TABLE OF CONTENTS

Page	
ï	Copyright; Additional Copies
iii	Dedication
iv	Foreword; Preface and Acknowledgments
Chapt	ter 1 M. F. Hochella, Jr. & A. F. White
	NERAL-WATER INTERFACE GEOCHEMISTRY: AN OVERVIEW
1	INTRODUCTION
3	THE IMPORTANCE OF MINERAL-WATER INTERFACE GEOCHEMISTRY
3	Metals in aquatic systems
4	Ore deposit formation
4 6	Sorption-concentration of ore metals
6	Hydrothermal leaching as a metal source for ore
6	Low-temperature chemical weathering
9	A REVIEW OF THIS BOOK
9	Atomistic approaches
10	Adsorption
12	Precipitation and dissolution
13	Oxidation-reduction reactions
15	ACKNOWLEDGMENTS
15	REFERENCES
Chap	oter 2 A. C. Lasaga
ATO	OMIC TREATMENT OF MINERAL-WATER SURFACE REACTIONS
17	Introduction
23	Definition and measurement of surfaces - crystal habits
26	SURFACE TOPOGRAPHY AND KINETICS
31	REACTION MECHANISMS AND TRANSITION STATE THEORY
36	Application of TST to quartz dissolution
39	AB INITIO METHODS IN MINERAL SURFACE REACTIONS
39	Ab initio theory
43	Ab initio studies of adsorption
56	Ab initio studies of mechanisms of water-rock kinetics
57	Transition state of the hydrolysis reaction
59	MOLECULAR DYNAMICS METHODS IN SURFACE STUDIES
63 70	Applications to surfaces MONTE CARLO METHODS IN SURFACE STUDIES
80	REFERENCES
Cha	
Спа	pter 3 M. F. Hochella, Jr.
	ATOMIC STRUCTURE, MICROTOPOGRAPHY, COMPOSITION, AND REACTIVITY OF MINERAL SURFACES
07	
87 97	INTRODUCTION EVENTUAL TROUBLESS TO THE PROPERTY OF THE PROPE
87 88	EXPERIMENTAL TECHNIQUES
88	Spectroscopies for determining surface composition
89	-2 · 45 protocol on specifoscopy (MI S)
90	
90	
70	surjuce unuissis by user torization (SALI)

90	Resonant ionization mass spectroscopy (RIMS)
90	Rutherford backscattering (RBS)
92	Resonant nuclear reaction (RNR) analysis
92	Scanning tunneling spectroscopy (STS)
93	Microscopies for determining surface microtopography
93	Optical methods
94	Scanning electron microscopy (SEM)
94	Transmission electron microscopy (TEM)
94	Scanning tunneling microscopy (STM)
95	Atomic force microscopy (AFM)
95	Tools for determining surface structure
95	Low energy electron diffraction (LEED)
96	Scanning tunneling microscopy (STM)
96	Atomic force microscopy (AFM)
97	MINERAL SURFACE COMPOSITION
97	Adventitious modification of mineral surfaces
98	Geochemically modified mineral surface compositions
98	Sorption modification
99	Detachment modification
99	Redox modification
101	Compositional inhomogeneities
103	MINERAL SURFACE MICROTOPOGRAPHY
103	Microtopography models Growth surfaces
103	
105 105	Cleavage surfaces Dissolution surfaces
103	MINERAL SURFACE ATOMIC STRUCTURE
108	General description of surface atomic structure
108	Surface structures in vacuum
109	Adsorption-induced surface structural modification
109	Structure of various mineral surfaces
111	Galena {001}
111	Hematite {001}
113	Rutile {110}
113	Olivine {010}
113	Albite {010}
116	Calcite {101}
116	REACTIVITY OF SURFACES
116	Some general concepts concerning surface reaction
116	The two-dimensional phase approximation
117	Heterogeneous (surface) catalysis
117	Examples of the effect of surface microtopography on reactivity
117	Carbon monoxide dissociation on Pt
117	Ethylene decomposition on various metals
119	Adsorption of gases on metals
119	Dissolution of minerals
120	²³⁵ U sorption on sheet silicates
120	Examples of the effect of surface composition on reactivity
120	Bonding modifiers on the surfaces of catalysts
121	Dissolution rates across the plagioclase series
122	Examples of the effect of surface atomic structure on reactivity
122	Catalytic reactions on single crystal melts
122	Mineral and glass dissolution reactions
123 123	Sorption reactions on minerals
126	Surface reactivity observed atom by atom CONCLUSIONS
128	ACKNOWLEDGMENTS
128	REFERENCES
120	NETERENCES

