Appendices

Appendix 1 SYSTEME INTERNATIONAL (SI) STANDARD UNITS OF MEASUREMENT AND THEIR DEFINITIONS

PHYSICAL QUANTITY	NAME	UNIT	SYMBOL
Length	metre		m
Mass	kilogram		kg
Time	second		s
Electric current	ampere		A
Thermodynamic temperature	kelvin		K
Amount of substance	mole		mol
Luminous intensity	candela		cd
Density	kilogram per cubic metre		kg m^{-3}
Velocity	metre per second		m s^{-1}
Acceleration	metre per second squared		m s^{-2}
Momentum	kilogram metre per second		kg m s^{-1}
Frequency	hertz		Hz (1 Hz = 1 s^{-1})
Force	newton		N (1 N = 1 kg m s^{-2})
Pressure	pascal		Pa (1 Pa = 1 N m^{-2})
Energy, work	joule		J (1 J = 1 N m)
Power	watt		W (1 W = 1 J s^{-1})
Electric charge	coulomb		C (1 C = 1 A s)
Electric potential	volt		V (1 V = 1 J C^{-1})
Electric resistance	ohm		Ω (1 Ω = 1 V A^{-1})
Moment of force	newton metre		N m
Heat capacity	joule per kelvin		J K^{-1}
Specific heat capacity	joule per kilogram per kelvin		J kg^{-1} K^{-1}
Specific latent heat	joule per kilogram		J kg^{-1}
Electric field strength	volt per metre		V m^{-1}
Electric resistivity	ohm metre		Ω m
Celsius temperature	degree Celsius		°C
Pressure	standard atmosphere		1 atm (1 atm = 101 325 Pa)
Power of lens	dioptre		D (1 D = 1 m^{-1})
Electric energy	kilowatt hour		kWh

Appendix 2 METRIC PREFIXES AND THEIR ORIGINS

PREFIX	ABBREVIATION	MEANING	ORIGIN
exa	E	10^{18}	Greek *exa* — out of
peta	P	10^{15}	Greek *peta* — spread out
tera	T	10^{12}	Greek *teratos* — monster
giga	G	10^{9}	Greek *gigas* — giant
mega	M	10^{6}	Greek *mega* — great
kilo	k	10^{3}	Greek *khilioi* — thousand
hecto	h	10^{2}	Greek *hekaton* — hundred
deca	da	10^{1}	Greek *deka* — ten
baseunit	—	10^{0}	
deci	d	10^{-1}	Latin *decimus* — tenth
centi	c	10^{-2}	Latin *centum* — hundred
milli	m	10^{-3}	Latin *mille* — thousand
micro	μ	10^{-6}	Greek *mikros* — very small
nano	n	10^{-9}	Greek *nanos* — dwarf
pico	p	10^{-12}	Italian *piccolo* — small
femto	f	10^{-15}	Greek *femten* — fifteen
atto	a	10^{-18}	Danish *atten* — eighteen

Appendix 3 PHYSICAL CONSTANTS

QUANTITY	SYMBOL	APPROXIMATE VALUE
Speed of light in a vacuum	c	3.00×10^{8} m s^{-1}
Gravitational constant	G	6.67×10^{-11} N m^2 kg^{-2}
Coulomb's constant	k	9.00×10^{9} N m^2 C^{-2}
Charge on electron	$-e$	-1.60×10^{-19} C
Charge on proton	e	1.60×10^{-19} C
Electron mass	m_e	9.11×10^{-31} kg
Proton mass	m_p	1.673×10^{-27} kg
Neutron mass	m_n	1.675×10^{-27} kg
Atomic mass unit	u	1.660×10^{-27} kg
Boltzmann's constant	k	1.38×10^{-23} JK^{-1}
Planck's constant	h	6.63×10^{-34} Js
Avagodro's number	Na	6.02×10^{23} mol^{-1}
Magnetic constant	k	2.0×10^{-7} N A^{-2}
Electron volt	eV	1.6×10^{-19} J

Appendix 4 THE GREEK ALPHABET

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

Appendix 5 USEFUL CONVERSION FACTORS

Mass
1 tonne = 10^3 kg
1 a.m.u. = 1.6606×10^{-27} kg

Length
1 km = 10^3 m
1 cm = 10^{-2} m
1 mm = 10^{-3} m
1 μm = 10^{-6} m
1 nm = 10^{-9} m

