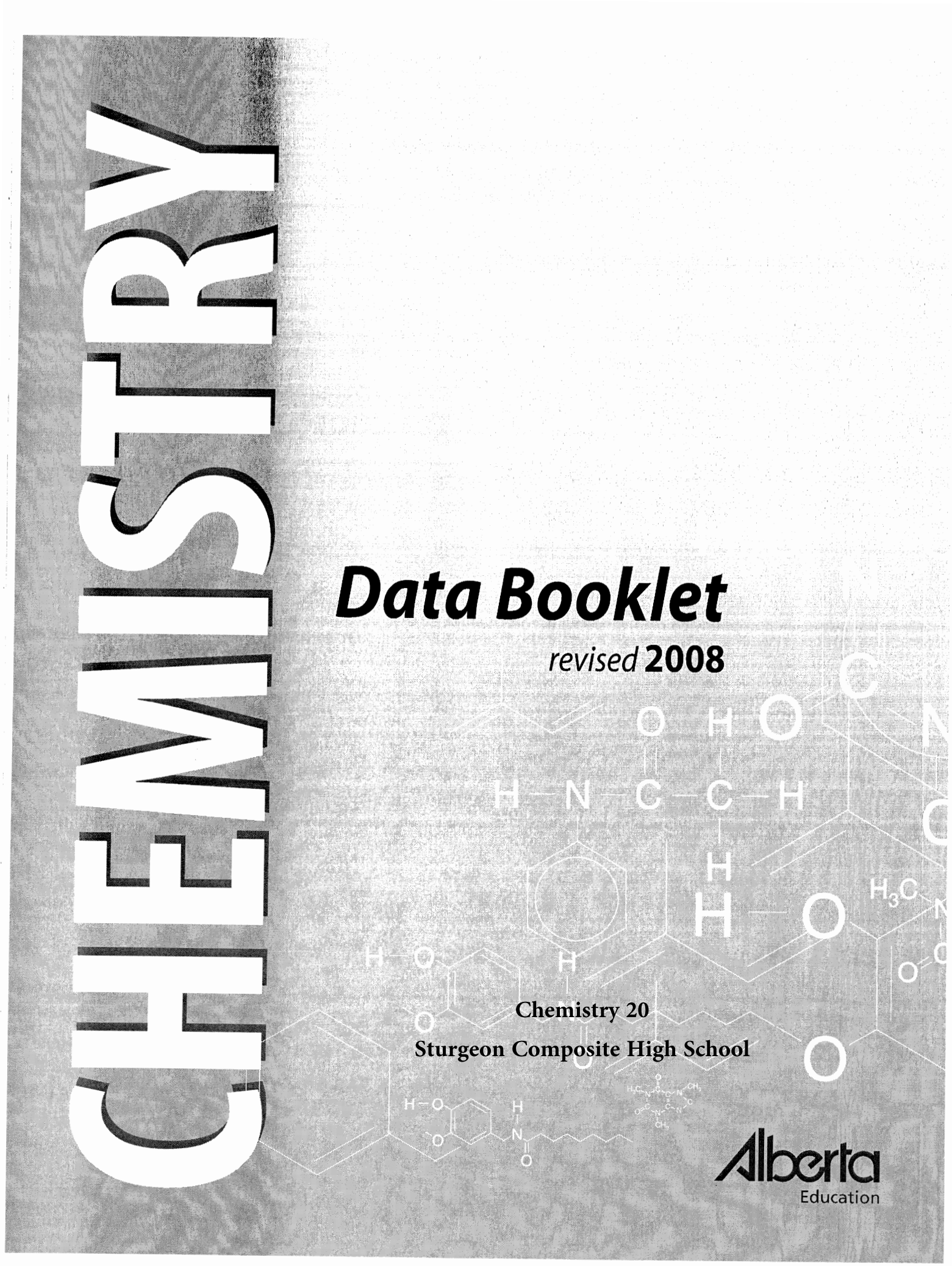
CHEMISTRY

Data Booklet

revised 2008

Chemistry 20

Sturgeon Composite High School



Alberta Education

1	2	3	4	5	6	7	8	9

Table of Common Polyatomic Ions

acetate (ethanoate)	CH_3COO^-	chromate	CrO_4^{2-}	phosphate	PO_4^{3-}
ammonium	NH_4^+	dichromate	$Cr_2O_7^{2-}$	hydrogen phosphate	HPO_4^{2-}
benzoate	$C_6H_5COO^-$	cyanide	CN^-	dihydrogen phosphate	$H_2PO_4^-$
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	$OOCCOO^{2-}$	hydrogen sulfite	HSO_3^-
perchlorate	ClO_4^-	hydrogen oxalate	$HOOCCOO^-$	hydrogen sulfide	HS^-
chlorate	ClO_3^-	permanganate	MnO_4^-	thiocyanate	SCN^-
chlorite	ClO_2^-	peroxide	O_2^{2-}	thiosulfate	$S_2O_3^{2-}$
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

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

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 *commision on atomic weights and isotopic abundances*. 2002. http://www.chem.qmw.ac.uk/iupac/AtWt/index.html.

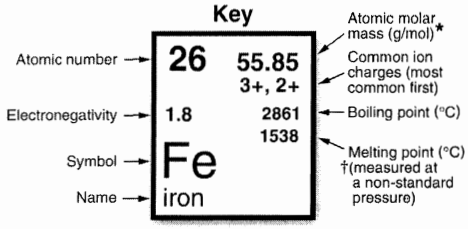
10	11	12	13	14	15	16	17	18

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



* Based on $^{12}_{6}C$
( ) Indicates mass of the most stable isotope

								2 4.00 — — –269 –272† He helium
			5 10.81 — 2.0 4000 2075 B boron	6 12.01 — 2.6 — 4489 C carbon	7 14.01 3– 3.0 –196 –210 N nitrogen	8 16.00 2– 3.4 –183 –219 O oxygen	9 19.00 1– 4.0 –188 –220 F fluorine	10 20.18 — — –246 –249 Ne neon
