

Solutions

Solubility of Selected Ionic Compounds in Aqueous Solutions at 25 °C

Ion	H ⁺ , Na ⁺ NH ₄ ⁺ , NO ₃ ⁻ ClO ₃ ⁻ , ClO ₄ ⁻ CH ₃ COO ⁻	F ⁻	Cl ⁻ Br ⁻ I ⁻	SO ₄ ²⁻	PO ₄ ³⁻ SO ₃ ²⁻ CO ₃ ²⁻	IO ₃ ²⁻ OOC ₂ COO ²⁻	S ²⁻	OH ⁻
Solubility greater than or equal to 0.1 mol/L (very soluble) (aq)	most	most	most	most	H ⁺ Na ⁺ K ⁺ NH ₄ ⁺	H ⁺ Na ⁺ K ⁺ NH ₄ ⁺ Li ⁺ Ni ²⁺ Zn ²⁺	H ⁺ Na ⁺ K ⁺ NH ₄ ⁺ Li ⁺ Mg ²⁺ Ca ²⁺	H ⁺ Na ⁺ K ⁺ NH ₄ ⁺ Li ⁺ Sr ²⁺ Ca ²⁺ Ba ²⁺
Solubility less than 0.1 mol/L (slightly soluble) (s)	RbClO ₄ CsClO ₄ AgCH ₃ COO Hg ₂ (CH ₃ COO) ₂	Li ⁺ Mg ²⁺ Ca ²⁺ Sr ²⁺ Ba ²⁺ Fe ²⁺ Hg ₂ ²⁺ Pb ²⁺	Cu ⁺ Ag ⁺ Hg ₂ ²⁺ Hg ²⁺ Pb ²⁺	Ca ²⁺ Sr ²⁺ Ba ²⁺ Hg ₂ ²⁺ Pb ²⁺ Ag ⁺	most Exception: Li ₂ CO ₃ is soluble	most Exceptions: Co(IO ₃) ₂ Fe ₂ (C ₂ O ₄) ₃ are soluble	most	most

Note: This solubility table is only a guideline that is established using the K_{sp} values. A concentration of 0.1 mol/L corresponds to approximately 10 g/L to 30 g/L depending on molar mass.

Acids and Bases

Rules for Naming Acids

Molecular Name	Classical System Example				IUPAC System Example
	Acid Name	Formula	Molecular Name	Acid Name	Acid Name
hydrogen <i>-ide</i>	<i>hydro-ic</i> acid	HCl(aq)	hydrogen <i>chloride</i>	<i>hydrochloric</i> acid	aqueous hydrogen chloride
hydrogen <i>-ate</i>	<i>-ic</i> acid	H ₃ PO ₄ (aq)	hydrogen <i>phosphate</i>	<i>phosphoric</i> acid	aqueous hydrogen phosphate
hydrogen <i>-ite</i>	<i>-ous</i> acid	H ₃ PO ₃ (aq)	hydrogen <i>phosphite</i>	<i>phosphorous</i> acid	aqueous hydrogen phosphite

Stoichiometry

$$n = \frac{m}{M}$$

General Formulas and Data

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\text{percent difference from theoretical value} = \frac{\text{experimental value} - \text{theoretical value}}{\text{theoretical value}} \times 100\%$$

$$\text{percent efficiency} = \left(\frac{\text{output}}{\text{input}} \right) \times 100\%$$

$$\text{magnification} = \left(\text{power of ocular lens} \right) \times \left(\text{power of objective lens} \right)$$

$$M_1 D_1 = M_2 D_2$$

Kinematics

$$\vec{v}_{\text{ave}} = \frac{\Delta \vec{d}}{\Delta t}$$

$$\vec{a}_{\text{ave}} = \frac{\Delta \vec{v}}{\Delta t}$$

Dynamics

$$\vec{a} = \frac{\vec{F}_{\text{net}}}{m}$$

$$\vec{g} = \frac{\vec{F}_g}{m}$$

Energy

$$W = \Delta E$$

$$W = F \Delta d$$

$$E_k = \frac{1}{2} m v^2$$

$$E_p = mgh$$

$$Q = mc \Delta t$$

$$\Delta_{\text{fus}} H = \frac{Q}{n}$$

$$\Delta_{\text{vap}} H = \frac{Q}{n}$$

Selected SI Prefixes

Prefix	Exponential Symbol	Value
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Average acceleration due to gravity on surface of Earth = 9.81 m/s^2

Name	Formula	$\Delta H_{\text{fusion}}^*$ (kJ/mol)	$\Delta H_{\text{vaporization}}^*$ (kJ/mol)	Specific Heat Capacity [†] (J/(g · °C))
ice	$\text{H}_2\text{O}_{(s)}$	6.01	—	2.00
water	$\text{H}_2\text{O}_{(l)}$	—	40.65	4.19
steam	$\text{H}_2\text{O}_{(g)}$	—	—	2.02

