Table C-1

Color Key		
Carbon	Bromine	Sodium/ Other metals
Hydrogen	Iodine	Gold
Oxygen	Sulfur	Copper
Nitrogen	Phosphorus	Electron
Chlorine	Silicon	Proton
Fluorine	Helium	Neutron

Table C-2

Symbols and Abbreviations

α = rays from radioactive materials, helium nuclei	*E* = energy, electromotive force	min = minute (*time*)
β = rays from radioactive materials, electrons	*F* = force	N = newton (*force*)
γ = rays from radioactive materials, high-energy quanta	*G* = free energy	N_A = Avogadro's number
Δ = change in	g = gram (*mass*)	*n* = number of moles
λ = wavelength	Gy = gray (*radiation*)	*P* = pressure, power
ν = frequency	*H* = enthalpy	Pa = pascal (*pressure*)
A = ampere (*electric current*)	Hz = hertz (*frequency*)	*q* = heat
amu = atomic mass unit	*h* = Planck's constant	*R* = ideal gas constant
Bq = becquerel (*nuclear disintegration*)	h = hour (*time*)	*S* = entropy
°C = Celsius degree (*temperature*)	J = joule (*energy*)	s = second (*time*)
C = coulomb (*quantity of electricity*)	K = kelvin (*temperature*)	Sv = sievert (*absorbed radiation*)
c = speed of light	K_a = ionization constant (*acid*)	*T* = temperature
cd = candela (*luminous intensity*)	K_b = ionization constant (*base*)	*V* = volume
c = specific heat	K_{eq} = equilibrium constant	V = volt (*electric potential*)
D = density	K_{sp} = solubility product constant	*v* = velocity
	kg = kilogram (*mass*)	W = watt (*power*)
	M = molarity	*w* = work
	m = mass, molality	*X* = mole fraction
	m = meter (*length*)	
	mol = mole (*amount*)	

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Table C-3

SI Prefixes		
Prefix	**Symbol**	**Scientific notation**
femto	f	10^{-15}
pico	p	10^{-12}
nano	n	10^{-9}
micro	μ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}
deka	da	10^{1}
hecto	h	10^{2}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}
peta	P	10^{15}

Table C-4

The Greek Alphabet					
Alpha	A	α	Nu	N	ν
Beta	B	β	Xi	Ξ	ξ
Gamma	Γ	γ	Omicron	O	o
Delta	Δ	δ	Pi	Π	π
Epsilon	E	ϵ	Rho	P	ρ
Zeta	Z	ζ	Sigma	Σ	σ
Eta	H	η	Tau	T	τ
Theta	Θ	θ	Upsilon	Υ	υ
Iota	I	ι	Phi	Φ	ϕ
Kappa	K	κ	Chi	X	χ
Lambda	Λ	λ	Psi	Ψ	ψ
Mu	M	μ	Omega	Ω	ω

Table C-5

Physical Constants		
Quantity	**Symbol**	**Value**
Atomic mass unit	amu	1.6605×10^{-27} kg
Avogadro's number	N	6.022×10^{23} particles/mole
Ideal gas constant	R	8.31 L·kPa/mol·K 0.0821 L·atm/mol·K 62.4 mm Hg·L/mol·K 62.4 torr·L/mol·K
Mass of an electron	m_e	9.109×10^{-31} kg 5.48586×10^{-4} amu
Mass of a neutron	m_n	1.67492×10^{-27} kg 1.008 665 amu
Mass of a proton	m_p	1.6726×10^{-27} kg 1.007 276 amu
Molar volume of ideal gas at STP	V	22.414 L/mol
Normal boiling point of water	T_b	373.15 K 100.0°C
Normal freezing point of water	T_f	273.15 K 0.00°C
Planck's constant	h	$6.626\,076 \times 10^{-34}$ J·s
Speed of light in a vacuum	c	$2.997\,925 \times 10^{8}$ m/s

