

## Index

### **a**

absorbance 8, 77, 146, 260, 261, 264,  
266–268, 272, 282, 285, 287, 288,  
290, 294, 345, 346

absorption and emission measurement,  
polarized light  
linear dichroism 281, 282  
luminescence anisotropy 283–284,  
350, 434

absorption dissymmetry factor 285,  
286

absorption spectroscopy  
double-beam instruments 259, 260  
qualitative and quantitative  
applications 260  
single-beam instruments 259

actinometry  
absolute actinometers 289  
azobenzene 291  
chemical actinometers 289  
potassium ferrioxalate 289–290  
potassium reineckate 290–291

adiabatic potential energy surface 19,  
62

adiabatic processes 62, 63, 157

aggregation-induced emission (AIE)  
489–493

aggregation-induced quenching (AIQ)  
489

alkenes 173–180, 182

ammonia 32–34

AND logic gate 344, 345

aniline 117

anisotropy 283–284, 350, 434

anthracene 183, 184, 281, 344, 349

arc lamps 245–247, 261, 271

aromatic compounds  
benzene 38–40, 115–116  
benzophenone 89–90, 186  
naphthalene 86–89, 184

artificial leaf 414, 415

artificial photosynthesis  
carbon dioxide reduction 405  
water oxidation 405

aryl halides 322, 323, 326, 327

atmospheric photochemistry 457–459

atomic orbital (AO) 13, 15, 21, 22, 24,  
26, 27, 31, 33, 35, 40, 43, 99

Aufbau Principle 14, 15, 17, 22

avoided crossing 62–63, 133, 175

azobenzene 189, 365, 383, 384, 429,  
472, 496, 498  
actinometry 291  
photochromism 448

azulene 73

### **b**

back electron transfer 157–158, 355,  
369, 371, 375

bacterial photosynthesis  
*Rhodospseudomonas viridis*, RC  
structure 399, 400

- bandgap energy 99, 102, 103, 409, 465  
 bathochromic shift 78–80, 437  
 Beer–Lambert law 7, 260, 287  
 benzene 38–40, 115  
 benzophenone 89–90, 117, 186, 494  
 biacetyl 281  
 bimolecular quenching  
   kinetic details 146, 147  
   static vs. dynamic quenching  
     147–148  
   Stern–Volmer equation 144–146,  
     267–268  
 binuclear Ru complexes 129, 131  
 bioluminescence 1, 440–441  
 biphotonic processes 66, 427  
 BODIPY 72  
 Born–Oppenheimer (BO)  
   approximation  
     adiabatic PES 62  
     conical intersections 62, 63  
     light absorption 56  
     Schrödinger equation 18  
     total molecular energy 20  
 1,3-butadiene 178
- C**
- caprolactam 476  
 carbonyl compounds  
   ketones and aldehydes 186  
   photochemical primary processes  
     186–188  
   photoreactions 186  
 carotene 186, 357–359, 403, 502  
 catalyzed deactivation 168  
 catenane 367, 380–383  
 cells and irradiation equipment 255  
 charge recombination 70, 103, 155,  
   158, 256, 354, 356, 358, 361, 400,  
   413, 414, 465, 502, 504  
 charge separation 158, 355–361,  
   398–402, 407–409, 412, 462, 465,  
   501–504  
 charge-transfer process 70–73, 294,  
   333  
 charge-transfer state 70, 73, 502  
 chemical reactions  
   conventional chemical time-scale  
     75  
   electronically excited state 75  
   unimolecular excited-state processes  
     75  
 chemical synthesis and light  
   caprolactam 476  
   perfumes 477–478  
   photochlorination, polymers 476  
   vitamins 476–477  
 chemiluminescence 82, 306, 309,  
   314–315  
 chirality-induced spin selectivity (CISS)  
   503–504  
 chlorofluorocarbons (CFCs) 458, 459  
 chloromethane 191  
 chromium complexes 93–95, 119, 205,  
   217–222, 308, 320, 485, 486  
 circular dichroism 284  
 circularly polarized luminescence 221  
 cobalt complexes 95–97, 199–201, 236,  
   320, 433  
 Condon approximation 56, 61  
 conduction band (CB) 99, 256, 330,  
   408, 424, 459, 464  
 $[\text{Co}(\text{NH}_3)_6]^{3+}$  50, 95–98, 200, 201  
 conical intersections 62, 63, 176, 423,  
   425  
 copper complexes 201–202, 205, 224,  
   226–228, 433, 485–488, 499  
 coronene 130  
 correction of spectra  
   emission 263  
   excitation 263–264  
 Coulombic mechanism 162–167  
 $[\text{Cr}(\text{en})_3]^{3+}$  93–95  
 $[\text{Cr}(\text{NH}_3)_6]^{3+}$  50, 200  
 crown ether 362, 496, 497, 499  
 cycloaddition reaction 178, 182