1	2	3	4	5	6	7	8	9
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Table of Common Polyatomic Ions

acetate (ethanoate)	CH ₃ COO ⁻	chromate	CrO ₄ ²⁻	phosphate	PO ₄ ³⁻
ammonium	NH ₄ ⁺	dichromate	Cr ₂ O ₇ ²⁻	hydrogen phosphate	HPO ₄ ²⁻
benzoate	C ₆ H ₅ COO ⁻	cyanide	CN ⁻	dihydrogen phosphate	H ₂ PO ₄ ⁻
borate	BO ₃ ³⁻	hydroxide	OH ⁻	silicate	SiO ₃ ²⁻
carbide	C ₂ ²⁻	iodate	IO ₃ ⁻	sulfate	SO ₄ ²⁻
carbonate	CO ₃ ²⁻	nitrate	NO ₃ ⁻	hydrogen sulfate	HSO ₄ ⁻
hydrogen carbonate (bicarbonate)	HCO ₃ ⁻	nitrite	NO ₂ ⁻	sulfite	SO ₃ ²⁻
		oxalate	O ₂ C ₂ O ₂ ²⁻	hydrogen sulfite	HSO ₃ ⁻
perchlorate	ClO ₄ ⁻	hydrogen oxalate	HO ₂ C ₂ O ₂ ⁻	hydrogen sulfide	HS ⁻
chlorate	ClO ₃ ⁻	permanganate	MnO ₄ ⁻	thiocyanate	SCN ⁻
chlorite	ClO ₂ ⁻	peroxide	O ₂ ²⁻	thiosulfate	S ₂ O ₃ ²⁻
hypochlorite	ClO ⁻ or OCl ⁻	persulfide	S ₂ ²⁻		

1 1.01 1+, 1- 2.2 -253 -259 H hydrogen	3 6.94 1+ 1.0 1342 181 Li lithium	4 9.01 2+ 1.6 2467 1287 Be beryllium	11 22.99 1+ 0.9 883 98 Na sodium	12 24.31 2+ 1.3 1090 650 Mg magnesium	19 39.10 1+ 0.8 759 64 K potassium	20 40.08 2+ 1.0 1484 842 Ca calcium	21 44.96 3+ 1.4 2836 1541 Sc scandium	22 47.87 4+, 3+ 1.5 3287 1668 Ti titanium	23 50.94 5+, 4+ 1.6 3407 1910 V vanadium	24 52.00 3+, 2+ 1.7 2671 1907 Cr chromium	25 54.94 2+, 4+ 1.6 2061 1246 Mn manganese	26 55.85 3+, 2+ 1.8 2861 1538 Fe iron	27 58.93 2+, 3+ 1.9 2927 1495 Co cobalt				
37 85.47 1+ 0.8 688 39 Rb rubidium	38 87.62 2+ 1.0 1382 777 Sr strontium	39 88.91 3+ 1.2 3345 1522 Y yttrium	40 91.22 4+ 1.3 4409 1855 Zr zirconium	41 92.91 5+, 3+ 1.6 4744 2477 Nb niobium	42 95.94 6+ 2.2 4639 2623 Mo molybdenum	43 (98) 7+ 2.1 4265 2157 Tc technetium	44 101.07 3+, 4+ 2.2 4150 2334 Ru ruthenium	45 102.91 3+ 2.3 3695 1964 Rh rhodium	55 132.91 1+ 0.8 671 29 Cs cesium	56 137.33 2+ 0.9 1897 727 Ba barium	57-71	72 178.49 4+ 1.3 4603 2233 Hf hafnium	73 180.95 5+ 1.5 5458 3017 Ta tantalum	74 183.84 6+ 1.7 5555 3422 W tungsten	75 186.21 7+ 1.9 5596 3186 Re rhenium	76 190.23 4+ 2.2 5012 3033 Os osmium	77 192.22 4+ 2.2 4428 2446 Ir iridium
87 (223) 1+ 0.7 — 27 Fr francium	88 (226) 2+ 0.9 1737 700 Ra radium	89-103	104 (261) Rf rutherfordium	105 (262) Db dubnium	106 (266) Sg seaborgium	107 (264) Bh bohrium	108 (277) Hs hassium	109 (268) Mt meitnerium									

References

Lide, D.R. 2001. *CRC Handbook of Chemistry and Physics*. 82nd ed. Boca Raton: CRC Press.

Dean, John A. 1999. *Lange's Handbook of Chemistry*. 15th ed. New York: McGraw-Hill, Inc.

IUPAC commission on atomic weights and isotopic abundances. 2002. <http://www.chem.qmw.ac.uk/iupac/AtWt/index.html>.

