

**TRANSPORT
PHENOMENA
DATA COMPANION**

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Preface

Many of the data needed for calculations in chemical engineering are dispersed over the literature. Moreover, various systems of units are used, often forcing the user to perform tedious conversions before a 'quick' calculation can be started. In this companion the authors have compiled those data that, according to their experience, are used frequently in transport phenomena and related subjects and, since all data are in S.I. units, rapid access to various calculations is facilitated.

This book is of course no substitute for a complete literature survey and no compendium on all data available in literature. On many occasions a selection had to be made from a multitude of expressions. For instance, for the mass transfer to bubbles, drops and particles, dozens of correlations are available. In those cases the most general correlation or the expression most commonly used has been chosen.

This companion consists of four parts. The first part is general and gives information varying from the Greek alphabet to calibration curves for thermocouples and pH ranges of indicators.

The second part consists of frequently used mathematics. In addition to general mathematical techniques, a selection of vectorial and tensorial calculus relevant to hydrodynamics and elementary rheology has been added.

The third part is a compendium of the transport phenomena. A systematic arrangement facilitates its use. The figures are in such a form that easy reading and accuracy are combined.

In the final part various material properties are given. Special attention has been paid to the most commonly used materials: air and water, but also frequently used materials like for instance hydrocarbons, foods and others are included.

For easy access to the data an extensive index is very important, so, special attention has been given to make the index as complete as possible.

We hope this book will be useful for all those involved in transport phenomena, students, scientists as well as engineers, and we are grateful to everybody who has contributed to improve this companion by suggestions and criticism. Any further suggestions and amendments will be gratefully received.

Groningen and Delft,

L.P.B.M. Janssen

M.M.C.G. Warmoeskerken

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Miscellaneous

Greek Alphabet

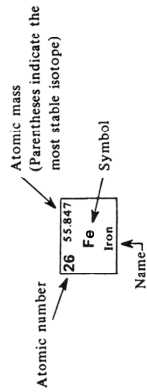
A	α	alpha	N	ν	nu
B	β	beta	Ξ	ξ	xi
Γ	γ	gamma	O	o	omicron
Δ	δ	delta	Π	π	pi
E	ϵ	epsilon	P	ρ	rho
Z	ζ	zeta	Σ	σ	sigma
H	η	eta	T	τ	tau
Θ	ϑ	theta	Υ	υ	upsilon
I	ι	iota	Φ	φ	phi
K	κ	kappa	X	χ	chi
Λ	λ	lambda	Ψ	ψ	psi
M	μ	mu	Ω	ω	omega

S.I. Prefixes

<i>prefix</i>	<i>symbol</i>	<i>factor</i>
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
hecto	h	10^2
deca	da	10
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Periodic Table

period	I A	II A	III B	IV B	V B	VI B	VII B	VIII B	IB	II B	III A	IV A	V A	VI A	VII A	VIII A		
1	1 1.0079 H Hydrogen															2 4.0026 He Helium		
2	3 6.939 Li Lithium	4 9.0122 Be Beryllium														10 20.183 Ne Neon		
3	11 22.9898 Na Sodium	12 24.312 Mg Magnesium														18 39.948 Ar Argon		
4	19 39.098 K Potassium	20 40.08 Ca Calcium	21 44.956 Sc Scandium	22 47.90 Ti Titanium	23 50.942 V Vanadium	24 51.996 Cr Chromium	25 54.938 Mn Manganese	26 55.847 Fe Iron	27 58.933 Co Cobalt	28 58.71 Ni Nickel	29 63.54 Cu Copper	30 65.38 Zn Zinc	31 69.72 Ga Gallium	32 72.59 Ge Germanium	33 74.922 As Arsenic	34 78.96 Se Selenium	35 79.909 Br Bromine	36 83.80 Kr Krypton
5	37 85.47 Rb Rubidium	38 87.62 Sr Strontium	39 88.905 Y Yttrium	40 91.224 Zr Zirconium	41 91.906 Nb Niobium	42 95.94 Mo Molybdenum	43 (98) Tc Technetium	44 101.07 Ru Ruthenium	45 102.905 Rh Rhodium	46 106.4 Pd Palladium	47 107.870 Ag Silver	48 112.40 Cd Cadmium	49 114.82 In Indium	50 118.69 Sn Tin	51 121.75 Sb Antimony	52 127.60 Te Tellurium	53 126.904 I Iodine	54 131.30 Xe Xenon
6	55 132.9054 Cs Cesium	56 137.34 Ba Barium	57 - 71 Lanthanum series	72 178.49 Hf Hafnium	73 180.948 Ta Tantalum	74 183.85 W Wolfram	75 186.2 Re Rhenium	76 190.2 Os Osmium	77 192.2 Ir Iridium	78 195.09 Pt Platinum	79 196.99 Au Gold	80 200.59 Hg Mercury	81 204.37 Tl Thallium	82 207.19 Pb Lead	83 208.980 Bi Bismuth	84 (210) Po Polonium	85 (210) At Astatine	86 (222) Rn Radon
7	87 (223) Fr Francium	88 (226) Ra Radium	89 - 103 Actinide series	104 Rutherfordium	105 Dubnium													



57	58	140.12	140.907	144.24	61 (147)	62 150.35	63 151.96	64 157.25	65 158.92	66 162.50	67 164.93	68 167.26	69 168.934	70 173.04	71 174.97
La Lanthanum	Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium	Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium	
89 (227) Ac Actinium	90 232.038 Th Thorium	91 (231) Pa Protactinium	92 238.03 U Uranium	93 237 Np Neptunium	94 242 Pu Plutonium	95 243 Am Americium	96 243 Cm Curium	97 247 Bk Berkelium	98 247 Cf Californium	99 251 Es Einsteinium	100 (254) Fm Fermium	101 (258) Md Mendelevium	102 (259) No Nobelium	103 (260) Lw Lawrencium	

1) Lanthanide series

2) Actinide series

Mathematical Constants

π	=	3.141592653590
e	=	2.718281828459
π^e	=	22.459157718361
e^π	=	23.140692632779
$^{10}\log e$	=	0.434294481903
$^e\log 10$	=	2.302585092994
1 radian	=	$57^\circ 17' 44.8''$
1°	=	0.0174532925 radians
$1'$	=	0.0002908882 radians
$1''$	=	0.0000048481 radians

Standard S.I. Units

<i>quantity</i>	<i>S.I. unit</i>	<i>symbol</i>
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K
luminous intensity	candela	cd

Derived S.I. Units

<i>quantity</i>	<i>S.I. unit</i>	<i>symbol</i>	<i>relation</i>
frequency	Hertz	Hz	$\frac{1}{s}$
force	Newton	N	$\frac{kg\ m}{s^2}$
pressure, stress	Pascal	Pa	$\frac{N}{m^2}$
energy, work	Joule	J	N m
power	Watt	W	$\frac{J}{s}$