			13 26.98 3+ 1.6 2519 660 Al aluminium	14 28.09 — 1.9 3265 1414 Si silicon	15 30.97 3– 2.2 281 44 P phosphorus	16 32.07 2– 2.6 445 115 S sulfur	17 35.45 1– 3.2 –34 –101 Cl chlorine	18 39.95 — — –186 –189 Ar argon
28 58.69 2+, 3+ 1.9 2913 1455 Ni nickel	29 63.55 2+, 1+ 1.9 2562 1085 Cu copper	30 65.39 2+ 1.7 907 420 Zn zinc	31 69.72 3+ 1.8 2204 30 Ga gallium	32 72.64 4+ 2.0 2833 938 Ge germanium	33 74.92 3– 2.2 — 817 As arsenic	34 78.96 2– 2.6 685 221 Se selenium	35 79.90 1– 3.0 59 –7 Br bromine	36 83.80 — — –153 –157† Kr krypton
46 106.42 2+, 4+ 2.2 2963 1555 Pd palladium	47 107.87 1+ 1.9 2162 962 Ag silver	48 112.41 2+ 1.7 767 321 Cd cadmium	49 114.82 3+ 1.8 2072 157 In indium	50 118.71 4+, 2+ 2.0 2602 232 Sn tin	51 121.76 3+, 5+ 2.1 1587 631 Sb antimony	52 127.60 2– 2.1 988 450 Te tellurium	53 126.90 1– 2.7 184 114 I iodine	54 131.29 — 2.6 –108 –112† Xe xenon
78 195.08 4+, 2+ 2.2 3825 1768 Pt platinum	79 196.97 3+, 1+ 2.4 2856 1064 Au gold	80 200.59 2+, 1+ 1.9 357 –39 Hg mercury	81 204.38 1+, 3+ 1.8 1473 304 Tl thallium	82 207.21 2+, 4+ 1.8 1749 327 Pb lead	83 208.98 3+, 5+ 1.9 1564 271 Bi bismuth	84 (209) 2+, 4+ 2.0 962 254 Po polonium	85 (210) 1– 2.2 — 302 At astatine	86 (222) — — –62 –71 Rn radon
110 (281) Uun ununnilium	111 (272) Uuu unununium	112 (285) Uub ununbium		114 (289) Uuq ununquadium				

63 151.96 3+, 2+ — 1529 822 Eu europium	64 157.25 3+ 1.2 3273 1313 Gd gadolinium	65 158.93 3+ — 3230 1356 Tb terbium	66 162.50 3+ 1.2 2567 1412 Dy dysprosium	67 164.93 3+ 1.2 2700 1474 Ho holmium	68 167.26 3+ 1.2 2868 1529 Er erbium	69 168.93 3+ 1.3 1950 1545 Tm thulium	70 173.04 3+, 2+ — 1196 819 Yb ytterbium	71 174.97 2+ 1.0 3402 1663 Lu lutetium
95 (243) 3+, 4+ — 2011 1176 Am americium	96 (247) 3+ — 3100 1345 Cm curium	97 (247) 3+, 4+ — — — 1050 Bk berkelium	98 (251) 3+ — — — 900 Cf californium	99 (252) 3+ — — — 860 Es einsteinium	100 (257) 3+ — — — 1527 Fm fermium	101 (258) 2+, 3+ — — — 827 Md mendelevium	102 (259) 2+, 3+ — — — 827 No nobelium	103 (262) 3+ — — — 1627 Lr lawrencium

Chemistry Notation

Symbol	Term	Unit(s)
c	specific heat capacity	J/(g · °C) or J/(g · K)
C	heat capacity	J/°C or J/K
E	electrical potential	V or J/C
E_k	kinetic energy	kJ
E_p	potential energy	kJ
ΔH	enthalpy (heat)	kJ
$\Delta_f H°$	standard molar enthalpy of formation	kJ/mol
I	current	A or C/s
K_c	equilibrium constant	—
K_a	acid ionization (dissociation) constant	—
K_b	base ionization (dissociation) constant	—
M	molar mass	g/mol
m	mass	g
n	amount of substance	mol
P	pressure	kPa
Q	charge	C
T	temperature (absolute)	K
t	temperature (Celsius)	°C
t	time	s
V	volume	L
c	amount concentration	mol/L

Symbol	Term
Δ	delta (change in)
°	standard
[ ]	amount concentration

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}

Miscellaneous

25°C.....	equivalent to 298.15 K
Specific heat capacity..... (at 298.15 K and 100.000 kPa)	c_{air} = 1.01 J/(g • °C) c_{wood} = 1.26 J/(g • °C) c_{glass} = 0.84 J/(g • °C) $c_{Styrofoam}$ = 0.30 J/(g • °C)
Mass of 1.00 mol of dry air.....	m_{air} = 29.18 g
Avogadro constant.....	$N_A = 6.02 \times 10^{23}$ particles/mol
Water autoionization constant..... (Dissociation constant)	$K_w = 1.00 \times 10^{-14}$ at 298.15 K (for ion concentrations in mol/L)
Faraday constant.....	$F = 9.65 \times 10^4$ C/mol
Gas constant	R = 8.314 (L • kPa)/(K • mol)
Ideal gas law.....	$PV = nRT$
Combined gas law	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
Quadratic formula	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
Commonly accepted standards.....	STP = 273.15 K and 101.325 kPa (1 atm) SATP = 298.15 K and 100.000 kPa
Molar Volume	V_{STP} = 22.4 L/mol V_{SATP}= 24.8L/mol
Gas conversions.....	1 atm = 101.325 1 atm = 760 mmHg

$pH = -\log [H_3O^+]$ $[H_3O^+]=10^{-pH}$

Strong Acids

perhloric acid	$HClO_{4(aq)}$
hydroiodic acid	$HI_{(aq)}$
hydrobromic acid	$HBr_{(aq)}$
hydrochloric acid	$HCl_{(aq)}$
sulfuric acid	$H_2SO_{4(aq)}$
nitric acid	$HNO_{3(aq)}$

Solubility of Some Common Ionic Compounds in Water at 298.15 K

Ion	**H^+ Na^+ NH_4^+, NO_3^- ClO_3^-, ClO_4^- CH_3COO^-**	**F^-**	**Cl^- Br^- I^-**	**SO_4^{2-}**	**CO_3^{2-} PO_4^{3-} SO_3^{2-}**	**IO_3^- $OOCCOO^{2-}$**	**S^{2-}**	**OH^-**
Solubility greater than or equal to 0.1 mol/L **(very soluble)**	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)**	$RbClO_4$ $CsClO_4$ $AgCH_3COO$ $Hg_2(CH_3COO)_2$	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_2CO_3 is soluble	most **Exceptions:** $Co(IO_3)_2$ $Fe_2(C_2O_4)_3$ 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.

