Canvas of Nano	3
1.1	Nano and Nature	3
1.2	Our Technologies and the World We Live in	5
1.3	Nano—The Beginning	9
	Review Questions	12
	References	12
0 T	PART TWO Experimental Methods	
	stigating and Manipulating Materials in the Nanoscale	15
2.1	Introduction	15
2.2	Electron Microscopies	20
2.3	Scanning Probe Microscopies	43
2.4	Optical Microscopies for Nanoscience and Technology	54 50
2.5	1	59
	X-Ray Diffraction Associated Techniques	75
2.7	Review Questions	81
	References	81 82
	Additional Reading	84
	Tunnionii Icanniz	04

PART THREE Diversity in Nanosystems

3.	Fullerenes		89
	3.1	Introduction	89
	3.2	Discovery and Early Years	91
	3.3	Synthesis and Purification of Fullerenes	94
	3.4	Mass Spectrometry and Ion/Molecule Reactions	95
	3.5	Chemistry of Fullerenes in the Condensed Phase	96
	3.6	Endohedral Chemistry of Fullerenes	99
	3.7	Orientational Ordering	100
	3.8	Pressure Effects	101
	3.9	Conductivity and Superconductivity in Doped Fullerenes	102
	3.10	Ferromagnetism in C_{60} .TDAE	103
	3.11	Optical Properties	103
	3.12	Some Unusual Properties	104
		Review Questions	105
		References	106
		Additional Reading	112
4.	Carb	on Nanotubes	114
	4.1	Introduction	114
	4.2	Synthesis and Purification	117
	4.3	Filling of Nanotubes	119
	4.4	Mechanism of Growth	120
	4.5	Electronic Structure	120
	4.6	Transport Properties	122
	4.7	Mechanical Properties	122
	4.8	Physical Properties	123
	4.9	Applications	123
	4.10	Nanotubes of Other Materials	124
		Review Questions	125
		References	126
		Additional Reading	127

5.	Self-	assembled Monolayers	128
	5.1	Introduction	128
	5.2	Monolayers on Gold	129
	5.3	Growth Process	138
	5.4	Phase Transitions	141
	5.5	Patterning Monolayers	142
	5.6	Mixed Monolayers	144
	5.7	SAMS and Applications	144
		Review Questions	153
		References	154
		Additional Reading	155
6.	. Gas Phase Clusters		156
	6.1	Introduction	156
	6.2	History of Cluster Science	158
	6.3	Cluster Formation	158
	6.4	Cluster Growth	161
	6.5	Detection and Analysis of Gas Phase Clusters	163
	6.6	Types of Clusters	166
	6.7	Properties of Clusters	172
	6.8	Bonding in Clusters	176
		Review Questions	177
		References	177
		Additional Reading	178
7.	Sem	iconductor Quantum Dots	179
	7.1	Introduction	179
	7.2	Synthesis of Quantum Dots	182
	7.3	Electronic Structure of Nanocrystals	187
	7.4	How Do We Study Quantum Dots?	189
	7.5	Correlation of Properties with Size	194
	7.6	Uses	195
		Review Questions	197
		References	198
		Additional Reading	198

x CONTENTS

8.	Moı	nolayer-protected Metal Nanoparticles	199
	8.1	Introduction	199
	8.2	Method of Preparation	200
	8.3	Characterization	200
	8.4	Functionalized Metal Nanoparticles	204
	8.5	Applications	206
	8.6	Superlattices	208
		Review Questions	212
		References	213
		Additional Reading	214
9.	Core	e-shell Nanoparticles	215
	9.1	Introduction	215
	9.2	Types of Systems	216
	9.3	Characterization	225
	9.4	Properties	227
	9.5	Applications	234
		Review Questions	240
		References	241
		Additional Reading	243
10.	Nan	oshells	244
	10.1	Introduction	244
	10.2	Types of Nanoshells	245
	10.3	Properties	252
	10.4	Characterization	255
	10.5	Applications	257
		Review Questions	259
		References	259
		Additional Reading	260
		D	
		PART FOUR Evolving Interfaces of Nano	
11.		obiology	263
		Introduction	263
	11.2	Interaction Between Biomolecules and Nanoparticle Surfaces	264

199

	11.3	Different Types of Inorganic Materials Used	
		for the Synthesis of Hybrid Nano-bio Assemblies	269
	11.4	Applications of Nano in Biology	271
	11.5	1	254
	11 /	in Medical Diagnosis and Biotechnology	276
		Current Status of Nanobiotechnology	278
	11.7	Future Perspectives of Nanobiology	280
		Review Questions	280
		References	281
	-	Additional Reading	282
12.	Nano	osensors	283
	12.1	Introduction	283
	12.2	What is a Sensor?	284
	12.3	Nanosensors—What Makes Them Possible?	285
	12.4	Order from Chaos—Nanoscale Organization for Sensors	285
	12.5	Characterization—To Know What has been Put In	288
	12.6	Perception—Nanosensors Based on Optical Properties	289
	12.7	Nanosensors Based on Quantum Size Effects	291
	12.8	Electrochemical Sensors	293
	12.9	Sensors Based on Physical Properties	294
	12.10	Nanobiosensors—A Step towards Real-time Imaging	
		and Understanding of Biological Events	296
	12.11	Smart Dust—Sensors of the Future	298
		Review Questions	299
		References	299
		Additional Reading	300
13.	Nano	omedicines	301
	13.1	Introduction	301
	13.2	Approach to Developing Nanomedicines	302
	13.3	Various Kinds of Nanosystems in Use	303
	13.4	Protocols for Nanodrug Administration	305
	13.5	Nanotechnology in Diagnostic Applications	307
	13.6	Materials for Use in Diagnostic and Therapeutic Applications	310
	13.7	Future Directions	312
		Reziezu Ouestions	212

xii CONTENTS

		References	313
		Additional Reading	31
14.	Mol	ecular Nanomachines	310
	14.1		310
	14.2	Covalent and Non-covalent Approaches	317
		Molecular Motors and Machines	318
		Molecular Devices	319
	14.5	Single Molecule Devices	320
		Practical Problems with Molecular Devices	327
		Review Questions	328
		References	328
		Additional Reading	329
15.	Nanotribology		330
	15.1	Introduction	330
	15.2	Studying Tribology at the Nanoscale	331
		Nanotribology Applications	337
		Outstanding Issues	341
		Review Questions	342
		References	342
		Additional Reading	343
		· ·	010
		PART FIVE	
		Society and Nano	
16.	Soci	etal Implications of Nanoscience and Nanotechnology	347
	(in E	Developing Countries)	01,
	16.1	Introduction	348
	16.2	From the First Industrial Revolution to the Nano Revolution	349
	16.3	Implications of Nanoscience and Nanotechnology on Society	351
	16.4	Issues—An Outlook	353
	16.5	Nano Policies and Institutions	358
	16.6	Nanotech and War—Nano Arms Race	360
	16.7	Public Perception and Public Involvement in the Nano Discourse	360
	16.8	Harnessing Nanotechnology for Economic and Social Development	362