57 138.91 3+ 1.1 3464 918 La lanthanum	58 140.12 3+ 1.1 3443 798 Ce cerium	59 140.91 3+ 1.1 3520 931 Pr praseodymium	60 144.24 3+ 1.1 3074 1021 Nd neodymium	61 (145) 3+ — 3000 1042 Pm promethium	62 150.36 3+, 2+ 1.2 1794 1074 Sm samarium
89 (227) 3+ 1.1 3198 1051 Ac actinium	90 232.04 4+ 1.3 4788 1750 Th thorium	91 231.04 5+, 4+ 1.5 — 1572 Pa protactinium	92 238.03 6+, 4+ 1.7 4131 1135 U uranium	93 (237) 5+ 1.3 — 644 Np neptunium	94 (244) 4+, 6+ 1.3 3228 640 Pu plutonium

10	11	12	13	14	15	16	17	18
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Legend for Elements

Solid	Liquid	Gas
Natural	Synthetic	

Note: The legend denotes the physical state of the elements at exactly 101.325 kPa and 298.15 K.

Key

Atomic number → 26 55.85
 Electronegativity → 1.8 2861
 Symbol → Fe 1538
 Name → iron

Atomic molar mass (g/mol)*
 Common ion charges (most common first)
 Boiling point (°C)
 Melting point (°C) † (measured at a non-standard pressure)

* Based on $^{12}_6\text{C}$
 () Indicates mass of the most stable isotope

2	4.00
—	—
—	-269
—	-272†
He	
helium	

5	10.81	6	12.01	7	14.01	8	16.00	9	19.00	10	20.18
2.0	4000	2.6	—	3.0	-196	3.4	-183	4.0	-188	—	-246
2075	2075	4489	—	-210	-219	-219	-220	-220	-220	—	-249
B		C		N		O		F		Ne	
boron		carbon		nitrogen		oxygen		fluorine		neon	

13	26.98	14	28.09	15	30.97	16	32.07	17	35.45	18	39.95
1.6	2519	1.9	3265	2.2	281	2.6	445	3.2	-34	—	-186
660	660	1414	—	44	—	115	—	-101	—	—	-189
Al		Si		P		S		Cl		Ar	
aluminium		silicon		phosphorus		sulfur		chlorine		argon	

28	58.69	29	63.55	30	65.39	31	69.72	32	72.64	33	74.92	34	78.96	35	79.90	36	83.80
1.9	2913	1.9	2562	1.7	907	1.8	2204	2.0	2833	2.2	—	2.6	685	3.0	59	—	-153
1455	1455	1085	1085	420	420	30	30	938	938	817	817	221	221	-7	-7	—	-157†
Ni		Cu		Zn		Ga		Ge		As		Se		Br		Kr	
nickel		copper		zinc		gallium		germanium		arsenic		selenium		bromine		krypton	

46	106.42	47	107.87	48	112.41	49	114.82	50	118.71	51	121.76	52	127.60	53	126.90	54	131.29
2.2	2963	1.9	2162	1.7	767	1.8	2072	2.0	2602	2.1	1587	2.1	988	2.7	184	2.6	-108
1555	1555	962	962	321	321	157	157	232	232	631	631	450	450	114	114	—	-112†
Pd		Ag		Cd		In		Sn		Sb		Te		I		Xe	
palladium		silver		cadmium		indium		tin		antimony		tellurium		iodine		xenon	

78	195.08	79	196.97	80	200.59	81	204.38	82	207.21	83	208.98	84	(209)	85	(210)	86	(222)
2.2	3825	2.4	2856	1.9	357	1.8	1473	1.8	1749	1.9	1564	2.0	962	2.2	—	—	-62
1768	1768	1064	1064	-39	-39	304	304	327	327	271	271	254	254	302	302	—	-71
Pt		Au		Hg		Tl		Pb		Bi		Po		At		Rn	
platinum		gold		mercury		thallium		lead		bismuth		polonium		astatine		radon	

110 (281)	111 (272)	112 (285)		114 (289)													
Uun	Uuu	Uub		Uuq													
ununnilium	unununium	ununbium		ununquadium													

63	151.96	64	157.25	65	158.93	66	162.50	67	164.93	68	167.26	69	168.93	70	173.04	71	174.97
—	1529	1.2	3273	—	3230	1.2	2567	1.2	2700	1.2	2868	1.3	1950	—	1196	1.0	3402
822	822	1313	1313	1356	1356	1412	1412	1474	1474	1529	1529	1545	1545	819	819	1663	1663
Eu		Gd		Tb		Dy		Ho		Er		Tm		Yb		Lu	
europium		gadolinium		terbium		dysprosium		holmium		erbium		thulium		ytterbium		lutetium	

95 (243)	96 (247)	97 (247)	98 (251)	99 (252)	100 (257)	101 (258)	102 (259)	103 (262)
—	—	—	—	—	—	—	—	—
2011	3100	3100	—	—	—	—	—	—
1176	1345	1050	900	860	1527	827	827	1627
Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium