

## Index

### **a**

- abrasion 305
- accommodation coefficient 222
- activated carbons 244
- activator 165
- adhesion
  - force(s) 24, 129–131, 151, 289, 379
  - rolling friction 288–289
- adhesive 130, 135, 157, 158, 198, 295, 305, 306
- adhesive contact 295, 306
- adsorbate 191–194, 204, 209, 212, 217, 219, 220, 228, 235, 250, 251, 284, 292
- adsorbate structures 179–180
- adsorpt 219, 220
- adsorption
  - BET adsorption isotherm 232–235
  - chemisorption and
    - temperature-programmed desorption 248–249
  - classification of adsorption isotherms 222–224
  - and desorption rates 219
  - differential quantities of 226–228
  - energy 248
  - heats of 224–226
  - Langmuir adsorption isotherm 228–230
  - Langmuir adsorption with lateral interactions 231–232
  - Langmuir constant and Gibbs energy 230–231
  - on heterogeneous surfaces 235
  - planar surfaces, measuring to 236–238
  - to porous materials
    - capillary condensation 241–242
    - definitions and classification 239–241
    - hysteresis and ink-bottle effect 243–244
    - mercury intrusion porosimetry 246–248
  - powders and textured materials 238–239
  - from solution 249–251
  - time 221–222
- adsorption isotherm 219, 222, 224, 227, 238
  - for pentanol 48
  - presentation of 224
- adsorption time(s) 124, 221–222, 229
- adsorptive 219, 220, 222
- advancing contact angle 139, 146, 149, 150, 152, 154, 160, 162
- aerosol 2, 21
- AgCl 75, 82, 361
- agglomerate of silicon oxide particles 3
- aggregation number 315, 316, 318, 320
- AgI 75, 76, 81, 114
- aging behavior 304

- alcohol 49, 120, 347, 350  
 alkyl glycosides 313  
 alkyl polyglycosides 313, 336  
 alkylbenzenesulfonate 310  
 alkylcarboxylate 310  
 alkyltrimethylpropanesultaine 312  
 alkylethylene glycol 47, 311, 313, 336,  
 344  
 alkylethylene oxides 313  
 alkylglucoside 312  
 alkylsulfate 309, 310, 318, 319  
 $\text{Al}_2\text{O}_3$  76, 77, 221, 262, 264  
 Amontons' law 284–286, 288, 289, 295  
   of friction 284  
 amphiphilic molecules 48, 304, 305, 309,  
 347–351, 367, 368  
 amphoteric surfactants 313  
 anionic surfactants 309, 313  
 annealing 164, 181, 182, 186, 378  
 antifoam agents 304  
 antifoamers 304, 343  
 antioxidants 304  
 antiwear additive 305  
 AOT 311  
 apparent contact angle 149, 150, 152,  
 160  
 aquaplaning effect 297  
 aquatic birds 157  
 Archard's wear equation 305  
 asperities 285–287, 295–297, 299, 305,  
 306  
 association colloids 314  
 atomic beam diffraction 209  
 atomic beams 209, 217  
 atomic force microscope (AFM) 110,  
 111, 120, 123, 126, 131, 133, 179,  
 203–207, 217, 263, 264, 291, 283,  
 293, 295, 321, 367, 378, 388  
 atomic form factor 402  
 atomic layer deposition (ALD) 261, 262,  
 280  
 atomic stick-slip friction 293  
 attenuated total reflection (ATR) 211,  
 355  
 attenuated total reflection infrared  
   spectroscopy (ATR-IR) 211, 355  
 Auger electron spectroscopy (AES) 196,  
 214, 215, 217
- b**
- Bénard–Marangoni convection 50  
 Bancroft's rule 329, 344  
 Barrel etching 275, 276  
 bending elastic modulus 335  
 bending rigidity 335, 336  
 BET adsorption isotherm 232–235, 238,  
 252, 385  
 bilayers 105, 112, 121, 314–323, 335  
 binding potential 140  
 biological membranes 322–323  
 black films 342  
 block copolymer 244, 314  
 bolaform surfactant 313  
 Boltzmann equation 56, 57, 59–61, 89,  
 114, 115, 117, 375  
 boundary lubrication 284, 285, 296,  
 299–300, 303, 306, 307  
 boundary slip 300  
 Boussinesq number 366  
 Bragg condition 359, 357, 395–397,  
 400  
 Bravais lattices 177, 178, 217  
 Brewster angle microscopy 354, 355,  
 367, 368  
 bridging forces 125  
 Brownian motion 2, 111, 193  
 bubble in a liquid 15, 22  
 bulk systems, thermodynamic functions  
   for 33–34  
 Burgers vector 190, 191, 199  
 butter 3, 330
- c**
- calorimeter 189, 225  
 canal surface viscosimetry 365  
 capacitances 63, 82–83  
 capacity 81–83  
   diffuse layer 63, 67, 72  
   Helmholtz layer 67

- Stern layer 67–68
- capillary condensation 23–26, 31, 223, 224, 240–244, 252, 373
- capillary constant 15, 24, 157
- capillary force 24–26, 146, 151, 156
- capillary length 15, 365
- capillary number 160–162
- capillary penetration technique 155
- capillary rise 17, 50, 153–155, 381
- capillary waves 357, 365, 366
- captive bubble method 147
- Cassie state 150, 151
- Cassie–Baxter equation 149, 150
- cationic surfactants 313
- cavitation 122, 306
- centrifuge 90, 130
- centrifuge method 130, 131
- ceramic foams 338
- cetyltrimethylammonium bromide (CTAB) 122, 216, 313, 314, 320, 321, 336, 351
- Champagne 30
- characteristic length scale 3, 15, 324
- charged surfactants 49, 318, 320
- chemical binding energies 220
- chemical vapor deposition (CVD) 259–262
  - diamond films 260–262
  - index 259
  - diamond films 260
- chemisorbed polymers 268, 269
- chemisorption 220, 248–249, 251, 261, 266
- chronoamperometry 82, 83
- clay 3, 78, 119, 132, 246
- cleavage 106, 182, 183, 188, 217
- closed system 38, 39
- cloud point 316
- critical micellization concentration (CMC) 48, 167, 310, 314–319, 322, 324
  - of alkylsulfates 318–319
- CMC *see* critical micellization concentration (CMC)
- coagulation 112, 117, 119, 331
- coalescence 326, 330–333
- coarsening process 343
- coefficient of friction 284, 285, 288, 292, 297
- coherent interface 198
- coincident site lattice (CSL) model 199, 200
- cold welding 286, 306
- collector 165
- colloid(s) 1, 2
  - dispersion 1
  - probe technique 111, 131, 289, 295, 296
  - systems 1, 2
- competitive ablation and polymerization scheme (CAP) 272
- composite material 3, 132, 198
- concentration profile, of solute 37, 47, 48, 192, 195–197
- condensation coefficient 230
- conductivity 55, 69, 79, 81, 88, 89, 257, 260, 325, 326, 338, 361
- conductometric titration 81, 82
- confined liquid 119–121, 300
- confocal microscopy 200
- constant charge 79, 116
- constant potential 116, 117
- contact angle 15, 135–137, 141, 142, 264
  - advancing 145–146
  - hysteresis 145–148, 169
  - receding 145–146, 151
- contact line, phase 135
- continuity equation 86
- continuous phase 321, 324–326, 328, 329, 334
- conversion factors 409
- core region 140–142
- corrosion inhibitors 305
- cosurfactants 333, 336
- Coulomb force 93, 112
- Coulomb's law of friction 284, 286, 293
- creaming 331–333

