

## Chemistry

## FORMULAE SHEET

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

$$q = mc\Delta T$$

$$pK_a = -\log_{10}[K_a]$$

$$c = \frac{n}{V}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$A = \epsilon lc = \log_{10} \frac{I_0}{I}$$

$$PV = nRT$$

$$\text{pH} = -\log_{10}[\text{H}^+]$$

Avogadro constant, $N_A$ .....	$6.022 \times 10^{23} \text{ mol}^{-1}$
Volume of 1 mole ideal gas: at 100 kPa and	
at 0°C (273.15 K) .....	22.71 L
at 25°C (298.15 K) .....	24.79 L
Gas constant .....	$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
Ionisation constant for water at 25°C (298.15 K), $K_w$ .....	$1.0 \times 10^{-14}$
Specific heat capacity of water .....	$4.18 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$

## DATA SHEET


## Solubility constants at 25°C

<i>Compound</i>	$K_{sp}$	<i>Compound</i>	$K_{sp}$
Barium carbonate	$2.58 \times 10^{-9}$	Lead(II) bromide	$6.60 \times 10^{-6}$
Barium hydroxide	$2.55 \times 10^{-4}$	Lead(II) chloride	$1.70 \times 10^{-5}$
Barium phosphate	$1.3 \times 10^{-29}$	Lead(II) iodide	$9.8 \times 10^{-9}$
Barium sulfate	$1.08 \times 10^{-10}$	Lead(II) carbonate	$7.40 \times 10^{-14}$
Calcium carbonate	$3.36 \times 10^{-9}$	Lead(II) hydroxide	$1.43 \times 10^{-15}$
Calcium hydroxide	$5.02 \times 10^{-6}$	Lead(II) phosphate	$8.0 \times 10^{-43}$
Calcium phosphate	$2.07 \times 10^{-29}$	Lead(II) sulfate	$2.53 \times 10^{-8}$
Calcium sulfate	$4.93 \times 10^{-5}$	Magnesium carbonate	$6.82 \times 10^{-6}$
Copper(II) carbonate	$1.4 \times 10^{-10}$	Magnesium hydroxide	$5.61 \times 10^{-12}$
Copper(II) hydroxide	$2.2 \times 10^{-20}$	Magnesium phosphate	$1.04 \times 10^{-24}$
Copper(II) phosphate	$1.40 \times 10^{-37}$	Silver bromide	$5.35 \times 10^{-13}$
Iron(II) carbonate	$3.13 \times 10^{-11}$	Silver chloride	$1.77 \times 10^{-10}$
Iron(II) hydroxide	$4.87 \times 10^{-17}$	Silver carbonate	$8.46 \times 10^{-12}$
Iron(III) hydroxide	$2.79 \times 10^{-39}$	Silver hydroxide	$2.0 \times 10^{-8}$
Iron(III) phosphate	$9.91 \times 10^{-16}$	Silver iodide	$8.52 \times 10^{-17}$
		Silver phosphate	$8.89 \times 10^{-17}$
		Silver sulfate	$1.20 \times 10^{-5}$

### Infrared absorption data

Bond	Wavenumber/cm <sup>-1</sup>
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550 (broad)
C—H	2850–3300
O—H (acids)	2500–3000 (very broad)
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

### <sup>13</sup>C NMR chemical shift data

Type of carbon	δ/ppm
$\begin{array}{c}   \quad   \\ - C - C - \\   \quad   \end{array}$	5–40
$\begin{array}{c}   \\ R - C - Cl \text{ or } Br \\   \end{array}$	10–70
$\begin{array}{c}   \\ R - C - C - \\    \quad   \\ O \end{array}$	20–50
$\begin{array}{c}   \quad / \\ R - C - N \\   \quad \backslash \end{array}$	25–60
$\begin{array}{c}   \\ - C - O - \\   \end{array}$	alcohols, ethers or esters
$\begin{array}{c} \backslash \quad / \\ C = C \\ / \quad \backslash \end{array}$	50–90
R—C≡N	90–150
	110–125
$\begin{array}{c} R - C - \\    \\ O \end{array}$	esters or acids
$\begin{array}{c} R - C - \\    \\ O \end{array}$	aldehydes or ketones
	160–185
	190–220

### UV absorption

(This is not a definitive list and is approximate.)

Chromophore	λ <sub>max</sub> (nm)
C—H	122
C—C	135
C=C	162

Chromophore	λ <sub>max</sub> (nm)
C≡C	173 178 196 222
C—Cl	173
C—Br	208

### Some standard potentials

$\text{K}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{K}(s)$	-2.94 V
$\text{Ba}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ba}(s)$	-2.91 V
$\text{Ca}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ca}(s)$	-2.87 V
$\text{Na}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Na}(s)$	-2.71 V
$\text{Mg}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Mg}(s)$	-2.36 V
$\text{Al}^{3+} + 3\text{e}^-$	$\rightleftharpoons$	$\text{Al}(s)$	-1.68 V
$\text{Mn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Mn}(s)$	-1.18 V
$\text{H}_2\text{O} + \text{e}^-$	$\rightleftharpoons$	$\frac{1}{2}\text{H}_2(g) + \text{OH}^-$	-0.83 V
$\text{Zn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Zn}(s)$	-0.76 V
$\text{Fe}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Fe}(s)$	-0.44 V
$\text{Ni}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ni}(s)$	-0.24 V
$\text{Sn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Sn}(s)$	-0.14 V
$\text{Pb}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Pb}(s)$	-0.13 V
$\text{H}^+ + \text{e}^-$	$\rightleftharpoons$	$\frac{1}{2}\text{H}_2(g)$	0.00 V
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$	$\text{SO}_2(aq) + 2\text{H}_2\text{O}$	0.16 V
$\text{Cu}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Cu}(s)$	0.34 V
$\frac{1}{2}\text{O}_2(g) + \text{H}_2\text{O} + 2\text{e}^-$	$\rightleftharpoons$	$2\text{OH}^-$	0.40 V
$\text{Cu}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Cu}(s)$	0.52 V
$\frac{1}{2}\text{I}_2(s) + \text{e}^-$	$\rightleftharpoons$	$\text{I}^-$	0.54 V
$\frac{1}{2}\text{I}_2(aq) + \text{e}^-$	$\rightleftharpoons$	$\text{I}^-$	0.62 V
$\text{Fe}^{3+} + \text{e}^-$	$\rightleftharpoons$	$\text{Fe}^{2+}$	0.77 V
$\text{Ag}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Ag}(s)$	0.80 V
$\frac{1}{2}\text{Br}_2(l) + \text{e}^-$	$\rightleftharpoons$	$\text{Br}^-$	1.08 V
$\frac{1}{2}\text{Br}_2(aq) + \text{e}^-$	$\rightleftharpoons$	$\text{Br}^-$	1.10 V
$\frac{1}{2}\text{O}_2(g) + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$	$\text{H}_2\text{O}$	1.23 V
$\frac{1}{2}\text{Cl}_2(g) + \text{e}^-$	$\rightleftharpoons$	$\text{Cl}^-$	1.36 V
$\frac{1}{2}\text{Cr}_2\text{O}_7^{2-} + 7\text{H}^+ + 3\text{e}^-$	$\rightleftharpoons$	$\text{Cr}^{3+} + \frac{7}{2}\text{H}_2\text{O}$	1.36 V
$\frac{1}{2}\text{Cl}_2(aq) + \text{e}^-$	$\rightleftharpoons$	$\text{Cl}^-$	1.40 V
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$	$\rightleftharpoons$	$\text{Mn}^{2+} + 4\text{H}_2\text{O}$	1.51 V
$\frac{1}{2}\text{F}_2(g) + \text{e}^-$	$\rightleftharpoons$	$\text{F}^-$	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for the standard potentials. Some data may have been modified for examination purposes.

# PERIODIC TABLE OF THE ELEMENTS

1 H 1.008 Hydrogen		4 Be 9.012 Beryllium		12 Mg 24.31 Magnesium		20 Ca 40.08 Calcium		38 Sr 87.61 Strontium		56 Ba 137.3 Barium		88 Ra Radium		2 He 4.003 Helium																												
3 Li 6.941 Lithium		11 Na 22.99 Sodium		19 K 39.10 Potassium		37 Rb 85.47 Rubidium		55 Cs 132.9 Caesium		87 Fr Francium		5 B 10.81 Boron		13 Al 26.98 Aluminium																												
6 C 12.01 Carbon		14 Si 28.09 Silicon		32 Ge 72.64 Germanium		50 Sn 118.7 Tin		82 Pb 207.2 Lead		114 Fl Flerovium		6 C 12.01 Carbon		14 Si 28.09 Silicon																												
7 N 14.01 Nitrogen		15 P 30.97 Phosphorus		33 As 74.92 Arsenic		51 Sb 121.8 Antimony		83 Bi 209.0 Bismuth		115 Mc Moscovium		7 N 14.01 Nitrogen		15 P 30.97 Phosphorus																												
8 O 16.00 Oxygen		16 S 32.07 Sulfur		34 Se 78.96 Selenium		52 Te 127.6 Tellurium		84 Po Polonium		116 Lv Livermorium		8 O 16.00 Oxygen		16 S 32.07 Sulfur																												
9 F 19.00 Fluorine		17 Cl 35.45 Chlorine		35 Br 79.90 Bromine		53 I 126.9 Iodine		85 At Astatine		117 Ts Tennessine		9 F 19.00 Fluorine		17 Cl 35.45 Chlorine																												
10 Ne 20.18 Neon		18 Ar 39.95 Argon		36 Kr 83.80 Krypton		54 Xe 131.3 Xenon		86 Rn Radon		118 Og Oganesson		10 Ne 20.18 Neon		18 Ar 39.95 Argon																												
													<b>KEY</b>																													
													Atomic Number Symbol		79 Au Gold																											
													Standard Atomic Weight Name		197.0 Gold																											
													25 Mn Manganese		26 Fe Iron		27 Co Cobalt		28 Ni Nickel		29 Cu Copper		30 Zn Zinc																			
													43 Tc Technetium		44 Ru Ruthenium		45 Rh Rhodium		46 Pd Palladium		47 Ag Silver		48 Cd Cadmium																			
													75 Re Rhenium		76 Os Osmium		77 Ir Iridium		78 Pt Platinum		79 Au Gold		80 Hg Mercury																			
													107 Bh Bohrium		108 Hs Hassium		109 Mt Meitnerium		110 Ds Darmstadtium		111 Rg Roentgenium		112 Cn Copernicium																			
													24 Cr Chromium		25 Mn Manganese		26 Fe Iron		27 Co Cobalt		28 Ni Nickel		29 Cu Copper		30 Zn Zinc																	
													42 Mo Molybdenum		43 Tc Technetium		44 Ru Ruthenium		45 Rh Rhodium		46 Pd Palladium		47 Ag Silver		48 Cd Cadmium																	
													74 W Tungsten		75 Re Rhenium		76 Os Osmium		77 Ir Iridium		78 Pt Platinum		79 Au Gold		80 Hg Mercury																	
													106 Sg Seaborgium		107 Bh Bohrium		108 Hs Hassium		109 Mt Meitnerium		110 Ds Darmstadtium		111 Rg Roentgenium		112 Cn Copernicium																	
													22 Ti Titanium		23 V Vanadium		24 Cr Chromium		25 Mn Manganese		26 Fe Iron		27 Co Cobalt		28 Ni Nickel		29 Cu Copper															
													40 Zr Zirconium		41 Nb Niobium		42 Mo Molybdenum		43 Tc Technetium		44 Ru Ruthenium		45 Rh Rhodium		46 Pd Palladium		47 Ag Silver															
													72 Hf Hafnium		73 Ta Tantalum		74 W Tungsten		75 Re Rhenium		76 Os Osmium		77 Ir Iridium		78 Pt Platinum		79 Au Gold															
													104 Rf Rutherfordium		105 Db Dubnium		106 Sg Seaborgium		107 Bh Bohrium		108 Hs Hassium		109 Mt Meitnerium		110 Ds Darmstadtium		111 Rg Roentgenium															
													Actinoids		Rutherfordium		Seaborgium		Bohrium		Hassium		Meitnerium		Darmstadtium		Roentgenium		Copernicium													
													57-71 Lanthanoids		89-103 Actinoids		Rutherfordium		Seaborgium		Bohrium		Hassium		Meitnerium		Darmstadtium		Roentgenium		Copernicium											
													57 La 138.9 Lanthanum		58 Ce 140.1 Cerium		59 Pr 140.9 Praseodymium		60 Nd 144.2 Neodymium		61 Pm Promethium		62 Sm 150.4 Samarium		63 Eu 152.0 Europium		64 Gd 157.3 Gadolinium		65 Tb 158.9 Terbium		66 Dy 162.5 Dysprosium		67 Ho 164.9 Holmium		68 Er 167.3 Erbium		69 Tm 168.9 Thulium		70 Yb 173.1 Ytterbium		71 Lu 175.0 Lutetium	
													89 Ac Actinium		90 Th 232.0 Thorium		91 Pa 231.0 Protactinium		92 U 238.0 Uranium		93 Np Neptunium		94 Pu Plutonium		95 Am Americium		96 Cm Curium		97 Bk Berkelium		98 Cf Californium		99 Es Einsteinium		100 Fm Fermium		101 Md Mendelevium		102 No Nobelium		103 Lr Lawrencium	

## Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium
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## Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium
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Standard atomic weights are abridged to four significant figures. Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version). The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.