

Table of Contents

1	Introduction	1
1.1	Inorganic Trace Analysis in Science and Technology	1
1.2	The Role of Enrichment Techniques in Inorganic Trace Analysis	2
2	General Aspects of Enrichment Techniques	5
2.1	Trace Recovery	5
2.2	Enrichment Factor	6
2.3	Contamination	6
2.4	Simplicity and Rapidity	7
2.5	Sample Size	8
3	Control of Contamination and Loss	9
3.1	Airborne Contamination	9
3.1.1	Clean Rooms	10
3.1.2	Clean Hoods or Benches	12
3.1.3	Other Means to Reduce Airborne Contamination	12
3.2	Contamination and Loss Due to Apparatus	13
3.2.1	Selection of Materials	13
3.2.2	Surface Treatment	16
3.2.3	Cleaning of Containers	16
3.3	Contamination Due to Reagents	17
3.3.1	Selection of Commercial Reagents	17
3.3.2	Preparation of High-Purity Reagents in Analytical Laboratories	17
3.4	Other Sources of Contamination and Loss	20
4	Volatilization	21
4.1	Volatilization from Solutions	22
4.1.1	Volatilization of Trace Elements from Solutions	22
4.1.2	Volatilization of the Matrix from Solutions	22
4.2	Volatilization from Solid and Molten States	27
4.2.1	Volatilization of Trace Elements from Solid and Molten States	27
4.2.2	Volatilization of the Matrix from Solid and Molten States	28
5	Liquid-Liquid Extraction	30
5.1	General Procedures	30
5.1.1	Batch Extraction	30
5.1.2	Continuous Extraction	33
5.1.3	Countercurrent and Chromatographic Extractions	33

5.1.4	Backwashing	34
5.1.5	Stripping	35
5.2	Extraction of Metal Chelates	35
5.2.1	Chelate Extraction Systems	35
5.2.2	Equilibria in Chelate Extraction Systems	37
5.2.3	Masking	41
5.2.4	Synergism	42
5.2.5	Coextraction	42
5.2.6	Extraction Rate	43
5.2.7	Chelate Extraction of Trace Elements	43
5.2.8	Chelate Extraction of Matrix Elements	44
5.3	Extraction of Ion Pairs	46
5.3.1	Ion-Association Systems	46
5.3.2	Ion-Association Extraction of Trace Elements	50
5.3.3	Ion-Association Extraction of Matrix Elements	50
5.4	Special Extractions	50
5.4.1	Three-Phase Extraction	50
5.4.2	Homogeneous Extraction	50
5.4.3	Extraction with Molten Organic Compounds	51
5.4.4	Extraction of Trace Elements from Nonaqueous Samples	51
6	Selective Dissolution	52
6.1	Selective Dissolution of the Matrix	52
6.2	Selective Dissolution of Trace Elements	53
7	Precipitation	56
7.1	Precipitation of Matrix Elements	56
7.1.1	Coprecipitation Phenomena	57
7.1.2	Application of Matrix Precipitation	60
7.2	Precipitation of Trace Elements	61
7.2.1	Carrier Precipitation	61
7.2.2	Application of Carrier Precipitation	62
8	Electrochemical Deposition and Dissolution	67
8.1	Electrodeposition on Solid Electrodes	67
8.2	Electrodeposition on Mercury Cathodes	69
8.2.1	Deposition of Trace Elements	70
8.2.2	Deposition of Matrix Elements	73
8.3	Spontaneous Electrochemical Deposition	73
8.4	Anodic Dissolution	74
9	Sorption, Ion Exchange and Liquid Chromatography	75
9.1	General Procedures	75
9.1.1	Batch Operation	75
9.1.2	Filtration through a Permeable Sorbent Disk	75
9.1.3	Column Operation and Chromatography	76
9.2	Separation with Ion Exchange Resins	79
9.2.1	Ion Exchange Resins	81
9.2.2	Ion Exchange Reactions and Equilibria	82

9.2.3	Sorption of Trace Elements on Ion Exchange Resins	83
9.2.4	Removal of Matrix Elements by Sorption on Ion Exchange Resins	88
9.2.5	Sorption of Matrix and Trace Elements on Ion Exchange Resins Followed by Chromatographic Elution	88
9.3	Separation with Cellulosic Exchangers	88
9.4	Separation with Polyurethane Foams	90
9.5	Separation with Miscellaneous Organic Sorbents	90
9.6	Separation with Activated Carbon	92
9.7	Inorganic Ion Exchangers	93
10	Flotation	94
10.1	General Procedures	94
10.2	Carrier Precipitation Followed by Flotation	95
10.2.1	Important Experimental Factors	95
10.2.2	Applications	97
10.3	Ion Flotation	98
10.3.1	Important Experimental Factors	98
10.3.2	Applications	99
11	Freezing and Zone Melting	100
11.1	Freeze Concentration of Dilute Aqueous Solutions	100
11.2	Enrichment of Impurities in Solids by Zone Melting	101
12	Enrichment Techniques in Water Analysis	103
12.1	Separation Based on the Particle Size and Density	104
12.1.1	Filtration and Ultrafiltration	104
12.1.2	Dialysis	104
12.1.3	Gel Filtration	104
12.1.4	Centrifugation	105
12.2	Separation Based on Chemical Reactivity	105
12.2.1	Volatilization	105
12.2.2	Liquid-Liquid Extraction	106
12.2.3	Carrier Precipitation	106
12.2.4	Electrodeposition	107
12.2.5	Sorption, Ion Exchange and Liquid Chromatography	107
13	Enrichment Techniques in Gas Analysis	108
13.1	Separation of Particles	108
13.2	Separation of Gaseous Trace Constituents	109
	Literature	110
	Appendix	126
A.1	Solvents	126
A.2	Masking Agents	127
A.3	Ion Exchange Data	129
	Index of Abbreviations and Symbols	139
	Subject Index	142