Volume
1 litre (L) = 1000 cm^3 = 10^{-3} m^3
1 gallon (US) = 3.7854 L
1 gallon (UK) = 4.5461 L

Density
1 g cm^{-3} = 10^{-3} kg m^{-3}

Time
1 min = 60 s
1 h = 60 min = 3600 s
1 solar day = 24 h = 1440 min = 86 400 s

Velocity
1 km h^{-1} = 0.2778 m s^{-1}

Angle
1 rad = 57.295°

1° = 0.0175 rad

Frequency
1 Hz = 1 cycle s^{-1}
1 rev min^{-1} = 0.0167 Hz

Force
1 N = 1 kg m s^{-2}

Pressure
1 Pa = 1 N m^{-2}
1 atm = 1.013×10^5 Pa = 760 Torr
= 760 mmHg

Appendix 6 PERIODIC TABLE OF THE ELEMENTS

I A	II A	III B	IV B	V B	VI B	VII B	VIII			I B	II B	III A	IV A	V A	VI A	VII A	
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											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
11 Na Sodium 22.99	12 Mg Magnesium 24.31											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
19 K Potassium 39.10	20 Ca Calcium 40.06	21 Sc Scandium 44.96	22 Ti Titanium 47.90	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.70	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (97)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Cesium 132.9	56 Ba Barium 137.3	57[1] La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.9	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium 226.0	89[2] Ac Actinium (227)	104 Rf Rutherfordium (257)	105 Db Dubnium (260)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Uuu (272)	112 Uub (285)	113 Uut	114 Uuq	115 Uup	116 Uuh		

Key

6 C Carbon 12.01

← Atomic number
← Symbol
← Atomic mass

Lanthanoid Series[1]	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
Actinoid Series[2]	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium 237.0	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (253)	101 Md Mendelevium (256)	102 No Nobelium (254)	103 Lr Lawrencium (257)

Appendix 7 RELATIVE ATOMIC MASSES

NAME	SYMBOL	ATOMIC NUMBER	RELATIVE ATOMIC MASS	NAME	SYMBOL	ATOMIC NUMBER	RELATIVE ATOMIC MASS
* Actinium	Ac	89	(227)	Mercury	Hg	80	200.6
Aluminium	Al	13	27.0	Molybdenum	Mo	42	95.9
* Americium	Am	95	(243)	Neodymium	Nd	60	144.2
Antimony	Sb	51	121.8	Neon	Ne	10	20.2
Argon	Ar	18	39.9	* Neptunium	Np	93	(237)
Arsenic	As	33	74.9	Nickel	Ni	28	58.7
* Astatine	At	85	(210)	Niobium	Nb	41	92.9
Barium	Ba	56	137.3	Nitrogen	N	7	14.0
* Berkelium	Bk	97	(247)	* Nobelium	No	102	(259)
Beryllium	Be	4	9.0	Osmium	Os	76	190.2
Bismuth	Bi	83	209.0	Oxygen	O	8	16.0
Boron	B	5	10.8	Palladium	Pd	46	106.4
Bromine	Br	35	79.9	Phosphorus	P	15	31.0
Cadmium	Cd	48	112.4	Platinum	Pt	78	195.1
Caesium	Cs	55	132.9	* Plutonium	Pu	94	(244)
Calcium	Ca	20	40.1	* Polonium	Po	84	(209)
* Californium	Cf	98	(251)	Potassium	K	19	39.1
Carbon	C	6	12.0	Praseodymium	Pr	59	140.9
Cerium	Ce	58	140.1	* Promethium	Pm	61	(145)
Chlorine	Cl	17	35.5	* Protactinium	Pa	91	(231)
Chromium	Cr	24	52.0	* Radium	Ra	88	(226)
Cobalt	Co	27	58.9	* Radon	Rn	86	(222)
Copper	Cu	29	63.5	Rhenium	Re	75	186.2
* Curium	Cm	96	(247)	Rhodium	Rh	45	102.9
Dysprosium	Dy	66	162.5	Rubidium	Rb	37	85.5
* Einsteinium	Es	99	(254)	Ruthenium	Ru	44	101.1
Erbium	Er	68	167.3	Rutherfordium	Rf	104	261
Europium	Eu	63	152.0	Samarium	Sm	62	150.4
* Fermium	Fm	100	(257)	Scandium	Sc	21	45.0
Fluorine	F	9	19.0	Selenium	Se	34	79.0
* Francium	Fr	87	(223)	Silicon	Si	14	28.1
Gadolinium	Gd	64	157.3	Silver	Ag	47	107.9
Gallium	Ga	31	69.7	Sodium	Na	11	23.0
Germanium	Ge	32	72.6	Strontium	Sr	38	87.6
Gold	Au	79	197.0	Sulfur	S	16	32.1
Hafnium	Hf	72	178.5	Tantalum	Ta	73	180.9

Appendix 7 Cont'd

NAME	SYMBOL	ATOMIC NUMBER	RELATIVE ATOMIC MASS	NAME	SYMBOL	ATOMIC NUMBER	RELATIVE ATOMIC MASS
Helium	He	2	4.0	* Technetium	Tc	43	(98)
Holmium	Ho	67	164.9	Tellurium	Te	52	127.6
Hydrogen	H	1	1.0	Terbium	Tb	65	158.9
Indium	In	49	114.8	Thallium	Tl	81	204.4
Iodine	I	53	126.9	* Thorium	Th	90	232.0
Iridium	Ir	77	192.2	Thulium	Tm	69	168.9
Iron	Fe	26	55.8	Tin	Sn	50	118.7
Krypton	Kr	36	83.8	Titanium	Ti	22	47.9
Lanthanum	La	57	138.9	Tungsten	W	74	183.9
* Lawrencium	Lr	103	(260)	* Uranium	U	92	238.0
Lead	Pb	82	207.2	Vanadium	V	23	50.9
Lithium	Li	3	6.9	Xenon	Xe	54	131.3
Lutetium	Lu	71	175.0	Ytterbium	Yb	70	173.0
Magnesium	Mg	12	24.3	Yttrium	Y	39	88.9
Manganese	Mn	25	54.9	Zinc	Zr	30	65.4
* Mendelevium	Md	101	(256)	Zirconium	Zr	40	91.2

* Unstable elements.
Value in brackets is the mass number of the isotope with the longest half-life.

Appendix 8 PROPERTIES OF THE NUCLIDES

Z = atomic number = number of protons
A = atomic mass = number of protons plus neutrons
M = exact mass of the nuclide including electrons (in u)

Z	A	M	Z	A	M
−1e	0	0.000549	36Kr	84	83.911505
0n	1	1.008665		90	89.9197
1p	1	1.007276		91	90.923
				92	91.92182
			37Rb	90	89.9148
1H	1	1.007825	38Sr	88	87.905628
	2	2.014102		90	89.90775
	3	3.016050		93	92.9142
2He	3	3.016030		94	93.9154
	4	4.002603	42Mo	100	99.9076
	6	6.018893	47Ag	107	106.905091
	8	8.034		108	107.905953
3Li	6	6.015124	48Cd	113	112.904408
	7	7.016004	49In	115	114.90387
	8	8.022487		116	115.90553
	9	9.02680	50Sn	116	115.90179
4Be	6	6.01972	52Te	137	136.910
	7	7.016929	54Xe	135	134.91350
	9	9.012186	55Cs	130	129.90676
5B	8	8.024609		135	134.90590
	10	10.012938	56Ba	136	135.90456
	11	11.009305		141	140.91402
6C	9	9.03104		143	142.921
	10	10.01686		144	143.923
	11	11.011432	81Tl	208	207.98201
	12	12.000000	82Pb	206	205.97447
	13	13.003354		208	207.97666
	14	14.003242	83Bi	212	211.99128
7N	12	12.01864	84Po	212	211.988865
	13	13.005738		216	216.00192
	14	14.003074	86Rn	220	220.01139
8O	13	13.0248		222	222.01761
	16	15.994915	88Ra	224	224.02020
	17	16.999133		226	226.02544
	18	17.999161		228	228.03110
11Na	22	21.994437	89Ac	228	228.03104
	23	22.989771	91Pa	234	234.04342
	24	23.990964	92U	233	233.03965
13Al	27	26.981541		234	234.04098
15P	30	29.97832		235	235.04394
	31	30.973765		236	236.04559
	32	31.973909		238	238.05082
16S	35	34.969033		239	239.05433
17Cl	36	35.968307	93Np	239	239.05295
19K	40	39.964000	94Pu	239	239.05218
28Ni	61	60.93106		240	240.05384
	64	63.92796		241	241.05687
29Cu	64	63.929757	95Am	239	239.05304
30Zn	64	63.929140		241	241.05685
	65	64.92923			