Index

a-helix 5
1. law of thermodynamics 42
2. law of thermodynamics 44

a
acetyl choline receptor 297
acetylcholine 297
acetylcholine receptor 297
actin filaments 43
action potential 36, 302, 305, 306
– changes in lipid state 306, 310
– fluorescence 306
– forces 306, 309
– isentropic pulses 311
– phase transitions 310
– reversible heat changes 306, 309
– saltatory conduction 307
– thickness changes 306
– thickness changes 309
activation
– thermal 252
activity coefficient 109
adiabatic 55
adsorption 189
AFM 149, 151
aggregation 198
alamethicin 141, 151, 189
alcohols 327
alkaline phosphatase 10
all-trans configuration 16
amino acids
– apolar 66
– transfer from oil to water 67
amoeba 36
anesthesia 1, 36, 39, 320
– alkansols 327
– effect of calcium 333
– freezing point depression 327
– inflammation 333
– influence on lipid melting 327
– neurotransmitters 334
– pH dependence 333
– pressure profile 331
– pressure reversal 330, 332
anesthetics 111, 112
– additivity 325
– liquid 326
– volatile 326
anesthesia
– alcohols 327
anomalous subdiffusion 168
antibiotic peptide 285
arachidic acid 33
arachidonic acid 33
asymmetry 7
– in lipid composition 34
atomic force microscopy 130, 131, 149, 151, 262
ATP 43
axon 301, 305, 313
– squid 302

b
bacillus subtilis 36, 92
bacteriorhodopsin 141, 162
band 3 protein 145, 162
barophilic bacteria 38, 40
bending 213
bending modulus 218, 220, 231, 237, 239, 247, 251, 252
– DPPC 251
bending rigidity 239
benzine 66
bicontinuous phases 24
bilayer 4, 6
bilayer network 239, 259
bilayer networks 271
bilayer stack 247
bilayers 30
binding
– asymmetric proteins 197
– charged drugs 260, 261
– Langmuir isotherm 189
black lipid membrane 291
Boltzmann constant 52
Boltzmann distribution 51, 125
brain lipoids 326
Brownian motion 165
budding 253
cable theory 311
calcium 3
– influence of membrane permeability 295
calcium channel 297
calorimeter 53
calorimetry
– pressure 87, 234, 235
cannabis 323
canonical ensemble 50, 51, 225
capacitor 43
capillary forces 8, 9
carbon dioxide 323
cardiolipin 30–32
carbon dioxide 32
chain melting 9, 35, 75, 252
charge density 258
chemical potential 47, 99, 100, 109, 110, 113, 292
circularity 31, 215, 218
chloroform 323
cholesteric 214
cubicle 1, 32, 119, 120, 159, 212, 249, 284, 285, 326
clathrate structures 63, 73
coke 323
cold denaturation 69
compressibility
– lateral 94
– monolayers 94
compressibility 10, 42
– additivity 230
– adiabatic 55–57, 241, 242, 244, 312
– area 227, 229, 230, 237–240, 245, 246, 248
– isentropic 312
– isothermal 241, 312
– isothermal area 54, 55, 229
– isothermal volume 54, 55, 228
– lateral 291, 312
– liquids 225
– volume 227, 238–240, 245
compression modulus 227–229
– area 230
computer models 123
conductance 304
– lipid membrane 291
cold denaturation 69
confocal fluorescence microscopy 137
continuous transition 134
cooperative unit size 85, 87
cooperativity 85, 87, 99, 131, 263
coordination number 128
critical behavior 134
critical micelle concentration 16
critical point 114, 134
critical slowing-down 283
cubic phase 24, 220, 222
cubic phases 27
cubic space groups 24, 25, 27
current–voltage relationship 293, 294
curvature 79, 253, 257, 267
– radius of 230
– spontaneous 258
curvature transitions 274
cytochrome b_{5} 144, 162
cytochrome c 6, 153, 154, 163, 189, 196, 200
cytochrome c oxidase 141
d Danielli and Davson
– membrane model 2
Debye constant 65
Debye length 66, 175
Debye–Hückel theory 74
dendrite 301
densitometry 232, 234
density 89
density of states 134
detailed balance 125
detergent 159, 160
detergent extraction 120, 159, 163
detergent resistant membrane 163
detergent-resistant domain 159
diacyl glycerols 32, 118
diacyl phosphatidylcholine 272
diacyl phosphatidylethanolamines 262
diacyl phosphatidylethanolamine 262
dielectric constant 64, 66, 74
– table 65
diethylether 323
differential scanning calorimeter 76
differential scanning calorimetry 75, 76
diffuse double layer 173
diffusion 6, 135, 165, 168
anomalous 168
confinement 169, 170
constants 165, 166, 171
corralled 169, 170
obstacles 169
with flow 169
dipalmitoyl phosphatidylcholine 316
dispersion 312, 315
dispersion forces 83
divalent ions 66
DLPC 116, 272
DMG 91, 118
DMPC 25, 79, 80, 91, 116, 118, 135, 136, 239, 256, 260, 263, 272
DMPC–DSPC mixtures 248
DMPE 91, 116
DMPG 26, 116, 153, 256, 259, 260
DNA 31
domain boundaries 132
domain formation 8, 31, 131, 136
domain interface 248
fluctuations 138
domains 87, 108
coexistence 252
dopamine 334
DOPC 35, 75
DPPE 30
DPPG 30, 260
DPPS 30
DRM 159, 160
detergent resistant membrane 163
DSC 75, 76
DSPC 36, 80, 91, 116, 135, 136, 263
e
E. coli 36, 37, 39, 232
E.coli 9, 92
ED50 effective anesthetic dose 325, 326, 328, 329, 335
efficiency 43, 44
elasticity
bending 247
elastic constants 55, 79, 109, 251, 273
nonlinearity 312
temperature dependence 231
elastic theory of membranes 217
elasticity 10, 211
bending 230, 231, 238, 239, 245–248, 251
 electromechanical coupling 312, 317
electron density 19
electron microscopy 4, 5, 259
electrostatic 43
electrostatic potential 10, 64
electrostats 153, 199
binding of proteins 184
free energy 180
influence on melting 181
ion screening 175
lateral pressure 185
protonation 183
shift of pKₐ 183
endocytosis 252, 253
energy
internal 41, 42
ensemble
canonical 228
entropy production 58
equilibration 277, 278
equivalent circuit 305
ergodic theorem 126
ergosterol 32
erthrocyte 35, 326
erthrocytes 2, 6, 7, 32, 34, 35
ethane 66
ethanol 323, 327, 332
ether 3
Euler equation 314
eutic phase diagram 110
eutic point 111, 116
exocytosis 221, 252, 253
extensive variable 44, 47
extensive variables 41
f
fatty acid composition 34
fatty acids 32
FCS 170
Ferrenberg-Swendsen method 132
fibroblasts 10, 161
field
electrostatic 43
first order transition 134, 137
fission 260
fluctuation dissipation theorem 127
fluctuation theorem 54
fluctuations 54, 83, 126, 130, 165, 277
additivity 227
– area 229, 245
– at domain interfaces 248
– at protein interfaces with lipids 150
– autocorrelation 284
– curvature 245–247, 249
– domain size 283
– enthalpy 226, 234, 237
– Gaussian 282
– local 137, 248, 249
– volume 228, 234, 237
fluid mosaic model 4, 6, 7
fluid phase 17, 78, 79
fluorescence correlation spectroscopy (FCS) 169, 170
fluorescence recovery 169
fluxes
– thermodynamic 278, 279
force
– thermodynamic 281, 283
forces
– thermodynamic 278, 279
framicidin A 285
FRAP 169
free energy 46
– bending 258
– electrostatic 199
– Gibbs 257
freezing point depression 111, 327
function of state 41, 42
functions of state
– entropy 44, 45
– Gibbs free energy 46
– Helmholtz free energy 46
– internal energy 45
fusion 260
fusion pore 220, 252
– energy 222

G
gauche configuration 84
Gaussian distribution of states 282
Gaussian modulus 218, 220
gel phase 16, 78, 79
giant lipid vesicle 9, 10
Gibbs free energy 46
Gibbs’ isotherm 193
Gibbs’ phase rule 48, 105
– degrees of freedom 105
Gibbs–Duhem relation 48
Gibbs-Duhem relation 105
glass 159
glass beads 255
glycerol backbone 32
glycolipids 263
Gorter and Grendel
– membrane model 2
Gouy–Chapman theory 173, 318
– high potential approximation 179
– low potential approximation 178
Gouy-Chapman theory 66
GPI-anchored proteins 10, 161
gramicidin A 141, 142, 147–149, 162, 248, 249
– aggregate 249

h
H₂-phase 17, 23, 27
halothane 111
Hamiltonian 267–269
head group 3
head group orientation 280
head groups 30
heat 42
heat capacity 53, 68, 75, 76, 80, 127, 130, 134, 135, 226, 237, 239, 241, 242, 246, 281
– baseline determination 76, 77
– excess 226, 232, 234
– intrinsic 226
heat engine 43
Helmholtz free energy 46
hemagglutinin 161
hemoglobin 192
hemolysis 323
Hodgkin–Huxley model 302, 311
Hofmeister series 72–74, 293
Hooke’s law 214, 227
hTfR protein 161
human transferrin receptor 161
hydrodynamics 168, 314
hydrogel 107
hydrogen bonds 63, 73
– in ice 63
hydrophobic effect 15, 66, 74, 77, 141, 143
– free energy of transfer to water 66, 67
– influence of double bonds 67
– table for amino acids 68
– temperature dependence 67
hydrophobic matching 8, 71, 72, 74, 77, 141, 142
– chain length dependence 147
– protein function 152
hydrophobicity scale 70, 71, 74
hydrostatic pressure
– anesthesia 332

i
ice 63
– structure 63
ice structure 63
ideal gas 1
ideal mixture 109
ideal mixtures 99
ideal solution 99
ideal solution theory 113
inflammation 333
integral proteins 6, 10
intensive variable 44, 47
intensive variables 41, 292, 296
inverse hexagonal phase 17, 23, 27, 118
ion channel 4, 302, 303, 305
– current histogram 294
ion channels 297
– in lipid membranes 291
– in the absence of proteins 289
– proteins 289
– silicon rubber 298
ion channels in lipid membranes
– dependence on calcium 294
– dependence on intensive variables 293
– dependence on lateral pressure 296
– dependence on pH 295
– dependence on temperature 293
ion distribution
– around membranes 176
ionic strength 65, 256, 258, 260
– definition of 175
irreversibility 44, 45
Ising model 123, 128, 135, 138, 143, 267
– two dimensional 123
isolator 289
isotherm
– Hill 196
– Langmuir 192, 195
– scaled particle theory 194–196
– van der Waals 194–196
isotropic phase 118

k
K+–channel 303, 305
kinetics 165
Kirchhoff’s laws 305
kosmotropes 72, 73
Kratky balance 88, 232

l
lamellar phases 16
– $L_a$ phase 17
– $L_d$ 16
– $L_o$ 16
– $P_{2/1}$ phase 17
– ripple phase 17
Langmuir 194
Langmuir film balance 2
Langmuir isotherm 93, 189, 192, 195
Langmuir isotherms 95
Langmuir trough 94
lanosterol 32
lattice
– triangular 78
lattice models 123
lattice order 273
laughing gas 323
lauric acid 33
lever rule 102, 120
linkage relations 56
linoleic acid 33
lipid composition 29
– dependence on pressure 37
– dependence on solvents 39
– dependence on temperature 36
lipid melting 69
lipid recruiting 9
lipid–protein interactions 141
LIPIDAT database 81
lipids
– charged 258, 271
lipoids 1
liquid crystal
– cholesteric 212
– lyotropic 212
– nematic 211
– smectic 211
liquid crystals 211
liquid-condensed phase 94, 96
liquid-disordered phase 17, 78, 79, 119, 120
liquid-expanded phase 94, 96
liquid-ordered phase 78, 119, 120
liquid-ordered state 159
liver cells 32, 36
losartan 261, 262
luciferase 323
lung surfactant 92, 236, 285
– bovine 232, 235, 236
lysozyme 72

m
main transition 79, 80, 256, 263, 270
margainin 151, 189
mass action law 49, 190
mattress model 7, 9
Maxwell relations 55–57
mechanosensitivity 296
melibiose 152
melibiose permease 152, 162
melittin 151, 189
melting
– biological membranes 92
– coupling to geometry 258
– effect of chain length 260
– influence of curvature 253
– lipid mixtures 91
melting point depression 111, 112
melting temperature 81
Index

melt transitioning 8
membrane
– charge asymmetry 317
– negatively charged 199
membrane potential 177
membrane thickness 22
membranes
– supported 255
metastability 90
Metropolis algorithm 125
Meyer
– Hans 324
Meyer–Overton rule 324, 326
micelles 16
microcanonical ensemble 52
microscopy
– confocal 252
minimal surface 220
mitochondria 5, 6, 32, 34
mixing
– non ideal 123
mixing entropy 123
mixing gap 114, 115
molecular dynamics simulations 139
monolayer 2, 131, 157, 230, 231, 254
– inner 231, 245, 246
– outer 231, 245, 246
monolayer trough 93
monolayers 9, 10, 89, 93, 95, 158, 218, 255, 268
– domain formation 96
Monte Carlo simulation 152
Monte Carlo simulations 41, 123, 124,
126, 127, 130, 131, 135, 136, 143, 147, 150,
154, 155, 167, 283
Monte Carlo snapshot 130, 131, 136
Mouritsen and bloom
– mattress model 7
multilamellar phase 18
multilamellar vesicles, MLV 18, 19, 27
multilayer 246, 247
muscle 43
myelination 302
myosin 43
myristic acid 25, 33
myristoleic acid 33

n
Na+–channel 303
narcosis 324
narcotics 326
nearest neighbor interactions 128, 136,
143, 268
nerve 301
– bullfrog 306
– crab 306
– garfish olfactory 307, 308
– myelinated 306
– nonmyelinated 306
– pike olfactory 306
– rabbit vagus 306
nerve cell 5, 326
nerve pulse 289, 327
nerves 244
neuron 5, 32
neurotransmitter 285
neurotransmitters 262, 334
neutron diffraction 18, 27
neutron scattering 171
nitrous oxide 323
NMR 170
nuclear magnetic resonance (NMR) 170
nucleus 5

o
octanol 111, 325, 326
oil-water partition coefficient 1
olive oil 325
Onsager 279
Onsager1931 59
opalescence 25, 259
opium 323
optical tweezers 239
order parameter 119, 138
osmotic barrier 1
osmotic pressure 1
Ostwald, Wilhelm 1
Overton
– Charles Ernest 323, 324
Overton, Charles Ernest 1

p
pain 323
palmitic acid 32, 33
palmitoleic acid 33
partition coefficient 325
partition function 51, 127, 129, 191
patch clamp 297, 305
peptide aggregation 149
percolation 166, 167
– treshold 167
periodic boundary conditions 130
permeability 1, 4, 36, 249, 323
– domain boundaries 290
– for ions 289
– phase transition 289
– relation to compressibility 290
– relation to heat capacity 290
– sodium 289
– water 221, 289
Index

permittivity 64
perturbation 277, 280
– volume 241, 243
Pfeffer, Wilhelm 1
pH 295
phase boundaries 107
phase boundary 103
phase diagram 102, 110
– eutectic 110, 115, 116
– ideal mixture 102
phase diagrams
– DLPC-DPPC 116
– DLPC-DPPC 117
– DMPC–DMPE 117
– DMPC–DMPG 116
– DMPC–DMG 118
– DMPC–DMPG 116
– DMPC-DSFPC 116, 117
– DPPC–cholesterol 119
– eutectic 119
– regular solution 114, 115
– sphingomyelin–POPC–cholesterol 120
– ternary 120
phase rule 120
phase separation 131
phase transition 8
– continuous 108
– first order 108
phenomenological coefficients 59, 279, 283
phenomenological equations 59, 279, 280
phosphatidic acid 30, 31
phosphatidylcholine 30, 31, 35
phosphatidylcholines 16
phosphatidylethanolamine 30, 31, 35
phosphatidylethanolamines 16, 24, 116
phosphatidylglycerol 30, 31, 200
phosphatidylserine 30, 31, 35
phospholipase A₂ 163
– hydrolysis 163
phospholipase A₂ 157, 158
– activity 157
– hydrolysis 157, 158
– lag time 157
piezoelectricity 312, 318
Pink model 138
pipette aspiration 228
placental alkaline phosphatase (PLAP) 161
placental alkaline phosphatase–PLAP 10
PLAP protein 161
plasma membrane 1, 4, 32, 34
Poisson equation 173
Poisson–Boltzmann equation 174
POPC 120
pore formation 151, 248, 249, 252
potassium channel 298
potential
– electrostatic 64, 173, 177
premeability 249
pressure 36–38, 87, 88
– hydrostatic 42, 227, 235, 236
– lateral 43, 185, 201, 227, 228, 296, 330
– lateral pressure profile 331
presynaptic membrane 221
pretransition 79, 80, 256, 261, 262, 270, 273
– chain length dependence 263
– head group dependence 263
progesterone 32
protein
– aggregation 196, 198, 249
– binding 196
– conformational change 142
– excluded volume 192
– hard sphere 197
– integral 141, 143, 189
– interface 249
– peripheral 152, 189
– rectangular cross section 197
– surface gas 193, 199
– transmembrane 141
protein aggregation 8, 142
protein binding 10, 153
– simulation 152
protein clusters 150
protein diffusion 156
protein distribution 11
protein kinase c 118
protein precipitation 72
protein unfolding 9
protein-protein interactions 6, 8
proteins
– basic 189
– conformational equilibria 332
protonation
– of charged membranes 183
protoplasm 1
protoplasts 1
pulse propagation 244
r
racemate 216
radius of curvature 219
raft 109, 120, 249
rafs 10, 32, 158–161, 163
random number generation 125, 126, 130
reciprocal relations 59
regular solution 99
regular solution theory 109, 113, 123, 132, 327
relaxation 277, 283
Index

- domain size 280, 281
- influence of anesthetics 286
- influence of antibiotic peptides 286
- influence of cholesterol 285
- influence of neurotransmitter 286
- relation to heat capacity 283–285
- relation to ion channels 287
- resonator 243
- ultrasonic 227, 242
- resting potential 35, 304
- rhodopsin 141
- ripple periodicity 266, 268
- ripple phase 17, 80, 239, 256, 262, 263, 265, 269, 270
- saddle point 220
- saltatory conduction 307
- saturated lipid chains 32
- saturated lipids 33, 35, 39
- scaled particle theory 195
- isotherm 195
- scaling invariance 134
- Schwann cell 5, 302
- second messenger 118
- secretion 221, 252
- sedimentation 234
- serotonin 285, 334
- sex hormones 32
- signal cascade 159
- signal transduction 9, 142, 166
- simulations
  - Monte Carlo 256, 264, 269
- Singer and Nicolson
  - membrane model 5
- single particle tracking 170
- solid-ordered phase 16, 78, 79, 119
- soliton 165, 315, 316
- capacitive energy 317, 318
- internal energy 316
- thickness changes 318
- solitons 312
- solvent
  - apolar 66
  - interaction with 257
  - polar 66
- solvent interactions 268
- sound 314
- sound propagation 55, 58, 241, 311
- sound pulse 313
- sound velocity 243, 315
- sound velocity number 244
- sound wave 241
- specific volume 89, 232
- spectrin 6
- sphingolipids 159, 249
- sphingomyelin 10, 32, 34, 35, 120
- sphingomyelin 75
- splay 212
- sponge phase 25, 220
- sponge phases 25, 27
- spontaneous curvature 214
- twist 216
- twist 216
- standard state 49, 100
- statistical averages 52
- statistical thermodynamics
  - entropy 51
  - probability 51
- stearic acid 33
- sterols
  - cholesterol 32
  - ergosterol 32
  - lanosterol 32
- Stoke’s law 279
- sub-main transition 272, 273
- suberyldicholine 297
- sucrose 1
- sugar symporter 152
- surface potential 177
- surfactant protein C 92
- swelling
  - critical 246, 247
- symmetric membrane 215
- synaptic gap 221
- t
- tadpoles
  - anesthesia 326
- tangential construction 104
- temperature
  - definition of 44
- ternary mixtures 120
- testosterone 32
- thermodynamic average 126
- thermodynamic equilibrium 113
- thermodynamic fluxes 59, 278, 279
- thermodynamic force 281, 283
- thermodynamic forces 35, 278, 279
- thermodynamic variables 41, 277, 278
- extensive 43, 48
- intensive 43, 48
- thermodynamics 41
  - equilibrium 44–46
  - first law 42
  - linear nonequilibrium 279
  - second law 44
- thermodynamics forces 58, 59
- thermodynamics of solutions 1
- tie-line 120
- titration calorimetry 75
- trafficking 159
trans configuration  84  
transition  
– between different geometries  257  
– continuous  134, 282  
– first order  133, 134, 137, 282  
transitions  
– biological membranes  312  
triangular lattice  16, 27, 128, 264  
triple point  110, 116  
triton  159, 160  
twist  212  

u  
ultrasonic velocity  227  
undulations  247, 262  
unsaturated lipids  33, 35, 39  

v  
vane der Waals  
– equation of state  194, 195  
– isotherm  194, 195  
van’t Hoff’s law  86  
van’t Hoff, Jacobus Henricus  1  
variables  
– thermodynamic  277, 278  
vesicle  
– topology  220  
vesicle shape  
– coupling to melting  252  
vesicles  
– DPPC  251, 252  
– extruded  235  
– fission  252  
– fusion  252  
– geometry  255  
– giant  252, 270  
– giant vesicles  136  
– large  270  
– large unilamellar  134, 226  
– multilamellar  134, 254, 258, 262, 270  
– shape  251  
– small unilamellar  134  
– structural transitions  255  
– unilamellar  255  
– volume-to-area ratio  221  
vibrating capillary  232  
viscosity  25, 165, 259, 261, 262  
volume changes  88  
volume compressibility  237  
volume expansion coefficient  89, 232, 234, 241  

w  
WALP peptide  149  
water  15, 63, 141  
– as a component  106  
– boiling point  64  
– density  64  
– diffusion coefficient  64  
– in biological cells  107  
– in cells  63  
– melting point  64  
– molar mass  64  
– properties  64  
– specific heat  64  
– speed of sound  64  
– sublimation  63  
– thermal conductivity  64  
– thermal diffusivity  64  
– vapor  63  
water activity  73  
Wilhelmy balance  93  
Wimley–White hydrophobicity scale  74  
Wimley-White hydrophobicity scale  70, 71  
work  42  

x  
X-ray crystallography  5, 18, 264  
X-ray diffraction  18, 27  
– Bragg peaks  19  
– constructive interference  19  
– diffraction pattern  18  
– diffraction peaks  21  
– electron density  19, 22, 27  
– interference function  20  
– structure amplitude  19  
– structure factor  19–21  
– wave vector  18  

z  
zwitter-ionic lipids  31