
Appendix 1: SI prefixes and multiplication factors

Multiplication factor		Prefix	Symbol
1 000 000 000 000 000 000 000 000 000	= 10^{18}	exa	E
1 000 000 000 000 000 000 000	= 10^{15}	peta	P
1 000 000 000 000	= 10^{12}	tera	T
1 000 000 000	= 10^9	giga	G
1 000 000	= 10^6	mega	M
1 000	= 10^3	kilo	k
100	= 10^2	hecto	h
10	= 10^1	deca	da
0.1	= 10^{-1}	deci	d
0.01	= 10^{-2}	centi	c
0.001	= 10^{-3}	milli	m
0.000 001	= 10^{-6}	micro	μ
0.000 000 001	= 10^{-9}	nano	n
0.000 000 000 001	= 10^{-12}	pico	p
0.000 000 000 000 001	= 10^{-15}	femto	f
0.000 000 000 000 000 001	= 10^{-18}	atto	a

Appendix 2: Derived units

Through common usage, fundamental units have been given names. None of them is a recognized SI unit.

Length	Area
Micron (μm)	$= 10^{-6} \text{ m}$
Angstrom (\AA)	$= 10^{-10} \text{ m}$
Fermi (fm)	$= 10^{-15} \text{ m}$
Are (a)	$= 100 \text{ m}^2$
Barn (b)	$= 10^{-28} \text{ m}^2$
Mass Tonne (t)	$= 10^3 \text{ kg}$
Time Minute (min)	$= 60 \text{ s}$
Hour (h)	$= 3,600 \text{ s}$
Day (d)	$= 86,400 \text{ s}$
Year (a)	$\approx 3.1557 \times 10^7 \text{ s}$

Appendix 3: Derived units in SI and c.g.s.

Quantity	Dimensions	SI	c.g.s.	Ratio c.g.s./SI
Acceleration	LT^{-2}	$m\ s^{-2}$	$cm\ s^{-2}$	10^{-2}
Area	L^2	m^2	cm^2	10^{-4}
Density	ML^{-3}	$kg\ m^{-3}$	$g\ cm^{-3}$	10^{-3}
Energy	ML^2T^{-2}	joule	erg	10^{-7}
Force	MLT^{-2}	newton	dyne	10^{-5}
Length	L	metre	centimetre	10^{-2}
Mass	M	kilogram	gram	10^{-3}
Power	ML^2T^{-3}	watt	$erg\ s^{-1}$	10^{-7}
Pressure	$ML^{-1}T^{-2}$	pascal	$dyne\ cm^{-2}$	10^{-1}
Surface tension	MT^{-2}	$N\ m^{-1}$	$dyne\ cm^{-1}$	10^{-3}
Time	T	second	second	1
Velocity	LT^{-1}	$m\ s^{-1}$	$cm\ s^{-1}$	10^{-2}
Viscosity	$ML^{-1}T^{-1}$	$kg\ m^{-1}\ s^{-1}$	poise	10^{-1}
Volume	L^3	m^3	cm^3	10^{-6}

Appendix 4: Abbreviations used for piping and instrumentation diagrams (P&IDs)

Analyser controller	AC
Analyser transmitter	AT
Differential pressure controller	DPC
Differential pressure transmitter	DPT
Flow indicator	FI
Flow controller	FC
Flow indicator and controller	FIC
Level controller	LC
Level indicator	LI
Level indicator and controller	LIC
Level transmitter/sensor	LT
High level alarm	LAH
Very high level alarm	LAHH
Low level alarm	LAL
Very low level alarm	LALL
pH controller	pHC
pH sensor/transmitter	pHT
Pressure indicator	PI
Pressure controller	PC
Pressure indicator and controller	PIC
Pressure transmitter	PT
Temperature controller	TC
Temperature indicator	TI
Temperature indicator and controller	TIC
Temperature sensor/transmitter	TT

Appendix 5: Dimensions and units

Quantity	Dimension	Unit
Acceleration	$[LT^{-2}]$	ms^{-2}
Area	$[L^2]$	m^2
Density	$[ML^{-3}]$	$kg\ m^{-3}$
Energy	$[ML^2T^{-2}]$	J
Force	$[MLT^{-2}]$	N
Length	$[L]$	m
Mass	$[M]$	kg
Momentum	$[MLT^{-1}]$	N s
Pressure	$[ML^{-1}T^{-2}]$	Pa
Shear stress	$[ML^{-1}T^{-2}]$	Pa
Shear rate	$[T^{-1}]$	s^{-1}
Time	$[T]$	s
Viscosity	$[ML^{-1}T^{-1}]$	Pa s
Volume	$[L^3]$	m^3
Work	$[ML^2T^{-1}]$	W

Appendix 6: Greek alphabet

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

Appendix 7: Periodic table

PERIODIC TABLE OF THE ELEMENTS

Group	1	2	Period 1										13	14	15	16	17	18										
	I	II	Period 1										IIIA	IVA	V	VI	VII	VIII										
	IA	IIA	Period 1										IIIA	IVA	VA	VIA	VIIA	VIIIA										
2	3 Li lithium 6.94	4 Be beryllium 9.01	Period 1 1 H hydrogen 1.0079										5 B boron 10.81	6 C carbon 12.01	7 N nitrogen 14.01	8 O oxygen 16.00	9 F fluorine 19.00	10 Ne neon 20.18	2 He helium 4.00									
3	11 Na sodium 22.99	12 Mg magnesium 24.31	Period 1 1 H hydrogen 1.0079										13 Al aluminum 26.98	14 Si silicon 28.09	15 P phosphorus 30.97	16 S sulfur 32.06	17 Cl chlorine 35.45	18 Ar argon 39.95										
4	19 K potassium 39.10	20 Ca calcium 40.08	Period 1 1 H hydrogen 1.0079										21 Sc scandium 44.96	22 Ti titanium 47.87	23 V vanadium 50.94	24 Cr chromium 52.00	25 Mn manganese 54.94	26 Fe iron 55.84	27 Co cobalt 58.93	28 Ni nickel 58.69	29 Cu copper 63.55	30 Zn zinc 65.41	31 Ga gallium 69.72	32 Ge germanium 72.64	33 As arsenic 74.92	34 Se selenium 78.96	35 Br bromine 79.90	36 Kr krypton 83.80
5	37 Rb rubidium 85.47	38 Sr strontium 87.62	Period 1 1 H hydrogen 1.0079										39 Y yttrium 88.91	40 Zr zirconium 91.22	41 Nb niobium 92.91	42 Mo molybdenum 95.94	43 Tc technetium (98)	44 Ru ruthenium 101.07	45 Rh rhodium 102.90	46 Pd palladium 106.42	47 Ag silver 107.87	48 Cd cadmium 114.82	49 In indium 114.82	50 Sn tin 118.71	51 Sb antimony 121.76	52 Te tellurium 127.60	53 I iodine 126.90	54 Xe xenon 131.29
6	55 Cs cesium 132.91	56 Ba barium 137.33	Period 1 1 H hydrogen 1.0079										57 La lanthanum 138.91	58 Ce cerium 140.12	59 Pr praseodymium 140.91	60 Nd neodymium 144.24	61 Pm promethium (145)	62 Sm samarium 151.96	63 Eu europium 151.96	64 Gd gadolinium 157.25	65 Tb terbium 158.93	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.04	71 Lu lutetium 174.97	
7	87 Fr francium (223)	88 Ra radium (226)	Period 1 1 H hydrogen 1.0079										89 Ac actinium (227)	90 Th thorium 232.04	91 Pa protactinium 231.04	92 U uranium 238.03	93 Np neptunium (237)	94 Pu plutonium (244)	95 Am americium (243)	96 Cm curium (247)	97 Bk berkelium (247)	98 Cf californium (251)	99 Es einsteinium (252)	100 Fm fermium (257)	101 Md mendelevium (258)	102 No nobelium (259)	103 Lr lawrencium (262)	
			Period 1 1 H hydrogen 1.0079										111 Rg roentgenium (272)	112 Cn copernicium (272)	113 Nh nihonium (272)	114 Fl flerovium (272)	115 Lv livermorium (272)	116 Lv livermorium (272)	117 Ts tennessine (272)	118 Og oganesson (272)								

Molar masses (atomic weights) are given to the number of significant figures given here can be regarded as typical of most naturally occurring samples.

Appendix 8: Fundamental constants

Constant	Units
Absolute zero	-273.15 °C
Acceleration due to gravity	9.806 m s ⁻²
Avogadro constant	6.022 169 169 x 10 ²³ mol ⁻¹
Boltzmann constant	1.380 622 x 10 ⁻²³ J K ⁻¹
Faraday constant	9.648 670 x 10 ⁴ C mol ⁻¹
Molar volume at s.t.p.	2.241 36 x 10 ⁻² m ³ mol ⁻¹
Planck constant	6.626 196 x 10 ⁻³⁴ J s
Speed of light	2.999 925 x 10 ⁸ m s ⁻¹
Stefan–Boltzmann constant	5.670 400 x 10 ⁻⁸ W m ⁻² K ⁻⁴
Triple point of water	273.16 K
University gas constant	8.314 34 J mol ⁻¹ K ⁻¹

Appendix 9: Recommended web links

SEE WEB LINKS

This is a web-linked dictionary. To access the websites listed below, go to the dictionary's web page at www.oup.com/uk/reference/resources/chemeng, click on **Web links** in the Resources section and locate the entry in the alphabetical list, then click straight through to the relevant websites.

ACHEMA Ausstellungs-Tegung fuer Chemisches Apparatewesen

- Official website of ACHEMA.

air pollution

- Official website of Environmental Protection UK.

ALARP

- Official website of the Health and Safety Executive UK offering risk assessment advice.

American Institute of Chemical Engineers

- Official website of the American Institute of Chemical Engineers.

American National Standards Institute

- Official website of the American National Standards Institute.

American Petroleum Institute

- Official website of the American Petroleum Institute.

American Society for Testing Materials (ASTM International)

- Official website of ASTM International.

American Society of Mechanical Engineers

- Official website of the American Society of Mechanical Engineers.

Arrhenius, Svante August

- Official website of the Nobel Prize organization, with a transcript of Arrhenius' lecture of 1903.

ATEX

- Official website of the Health and Safety Executive, UK, outlining information on ATEX and explosive atmospheres.

BSI

- Official website of BSI, with information about BSI standards.

carbon credit

- Official website of Carbon Futures, with an explanation of how carbon trading works.

carbon footprint

- Official website of the Carbon Trust.

CEFIC

- Official website of Conseil Européen des Fédérations de l'Industrie Chimique.

CERN

- Official information website of CERN, accessible to the public.

chartered chemical engineer

- Official website of the Engineering Council.

CHEMECA

- Official website for CHEMECA conference 2012.

Chemical & Engineering News

- Online access to *Chemical & Engineering News*.

Chemical Engineering

- Online access to *Chemical Engineering* magazine.

Clean Air Act

- Official website of HM Government managed by the National Archives to publish all enacted legislation in the UK.

DECHEMA

- Official website of DECHEMA.

DSEAR

- Official website of the Health and Safety Executive, DSEAR regulations.

ECHA

- Official website of the European Chemical Agency.

electrolytic separation

- Official website of the Norsk Industriarbeider Museum, Vemork (Norwegian Industrial Workers Museum).

Environment Agency (EA)

- Official website of the UK Environment Agency.

Environmental Protection Agency (EPA)

- Official website of the US Environmental Protection Agency.

European Federation of Chemical Engineering

- Official website of the European Federation of Chemical Engineering.

fire

- Official website of the National Fire Protection Association in the US.

fluoridization

- Official website of the British Fluoridation Society.

Hortonsphere

- Official website of the Chicago Bridge and Iron Company.

HSE

- Official website of the Health and Safety Executive in the UK.

Institution of Chemical Engineers

- Official website of the Institution of Chemical Engineers.

International Council of Chemical Associations

- Official website of the International Council of Chemical Associations.

JET

- Official website of EFDA JET programme

Mono pump

- Official website of Mono Company.

Nelson–Farrar cost index

- Official website of *Oil and Gas Journal* containing the Nelson–Farrar cost index.

Organization of the Petroleum Exporting Countries

- Official website of OPEC.

personal protective equipment

- Official website of the UK Health and Safety Executive.

radioactive waste

- Official website of the UK Nuclear Decommissioning Authority.

Royal Australian Chemical Institute

- Official website of the Royal Australian Chemical Institute.

Rutherford, Lord Ernest

- Official website of McGill University and its museum to Rutherford.

SEPA

- Official website of Scottish Environment Protection Agency.

SI units

- Official website of National Institute of Standards and Technology (NIST).

Stockholm Convention on Persistent Organic Pollutants

- Official website of the Stockholm Convention.

sustainability

- Official website of the United Nations Environment Programme.

TCE

- Official website of the magazine *TCE*.

total dissolved solids

- Official website of the World Health Organization information on water sanitation.

unionfining processes

- Website of Honeywell UOP Company.

UNIPOL process

- Website for Dow Company's UNIPOL process.

UVOX process

- Website of UVOX Redox Systems, with page describing UV disinfection and ozone oxidation with UVOX Redox Systems.

Welsh process

- Official website of the Copper Development Association Inc., Education pages.

World Chemical Engineering Council (WCCE)

- Official website of the World Chemical Engineering Council.

Young, James

- Official website of the Museum of the Scottish Shale Oil Industry, page devoted to James Young biography.

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- Welty, J. R., C. E. Wicks, and R. E. Wilson (eds.) (2008) *Fundamentals of Momentum, Heat and Mass Transfer* (5th edn), New York: John Wiley.

Oxford Paperback Reference

A Dictionary of Chemistry

Over 4,700 entries covering all aspects of chemistry, including physical chemistry and biochemistry.

'It should be in every classroom and library ... the reader is drawn inevitably from one entry to the next merely to satisfy curiosity.'

School Science Review

A Dictionary of Physics

Ranging from crystal defects to the solar system, 4,000 clear and concise entries cover all commonly encountered terms and concepts of physics.

A Dictionary of Biology

The perfect guide for those studying biology — with over 5,500 entries on key terms from biology, biochemistry, medicine, and palaeontology.

'lives up to its expectations; the entries are concise, but explanatory'

Biologist

'ideally suited to students of biology, at either secondary or university level, or as a general reference source for anyone with an interest in the life sciences'

Journal of Anatomy

OXFORD

Oxford Paperback Reference

A Dictionary of Psychology

Andrew M. Colman

Over 9,000 authoritative entries make up the most wide-ranging dictionary of psychology available.

‘impressive ... certainly to be recommended’

Times Higher Education Supplement

‘probably the best single-volume dictionary of its kind.’

Library Journal

A Dictionary of Economics

John Black, Nigar Hashimzade, and Gareth Myles

Fully up-to-date and jargon-free coverage of economics. Over 3,400 terms on all aspects of economic theory and practice.

‘strongly recommended as a handy work of reference.’

Times Higher Education Supplement

A Dictionary of Law

An ideal source of legal terminology for systems based on English law. Over 4,200 clear and concise entries.

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The Concise Oxford Companion to English Literature

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