- creaming effect 332, 333
  - critical micellar concentration (CMC)
    - 48, 167, 310, 314–318, 322, 324
  - critical radius 28, 241, 243
  - critical temperature 220, 240, 350, 352
  - crystalline solid surfaces
    - adsorbate structures 179–180
    - clean surfaces, preparation of 181
      - cleavage 182–183
      - thermal treatment 181
    - diffraction methods 206–209
    - electron microscopy 201–203
    - optical microscopy 200–201
    - optical spectroscopy of surfaces
      - 209–213
    - periodic structure of 176
    - scanning probe microscopes (SPMs)
      - 203–206
    - secondary ion mass spectrometry
      - 215–217
    - spectroscopy of inner electrons
      - 213–214
    - spectroscopy with outer electrons
      - 214–215
    - substrate structure 176–178
    - surface diffusion 191–198
    - thermodynamics of 183–191
  - crystalline surfaces 176–180, 197, 217, 301, 302
  - curvatures 14, 15, 39, 335
    - of sphere, cylinder, and drop 12
  - curved liquid surface 10–13, 20, 21
  - cyclic voltammetry 83
  - cylindrical micelles 245, 320, 321
- d**
- DDAB 311
  - de-inking of paper 165
  - Debye interaction 96
  - Debye length 5, 57, 58, 60–63, 79, 87–90, 121, 132, 328, 375
  - Debye–Hückel approximation 57
  - Debye–Hückel model 61
  - deep reactive ion etching (DRIE) 275, 280
  - defoamers 343, 344
  - demulsification 324, 326, 328, 331–333
  - demulsifiers 304
  - density, liquid surface 5
  - depletion forces 126–127
  - depressant 165, 304
  - Derjaguin approximation 107–109, 114, 117
  - desorption energy 248, 249, 253
  - detergency 3, 158, 166–167, 309
  - detergents 45, 309, 313
  - dewetting 158–165
  - dialkyldimethylammonium bromide
    - 311
  - dialkylglycerophosphatidyl choline,
    - nomenclature of 348
  - diamond CVD film 260–262
  - diblock copolymer 313, 314
  - diffraction at surfaces 399–400
  - diffraction at three-dimensional crystals
    - Bragg condition 395, 396
    - Ewald construction 398–399
    - Laue condition 395–397
    - reciprocal lattice 397–398
  - diffraction peaks intensity 400–403
  - diffuse double layer 54, 57, 58, 63, 64, 91
  - diffuse electric double layer 58, 65
  - Diffuse Reflectance Infrared Fourier Transform Spectroscopy 211
  - diffusion 191, 193–195, 197
    - coefficient 140, 192–194, 196–198, 331
    - surface 191–198
  - dilational elastic modulus 362, 363
  - dilational surface viscosity 362
  - dilational viscosity 362, 365, 366
  - dimeric surfactants 313
  - dipalmitoyl phosphatidylcholine (DPPC)
    - 213, 348, 352, 354
  - dip coating 163, 164
  - dipole moment 53, 80, 91, 94–97, 101, 105, 211, 262, 352, 354, 359, 360, 369
  - dipole–dipole interactions 95–97, 131, 354

- dipoles, in a monolayer 353, 356, 360, 362
- disjoining pressure 109–110, 114, 115, 125, 140, 142, , 159, 341
- dislocation 190  
edge 190  
screw 190
- disulfide 263
- dispersants 304
- dispersing agent 324, 326
- dispersion 2  
force 96  
interaction 96
- DLVO theory 116–119, 121–122, 132
- DMT model 129, 130
- dodecyl trimethylammonium bromide 313
- doping 79, 277
- double-layer force 112–119, 132, 142, 331
- double-wedge technique 182, 183
- drainage 152, 340, 343, 344
- DRIFT spectroscopy 211
- drop in vapor 21
- drop shape analysis 16
- drop volume method 171
- drop-weight method 17, 18, 32, 372
- droplet coalescence 331–333
- droplets in microemulsions 334
- dropping mercury electrode 73
- dry etching 274, 275, 277
- dry foam 340, 341
- dry friction 284–286, 295, 299
- Du Noüy ring tensiometer 18, 19
- dynamic contact angles 160–163
- dynamic friction 284, 286, 287, 307
- dynamic methods 19
- dynamic superlubricity 302
- dynamic viscosity 84, 303
- e**
- Einstein–Smoluchowski equation 193
- elastic deformation 128, 163, 184, 285
- elastic modulus 335, 362–364
- elastic properties of surfactant films 335–336
- elasto-hydrodynamic lubrication 298
- electric conductivity, of dilute emulsions 326
- electric double layer 53, 62–64, 91, 112, 328  
in aqueous electrolyte 54  
capacitance of 81  
mathematical description 55–68  
around a sphere 61  
Gibbs energy 64–65  
Gouy–Chapman model, for planar surfaces 57–59  
Grahame equation 62–63  
one-dimensional case 59–61  
Poisson–Boltzmann equation 56  
Stern model 67–68
- electric field strengths 360
- electric surface charge density 57
- electrified interfaces 68  
capacitances 82–83  
charged surfaces 73–80  
mercury 74  
mica 78–79  
oxides 76–78  
semiconductors 79–80  
silver iodide 75–76
- electrocapillarity 70–73
- electrokinetic phenomena 83–91
- potentiometric colloid titration 80–82
- types of potentials 68–70
- zeta potential 84  
electro-osmosis and streaming potential 86–88  
electrophoresis and sedimentation potential 88–91  
Navier–Stokes equation 84–86
- electro-osmosis 84, 86–88, 90, 91, 168, 376
- electrocapillarity 55, 70–74
- electrocapillary curves 72–74
- electrocapillary measurements 55
- electrochemical cell 69, 70

- electrochemical potential 69, 71
  - electrodeposition 280
  - electron beam evaporation 256
  - electron beam lithography 280
  - electron microscopy 196, 201–203, 240, 247, 325
  - electroneutrality 58, 62, 67, 71, 113
  - electron spectroscopy for chemical analysis (ESCA) 213
  - electrophoresis 84, 88–91, 168, 377
  - electroplating 280
  - electrostatic double-layer force 112
    - DLVO theory 116–119
    - electrostatic interaction between two identical surfaces 112–116
  - electrostatic double-layer repulsion 53, 331, 341
  - electrostatic interaction
    - between two identical surfaces 112–116
  - electrowetting 168–169
  - ellipsometry 159, 236–238, 251
  - Eloxal process 221
  - empirical law 6, 284, 286, 307
  - emulsifier 328, 329
  - emulsion(s) 1, 156, 172, 324, 326, 328–331, 333, 336, 337, 338, 391
  - energy dispersive X-ray analysis 214, 215
  - energy of adsorption
    - differential 226
    - integral 225
  - enthalpy 38, 41–43, 188, 189, 225–227, 391, 392
  - enthalpy of adsorption 226
    - differential 227
    - integral 225
  - entrainment of air 162
  - entropy of adsorption
    - differential 227
    - integral 225
  - environmental scanning electron microscopes (ESEM) 202, 203
  - erosion 305–306
  - etching 274
    - barrel 275, 276
    - chemical 274
    - deep reactive ion 275, 276, 280
    - dry 275
    - ion beam 275
    - physical 274
    - plasma 275, 276
    - reactive ion 275, 276
    - reactive ion beam 275
    - sputter 275
  - etching techniques 274–278
  - Euler's theorem 41, 42
  - evanescent field 210, 211
  - evaporation 17, 19, 22, 40, 50, 135, 136, 152, 154, 164, 196, 256, 257, 348, 366
  - Ewald construction 398
    - for surface diffraction 399
    - at Cu(110) surface 400
  - extended X-ray absorption fine structure (EXAFS) 214
  - extensive parameters 33, 34
  - external phase 1, 324
  - extreme pressure additive 305
- f**
- far-field interfacial energies 140
  - fatty acids 166, 305, 309, 314, 347, 351, 352
  - Fe<sub>3</sub>O<sub>4</sub> 77
  - Fiber 157–158
  - Fick's law 192, 197
  - field ion microscope 195
  - film balance 341, 342, 348, 365, 366, 368, 369
  - film pressure 213, 348–354, 358, 359, 366, 368, 369
    - vs. surface area per molecule 351
  - flocculation 126, 331, 332
    - kinetics 331
    - rate constant 332
  - flotation 3, 104, 146, 155, 156, 158, 164–166, 309, 338
  - fluid lubrication 297
  - fluid volume element, in flow field 85

- fluorescence microscopy 353, 354, 367, 368  
 foams 338–341, 343, 344  
   applications 338–339  
   soap films 341–343  
   structure 339–341  
 focused ion beam 280  
 forced wetting 158, 160, 162  
 Frank–van der Merwe growth 258  
 free solid surface energy 141, 142  
 fretting wear 306  
 Freundlich adsorption isotherm 235, 252, 385  
 Freundlich isotherms 250, 253, 387  
 friction 283, 302  
   Amontons' law 284–286  
   and adhesion 289–290  
   and lubrication *see* lubrication  
   Coulomb's law 284–286  
   macroscopic 292  
   measurement techniques 290–292  
   microscopic 293–296  
   rolling 288–289  
   static 286–288  
 friction coefficients 284, 292, 295–297, 299, 303  
   on ice 292  
   kinetic 286–287, 290, 295, 297, 299, 300  
   rolling 288–289  
   static 286–287, 290  
 friction force microscopy (FFM) 291, 293–295, 301, 302, 307  
   pictures, of graphite surface 294  
 friction forces 130, 131, 284, 290, 291, 303  
 friction modifiers 305  
 Froth 165, 338, 340  
 Frothing agent 165  
 Frumkin–Fowler–Guggenheim (FFG)  
   adsorption isotherms 231, 232  
 Frumkin–Fowler–Guggenheim (FFG)  
   isotherm 231, 232  
 FT-IR spectrometers 210  
 fundamental constants 408–409
- g**  
 galactocerebroside structure 358  
 Galvani potential 68, 71  
 gas–gas interfaces 1  
 Gecko 100  
 Gemini surfactants 313  
 geometrical structure factor 401  
 germanium 79  
 Gibbs adsorption isotherm 45–47, 72, 328  
   derivation 45–46  
   experimental aspects 48–49  
   ideal interface in 47  
   system of two components 46–47  
 Gibbs dividing plane 34, 36, 37, 40, 43, 51, 223, 224, 249  
 Gibbs energy 33, 41, 64, 230, 231  
   adsorption 226–228, 230–231  
   of electric double layer 64–65  
   interfacial 43  
   micellization 317–318  
 Gibbs free energy 9, 27–29, 95, 121, 126, 136–137, 154, 156–157, 166, 322, 326, 335, 343, 376, 391  
   of micellization 317  
 Gibbs free interaction energy 116, 118  
 Gibbs model, of ideal interface 35  
 Gibbs monolayers 347, 349, 363  
 glow discharge 181  
 Gouy–Chapman model 55, 57–59, 63  
 Gouy–Chapman theory 54, 62, 63, 66, 67, 83, 91, 376  
 Gouy–Chapman–Stern model 54, 67  
 grafting-from 269–270, 273  
 grafting-to 124, 269  
 Grahame equation 62–63, 68, 75, 90  
 grain boundary 198  
   tilt 198–199  
   twist 199  
 granular matter 2  
 granular system 2  
 grazing incidence X-ray diffraction 209, 356, 357, 388  
 Guggenheim, Edward Armand 34

