

Contents

Preface — V

List of contributing authors — XIII

Alberto Del Guerra and Daniele Panetta

- 1 Radiation measurement — 1**
 - 1.1 Physical basis of radiation detection — 1
 - 1.2 Interactions of charged particles with matter — 4
 - 1.3 Radiation detectors — 13
 - 1.4 Active systems for radiation detection — 17
 - 1.5 Passive systems for radiation detection — 25
 - 1.6 Applications of radiation detectors — 28
 - 1.7 Environmental and individual monitoring — 38
 - 1.8 Outlook — 41
 - 1.9 References — 43
 - 1.10 Suggested reading — 43

Werner Rühm

- 2 Radiation dosimetry — 45**
 - 2.1 Introduction — 45
 - 2.2 Radiation dose concepts — 47
 - 2.3 Examples — 60
 - 2.4 Effective doses from natural and artificial sources — 72
 - 2.5 Outlook — 74
 - 2.6 References — 75

Klaus Eberhardt

- 3 Elemental analysis by neutron activation – NAA — 77**
 - 3.1 History — 77
 - 3.2 Principle of neutron activation analysis — 80
 - 3.3 Quantitative element determination — 89
 - 3.4 Fission reactors as neutron sources
for neutron activation analysis — 92
 - 3.5 Applications of Neutron Activation Analysis — 93
 - 3.6 Outlook — 96
 - 3.7 References — 98

Klaus Wendt

- 4 Radioisotope mass spectrometry — 101**
 - 4.1 Introduction – long-lived radioisotopes, origin and relevance — 101

- 4.2 Radioisotope mass spectrometry — **104**
- 4.3 Components of radioisotope mass spectrometry — **105**
- 4.4 Individual systems of RMS — **111**
- 4.5 Outlook — **128**
- 4.6 References — **132**

Heinz Gäggeler and Sönke Szidat

- 5 Nuclear dating — 133**
 - 5.1 Introduction — **133**
 - 5.2 Environmental radionuclides — **139**
 - 5.3 Dating with a single radionuclide — **140**
 - 5.4 Accumulation dating with a radioactive parent and a stable daughter — **155**
 - 5.5 Accumulation dating with a radioactive parent and a radioactive daughter — **161**
 - 5.6 Dating with nuclides emitted during nuclear weapons testing and nuclear accidents — **163**
 - 5.7 Fission tracks — **165**
 - 5.8 Thermoluminescence dating — **165**
 - 5.9 Outlook — **166**
 - 5.10 References — **167**

Clemens Walther and Michael Steppert

- 6 Chemical speciation of radionuclides in solution — 169**
 - 6.1 Introduction — **169**
 - 6.2 Absorption spectroscopy (UV-VIS, LPAS) — **170**
 - 6.3 X-ray absorption near edge structure spectroscopy (XANES) — **175**
 - 6.4 Liquid-liquid extraction — **179**
 - 6.5 Capillary electrophoresis (CE) — **180**
 - 6.6 Electrospray ionization mass spectrometry (ESI) — **182**
 - 6.7 Extended X-ray absorption fine structure spectroscopy (EXAFS) — **185**
 - 6.8 Infrared (IR) vibration spectroscopy — **189**
 - 6.9 Raman spectroscopy — **191**
 - 6.10 Nuclear magnetic resonance (NMR) — **194**
 - 6.11 Fluorescence spectroscopy — **199**
 - 6.12 Colloid detection — **204**
 - 6.13 Field flow fractionation (FFF) — **208**
 - 6.14 X-ray photoelectron spectroscopy (XPS) — **210**
 - 6.15 Outlook — **212**
 - 6.16 References — **214**

Norbert Trautmann and Frank Roesch

- 7 Radiochemical separations — 215**
 - 7.1 Introduction — 215
 - 7.2 Precipitation and co-precipitation — 218
 - 7.3 Liquid-liquid extraction — 220
 - 7.4 Solid phase-based ion exchange — 223
 - 7.5 Thin layer chromatography/high performance liquid chromatography — 227
 - 7.6 Electrodeposition/electrophoresis/electromigration — 229
 - 7.7 Volatilization/sublimation/evaporation — 233
 - 7.8 Hot atom chemistry/SZILLARD-CHALMERS-type separations — 242
 - 7.9 Outlook — 251
 - 7.10 References — 252

Norman M. Edelstein and Lester R. Morss

- 8 Radioelements: Actinides — 255**
 - 8.1 Introduction — 255
 - 8.2 General properties of the actinides — 257
 - 8.3 The elements: Discovery, availability, properties, and usage — 266
 - 8.4 Recommended reading — 291

Christoph E. Düllmann

- 9 Radioelements: Transactinides — 293**
 - 9.1 Introduction — 293
 - 9.2 The concept of the “Island of Stability of Superheavy Elements” — 294
 - 9.3 The discovery of the transactinide elements — 296
 - 9.4 Naming of new elements — 298
 - 9.5 Synthesis and nuclear properties of superheavy elements — 301
 - 9.6 Relativistic effects and the Periodic Table of the Elements — 306
 - 9.7 Methods for experimental chemical studies of transactinide elements — 309
 - 9.8 Chemical properties of the transactinide elements — 315
 - 9.9 Outlook — 328
 - 9.10 References — 330

Gert Langrock and Peter Zeh

- 10 Nuclear energy — 331**
 - 10.1 Introduction — 331
 - 10.2 Relevant basic physics — 335
 - 10.3 Evolution of nuclear power reactors — 339
 - 10.4 Main components of a nuclear power reactor — 343
 - 10.5 Common power reactor types — 354

- 10.6 The fuel cycle — **359**
- 10.7 Radionuclide generation in nuclear reactors — **375**
- 10.8 Some chemical aspects in nuclear reactors — **382**
- 10.9 Research reactors — **385**
- 10.10 Suggested reading — **388**
- 10.11 References — **389**

Thomas Moenius

- 11 Life sciences: Isotope labeling with tritium and carbon-14 — 391**
- 11.1 Introduction — **391**
- 11.2 Labeling strategies — **401**
- 11.3 Labeling with tritium — **406**
- 11.4 Labeling with carbon-14 — **415**
- 11.5 Outlook — **424**
- 11.6 Further Reading — **426**
- 11.7 References — **426**

Tobias L. Ross and Frank Roesch

- 12 Life sciences: Nuclear medicine diagnosis — 429**
- 12.1 Introduction — **429**
- 12.2 The tracer principle — **430**
- 12.3 Radionuclides for noninvasive molecular imaging — **434**
- 12.4 Molecular imaging: Tomography — **443**
- 12.5 Molecular imaging: Concepts — **446**
- 12.6 Radiopharmaceutical chemistry for molecular imaging — **451**
- 12.7 Radiopharmaceuticals for molecular imaging — **464**
- 12.8 Outlook — **498**
- 12.9 Further reading — **504**

Cathy S. Cutler

- 13 Life sciences: Therapy — 505**
- 13.1 Introduction — **505**
- 13.2 Historical background — **506**
- 13.3 Classifications — **507**
- 13.4 “Therapeutic” particles and corresponding radionuclides — **510**
- 13.5 LET and ionization — **528**
- 13.6 Selected radiotherapeutics — **531**
- 13.7 Outlook — **546**
- 13.8 References — **551**

Symbols and abbreviations — 553

Index — 565