Chapter 4 G. A. Parks

SURFACE ENERGY AND ADSORPTION AT MINERAL/WATER INTERFACES: AN INTRODUCTION

133	INTRODUCTION
133	PARTICLE SIZE, SHAPE, AND SURFACE AREA
135	THERMODYNAMICS
135	Surface free energy
135	Gibbs' definition of surface excess properties: the dividing surface
137	Contribution of surfaces and interfaces to thermodynamic criteria of
151	equilibrium
137	The Laplace (or Young-Laplace) equation: Curved surfaces imply a
131	
120	pressure gradient
138	The Kelvin effect: Equilibrium constants depend on A _s
139	The Kelvin equation and vapor pressures
140	The Freundlich-Ostwald equation
141	The Gibbs equation: Adsorption reduces surface free energy
142	REACTIONS WITH WATER
142	Fracture surfaces
142	Hydroxylation
142	High field gradients enhance dissociation of electrolytes
143	Hydration
146	Immersion, surface ionization, and electrified interfaces
147	Surface charge
147	Origins of charge
149	Electrified interfaces
150	SORPTION: REACTIONS WITH AQUEOUS SOLUTES
150	pH and ionic strength dependence
152	Non-specific or physical adsorption
152	Concentration dependence
153	Specific or chemical adsorption
154	Concentration dependence
157	Hydrolysis, polymerization, and precipitation
158	Competition and synergism between adsorbate and complexing
130	
158	ligands Identifying counting reactions. Class to the composition and
130	Identifying sorption reactions: Clues to the composition and
159	structure of surface complexes
162	Surface charge
	Proton stoichiometry
162	The last analysis
163	SURFACE AND INTERFACIAL FREE ENERGIES OF QUARTZ
163	Fracture surface energy
165	APPLICATIONS
165	Fracture and crack propagation
167	Ostwald ripening and the Ostwald step rule
168	Earthquake prediction
169	ACKNOWLEDGMENTS
169	REFERENCES
Ch.	
Cnaj	oter 5 J. A. Davis and D. B. Kent
	SURFACE COMPLEXATION MODELING IN AQUEOUS

GEOCHEMISTRY

Surface functional groups and mineral types
Oxides and aluminosilicates without permanent charge

177

178

178 179 INTRODUCTION

SURFACE FUNCTIONAL GROUPS

179	Types of surface hydroxyl groups
179	Density of surface hydroxyl groups
183	Site density determined by adsorption
184	Organic matter
184	Minerals with permanent structural charge
184	Phyllosilicate minerals
185	Kaolinite
185	Smectites, vermiculites, and illitic micas
187	Manganese oxides
187	Carbonate minerals
188	Sulfide minerals
189	SURFACE AREA AND POROSITY
189	Physical methods
190	Gas adsorption
190	Adsorption isotherms on minerals
192	BET analysis
192	Problems caused by microporosity
193	Low surface area materials
193	Evaluation of microporosity
195	Surface area of clay minerals and soils
197	ADSORPTION OF IONS AT HYDROUS OXIDE SURFACES IN WATER
197	Adsorption of cations
199	Adsorption of anions
199	Surface site heterogeneity and competitive adsorption of ions
202	Kinetics of sorption reactions
203	
	Reversibility of sorption processes
204	Effect of solution speciation on ion adsorption
204	Adsorption of hydrophobic molecules
204	THE ELECTRIFIED MINERAL-WATER INTERFACE
204	Definition of mineral surface charge
205	Classical electrical double layer models
206	The electrical double layer at oxide surfaces
206	The Nernst equation and proton surface charge
209	The zero surface charge condition
211	Zeta potential
212	
	Early developments of surface coordination theory
213	MODELS FOR ADSORPTION-DESORPTION EQUILIBRIUM
213	Empirical adsorption models
214	Distribution coefficients
214	Langmuir isotherm
215	Freundlich and other isotherms
215	General partitioning equation
217	Surface complexation models
218	Properties of solvent water at the interface
218	
	Surface acidity of hydrous oxides
219	Surface coordination reactions
219	The Constant Capacitance Model (CCM)
220	The Diffuse Double Layer Model (DDLM)
222	Triple Layer Model (TLM)
225	Four layer models
225	The non-electrostatic surface complexation model
225	Proton stoichiometry in surface complexation reactions
226	
	Parameter estimation
228	Comparison of the performance of surface complexation models
230	APPLICATIONS IN AQUEOUS GEOCHEMISTRY
231	Surface area and functional groups of soils and sediments
233	Observations of sorption phenomena in complex mineral-water systems
233	Effect of aqueous composition
	zyjeer of aqueeus composition

Char	G. Sposit MOLECULAR MODELS OF ION ADSORPTION
	REFERENCES
247	Adsorption from solution
247	t - and α_s plots
246 247	Sample drying
246 246	Gas adsorption
246 246	APPENDIX A. DETAILS OF SURFACE AREA MEASUREMENT
245	LIST OF TERMS AND SYMBOLS
245	ACKNOWLEDGMENTS
243	CONCLUDING REMARKS
0.40	materials
242	Guidelines for surface complexation modeling with natural composite
	materials
240	SCM modeling to dominant adsorptive components of composite
240	Modeling with electrical double layer corrections
239	Modeling with the non-electrostatic SCM
239	Use of surface complexation models with soils and sediments
238	Modeling based on the partitioning equation
237	Distribution coefficients
237	Use of empirical adsorption models for soils and sediments
236	The electrical double layer of soils and sediments
230	materials
236	Special problems in sorption experiments with natural composite
235	materials Interactive effects of mineral phases
234	Identification of dominant sorptive mineral components in composite

INTRODUCTION
DIFFUSE DOUBLE LAYER MODELS
Modified Gouy-Chapman theory
Accuracy of MGC theory
Counterion condensation
SURFACE COORDINATION MODELS
Types of surface coordination
The Bragg-Williams approximation
Surface complexation equilibria
APPLICATIONS
Proton adsorption
Metal cation adsorption
Coion exclusion
CONCLUDING REMARKS
ACKNOWLEDGMENTS
REFERENCES

Chapter 7

P. W. Schindle

CO-ADSORPTION OF METAL IONS AND ORGANIC LIGANDS: FORMATION OF TERNARY SURFACE COMPLEXES

281	INTRODUCTION
282	Adsorption of organic compounds
282	Hydrophobic expulsion
283	Electrostatic attraction

285	Surface complexation
286	Adsorption of metal ions
286	Electrostatic attraction
287	How to distinguish between inner sphere and outer sphere
201	· •
200	complexes
288	Co-adsorption of metal ions and organic ligands
289	THERMODYNAMIC STABILITY
289	Conditional and intrinsic constants
291	Evaluating intrinsic stability constants
291	Studies at low surface coverage
291	Extrapolation techniques
292	Double layer techniques
	Sability of the same and the sa
292	Stability constants of ternary surface complexes
292	Definitions
293	Predictions from statistics
296	Experimental results
298	Charge effects
298	Ternary surface complexes with π-acceptor ligands
299	SPECTROSCOPY
299	Methods
300	Results
300	THE ROLE OF TERNARY SURFACE COMPLEXES IN NATURE AND TECHNOLOGY
300	Effect of organic ligands upon the fate of trace metals in aquatic
	environments
302	The structure of the clay-organic interface
304	Ternary surface complexes in froth flotation
304	Ternary surface complexes in heterogeneous redox reactions
305	ACKNOWLEDGMENTS
305	REFERENCES
303	REFERENCES
Chap	ter 8 Gordon E. Brown, Jr.
Chap	
Chap	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION
Chap	ter 8 Gordon E. Brown, Jr.
Chap	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES
Chap	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW
Chap 309 310	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption
Chap	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction
Chap 309 310	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption
309 310 311	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms
309 310 311 313	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces
309 310 311	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL
309 310 311 313 319	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES
309 310 311 313 319 320	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS)
309 310 311 313 319 320 324	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra
309 310 311 313 319 320 324 328	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra
309 310 311 313 319 320 324 328 328	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra
309 310 311 313 319 320 324 328	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra
309 310 311 313 319 320 324 328 328 329	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra
309 310 311 313 319 320 324 328 328 329 333	ter 8 Gordon E. Brown, Jr. SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications
309 310 311 313 319 320 324 328 328 329 333 333	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies
309 310 311 313 319 320 324 328 329 333 333 333	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies FTIR and Raman spectroscopy
309 310 311 313 319 320 324 328 329 333 333 335 335	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies FTIR and Raman spectroscopy Mössbauer spectroscopy
309 310 311 313 319 320 324 328 329 333 333 333	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies FTIR and Raman spectroscopy Mössbauer spectroscopy XAS STUDIES OF CHEMISORPTION REACTION MECHANISMS AT SOLID/LIQUID
309 310 311 313 319 320 324 328 329 333 335 335 336	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies FTIR and Raman spectroscopy Mössbauer spectroscopy
309 310 311 313 319 320 324 328 329 333 333 335 335	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies FTIR and Raman spectroscopy Mössbauer spectroscopy XAS STUDIES OF CHEMISORPTION REACTION MECHANISMS AT SOLID/LIQUID INTERFACES
309 310 311 313 319 320 324 328 328 329 333 335 335 335 336	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES Introduction and Overview Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces Overview of Structural Methods Providing Molecular-level Information About Chemisorbed Species X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies FTIR and Raman spectroscopy Mössbauer spectroscopy XAS STUDIES OF CHEMISORPTION REACTION MECHANISMS AT SOLID/LIQUID INTERFACES Co(II) on γ-Al ₂ O ₃ and TiO ₂ (rutile)
309 310 311 313 319 320 324 328 328 329 333 335 335 335 336	SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES INTRODUCTION AND OVERVIEW Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces OVERVIEW OF STRUCTURAL METHODS PROVIDING MOLECULAR-LEVEL INFORMATION ABOUT CHEMISORBED SPECIES X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies FTIR and Raman spectroscopy Mössbauer spectroscopy XAS STUDIES OF CHEMISORPTION REACTION MECHANISMS AT SOLID/LIQUID INTERFACES CO(II) on γ-Al ₂ O ₃ and TiO ₂ (rutile) Co(II) on kaolinite and α-SiO ₂ (quartz)
309 310 311 313 319 320 324 328 328 329 333 335 335 335 336	ter 8 SPECTROSCOPIC STUDIES OF CHEMISORPTION REACTION MECHANISMS AT OXIDE-WATER INTERFACES Introduction and Overview Chemisorption versus physiosorption The need for molecular-level information about chemisorption reaction mechanisms The structure of "clean" and "real" surfaces Overview of Structural Methods Providing Molecular-level Information About Chemisorbed Species X-ray absorption spectroscopy (XAS) Production of x-ray absorption spectra XANES and pre-edge spectra EXAFS spectra Analysis of EXAFS spectra Other in situ spectroscopic methods and selected applications Magnetic resonance spectroscopies FTIR and Raman spectroscopy Mössbauer spectroscopy XAS STUDIES OF CHEMISORPTION REACTION MECHANISMS AT SOLID/LIQUID INTERFACES Co(II) on γ-Al ₂ O ₃ and TiO ₂ (rutile)