**h**

Hagen–Poiseuille law 167  
 Hamaker constant 99, 101, 102,  
 104–106, 118, 131, 142, 144, 145,  
 299, 377, 378  
 heat of adsorption 221, 224, 225,  
 227–230, 232  
 HEED 208  
 helium 106, 238  
 surface energy of 106  
 Helmholtz energy 33, 38, 39, 41, 95  
 interfacial 42  
 Helmholtz free energy 95, 96  
 Helmholtz layer 54, 67, 91  
 Henry adsorption isotherm 222–224  
 Hertz model 127–129, 133, 285, 379  
 heteroepitaxy 258, 260  
 heterogeneous nucleation 26, 27, 143  
 heterogeneous surfaces 235  
 heterophase interface 198, 217  
 hexadecyl trimethylammonium bromide  
 313  
 high energy electron diffraction 208  
 high internal phase emulsions (HIPE)  
 325  
 higher-angle grain boundaries 199  
 highly oriented pyrolytic graphite  
 (HOPG) 182, 293, 301  
 Hofmeister series 66  
 homoepitaxy 258, 259  
 homogeneous nucleation 26, 27  
 homophase interfaces 198  
 hydration force 112, 121, 328  
 hydration repulsion 121, 132, 318, 328  
 hydraulic radius 240, 252  
 hydrodynamic lubrication 296–300, 307,  
 390  
 hydrodynamic theory 161, 163  
 hydrophile–lipophile balance (HLB)  
 329, 344  
 scale 329  
 hydrophilic surface 121, 136, 149, 281,  
 318, 388, 389  
 hydrophobic effect 318, 390  
 hydrophobic force 122, 132, 165

hydrophobic interaction 122, 268  
 hydrophobic surface 136, 142, 149, 159,  
 165  
 hysteresis, isotherm 243

**i**

ice 220, 230, 292  
 ideal freely jointed chain 122  
 ideal interface 34, 35, 40, 41, 46, 47  
 immersion method 251  
 impedance spectroscopy 83  
 inclined plane tribometers 290  
 incoherent interface 198  
 infrared reflection absorption  
 spectroscopy (IRRAS/IRAS) 211,  
 217, 355  
 infrared (IR) spectroscopy 209–217,  
 355–356  
 Iniferter 271  
 ink 123, 239, 244, 247  
 ink bottle pore 239, 244, 247  
 inner Helmholtz plane (IHP) 54  
 inner phase 1, 68, 324–326  
 inner phase volume fraction 325  
 inner potential 56, 68–70  
 inorganic films 255  
 insoluble monolayers 347, 348, 368  
 intensity of diffraction peaks 400–403  
 interface 1  
 Gibbs adsorption isotherm 45–51  
 derivation 45–46  
 experimental aspects 48–49  
 Marangoni effect 49–51  
 system of two components 46–47  
 pure liquids 43–45  
 thermodynamic relations for systems  
 with 38–43  
 equilibrium conditions 39–40  
 Gibbs energy 41  
 Helmholtz energy 38–39  
 interface location 40  
 interfacial excess energies 41–43  
 internal energy 38–39  
 interfaces and colloids 1, 3  
 interface potential 140–142



- interface thickness 5  
 interfacial enthalpy 42, 43  
 interfacial excess 35, 41, 43, 47, 71, 72  
     Helmholtz energy 41  
 interfacial Gibbs energy 43, 51  
 interfacial Helmholtz energy 41–43  
 interfacial potential 141  
 interfacial tension 3, 10, 40, 41, 70, 72,  
     136, 138, 154, 157, 169–173,  
     327–329, 335, 373  
 interference microscopy 200  
 internal energy 33, 38  
     densities 35  
     interfacial 35, 41–43  
 internal surface energy 41, 43–45, 186,  
     226  
 interphase 34, 198  
 intersegment force 125  
 inverse gas chromatography 188  
 inverted micelles 319, 321, 322  
 ion beam etching 275  
 ion etching 275, 376  
 ion mass spectrometry 215–217  
 ion plating 257, 280  
 ionic liquids 138  
 ionic surfactants 316–319, 328, 336,  
     344  
 ionizing electrode method 360, 361  
 isoelectric point (iep) 84  
 isolated system 38
- j**
- JKR model 128–131, 133, 289, 290, 295,  
 379
- k**
- Keesom interaction 95–97, 106  
 Kelvin equation 20–23, 28, 31, 139,  
     241–242, 373  
 Kelvin length 20–21, 26  
 Kelvin probe 360  
 Kelvin question 23  
 kinematic viscosity 84, 300, 303  
 kinetic friction coefficient 286–287, 290  
 kinetic theory of ideal gases 5, 221, 229
- Kirchhoffs law 70  
 Krafft temperature 316  
 Kugelschaum 339–340
- l**
- lab-on-chip 167  
 lamellar phase 321, 338  
 Langmuir adsorption isotherm 228–230,  
     232, 251  
 Langmuir constant 229–231, 252  
 Langmuir equation 228, 230, 231, 235  
 Langmuir trough 348–349, 368  
 Langmuir–Blodgett transfer technique  
     366–368  
 Laplace equation 11–15, 40, 141, 142  
     application 14–15  
     derivation of 13–14  
     fundamental implications 12  
 Laplace pressure 11, 17, 20–21, 24–25,  
     154–155, 158, 173, 327, 335, 343,  
     344  
 laser-induced thermal desorption (LITD)  
     197, 248  
 lateral force microscopy (LFM) 291  
 Laue condition 395–400  
 Launderometer 166  
 LB film 367–368  
 LB transfer 213, 366–368  
 Lifshitz theory 100–105  
 LIGA 280  
 line tension 142–145, 172, 354, 369,  
     381  
 linear polymer 122–123  
 lipid 3, 320, 366, 392  
 lipid bilayers 105, 112, 121, 321–323,  
     348, 354–355  
 Lippmann equation 72, 74  
 liquid-condensed phase 351–352  
 liquid crystals 1, 10, 316, 350  
 liquid-expanded phase 351–352  
 liquid foams 110, 338, 339, 343, 344  
 liquid–liquid interfaces 1, 3, 10, 326,  
     328, 330, 364  
 liquid marble 330

- liquid phase 6, 27–28, 35, 56, 71, 142, 162, 243–244, 278, 315, 317, 343, 349, 351, 359–360
  - liquid superlubricity 302–303
  - liquid surface 5, 183 *see also*
    - Young–Laplace equation
    - capillary condensation 23–26
    - curved 10–13
    - Kelvin equation 20–22
    - microscopic structure of 5–6
    - nucleation theory 26–31
    - surface tension 6–10
  - lithography 276, 278–281
  - London interaction 96, 131
  - Lotus effect 151
  - low pressure chemical vapor deposition (LPCVD) 259
  - low-energy electron diffraction (LEED) 208, 399
    - diffraction pattern 208
    - experiment 399
  - low-energy electrons 208, 215, 306
  - lower critical solution temperature (LCST) 270–271
  - lubricant 158, 303
    - infused surfaces 152
    - solid 302
  - lubrication 283, 296–298
    - boundary 296, 299–300
    - elasto-hydrodynamic 298
    - fluid 297
    - hydrodynamic 296–298
    - lubricants 303–305
    - mixed 296, 299
    - superlubricity 301–303
    - thin film 300–301
- m**
- macroemulsion 323–328
    - coalescence and demulsification 332–333
    - evolution and aging 330–332
    - stabilization 328–330
  - macropore 240
  - macroscopic friction 283–284, 292, 296, 302, 307
  - macroscopic quantities 140
  - macroscopic wetting 143, 150
  - magnetic needles 365
  - Marangoni effect 49–51, 329, 343
  - margarine 330
  - maximum bubble pressure method 17, 18
  - Maxwell relations 42
  - MCM-41 244
  - mean free path 255–256, 259
  - mean micellar aggregation number 315
  - membrane proteins 322–323
  - membrane resistance, specific 322
  - Meniscus force 24, 122, 382
  - mercury 10, 55, 70, 73–74, 76, 376
  - mercury porosimetry 246–248
  - mesophases 350
  - mesopores 223, 240
  - mesoporous silica 244, 245
  - mesoscopic film 142
  - metal–electrolyte interface, with applied potential 70
  - metal foams 338
  - metal organic chemical vapor deposition 260
  - metal–organic frameworks (MOF) 245–246
  - methylene diphenyl diisocyanate (MDI) 339
  - mica 73, 78–79, 110, 121, 132, 213, 296, 366
  - micelles 48, 121–122, 167–168, 244–245, 304, 309–344, 390
  - micellization 317, 318
    - for ionic surfactants 316
    - thermodynamics of 317–319
  - microcontacts 285–286, 289, 290, 292, 293, 295, 299, 390
  - microelectromechanical systems (MEMS) 280, 300–301
  - microemulsion 324, 334
    - droplet size 334–335
    - factors influencing structure 336–338

- microfluidics 88, 167, 168  
 microlithography 278  
 micropillar arrays 150  
 micropores 222, 240  
 microscopic friction 293–296  
 microtribology 293  
 milk 3, 135, 324–325  
 Miller–Bravais indices 177  
 Miller indices 176–177, 397  
 miniemulsion 324  
 mixed lubrication 296, 299–300, 305, 307  
 $\text{MnO}_2$  77  
 modified Laplace equation 141  
 modulus of Gaussian curvature 335  
 molar Gibbs energy 21, 27–28, 226, 317, 327  
 molecular beam epitaxy (MBE) 183, 198, 217, 258–259, 280  
 molecular kinetic theory 163  
 molecular structure  
   of liquid–vapor interface 9  
   of water 6  
 monolayers 347, 350–358, 360, 361, 366, 367  
   with an applied shear 362  
   coverage 256  
   experimental techniques 353  
     IR spectroscopy 355  
     optical microscopy 353  
     rheologic properties of liquid surfaces 361  
     sum frequency generation spectroscopy 355  
     surface potential 359  
     X-ray reflection and diffraction 356  
 Gibbs 347, 349  
 insoluble 347–348  
 Langmuir–Blodgett transfer 366–368  
 mesophases 350  
   phase behavior of 352  
   surface potential measurements 360, 361  
 monomolecular amphiphilic films, phases of 350  
 multicomponent liquids 35
- n***  
 nanocontacts 295  
 nanolithography 280  
 nanoparticles 3, 269, 322  
 nanotribology 292, 293, 296, 307  
 Navier–Stokes equation 84–87, 297  
 Nearest neighbor broken bond model 186, 217  
 Nernst equation 75, 76  
 Neumann triangle 171  
 neutron reflectivity 48  
 Newtonian fluid 84, 297, 298  
 no-slip boundary condition 300  
 nodoids 12, 13  
 non-DLVO forces, in aqueous medium 121–122  
 non-polar liquids 55, 151, 323  
 nonionic surfactants 313, 316–318, 329, 336, 344  
 nonlinear optical effects 212  
 nucleation 3, 22, 26–31, 143, 165, 191, 259, 260  
 nucleation theory 26–31  
 null ellipsometer 237
- o***  
 4-octyl-4'-cyanobiphenyl (8CB) 10  
 oil-in-water emulsion 325, 328–330  
 O-lattice theory 200  
 oligomeric surfactants 313  
 optical microscopy 138, 172, 200–201, 217, 353–366  
 optical tweezers 111, 112  
 organic monomolecular layer, LB transfer technique 367  
 oscillating drop 19, 20  
 osmotic stress method 112  
 Ostwald ripening 21, 324, 343  
 outer Helmholtz plane (OHP) 54, 80  
 outer phase 324  
 O/W droplet 335  
 O/W microemulsion 336, 337  
 oxidation 220, 221, 371, 277, 292, 304, 306, 389

- oxide 76, 78, 80, 175, 181, 220, 221, 269, 278, 292, 313, 389
- P**
- packing ratio 319
- paint 2, 3, 50, 135, 158, 255
- partial wetting 135
- particle 3, 25–26, 61, 64, 69, 155, 165
  - quartz 99
  - spherical 24
- pendant bubbles 17
- pendant drops 16
- phase diagram, of a water-in-octane- $C_{12}E_5$  emulsion 337
- phase inversion temperature (PIT) 329, 336–338
- phase modulation IRRAS 211
- phospholipids 348, 352
- phosphatidyl cholines (PC) 347
- phosphatidyl ethanolamines (PE) 347
- phosphatidyl glycerol (PG) 347
- phosphatidyl serines (PSs) 347
- phospholipids 66, 321, 347, 348, 351, 352, 354, 368
  - chemical structure of 348
- photoemission electron microscopy (PEEM) 196
- photolithography 278–281
- photoresist 164, 182, 276, 278–281, 389
- physical etching 274, 275
- physical vapor deposition (PVD) 256–259
- Physisorption 220, 223, 230, 242, 248, 251, 266
- Physisorption isotherms 223
- Pickering emulsions 330
- pin-on-disk tribometer 290
- plasma ashing 181, 182
- plasma cleaning 181, 182, 266
- plasma-enhanced chemical vapor deposition (PECVD) 259
- plasma etching 181, 275, 276
- plasma polymerization 272–274
- plastic deformation 184, 186, 284–286, 289, 292, 306
- Plateau border 340, 343, 344
- PLAWM trough 349
- plunging-tape experiment 161
- Pluronic 314
- PNIPAM 270, 271
- point of zero charge (pzc) 72, 74, 75, 77, 81, 84
- Poisson equation 56, 62, 87
- Poisson–Boltzmann equation 56, 57, 59–62, 65–67, 87, 89, 91, 114, 115, 117, 375
- polarizability 66, 95, 100, 101
- polarizable electrode 66, 76, 95, 96, 100, 101
- polarizer-compensator-sample-analyzer (PCSA) ellipsometer 237
- poly(dimethylsiloxane) 8
- poly(ethyleneimine hydroxid) (PEI) 267
- polyallylamine 267, 273
- polydimethylsiloxane (PDMS) 8, 138, 139, 149, 152, 159, 220, 269, 270, 296, 313
- polyederschaum 340
- polyelectrolyte 64, 122, 267–268, 303, 389
- polyhedral foam 340
- polylysine 267
- polymer(s) 76, 122–125, 266, 268, 328
  - brush 124
  - film 163–165
  - properties of 122–123
  - structure 124
- polymer-coated surfaces, force between 123–126
- polymeric surfactant 313, 314, 344
- polymerization 268, 270, 271
  - atom transfer radical polymerization (ATRP) 271, 274
  - grafting-from 270, 273
  - plasma 272–274
  - pulsed plasma 273

reversible addition fragment chain  
   transfer (RAFT) 271  
   surface-initiated (SIP) 269, 271  
 polymethyl methacrylate (PMMA) 280,  
   382  
 polypropylene 159  
 polystyrene 92, 103, 104, 126, 132, 165,  
   173, 267, 277, 281, 340, 378, 382,  
   389  
 polystyrene sulfonate 267  
 polyurethane (PUR) foams 338, 339  
 pore-size distribution 246  
 pore space 239  
 porous material 31, 154, 155, 222, 224,  
   236, 238–246, 251  
 porous solid 2, 23, 220, 222, 240, 339  
 potential determining ions 75, 76, 80,  
   81, 84  
 potentiometric colloid titration  
   80–82  
 potentiometric titration 80–82  
   of latex particles 82  
 pour point depressants 304  
 powder 50, 130–131, 135, 154–155, 175,  
   189, 211, 224–225, 236, 238–240,  
   247, 251, 330  
 Prandtl–Tomlinson model 301, 302  
 precursor film 159  
 primary energy minimum 118, 332  
 principal curvatures 14, 15, 335  
 propanol 8, 45, 103, 120, 374  
 protein 53, 58, 66, 76, 89, 112, 123, 167,  
   239, 249, 272, 322, 323, 328, 330,  
   353  
 pulp 165  
 pulsed plasma polymerization 273  
 pulsed plasma technique 273  
 pump-probe-type experiments 212  
 pure liquids 35, 43–45, 51, 170, 341

**q**

quartz crystal microbalance (QCM) 236,  
   256, 291, 293  
 quartz particle 99, 103, 168, 236, 252,  
   256, 283, 291, 294

**r**

radiation scattering at parallel lattice  
   planes 396  
 radius of curvature 11, 13, 23–25, 120,  
   143, 204, 241, 243, 296, 337  
 radius of gyration 123, 124  
 RCA method 266  
 reactive ion beam etching 275  
 reactive ion etching 275, 276  
 Read–Shockley equation 199  
 real vs. ideal isotherms 352  
 receding contact angle 139, 145–147,  
   153, 160, 161, 247, 264  
 reciprocal lattice 383, 397–405  
 RED 58, 208  
 refined base oils 303  
 refractive index 100, 102, 103, 200, 211,  
   237, 251, 260, 368  
 relative adsorption 36  
 relative equilibrium vapor pressure  
   22  
 retardation 101, 106  
 retarded Van der Waals forces  
   105–106  
 reversible electrode 76, 82, 83  
 Reynolds number 167, 297  
 RHEED 208  
 rheologic properties of liquid surfaces  
   361–366  
 rheology 361  
 rheometer 364, 365  
 ring tensiometer 18, 19, 31  
 robust superamphiphobic surfaces 151  
 rodlike micelles 320  
 rolling friction 288–289, 307  
 roughness 26, 83, 100, 110, 111, 139,  
   148–150, 172, 266, 268, 285, 286,  
   296, 307, 356, 357, 388

**s**

saddle-splay modulus 335, 336  
 saturated alkyl chains 347  
 scanning electron microscope/microscopy  
   (SEM) 111, 201–206, 217  
   environmental 202

- scanning force microscope (SFM) 111, 203
- scanning tunneling microscope (STM) 179, 190, 196, 197, 203–205, 207, 217, 251, 384, 388
- Schulze–Hardy rule 116
- second harmonic generation (SHG) 212
- secondary energy minimum 118, 119, 331
- secondary ion mass spectrometry (SIMS) 215
  - dynamic 215
  - static 216
- sedimentation potential 84, 88–91
- self-assembled monolayer (SAM) 262–266, 270, 280
- self-energy 55
- semicoherent interface 198
- semiconductor 79–80, 176, 178, 198, 208, 217, 258, 260–262, 278–280
- semiconductor surfaces 178, 262
- semiconductor–electrolyte interface potential 79, 80
- sessile bubbles 17
- sessile drop 15, 16, 31, 136, 139, 143, 146, 155, 160, 380
- shape, of water drop resting on flat surface 16
- shear rate 84, 85, 297, 298, 364
- shear thinning 297, 298
- shear thinning effect 297, 298
- shear viscosity 362–365
- Shuttleworth equation 185
- silanes 244, 262–266, 269, 280, 388
- silanization 265, 266, 289
- silicon, semiconductor 79
- silicone surfactants 159, 313
- silver chloride 75
- silver iodide 75
- simple liquid structure 120
- single “ink bottle” pore 244
- single-chain surfactants 320
- sintering 175
- SiO<sub>2</sub> 2, 76, 77, 99, 102–104, 114, 132, 168, 259, 262, 264, 277, 289, 380
- size of a polymer 123
- slip phase 300
- slippery lubricant-infused surfaces (SLIPS) 152
- small-angle neutron scattering (SANS) 315, 318
- small-angle X-ray scattering (SAXS) 315
- soap(s) 303, 309, 314, 326, 341–344, 368
- soap films 341–344, 368
- sodium dodecanoate 309
- sodium dodecyl sulfate (SDS) 48, 49, 168, 309, 310, 314, 316–318, 320, 336, 344, 355, 356
- solid foams 338, 339
- solid friction 284
- solid–liquid interfaces 219
- solid mechanics 184
- solid–solid interfaces 1, 198–200, 217
- solid-stabilized emulsions 330
- solubility and CMC 317
- soluble amphiphiles 309, 347
- solvation forces 119, 120
- specific membrane resistance 322
- specific surface area 2, 80, 224, 236, 238, 239, 244, 246, 251, 252
- spherical particles 3, 24, 61, 90, 112, 118, 126–132, 156, 247, 326, 381
  - in contact 128
- spin coating 163, 164, 278, 279
- spinning drop method 171
- spontaneous curvature 333, 335–337
  - of surfactant film 336
- spontaneous spreading 158–160, 162
- spray coating 164
- spreading coefficient 140, 141, 170, 173
- sputter deposition 256
- sputter etching 275
- sputtering 181, 182, 215–217, 256, 257, 280, 389
- static contact angle 147
- static friction coefficient 286, 290
- steric and depletion interaction 122–127
- steric force 122, 124, 126, 328
- steric repulsion 121, 328

- Stern layer 54, 57, 67–68, 83  
 Stern model 67–68  
 stick-slip friction 286–289, 294, 301, 302  
   atomic 293  
 stick-slip motion 286–287, 300–302, 305  
 sticking probability 230  
 Stokes equation 84–87, 297  
 Stokes law 89  
 Stranski–Krastanov growth 258, 259  
 streaming potential 84, 86–88, 91  
 Stribeck diagram 299, 300  
 structural superlubricity 301  
 structure factor 383, 401–403  
 Styrofoam 338  
 SU-8 280  
 substrate structure 176–177, 179, 217, 279  
 sum frequency generation (SFG) 212, 355, 356  
   spectroscopy 212, 355, 356  
 superamphiphobic surfaces 151  
 superhydrophobic surfaces 150–152  
 superhydrophobicity 150  
 superlattice 179–180, 209, 217  
 superlubricity 301  
   dynamic 302  
   liquid 302–303  
   structural 301  
   thermal 302  
 superoleophobic surfaces 151  
 superposition principle 94  
 superspreading 159  
 surface 1  
   dilatational viscosity 362  
   elastic modulus 362  
   shear viscosity 362  
 surface active agents 46, 309  
 surface active molecules, types of 314  
 surface charge 53–58, 62–63, 66–78, 80–81, 84, 86–87, 89, 91, 112–114, 116–117, 202, 206, 249, 376  
 surface diffusion 191–198  
 surface dilatational viscosity 362, 365–366  
 surface elastic modulus 362–364, 366  
 surface energies 129, 217  
   interfacial 44  
   internal 44  
   solid 183–188  
 surface enthalpy 43, 188–189  
 surface entropy 7, 42–45, 374  
 surface excess 34–37, 43, 47–48, 51, 223–224, 249, 251, 347, 349–350, 363, 374  
 surface fatigue 306  
 surface force apparatus (SFA) 110, 111, 119, 122, 123, 131, 283, 291, 293, 295–296, 300, 303, 307  
 surface forces 93  
   Derjaguin approximation 107–109  
   disjoining pressure 109–110  
   measurement 110–112  
 surface intensive parameter 184–185  
 surface melting 181, 292, 306  
 surface modification  
   chemical vapor deposition 259–262  
   etching techniques 274–278  
   lithography 278–280  
   physical vapor deposition 256–259  
   soft matter deposition  
     physisorption of polymers 266–268  
     plasma polymerization 272–274  
     polymerization 268–271  
     self-assembled monolayers 262–266  
 surface potential 57, 62, 69, 76, 113  
   vs. charge 63  
   monolayer 359–361  
   jump 69  
   measurements 360, 361  
 surface reconstruction 178–179, 217, 220  
 surface relaxation 177–179, 217  
 surface rotational rheometry 364, 365  
 surface roughness and heterogeneity 149–150  
 surface shear viscosity 362–363, 365  
 surface strain 184–185, 362–353  
 surface stress 183–186, 188, 217  
 surface structure 145, 149–150, 176, 178–179, 181–182, 201, 207, 217, 261–262, 276, 280, 399

- surface tension 6–8, 15, 39–41, 44, 45, 143, 183–186, 188
  - of charged surfactants 49
  - gradient in 50
  - measurement technique 15–20
  - solid 185
  - unit of 7
- surface viscosity 362–363, 366
- surfactant(s) 46, 165, 167, 309, 327, 329
  - aggregates distribution 316
  - aggregates formed by 321
  - aggregate structure 319–322
  - amphoteric 313
  - anionic 309
  - bolaform 313
  - cationic 313
  - characteristic property of 314
  - dimeric 313
  - gemini 313
  - ionic 316
  - nonionic 313, 316
  - oligomeric 313
  - polymeric 313
  - structure of 310–312
  - temperature influence 316, 317
  - tetrameric 313
  - trimeric 313
  - zwitterionic 313, 319
- surfactant films, elastic properties of 335–336
- surfactant numbers 320
- surfactant parameter 319–321, 335, 344
- suspending power 167
- suspension 2, 53, 304
- symbols 42, 59, 114, 120, 136, 169, 178, 180, 184, 220, 260, 264, 290, 350, 405–409
- t**
- tears of wine 50
- Teflon 106
  - surface energy of 106
- temperature-programmed desorption 248–249
- TEMPO 271
- tensides 309
- tensiometer
  - bubble pressure 17
  - drop volume 171
  - du Nouy ring 18
  - pendant drop 16
  - spinning drop 171
  - Wilhelmy plate 19
- terrace-ledge-kink (TLK) 189
- terraces 189, 217
- tetrameric surfactants 313
- thermal decomposition 304
- thermal desorption spectroscopy (TDS) 248, 252, 387
- thermal superlubricity 302
- thermal treatment 181, 182, 217
- thermodynamic considerations 198
- thermodynamic functions, for bulk systems 33–34
- thermodynamics of micellization 317–319
- theta solvent 123
- theta temperature 123
- thick films 163, 169–171, 173, 280
- thin film 104, 140
  - balance 341, 342
  - lubrication 300–301
- thiols 180, 249, 263–264, 266, 280, 389
- three-phase contact line 19, 135, 138, 143, 147–148, 172
- tilted plate method 146–147
- TiO<sub>2</sub> 76, 77, 264, 266
- TOF-SIMS 216–217
- toluene 51, 126, 220, 322–323, 339, 374
- toluene diisocyanate (TDI) 339
- Tomlinson's model 293, 294
- total internal reflection 210, 211
- total internal reflection fluorescence (TIRF) 211
- total internal reflection microscopy (TIRM) 111, 384
- transmission electron microscope (TEM) 201, 296
- triblock copolymer 314
- tribochemical reactions 306



- tribology 4, 283
  - tribometers 290
  - tribosystem 284
  - trifunctional silane 265
  - trimeric surfactant 313
  - twist boundary 199
- U**
- ultrafast laser pulses 212
  - ultrafast pump-probe experiments 213
  - ultrahigh vacuum (UHV) 31, 175–176, 180–181, 188, 197, 205–208, 217, 220, 248, 255, 299, 301, 303
  - ultraviolet photon spectroscopy 70
  - unduloids 12–13
  - unit of surface tension 7
  - unsaturated alkyl chains 347
  - UV photoemission spectroscopy (UPS) 215, 217
- V**
- vacuum, types 255, 256
  - van der Waals
    - attraction 99, 187, 220
    - between macroscopic solids 97–106
      - Lifshitz theory 100–105
      - microscopic approach 97–100
      - retarded Van der Waals forces 105–106
      - surface energy 106
    - between molecules 93–97
    - energy 98, 99
    - equation of state 97, 350
    - force 98, 99, 101, 102, 104–107, 110, 117, 120, 219, 295, 299, 331
    - interaction 96–98, 101, 164, 187, 220, 331, 333, 352, 354
    - type equation 350
  - vapor condenses 22, 26, 230
  - vapor pressure, of drop 20, 22
  - vertical force component 13, 138
  - vibrating electrode method 360
  - vicinal surface 189–190, 217
  - viscoelastic hysteresis 289
  - viscosity 84, 298, 303, 326
    - dynamic 84, 303
    - kinematic 84, 300, 303
    - of lubricants 298
  - viscosity index (VI) 303–304
  - viscosity modifiers 304
  - void 239
  - volatile liquid 139, 140
  - volatility 304
  - Volmer–Weber growth 258–259
  - volta potential 68
- W**
- water purification 165
  - water-in-oil emulsion 304, 325, 329
  - wave vector 358, 395–396, 398–399
  - wear 283, 305, 306
    - abrasion 305
    - defined 305
    - erosion 305–306
    - fretting 306
  - wearless friction 293, 307
  - Wenzel equation 149
  - Wenzel state 150–151
  - wet and dry etching 274
  - wet foam 339–340
  - wetting
    - applications 135
    - detergency 166–167
    - and dewetting
      - coating 163–164
      - dynamic contact angles 160–163
      - spontaneous spreading 158–160
    - electrowetting 168–169
    - flotation 164–165
    - microfluidics 167–168
    - of real surfaces
      - advancing and receding contact angles 145–146
      - contact angle hysteresis, causes of 147–149
      - measurement of contact angles 146–147
      - superhydrophobic surfaces 150–152
      - surface roughness and heterogeneity 149–150

wetting (*contd.*)

- surfaces with low sliding angle 152
- road pavements 135
- thick films 169–172
- wetting geometries
  - capillary rise 153–155
  - network of fibers 157
  - particles at interfaces 155–157
- wetting line 135, 143, 147–150, 162–163
- wetting potential 140
- wetting transition 143–144
- Wilhelmy plate method 19, 31, 32, 146–147, 349, 365–366, 372
- Wood's notation 180
- work function 70, 196, 203
- wormlike micelles 320
- Wulff construction 186, 217

**X**

## X-ray

- diffraction 356, 357, 359, 400
- grazing incidence diffraction 357, 359
- reflection 356–359, 369
- X-ray photoemission spectroscopy (XPS) 213–215, 217

**Y**

- yield stress 285–286, 289, 390
- Young's equation 135–140
  - derivation 136–140
  - equilibrium contact angle 135–136
  - interfacial energy, estimation of 144–145
  - line tension 142–143
  - surface forces 140–142
  - wetting transitions 143–144
- Young–Laplace equation 11, 17, 40
  - application 14–15
  - derivation of 13–14
  - fundamental implications 12

**Z**

- zeolites 236, 240, 244–246
- zeta potential 83–84
  - electro-osmosis and streaming potential 86–88
  - electrophoresis and sedimentation potential 88–91
  - Navier–Stokes equation 84–86
- zwitterionic amphiphiles 347
- zwitterionic surfactants 313, 319

















