Contents

Preface to the first edition —— V
Preface to the revised edition —— VII
Chapter 1
Quick engineering and orders of magnitude —— 1
Physical constants at 20 °C —— 1
Orders of magnitude —— 1
Fluid flow 1
Pressure drop in pipes —— 1
Darcy's law for porous media —— 2
Flow forces on an object —— 2
Simplified Bernoulli's equation (incompressible media) ——
Heat transfer —— 2
Internal versus external heat transfer —— 2
Stationary heat transfer —— 3
Heat transfer coefficients: h [W/m² K] —— 3
Instationary heat transfer —— 4
Radiation —— 4
Mass transfer —— 5
Stationary mass transfer —— 5
Instationary mass transfer —— 6
List of symbols and abbreviations —— 6
Chapter 2
Miscellaneous —— 7
Greek alphabet —— 7
Système Internationale (International System of Units) —— 7
SI base units —— 7
SI named units —— 7
SI accepted units —— 8
SI prefixes —— 9 Periodic table —— 10
Mathematical constants —— 13
Physical constants —— 13
Values of the gas constant —— 14
Conversion factors —— 15
Temperature conversion —— 17
Temperature scales —— 17
Approximations for physical properties of water and air —— 18



```
Notation --- 18
        Indices —— 18
        Water ---- 18
        Water vapor --- 19
        Humid air --- 19
        Dry air — 19
    pH range of acid-base indicators --- 20
Chapter 3
Mathematics —— 21
    Quadratic and cubic relations --- 21
    Volume and surface of some bodies --- 22
   Integrals --- 25
        Basic integrals --- 25
        Functions of a + bx - 26
        Functions of a + bx^2 - 27
        Functions of a + bx + cx^2 — 27
        Functions of \sqrt{a+bx}—28
        Functions of \sqrt{a^2 + x^2}—29
        Functions of \sqrt{a^2-x^2} 29
        Function of \sqrt{x^2 - a^2} 30
        Transcendental functions --- 30
    Elementary differential equations --- 33
        First order --- 33
        Second order --- 34
        Second order, general --- 35
   Approximations for Bessel's functions --- 36
   The error function --- 39
    Laplace transforms --- 41
        Notation --- 41
        Definition --- 41
        Properties —— 41
        Frequently used Laplace transforms — 43
   Vector and tensors — 44
        Vector mathematics --- 44
        Tensor mathematics — 44
        Invariants of a tensor --- 45
        Other vector and tensor operations — 46
   Differentiation in vector and tensor notation —— 47
        Notation --- 47
        Nabla operator ---- 47
        Nabla operations in a Cartesian coordinate system —— 47
```

```
Nabla identities —— 48
        Scalar derivatives with respect to time —— 49
        Tensorial derivatives with respect to time —— 49
    Linear regression --- 50
        "Curve fit" of linear, exponential, and power functions —— 50
Chapter 4
Transport phenomena ---- 53
    Concentration notation --- 53
        Standard quantities — 53
        Derived quantities — 53
        Relations --- 53
    Microscopic balances in general form —— 54
    Bernoulli's equations --- 57
    Microscopic balances for idealized materials — 59
        Notation --- 59
        Continuity equations (total mass balances) — 59
        Navier-Stokes equations (momentum balances) —— 59
        Fourier equations (thermal energy balances) —— 61
        Fick's equations (component mass balances) — 62
   Continuity equation and momentum balance for special cases —— 63
        Continuity equation for compressible flow —— 63
        Momentum balance for incompressible non-Newtonian fluids —— 63
   Macrobalances — 66
        Unsteady-state balances --- 66
        Steady-state balances — 66
   Elementary differential equations for flow, heat transfer, and mass
   transfer --- 68
        Fluid flow --- 68
        Heat transfer --- 73
        Mass transfer --- 77
   Frequently occurring flow fields in tensor notation —— 83
   Rheological models — 84
       Notation — 84
       One-dimensional --- 84
       Tensorial --- 84
   Pressure-throughput characteristics for laminar flow of liquids in a straight
   round tube --- 86
        Notation --- 86
   Residence time distribution — 87
   Quantities and their dimensions - 90
   Alphabetical list of dimensionless numbers — 92
```

```
Frequently used dimensionless correlations — 97
    List of symbols and abbreviations —— 101
Analogies between heat transfer and mass transfer — 102
Drag coefficient C_w for flow around obstacles — 103
    Drag coefficients — 103
    Packed and fluidized beds — 104
Drag coefficient in a packed bed as function of Reynolds based on the
hydraulic diameter --- 105
Friction coefficient K_w for flow through tube systems —— 107
    Friction factor for flow in tubes —— 109
    Friction factors for pressure flow in pipes —— 110
Hydraulic diameters and Reynolds numbers —— 111
    The power number Po of impellers as a function of Re —— 112
Humidity diagram for air-water systems at atmospheric pressure (I) —— 113
Humidity diagram for air-water systems at atmospheric pressure (II) — 114
Fourier instationary heat and mass transfer —— 115
    Heat transfer — 115
    Mass transfer — 115
Fourier instationary heat and mass transfer (center T or C) —— 116
Fourier instationary heat and mass transfer (average T or C) —— 117
Shapes of free rising bubbles or drops in Newtonian liquids —— 118
Rising Velocity of Air Bubbles in Water — 119
Rising velocity or fall velocity of drops in liquids of low viscosity \eta_c < 5 mPa s — 120
Two-phase gas-liquid flow in horizontal tubes — 121
Two-phase cocurrent flow of gas-liquid through vertical tubes —— 123
Formation of bubbles at a nozzle — 124
    In stationary liquid —— 124
    In flowing liquid —— 124
Mass transfer with first-order chemical reaction —— 125
    Symbols —— 125
Radiation —— 126
    Stefan-Boltzmann law — 126
    Wien's displacement law — 126
    Kirchhoff's law --- 126
    Planck's law --- 126
    Blackbody radiation exchange —— 126
    Wavelength-temperature scale of light sources —— 127
    Color temperature scale (in kelvin) —— 127
    The electromagnetic spectrum —— 128
    Emission coefficients of various materials —— 128
Environmental data --- 130
    General --- 130
```

```
Atmosphere --- 131
        Solar energy — 132
        Energy storage —— 133
    Heating values —— 134
Chapter 5
Material properties --- 135
   Water —— 135
   Ice --- 143
   Air — 144
    Physical properties of some materials —— 147
        Notation —— 155
        Foods --- 156
    Compressibility of gases — 158
   Antoine's parameters — 161
   Solubility table —— 162
    Solubility parameters — 165
    Diffusion coefficients --- 166
    Henry's law --- 168
        Henry's law constant for the solubility of gases in water —— 168
        Henry's law constant for the solubility of gases in ionic solutions —— 169
    Equilibrium data for hydrocarbons — 170
    Dynamic viscosity ---- 175
    Surface tension —— 182
```

Index ---- 185