- cyclobutene 176–177  
 cyclodextrin 138, 383, 384  
 cyclometallated complexes 467, 468  
   characteristics of 208  
   iridium 210–212  
   platinum 212–216  
   polypyridines 208  
   rhodium 208–210
- d**
- d atomic orbitals 42  
 decoding 344–347  
 delayed fluorescence 82–83, 87, 89,  
   95, 152, 228, 234, 467, 487, 495  
 dendrimer 140, 350–353, 384, 435  
 detectors, in photochemistry 256–258  
 Dexter mechanism 165  
 diabatic processes 63, 157  
 dichroism 281, 284  
 dicyanoethylene 158  
 di- $\pi$ -methane reaction 178  
 dimethoxynaphthalene 158  
 dimethylaminobenzonitrile 118–119  
 dioxygen 83–86, 88, 146, 150, 168, 402,  
   403, 493  
 dipole-dipole mechanism 163–165  
 DNA photocleavage  
   nucleic acid 432–433  
   photoinduced electron-transfer  
     processes 433  
 donor-acceptor complexes 133–135  
 dye lasers 247, 248, 252  
 dye-sensitized solar cells (DSSCs) 225,  
   412, 447, 463–465, 501  
 dynamic quenching 147–148, 297,  
   320, 326, 495
- e**
- efficiency of a process 8  
 Einstein (unit) 7  
 Einstein coefficients 73  
 electrochemiluminescence (ECL) 122,  
   309–310, 345, 467, 493  
 electrocyclic processes 176–177  
 electroluminescent materials  
   LECs 467–469  
   LEDs 465–466  
   OLEDs 466–467  
 electromagnetic spectrum 5, 6, 423,  
   457  
 electronic configuration 14–18, 21, 22,  
   24–27, 31–37, 39–42, 47–53  
 electron transfer 119–122, 143  
   electronic factor 158–160  
   extension cables 362–363  
   Marcus theory 154–157  
   photosensitization 311  
   quantum mechanical theory 157  
   switches 360–361  
   wires 354–360  
 El-Sayed rules 68, 90  
 emission  
   anisotropy 283–284, 350, 434  
   spontaneous 73, 74, 249  
   stimulated 73, 248, 249, 252, 423  
 emission lifetime measurements  
   data analysis 278–279  
   luminescence lifetime standards  
     281  
   phase shift 279–281  
   single flash 274–275  
   single-photon counting 276–278  
   upconversion techniques 276  
 emission spectroscopy  
   emission quantum yields 268–271  
   emission spectra 263  
   excitation spectra 263–264  
   instrumentation 261–262  
   luminescence intensity vs.  
     concentration 266–267  
   spurious bands 264–266  
 encoding 344–347  
 encounter complex 146–150, 168, 185  
 energy-gap law 69, 155, 228  
 energy migration 151, 165, 283, 284,  
   351, 353, 398, 462

- energy reservoir 95, 137–138
- energy transfer
- Coulombic mechanism 163–165
  - exchange mechanism 165–166
  - Fermi golden rule 162
  - Franck–Condon factor 162
  - Marcus-type kinetic approach 161
  - trivial energy transfer 161
- energy transfer 143, 161–167
- Dexter mechanism 165
  - dipole-dipole mechanism 163–165
  - Förster mechanism 163–165
  - Förster resonance energy transfer (FRET) 163–165
- energy transfer, molecular devices
- light-harvesting antennas 350–354
  - plug/socket systems 349–350
  - switches 348–349
  - wires 346–348
- energy-transfer photosensitization 318
- energy upconversion 138, 151–153, 222
- eosin 82
- environmental protection,
- photocatalysis
  - photo-assisted Fenton reaction 332
  - pollution remediation 332–333
  - principles 331
  - solar disinfection (SODIS) 331
- ethene 35–38, 58, 114, 115, 173
- ethyne 114–115
- exchange mechanism, energy transfer 165–166
- excimer 214
- definition 125
  - potential energy curves 126
  - supramolecular systems 138–140
- exciplex 377
- definition 125
  - supramolecular systems 138–140
- excited-state
- catalyzed deactivation 168
  - dipole moments 117–119
  - energy 110–111
  - excimers and exciplexes 125–127
  - geometry 111–112
  - lifetime 109–110
  - proton transfer 122–125
  - redox properties 119–122
- exciton 100, 102, 103, 353, 456, 462, 463, 466, 500, 502
- experimental techniques
- absorption and emission
    - measurement, polarized light 281–286  - apparatus 245–258
  - fluorescence correlation spectroscopy (FCS) 296–297
  - photothermal methods 292
  - reaction quantum yields 287–291
  - single-molecule spectroscopy 294–296
  - X-ray techniques 297–298
- explosives detection 456
- f**
- Fenton reaction 332
- Fermi golden rule 68, 157, 162
- Fermi level 100, 101
- filters 253–254
- flash photolysis 152, 234, 271
- fluorene 124
- fluorescein 82, 269
- fluorescence (definition) 73
- fluorescence anisotropy 283–284, 350, 434
- fluorescence correlation spectroscopy (FCS) 296–297
- formaldehyde 40–42, 57, 116, 117, 186
- Förster cycle 123–124
- Förster-mechanism 163
- Förster resonance energy transfer (FRET) 163–165 348, 351, 437, 438

Franck–Condon factor 62, 70, 74, 86,  
160, 162, 400  
Franck–Condon principle 57, 59–62,  
64, 84, 86, 112, 286  
fullerene 183, 357, 358, 361, 462

**g**

geometry, excited states  
  benzene 115–116  
  ethene 114  
  ethyne 114–115  
  formaldehyde 116  
  Franck–Condon principle 112  
  small molecules 112–114  
  square planar metal complexes  
    116–117  
gerade symmetry 12, 58  
green fluorescent protein (GFP)  
  433  
green photochemistry 319  
Grothaus–Draper law 2, 7  
group theory 27–31

**h**

halogen compounds 190–193  
harmonic bands 252, 264–266  
HAT process 327–330  
heavy-atom effect 59, 88, 94, 168, 180,  
191  
heterogeneous photocatalysis 101,  
320, 330–332  
hexaphenylsilole 489  
hexathiobenzene 490  
hexathiophene 491  
highest occupied molecular orbital  
  (HOMO) 14  
history of photochemistry 2  
holography 67, 474–475  
hopping mechanism 158, 167, 347,  
433  
Hund's rules 14, 16, 18, 22, 51, 229  
Hush theory 160  
hydrogen atom 11–13

hydrogen atom transfer 320  
hydrogen evolution 412–415  
hyperfine interaction 68–70  
hypsochromic shift 78–80, 437

**i**

image intensifier 257  
incandescent lamps 245–247  
inner filter effect 266  
inorganic photovoltaic (PV) cells  
  concentrated photovoltaic (CPV)  
    systems 460  
  silicon 459  
integrating sphere 269–271  
internal conversion 68, 70, 73, 74, 76,  
86–88  
intersystem crossing 68, 70–73, 76, 82,  
83, 88–90  
intervalence transfer 133  
intraconfigurational excited states 26,  
49, 52  
inverted region, electron transfer 155,  
160, 320, 400  
iridium complexes 205, 207, 211, 320,  
322, 323, 347, 430, 468, 490  
iron complexes 225, 290  
irreducible representation 22, 28–30,  
33, 58, 68

