

# Index

## A

Absorption, 311, 314, 317, 318, 320, 321, 323  
Acentric factor, 162, 163  
Activation energy, 451, 470, 474  
Activity coefficient, 139–141, 145–147, 149, 150, 152, 168, 169, 179–182, 186, 189, 194, 196–199, 362  
Addition formula, 4, 63, 92  
Adiabatic drier, 364, 365  
Adiabatic saturation, 366, 371, 388, 390  
Adsorption, 393, 465–470, 472, 474–476, 478  
Annular flow, 599, 640, 687  
Antoine equation, 138, 217, 220  
Arrhenius equation, 424, 426, 427, 451, 452, 474  
Azeotrope, 169, 170, 249

## B

Bacterial growth curve, 527  
Bernoulli equation, 580, 581, 584, 648, 651  
Bingham fluid, 589–591  
Boiling point elevation, 185, 188–190  
Boundary layer, 347, 348, 517, 656–659, 666–668, 723–726  
Bound moisture, 386  
Bubble point, 212, 215, 216, 218, 220, 252, 253, 255–257, 264, 266, 267, 273, 274, 276, 277, 285, 288, 290, 295, 300, 303

## C

Cascade of reactors model, 439–443  
Chain rule, 14, 15, 148, 425, 471

Characteristic roots, 19, 20, 22, 70  
Chemical potential, 127, 139, 156, 173, 175, 179, 184, 212, 213, 255, 333, 352, 361, 392  
Chemisorption, 468  
Chemostat, 571–573  
Clausius–Clayperon equation, 175, 195  
Complementary solution, 23  
Complex conjugate, 2  
Complex exponential, 85  
Compressibility factor, 133, 162, 163  
Concentration polarization, 346, 348–354, 356, 358  
Confidence interval, 108, 110–112  
Constant rate period (CRP), 364, 365, 367, 368, 373, 376, 377, 380–382, 384, 385, 387  
Continuity equation, 583, 588, 593, 597, 604, 614, 617, 622, 625, 626, 635, 638–641, 644, 694, 696, 698, 701, 725  
Convolution theorem, 44  
Cover up rule, 10–13, 53–56, 68, 536  
Creeping flow, 593, 652–655, 691, 692, 694, 695, 697, 699, 704, 705, 708, 709  
Critical point, 138, 202  
Critical wetness, 367, 376  
Crystallization, 391, 392, 394, 395, 398, 408  
Cyclic rule, 36, 133

## D

Damköhler number, 480, 481, 556, 558, 561  
Delta pulse input to reactor, 435  
De Moivre's theorem, 2  
Deviatoric component of transfer function, 68

Dew point, 212, 215, 216, 218, 220, 252, 253, 256, 257, 266, 273, 274, 278, 279, 284, 286, 288, 300, 369, 373, 374  
 Double angle formula, 3, 82  
 Drag force, 592, 596, 598, 711  
 Dry bulb temperature, 369, 371, 372  
 Dynamic pressure, 592, 596, 603, 617, 621, 625

**E**

Eigenfunction, eigenvector and eigenvalue, 113–126  
 Eley-Rideal adsorption model, 474, 475  
 Enthalpy of adsorption, 468, 470  
 Entropy, 128, 139, 142, 143, 168  
 Entropy of compression, 206, 207  
 Entropy of fusion, 186  
 Entropy of mixing, 143, 168  
 Entropy of vaporization, 188  
 Entry length, 661  
 Enzyme inhibition, 551  
 Enzyme kinetics, 548, 550, 557  
 Equation of state (EOS), 129, 133, 134, 156–158, 200, 203–207  
 Equilibrium moisture, 382, 383, 386, 388  
 Eutectic point, 192, 193  
 Even function, 3, 7, 41, 89, 91, 96  
 Exact differential, 28  
 Excess Gibbs free energy, 144, 146, 148, 149, 151, 154, 155, 168, 181, 182, 199

**F**

Falling rate period (FRP), 364, 365, 367, 368, 373, 376–378, 380–382, 385, 387, 388  
 Fenske equation, 286, 289, 294, 299  
 Fick's law of diffusion, 333, 347  
 Filtration, 350, 357, 361  
 Form drag, 592, 594–596, 711, 712  
 Fourier series, v, 7, 8, 85–91, 94, 95, 97–99  
 Free moisture, 377, 379, 380, 383, 384, 386, 387  
 Freezing point depression, 185–187, 192–194  
 Friction factor, 581, 648, 651, 657–661, 666, 670  
 Friction velocity, 657, 659, 660, 666, 667, 670, 671  
 Fugacity, 127–129, 136, 137, 139–141, 149, 150, 155–157, 168, 171, 177, 179, 180, 196, 197, 220, 346