.

Other XAS studies of sorption complexes at solid/water or solid interfaces SEXAFS STUDIES OF MOLECULAR CHEMISORPTION AT SOLID/VACULATER ACES CONCLUSIONS AND OUTLOOK ACKNOWLEDGMENTS REFERENCES	43	$Np(V)$ on α -FeOOH and $U(VI)$ on ferric oxide-hydroxide gels
interfaces SEXAFS STUDIES OF MOLECULAR CHEMISORPTION AT SOLID/VACUINTERFACES 352 CONCLUSIONS AND OUTLOOK 353 ACKNOWLEDGMENTS 353 REFERENCES Chapter 9 JW. Zhang & G. H	47	Se oxyanions on α-FeOOH
SEXAFS STUDIES OF MOLECULAR CHEMISORPTION AT SOLID/VACUINTERFACES CONCLUSIONS AND OUTLOOK ACKNOWLEDGMENTS REFERENCES Chapter 9 JW. Zhang & G. H MECHANISMS OF GROWTH AND DISSOLUTION OF SPARINGLY SOLUBLE SALTS INTRODUCTION THE DRIVING FORCES FOR GROWTH AND DISSOLUTION Definition Calculation NUCLEATION THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS Instrumentation for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination STORM ACKNOWLEDGMENT ACKNOWLEDGMENT	47	Other XAS studies of sorption complexes at solid/water or solid/air
INTERFACES CONCLUSIONS AND OUTLOOK ACKNOWLEDGMENTS REFERENCES Chapter 9 JW. Zhang & G. H MECHANISMS OF GROWTH AND DISSOLUTION OF SPARINGLY SOLUBLE SALTS INTRODUCTION 365 THE DRIVING FORCES FOR GROWTH AND DISSOLUTION Definition Calculation NUCLEATION 372 THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration 376 Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium carbonate ACKNOWLEDDMENT		interfaces
352 CONCLUSIONS AND OUTLOOK 353 ACKNOWLEDGMENTS 353 REFERENCES Chapter 9 JW. Zhang & G. H MECHANISMS OF GROWTH AND DISSOLUTION OF SPARINGLY SOLUBLE SALTS 365 INTRODUCTION 365 THE DRIVING FORCES FOR GROWTH AND DISSOLUTION 366 Definition 367 Definition 368 Calculation 369 NUCLEATION 372 THE CRYSTAL-SOLUTION INTERFACE 372 Kink densities 372 Steps from surface nucleation 373 Steps from screw dislocations 375 CRYSTAL GROWTH RATE LAWS 375 Volume diffusion 376 Adsorption and surface diffusion 377 Surface nucleation 378 Combined mechanisms 379 CRYSTAL DISSOLUTION RATE LAWS 379 INFLUENCE OF ADDITIVES ON THE RATES 380 Inactivation of kink sites 381 Reduction of the concentration of growth units on a terr 382 Experimental approaches 383 Free drift method 384 Ocentionstatic method 385 Constant composition method 386 Titrant composition for CC experiments 387 Systems involving acid or base addition 388 Instrumentation for CC method 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 CALCium phosphate 380 Alkaline earth fluoride 381 Calcium phosphate 382 ACKNOWLEDGMENT	348 S	SEXAFS STUDIES OF MOLECULAR CHEMISORPTION AT SOLID/VACUUM
Chapter 9 JW. Zhang & G. H MECHANISMS OF GROWTH AND DISSOLUTION OF SPARINGLY SOLUBLE SALTS 365 INTRODUCTION 365 THE DRIVING FORCES FOR GROWTH AND DISSOLUTION Definition Calculation NUCLEATION 372 THE CRYSTAL-SOLUTION INTERFACE Kink densities 373 Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination SEPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Chapter 9 JW. Zhang & G. H MECHANISMS OF GROWTH AND DISSOLUTION OF SPARINGLY SOLUBLE SALTS 365 INTRODUCTION 365 THE DRIVING FORCES FOR GROWTH AND DISSOLUTION 366 Definition 367 ORIGINATION 372 THE CRYSTAL-SOLUTION INTERFACE Kink densities 373 Steps from surface nucleation 374 Steps from screw dislocations 375 CRYSTAL GROWTH RATE LAWS Volume diffusion 376 Adsorption and surface diffusion 377 Surface nucleation 378 CRYSTAL DISSOLUTION RATE LAWS 379 INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT	352 C	CONCLUSIONS AND OUTLOOK
Chapter 9 MECHANISMS OF GROWTH AND DISSOLUTION OF SPARINGLY SOLUBLE SALTS 365 INTRODUCTION 365 THE DRIVING FORCES FOR GROWTH AND DISSOLUTION OEfinition 368 Calculation 369 NUCLEATION 372 THE CRYSTAL-SOLUTION INTERFACE 372 Kink densities 372 Steps from surface nucleation 373 Steps from surface nucleation 375 CRYSTAL GROWTH RATE LAWS 375 Volume diffusion 376 Integration 377 Surface nucleation 378 Combined mechanisms 379 CRYSTAL DISSOLUTION RATE LAWS 379 Inhibitory effect of additives Inactivation of kink sites Retardation of kink sites Retardation of the concentration of growth units on a terr 381 381 Dual effects of additives 382 EXPERIMENTAL METHODS 382 EXPERIMENTAL METHODS 383 Systems involving supporting electrolytes 384 Systems involving supporting electrolytes 385 Systems involving supporting electrolytes 386 Systems involving acid or base addition Instrumentation for CC experiments 387 Systems involving acid or base addition Instrumentation for CC method Rate determination 387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT	353 A	ACKNOWLEDGMENTS
MECHANISMS OF GROWTH AND DISSOLUTION OF SPARINGLY SOLUBLE SALTS 365 INTRODUCTION 365 THE DRIVING FORCES FOR GROWTH AND DISSOLUTION 366 Calculation 367 THE CRYSTAL-SOLUTION INTERFACE 372 Steps from surface nucleation 373 Steps from screw dislocations 375 CRYSTAL GROWTH RATE LAWS 375 Volume diffusion 376 Adsorption and surface diffusion Integration 377 Surface nucleation 378 CRYSTAL DISSOLUTION RATE LAWS 379 INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives 380 380 Retardation of step movement Reduction of the concentration of growth units on a terr 381 381 382 Retardation of step movement Reduction of the concentration of growth units on a terr 382 EXPERIMENTAL METHODS 382 EXPERIMENTAL METHODS 383 Systems involving supporting electrolytes 384 Systems involving supporting electrolytes 385 Systems involving supporting electrolytes 385 Systems involving acid or base addition Instrumentation for CC method Rate determination 387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate ACKNOWLEDGMENT	353 R	REFERENCES
MECHANISMS OF GROWTH AND DISSOLUTION OF SPARINGLY SOLUBLE SALTS 365 INTRODUCTION 365 THE DRIVING FORCES FOR GROWTH AND DISSOLUTION 366 Calculation 367 THE CRYSTAL-SOLUTION INTERFACE 372 Steps from surface nucleation 373 Steps from screw dislocations 375 CRYSTAL GROWTH RATE LAWS 375 Volume diffusion 376 Adsorption and surface diffusion Integration 377 Surface nucleation 378 CRYSTAL DISSOLUTION RATE LAWS 379 INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives 380 380 Retardation of step movement Reduction of the concentration of growth units on a terr 381 381 382 Retardation of step movement Reduction of the concentration of growth units on a terr 382 EXPERIMENTAL METHODS 382 EXPERIMENTAL METHODS 383 Systems involving supporting electrolytes 384 Systems involving supporting electrolytes 385 Systems involving supporting electrolytes 385 Systems involving acid or base addition Instrumentation for CC method Rate determination 387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate ACKNOWLEDGMENT		
INTRODUCTION THE DRIVING FORCES FOR GROWTH AND DISSOLUTION Definition Calculation NUCLEATION THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from surface nucleation Steps from surface diffusion CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT	Chapter	r 9 JW. Zhang & G. H. Nancollas
INTRODUCTION THE DRIVING FORCES FOR GROWTH AND DISSOLUTION Definition Calculation NUCLEATION THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from surface nucleation Steps from surface diffusion CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT	-	MECHANISMS OF GROWTH AND DISSOLUTION
THE DRIVING FORCES FOR GROWTH AND DISSOLUTION Definition Calculation NUCLEATION THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
THE DRIVING FORCES FOR GROWTH AND DISSOLUTION Definition Calculation NUCLEATION THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT	265 T	(NITROD) ICTION
Definition Calculation NUCLEATION THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Calculation NUCLEATION THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from surface nucleation CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
NUCLEATION THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
THE CRYSTAL-SOLUTION INTERFACE Kink densities Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Steps from surface nucleation Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate		
Steps from screw dislocations CRYSTAL GROWTH RATE LAWS Volume diffusion Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate		
75 CRYSTAL GROWTH RATE LAWS 75 Volume diffusion 76 Adsorption and surface diffusion 77 Integration 78 Combined mechanisms 79 CRYSTAL DISSOLUTION RATE LAWS 79 INFLUENCE OF ADDITIVES ON THE RATES 79 Inhibitory effect of additives 78		
375 Volume diffusion 376 Adsorption and surface diffusion 377 Surface nucleation 378 Combined mechanisms 379 CRYSTAL DISSOLUTION RATE LAWS 379 INFLUENCE OF ADDITIVES ON THE RATES 380 Inactivation of kink sites 380 Retardation of step movement 381 Reduction of the concentration of growth units on a terr 382 EXPERIMENTAL METHODS 382 Experimental approaches 382 Free drift method 383 Potentiostatic method 384 Constant composition method 385 Systems containing only lattice ions 386 Systems involving supporting electrolytes 387 Systems involving acid or base addition 388 Instrumentation for CC method 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 380 Calcium phosphate 381 Adsaline earth fluoride 382 Calcium carbonate 383 CAKNOWLEDGMENT		
Adsorption and surface diffusion Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Integration Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Surface nucleation Combined mechanisms CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Constant composition method Titrant composition for CC experiments Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
CRYSTAL DISSOLUTION RATE LAWS INFLUENCE OF ADDITIVES ON THE RATES Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Bull effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Constant composition method Titrant composition for CC experiments Systems containing only lattice ions Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