**j**

Jablonski diagram  
  electronically excited states 64  
  energy 64  
  formaldehyde 42  
  ground and excited states, molecule  
    64  
  light absorption 42  
  organic molecules 64  
  photophysical processes 64  
  time 64–65  
jaundice 426  
j-j coupling 14, 15

**k**

Kasha's rule 73, 76, 83, 264  
 Koopmans' theorem 203, 209

**l**

lanthanide complexes 131, 231, 433, 455  
 lanthanide ions 51, 451  
 lanthanoids 228–231  
 Laporte rule 220  
 laser  
   four-level systems 249  
   Nd:YAG laser 250  
   population inversion 248–252  
   properties 251  
   ruby laser 249–250  
   three-level systems 249  
   Ti:sapphire laser 250–252  
 leaf color 403  
 lifetime 109–110  
 lifetime of excited states 8, 76  
   temperature dependence 81  
 ligand-centered (LC) transitions 48, 49, 199, 209, 228  
 ligand-to-metal charge-transfer (LMCT) 48, 53, 199, 329, 486  
 light absorption  
   Bohr equation 55–57  
   Born–Oppenheimer approximation 56  
   dipole moment operator 56  
   eigenfunctions 56  
   electronic transition moment 57  
   Franck–Condon principle 59–62  
   oscillator strength 56  
   Schrödinger equation 55  
   spin selection rules 59  
   symmetry selection rules 57–59  
 light absorption sensitizers (LAS) 310–312  
 light conversion and chemical energy  
   chemiluminescence 309–310  
   ECL 310  
   LAS 311  
   LES 312  
   oscillating chemiluminescence 314–315  
   [Ru(bpy)<sub>3</sub>]<sup>2+</sup> 307  
 light emission sensitizers (LES) 312–314  
 light-emitting diodes (LEDs) 447, 465–466  
 light-emitting electrochemical cells (LECs) 210, 310, 447, 467–469  
 light for chemical synthesis  
   caprolactam 476  
   hotochlorination, polymers 476  
   perfumes 477–478  
   vitamins 476–477  
 light-harvesting antennas 150, 350–353, 398, 401, 407, 431, 491, 499  
 light-powered molecular devices 339–385  
 light-powered molecular machines 2, 363–385  
 light sources, experimental techniques  
   arc lamps 245–247  
   dye lasers 247, 248  
   high-pressure lamps 246–247  
   incandescent lamps 245, 246  
   xenon lamps 246  
 linear combination of atomic orbitals (LCAO) 21, 22  
 linear dichroism (LD) 281–283  
 linkage photoisomerization 237  
 lowest unoccupied molecular orbital (LUMO) 26  
 luciferins 441  
 luminescence *see* emission  
 luminescence dissymmetry factor 285, 286  
 luminescence anisotropy  
   depolarization processes 284  
   energy migration 284

- linearly polarized light, excitation 283
  - trivial processes 284
  - luminescence intensity measurements
    - emission wavelength 267
    - excitation wavelength 266–267
    - geometric factors 266
    - inner filter effects 266
    - optically diluted solutions 266
  - luminescent metal complexes
    - chromium(III) 93
    - copper 201–202
    - Cr(III) and V(III) Complexes 485–486
    - Cu(I) Complexes 486–488
    - iridium(III) 212
    - iron(III) 225
    - lanthanoids 228–231
    - platinum(II) 216
    - porphyrin 91, 231–234
    - rhodium(III) 210
    - ruthenium(II) 97, 208
  - luminescent molecular thermometer (LMT) 451
  - luminescent sensors 343–344
    - amplifying signal 435–436
    - detection explosives 455–456
    - measuring blood analytes 439–440
    - oxygen sensing and bioimaging 436–437
    - principles 434–435
    - thermometers 451–453
    - voltage neuron sensor 437–439
    - warfare chemical agents 453–455
    - wind tunnel research 450
  - luminophore 137, 434, 450, 451, 489, 490
- m**
- manganese complexes 224
  - Marcus theory 154–157, 320, 400
  - matrix isolation 254
  - metal centered (MC) transitions 48, 49, 98, 198, 485
  - metal complexes 197
    - chromium(III) 93
    - cobalt(III) 95, 201
    - copper(I) 201–202, 228
    - excited-state redox potentials 206
    - iridium(III) 212
    - iron(III) 225
    - lanthanoids 229
    - luminescence 209
    - platinum(II) 216
    - rhodium(III) 206, 210
    - Ru(II)–Ru(III) complex 131
  - metallophilic interactions in Pt(II) complexes 492
  - metalloporphyrins 231, 232, 234
  - metal–metal to ligand charge transfer (MMLCT) 492
  - metal-to-ligand charge-transfer (MLCT) transitions 47, 53, 199
  - methane 34–35, 396, 405
  - microstate 15, 16, 18, 24, 26, 51
  - mixed-valence compounds 131–133
  - molar absorption coefficient 8, 72, 75, 77, 80
  - molecular devices, electron transfer
    - extension cables 362–363
    - switches 360–362
    - wires 354–360
  - molecular devices, energy transfer
    - light-harvesting antennas 350–353
    - plug/socket systems 349–350
    - switches 348–349
    - wires 346–348
  - molecular devices, information processing
    - molecular logics 343–346
    - photochromic systems 342–343
  - molecular logics 343
    - AND logic gate 344
    - decoding 344–346

- molecular logics (*contd.*)  
 encoding 344–346  
 luminescent sensors 343–344
- molecular orbital (MO) theory 11  
 atoms to molecules 18–22  
 group theory 27  
 heteronuclear diatomic molecules 26–27  
 homonuclear diatomic molecules 22–26  
 polyatomic molecules 27
- molecular organic photochemistry  
 aromatic compounds 180–186  
 carbonyl compounds 186–188  
 saturated oxygen and sulfur compounds 190  
 solid-state photochemistry 191–193
- molecular pumps 372
- molecular shuttles 373, 374
- molecular walkers 377–380
- monochromators 252–254, 259, 260, 262–266, 285, 286
- multiphotonic processes 2, 7, 66–67, 276
- n**
- naphthalene 7, 86–89, 124, 269, 281, 361, 369, 451
- 2-naphthol 122–124
- natural photosynthesis 111, 155, 317, 324, 359, 398–404, 414
- Nd(III) complexes 51, 352
- Nd:YAG laser 250, 252
- nitrogen compounds 188–190
- nitrobenzene 117
- nonadiabatic potential energy surface 62
- nonlinear process 248, 276
- nonradiative process 8
- nonspectroscopic state 114
- nonvertical state 114, 175
- normal region, electron transfer 156, 160
- Norrish photoreactions 187, 271
- nuclear factor, electron transfer 160
- o**
- optical brightening agents (OBAs) 457
- optical electron transfer 157, 160, 161
- optically diluted solutions 266
- optical parametric amplifiers (OPA) 251, 273
- orbital angular momentum 12, 14–15, 18
- organic light-emitting diodes (OLEDs) 465
- organic solar cells (OSCs) 414, 447, 462–463
- oscillating chemiluminescence 314–315
- oscillator strength 56, 74, 163, 165, 167, 487, 488
- osmium(II) complexes 205, 269, 320, 347, 352
- oxygen atom 15, 16
- oxygen-evolving complex (OEC) 401 413–414
- oxygen molecule  
 atmospheric 457–459  
 electronic states 83  
 quenching 450  
 singlet oxygen 180, 427
- p**
- paramagnetic quenching 168
- Paternò-Büchi reaction 187
- Pauli principle 13, 15, 34
- perfumes 477–478
- perovskite 415, 460–462, 465
- perovskite solar cells 461
- peryleneimide 323–325, 361
- phenol 124, 269, 360
- phosphorescence, definition 73
- photoacoustic spectroscopy 292–294
- photoactivated chemotherapeutic (PACT) 428, 429



