

CONTENTS

<i>List of figures</i>	<i>page ix</i>
<i>List of tables</i>	<i>xii</i>
<i>Preface</i>	<i>xiii</i>
PART I THE ROLE OF ANALYTICAL CHEMISTRY IN ARCHAEOLOGY	1
1. ARCHAEOLOGY AND ANALYTICAL CHEMISTRY	3
1.1 The history of analytical chemistry in archaeology	5
1.2 Basic archaeological questions	10
1.3 Questions of process	25
2. AN INTRODUCTION TO ANALYTICAL CHEMISTRY	31
2.1 What is chemistry?	31
2.2 Analytical chemistry	38
2.3 Special considerations in the analysis of archaeological material	42
PART II THE APPLICATION OF ANALYTICAL CHEMISTRY TO ARCHAEOLOGY	45
3. ELEMENTAL ANALYSIS BY ABSORPTION AND EMISSION SPECTROSCOPIES IN THE VISIBLE AND ULTRAVIOLET	47
3.1 Optical emission spectroscopy (OES)	47
3.2 Atomic absorption spectroscopy (AAS)	48
3.3 Inductively coupled plasma atomic emission spectroscopy (ICP–AES)	57
3.4 Comparison of analysis by absorption/emission spectrometries	60
3.5 Greek pots and European bronzes – archaeological applications of emission/absorption spectrometries	62
4. MOLECULAR ANALYSIS BY ABSORPTION AND RAMAN SPECTROSCOPY	70
4.1 Optical and UV spectrophotometry	70
4.2 Infrared absorption spectroscopy	77

4.3 Raman spectroscopy	83
4.4 Soils, bone, and the “Baltic shoulder” – archaeological applications of vibrational spectroscopy	85
5. X-RAY TECHNIQUES AND ELECTRON BEAM MICROANALYSIS	93
5.1 Introduction to X-rays	93
5.2 X-ray fluorescence (XRF) spectrometry	101
5.3 Electron microscopy as an analytical tool	109
5.4 X-ray diffraction	113
5.5 Other X-ray related techniques	116
5.6 A cornucopia of delights – archaeological applications of X-ray analysis	118
6. NEUTRON ACTIVATION ANALYSIS	123
6.1 Introduction to nuclear structure and the principles of neutron activation analysis	123
6.2 Neutron activation analysis in practice	128
6.3 Practical alchemy – archaeological applications of NAA	130
7. CHROMATOGRAPHY	137
7.1 Principles of chromatography	137
7.2 Classical liquid column chromatography	139
7.3 Thin layer chromatography (TLC)	139
7.4 Gas chromatography (GC)	142
7.5 High performance liquid chromatography (HPLC)	146
7.6 Sticky messengers from the past – archaeological applications of chromatography	147
8. MASS SPECTROMETRY	160
8.1 Separation of ions by electric and magnetic fields	160
8.2 Light stable isotopes (δD , $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{18}\text{O}$, and $\delta^{34}\text{S}$)	169
8.3 Heavy isotopes (Pb, Sr) – thermal ionization mass spectrometry (TIMS)	173
8.4 Combined techniques – GC–MS	174
8.5 Isotope archaeology – applications of MS in archaeology	176
9. INDUCTIVELY COUPLED PLASMA–MASS SPECTROMETRY (ICP–MS)	195
9.1 Types of ICP analysis	195
9.2 Comparison with other techniques	200
9.3 Instrument performance	202
9.4 Splitting hairs – archaeological applications of ICP–MS	208

PART III SOME BASIC CHEMISTRY FOR ARCHAEOLOGISTS	215
10. ATOMS, ISOTOPES, ELECTRON ORBITALS, AND THE PERIODIC TABLE	217
10.1 The discovery of subatomic particles	217
10.2 The Bohr–Rutherford model of the atom	227
10.3 Stable and radioactive isotopes	230
10.4 The quantum atom	238
10.5 The periodic table	243
11. VALENCY, BONDING, AND MOLECULES	249
11.1 Atoms and molecules	249
11.2 Bonds between atoms	253
11.3 Intermolecular bonds	258
11.4 Lewis structures and the shapes of molecules	260
11.5 Introduction to organic compounds	263
11.6 Isomers	269
12. THE ELECTROMAGNETIC SPECTRUM	275
12.1 Electromagnetic waves	275
12.2 Particle–wave duality	279
12.3 Emission lines and the Rydberg equation	281
12.4 Absorption of EM radiation by matter – Beer’s law	286
12.5 The EM spectrum and spectrochemical analysis	288
12.6 Synchrotron radiation	290
13. PRACTICAL ISSUES IN ANALYTICAL CHEMISTRY	294
13.1 Some basic procedures in analytical chemistry	294
13.2 Sample preparation for trace element and residue analysis	302
13.3 Standards for calibration	306
13.4 Calibration procedures and estimation of errors	309
13.5 Quality assurance procedures	319
<i>Epilogue</i>	322
<i>Appendices</i>	326
I Scientific notation	326
II Significant figures	327
III Seven basic SI units	328
IV Physical constants	329
V Greek notation	330
VI Chemical symbols and isotopes of the elements	331
VII Electronic configuration of the elements (to radon, $Z = 86$)	335

viii *Contents*

VIII Some common inorganic and organic sample preparation methods used in archaeology	337
IX General safe practice in the laboratory	340
X COSHH assessments	342
<i>References</i>	350
<i>Index</i>	391