Table C-6

Properties of Elements

Element	Symbol	Atomic Number	Atomic Mass* (amu)	Melting Point (°C)	Boiling Point (°C)	Density (g/cm^3) (gases measured at STP)	Atomic Radius (pm)	First Ionization Energy (kJ/mol)	Standard Reduction Potential (V) (for elements from or to oxidation state indicated)	Enthalpy of Fusion (kJ/mol)	Specific Heat (J/g • C°)	Enthalpy of Vaporization (kJ/mol)	Abundance in Earth's Crust (%)	Major Oxidation States
Actinium	Ac	89	[227]	1050	3300	10.07	203	499	(3+)−2.13	14.3	0.120	293	trace	3+
Aluminum	Al	13	26.981539	660.37	2517.6	2.699	143	577.5	(3+)−1.67	10.71	0.9025	290.8	8.1	3+
Americium	Am	95	[243]	1176	2607	13.67	183	579	(3+)−2.07	10	—	238.5	—	2+, 3+, 4+
Antimony	Sb	51	121.760	630.7	1587	6.697	161	834	(3+)+0.15	19.5	0.2072	193	2×10^{-5}	3+, 5+
Argon	Ar	18	39.948	−189.37	−185.86	0.001784	98	1521	—	1.18	0.52033	6.52	4×10^{-6}	
Arsenic	As	33	74.92159	816 (2840 kPa)	615 (sublimes)	5.778	121	947	(3+)+0.24	27.7	0.3289	— (sublimes)	1.9×10^{-4}	3+, 5+
Astatine	At	85	[210]	300	350	—	—	916	(1−)+0.2	23.8	—	90.3	trace	1−, 5+
Barium	Ba	56	137.327	726.9	1845	3.62	222	502.9	(2+)−2.92	8.012	0.2044	140	0.039	2+
Berkelium	Bk	97	[247]	986	—	14.78	170	601	(3+)−2.01	—	—	—	—	3+, 4+
Beryllium	Be	4	9.012182	1287	2468	1.848	112	899.5	(2+)−1.97	7.895	1.824	297.6	2×10^{-4}	2+
Bismuth	Bi	83	208.98037	271.4	1564	9.78	151	703	(3+)+0.317	10.9	0.1221	179	8×10^{-7}	3+, 5+
Bohrium	Bh	107	[264]	—	—	—	—	—	—	—	—	—	—	
Boron	B	5	10.811	2080	3927	2.46	85	800.6	(3+)−0.89	50.2	1.026	504.5	9×10^{-4}	3+
Bromine	Br	35	79.904	−7.25	59.35	3.1028	119	1139.9	(1−)+1.065	10.571	0.47362	29.56	2.5×10^{-4}	1−, 1+, 3+, 5+
Cadmium	Cd	48	112.411	320.8	770	8.65	151	867.7	(2+)−0.4025	6.19	0.2311	100	1.6×10^{-5}	2+
Calcium	Ca	20	40.078	841.5	1484	1.55	197	589.8	(2+)−2.84	8.54	0.6315	155	4.66	2+
Californium	Cf	98	[251]	900	—	—	186	608	(3+)−2	—	—	—	—	3+, 4+
Carbon	C	6	12.011	3620	4200	2.266	77	1086.5	(4−)+0.132	104.6	0.7099	711	0.018	4−, 2+, 4+
Cerium	Ce	58	140.115	804	3470	6.773	181.8	541	(3+)−2.34	5.2	0.1923	313	0.007	3+, 4+
Cesium	Cs	55	132.90543	28.4	674.8	1.9	262	375.7	(1+)−2.923	2.087	0.2421	67	2.6×10^{-4}	1+
Chlorine	Cl	17	35.4527	−101	−34	0.003214	91	1255.5	(1−)+1.3583	6.41	0.47820	20.41	0.013	1−, 1+, 3+, 5+
Chromium	Cr	24	51.9961	1907	2679	7.2	128	652.8	(3+)−0.74	20.5	0.4491	339	0.01	2+, 3+, 6+
Cobalt	Co	27	58.9332	1495	2912	8.9	125	758.8	(2+)−0.277	16.192	0.4210	382	0.0028	2+, 3+
Copper	Cu	29	63.546	1085	2570	8.92	128	745.5	(2+)+0.34	13.38	0.38452	304	0.0058	1+, 2+
Curium	Cm	96	[247]	1340	3540	13.51	174	581	(3+)−2.06	—	—	—	—	3+, 4+
Dubnium	Db	105	[262]	—	—	—	—	—	—	—	—	—	—	—
Dysprosium	Dy	66	162.5	1407	2600	8.536	178.1	572	(3+)−2.29	10.4	0.1733	250	6×10^{-4}	2+, 3+
Einsteinium	Es	99	[252]	860	—	—	186	619	(3+)−2	—	—	—	—	3+
Erbium	Er	68	167.26	1497	2900	9.045	176.1	589	(3+)−2.32	17.2	0.1681	293	3.5×10^{-4}	3+
Europium	Eu	63	151.965	826	1596	5.245	208.4	547	(3+)−1.99	10.5	0.1820	176	2.1×10^{-3}	2+, 3+
Fermium	Fm	100	[257]	—	—	—	—	627	(3+)−1.96	—	—	—	—	2+, 3+
Fluorine	F	9	18.9984032	−219.7	−188.2	0.001696	69	1681	(1−)+2.87	0.51	0.8238	6.54	0.0544	1−
Francium	Fr	87	[223]	27	650	—	280	393	—	2	—	63.6	trace	1+
Gadolinium	Gd	64	157.25	1312	3000	7.886	180.4	592	(3+)−2.29	15.5	0.2355	311.7	6.3×10^{-4}	3+
Gallium	Ga	31	69.723	29.77	2203	5.904	134	578.8	(3+)−0.529	5.59	0.3709	256	0.0018	1+, 3+
Germanium	Ge	32	72.64	945	2850	5.323	123	761.2	(4+)+0.124	31.8	0.3215	334.3	1.5×10^{-4}	2+, 4+

* [ ] indicates mass of longest-lived isotope.

Table C-6

Properties of Elements (continued)