**G**

Gel effect, 349  
 Generalized correlation for fugacity coefficient, 172  
 Gibbs–Duhem (GD) equation, 139, 147, 151, 160, 161, 165, 168, 183, 198  
 Gilliland correlation, 296  
 Gradient operator, 623, 701

**H**

Heaviside function, 514  
 Heavy key (HK), 287–289, 291, 293, 298–301, 303, 304  
 Heavy non-key (HNC), 287, 299, 301  
 Henry's law and reference state, 138, 139, 141, 147, 150, 197  
 Hessian matrix, 118–120, 122  
 Hyperbolic functions, 2–3  
 Hypothesis test, 101, 103, 110

**I**

Ideal solution, 139, 145, 147, 149, 168, 190, 192, 196, 361  
 Immobilized enzyme, 543, 556, 557  
 Improper fraction, 12  
 Inexact differential, 28, 29, 31  
 Injection moulding, 582  
 Integration by parts, 8, 14–16, 59, 84, 90, 96, 416, 668  
 Inverse function, 5, 6

**K**

Karman–Nikuradse equation, 660  
 Kremser–Souders–Brown (KSB) equation, 312, 315, 316  
 K value, 255, 273, 283, 285, 286, 311, 312, 314

**L**

Laminar flow, 607, 613, 625, 629, 657, 660, 666, 667, 678, 724  
 Langmuir adsorption model, 468, 474  
 Langmuir–Hinshelwood, 468, 474, 475  
 Laplace transform, v, 9, 43, 44, 52–60, 63–68, 70, 72, 78, 427–430, 435–437, 439, 440, 443, 444, 513, 514  
 Laplacian operator, 701  
 Latent heat, 305, 306, 380, 389, 390  
 Law of corresponding states, 163

Lever rule, 215  
 Lewis/Randall (LR) reference state, 137, 139,  
 141, 147, 149, 151, 185, 188, 198  
 Light key (LK), 287, 291, 293, 298, 299, 301  
 Light non-key (LNK), 287, 299  
 Lubrication approximation, 612, 615, 616,  
 620, 623

**M**

Maclaurin's series, 7  
 Margules equation, 145–148, 150, 181, 193,  
 194, 196  
 Maximum reflux, 308, 309  
 Maxwell relations, 205  
 McCabe–Thiele diagram, 228, 243, 244, 248,  
 259, 261  
 Mean residence time, 71, 76, 427, 432, 436,  
 438, 439, 441, 445, 451, 513, 524,  
 525, 573  
 Mechanical energy dissipation, 681, 686,  
 687, 690  
 Membrane permeability, 347, 357  
 Method of characteristics, 44, 46, 50  
 Method of undetermined coefficients, 23  
 Michaelis–Menten (MM) kinetics, 539, 542,  
 548, 549, 551, 552, 554, 556, 557  
 Minimum reflux, 227, 228, 230, 232, 235, 238,  
 242, 244, 246, 249, 250, 258, 259, 290,  
 296, 298, 308, 310  
 Moments of Laplace for RTD, 427, 436, 438  
 Moments of population density, 412, 416  
 Monod growth model, 527, 529, 531–533, 537,  
 538, 543, 544

**N**

Navier–Stokes equation, 583, 584, 600,  
 602, 608, 613, 616, 617, 620, 621,  
 623, 625, 626, 628, 629, 633, 634,  
 640, 641, 645, 653–655, 657, 673,  
 675, 677, 679, 684–686, 688, 692,  
 694, 695, 699, 705, 706, 709–711,  
 714–718, 721–723, 725  
 Negative angle formula, 3  
 Newtonian fluid, 584, 587, 593, 599, 602, 607,  
 613, 616, 625, 628, 633, 638, 640, 644,  
 652, 653, 655, 673, 675, 679, 686, 688,  
 692, 694, 695, 701, 705, 709, 713, 716,  
 721, 724  
 Nomogram, 273, 277  
 Non-adiabatic drier, 364

Non-key, 290, 293, 294  
 Normal distribution, 101, 102, 104, 107, 109,  
 110, 112, 113  
 Normal stress, 711  
 Nucleation for crystal growth, 395,  
 399, 408  
 Nucleation site for bubble formation, 174–175  
 Numerical integration, 342–344

**O**

Odd function, 3, 7, 41, 86, 94, 98  
 Operating line for distillation, absorption,  
 stripping, 220–225  
 Operating line for drier, 364, 373  
 Order of magnitude (OOM) analysis, 583,  
 695, 696  
 Osmotic pressure, 349, 352, 353, 357, 358,  
 361, 363