- photoactivated molecular machine
  - 495–498
- photoactivated molecular tweezer
  - 498–499
- photo-assisted Fenton reaction 332
- photocage 428, 430
- photocatalysis 317–332
  - environmental protection 331–333
  - heterogeneous 330–331
  - TON and TOF 407
- photocatalytic processes 317–320, 328, 330, 407
- photocatalytic solar hydrogen
  - production 505
- photocatalytic water splitting 504–505
- photochemical damage, living systems
  - DNA 424–425
  - proteins 425–426
- photochemical primary process 2
- photochemical secondary process 2
- photochromic systems 360
  - applications 449
  - definition 447
  - ophthalmic industry 449
- photocleaving agents, nucleic acid
  - 432–433
- photocontrolled valves 383–385
- photocycloaddition reactions
  - 178–179, 183, 192
- photodegradation 185, 332, 424, 439, 470
- photodimerization 178, 179, 184, 192
- photodynamic therapy (PDT)
  - photosensitizer 426
  - singlet oxygen lifetime 427
- photoelectrochemical cells 101, 225, 407, 408, 410, 412–415, 463
- photoinduced chain reaction 318
- photodiode 256
- photodissociation reactions 235
- photogalvanic effect 312, 313
- photoisomerization
  - azobenzene 189, 291, 448
  - double bonds 174–176
  - metal complexes 116–117, 235
  - photochromic compounds 447
- photolithography 472–473
- photomultiplier 256, 257
- photooxidation reactions 236
- photophysical process 2, 64
- photopolymerization 138, 153, 192, 469–470
- photorearrangement 182, 192
- photoredox catalysis 318
  - merging photocatalytic and organocatalytic cycles 322
  - reductive dehalogenation catalyzed by visible light 322
- photoreduction reactions 236
- photorefractive spectroscopy 293–294
- photosensitizer 152, 153, 184, 210, 221, 224, 225, 311, 317, 322, 326, 331, 367, 370, 371, 410, 413, 426, 464, 495
- photostabilizers 470
- photostationary state 77, 174–176, 189
- photosubstitution 180–182, 235, 430
- photosynthesis 1, 6, 111, 153, 155, 210, 317, 324, 330, 350, 357, 359, 375, 395—415, 421, 423, 505
  - artificial photosynthesis 405–413
  - natural photosynthesis 398–404
  - Z-scheme 324, 401, 402, 411, 412
- phototherapy 426, 431
- photothermal methods
  - photoacoustic spectroscopy 292, 293
  - photorefractive spectroscopy 293, 294
- phototransposition 182
- photovoltaic (PV) cells 459–462
- platinum complexes 116–117, 198, 212–216, 430, 436, 450, 492, 493
- polarized light 117, 281–286
- polyelectronic atoms
  - angular momentum 14

- polyelectronic atoms (*contd.*)  
   electron nucleus interaction 15  
   electronic configuration 14  
   Pauli principle 13  
   Russell–Saunders coupling 14  
   spin–orbit interaction 14
- polymers and light  
   holography 474–475  
   photochemical curing 471  
   photodegradation 470  
   photolithography 472–473  
   photopolymerization 469–470  
   stabilization, commercial polymers  
     470–471  
   stereolithography 473–474
- polyoxometalates 327–330
- porphyrins 91, 93, 129, 130, 136, 188,  
 207, 231–234, 348, 350, 351, 353,  
 357–359, 361, 403, 427, 436, 450,  
 465, 467
- potential energy surface (PES)  
   crossing and conical intersection 62  
   excited-state vibrational level 61  
   Franck–Condon principle 59–62  
   radiative and radiationless  
     deactivations 63
- proton transfer 122–125, 273, 359,  
 360, 406, 470
- psoriasis, photochemotherapy 431
- pump-probe technique 273
- pyrene 126–127, 137, 139, 448, 452
- q**
- Q-switching 251
- quantum counter 264
- quantum efficiency 8, 9
- quantum dots 99, 101–103, 296, 433,  
 462, 463, 499
- quantum yield 76, 83  
   definition 8–10  
   emission 83, 268–271  
   reaction 287–288
- quenching  
   constant 145  
   definition 143  
   dynamic 147–148  
   paramagnetic 168  
   static 147–148  
   Stern–Volmer equation 144–146,  
     267–268
- quinine sulfate 269
- r**
- radiationless deactivation 63, 67–73
- radiative deactivation 65, 73–75
- radiative lifetime 74–75, 90, 99,  
 185, 207
- radiative process 8
- radical-pair intersystem crossing  
   (RP-isc) 70, 356
- Raman bands 264, 265
- Rayleigh and Tyndall bands 264
- Rayleigh scattering 264, 266, 269, 295
- Reichardt's dye 80
- reorganizational energy 131, 155
- rhenium complexes 237, 430
- rhodamine B 264, 281, 384
- rhodium complexes 205–210, 355,  
 430, 433
- rhodopsin 422, 423
- rigidochromism 80
- rose Bengal 281
- rose oxide 477
- rotaxanes 367–378, 390–393, 496
- $[\text{Ru}(\text{bpy})_3]^{2+}$  52, 53, 97–99, 121, 152,  
 198, 202–208, 219–223, 225, 264,  
 265, 269, 278, 279, 281, 307–315,  
 319, 322, 345–347, 362, 363, 371,  
 373, 376, 406, 413, 428
- ruby laser 95, 249
- ruthenium complexes 81, 124, 131,  
 132, 137, 320, 352, 355, 427, 428,  
 430, 433, 464
- correlation, spectroscopic and  
     electrochemical parameters  
     204, 205

- electrochemical properties 203
- excited-state redox potentials
  - 204–206
- polypyridine complexes 202–204
- solar cell 464
- Russell–Saunders coupling 14, 15, 18, 25, 51
  
- S**
- sacrificial system 225, 321, 322, 324, 327, 371, 374–377, 411, 412, 488
- Schrödinger equation 11–13, 18, 19, 55
- selection rules
  - definition 57
  - spin 59
  - symmetry 57–59
- semiconductors
  - conduction band 99
  - electron–hole charge carriers 100
  - electronic energy levels 99
  - Fermi level 100
  - p–n junction 101, 459
  - quantum dots 102–103
  - radiative transitions 101
  - valence band 99
- sensitized luminescence 143, 148
- sensitized reaction 143
- Shockley–Queisser limit 500
- sigmatropic rearrangement 177–178
- single-molecule spectroscopy (SMS)
  - 294–296
- single-photon counting 276–278
- singlet fission 499–503
- singlet oxygen 72, 86, 150, 166, 180, 184–186, 234, 424–428, 432, 478
- sodium atom 17, 18, 83, 84
- solar cells
  - definition 459
  - DSSCs 463–465
  - inorganic photovoltaic (PV) cells 459–462
  - Shockley–Queisser limit 460
  - solar disinfection (SODIS) 331
  - solar energy
    - artificial photosynthesis 396, 405
    - natural photosynthesis 398
  - solid-state photochemistry 192–193
  - solvatochromic dyes 80
  - solvatochromic shift 77
  - solvent and temperature effects
    - crossing of states 81
    - excited state lifetime 81
    - solvatochromic shift 77–80
    - thermally activated delayed fluorescence 82–83
  - Soret band 91
  - spectral overlap 161–164
  - spectrofluorimeter 146, 252, 261, 262, 264, 267, 269, 275, 276, 281, 283, 286, 298
  - spin-allowed transition 59
  - spin angular momentum 12, 25
  - spin crossover (SCO) 223–224
  - spin-flip phosphorescence 218
  - spin-forbidden transition 59
  - spin multiplicity 53, 59, 68
  - spin–orbit charge-transfer intersystem crossing (SOCT-isc) 70, 71
  - spin–orbit coupling 15, 51, 59, 68, 69, 72, 76, 88, 168, 174, 198, 229, 487
  - spontaneous emission 73
  - Stark–Einstein law 2
  - state diagram 11, 15, 17
  - static quenching 147, 326
  - steady-state spectroscopy 258–271
  - stereolithography 473–474
  - Stern–Volmer equation 144–146, 267, 321, 326
  - stilbene 175, 380, 457
  - stimulated emission 73, 248
  - Stokes shift 74, 120, 218, 219, 250, 267
  - stray light 252
  - streak camera 257, 258, 273, 275
  - sulfur compounds 190
  - sunscreens 255, 423–425

- superexchange mechanism 158, 166, 167, 347, 355, 433
  - superfluorescence 462
  - supramolecular systems 129–131
    - donor–acceptor complexes 133–135
    - excimers and exciplexes formation 138–140
    - excited state 135–138
    - mixed-valence compounds 131–133
  - symmetry allowed transition 41, 86
  - symmetry forbidden transition 58
- t**
- term symbol 14, 25
  - tetracene, singlet exciton fission 502
  - tetracyanoporphyrin (TCNP) 359
  - thermally activated delayed
    - fluorescence (TADF) 82–83, 87, 228, 467, 487, 494, 495
  - thermometers
    - luminescent molecular thermometer (LMT) 451
    - Ni(II) complex 451
    - thermographic phosphors 451
  - time-correlated single-photon counting (TCSPC) 276–278
  - time-resolved spectroscopy 271–281
  - Ti:sapphire laser 250–252, 273, 276
  - titanium dioxide 101, 330–333, 402, 410, 412–414, 424, 463, 464, 469
  - transient absorption spectroscopy
    - femtosecond resolution 273–274
    - flash photolysis 271
    - nanosecond resolution 271–273
  - transient grating (TG) 293, 294
  - transient lens (TL) 293
  - transition metal complexes 42–49, 197–200
  - transition moment 56, 281–283
  - transmittance 253, 254, 271
  - triplet–triplet annihilation 82, 151–153, 248, 503
  - trivial energy transfer 161
  - tryptophan 426
  - turnover frequency (TOF) 407
  - turnover number (TON) 318, 407
  - twisted intramolecular charge transfer (TICT) 118, 119, 452
  - two-photon driven photoredox catalysis 322–327
- u**
- ungerade symmetry 12, 58
  - upconversion processes 66, 151, 222
- v**
- valence band (VB) 99, 256, 408, 462
  - vanadium complexes 433, 485, 486
  - vertical transition 61
  - vibrational relaxation 67, 162, 176, 250, 273, 500
  - vibronic coupling 59, 68, 229
  - vision
    - opsine 422
    - photoreceptor 421
    - primary photochemical 422, 423
    - retinal 422
    - rhodopsin 422, 423
  - vitamins, synthesis of 476–477
  - voltage neuron sensor 437–439
- w**
- warfare chemical agents
    - fluorescent detection 453, 454
    - Sarin, Soman, and Tabun 453
    - sulfur mustard (SM) 453–455
  - water 31–32

water splitting  
  by photocatalytic semiconductor  
    nanoparticles 408–412  
  in photoelectrochemical cells  
    412–415

Wigner spin conservation rules 149

wind tunnel research 436, 450

Woodward–Hoffmann orbital  
  symmetry rules 177

## **X**

X-ray absorption spectroscopy (XAS)  
  223, 227, 298

X-ray techniques

  diffraction techniques 298

  XAS 298

  X-ray fluorescence excitation  
    spectroscopy 298

xenon lamps 246, 275

## **Z**

Zn(II) porphyrin 129, 130, 136, 465

Zn(II) tetraphenylporphyrin 91–93

Z-scheme 324, 401, 402, 411, 412