Element	Symbol	Atomic Number	Atomic Mass* (amu)	Melting Point (°C)	Boiling Point (°C)	Density (g/cm^3) (gases measured at STP)	Atomic Radius (pm)	First Ionization Energy (kJ/mol)	Standard Reduction Potential (V) (for elements from or to oxidation state indicated)	Enthalpy of Fusion (kJ/mol)	Specific Heat (J/g•C°)	Enthalpy of Vaporization (kJ/mol)	Abundance in Earth's Crust (%)	Major Oxidation States
Gold	Au	79	196.96654	1064	2856	19.32	144	889.9	(3+)+1.52	12.4	0.12905	324.4	3×10^{-7}	1+, 3+
Hafnium	Hf	72	178.49	2227	4603	13.28	159	654.4	(4+)−1.56	29.288	0.1442	661	3×10^{-4}	4+
Hassium	Hs	108	[277]	—	—	—	—	—	—	—	—	—	—	—
Helium	He	2	4.002602	−269.7 (2536 kPa)	−268.93	0.00017847	31	2372	—	0.02	5.1931	0.084	—	
Holmium	Ho	67	164.9032	1461	2600	8.78	176.2	581	(3+)−2.33	17.1	0.1646	251	1.5×10^{-4}	3+
Hydrogen	H	1	1.00794	−259.19	−252.76	0.0000899	37	1312	(1+) 0.0000	0.117	14.298	0.904	—	1 −, 1+
Indium	In	49	114.818	156.61	2080	7.29	167	558.2	(3+)−0.3382	3.26	0.2407	231.8	2×10^{-5}	1+, 3+
Iodine	I	53	126.90447	113.6	184.5	4.93	138	1008.4	(1−)+0.5355	15.517	0.21448	41.95	4.6×10^{-5}	1 −, 1+, 5+, 7+
Iridium	Ir	77	192.22	2447	4550	22.65	135.5	880	(4+)+0.926	26.4	0.1306	563.6	1×10^{-7}	3+, 4+, 5+
Iron	Fe	26	55.845	1536	2860	7.874	126	759.4	(3+)−0.4	13.807	0.4494	350	5.8	2+, 3+
Krypton	Kr	36	83.80	−157.2	−153.35	0.0037493	112	1351	—	1.64	0.2480	9.03	—	
Lanthanum	La	57	138.9055	920	3420	6.17	187	538	(3+)−2.37	8.5	0.1952	402	0.0035	3+
Lawrencium	Lr	103	[262]	—	—	—	—	—	(3+)−2.06	—	—	—	—	3+
Lead	Pb	82	207.2	327	1746	11.342	146	715.6	(2+)−0.1251	4.77	0.1276	178	0.0013	2+, 4+
Lithium	Li	3	6.941	180.5	1347	0.534	156	520.2	(1+)−3.045	3	3.569	148	0.002	1+
Lutetium	Lu	71	174.967	1652	3327	9.84	173.8	524	(3+)−2.3	11.9	0.1535	414	8×10^{-5}	3+
Magnesium	Mg	12	24.305	650	1105	1.738	160	737.8	(2+)−2.356	8.477	1.024	127.4	2.76	2+
Manganese	Mn	25	54.93805	1246	2061	7.43	127	717.5	(2+)−1.18	12.058	0.4791	219.7	0.1	2+, 3+, 4+, 6+, 7+
Meitnerium	Mt	109	[268]	—	—	—	—	—	—	—	—	—	—	—
Mendelevium	Md	101	[258]	—	—	—	—	635	—	—	—	—	—	2+, 3+
Mercury	Hg	80	200.59	−38.9	357	13.534	151	1007	(2+)+0.8535	2.2953	0.13950	59.1	2×10^{-6}	1+, 2+
Molybdenum	Mo	42	95.94	2623	4679	10.28	139	685	(6+) 0.114	36	0.2508	590	1.2×10^{-4}	4+, 5+, 6+
Neodymium	Nd	60	144.24	1024	3111	7.003	181.4	530	(3+)−2.32	7.13	0.1903	283.7	0.004	2+, 3+
Neon	Ne	10	20.1797	−248.61	−246.05	0.0008999	71	2081	—	0.34	1.0301	1.77	—	
Neptunium	Np	93	[237]	640	3900	20.45	155	597	(5+)−0.91	9.46	—	336	—	2+, 3+, 4+, 5+, 6+
Nickel	Ni	28	58.6934	1455	2883	8.908	124	736.7	(2+)−0.257	17.15	0.4442	375	0.0075	2+, 3+, 4+
Niobium	Nb	41	92.90638	2477	4858	8.57	146	664.1	(5+)−0.65	26.9	0.2648	690	0.002	4+, 5+
Nitrogen	N	7	14.0067	−210	−195.8	0.0012409	75	1402	(3−)−0.092	0.72	1.0397	5.58	0.002	3−, 2−, 1−, 1+, 2+, 3+, 4+, 5+
Nobelium	No	102	[259]	—	—	—	—	642	(2+)−2.5	—	—	—	—	2+, 3+
Osmium	Os	76	190.23	3045	5025	22.57	135	840	(4+)+0.687	31.7	0.130	627.6	2×10^{-7}	4+, 6+, 8+
Oxygen	O	8	15.9994	−218.8	−183	0.001429	60	1313.9	(2−) 1.229	0.44	0.91738	6.82	45.5	2−, 1−
Palladium	Pd	46	106.42	1552	2940	11.99	137	805	(2+) 0.915	17.6	0.2441	362	3×10^{-7}	2+, 4+
Phosphorus	P	15	30.973762	44.2	280.5	1.823	109	1012	(3−)−0.063	0.659	0.76968	49.8	0.11	3−, 3+, 5+
Platinum	Pt	78	195.078	1769	3824	21.41	138.5	868	(4+)+1.15	19.7	0.1326	510.4	1×10^{-6}	2+, 4+
Plutonium	Pu	94	[244]	640	3230	19.86	162	585	(4+)−1.25	2.8	0.138	343.5	—	3+, 4+, 5+, 6+
Polonium	Po	84	[209]	254	962	9.4	164	813	(4+)+0.73	3.81	0.125	103	—	2−, 2+, 4+, 6+
Potassium	K	19	39.0983	63.2	766.4	0.862	231	418.8	(1+)−2.925	2.334	0.7566	76.9	1.84	1+
Praseodymium	Pr	59	140.90765	935	3520	6.782	182.4	522	(3+)−2.35	11.3	0.1930	332.6	9.1×10^{-4}	3+, 4+
Promethium	Pm	61	[145]	1042	3000	7.2	183.4	536	(3+)−2.29	8.17	—	293	—	3+

* [ ] indicates mass of longest-lived isotope.

Table C-6

Properties of Elements (continued)

Element	Symbol	Atomic Number	Atomic Mass* (amu)	Melting Point (°C)	Boiling Point (°C)	Density (g/cm^3) (gases measured at STP)	Atomic Radius (pm)	First Ionization Energy (kJ/mol)	Standard Reduction Potential (V) (for elements from or to oxidation state indicated)	Enthalpy of Fusion (kJ/mol)	Specific Heat (J/g • C°)	Enthalpy of Vaporization (kJ/mol)	Abundance in Earth's Crust (%)	Major Oxidation States
Protactinium	Pa	91	231.03588	1552	4227	15.37	163	568	(5+)−1.19	14.6	—	481	trace	3+, 4+, 5+
Radium	Ra	88	[226]	700	1630	5	228	509.1	(2+)−2.916	8.36	—	136.8	—	2+
Radon	Rn	86	[222]	−71	−62	0.00973	140	1037	—	16.4	—	16.4	—	
Rhenium	Re	75	186.207	3180	5650	21.232	137	760	(7+)+0.34	33.4	0.1368	707	1×10^{-7}	3+, 4+, 6+, 7+
Rhodium	Rh	45	102.9055	1960	3727	12.39	134	720	(3+)+0.76	21.6	0.2427	494	1×10^{-7}	3+, 4+, 5+
Rubidium	Rb	37	85.4678	39.5	697	1.532	248	403	(1+)−2.925	2.19	0.36344	69.2	0.0078	1+
Ruthenium	Ru	44	101.07	2310	4119	12.41	134	711	(4+)+0.68	25.5	0.2381	567.8	—	2+, 3+, 4+, 5+
Rutherfordium	Rf	104	[261]	—	—	—	—	—	—	—	—	—	—	—
Samarium	Sm	62	150.36	1072	1800	7.536	180.4	542	(3+)−2.3	8.9	0.1965	191	7×10^{-4}	2+, 3+
Scandium	Sc	21	44.95591	1539	2831	3	162	631	(3+)−2.03	15.77	0.5677	304.8	0.0022	3+
Seaborgium	Sg	106	[266]	—	—	—	—	—	—	—	—	—	—	—
Selenium	Se	34	78.96	221	685	4.79	117	940.7	(2−)− 0.924	5.43	0.3212	26.3	5×10^{-6}	2−, 2+, 4+, 6+
Silicon	Si	14	28.0855	1411	3231	2.336	118	786.5	(4−)−0.143	50.2	0.7121	359	27.2	2+, 4+
Silver	Ag	47	107.8682	961	2195	10.49	144	730.8	(1+)+0.7991	11.65	0.23502	255	8×10^{-6}	1+
Sodium	Na	11	22.989768	97.83	897.4	0.968	186	495.9	(1+)−2.714	2.602	1.228	97.4	2.27	1+
Strontium	Sr	38	87.62	776.9	1382	2.6	215	549.5	(2+)−2.89	7.4308	0.301	137	0.0384	2+
Sulfur	S	16	32.065	115.2	444.7	2.08	103	999.6	(2−)−0.45	1.7272	0.7060	9.62	0.03	2−, 4+, 6+
Tantalum	Ta	73	180.9479	3017	5458	16.65	146	760.8	(5+)−0.81	36.57	0.1402	737	2×10^{-4}	4+, 5+
Technetium	Tc	43	[98]	2157	4265	11.5	136	702	(6+)+0.83	23.0	—	577	—	2+, 4+, 6+, 7+
Tellurium	Te	52	127.60	450	990	6.25	138	869	(2−)−1.14	17.4	0.2016	50.6	2×10^{-7}	2−, 2+, 4+, 6+
Terbium	Tb	65	158.92534	1356	3230	8.272	177.3	564	(3+)−2.31	10.3	0.1819	293	1×10^{-4}	3+, 4+
Thallium	Tl	81	204.3833	303.5	1457	11.85	170	589.1	(1+)−0.3363	4.27	0.1288	162	7×10^{-5}	1+, 3+
Thorium	Th	90	232.0381	1750	4787	11.78	179	587	(4+)−1.83	16.11	0.1177	543.9	8.1×10^{-4}	4+
Thulium	Tm	69	168.93421	1545	1950	9.318	175.9	596	(3+)−2.32	18.4	0.1600	213	5×10^{-5}	
Tin	Sn	50	118.710	232	2623	7.265	141	708.4	(4+)+0.151	7.07	0.2274	296	2.1×10^{-4}	2+, 4+
Titanium	Ti	22	47.867	1666	3358	4.5	147	658.1	(4+)−0.86	14.146	0.5226	425	0.63	2+, 3+, 4+
Tungsten	W	74	183.84	3422	5555	19.3	139	770.4	(6+)−0.09	35.4	0.1320	806	1.2×10^{-4}	4+, 5+, 6+
Ununbium	Uub	112	[285]											
Ununhexium	Uuh	116	[289]											
Ununnilium	Uun	110	[281]											
Ununoctium	Uuo	118	[293]											
Ununquadium	Uuq	114	[289]											
Unununium	Uuu	111	[272]											
Uranium	U	92	238.0289	1130	4131	19.05	156	597	(6+)−0.83	12.6	0.11618	423	2.3×10^{-4}	3+, 4+, 5+, 6+
Vanadium	V	23	50.9415	1917	3417	6.11	134	650.3	(4+)−0.54	22.84	0.4886	459.7	0.0136	2+, 3+, 4+, 5+
Xenon	Xe	54	131.293	−111.8	−108.09	0.0058971	218	1170	—	2.29	0.15832	12.64	—	
Ytterbium	Yb	70	173.04	824	1196	6.973	193.3	603	(3+)−2.22	7.66	0.1545	155	3.4×10^{-4}	2+, 3+
Yttrium	Y	39	88.90585	1530	3264	4.5	180	600	(3+)−2.37	17.15	0.2984	393	0.0035	3+
Zinc	Zn	30	65.39	419.6	907	7.14	134	906.4	(2+)−0.7626	7.322	0.3884	115	0.0076	2+
Zirconium	Zr	40	91.224	1852	4400	6.51	160	640	(4+)−1.7	20.92	0.2780	590.5	0.0162	4+

* [ ] indicates mass of longest-lived isotope.