**P**

Packed bed reactor (PBR), 419–422, 439, 441,  
 516, 517, 556, 559–561  
 Partial fractions, 9–13, 53–56, 58, 68, 130,  
 514, 535  
 Partial molar enthalpy, 159, 160, 162, 166  
 Partial molar Gibbs energy, 127, 144, 156,  
 179, 362  
 Partial molar heat of mixing, 164  
 Partial molar property, 139, 153, 154, 160, 163,  
 165, 168  
 Particular integral, 23–25, 27  
 Phase diagram, 169, 215  
 Physisorption, 465, 468  
 Plug flow reactor (PFR), 74, 419–422,  
 432–434, 436, 439, 440, 442, 444–446,  
 448, 521, 525  
 Poiseuille flow, 607, 608  
 Power series, 6  
 Poynting correction, 177  
 Prandtl–Karman coordinates, 660  
 Principle of orthogonality, 41  
 Product rule, 8, 430, 431, 717  
 Psychrometric chart, 366, 369, 373, 375, 379,  
 383, 388

**Q**  
 Q-line in distillation, 241, 247, 259,  
 261, 305  
 Quotient rule, 8

**R**

- Raoult's law, 170, 212–214, 220
- Real solution, 361
- Recycle loop, 445
- Reduced pressure, 138, 163, 172, 215
- Reduced temperature, 138, 163, 172, 216
- Reflux ratio, 222, 227, 228, 230, 232–235, 238, 242, 244–247, 249, 250, 258, 259, 261, 267–270, 290, 296, 298, 303, 305, 308–310
- Rejection ratio, 350, 357
- Relative humidity (RH), 366, 370, 374, 383, 386, 388
- Residence time distributions (RTDs), 6, 427–429, 434–439, 443–446, 448, 518, 521
- Respiratory quotient, 572, 574
- Retention ratio, 350, 352
- Reverse osmosis, 350, 353, 354, 361
- Reynolds number (Re), 351, 399, 400, 581, 652
- Roughness factor, 579, 581

**S**

- Schmidt number (Sc), 351, 399, 400
- Second law of thermodynamics, 175, 176, 204
- Sensible heat, 380, 390
- Separation of variables (VS), 37, 40, 43, 716, 718, 721
- Shear stress, 584, 588–591, 596, 597, 604, 617, 620, 621, 629, 634, 635, 640, 642, 643, 648, 654, 656–658, 660, 661, 667, 670, 673, 681–684, 690, 713, 715, 725
- Sherwood number, 351, 394, 399, 401
- Shrinking core model (SCM), 454, 455, 457, 463
- Simpson's method for integration, 526
- Skin drag, 596, 711
- Solid–liquid equilibrium, 185
- Specific growth rate, 530, 532, 533, 543, 544, 572, 573, 576
- Specific humidity, 366, 367, 370, 371, 373, 374, 379, 389, 390
- Stoke's flow, 652
- Stream function, 724, 726–728
- Streamline, 625, 681, 695, 724, 726, 727
- Stress tensor, 596, 621
- Stripping column, 311–315, 324, 332–334
- Substitution method, 82, 335, 482, 492, 495
- Surface tension, 173, 174, 195, 392, 393, 406, 587, 590, 601

**T**

- Taylor's series, 6, 8, 616
- T-distribution and t-test, 104, 105, 109, 110
- Terminal velocity, 593, 598, 599
- Thermal conductivity, 39, 630, 666, 674, 677
- Thermal diffusivity, 38, 630, 664, 671, 677
- Thermodynamic consistency, 151, 152
- Thiele modulus, 482, 486, 488–492, 495, 498, 511
- Time-averaged energy and velocity, 664, 667
- Torque, 600, 601, 640, 642, 643, 652, 654, 656, 690
- Total reflux, 267, 269, 286, 289, 290, 297, 299, 309
- Transfer function, 61, 63–72, 74–76, 78, 79, 427, 429, 438–440
- Trigonometric formulae and identities, 3, 4
- Turbulent core, 666–668

**U**

- Underwood's equation, 290, 295–299, 303
- Unit step input function, 68, 435

**V**

- Van der Waals interactions, 465, 468
- Van Laar equation, 169, 170, 183, 184
- Vapor–liquid equilibrium (VLE), 155, 157, 169, 183, 188, 191, 197, 202, 211, 212, 217, 218, 228, 232, 235, 255, 256, 264, 267, 299, 324, 325
- Vapor pressure, 156, 169, 172, 174, 177, 179, 180, 201, 212, 213, 217, 220, 254, 278–280, 386, 406, 466
- Variance in statistics, 72, 104
- Variance of residence time distribution, 428
- Velocimetry, 656
- Vessel in series model, 427–429, 434, 435, 437
- Virial equation of state, 132, 133, 200, 206
- Viscous loss, 580, 581, 647, 648, 651, 663
- Viscous sublayer, 666, 667, 670, 672

**W**

- Wall shear stress, 657, 658, 660, 661, 667, 670
- Wet bulb temperature, 365–372, 374, 379, 383, 384

**Y**

- Yield coefficient, 527, 530, 533, 534, 544, 545, 572, 574–576
- Yield stress, 590, 591