279 CRYSTAL DISSOLUTION RATE LAWS 279 INFLUENCE OF ADDITIVES ON THE RATES 279 Inhibitory effect of additives 280 Inactivation of kink sites 280 Retardation of step movement 281 Reduction of the concentration of growth units on a terr 282 EXPERIMENTAL METHODS 282 Experimental approaches 282 Free drift method 282 Potentiostatic method 283 Titrant composition for CC experiments 283 Systems containing only lattice ions 284 Systems involving supporting electrolytes 285 Systems involving acid or base addition 286 Instrumentation for CC method 287 Rate determination 288 GROWTH AND DISSOLUTION OF REACTION MECHANISMS 289 Calcium phosphate 290 ACKNOWLEDGMENT		
Influence of Additives Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS Titrant composition method Constant composition method Titrant composition for CC experiments Systems containing only lattice ions Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Inhibitory effect of additives Inactivation of kink sites Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS Instrumental approaches Potentiostatic method Constant composition method Titrant composition for CC experiments Systems containing only lattice ions Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
380 380 380 381 381 Retardation of step movement 381 Reduction of the concentration of growth units on a terr 381 382 EXPERIMENTAL METHODS 382 Experimental approaches 382 Free drift method 382 Potentiostatic method 383 Titrant composition for CC experiments 383 Systems containing only lattice ions 384 Systems involving supporting electrolytes 384 Systems involving acid or base addition 385 Instrumentation for CC method 387 Rate determination 388 GROWTH AND DISSOLUTION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 380 Calcium phosphate Alkaline earth fluoride Calcium carbonate 392 ACKNOWLEDGMENT		
Retardation of step movement Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL Constant composition method Titrant composition for CC experiments Systems containing only lattice ions Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Reduction of the concentration of growth units on a terr Dual effects of additives EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL METHODS EXPERIMENTAL Composition method Constant composition method Systems containing only lattice ions Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
Dual effects of additives EXPERIMENTAL METHODS Experimental approaches Free drift method Potentiostatic method Constant composition method Titrant composition for CC experiments Systems containing only lattice ions Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		
282 EXPERIMENTAL METHODS 282 Experimental approaches 282 Free drift method 283 Potentiostatic method 284 Constant composition method 285 Systems containing only lattice ions 286 Systems involving supporting electrolytes 287 Systems involving acid or base addition 288 Systems involving acid or base addition 289 Instrumentation for CC method 280 Rate determination 280 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 281 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 282 Calcium phosphate 283 Alkaline earth fluoride 284 Calcium carbonate 285 CACKNOWLEDGMENT		
382 Experimental approaches 382 Free drift method 382 Potentiostatic method 383 Titrant composition for CC experiments 384 Systems containing only lattice ions 384 Systems involving supporting electrolytes 384 Systems involving acid or base addition 385 Instrumentation for CC method 386 Rate determination 387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride Calcium carbonate 392 ACKNOWLEDGMENT		
382 Free drift method 382 Potentiostatic method 383 Titrant composition for CC experiments 383 Systems containing only lattice ions 384 Systems involving supporting electrolytes 385 Instrumentation for CC method 387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride 392 Calcium carbonate 392 ACKNOWLEDGMENT		
382 Potentiostatic method 383 Constant composition method 383 Titrant composition for CC experiments 384 Systems containing only lattice ions 384 Systems involving supporting electrolytes 385 Instrumentation for CC method 387 Rate determination 387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride 392 Calcium carbonate 392 ACKNOWLEDGMENT	382	
382 Constant composition method 383 Titrant composition for CC experiments 384 Systems containing only lattice ions 384 Systems involving supporting electrolytes 385 Instrumentation for CC method 387 Rate determination 387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride 392 Calcium carbonate 392 ACKNOWLEDGMENT	382	
383 383 384 384 384 384 384 385 386 387 387 387 387 388 389 389 389 389 391 392 392 392 392 Titrant composition for CC experiments Systems containing only lattice ions Systems involving supporting electrolytes Systems involving acid or base addition Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT	382	
384 384 384 385 385 387 387 387 388 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride Calcium carbonate 392 ACKNOWLEDGMENT	383	
384 385 385 Instrumentation for CC method 387 Rate determination 388 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride Calcium carbonate 392 ACKNOWLEDGMENT		Systems containing only lattice ions
Instrumentation for CC method Rate determination EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS Calcium phosphate Alkaline earth fluoride Calcium carbonate ACKNOWLEDGMENT		Systems involving supporting electrolytes
387 Rate determination 387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride 392 Calcium carbonate 392 ACKNOWLEDGMENT		
387 EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS 389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride 392 Calcium carbonate 392 ACKNOWLEDGMENT		
389 GROWTH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS 389 Calcium phosphate 391 Alkaline earth fluoride 392 Calcium carbonate 392 ACKNOWLEDGMENT		
389 Calcium phosphate 391 Alkaline earth fluoride 392 Calcium carbonate 392 ACKNOWLEDGMENT		EXPERIMENTAL DETERMINATION OF REACTION MECHANISMS
391 Alkaline earth fluoride 392 Calcium carbonate 392 ACKNOWLEDGMENT		ORUW IH AND DISSOLUTION OF SOME ALKALINE EARTH SALTS
392 Calcium carbonate 392 ACKNOWLEDGMENT		
392 ACKNOWLEDGMENT		
~~~ Augustus		
		A SALAN TOLIN

## Chapter 10

INTRODUCTION

397

398

445

**CASE STUDIES** 

### W. H. Casey & B. Bunker

# LEACHING OF MINERAL AND GLASS SURFACES DURING DISSOLUTION

THE STRUCTURE OF MIXED-OXIDE MINERALS AND GLASSES

399	The simplified structure of oxide minerals and glasses
3//	Reactive and unreactive sites in a structure
404	The effect of temperature
404	GENERAL REACTION MECHANISMS
405	Hydration
407	Ion-exchange reactions
408	Hydrolysis reactions
412	The pH-dependence of leaching rates
414	EXAMPLES
414	Phosphate oxynitride glass
416	Plagioclase
417	Beryl
419	PROPERTIES OF THE LEACHED LAYER
419	Changes in cation coordination with leaching
421	Repolymerization of hydroxyl groups subsequent to leaching
421	Crazing and spallation of the leached layer
423	Chemisorption in the leaching layer
423	CONCLUSIONS
424	ACKNOWLEDGMENTS
424	REFERENCES
Chap	ter 11 J. G. Hering & W. Stumm
_	•
•	OXIDATION AND REDUCTIVE DISSOLUTION OF MINERALS
427	INTRODUCTION
427 428	
427 428 428	INTRODUCTION Objectives BACKGROUND
427 428	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems
427 428 428 428	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species
427 428 428 428 428	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants
427 428 428 428 428 428 431	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota
427 428 428 428 428 431 434	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals
427 428 428 428 428 431 434 434	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on
427 428 428 428 428 431 434 434 434 434	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on surface structure
427 428 428 428 428 431 434 434 434	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on surface structure Surface-controlled dissolution kinetics and the surface complexation
427 428 428 428 428 431 434 434 434 434 435	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on surface structure Surface-controlled dissolution kinetics and the surface complexation model
427 428 428 428 428 431 434 434 434 434 434 437	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on surface structure Surface-controlled dissolution kinetics and the surface complexation model Reactivity of surface species and redox reactions at mineral surfaces
427 428 428 428 428 431 434 434 434 434 435 437 439	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on surface structure Surface-controlled dissolution kinetics and the surface complexation model Reactivity of surface species and redox reactions at mineral surfaces Application of surface complexation model to surface-controlled dissolution: model assumptions
427 428 428 428 428 431 434 434 434 434 434 437	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on surface structure Surface-controlled dissolution kinetics and the surface complexation model Reactivity of surface species and redox reactions at mineral surfaces Application of surface complexation model to surface-controlled
427 428 428 428 428 431 434 434 434 434 435 437 439	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on surface structure Surface-controlled dissolution kinetics and the surface complexation model Reactivity of surface species and redox reactions at mineral surfaces Application of surface complexation model to surface-controlled dissolution: model assumptions Application of the surface complexation model: a generalized rate law for dissolution Application of the surface complexation model: a descriptive
427 428 428 428 428 431 434 434 434 434 435 437 439	INTRODUCTION Objectives BACKGROUND Redox processes in natural systems Major redox couples and the distribution of redox-active species Specific reductants and oxidants Role of the biota Reductive and oxidative dissolution of minerals Some theoretical background Dependence of the rate of surface-controlled mineral dissolution on surface structure Surface-controlled dissolution kinetics and the surface complexation model Reactivity of surface species and redox reactions at mineral surfaces Application of surface complexation model to surface-controlled dissolution: model assumptions Application of the surface complexation model: a generalized rate law for dissolution

445	Reductive dissolution of iron oxides
445	Reaction with a reductant
447	Reaction with a reduced metal and a ligand
449	Reaction with a (non-metal) reductant and a ligand
452	Reductive dissolution of manganese oxides
452	Oxidative dissolution of pyrite
453	Oxidative dissolution of uranium(IV) oxides
453	Oxidative dissolution of iron (II) silicates
454	DISCUSSION
454	Applicability and limitations of the surface complexation model
454	Laboratory studies
454	Applicability to field observations
455	Dissolution and its reverse: precipitation
456	Some geochemical implications
458	Concluding Remarks
459	ACKNOWLEDGMENTS
459	REFERENCES
Chap	ter 12 A. F. White
HET	FEROGENEOUS ELECTROCHEMICAL REACTIONS ASSOCIATED
	TH OXIDATION OF FERROUS OXIDE AND SILICATE SURFACES
467	INTRODUCTION
469	SOLID STATE ELECTROCHEMISTRY
471	OXIDATION OF FERROUS-CONTAINING OXIDES
472	Solid state electron transfer
472	Solid state oxidation
473	Oxide electrode processes
480	Heterogeneous redox reactions
480	Reductive dissolution involving transition metals
482	Oxidative electron transfer
483	OXIDATION OF FERROUS ORTHO- AND CHAIN SILICATES
484	Solid state electron transfer
485	Solid state oxidation
487	Dissolution processes
487	Coupled electron-cation transport
489	Dissolved oxygen reduction
491	Actinide reduction on olivine and basalt
491	Nitrate reduction
493	OXIDATION OF MICAS
494 495	Oxidation of structural Fe
493 496	Dissolution
498	Heterogeneous redox reactions
498 498	Reduction of transition metals
500	Reduction of organics
500	OXIDATION OF CLAY MINERALS
501	Structural oxidation
501	Dissolution Heterogeneous and various services
501	Heterogeneous reduction reactions
503	Reduction of transition metals CONCLUSIONS
505	ACKNOWLEDGMENTS
505	REFERENCES
505	الزملية ومهدومه

Chap	G. M. Bancroft & M. M. Hyland SPECTROSCOPIC STUDIES OF ADSORPTION/REDUCTION REACTIONS OF AQUEOUS METAL COMPLEXES ON SULPHIDE SURFACES
511	Introduction
513	BRIEF REVIEW OF LABORATORY STUDIES
514	SURFACE STUDIES OF METAL COMPLEX/SULPHIDE SYSTEMS
514	An introduction to X-ray photoelectron spectroscopy (XPS)
520	An introduction to Auger electron spectroscopy (AES) and a comparison of techniques
522	The chemistry of the surface from XPS and Raman spectroscopies
535	Spatial distribution of metal species from SEM and Auger studies
542	Other techniques for obtaining surface information
546	Summary of mechanisms
552	GEOCHEMICAL IMPLICATIONS OF THE LABORATORY STUDIES
552	The nature of Au in natural sulphides from SEM, SIMS, and Mössbauer studies
555	ACKNOWLEDGMENTS
555	REFERENCES
Chap	oter 14 T. D. Waite
PHO	OTO-REDOX PROCESSES AT THE MINERAL-WATER INTERFACE
559	Introduction
560	PHOTO-REDOX PROCESSES INVOLVING ABSORPTION BY MINERALS
560	Electronic structure and optical properties of minerals
560	Molecular orbital theory
563	Band theory
566	Semiconducting minerals

559	INTRODUCTION
560	PHOTO-REDOX PROCESSES INVOLVING ABSORPTION BY MINERALS
560	Electronic structure and optical properties of minerals
560	Molecular orbital theory
563	Band theory
566	Semiconducting minerals
568	Effects of illumination
568	Charge carrier mobility
569	Interfacial electron transfer
569	Surface states
571	Space charge layer, band bending and electron transfer
576	Factors influencing semiconductor reactivity
576	Morphology
577	Size
579	Substitutional doping
579	Surface modification
580	Attachment to supports
580	Intercalation of foreign species into semiconductors
581	Applications of geochemical significance
581	Photodissolution of semiconducting minerals
584	Hydrogen peroxide production
586	Degradation of organic and inorganic pollutants
587	PHOTO-REDOX PROCESSES INVOLVING INTERFACIAL CHARGE TRANSFER TO
	THE MINERAL SUBSTRATE
587	Charge injection into semiconductors
588	Charge transfer via adsorbed chromophores
589	Charge transfer via photoactive surface complexes

590	PHOTO-REDOX PROCESSES INVOLVING CHROMOPHORES ADSORBED ON OR
	INCORPORATED IN MINERAL SUBSTRATES
591	Photoprocesses of chromophores adsorbed to silica and clay surfaces
591	Photoprocesses on particulate silica and silica gel
593	Photoprocesses on clay minerals
593	Photoprocesses in zeolites
593	General features of zeolites
594	Photochemistry of inorganic ions exchanged into zeolites
595	Photochemistry of organic molecules in zeolites
595	CONCLUSIONS
597	REFERENCES