

CONTENTS

	Page
1. Introduction	1
2. Ore Breakdown Processes	4
Dilute Acid Leaching	5
Concentrated Acid Breakdown	26
Alkali Breakdown	32
Dilute Alkali Carbonate Leaching	38
Chlorination Breakdown	43
Fluoride Breakdown Processes	62
References	66
3. Ion-Exchange Purification	70
Theory	70
Methods of Application	74
Chemical Composition and Structure of Resins	77
Process Design	82
Ion-Exchange Plant	90
Uranium Extraction by Ion-Exchange	101
Extraction of Thorium by Ion-Exchange	113
Purification of Zirconium by Ion-Exchange	116
Separation of Niobium and Tantalum by Ion-Exchange	118
Extraction of Vanadium by Ion-Exchange	119
References	121
4. Solvent Extraction	125
Theory	125
Solvent Extraction Plant	141
Purification of Uranium by Solvent Extraction	162
Purification of Thorium by Solvent Extraction	176
Purification of Zirconium by Solvent Extraction	180
Purification of Niobium by Solvent Extraction	185
References	187
5. Dryway Conversion Processes	192
Static Bed Reactors	192
Stirred Bed Reactors	194
Rotating Kiln Reactors	195
Vibrating Tray Reactors	196
Moving Bed Reactors	196
Fluidized Bed Reactors	199
Production of Uranium Tetrafluoride by the Static bed Method	203
Production of Thorium Fluoride by the Stirred Bed Process	207
Production of Uranium Tetrafluoride by the Fluidized Bed Process	208
References	220
6. Metal Production by High Temperature Reduction Techniques	222
Theory	222
Ingot Production Processes	227
Metal Powder Production Processes	239
Metal Sponge Production Processes	250
References	272
7. Molten Salt Electrolytic Processes	274
Comparison with Metal Reduction	274
Inert Salts	274
Cell Atmosphere	276
Electrolysis Plant	276

	Introduction of Rare Metal Salt	278
	Electrolytic Purification	279
	Recovery of Metal Product	279
	Electrolysis of Beryllium Chloride	280
	Production of Uranium Metal by Electrolysis	281
	Zirconium electrolysis from a Chloride-Fluoride Melt	286
	Production of Thorium Metal by Electrolysis	289
	Production of Titanium Metal by Electrolysis	294
	References	296
8.	Iodide Decomposition Processes	298
	Reaction Conditions	298
	Plant and Equipment	300
	Product Purity	306
	Alternative Feed Materials	306
	Recycling of Residues	306
	Continuous Operation	307
	Production of Titanium by Iodide Decomposition	307
	Production of Zirconium by Iodide Decomposition	309
	Production of Thorium by Iodide Decomposition	311
	References	312
9.	Flowsheets from Ore to Metal	314
	Uranium	315
	Thorium	321
	Zirconium	326
	Hafnium	330
	Titanium	332
	Niobium	334
	Tantalum	338
	Vanadium	340
	Beryllium	342
	Index	347