Table C-7

Electron Configurations of Elements

	Elements	Sublevels																	
		1s	2s	2p	3s	3p	3d	4s	4p	4d	4f	5s	5p	5d	5f	6s	6p	6d	6f	7s
1	Hydrogen	1																		
2	Helium	2																		
3	Lithium	2	1																	
4	Beryllium	2	2																	
5	Boron	2	2	1																
6	Carbon	2	2	2																
7	Nitrogen	2	2	3																
8	Oxygen	2	2	4																
9	Fluorine	2	2	5																
10	Neon	2	2	6																
11	Sodium	2	2	6	1															
12	Magnesium	2	2	6	2															
13	Aluminum	2	2	6	2	1														
14	Silicon	2	2	6	2	2														
15	Phosphorus	2	2	6	2	3														
16	Sulfur	2	2	6	2	4														
17	Chlorine	2	2	6	2	5														
18	Argon	2	2	6	2	6														
19	Potassium	2	2	6	2	6		1												
20	Calcium	2	2	6	2	6		2												
21	Scandium	2	2	6	2	6	1	2												
22	Titanium	2	2	6	2	6	2	2												
23	Vanadium	2	2	6	2	6	3	2												
24	Chromium	2	2	6	2	6	5	1												
25	Manganese	2	2	6	2	6	5	2												
26	Iron	2	2	6	2	6	6	2												
27	Cobalt	2	2	6	2	6	7	2												
28	Nickel	2	2	6	2	6	8	2												
29	Copper	2	2	6	2	6	10	1												
30	Zinc	2	2	6	2	6	10	2												
31	Gallium	2	2	6	2	6	10	2	1											
32	Germanium	2	2	6	2	6	10	2	2											
33	Arsenic	2	2	6	2	6	10	2	3											
34	Selenium	2	2	6	2	6	10	2	4											
35	Bromine	2	2	6	2	6	10	2	5											
36	Krypton	2	2	6	2	6	10	2	6											
37	Rubidium	2	2	6	2	6	10	2	6			1								
38	Strontium	2	2	6	2	6	10	2	6			2								
39	Yttrium	2	2	6	2	6	10	2	6	1		2								
40	Zirconium	2	2	6	2	6	10	2	6	2		2								
41	Niobium	2	2	6	2	6	10	2	6	4		1								
42	Molybdenum	2	2	6	2	6	10	2	6	5		1								
43	Technetium	2	2	6	2	6	10	2	6	5		2								
44	Ruthenium	2	2	6	2	6	10	2	6	7		1								
45	Rhodium	2	2	6	2	6	10	2	6	8		1								
46	Palladium	2	2	6	2	6	10	2	6	10										
47	Silver	2	2	6	2	6	10	2	6	10		1								
48	Cadmium	2	2	6	2	6	10	2	6	10		2								
49	Indium	2	2	6	2	6	10	2	6	10		2	1							
50	Tin	2	2	6	2	6	10	2	6	10		2	2							
51	Antimony	2	2	6	2	6	10	2	6	10		2	3							
52	Tellurium	2	2	6	2	6	10	2	6	10		2	4							
53	Iodine	2	2	6	2	6	10	2	6	10		2	5							
54	Xenon	2	2	6	2	6	10	2	6	10		2	6							

Table C-7

Electron Configurations of Elements (continued)

	Elements	Sublevels																		
		1s	2s	2p	3s	3p	3d	4s	4p	4d	4f	5s	5p	5d	5f	6s	6p	6d	6f	7s	7p
55	Cesium	2	2	6	2	6	10	2	6	10		2	6			1					
56	Barium	2	2	6	2	6	10	2	6	10		2	6			2					
57	Lanthanum	2	2	6	2	6	10	2	6	10		2	6	1		2					
58	Cerium	2	2	6	2	6	10	2	6	10	2	2	6			2					
59	Praseodymium	2	2	6	2	6	10	2	6	10	3	2	6			2					
60	Neodymium	2	2	6	2	6	10	2	6	10	4	2	6			2					
61	Promethium	2	2	6	2	6	10	2	6	10	5	2	6			2					
62	Samarium	2	2	6	2	6	10	2	6	10	6	2	6			2					
63	Europium	2	2	6	2	6	10	2	6	10	7	2	6			2					
64	Gadolinium	2	2	6	2	6	10	2	6	10	7	2	6	1		2					
65	Terbium	2	2	6	2	6	10	2	6	10	9	2	6			2					
66	Dysprosium	2	2	6	2	6	10	2	6	10	10	2	6			2					
67	Holmium	2	2	6	2	6	10	2	6	10	11	2	6			2					
68	Erbium	2	2	6	2	6	10	2	6	10	12	2	6			2					
69	Thulium	2	2	6	2	6	10	2	6	10	13	2	6			2					
70	Ytterbium	2	2	6	2	6	10	2	6	10	14	2	6			2					
71	Lutetium	2	2	6	2	6	10	2	6	10	14	2	6	1		2					
72	Hafnium	2	2	6	2	6	10	2	6	10	14	2	6	2		2					
73	Tantalum	2	2	6	2	6	10	2	6	10	14	2	6	3		2					
74	Tungsten	2	2	6	2	6	10	2	6	10	14	2	6	4		2					
75	Rhenium	2	2	6	2	6	10	2	6	10	14	2	6	5		2					
76	Osmium	2	2	6	2	6	10	2	6	10	14	2	6	6		2					
77	Iridium	2	2	6	2	6	10	2	6	10	14	2	6	7		2					
78	Platinum	2	2	6	2	6	10	2	6	10	14	2	6	9		1					
79	Gold	2	2	6	2	6	10	2	6	10	14	2	6	10		1					
80	Mercury	2	2	6	2	6	10	2	6	10	14	2	6	10		2					
81	Thallium	2	2	6	2	6	10	2	6	10	14	2	6	10		2	1				
82	Lead	2	2	6	2	6	10	2	6	10	14	2	6	10		2	2				
83	Bismuth	2	2	6	2	6	10	2	6	10	14	2	6	10		2	3				
84	Polonium	2	2	6	2	6	10	2	6	10	14	2	6	10		2	4				
85	Astatine	2	2	6	2	6	10	2	6	10	14	2	6	10		2	5				
86	Radon	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6				
87	Francium	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6			1	
88	Radium	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6			2	
89	Actinium	2	2	8	2	6	10	2	6	10	14	2	6	10		2	6	1		2	
90	Thorium	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	2		2	
91	Protactinium	2	2	6	2	6	10	2	6	10	14	2	6	10	2	2	6	1		2	
92	Uranium	2	2	6	2	6	10	2	6	10	14	2	6	10	3	2	6	1		2	
93	Neptunium	2	2	6	2	6	10	2	6	10	14	2	6	10	4	2	6	1		2	
94	Plutonium	2	2	6	2	6	10	2	6	10	14	2	6	10	6	2	6			2	
95	Americium	2	2	6	2	6	10	2	6	10	14	2	6	10	7	2	6			2	
96	Curium	2	2	6	2	6	10	2	6	10	14	2	6	10	7	2	6	1		2	
97	Berkelium	2	2	6	2	6	10	2	6	10	14	2	6	10	9	2	6			2	
98	Californium	2	2	6	2	6	10	2	6	10	14	2	6	10	10	2	6			2	
99	Einsteinium	2	2	6	2	6	10	2	6	10	14	2	6	10	11	2	6			2	
100	Fermium	2	2	6	2	6	10	2	6	10	14	2	6	10	12	2	6			2	
101	Mendelevium	2	2	6	2	6	10	2	6	10	14	2	6	10	13	2	6			2	
102	Nobelium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6			2	
103	Lawrencium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	1		2	
104	Rutherfordium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	2		2?	
105	Dubnium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	3		2?	
106	Seaborgium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	4		2?	
107	Bohrium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	5		2?	
108	Hassium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	6		2?	
109	Meitnerium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	7		2?	
110	Ununnilium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	8		2?	
111	Unununium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	9		2?	
112	Unumbium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	10		2?	
114	Ununquadium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	10		2?	2?
116	Ununhexium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	10		2?	4?
118	Ununodium	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	10		2?	6?

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Table C-8

Names and Charges of Polyatomic Ions

1−	2−	3−	4−
Acetate, CH_3COO^-	Carbonate, CO_3^{2-}	Arsenate, AsO_4^{3-}	Hexacyanoferrate(II), $Fe(CN)_6^{4-}$
Amide, NH_2^-	Chromate, CrO_4^{2-}	Arsenite, AsO_3^{3-}	Orthosilicate, SiO_4^{4-}
Astatate, AtO_3^-	Dichromate, $Cr_2O_7^{2-}$	Borate, BO_3^{3-}	Diphosphate, $P_2O_7^{4-}$
Azide, N_3^-	Hexachloroplatinate, $PtCl_6^{2-}$	Citrate, $C_6H_5O_7^{3-}$	
Benzoate, $C_6H_5COO^-$	Hexafluorosilicate, SiF_6^{2-}	Hexacyanoferrate(III), $Fe(CN)_6^{3-}$	
Bismuthate, BiO_3^-	Molybdate, MoO_4^{2-}	Phosphate, PO_4^{3-}	
Bromate, BrO_3^-	Oxalate, $C_2O_4^{2-}$		
Chlorate, ClO_3^-	Peroxide, O_2^{2-}	**1+**	**2+**
Chlorite, ClO_2^-	Peroxydisulfate, $S_2O_8^{2-}$	Ammonium, NH_4^+	Mercury(I), Hg_2^{2+}
Cyanide, CN^-	Phosphite, HPO_3^{2-}	Neptunyl(V), NpO_2^+	Neptunyl(VI), NpO_2^{2+}
Formate, $HCOO^-$	Ruthenate, RuO_4^{2-}	Plutonyl(V), PuO_2^+	Plutonyl(VI), PuO_2^{2+}
Hydroxide, OH^-	Selenate, SeO_4^{2-}	Uranyl(V), UO_2^+	Uranyl(VI), UO_2^{2+}
Hypobromite, BrO^-	Selenite, SeO_3^{2-}	Vanadyl(V), VO_2^+	Vanadyl(IV), VO^{2+}
Hypochlorite, ClO^-	Silicate, SiO_3^{2-}		
Hypophosphite, $H_2PO_2^-$	Sulfate, SO_4^{2-}		
Iodate, IO_3^-	Sulfite, SO_3^{2-}		
Nitrate, NO_3^-	Tartrate, $C_4H_4O_6^{2-}$		
Nitrite, NO_2^-	Tellurate, TeO_4^{2-}		
Perbromate, BrO_4^-	Tellurite, TeO_3^{2-}		
Perchlorate, ClO_4^-	Tetraborate, $B_4O_7^{2-}$		
Periodate, IO_4^-	Thiosulfate, $S_2O_3^{2-}$		
Permanganate, MnO_4^-	Tungstate, WO_4^{2-}		
Perrhenate, ReO_4^-			
Thiocyanate, SCN^-			
Vanadate, VO_3^-			

Table C-9

Ionization Constants

Substance	Ionization Constant	Substance	Ionization Constant	Substance	Ionization Constant
HCOOH	1.77×10^{-4}	HBO_3^{-2}	1.58×10^{-14}	HS^-	1.00×10^{-19}
CH_3COOH	1.75×10^{-5}	H_2CO_3	4.5×10^{-7}	HSO_4^-	1.02×10^{-2}
$CH_2ClCOOH$	1.36×10^{-3}	HCO_3^-	4.68×10^{-11}	H_2SO_3	1.29×10^{-2}
$CHCl_2COOH$	4.47×10^{-2}	HCN	6.17×10^{-10}	HSO_3^-	6.17×10^{-8}
CCl_3COOH	3.02×10^{-1}	HF	6.3×10^{-4}	$HSeO_4^-$	2.19×10^{-2}
HOOCCOOH	5.36×10^{-2}	HNO_2	5.62×10^{-4}	H_2Se0_3	2.29×10^{-3}
$HOOCCOO^-$	1.55×10^{-4}	H_3PO_4	7.08×10^{-3}	$HSeO_3^-$	4.79×10^{-9}
CH_3CH_2COOH	1.34×10^{-5}	$H_2PO_4^-$	6.31×10^{-8}	HBrO	2.51×10^{-9}
C_6H_5COOH	6.25×10^{-5}	HPO_4^{2-}	4.17×10^{-13}	HClO	2.9×10^{-8}
H_3AsO_4	6.03×10^{-3}	H_3PO_3	5.01×10^{-2}	HIO	3.16×10^{-11}
$H_2AsO_4^-$	1.05×10^{-7}	$H_2PO_3^-$	2.00×10^{-7}	NH_3	5.62×10^{-10}
H_3BO_3	5.75×10^{-10}	H_3PO_2	5.89×10^{-2}	H_2NNH_2	7.94×10^{-9}
$H_2BO_3^-$	1.82×10^{-13}	H_2S	9.1×10^{-8}	H_2NOH	1.15×10^{-6}

Table C-10

Solubility Guidelines

A substance is considered soluble if more than three grams of the substance dissolves in 100 mL of water. The more common rules are listed below.

1. All common salts of the group 1A elements and ammonium ions are soluble.
2. All common acetates and nitrates are soluble.
3. All binary compounds of group 7A elements (other than F) with metals are soluble except those of silver, mercury(I), and lead.
4. All sulfates are soluble except those of barium, strontium, lead, calcium, silver, and mercury(I).
5. Except for those in Rule 1, carbonates, hydroxides, oxides, sulfides, and phosphates are insoluble.

Solubility of Compounds in Water

	Acetate	Bromide	Carbonate	Chlorate	Chloride	Chromate	Hydroxide	Iodide	Nitrate	Oxide	Perchlorate	Phosphate	Sulfate	Sulfide
Aluminum	S	S	—	S	S	—	I	S	S	I	S	I	S	D
Ammonium	S	S	S	S	S	S	S	S	S	—	S	S	S	S
Barium	S	S	P	S	S	I	S	S	S	S	S	I	I	D
Calcium	S	S	P	S	S	S	S	S	S	P	S	P	P	P
Copper (II)	S	S	—	S	S	—	I	—	S	I	S	I	S	I
Hydrogen	S	S	—	S	S	—	—	S	S	S	S	S	S	S
Iron(II)	—	S	P	S	S	—	I	S	S	I	S	I	S	I
Iron(III)	—	S	—	S	S	I	I	S	S	I	S	P	P	D
Lead(II)	S	S	—	S	S	I	P	P	S	P	S	I	P	I
Lithium	S	S	S	S	S	?	S	S	S	S	S	P	S	S
Magnesium	S	S	P	S	S	S	I	S	S	I	S	P	S	D
Manganese(II)	S	S	P	S	S	—	I	S	S	I	S	P	S	I
Mercury(I)	P	I	I	S	I	P	—	I	S	I	S	I	P	I
Mercury(II)	S	S	—	S	S	P	I	P	S	P	S	I	D	I
Potassium	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Silver	P	I	I	S	I	P	—	I	S	P	S	I	P	I
Sodium	S	S	S	S	S	S	S	S	S	D	S	S	S	S
Strontium	S	S	P	S	S	P	S	S	S	S	S	I	P	S
Tin(II)	D	S	—	S	S	I		S	D	I	S	I	S	I
Tin(IV)	S	S	—	—	S	S	I	D	—	I	S	—	S	I
Zinc	S	S	P	S	S	P	P	S	S	P	S	I	S	I

S – soluble P – partially soluble I – insoluble D – decomposes

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Table C-11

Specific Heat Values (J/g·K)

