

Index

A

Absorption, 479
Accommodation coefficient, 380
Acetylene, role in soot formation, 376–377
Adiabatic flame temperature, 78–80
Adsorption, 479, 497–502
 equipment, 503
 isotherm, 498
 zone, 500
Aerosol, 290
Agglomeration, 328
Air pollutants, 4–5
 hazardous, 7
 organic, 3, 6, 7
Air pollution
 control strategies, 521–524
 control, long-term, 524–526
 engineering, 2
 study of, 1
Aldehydes, 104–105
Alkenes, 104
Alúmina, 266
Aluminosilicates, 360
Ammonia, 4
 formation in combustion, 181
 injection, 192–198
 use in NO_x control, 192–198
Arrhenius form, 23

Ash, 358
 aerosol, 370
 formation from coal, 359
 mechanisms of formation of, 360–361, 363
 size distributions, 362, 364
 trace elements in, 359
 vaporization, 364–370
Atomizers, 143
Autocorrelation
 Eulerian, 48
Avalanche, electron, 416

B

Baghouse, 452
Bassett history integral, 298
Bed
 filter, 433
 fluidized, 145
BET method, 154, 220
Binomial distribution, 41, 42
Blowby, 261
Blowdown, 260
Boltzmann constant, 22
Boltzmann distribution, 342, 420
Bond strengths, 103
Brake mean effective pressure (BMEP), 248
Brake specific fuel consumption (BSFC), 228

- Brownian diffusion, 392, 435
- Brownian motion, 308–312
- Bunsen burner, 114
- Burke and Schumann model, 127
- C**
- Calcites, 360
- Calcium, species vapor pressures, 369
- Carbon dioxide, 4
- Carbon monoxide, 5
 - oxidation quenching, 204
 - role in combustion, 201 et seq.
- Carburetor, 254–259
- Catalyst, three-way, 267
- Cenosphere, 360
- Chapman-Enskog, 295, 318
- Char, 147, 372
 - oxidation, 149 et seq.
 - role in NO_x formation, 190
- Charging
 - diffusion, 420–423
 - field, 418–420
- Chemical potential, 81
- Chemiluminescence, 127
- Choke, 258
- Clapeyron equation, 138
- Clean Air Act, 11
 - Amendments, 11
- Coagulation
 - characteristic time for, 338–339
 - coefficient, 328, 331
 - equation, 331–337
- Coal, 61–62
 - ash content of, 365
 - combustion systems, 146–147
 - composition of, 64–66
 - devolatilization, 146–149
 - mineral inclusions in, 360
 - nitrogen content of, 180
 - particles, 157
- Coefficient of skewness, 42
- Coefficient of variation, 42
- Coke, 372–373
- Collision
 - frequency of gas molecules, 22
- Combustion
 - equilibria, 98–100
 - kinetics, 101–113
 - staged, 191
 - stoichiometry, 63–67
- Compression ratio, 229
- Control volume, 68
- Convection, forced, 145
- Converter, catalytic, 266–267
- Corona (see Electrostatic Precipitation)
- Costs
 - control, 524
 - damage, 524
- Crank angle, 227
- Crankcase, 261
- Creeping flow, 291
- Crevice, piston, 244
- Cyclone separators, 402–411
 - dimensions of, 408
 - laminar flow, 404–406
 - Leith-Licht theory, 410
 - turbulent flow, 406–408
- Cylinder
 - collection efficiency of, 449–452
 - deposition of particles on
 - Brownian diffusion, 438–440
 - Impaction, 441–445
 - Interception, 440–441
 - flow field around, 436–437
- D**
- Dalton's law, 83
- Detailed balancing, 24, 94–96
- Diameter
 - aerodynamic, 307
 - aerodynamic impaction, 308
 - classical aerodynamic, 308
 - cut, 394
 - median, 326
 - Stokes, 307
- Dibutylphthalate, 320, 344
- Diesel (see Engine, diesel)
- Diesel filter, 475–476
- Diesel particulate matter, 386
- Diffusiophoresis, 314
- Discharge coefficient, 143
- Drag, 291
- Drag coefficient, 292–293, 305–307
- Driving cycle, 6
- Dual alkalai, 509
- E**
- Eddies, 127
- Effectiveness factor, 156
- Efficiency
 - collection, 393
 - fractional, 394
 - grade, 394
 - overall, 393
- Effusion flux, 316
- Electric field
 - motion of a particle in, 305

- Electron beam process, 516–517
 Electrostatic precipitation, 411–432
 corona, 415–417, 426
 Deutsch equation, 415
 electric field in, 425–429
 particle charging in, 417–425
 Elemental potentials, 98
 Elution, 499
 Emissivity, 151
 Energy
 activation, 22
 internal, 68
 kinetic, 68
 total, 68
 Engine
 diesel, 269–272
 direct injection (DI), 269
 indirect injection (IDI), 270
 gas turbine, 280–284
 spark-ignition, 227
 stratified charge, 277–280
 Ensemble, 310
 Ensemble average, 48
 Enthalpy
 of combustion, 75–76
 of formation, 71, 73
 of reaction, 70
 Entropy
 partial molar, 82
 reference, 73
 Equation
 conservation of energy, 33
 convective diffusion, 30
 general dynamic for aerosols, 328–331
 Equilibrium
 conditions for thermodynamics, 81–83
 partial, 186, 206–210
 Equilibrium constant, 24, 83
 temperature dependence of, 83–87, 103
 Equivalence ratio, 66
 Error function, 326
 Ethane, pyrolysis of, 27–29
 Evaporative emissions, 261–264
 Excess air, 66
 Exhaust gas recirculation (EGR), 252
 Expectation, 39
 Exponential distribution, 44
 Extent of reaction, 18–19, 82–83
- F**
- Fick's law, 30, 480
 Filtration
 by granular bed, 455–456
 collection efficiency by inertial impaction
 and interception, 446–448
 collection efficiency of a filter bed, 433
 industrial fabric, 452–455
 Flame, 113
 diffusion, 113, 126, 127
 laminar, 115, 116, 126
 premixed, 113, 116, 120
 speed, laminar, 113, 116–118
 thickness, 118, 124
 turbulent, 115, 120, 127
 Flash point, 61
 Flow coefficient, 255
 Flue gas desulfurization (FGD), 505
 Flue gas recycle, 191
 Flux matching, 317
 Fly ash, 360
 Fourier's law, 34
 Friction coefficient, 296
 Friction factor, 125
 Fuchs, 317–318, 332
 Fuel NO_x , 179–183
 control, 191
 Fuel/air ratio, 63
 Fuels
 properties of gaseous, 60
 properties of liquid, 61
 properties of solid, 62
- G**
- Galileo number, 306
 Gamma distribution, 45
 Gas absorption, 484–497
 Gas constant, universal, 55
 Gas, natural, 60
 Gasoline, 6
 Gaussian distribution (see Normal distribution)
 Gibbs free energy, 81
 in particle-gas system, 341
 minimization of, 96
 Gravity, API, 61
 Growth law, 330
 Gypsum, 219
- H**
- Hamaker theory, 334
 Heat of reaction, 23
 Heat transfer coefficient, 151
 Heating value
 higher (HHV), 76
 lower (LHV), 76
 Henry's law, 483

Heteroatoms, 358
 Hot soak, 262
 Hydrocarbons
 in ambient air, 6
 non-methane, 5
 polycyclic aromatic, 215–216
 pyrolysis kinetics, 26–29
 unburned, 244–247
 Hydrogen cyanide, 181
 Hydrogen peroxide, 105
 Hydrogen sulfide, 4

I

Impaction, 435
 Impactor, cascade, 301–304
 Incineration, 480
 Indicated mean effective pressure (IMEP),
 248
 Indicated specific fuel consumption (ISFC),
 248
 Inertial subrange, 47
 Initiation, 102
 Interception, 435
 Isocyanic acid, 198

K

Kelvin effect, 319, 341
 Kerosene, 61
 equilibrium composition and temperature
 for combustion of, 99–100
 Kinetics, chemical, 17–29
 Knock, 229
 Knudsen number, 154, 293–295
 Kolmogorov micro scales, 47
 Kronecker delta, 328
 Kuwabara, 437

L

Lagrange multipliers, 97
 Langevin equation, 308
 Lewis number, 141
 LIMB, 221
 Lime, 219, 505
 PH control in, 509–511
 scrubbing, 506–509
 Limestone, 220, 505
 scrubbing, 506–509
 Linear programming, 526–527
 Log-normal distribution, 325–327, 354–356

M

Magnesites, 360
 Magnesium oxide, 511
 Mass transfer coefficient, 482
 Mass, reduced, 22
 Mean, 39
 Mean effective pressure (MEP), 248
 Mean free path, 293–294
 Mechanism, 101
 global, 108–111
 Microscale, 49–51
 concentration, 53, 121–122, 133
 Kolmogorov, 47
 Taylor, 50, 121–122
 Millikan, 296
 Mixing
 turbulent, 133–135
 characteristic time for, 133
 Mobility
 electrical, 305
 particle, 312
 Moments, of probability distributions, 41
 central, 41
 noncentral, 41
 Motor vehicle exhaust aerosols, 385

N

National Ambient Air Quality Standards
 (NAAQS), 11, 14
 Navier-Stokes equations, 291
 New Source Performance Standards (NSPS),
 11, 16
 Newton's method, 86
 Nitric oxide, 4
 Nitrogen dioxide, 4
 formation in combustion, 198–200
 Nitrogen oxides, 2–3
 ratios in emissions, 8
 removal from effluent streams, 512
 Normal (Gaussian) distribution, 44, 131,
 325
 Nucleation
 homogeneous, 340–346
 of volatilized ash, 371
 Nusselt number, 151

O

Octane, combustion of, 64
 Olefins (see Alkenes)
 Operating line, 486

- Orifice
 discharge coefficient for, 143
 pressure drop across, 143
- Overfire air ports, 177
- Ozone, 5
- P**
- Particulate matter, 8
 emission characteristics, 12–13
 emissions in U.S., 10
 motor vehicle emissions, 385–387
 National Ambient Air Quality Standard,
 15
- Particulate organic compounds (POCs), 3
- Parts per million, 5, 15–16
- Penetration, 394
- Phoretic effects, 313–315
- Photophoresis, 314
- Pluggage, soft, 507
- PM10, 15
- Poisson distribution, 40, 43, 45
- Poisson equation, 435
- Pore, 154
 diffusivity of gas molecules in, 155
- Positive crankcase ventilation (PCV), 261
- Prandtl number, 151
- Prevention of Significant Deterioration
 (PSD), 11
- Probability, 37
 density function, 38
 distribution function, 38–39
 for local equivalence ratio, 130–131
- Prompt NO, 174–176
- Proximate analysis, 61
- Pseudo-steady-state approximation (PSSA),
 24–26
- Pyridine, 181
- Pyrites, 360
- Pyrrrole, 181
- Q**
- Quenching wall, 244
- R**
- Radiation, 151
- Radicals
 hydroperoxyl, 104
 hydroxyl, 106
 peroxy, 104
- Rate constants, 23
 for combustion reactions, 112
- Reactions
 branching, 105
 chain carrying, 104
 chain length, 27
 chain propagation, 27
 elementary, 19
 independence of, 20–22
 mechanism, 20
 molecularity, 20
- Reactor, thermal, 265
- Regenerative process, 505, 511
- Regime
 continuum, 294, 315
 free molecule, 294, 316
 kinetic, 294, 316
 transition, 294, 316
- Reid vapor pressure, 262
- Resistivity, 417
- Respiratory tract, deposition of aerosols in,
 354
- Reynolds number, 115, 291
 for a cyclone, 409
 for flow in a rectangular channel, 399
- S**
- Schmidt number, 145
- Scrubber
 baffle, 459
 cyclone, 459
 fluidized-bed, 459
 impingement, 459
 packed-bed, 459
 plate, 459
 spray, 456, 459–463
 venturi, 458, 467–469
- Sedimentation, 391
- Segregation factor, 128, 132
- Selective catalytic reduction (SCR), 515
- Selective noncatalytic reduction, 514
- Self-preserving distribution, 339–340
 application to ash particles, 372
- Settling chamber, 394–395
 laminar flow, 396
 plug flow, 398
 turbulent flow, 399
- Shell Flue Gas Treatment system, 513
- Size distribution function, 321–323
 sectional representation of, 347
 self-preserving, 339–340
- Slip correction factor, 295–296
- Soot, 127, 373–375
 composition of, 375

Soot (*Contd.*)

- control of emissions, 381–385
- formation, 375–379
- oxidation, 379–381
- Sound, speed of, 230
- Space charge density, 425
- Spark retard, 250
- Specific fuel consumption (SFC), 248
- Specific heat, 72
- Speed, mean molecular, 316
- Sphere, deposition of particles on, 463–466
- Squish, 235
- Stability of droplets, 142
- Standard deviation, 42
 - geometric, 326
- State Implementation Plans (SIP), 11
- State, reference, 71
- Stefan-Boltzmann constant, 151
- Stiff equations, 107
- Stoichiometric coefficient, 17
- Stoichiometric ratio, 66
- Stokes law, 291–292
- Stokes number, 304
- Stokes-Einstein relation, 311
- Stop distance, 300
- Streamline, limiting, 441
- Sulfur dioxide
 - annual emissions in U.S., 9–10
 - oxidation, 219
 - removal from effluent streams, 505–512
- Sulfur oxides, 3
 - formation in combustion, 217–221
- Sulfur trioxide, 217–218
- Supercharger, 271
- Surface tension, 143
- Swirl, 128

T

- Theoretical air, 66
- Thermal de-NO_x process, 192–198
- Thermal NO_x, 168–174
 - control in combustors, 176–179
- Thermodynamics
 - first law of, 68–77
- Thermophoresis, 313
- Thiele modulus, 156
- Thiol, 217
- Thiophene, 217
- Throttle, 254
- Throwaway process, 505
- Time
 - characteristic, 35–36
- Ton, metric, 9

- Trajectory, critical, 441
- Transfer number, 138, 366
- Transfer unit, 488
- Turbocharger, 271
- Turbulence, 47
 - dissipation rate, 125
 - homogeneous, 48
 - in spark ignition engine, 235
 - intensity, 48
 - isotropic, 48
 - microscale, 49
 - scales of, 47
 - stationary, 48
 - statistical properties of, 48–51

U

- Ultimate analysis, 59
- Uniform distribution, 44
- Units, 54–55
- Urea, 198

V

- Valve
 - in internal combustion engine, 236, 259
 - poppet, 260
- van der Waals forces, 333–334
- van't Hoff's equation, 87
- Variable
 - continuous, 38
 - discrete, 38
 - random, 36–42
- Variance, 42
- Velocity
 - drift, 312
 - electrical migration, 305, 423
 - terminal settling, 299
- Venturi
 - carburetor, 254
 - scrubber, 467–468
- Volatile organic compounds (VOCs), 3
- Vortex, 245
- Vortex tubes, 122

W

- Water, nucleation of, 344–345
- Weber number, 271
- Wellmann-Lord process, 511
- Wet collectors, 456–459
- Work, 68
 - pumping, 260

Z

- Zeldovich mechanism, 168–172