

## 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


Compound	$K_{sp}$	Compound	$K_{sp}$
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	$1.20 \times 10^{-5}$

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

### 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
$\begin{array}{c} \backslash \quad / \\ C = C \\ / \quad \backslash \end{array}$	90–150
R—C≡N	110–125
	110–160
$\begin{array}{c} R - C - \\    \\ O \end{array}$	esters or acids
$\begin{array}{c} R - C - \\    \\ O \end{array}$	aldehydes or ketones

### 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

# 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	
													61 Pm Promethium		62 Sm Samarium		63 Eu Europium		64 Gd Gadolinium		65 Tb Terbium		66 Dy Dysprosium	
													93 Np Neptunium		94 Pu Plutonium		95 Am Americium		96 Cm Curium		97 Bk Berkelium		98 Cf Californium	
													92 U Uranium		93 Np Neptunium		94 Pu Plutonium		95 Am Americium		96 Cm Curium		97 Bk Berkelium	
													238.0 Uranium		238.0 Uranium		238.0 Uranium		238.0 Uranium		238.0 Uranium		238.0 Uranium	
													58 Ce Cerium		59 Pr Praseodymium		60 Nd Neodymium		61 Pm Promethium		62 Sm Samarium		63 Eu Europium	
													140.1 Cerium		140.9 Praseodymium		144.2 Neodymium		152.0 Europium		157.3 Gadolinium		158.9 Terbium	
													89 Ac Actinium		90 Th Thorium		91 Pa Protactinium		92 U Uranium		93 Np Neptunium		94 Pu Plutonium	
													232.0 Thorium		231.0 Protactinium		238.0 Uranium		238.0 Uranium		238.0 Uranium		238.0 Uranium	
													138.9 Lanthanum		140.9 Praseodymium		144.2 Neodymium		152.0 Europium		157.3 Gadolinium		158.9 Terbium	
													57 La Lanthanum		58 Ce Cerium		59 Pr Praseodymium		60 Nd Neodymium		61 Pm Promethium		62 Sm Samarium	
													138.9 Lanthanum		140.9 Praseodymium		144.2 Neodymium		152.0 Europium		157.3 Gadolinium		158.9 Terbium	
													89 Ac Actinium		90 Th Thorium		91 Pa Protactinium		92 U Uranium		93 Np Neptunium		94 Pu Plutonium	
													232.0 Thorium		231.0 Protactinium		238.0 Uranium		238.0 Uranium		238.0 Uranium		238.0 Uranium	
													138.9 Lanthanum		140.9 Praseodymium		144.2 Neodymium		152.0 Europium		157.3 Gadolinium		158.9 Terbium	
													57 La Lanthanum		58 Ce Cerium		59 Pr Praseodymium		60 Nd Neodymium		61 Pm Promethium		62 Sm Samarium	
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													232.0 Thorium		231.0 Protactinium		238.0 Uranium		238.0 Uranium		238.0 Uranium		238.0 Uranium	
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