Substance	c	Substance	c	Substance	c
AlF_3	0.8948	Fe_3C	0.5898	$NaVO_3$	1.540
$BaTiO_3$	0.79418	$FeWO_4$	0.37735	$Ni(CO)_4$	1.198
BeO	1.020	HI	0.22795	PbI_2	0.1678
CaC_2	0.9785	K_2CO_3	0.82797	SF_6	0.6660
$CaSO_4$	0.7320	$MgCO_3$	0.8957	SiC	0.6699
CCl_4	0.85651	$Mg(OH)_2$	1.321	SiO_2	0.7395
CH_3OH	2.55	$MgSO_4$	0.8015	$SrCl_2$	0.4769
CH_2OHCH_2OH	2.413	MnS	0.5742	Tb_2O_3	0.3168
CH_3CH_2OH	2.4194	Na_2CO_3	1.0595	$TiCl_4$	0.76535
CdO	0.3382	NaF	1.116	Y_2O_3	0.45397
$CuSO_4 \cdot 5H_2O$	1.12				

Table C-12

Molal Freezing Point Depression and Boiling Point Elevation Constants

Substance	K_{fp} (C°kg/mol)	Freezing Point (°C)	K_{bp} (C°kg/mol)	Boiling Point (°C)
Acetic acid	3.90	16.66	3.22	117.90
Benzene	5.12	5.533	2.53	80.100
Camphor	37.7	178.75	5.611	207.42
Cyclohexane	20.0	6.54	2.75	80.725
Cyclohexanol	39.3	25.15	--	--
Nitrobenzene	6.852	5.76	5.24	210.8
Phenol	7.40	40.90	3.60	181.839
Water	1.86	0.000	0.512	100.000

Table C-13

Heat of Formation Values

ΔH_f° (kJ/mol) (concentration of aqueous solutions is 1*M*)

Substance	ΔH_f°	Substance	ΔH_f°	Substance	ΔH_f°	Substance	ΔH_f°
Ag(s)	0	CsCl(s)	−443.04	H_3PO_4(aq)	−1279.0	NaBr(s)	−361.062
AgCl(s)	−127.068	Cs_2SO_4(s)	−1443.02	H_2S(g)	−20.63	NaCl(s)	−411.153
AgCN(s)	146.0	CuI(s)	−67.8	H_2SO_3(aq)	−608.81	$NaHCO_3$(s)	−950.8
Al_2O_3	−1675.7	CuS(s)	−53.1	H_2SO_4(aq)	−814.0	$NaNO_3$(aq)	−447.48
$BaCl_2$(aq)	−871.95	Cu_2S(s)	−79.5	$HgCl_2$(s)	−224. 3	NaOH(s)	−425.609
$BaSO_4$	−1473.2	$CuSO_4$(s)	−771.36	Hg_2Cl_2(s)	−265.22	Na_2CO_3(s)	−1130.7
BeO(s)	−609.6	F_2(g)	0	Hg_2SO_4(s)	−743.12	Na_2S(aq)	−447.3
$BiCl_3$(s)	−379.1	$FeCl_3$(s)	−399.49	I_2(s)	0	Na_2SO_4(s)	−1387.08
Bi_2S_3(s)	−143.1	FeO(s)	−272.0	K(s)	0	NH_4Cl(s)	−314.4
Br_2	0	FeS(s)	−100.0	KBr(s)	−393.798	O_2(g)	0
CCl_4(l)	−128.2	Fe_2O_3(s)	−824.2	$KMnO_4$(s)	−837.2	P_4O_6(s)	−1640.1
CH_4(g)	−74.81	Fe_3O_4(s)	−1118.4	KOH	−424.764	P_4O_{10}(s)	−2984.0
C_2H_2(g)	226.73	H(g)	217.965	LiBr(s)	−351.213	$PbBr_2$(s)	−278.7
C_2H_4(g)	52.26	H_2(g)	0	LiOH(s)	−484.93	$PbCl_2$(s)	−359.41
C_2H_6(g)	−84.68	HBr(g)	−36.40	Mn(s)	0	SF_6(g)	−1220.5
CO(g)	−110.525	HCl(g)	−92.307	$MnCl_2$(aq)	−555.05	SO_2(g)	−296.830
CO_2(g)	−393.509	HCl(aq)	−167.159	$Mn(NO_3)_2$(aq)	−635.5	SO_3(g)	−454.51
CS_2(l)	89.70	HCN(aq)	108.9	MnO_2(s)	−520.03	SrO(s)	−592.0
Ca(s)	0	HCHO	−108.57	MnS(s)	−214.2	TiO_3(s)	−939.7
$CaCO_3$(s)	−1206.9	HCOOH(l)	−424.72	N_2(g)	0	TlI(s)	−123.5
CaO(s)	−635.1	HF(g)	−271.1	NH_3(g)	−46.11	UCl_4(s)	−1019.2
$Ca(OH)_2$(s)	−986.09	HI(g)	26.48	NH_4Br(s)	−270.83	UCl_5(s)	−1059
Cl_2(g)	0	H_2O(l)	−285.830	NO(g)	90.25	Zn(s)	0
Co_3O_4(s)	−891	H_2O(g)	−241.818	NO_2(g)	33.18	$ZnCl_2$(aq)	−488.19
CoO(s)	−237.94	H_2O_2(l)	−187.8	N_2O(g)	82.05	ZnO(s)	−348.28
Cr_2O_3(s)	−1139.7	H_3PO_4(l)	−595.4	Na(s)	0	$ZnSO_4$(aq)	−1063.15