Flame Colour of Elements

Element	**Symbol**	**Colour**
lithium	Li	red
sodium	Na	yellow
potassium	K	violet
rubidium	Rb	violet
cesium	Cs	violet
calcium	Ca	yellowish red
strontium	Sr	scarlet red
barium	Ba	yellowish green
copper	Cu	blue to green
boron	B	yellowish green
lead	Pb	blue-white

Note: The flame test can be used to determine the identity of a metal or a metal ion. Blue to green indicates a range of colours that might appear.

Acid–Base Indicators at 298.15 K

Indicator	Suggested Abbreviation(s)	pH Range	Colour Change as pH Increases	K_a
methyl violet	HMv(aq) / Mv^-(aq)	0.0 – 1.6	yellow to blue	$\sim 2 \times 10^{-1}$
cresol red	H_2Cr(aq) / HCr^-(aq)	0.0 – 1.0	red to yellow	$\sim 3 \times 10^{-1}$
	HCr^-(aq) / Cr^{2-}(aq)	7.0 – 8.8	yellow to red	3.5×10^{-9}
thymol blue	H_2Tb(aq) / HTb^-(aq)	1.2 – 2.8	red to yellow	2.2×10^{-2}
	HTb^-(aq) / Tb^{2-}(aq)	8.0 – 9.6	yellow to blue	6.3×10^{-10}
orange IV	HOr(aq) / Or^-(aq)	1.4 – 2.8	red to yellow	$\sim 1 \times 10^{-2}$
methyl orange	HMo(aq) / Mo^-(aq)	3.2 – 4.4	red to yellow	3.5×10^{-4}
bromocresol green	HBg(aq) / Bg^-(aq)	3.8 – 5.4	yellow to blue	1.3×10^{-5}
methyl red	HMr(aq) / Mr^-(aq)	4.8 – 6.0	red to yellow	1.0×10^{-5}
chlorophenol red	HCh(aq) / Ch^-(aq)	5.2 – 6.8	yellow to red	5.6×10^{-7}
bromothymol blue	HBb(aq) / Bb^-(aq)	6.0 – 7.6	yellow to blue	5.0×10^{-8}
phenol red	HPr(aq) / Pr^-(aq)	6.6 – 8.0	yellow to red	1.0×10^{-8}
phenolphthalein	HPh(aq) / Ph^-(aq)	8.2 – 10.0	colourless to pink	3.2×10^{-10}
thymolphthalein	HTh(aq) / Th^-(aq)	9.4 – 10.6	colourless to blue	1.0×10^{-10}
alizarin yellow R	HAy(aq) / Ay^-(aq)	10.1 – 12.0	yellow to red	6.9×10^{-12}
indigo carmine	HIc(aq) / Ic^-(aq)	11.4 – 13.0	blue to yellow	$\sim 6 \times 10^{-12}$
1,3,5–trinitrobenzene	HNb(aq) / Nb^-(aq)	12.0 – 14.0	colourless to orange	$\sim 1 \times 10^{-13}$

Colours of Common Aqueous Ions

Ionic Species	Solution Concentration	
	1.0 mol/L	0.010 mol/L
chromate	yellow	pale yellow
chromium(III)	blue-green	green
chromium(II)	dark blue	pale blue
cobalt(II)	red	pink
copper(I)	blue-green	pale blue-green
copper(II)	blue	pale blue
dichromate	orange	pale orange
iron(II)	lime green	colourless
iron(III)	orange-yellow	pale yellow
manganese(II)	pale pink	colourless
nickel(II)	blue-green	pale blue-green
permanganate	deep purple	purple-pink

Notes: