APPENDIX A

Reference Tables

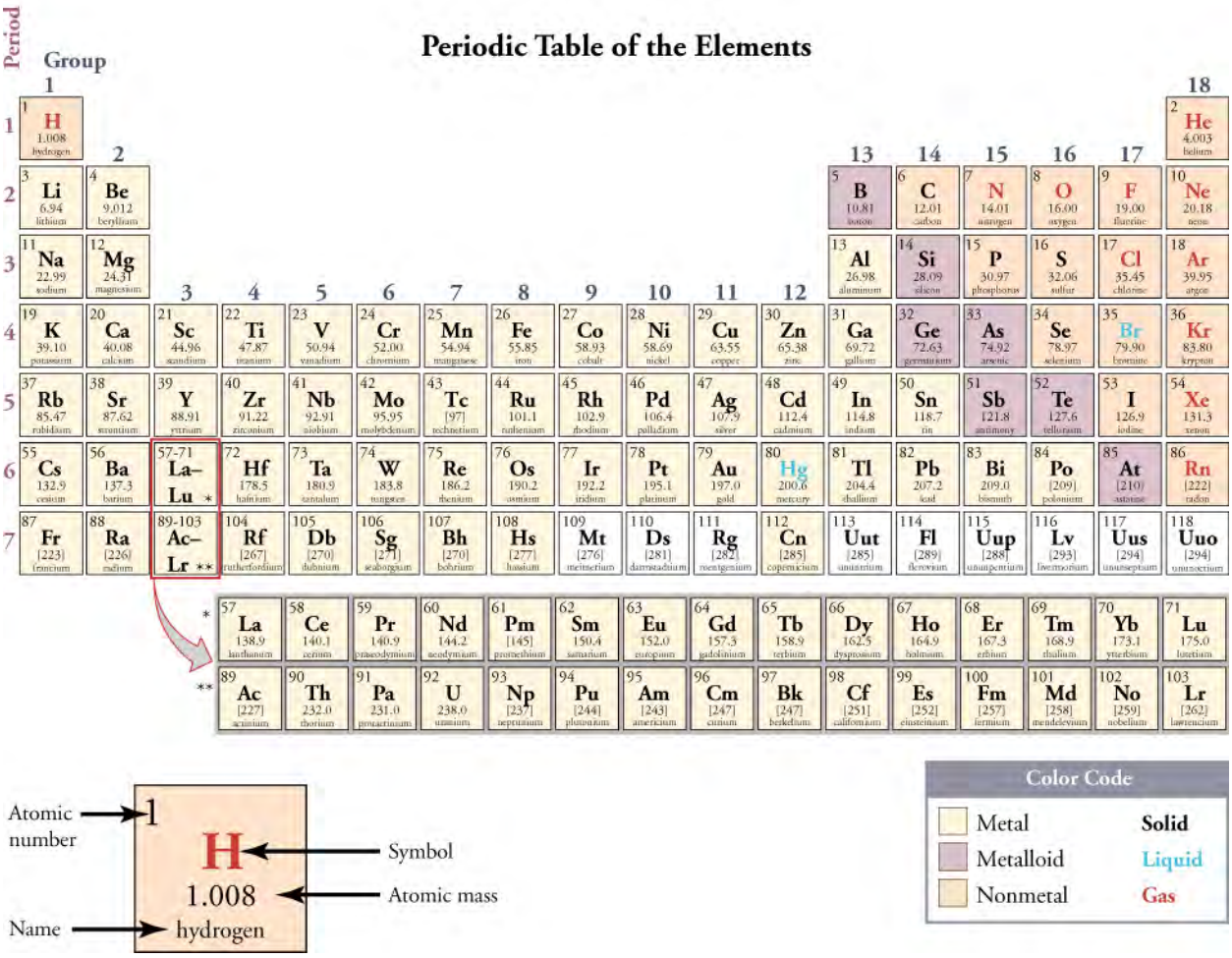

Figure A1 Periodic Table of Elements

Prefix	Symbol	Value	Prefix	Symbol	Value
tera	T	10^{12}	deci	d	10^{-1}
giga	G	10^{9}	centi	c	10^{-2}
mega	M	10^{6}	milli	m	10^{-3}
kilo	k	10^{3}	micro	μ	10^{-6}
hecto	h	10^{2}	nano	n	10^{-9}
deka	da	10^{1}	pico	p	10^{-12}

Table A1 Metric Prefixes for Powers of Ten and Their Symbols

Prefix	Symbol	Value	Prefix	Symbol	Value
___		10^0	femto	f	10^{-15}

Table A1 Metric Prefixes for Powers of Ten and Their Symbols

	Entity	Abbreviation	Name
Fundamental units	Length	m	meter
	Mass	kg	kilogram
	Time	s	second
	Current	A	ampere
Supplementary unit	Angle	rad	radian
Derived units	Force	$N = kg \cdot \frac{m}{s^2}$	newton
	Energy	$J = kg \cdot m^2$	joule
	Power	$W = \frac{J}{s}$	watt
	Pressure	$Pa = \frac{N}{m^2}$	pascal
	Frequency	$Hz = \frac{1}{s}$	hertz
	Electronic potential	$V = \frac{J}{C}$	volt
	Capacitance	$F = \frac{C}{V}$	farad
	Charge	$C = s \cdot A$	coulomb
	Resistance	$\Omega = \frac{V}{A}$	ohm
	Magnetic field	$T = \frac{N}{A \cdot m}$	tesla
	Nuclear decay rate	$Bq = \frac{1}{s}$	becquerel

Table A2 SI Units

Length	1 inch (in.) = 2.54 cm (exactly)
	1 foot (ft) = 0.3048 m
	1 mile (mi) = 1.609 km

Table A3 Selected British Units

Force	1 pound (lb) = 4.448 N
Energy	1 British thermal unit (Btu) = 1.055×10^3 J
Power	1 horsepower (hp) = 746 W
Pressure	1 lb/in^2 = 6.895×10^3 Pa

Table A3 Selected British Units

Length	1 light year (ly) = 9.46×10^{15} m
	1 astronomical unit (au) = 1.50×10^{11} m
	1 nautical mile = 1.852 km
	1 angstrom(Å) = 10^{-10} m
Area	1 acre (ac) = 4.05×10^3 m2
	1 square foot (ft^2) 9.29×10^{-2} m^3
	1 barn (*b*) = 10^{-28} m^2
Volume	1 liter (*L*) = 10^{-3} m^3
	1 U.S. gallon (gal) = 3.785×10^{-3} m^3
Mass	1 solar mass = 1.99×10^{30} kg
	1 metric ton = 10^3 kg
	1 atomic mass unit (*u*) = 1.6605×10^{-27} kg
Time	1 year (*y*) = 3.16×10^7 s
	1 day (*d*) = 86,400 s
Speed	1 mile per hour (mph) = 1.609 km / h
	1 nautical mile per hour (naut) = 1.852 km / h
Angle	1 degree (°) = 1.745×10^{-2} rad
	1 minute of arc (') = 1 / 60 degree
	1 second of arc (") = 1 / 60 minute of arc
	1 grad = 1.571×10^{-2} rad

Table A4 Other Units

Energy	1 kiloton TNT (kT) = 4.2×10^{12} J
	1 kilowatt hour (kW · *h*) = 3.60 × 106 J
	1 food calorie (kcal) = 4186 J
	1 calorie (cal) = 4.186 J
	1 electron volt (cV) = 1.60×10^{-19} J
Pressure	1 atmosphere (atm) = 1.013×10^{5} Pa
	1 millimeter of mercury (mm Hg) = 133.3 Pa
	1 torricelli (torr) = 1 mm Hg = 133.3 Pa
Nuclear decay rate	1 curie (Ci) = 3.70×10^{10} Bq

Table A4 Other Units

Circumference of a circle with radius *r* or diameter *d*	$C = 2\pi = \pi d$
Area of a circle with radius *r* or diameter *d*	$A = \pi r^2 = \pi d^2/4$
Area of a sphere with radius *r*	$A = 4\pi r^2$
Volume of a sphere with radius *r*	$V = (4/3)(\pi r^3)$

Table A5 Useful formulae

Symbol	Meaning	Best Value	Approximate Value
c	Speed of light in vacuum	$2.99792458 \times 10^{8}\,\text{m/s}$	$3.00 \times 10^{8}\,\text{m/s}$
G	Gravitational constant	$6.67384\,(80) \times 10^{-11}\,\text{N} \cdot \text{m}^2/\text{kg}^2$	$6.67 \times 10^{-11}\,\text{N} \cdot \text{m}^2/\text{kg}^2$
${}^{N}A$	Avogadro's number	$6.02214129\,(27) \times 10^{23}\,\text{J/K}$	6.02×10^{23}
k	Boltzmann's constant	$1.3806488\,(13) \times 10^{-23}\,\text{J/K}$	$1.38 \times 10^{-23}\,\text{J/K}$
R	Gas constant	$8.3144621\,(75)\ \text{J/mol} \cdot \text{K}$	$8.31\ \text{J/mol} \cdot \text{K} = 1.99\ \text{cal/mol} \cdot \text{K}$ $= 0.0821\ \text{atm} \cdot \text{L/mol} \cdot \text{K}$
σ	Stefan-Boltzmann Constant	$5.670373\,(21) \times 10^{-8}\,\text{W/m}^2 \cdot \text{K}$	$5.67 \times 10^{-8}\,\text{W/m}^2 \cdot \text{K}$
k	Coulomb force constant	$8.987551788\ldots \times 10^{9}\,\text{N} \cdot \text{m}^2/\text{C}^2$	$8.99 \times 10^{9}\,\text{N} \cdot \text{m}^2/\text{C}^2$

Table A6 Important Constants

Symbol	Meaning	Best Value	Approximate Value
^{q}e	Charge on electron	$-1.602176565\,(35) \times 10^{-19}\,\mathrm{C}$	$-1.60 \times 10^{-19}\,\mathrm{C}$
$^{\varepsilon}\mathrm{o}$	Permittivity of free space	$8.854187817... \times 10^{-12}\,\mathrm{C^2/N \cdot m^2}$	$8.85 \times 10^{-12}\,\mathrm{C^2/N \cdot m^2}$
$^{\mu}\mathrm{o}$	Permeability of free space	$4\pi \times 10^{-7}\,\mathrm{T \cdot m/A}$	$1.26 \times 10^{-6}\,\mathrm{T \cdot m/A}$
h	Planck's constant	$6.62606957\,(29) \times 10^{-34}\,\mathrm{J \cdot s}$	$6.63 \times 10^{-34}\,\mathrm{J \cdot s}$

Table A6 Important Constants

Alpha	A	α
Beta	B	β
Gamma	Γ	γ
Delta	Δ	δ
Epsilon	E	ε
Zeta	Z	ζ
Eta	H	η
Theta	Θ	θ
Iota	I	ι
Kappa	K	κ
Lambda	Λ	λ
Mu	M	μ
Nu	N	ν
Xi	Ξ	ξ
Omicron	O	o
Pi	Π	π
Rho	P	ρ
Sigma	Σ	σ
Tau	T	τ

Table A7 The Greek Alphabet

Upsilon	Υ	υ
Phi	Φ	ϕ
Chi	X	χ
Psi	Ψ	ψ
Omega	Ω	ω

Table A7 The Greek Alphabet

Sun	mass	1.99×10^{30} kg
	average radius	6.96×10^{8} m
	Earth-sun distance (average)	1.496×10^{11} m
Earth	mass	5.9736×10^{24} kg
	average radius	6.376×10^{6} m
	orbital period	3.16×10^{7} s
Moon	mass	7.35×10^{22} kg
	average radius	1.74×10^{6} s
	orbital period (average)	2.36×10^{6} s
	Earth-moon distance (average)	3.84×10^{8} m

Table A8 Solar System Data

Atomic number, Z	Name	Atomic Mass Number, A	Symbol	Atomic Mass (u)	Percent Abundance or Decay Mode	Half-life, $^{t}1/2$
0	neutron	1	n	1.008 665	β^-	10.37 min
1	Hydrogen	1	^{1}H	1.007 825	99.985%	
	Deuterium	2	^{2}H or D	2.014 102	0.015%	
	Tritium	3	^{3}H or T	3.016 050	β^-	12.33 y
2	Helium	3	^{3}He	3.016 030	1.38×10^{-4} %	

Table A9 Atomic Masses and Decay

Atomic number, Z	Name	Atomic Mass Number, A	Symbol	Atomic Mass (u)	Percent Abundance or Decay Mode	Half-life, $t_{1/2}$
		4	^{4}He	4.002 603	≈100%	
3	Lithium	6	^{6}Li	6.015 121	7.5%	
		7	^{7}Li	7.016 003	92.5%	
4	Beryllium	7	^{7}Be	7.016 928	EC	53.29 d
		9	^{9}Be	9.012 182	100%	
5	Boron	10	^{10}B	10.012 937	19.9%	
		11	^{11}B	11.009 305	80.1%	
6	Carbon	11	^{11}C	11.011 432	EC, β^+	
		12	^{12}C	12.000 000	98.90%	
		13	^{13}C	13.003 355	1.10%	
		14	^{14}C	14.003 241	β^-	5730 y
7	Nitrogen	13	^{12}N	13.005 738	β^+	9.96 min
		14	^{13}N	14.003 074	99.63%	
		15	^{14}N	15.000 108	0.37%	
8	Oxygen	15	^{15}O	15.003 065	EC, β^+	122 s
		16	^{16}O	15.994 915	99.76%	
		18	^{18}O	17.999 160	0.200%	
9	Fluorine	18	^{18}F	18.000 937	EC, β^+	1.83 h
		19	^{19}F	18.998 403	100%	
10	Neon	20	^{20}Ne	19.992 435	90.51%	
		22	^{22}Ne	21.991 383	9.22%	
11	Sodium	22	^{22}Na	21.994 434	β^+	2.602 y
		23	^{23}Na	22.989 767	100%	
		24	^{24}Na	23.990 961	β^-	14.96 h

Table A9 Atomic Masses and Decay

Atomic number, Z	Name	Atomic Mass Number, A	Symbol	Atomic Mass (u)	Percent Abundance or Decay Mode	Half-life, $t_{1/2}$
12	Magnesium	24	^{24}Mg	23.985 042	78.99%	
13	Aluminum	27	^{27}Al	26.981 539	100%	
14	Silicon	28	^{28}Si	27.976 927	92.23%	2.62h
		31	^{31}Si	30.975 362	β^-	
15	Phosphorus	31	^{31}P	30.973 762	100%	
		32	^{32}P	31.973 907	β^-	14.28 d
16	Sulfur	32	^{32}S	31.972 070	95.02%	
		35	^{35}S	34.969 031	β^-	87.4 d
17	Chlorine	35	^{35}Cl	34.968 852	75.77%	
		37	^{37}Cl	36.965 903	24.23%	
18	Argon	40	^{40}Ar	39.962 384	99.60%	
19	Potassium	39	^{39}K	38.963 707	93.26%	
		40	^{40}K	39.963 999	0.0117%, EC, β^-	1.28×10^9 y
20	Calcium	40	^{40}Ca	39.962 591	96.94%	
21	Scandium	45	^{45}Sc	44.955 910	100%	
22	Titanium	48	^{48}Ti	47.947 947	73.8%	
23	Vanadium	51	^{51}V	50.943 962	99.75%	
24	Chromium	52	^{52}Cr	51.940 509	83.79%	
25	Manganese	55	^{55}Mn	54.938 047	100%	
26	Iron	56	^{56}Fe	55.934 939	91.72%	
27	Cobalt	59	^{59}Co	58.933 198	100%	
		60	^{60}Co	59.933 819	β^-	5.271 y
28	Nickel	58	^{58}Ni	57.935 346	68.27%	

Table A9 Atomic Masses and Decay

Atomic number, Z	Name	Atomic Mass Number, A	Symbol	Atomic Mass (u)	Percent Abundance or Decay Mode	Half-life, $t_{1/2}$
		60	^{60}Ni	59.930 788	26.10%	
29	Copper	63	^{63}Cu	62.939 598	69.17%	
			^{65}Cu	64.927 793	30.83%	
30	Zinc	64	^{64}Zn	63.929 145	48.6%	
		66	^{66}Zn	65.926 034	27.9%	
31	Gallium	69	^{69}Ga	68.925 580	60.1%	
32	Germanium	72	^{72}Ge	71.922 079	27.4%	
		74	^{74}Ge	73.921 177	36.5%	
33	Arsenic	75	^{75}As	74.921 594	100%	
34	Selenium	80	^{80}Se	79.916 520	49.7%	
35	Bromine	79	^{79}Br	78.918 336	50.69%	
36	Krypton	84	^{84}Kr	83.911 507	57.0%	
37	Rubidium	85	^{85}Rb	84.911 794	72.17%	
38	Strontium	86	^{86}Sr	85.909 267	9.86%	
		88	^{88}Sr	87.905 619	82.58%	
		90	^{90}Sr	89.907 738	β^-	28.8 y
39	Yttrium	89	^{89}Y	88.905 849	100%	
		90	^{90}Y	89.907 152	β^-	64.1 h
40	Zirconium	90	^{90}Zr	89.904 703	51.45%	
41	Niobium	93	^{93}Nb	92.906 377	100%	
42	Molybdenum	98	^{98}Mo	97.905 406	24.13%	
43	Technetium	98	^{98}Tc	97.907 215	β^-	4.2×10^6 y
44	Ruthenium	102	^{102}Ru	101.904 348	31.6%	

Table A9 Atomic Masses and Decay

Atomic number, Z	Name	Atomic Mass Number, A	Symbol	Atomic Mass (u)	Percent Abundance or Decay Mode	Half-life, $t_{1/2}$
45	Rhodium	103	^{103}Rh	102.905 500	100%	
46	Palladium	106	^{106}Pd	105.903 478	27.33%	
47	Silver	107	^{107}Ag	106.905 092	51.84%	
		109	^{109}Ag	108.904 757	48.16%	
48	Cadmium	114	^{114}Cd	113.903 357	28.73%	
49	Indium	115	^{115}In	114.903 880	95.7%, β^-	4.4×10^{14} y
50	Tin	120	^{120}Sn	119.902 200	32.59%	
51	Antimony	121	^{121}Sb	120.903 821	57.3%	
52	Tellurium	130	^{130}Te	129.906 229	33.8%, β^-	2.5×10^{21} y
53	Iodine	127	^{127}I	126.904 473	100%	
		131	^{131}I	130.906 114	β^-	8.040 d
54	Xenon	132	^{132}Xe	131.904 144	26.9%	
		136	^{136}Xe	135.907 214	8.9%	
55	Cesium	133	^{133}Cs	132.905 429	100%	
		134	^{134}Cs	133.906 696	EC, β^-	2.06 y
56	Barium	137	^{137}Ba	136.905 812	11.23%	
		138	^{138}Ba	137.905 232	71.70%	
57	Lanthanum	139	^{139}La	138.906 346	99.91%	
58	Cerium	140	^{140}Ce	139.905 433	88.48%	
59	Praseodymium	141	^{141}Pr	140.907 647	100%	
60	Neodymium	142	^{142}Nd	141.907 719	27.13%	
61	Promethium	145	^{145}Pm	144.912 743	EC, α	17.7 y
62	Samarium	152	^{152}Sm	151.919 729	26.7%	

Table A9 Atomic Masses and Decay

Atomic number, Z	Name	Atomic Mass Number, A	Symbol	Atomic Mass (u)	Percent Abundance or Decay Mode	Half-life, $t_{1/2}$
63	Europium	153	^{153}Eu	152.921 225	52.2%	
64	Gadolinium	158	^{158}Gd	157.924 099	24.84%	
65	Terbium	159	^{159}Tb	158.925 342	100%	
66	Dysprosium	164	^{164}Dy	163.929 171	28.2%	
67	Holmium	165	^{165}Ho	164.930 319	100%	
68	Erbium	166	^{166}Ho	165.930 290	33.6%	
69	Thulium	169	^{169}Tm	168.934 212	100%	
70	Ytterbium	174	^{174}Yb	173.938 859	31.8%	
71	Lutecium	175	^{175}Lu	174.940 770	97.41%	
72	Hafnium	180	^{180}Hf	179.946 545	35.10%	
73	Tantalum	181	^{181}Ta	180.947 992	99.98%	
74	Tungsten	184	^{184}W	183.950 928	30.67%	
75	Rhenium	187	^{187}Re	186.955 744	62.6%, β^-	4.6×10^{10}y
76	Osmium	191	^{191}Os	190.960 920	β^-	15.4 d
		192	^{192}Os	191.961 467	41.0%	
77	Iridium	191	^{191}Ir	190.960 584	37.3%	
		193	^{193}Ir	192.962 917	62.7%	
78	Platinum	195	^{195}Pt	194.964 766	33.8%	
79	Gold	197	^{197}Au	196.966 543	100%	
		198	^{198}Au	197.968 217	β^-	2.696 d
80	Mercury	199	^{199}Hg	198.968 253	16.87%	
		202	^{202}Hg	201.970 617	29.86%	
81	Thallium	205	^{205}Tl	204.974 401	70.48%	

Table A9 Atomic Masses and Decay

Atomic number, Z	Name	Atomic Mass Number, A	Symbol	Atomic Mass (u)	Percent Abundance or Decay Mode	Half-life, $^{t}1/2$
82	Lead	206	^{206}Pb	205.974 440	24.1%	
		207	^{207}Pb	206.975 872	22.1%	
		208	^{208}Pb	207.976 627	52.4%	
		210	^{210}Pb	209.984 163	α, β^-	22.3 y
		211	^{211}Pb	210.988 735	β^-	36.1 min
		212	^{212}Pb	211.991 871	β^-	10.64 h
83	Bismuth	209	^{209}Bi	208.980 374	100%	
		211	^{211}Bi	210.987 255	α, β^-	2.14 min
84	Polonium	210	^{210}Po	209.982 848	α	138.38 d
85	Astatine	218	^{218}At	218.008 684	α, β^-	1.6 s
86	Radon	222	^{222}Rn	222.017 570	α	3.82 d
87	Francium 2	223	^{223}Fr	223.019 733	α, β^-	21.8 min
88	Radium	226	^{226}Ra	226.025 402	α	1.60×10^3 y
89	Actinium	227	^{227}Ac	227.027 750	α, β^-	21.8 y
90	Thorium	228	^{228}Th	228.028 715	α	1.91 y
		232	^{232}Th	232.038 054	100%, α	1.41×10^{10} y
91	Protactinium	231	^{231}Pa	231.035 880	α	3.28×10^4 y
92	Uranium	233	^{233}U	233.039 628	α	1.59×10^3 y
		235	^{235}U	235.043 924	0.720%, α	7.04×10^8 y
		236	^{236}U	236.045 562	α	2.34×10^7 y

Table A9 Atomic Masses and Decay

Atomic number, Z	Name	Atomic Mass Number, A	Symbol	Atomic Mass (u)	Percent Abundance or Decay Mode	Half-life, $t_{1/2}$
		238	^{238}U	238.050 784	99.2745%, α	4.47×10^9 y
		239	^{239}U	239.054 289	β^-	23.5 min
93	Neptunium	239	^{239}Np	239.052 933	β^-	2.355 d
94	Plutonium	239	^{239}Pu	239.052 157	α	2.41×10^4 y
95	Americium	243	^{243}Am	243.061 375	α, fission	7.37×10^3 y
96	Curium	245	^{245}Cm	245.065 483	α	8.50×10^3 y
97	Berkelium	245	^{247}Bk	247.070 300	α	1.38×10^3 y
98	Californium	249	^{249}Cf	249.074 844	α	351 y
99	Einsteinium	254	^{254}Es	254.088 019	α, β^-	276 d
100	Fermium	253	^{253}Fm	253.085 173	EC, α	3.00 d
101	Mendelevium	255	^{255}Md	255.091 081	EC, α	27 min
102	Nobelium	255	^{255}No	255.093 260	EC, α	3.1 min
103	Lawrencium	257	^{257}Lr	257.099 480	EC, α	0.646 s
104	Rutherfordium	261	^{261}Rf	261.108 690	α	1.08 mim
105	Dubnium	262	^{262}Db	262.113 760	α, fission	34 s
106	Seaborgium	263	^{263}Sg	263.11 86	α, fission	0.8 s
107	Bohrium	262	^{262}Bh	262.123 1	α	0.102 s
108	Hassium	264	^{264}Hs	264.128 5	α	0.08 ms
108	Meitnerium	266	^{266}Mt	266.137 8	α	3.4 ms

Table A9 Atomic Masses and Decay

Isotope	$^{t}1/2$	Decay Mode	Energy(MeV)	Percent		T-Ray Energy(MeV)	Percent
^{3}H	12.33 y	β^-	0.0186	100%			
^{14}C	5730 y	β^-	0.156	100%			
^{13}N	9.96 min	β^+	1.20	100%			
^{22}Na	2.602 y	β^+	1.20	90%	γ	1.27	100%
^{32}P	14.28 d	β^-	1.71	100%			
^{35}S	87.4 d	β^-	0.167	100%			
^{36}Ci	3.00 × 105 y	β^-	0.710	100%			
^{40}K	1.28 × 109 y	β^-	1.31	89%			
^{43}K	22.3 h	β^-	0.827	87%	γs	0.373	87%
						0.618	87%
^{45}Ca	165 d	β^-	0.257	100%			
^{51}Cr	27.70 d	EC			γ	0.320	10%
^{52}Mn	5.59d	β^+	3.69	28%	γ s	1.33	28%
						1.43	28%
^{52}Fe	8.27 h	β^+	1.80	43%		0.169	43%
						0.378	43%
^{59}Fe	44.6 d	β^- s	0.273	45%	γ s	1.10	57%
			0.466	55%		1.29	43%
^{60}Co	5.271 y	β^-	0.318	100%	γ s	1.17	100%
						1.33	100%
^{65}Zn	244.1 d	EC			γ	1.12	51%
^{67}Ga	78.3 h	EC			γ s	0.0933	70%
						0.185	35%
						0.300	19%

Table A10 Selected Radioactive Isotopes

Isotope	$^{t}1/2$	Decay Mode	Energy(MeV)	Percent		T-Ray Energy(MeV)	Percent
						others	
^{75}Se	118.5 d	EC			γ s	0.121	20%
						0.136	65%
						0.265	68%
						0.280	20%
						others	
^{86}Rb	18.8 d	β^- s	0.69	9%	γ	1.08	9%
			1.77	91%			
^{85}Sr	64.8 d	EC			γ	0.514 1	100%
^{90}Sr	28.8 y	β^-	0.546	100%			
^{90}Y	64.1 h	β^-	2.28	100%			
^{99m}Tc	6.02 h	IT			γ	0.142	100%
^{113}mIn	99.5 ^{m}in	IT			γ	0.392	100%
^{123}I	13.0 h	EC			γ	0.159	≈100%
^{131}I	8.040 d	β^- s	0.248	7%	γ s	0.364	85%
			0.607	93%		others	
			others				
^{129}Cs	32.3 h	EC			γ s	0.0400	35%
						0.372	32%
						0.411	25%
						others	
^{137}Cs	30.17 y	β^- s	0.511	95%	γ	0.662	95%
			1.17	5%			
^{140}Ba	12.79 d	β^-	1.035	≈100%	γ s	0.030	25%

Table A10 Selected Radioactive Isotopes

Isotope	$^{t}1/2$	Decay Mode	Energy(MeV)	Percent		T-Ray Energy(MeV)	Percent
						0.044	65%
						0.537	24%
						others	
^{198}Au	2.696 d	β^-	1.161	≈100%	γ	0.412	≈100%
^{197}Hg	64.1 h	EC			γ	0.0733	100%
^{210}Po	138.38 d	α	5.41	100%			
^{226}Ra	1.60 × 103 y	αs	4.68	5%	γ	0.186 1	100%
			4.87	95%			
^{235}U	7.038 × 108 y	α	4.68	≈100%	γ s	Numerous	<0.400%
^{238}U	4.468 × 109 y	αs	4.22	23%	γ	0.050	23%
			4.27	77%			
^{237}Np	2.14 × 106 y	αs	numerous		γ s	numerous	<0.250%
			4.96 (max.)				
^{239}Pu	2.41 × 104 y	αs	5.19	11%	γ s	7.5 × 10-5	73%
			5.23	15%		0.013	15%
			5.24	73%		0.052	15%
						others	
^{243}Am	7.37 × 103 y	αs	Max. 5.44		γ s	0.075	
			5.37	88%		others	
			5.32	11%			
			others				

Table A10 Selected Radioactive Isotopes

Symbol	Meaning	Best Value	Approximate Value
m_e	Electron mass	$9.10938291(40) \times 10^{-31}$ kg	9.11×10^{-31} kg

Table A11 Submicroscopic masses

Symbol	Meaning	Best Value	Approximate Value
m_p	Proton mass	$1.672621777(74) \times 10^{-27}$ kg	1.6726×10^{-27} kg
m_n	Neutron mass	$1.674927351(74) \times 10^{-27}$ kg	1.6749×10^{-27} kg
u	Atomic mass unit	$1.660538921(73) \times 10^{-27}$ kg	1.6605×10^{-27} kg

Table A11 Submicroscopic masses

Substance	p(kg/m^3)	Substance	p(kg/m^3)
Air	1.29	Iron	7.86×10^3
Air (at 20°C and Atmospheric pressure)	1.20	Lead	11.3×10^3
Aluminum	2.70×10^3	Mercury	13.6×10^3
Benzene	0.879×10^3	Nitrogen gas	1.25
Brass	8.4×10^3	Oak	0.710×10^3
Copper	8.92×10^3	Osmium	22.6×10^3
Ethyl alcohol	0.806×10^3	Oxygen gas	1.43
Fresh water	1.00×10^3	Pine	0.373×10^3
Glycerin	1.26×10^3	Platinum	21.4×10^3
Gold	1.93×10^3	Seawater	1.03×10^3
Helium gas	1.79×10^{-1}	Silver	10.5×10^3
Hydrogen gas	8.99×10^{-2}	Tin	7.30×10^3
Ice	0.917×10^3	Uranium	18.7×10^3

Table A12 Densities of common substances (including water at various temperatures)

Substance	Specific Heat (J/kg · °C)	Substance	Specific Heat (J/kg · °C)
Elemental solids		*Other solids*	
Aluminum	900	Brass	380
Beryllium	1830	Glass	837
Cadmium	230	Ice (–5 °C)	2090

Table A13 Specific heats of common substances

Substance	Specific Heat (J/kg · °C)	Substance	Specific Heat (J/kg · °C)
Copper	387	Marble	860
Germanium	322	Wood	1700
Gold	129	*Liquids*	
Iron	448	Alcohol (ethyl)	2400
Lead	128	Mercury	140
Silicon	703	Water (15 °C)	4186
Silver	234	*Gas*	
		Steam (100 °C)	2010

Note: To convert values to units of cal/g · °C, divide by 4186

Table A13 Specific heats of common substances

Substance	Melting Point (°C)	Latent Heat of Fusion (J/kg)	Boiling Point (°C)	Latent Heat of Vaporization (J/kg)
Helium	−272.2	5.23×10^3	−268.93	2.09×10^4
Oxygen	−218.79	1.38×10^4	−182.97	2.13×10^5
Nitrogen	−209.97	2.55×10^4	−195.81	2.01×10^5
Ethyl Alcohol	−114	1.04×10^5	78	8.54×10^5
Water	0.00	3.33×10^5	100.00	2.26×10^6
Sulfur	119	3.81×10^4	444.60	2.90×10^5
Lead	327.3	3.97×10^5	1750	8.70×10^5
Aluminum	660	3.97×10^5	2516	1.05×10^7
Silver	960.80	8.82×10^4	2162	2.33×10^6
Gold	1063.00	6.44×10^4	2856	1.58×10^6
Copper	1083	1.34×10^5	2562	5.06×10^6

Table A14 Heats of fusion and vaporization for common substances

Materials (Solids)	Average Linear Expansion Coefficient (α)$(°C)^{-1}$	Material (Liquids and Gases)	Average Volume Expansion Coefficient (B)$(°C)^{-1}$
Aluminum	24×10^{-6}	Acetone	1.5×10^{-4}
Brass and Bronze	19×10^{-6}	Alcohol, ethyl	1.12×10^{-4}
Concrete	12×10^{-6}	Benzene	1.24×10^{-4}
Copper	17×10^{-6}	Gasoline	9.6×10^{-4}
Glass (ordinary)	9×10^{-6}	Glycerin	4.85×10^{-4}
Glass (Pyrex)	3.2×10^{-6}	Mercury	1.82×10^{-4}
Invar (Ni-Fe alloy)	1.3×10^{-6}	Turpentine	9.0×10^{-4}
Lead	29×10^{-6}	Air* at 0°C	3.67×10^{-3}
Steel	13×10^{-6}	Helium*	3.665×10^{-3}

* The values given here assume the gases undergo expansion at constant pressure. However, the expansion of gases depends on the pressure applied to the gas. Therefore, gases do not have a specific value for the volume expansion coefficient.

Table A15 Coefficients of thermal expansion for common substances

Medium	v(m/s)	Medium	v(m/s)	Medium	v(m/s)
Gases		Liquids at 25°C		Solids*	
Hydrogen	1286	Glycerol	1904	Pyrex glass	5640
Helium	972	Seawater	1533	Iron	5950
Air	343	Water	1493	Aluminum	5100
Air	331	Mercury	1450	Brass	4700
Oxygen	317	Kerosene	1324	Copper	3560
		Methyl Alcohol	1143	Gold	3240
		Carbon tetrachloride	926	Lucite	2680
				Lead	1322
				Rubber	1600

Table A16 Speed of sound in various substances

Medium	*v*(m/s)	Medium	*v*(m/s)	Medium	*v*(m/s)

*Values given here are for propagation of longitudinal waves in bulk media. However, speeds for longitudinal waves in thin rods are slower, and speeds of transverse waves in bulk are even slower.

Table A16 Speed of sound in various substances

Source of Sound	*B(dB)*
Nearby jet airplane	150
Jackhammer machine gun	130
Siren; rock concert	120
Subway; power lawn mower	100
Busy traffic	80
Vacuum cleaner	70
Normal Conversation	60
Mosquito buzzing	40
whisper	30
Rustling leaves	10
Threshold of hearing	0

Table A17 Conversion of sound intensity to decibel level

Wavelength Range (nm)	Color Description
400-430	Violet
430-485	Blue
485-560	Green
560-590	Yellow
590-625	Orange
625-700	Red

Table A18 Wavelengths of visible light

Substance	Index of Refraction	Substance	Index of Refraction
Solids at 20°C		Liquids at 20°C	
Cubic zirconia	2.15	Benzene	1.501
Diamond (C)	2.419	Carbon disulfide	1.628
Flourite (CaF_2)	1.434	Carbon tetrachloride	1.461
Fused quartz (SiO_2)	1.458	Ethyl alcohol	1.361
Gallium phosphide	3.50	Glycerin	1.473
Glass, crown	1.52	Water	1.333
Glass, flint	1.66		
Ice (H_2O)	1.309	Gases at 0°C, 1 *atm*	
Polystyrene	1.49	Air	1.000 293
Sodium chloride (NaCl)	1.544	Carbon dioxide	1.000 45

Note: These values assume that light has a wavelength of 589 nm in vacuum.

Table A19 Indices of refraction

Hoop or thin cylindrical shell	$I_{CM} = MR^2$
Hollow cylinder	$I_{CM} = \frac{1}{2}M(R_1^2 + R_2^2)$
Solid cylinder or disk	$I_{CM} = \frac{1}{2}MR^2$
Rectangular plane	$I_{CM} = \frac{1}{12}M(a^2 + b^2)$
Long, thin rod with rotation axis through center	$I_{CM} = \frac{1}{12}ML^2$
Long, thin rod with rotation axis through end	$I_{CM} = \frac{1}{3}ML^2$
Solid sphere	$I_{CM} = \frac{2}{5}MR^2$
Thin spherical shell	$I_{CM} = \frac{2}{3}MR^2$

Table A20 Moments of inertia for different shapes

	μ_s	μ_k
Rubber on dry concrete	1.0	0.8

Table A21 Coefficients of friction for common objects on other objects

	μ_s	μ_k
Steel on steel	0.74	0.57
Aluminum on steel	0.61	0.47
Glass on glass	0.94	0.4
Copper on steel	0.53	0.36
Wood on wood	0.25-0.5	0.2
Waxed wood on wet snow	0.14	0.1
Waxed wood on dry snow	0.1	0.04
Metal on metal (lubricated)	0.15	0.06
Teflon on Teflon	0.04	0.04
Ice on ice	0.1	0.03
Synovial joints in humans	0.01	0.003

Note: All values are approximate. In some cases, the coefficient of friction can exceed 1.0.

Table A21 Coefficients of friction for common objects on other objects

Material	Dielectric Constant κ	Dielectric Strength* (10^6V/m)
Air (dry)	1.000 59	3
Bakelite	4.9	24
Fused quartz	4.3	8
Mylar	3.2	7
Neoprene rubber	6.7	12
Nylon	3.4	14
Paper	3.7	16
Paraffin-impregnated paper	3.5	11
Polystyrene	2.56	24
Polyvinyl chloride	3.4	40
Porcelain	6	8

Table A22 Dielectric constants

Material	Dielectric Constant κ	Dielectric Strength* (10^6V/m)
Pyrex glass	5.6	14
Silicone oil	2.5	15
Strontium titanate	233	8
Teflon	2.1	60
Vacuum	1.000 00	∞
Water	80	3

Table A22 Dielectric constants