

INDEX

- α -radiation (particles) 224, 225, 226, 227, 228, 230, 235
 absolute
 notation, of enantiomers 274
 temperature 219
 absorbance (*A*) 52, 287
 absorbed residues 148
 absorption
 edge, X-ray 98
 spectrum 286
 X-rays 107
 absorptivity (*a*) 286
 accuracy 208, 313
 in absorption measurements 287
 acid
 definition 299–301
 washing 190
 actinides 246
 activity 299
 areas, on archaeological sites 68
 Aegean 62, 134
 affinity 138
 Africa, isotope studies 184
 air path, XRF 107
 alchemy 33, 40, 130
 aliphatic compounds 149, 266, 267
 alkali metals 244, 247, 251
 alkaline earths 243
 alloys 256
 amalgam 256
 Amarna 156
 amber 13, 22, 89, 154
 American Chemical Society 4
 amino acid 23
 isotopic composition 323
 racemization (AAR) 146, 274
 amorphous organic residues 11, 148
 amphorae 151, 154, 156
 analysis
 archaeological material 42
 organic materials 22–5
 sequential 49, 58, 59
 simultaneous 59
 analyte 39, 314
 analytical chemistry
 classical 41
 definition 38
 history 39–42
 sensitivity
 AAS 49
 XRF 104, 105
 spectroscopy 289
 Ancient Mining and Metallurgy Committee, Royal Anthropological Society 64
 Andes 185
 Ångström unit (Å) 93
 angular momentum quantum number (*l*) 239
 animal lipids 151
 anion 36
 anomalies, in REE 213
 anthropogenic fractionation 19
 lead 192
 tin 193
 zinc 192
 anthropology 3
 antineutrino 235
 anti-Stokes line 83
 archaeological
 applications of absorption/emission spectrometries 62
 chemistry 4
 teaching 325
 materials
 considerations in analysis 42
 degradation 26–8
 identification 10
 archaeology 3, 4
 as science 4
 excavation 4
 experimental 18
 archaeometry 4, 9, 130
 aromatic compounds 266, 267
 artificial radioisotopes 123
 Aston, F. W. 41
 atom 32, 217, 238–43, 249
 atomic
 absorption spectroscopy (AAS) 47, 48–56, 63, 195, 303
 applications 56
 detection limits 55
 interferences 55
 sample preparation 66
 emission spectrometry 56, 57
 energy levels 241–3
 mass number (*A*) 124, 230, 231

Cambridge University Press

978-0-521-65572-9 - Analytical Chemistry in Archaeology

A. M. Pollard, C. M. Batt, B. Stern and S. M. M. Young

Index

[More information](#)392 *Index*

- atomic *cont.*
 mass unit (amu) 230
 number (*Z*) 229, 231, 245
 weights 243, 244, 245
 tabulation 219, 220
- Auger
 electron 95, 98, 110
 spectroscopy (AES) 98, 107, 121
 process 95, 118
- Australopithecine 188
- authenticity 4, 19, 20
 brass 19
 coins 20
- autodissociation 300
- Avogadro, A. 218, 219
 hypothesis 218
 number 219, 220, 221
- axial detector (in ICP–AES) 59, 60
- azimuthal quantum number (*l*) 239
- β -radiation (particles) 224, 225, 236
- backscattered electron
 image 311
 in electron microscopy 109
- Balmer, J. J. 281
- Baltic 13
 shoulder 89
- base, definition 300
- Basketmaker II 184
- “Beaker Folk” 190
- beam
 chopper 51
 damage, in electron microscopy 113
 splitter 51
 stimulated migration 112
- Becquerel, A. H. 224, 225
- Beer–Lambert law, *see* Beer’s law
- Beer’s law 49, 52, 71, 77, 101, 285–8
- beeswax 24, 156, 158–159
- Belize 185
- Bell Beaker 190
- bending 78
- Berkeley 132
- Berthelot, M. P. E. 7
- Berzelius, J. J. 7, 32, 40, 220
- binding energy 118, 233, 241
- biological
 hard tissue, degradation 27
 materials 9
- biomarkers 148, 149, 153, 157
 fecal 25
 in manure 152
- biomaterials 208
- biominerals 91
- biomolecules, preservation 9
- birch bark tar 24, 154
- bitumen 157, 25
- blanks 302, 309–20
- blood residues 23
- bog bodies 24
- Bohr, N. 230, 282, 283, 285
- model of atom 33
 –Rutherford model of atom 227–30, 238
 –Sommerfeld model 285
 theory of electronic orbitals 230
- Boltzmann equation 50
- bond order 262
- bonding 249, 253–8
 and electronic structure 250–2
 orbitals 257
- bone 9, 20, 22, 178, 191, 209
 by IR 88
 by PIXE and PIGE 121
 by XRD 120
 crystallinity 88
 crystallinity index 89
 diagenesis 21–2, 29, 121–2
 histology index 89
 lipids 151
 metabolism 22
 mineral 182
 porosity 89
 remodeling 188
 trace elements 20
- Bonn 133, 134
- Bragg’s law 105, 114, 115
- brass 18–19, 192
 calamine process 18
 direct process 18
 European in North America 19
 scientific instruments 18
- bremstrahlung 99, 117
- Brill, R. 177
- Britain, oxygen isotopes 191
- British Museum 325
 NAA protocol 128, 129
- Brønsted and Lowry acid 300
- bronze 193
 analysis of 8
- Bronze Age 8, 11, 16, 62, 64, 132, 134, 156, 192
- Brown, R. 220
- Brownian motion 220
- burner
 graphite furnace 53
 laminar flow 50
- C₃ photosynthesis 172, 182
- C₄ photosynthesis 172, 182, 188, 189
- cabbage 24
- Cahn–Ingold–Prelog convention 274
- calamine process 18
- calcified tissue, by FTRS 90
- calibration 309–19
 errors 314–19
 ICP–AES 58
 ICP–MS 205
 NAA 130
 of oxygen isotopes in bone 191
 standards 306–9
- Canada, isotope studies 184
- Cannizzaro, S. 219, 244
- Cape Town 189

Index

393

- capillary column 142, 144
 carbon
 isotopes 171–2
 fractionation, in photosynthesis 171
 in carbonate 21, 188
 preference index (CPI) 158
 orbital structure 263
 carboxylic acids 149
 caries 184
 Carnot, S. N. L. 7
 carrier gas 142
 cathode 222
 rays 222
 tube 41
 cation 36
 caulking 154
 Cavendish Laboratory, Cambridge 224, 227
 Cedar Mesa, Utah 184
 Central America, isotope studies 185
 ceramic 208
 absorbed residues, sample preparation 305
 by AAS 67
 by NAA 132
 by XRF 119
 comparison of analyses 134
 mineralogical change 27
 organic residues 23
 provenance 15
 cerium anomaly 213
 Certified Reference Materials (CRM) 307
 Chaco Canyon, New Mexico 26, 209
 Chadwick, J. 226, 227
 characteristic X-ray, *see* secondary X-ray
 characterizability, in provenance 15
 charge
 coupled device (CCD) 59, 75
 nuclear 228
 to mass ratio, of α -particles (E/M) 225
 to mass ratio, of electron (e/m) 222
 chemical
 analysis, instrumental 39, 42
 equations 37
 formula, and chemical structure 37
 interference 55
 ionization 162
 symbols 33, 35, 220, 231
 terminology 35–8
 chemistry
 definition 31
 inorganic 32
 organic 32
 physical 32
 relation to archaeology 5
 soil 29
 chewing gum, Mesolithic 24, 154
 chicha 186
 Childe, V. G. 64
 Chios turpentine 155
 chiral
 center 273
 compounds 145
 cholesterol 150
 chondrite normalization 212
 chopper 51
 chromatogram 145
 chromatography 137–9
 resolution 138
 retention time 139
 chronology, relative 13
 circularly polarized radiation 278
 Classic Chemistry website 217
 classical
 analytical chemistry 41
 scattering theory 228
 clay 15
 clean laboratory 303
 climate, and collagen isotopes 178
 cloud chamber 224
 coherent scattering 101
 coins 10
 authenticity 20
 by NAA 134
 cold vapor (CVAAS) 54
 collagen 21, 323
 extraction 187
 isotope studies 182
 and climate 178
 and latitude 180
 sample preparation 172
 thermal history 21
 colorimetry 40, 71, 86, 287, 288
 column
 chromatography 139, 148
 in HPLC 146
 combining errors 311
 common names 36, 267
 comparison 62
 AAS and NAA 133
 ICP–MS and NAA 200–1
 NAA and ICP–AES 134
 NAA and ICP–MS 135
 OES and NAA 133
 of absorption/emission spectrometries 60–1
 PIGE and LA–ICP–MS 121
 TIMS and MC–ICP–MS 201–2
 compound 34, 249
 specific isotope ratios 24
 Compton scattering, *see* incoherent scattering
 concentration of solutions 296–9
 condensed form, organic structures 265
 confidence interval 318, 319
 conformational isomers 269
 conjugated bonds 266
 conservation
 science 30
 strategies 26
 constructive interference 276
 contamination, in lipid analysis 152
 continuous flow
 analysis 87
 combustion isotope ratio mass spectrometry
 (CF–C–IRMS) 169, 173

394 *Index*

- continuous flow *cont.*
 injection 60
 continuum X-rays 99
 Control of Substances Hazardous to Health (COSHH) 302
 conversion, element to oxide 57
 cooking
 bone 120
 vessels 150
 cool plasma 203
 co-ordination 71
 number 254
 copper
 alloys 64
 Baltic 12
 by AAS 67
 corrosion 29
 deposits
 native 64
 ores 64
 Coppergate 25
 corpuscles 222
 correlation
 chart, in IR 79
 coefficient 315
 corrosion
 copper 29
 electrochemical 27
 lead 29
 products, metal 120
 Coulomb's law 253
 counting strategy, in NAA 127, 129
 covalent
 bonding 249, 256–8
 molecules 258
 Crete 62, 132, 157
 critical absorption edge 98
 Crooke's dark space 222
 crystal structure 254, 36
 crystalline materials 114
 crystallinity
 bone 88
 index (CI) 89
 cupellation 40
 cupronickel alloys 11
 Curie, I. 227
 Curie, M. S. 225
 Curie, P. 225
 cuvette 72
 Cyprus 133, 193
 δ -notation 170

 dairy products 24, 153
 Dakleh Oasis 191
 Dalton (mass units) 230
 Dalton, J. 34, 38, 218, 219, 220, 227
 atomic theory 38
 laws 32
 Damour, M. A. 12
 data
 analysis, in ICP–MS 208
 quality 208
 database, of NAA data 132, 133, 134
 dating 4, 13, 88, 161, 177, 274
 from technology 19
 FUN 7
 radiocarbon 173
 radiometric 237
 daughter, radioactive 234
 Davy, H. 6
 d-block elements 243, 246, 247, 248
 dead time, XRF 105
 Debye–Scherrer powder camera 115
 decay constant (λ) 237
 decision tree 65, 91
 degeneracy 50
 degradation
 biological hard tissue 27
 bone 88
 hair 210
 lipids 149
 processes 26–8
 deionized water 303
 delayed neutron activation analysis 126–8
 Democritus 32
 Dempster, A. J. 41
 dendrogram 131
 Denmark 186
 density 299
 of nucleus 229
 dental
 caries 184
 enamel 188, 189, 191, 209
 derivatization 142
 destructive interference 276
 detection limit 319
 in AAS 55
 in NAA 130
 diagenesis 26–8, 88, 190, 210
 bone 21, 29, 120, 182
 noncommutativity 28
 processes 28–30
 thermodynamic considerations 27–8
 trajectories 28
 diastereoisomers 272
 diet 21, 209, 323
 dietary reconstruction 21, 180–8, 223
 estimating proportions 186
 difference, error in 312
 diffraction grating 48, 54, 59, 74, 104
 dispersion 75
 echellette reflection 74
 diffractometer 115
 diffusionism 8, 134
 digestion
 open vessel 337
 REE analysis 213
 dipole
 –dipole bond 250, 259
 moment 84
 direct process, brass 18
 discharge

- lamp 77
 tube 281
- dispersion, of distribution 311
- dissolution techniques 56
- diterpenoids 154
- DNA 9, 22, 23
- Döbereiner, J. W. 243
- Dodson, R. W. 131
- Doppler broadening 49
- double
 beam instrument 52
 focusing mass analyzer 164, 166, 173
- Drake Plate 19
- drawing organic structures 265
- drift 206, 313
- dual beam spectrometer 76, 77
 infrared 79
- Dutch East India Company 189
- dye laser 73
- e/m*, for electron 222
- E/M*, for α -particles 225
- echellette reflection grating 74
- economic history 11
- ecosystems 172, 184
- Ecuador 185
- Egypt 213
- Einstein, A. 38, 225, 279
- elastic
 collisions 227
 scattering 83
- electrochemical
 corrosion 27
 equivalent 221
- electromagnetic
 radiation 93, 94, 286, 289
 spectrum 278
 and spectrochemical analysis 288–90
 waves 275–8
- electron 33, 221–4
 acceptor 300
 capture 236
 density 257
 impact source 161
 microprobe analysis (EPMA) 109–13
 microscopy 8
 analytical 109–13
 archaeological applications 119–20
 elemental mapping 112
 imaging 109, 311
 limits of detection 111
 standards 308
 orbitals 240
- electron spectroscopy for chemical analysis (ESCA), *see* X-ray photoelectron spectroscopy
- electronegativity 84, 248, 252, 253
- electronic
 configuration 49, 240–1, 249
 table of 335
 structure and bonding 250–2
- electrospray ionization 163
- electrothermal burner, in AAS (ETAAS), *see* graphite furnace
- element 33
 mapping, in electron microscopy 112
- elephant 91, 180, 189
- eluent 139
- elution 138
- emission spectrum 226, 230, 281–5
 hydrogen 282
 sodium 283
- enamel 188, 189, 191
- enantiomer 145, 272
 nomenclature 273
- energy
 dispersive X-ray fluorescence (EDXRF) 102, 111, 127
 applications 118
 level diagram 49, 238
- environmental
 archaeology 3
 chamber 111
 monitoring, in museums 30
- equations, chemical 37
- equilibrium constant (K) 296
- equivalent weights 38, 221, 297
- Ergolding Fischergasse 156
- error 309
 bars 312
 estimating 310–11
 in calibration 314–19
- escape depth 102, 106, 113
- estimating diet 21
- ethnographic data 68
- Europe, isotope studies 186
- European Bronze Age metal 64
- europium anomaly 213
- evolution, of life on earth 260
- ex Oriente lux* 8
- excavation 4
 Coppergate 25
- excited state 243
- experimental archaeology 18
 burials 210
- extended X-ray absorption fine structure (EXAFS) 98
- faience 3
 beads, by NAA 134
- Faraday, M. 6, 148, 221, 224
 archaeological analyses 6
 constant 221
 cup 167, 199
 law 224
- fast
 atom bombardment (FAB) 163
 neutron activation analysis (FNAA), *see* neutron activation analysis
- fatty acids 149
- f*-block elements 246, 248
- fecal material 25

396 *Index*

- field simulations of ancient technology 18
 filter, in XRF 106
 fine structure 285
 fingerprint
 in GC 175
 region, of infrared spectrum 78
 fire assay 40
 Fitch Laboratory, British School at Athens 62
 flame
 ionization detector (FID) 144
 photometry 41
 temperature, in AAS 50
 flint, by NAA 134
 fluid 34
 fluorescence
 detector 147
 radiation, in emission spectrum 285
 fluorescent
 X-ray, *see* secondary X-ray
 yield (ω) 95
 fluorine, in bone 7, 121
 food residues 9, 22
 forbidden transitions 285
 forensic
 anthropology 43
 science 4, 28, 32, 42, 210, 320
 fossilization processes 295
 four elements, in alchemy 33
 Fourier transform 276
 infrared microscopy 83
 infrared spectroscopy (FTIR) 80–3
 Raman spectroscopy (FTRS) 85, 90
 fractionation 233
 anthropogenic 192
 in soil chemistry 85
 isotope 170
 Fresenius, C. R. 40
 fugacity 299
 FUN dating 7
 functional groups 268, 269
 γ -rays (particles) 127, 129, 225, 226, 235, 312
- gas
 chromatography (GC) 79, 142–6, 153, 156, 169
 –combustion–isotope ratio mass spectrometry (GC-C-IRMS) 24, 153, 157
 –mass spectrometry (GC-MS) 23, 153, 156, 174–6
 discharge tube, *see* cathode ray tube
 Gay-Lussac, J. L. 218
 Geiger counter 105
 geochemical
 environment 67
 modeling 22, 29, 296
 prospection 68, 85
 geochemistry 13, 14
 of trace elements 67
 organic 22
 geometric isomers 272
 germanium detector 117, 127, 129, 131
 glass 177, 214
 beads, by NAA 134
 corrosion, by IR 87
 Göbel, C. C. T. C. 12
 gold, alchemical 40
 Goldschmidt, V. M. 13
 gradient
 elution, in HPLC 146
 of regression line 316
 Graham, T. 220
 gram
 –equivalent 38
 –molecular volume 219
 –molecular weight 219
 graphite furnace (GFAAS) 53, 56, 60
 gravimetry 6, 40
 Greece 132, 133
 Greek
 fire 158
 pottery 62
 symbols 331
 Greenland 178, 180, 186
 GRIP 180
 ground state 241
 groups, in periodic table 247
 gums 23
- hafting 154
 hair 210
 trace elements 21
 half-life ($T_{1/2}$) 236
 halogens 243, 247, 251
 hand-held XRF 119
 health and safety 301–2, 340
 heavy isotopes 173–4
 Helm, O. 13, 90
 Hertz, H. R. 279
 heteroatom compounds 266, 267
 heterogeneous mixture 35
 high performance liquid chromatography (HPLC)
 25, 146–7, 148
 –mass spectrometry (HPLC-MS) 147, 148
 –MS-MS 149
 high pressure gas discharge 72
 histology index 89
 history
 chemical analysis in archaeology 5–10
 relation to archaeology 3
 hole 94, 99
 hollow cathode lamp 50, 56
 hominid diet 188
 homogeneous mixture 35
 hopanes 158
 human
 evolution 188
 mobility 21, 188
 remains 9, 323
 chemical study of 20–2
 decay processes 24
 lipids 151
 hybrid orbitals 264
 hydrate 36

Index

397

- hydride generation (HGAAS) 54
 hydrofluoric acid 304
 digestion 337
 hydrogen
 bond 250, 259
 emission spectrum 282
 isotopes 171
 hydrological modeling 29
 hydronium ion 300
 hydroxyapatite 89, 91
 hyphenated techniques 42, 160, 166
- ice cores 180
 ideal gas 259
 identification of archaeological materials 10
 illicit antiquities 20
 Illinois Valley 182, 184
 imaging, in electron microscopy 109
 immunochemistry 153
 incoherent scattering 101
 India 214
 inductively coupled plasma
 –atomic emission spectroscopy (ICP–AES) 47,
 57, 60, 67, 131, 195
 –mass spectrometry (ICP–MS) 58, 59, 60,
 195–200, 302
 industrial archaeology 18
 inelastic scatter 127
 infrared 288
 spectroscopy (IR) 13, 25, 77–83, 118, 149, 154
 correlation chart 79
 microscope 82
 reflectance spectroscopy 88
 injection loop 146
 injector port 143
 inorganic chemistry 32
 insoluble 295
 instantaneous dipole 259
 instrumental
 blank 309
 chemical analysis 39, 42
 drift 206
 intensity (*I*) 278
 intercept, of regression line 316
 interference
 chemical 55
 in AAS 55
 in ICP–MS 206
 phenomena 114, 276
 spectral 55, 58
 interferogram 80
 interlaboratory comparison 62, 132
 AAS and ICP–AES 67
 OES and AAS 63
 OES and NAA 63
 of NAA data 133
 intermolecular bond 137, 258–60
 internal
 spike 48
 standard 207, 308–9
 in GC 145
- International Archaeometry Symposium 4
 interstitial substitution 256
 ion 243
 detectors, in mass spectrometry 167–9
 exchange columns 201
 sources, in mass spectrometry 161
 ionic
 bonding 249, 254–5
 product of water (K_w) 300
 ionization
 chamber 105
 suppressor 56
 iron 18
 ISO (International Organization for
 Standardization) 319
 isobaric interferences, in ICP–MS 203
 isomers 269–74
 isoprene 153
 isotope 33, 124, 231–3
 archaeology 160, 176–94, 177
 carbon 171–2
 dietary reconstruction 21, 180–8
 ecology 184
 fractionation, in metal production 19
 heavy 173–4
 hydrogen 171
 lead 173–4, 177, 192–4
 light 169–73
 nitrogen 172
 oxygen 171
 ratio mass spectrometer (IRMS) 168, 169, 173
 ratios
 compound specific 24
 in carbonate 21
 in collagen 182
 in human remains 21
 strontium 174, 189
 table of 331
 IUPAC nomenclature 36, 37, 268
 ivory 91, 189
- jade 12
 jet 11, 120
 Joliot, F. 227
- K spectrum, X-ray 96
 kava 25
 Kekulé, F. A. 7, 266
 Kelvin, temperature 219
 kernel density estimation (KDE) 193
 Khoisan hunter–gatherers 189
 kiln waster 15
 kinetics 28
 Klaproth, M. H. 6, 40
 Knossos 62, 133
 Kramer’s formula 99
- L spectrum, X-ray 96
 laboratory microcosm 30
 laminar flow burner 50, 53

398 *Index*

- lamp 150, 157
 hollow cathode 50, 56
 Lampadius, W. A. 40
 lanthanides 210, 246–8
 laser 72–3, 197
 ablation 73, 194, 200
 in mass spectrometry 170
 –inductively coupled plasma–mass spectrometry (LA–ICP–MS) 58, 59, 61, 197–8, 323
 standards 308
 desorption 168
 Late Woodland 183
 latent heat 35
 latitude 180
 lattice 36
 Lavoisier, A.-L. 33, 37, 40
 Law
 of Conservation of Mass 37
 of Constant Composition 38, 218
 of Definite Electrolytic Action 221
 of Multiple Proportions 34, 218
 of Octaves 244
 of Reciprocal Proportions 38
 Lawrence, E. 33
 Layard, A. H. 7
 lead
 anthropogenic fractionation 19
 corrosion 29
 isotopes 173–4, 177, 192–4, 233, 238, 322
 presentation of 193
 provenance 17
 “legacy” data 47, 63, 66
 Lewis
 acid, definition 300
 structures 260, 262
 ligand 71
 light stable isotopes 169–73
 systematics 170
 limits of detection
 comparison in absorption/emission spectrometries 61
 electron microscopy 111
 ICP–MS 198, 204
 XRF 108
 linear regression 316
 Linearbandkeramik (LBK) 190
 lipids 22, 23, 24, 305
 analysis 149
 distinguishing animal from vegetable 151
 in bone 151
 in dairy products 24
 in decay processes 24
 in human soft tissue 151
 in tuberculosis 24
 lithium metaborate fusion 338
 lithophile 13, 211
 Little Ice Age 178
 local, definition 15
 London forces 259
 looting 3, 20
 Lycurgus cup 122
 magic numbers 234
 magnetic
 quantum number (m_l) 239
 sector 164, 175
 main group elements 247
 maize 182, 184–6, 323
 Manchester radiochemistry group 133
 Manhattan Project 131
 manufacturing technology 17–19
 brass 18–19
 iron 18
 isotope fractionation 19
 manuring practices 152
 marble, weathering 120
 Marggraf, A. S. 41
 marine ecosystems 172
 mass
 absorption coefficient 102
 analysis 164–7
 chromatogram 175
 spectrograph 42
 spectrometry 8, 167–9
 spectrum 175
 mastic 155
 matrix 303
 assisted laser desorption ionization (MALDI)
 163, 168
 effects
 in calibration 307
 in ICP–MS 207
 in XRF 108
 matching 198, 207
 Maxwell, J. C. 277
 equations 290
 Maya 185
 mean lifetime (τ) 237
 measurability, in provenance 15
 Mediterranean 17, 62, 90, 131, 132, 151, 155, 192
 Mendeleev, D. I. 244, 245, 247
 Merck Index 37
 Mesolithic 24, 186
 –Neolithic transition 186, 323
 metabolic
 pathways, in photosynthesis 172
 routing 187
 metabolism, of bone 22
 metal
 analysis 208
 corrosion 27
 detectors 3
 properties 256
 provenance 16
 recycling 16
 XRF analysis 120
 metallic bonding 249, 255–6
 metalworking, origins 190
 meteoric water line 171
 methylation 142
 Meyer, J. L. 244

- Michelson interferometer 80
 microcosms, laboratory 30
 microprobe, electron, *see* electron microscopy
 microwave digestion 338
 Middle Mississippian 184
 mil (parts per thousand) 170
 milk 152
 proteins 153
 mineral identification, in pottery 120
 mineralization processes 295
 mineralogical change, ceramics 27
 minimum detectable level 319
 in ICP-MS 204
 Minoan 62, 63, 132
 mirror images, of molecules 272
 mixture 34
 heterogeneous 35
 homogeneous 35
 mobile phase 137
 mobility 21, 188, 209
 modeling
 geochemical 29
 hydrological 29
 molality 298
 molarity (M) 38, 297
 mole 35, 38, 297
 fraction 297, 298
 molecular
 marker 23
 orbitals 263
 vibrations 78
 weight 38
 molecule 34, 218, 249
 molybdenum blue, in phosphorus analysis 72, 86, 287
 Mommsen, H. 133
 monochromator 54, 74
 Moseley, H. G. J. 245
 law 96
 mull 80
 multicollector-inductively coupled plasma-mass spectrometry (MC-ICP-MS) 190, 193, 195, 199
 multiple collectors, in mass spectrometry 168, 173
 multivariate analysis 131, 208
 mummification 22, 158-159
 museum material, analysis of 4, 42
 by NAA 128
 Mycenae 7, 13, 63, 90, 132, 133

 (n, α) reaction 124
 (n, γ) reaction 124
 (n, p) reaction 124
 names
 common 36
 in organic chemistry 36
 IUPAC 36
 natural
 products 9, 22, 324
 radioactivity 224-6
 Neolithization 190

 Nernst glower 79
 neutron 33, 123, 124, 229, 230, 231, 238, 266-7
 capture cross-section 126
 neutron activation analysis (NAA) 8, 12, 17, 61, 63, 66, 67, 195, 200, 235
 calibration 130
 detection levels 130
 nuclear processes 125
 of archaeological material 128
 quantification 130
 New Archaeology 9
 Newlands, J. A. R. 244
 Newman projections, of isomers 269
 Newton, I. 41
 mechanics 239
 Nile silt 213
 nitrogen isotopes 172
 Nobel Prize 83, 217, 224, 225, 227, 280
 noble gases 247, 251
 nomenclature, of organic structures 266, 269
 non-commutativity, in diagenesis 28
 normal
 distribution 311
 solution (N) 38
 normality 38, 297
 nuclear
 fission 236
 instability 234
 magnetic resonance (NMR) 118
 processes, in NAA 125
 reactor 124, 129
 structure 123-6
 nucleons 231
 nucleus 33, 228-30, 238
 nuclides, table of 234
 nujol 80
 nutrition 21

 Oaxaca 191
 obsidian 14, 208
 by NAA 134
 by XRF 119
 comparison of analyses 135
 hydration, by IR 87
 octet rule 251
 olive oil 151
 Oppenheimer, J. R. 131
 optical
 activity 277
 emission spectroscopy (OES) 7, 47-8, 62, 64
 isomers 273
 spectroscopy, *see* ultraviolet and visible spectroscopy
 organic
 chemistry 32, 263
 names 36
 geochemistry 22
 material
 analysis 22-5
 survival 22
 transformation 149

400 *Index*

- organic *cont.*
 - residues 147
 - in ceramics 23
 - sample preparation 304–6
 - structures
 - drawing 265
 - nomenclature 266
- Orinoco River 185
- Ostwald ripening 88
- Oxford histology index 89
- oxidation state 36
- oxygen isotopes 171
 - in bone phosphate 178, 191
- palaeoclimatology 177, 180
- palaeotemperature reconstruction 171, 177
- particle
 - accelerator 129
- particle induced gamma ray emission (PIGE) 117
 - archaeological applications 121
- particle-wave duality 102, 109, 279–81
- parts per million (ppm) 299
- path difference 114
- pathology 21
- pattern recognition 131
- Pauli, W. 239
 - exclusion principle 239
- p*-block elements 247
- PDB (Pee Dee Belemnite) 171
- Pearson's product-moment correlation coefficient 315
- per mil 170
- Percy, J. 7
- Perey, M. C. 247
- periodic table 230, 243–8, 250, 254
 - underlying structure 239
- periodicity, of properties 239, 245, 247–8
- periods 245
- Perlman–Asaro database 63
- permafrost 24
- Perrin, J. B. 220
- pH, definition 299–301
- phase
 - change 35
 - difference 276
 - separation 66
- phase-sensitive detector 77
- philosophy of science 9
- phospholipids 150, 163
- phosphorus analysis 68
- photoelectric
 - absorption 101
 - effect 76, 280
- photoelectron 101, 110
- photographic
 - film 115
 - plate 48
- photomultiplier tube 48, 54, 59, 75
- photon energy (E) 279, 288
- photosynthesis 172
 - carbon fractionation 171
 - metabolic pathways 172
- physical
 - chemistry 32
 - constants 329
- physics 275
- pi bond (π) 264
- “picking” samples for XRD 115
- Pigments 122
- Pitldown Man 7
- Pinaceae* resin 154
- Pistacia* resin 155, 156
- pitch 154
- Planck's constant 93, 280, 282
- plane polarized radiation 277
- plants, psychoactive 25
- plasma 34, 57, 196
 - cool 203
 - screen 202
 - shield 208
 - torch 47, 57
- plates, TLC 140
- platinum 11
 - group elements (pge) 248
- Plücker, J. 41
- “Plum Pudding” model 227
- polar molecule 259
- polarity, of solvents 139
- polarization 277
- polyatomic interferences, in ICP-MS 203
- Pompeii 6
- population inversion 73
- porosity, bone 89
- positron emission 236
- post-depositional alteration 15
 - bone 21
- pottery 213, 214
- powder diffraction 113
- power (*P*) 278, 286
- precision 208, 313
- pre-Classic 185
- predictability 15
- preservation 323
 - by reburial 26
 - in situ 25–6
 - of soft tissue 24
- pressure broadening 49
- primary
 - standards 307
 - X-ray 101
- primeval lead 174
- principal
 - components analysis (PCA) 6
 - quantum number (*n*) 239, 282
 - series, in emission spectrum 284
- principle of superposition 276
- prism 48, 54, 74, 104
 - angular dispersion 74
 - resolving power 74
- product, error in 312
- production centre 15
- prompt γ 125

Index

401

- neutron activation analysis (PGNAA) 128
 proportional counter 105
 protective agent 55
 protein 22, 23
 analysis, by mass spectrometry 163
 proton 33, 123, 229, 230, 238
 induced X-ray emission (PIXE) 116, 131
 archaeological applications 121
 provenance 5, 14–15, 62, 208, 322
 “best” elements 67
 “best” method 67
 ceramics 15, 131
 humans 174
 lead isotope 17, 192–4
 metal 16
 NAA 132–3
 theory 12–17
 psychoactive plants 25
 pumice 134
 pyrolysis–gas chromatography–mass spectrometry (Py–GC–MS) 12
 pyrosynthetic materials 14
- quadrupole 164, 166–7, 175, 195, 199
 ICP–MS 199, 202
 qualitative analysis 38
 quality assurance (QA) 208, 313, 319–21
 quantification
 in ICP–MS 205
 in NAA 130
 quantitative analysis 38
 quantized energy levels 238
 quantum
 defect 283
 numbers 239–41, 263
 theory 239
 quartz prism 48
 quotient, error in 312
- racemic mixture 273
 racemization 273
 radial detector (in ICP–AES) 59
 radioactive 225
 decay 233, 234–8
 chains 173, 192, 237
 isotopes 233–4
 artificial 123
 sources 99, 104, 129
 radiocarbon dating 173
 radiogenic isotopes 238
 Raman, C. V. 83
 microscope 84
 shifts 85
 spectroscopy 83–5
 random errors 310
 rare earth elements (REE) 210–14, 246, 248
 profiles, in archaeology 213
 rare gases 247
 Rayleigh scattering, *see* elastic scattering
 reburial 26, 120
 recycling, metals 16, 17
- reference beam 52
 refractive index 74, 278
 regression equation 317
 relative
 chronology 13
 configuration, of enantiomers 273
 density 219
 releasing agent 55
 relevance of scientific analysis 10
 remodeling, bone 188
 repeatability 313
 Research Laboratory for Archaeology and the
 History of Art, Oxford University 62, 63, 131
 residual, of regression 318
 residue analysis 9
 absorbed 148
 amorphous 11, 148
 in amphorae 150, 151
 in cooking vessels 150
 in lamps 150
 visible 148
 resin 22, 23, 153
 Pinaceae 154
 pistacia 155, 156
 resolution
 chromatography 138, 144
 of mass analyzer 166, 167
 resonance
 radiation 285
 structures 262
 retardation 81
 retention
 factor 141
 time 139, 145
 reverse phase HPLC 147
 Richards, T. W. 7
 rocking 9
 Roman pottery 133
 Rome 6
 routing, metabolic 187, 324
 Royal Mint 108
 Royal School of Mines, London 7
 Royal Society 6
 Rutherford, Lord E. 224, 226
 model of atom 228–30
 Rydberg, J. R. 281
 constant 281
 equations 283
- safety manual 301
 SAM program 14, 64, 66
 sample blank 124, 309
 sample preparation 56, 196, 337
 for organic residues 304–6, 338
 for trace elements 302–4
 sampling cones 196
 sand-men 68
 saponification 143, 306
 saturated fatty acids 149
 sawhorse projection, of isomers 269
 Sayre, E. 131

402 *Index*

- s-block elements 247
- scanning electron microscope, *see* electron microscopy
- scatterplot 314
- Schliemann, H. 7, 13, 90
- scientific
 - analysis, relevance 10
 - instruments, brass 18
 - notation 326
- scissoring 78
- secondary
 - electron 109
 - image 109
 - ion mass spectrometry (SIMS) 163
 - standards 307–8
 - X-ray 101, 102, 104, 107, 110, 117
- secular equilibrium 238
- selected ion monitoring (SIM) 175
- selection rules
 - emission spectra 285
 - X-ray emission 96
- semiquantitative analysis 39
 - in ICP–MS 206
- sensitivity
 - AAS 49
 - XRF 104, 105
- sequential analysis 49, 58, 59, 105
- shape
 - molecules 260, 263
 - orbitals 239
- short periods 245
- Shroud of Turin 20
- SI units 328
- Si(Li) detector 103
- siderophile 13
- sigma bond (σ) 264
- significant figures 298, 313, 327
- silt 213
- silver, in lead ores 192
- silylation 142
- simultaneous analysis 59, 105
- sine wave 275
- single beam instrument 52
- single-focusing magnetic sector 164, 165
- site formation processes 10
- size, of nucleus 228
- skeletal components, trace element variation 209
- skimmer cones 196
- slag 208
- small angle X-ray scattering (SAXS) 293
- social organization 16
- sodium, emission spectrum 283
- soft
 - ionization techniques 162, 164, 169
 - tissue, preservation 24
- soil 29, 208
 - by ICP–AES 68
 - by ICP–MS 68, 79
 - fractionation techniques 85
 - phosphorus analysis 68, 85
 - processes 69
 - sample preparation 305
 - silhouettes 68
- solid
 - solution 35, 256
 - state detector 102, 103
- solubility 295–6
 - product 296
- solute 297
- solution 35
 - analysis by ICP–MS 196
 - chemistry 295–301
 - measures of concentration 296–9
- solvent 297
 - extraction 305
- S-option 197
- source 14
- South Africa 189
- South America, isotope studies 185
- sp* hybrid 264
- sp*² hybrid 264
- sp*³ hybrid 264
- space filling model 266
- spark source 47
- Special Theory of Relativity 225
- spectral
 - interference 55, 58
 - in XRF 108
 - series 283
- spectrochemical analysis, and EM spectrum 288–90
- spectrophotometry 72, 287
- spectroscopic notation, X-ray 94
- speed of light (*c*) 277, 278, 280
- spike 48, 308
- spin–orbit coupling 49, 285
- split-splitless injector 143
- spot tests 39, 107, 149
- spurious accuracy 313
- Sri Lanka 214
- stability, in provenance 15
- stable isotopes 230–3
- standard
 - operating procedures (SOP) 301, 320
 - reference materials (SRM) 12, 308
 - temperature and pressure (STP) 219
- standard deviation 310
 - of regression 318
- standards 306–9
 - internal 308
 - isotope 171
 - primary 307
 - secondary 307
 - solid 308
 - synthetic 306
 - TLC 141
- standing waves 276
- states of matter 34
- stationary phase 137, 140
- statistical procedures 208
- status 21
- stereoisomers 272

- steroids 150
 sterols 150
 in manure 152
 stimulated emission 73
 stoichiometry 35, 36, 250
 Stokes line 83
 stone 14
 axes 12
 Stoney, G. J. 221
 stretching 78
 strontium isotopes 174, 189, 209
 structural isomers 269
 Student's *t*-test 316
 subatomic particles 217
 succinic acid 89
 sum, error in 311
 surface sensitivity, of XRF 107
 survey data, in ICP-MS 204
 Sutton Hoo 68
 symbols, chemical 220, 231
 synchrotron radiation 98, 99, 290–3
 archaeological applications 292
 synthetic standards 306–7
 syringic acid 149
 systematic errors 309
 systematic names 36, 37, 267
- tandem mass spectrometry (MS-MS) 164
 taphonomy 27
 tartaric acid 149
 teaching 325
 technology, manufacturing 17–19
 teeth 209
 trace elements 21
 temperature, influence on provenance 16
 Teotihuacán 191
 tephra 118, 209
 terebinth 155
 terpenoids 152, 153
 terrestrial ecosystems 172
 test papers 87
 tetrahedral structure, of carbon 264
 textiles 23
 theoretical plates, in chromatography 139
 thermal analysis 80
 thermal history of collagen 21
 thermal ionization mass spectrometry (TIMS) 61,
 162, 168, 173, 189, 192, 194, 195, 201
 thermal neutrons 124, 127
 thermodynamics of diagenesis 27–8
 thin layer chromatography (TLC) 139–41, 148
 Thomson, J. J. 222, 227
 thorium decay chain 237
 time of flight (ToF) 168
 tin 193
 total
 dissolved solids (TDS) 303
 ion count (TIC) 175
 touchstone 40
 trace elements
 bone 20, 21, 181
 hair 21
 human tissue 209–10
 teeth 21
 trade in illicit antiquities 20
 trajectories, diagenetic 28
 transformation, of organic material 149
 transition metals 243, 246, 247, 252
 transmethylation 143
 transmission electron microscopy (TEM) 110
 archaeological applications 122
 transmittance (*T*) 286
 transmutation 124, 126, 234
 transport vessels 150
 tree rings 209
 triacylglycerols 150, 163, 175
 triads 243
 triglycerides, *see* triacylglycerols
 triterpenoids 154
 trivial names 268
 Troodos Mountains 193
 trophic level 182
 tropical forest ecosystem 185
t-test 316
 tuberculosis 24
 tune solution 202
 twisting 78
- ultraviolet/visible spectroscopy (UV/vis) 25, 47,
 70–7
 detector 146
 spectrophotometer 72
 Ulu Burun shipwreck 156
 UNESCO convention on cultural property 20
 uniqueness, in provenance 15
 unpaired electron 252
 unsaturated fatty acids 149
 uranium
 decay chains 237
 in groundwater 29
 series dating 29
 urea 32, 263
 USA, isotope studies 184
- vacancy 94, 117
 valency 34, 250, 252
 variable 36
 van der Waals' bond 250, 259, 272
 vapor generation (VGAAS) 54, 60
 vegetable lipids 151
 vibration 78
 infrared active 84
 infrared inactive 84
 vibrational spectroscopy 70
 Villard, P. 225
 visible residues 148, 304
 visualization, in TLC 141
 vitalist theory 32
 Vogel, A. I. 41
 von Lenard, P. E. A. 228
 von Pettenkofer, M. J. 243

404 *Index*

- wagging 78
- water cycle 171
- wavelength dispersive X-ray fluorescence (WDXRF) 104, 111
 - applications 118
- wavenumber 77, 278
- wax 22, 156
- WebElements 234
- windowless system 104
- wine 25, 149, 154
- Winkler, C. A. 245
- within-run precision 313
- Wocel, J. E. 12
- Wöhler, F. 32, 89
- work function (ϕ) 280

- X-ray 93–101, 224, 226, 288
 - absorption 107
 - absorption edge 98
 - characteristic 94
 - continuum 99
 - de-excitation 95, 118
 - fluorescent 101
 - primary 101, 107
 - production 94
 - secondary 101, 102, 104, 107, 110, 117
 - selection rules 96
 - spectra 245
 - spectroscopic notation 94
 - tube 99, 100, 104, 106
- X-ray diffraction (XRD) 113–16, 220, 292
- X-ray fluorescence (XRF) 8, 11, 12, 19, 101–9
 - archaeological applications 118–20
 - energy dispersive (EDXRF) 102, 111, 127
 - hand-held 11
 - limits of detection 108
 - matrix effects 108
 - surface sensitivity 107
 - wavelength dispersive (WDXRF) 104, 111
- X-ray photoelectron spectroscopy (XPS) 101, 107, 117

- Young's slits 279

- zinc, anthropogenic fractionation 19