



CHEMISTRY ATAR COURSE DATA BOOKLET 2017

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This document is valid for teaching and examining until 31 December 2017.

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Periodic table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
¹ H hydrogen 1.008																	² He helium 4.003
³ Li lithium 6.968	⁴ Be beryllium 9.012															⁹ F fluorine 19.00	
¹¹ Na sodium 22.99	¹² Mg magnesium 24.31															¹⁷ Cl chlorine 35.45	
¹⁹ K potassium 39.10	²⁰ Ca calcium 40.08	²¹ Sc scandium 44.96	²² Ti titanium 47.88	²³ V vanadium 50.94	²⁴ Cr chromium 52.00	²⁵ Mn manganese 54.94	²⁶ Fe iron 55.85	²⁷ Co cobalt 58.93	²⁸ Ni nickel 58.69	²⁹ Cu copper 63.55	³⁰ Zn zinc 65.38	³¹ Ga gallium 69.72	³² Ge germanium 72.59	³³ As arsenic 74.92	³⁴ Se selenium 78.96	³⁵ Br bromine 79.90	³⁶ Kr krypton 83.80
³⁷ Rb rubidium 85.47	³⁸ Sr strontium 87.62	³⁹ Y yttrium 88.91	⁴⁰ Zr zirconium 91.22	⁴¹ Nb niobium 92.91	⁴² Mo molybdenum 95.94	⁴³ Tc technetium	⁴⁴ Ru ruthenium 101.1	⁴⁵ Rh rhodium 102.9	⁴⁶ Pd palladium 106.4	⁴⁷ Ag silver 107.9	⁴⁸ Cd cadmium 112.4	⁴⁹ In indium 114.8	⁵⁰ Sn tin 118.7	⁵¹ Sb antimony 121.8	⁵² Te tellurium 127.6	⁵³ I iodine 126.9	⁵⁴ Xe xenon 131.3
⁵⁵ Cs caesium 132.9	⁵⁶ Ba barium 137.3	^{57–71} *La lanthanum 138.9	⁷² Hf hafnium 178.5	⁷³ Ta tantalum 180.9	⁷⁴ W tungsten 183.9	⁷⁵ Re rhenium 186.2	⁷⁶ Os osmium 190.2	⁷⁷ Ir iridium 192.2	⁷⁸ Pt platinum 195.1	⁷⁹ Au gold 197.0	⁸⁰ Hg mercury 200.6	⁸¹ Tl thallium 204.4	⁸² Pb lead 207.2	⁸³ Bi bismuth 209.0	⁸⁴ Po polonium	⁸⁵ At astatine	⁸⁶ Rn radon
⁸⁷ Fr francium	⁸⁸ Ra radium 226.0	^{89–103} **Ac actinium	¹⁰⁴ Rf rutherfordium	¹⁰⁵ Db dubnium	¹⁰⁶ Sg seaborgium	¹⁰⁷ Bh bohrium	¹⁰⁸ Hs hassium	¹⁰⁹ Mt meitnerium	¹¹⁰ Ds darmstadtium	¹¹¹ Rg roentgenium	¹¹² Cn copernicium	¹¹³ Uut ununtrium	¹¹⁴ Fle flerovium	¹¹⁵ Uup ununpentium	¹¹⁶ Lv livermorium	¹¹⁷ Uus ununseptium	¹¹⁸ Uuo ununoctium

Key:

Atomic number
Symbol Name
Standard
atomic weight

* Lanthanide series	⁵⁸ Ce cerium 140.1	⁵⁹ Pr praseodymium 140.9	⁶⁰ Nd neodymium 144.2	⁶¹ Pm promethium	⁶² Sm samarium 150.4	⁶³ Eu europium 152.0	⁶⁴ Gd gadolinium 157.3	⁶⁵ Tb terbium 158.9	⁶⁶ Dy dysprosium 162.5	⁶⁷ Ho holmium 164.9	⁶⁸ Er erbium 167.3	⁶⁹ Tm thulium 168.9	⁷⁰ Yb ytterbium 173.0	⁷¹ Lu lutetium 175.0
** Actinide series	⁹⁰ Th thorium 232.0	⁹¹ Pa protactinium	⁹² U uranium 238.0	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

[Data source: The International Union of Pure and Applied Chemistry Periodic Table of the Elements (2016)]

Formulae

Number of moles	n	$= \frac{m}{M} = \frac{\text{mass}}{\text{molar mass}}$
Number of moles of solute	n	$= cV$
Number of moles of a gas at STP	n	$= \frac{V}{22.71}$
Ideal gas law	PV	$= nRT$
Parts per million	ppm	$= \frac{\text{mass of solute (mg)}}{\text{mass of solution (kg)}}$
pH of a solution	pH	$= -\log [\text{H}^+]$

Units

Volumes are given in the units of litres (L), or millilitres (mL)

Temperatures are given in the units of degrees Celsius (°C) or kelvin (K)

It may be assumed that 0.0 °C = 273.15 K

Energy changes are given in kilojoules (kJ)

Pressures are given in kilopascals (kPa)

Solution concentrations are given in the units moles per litre (mol L⁻¹), grams per litre (g L⁻¹) or parts per million (ppm)

Constants

Universal gas constant, R = 8.314 J K⁻¹ mol⁻¹

Avogadro constant, N = 6.022 × 10²³ mol⁻¹

Volume of 1.00 mol of an ideal gas at 0.0 °C and 100.0 kPa is 22.71 L

S.T.P. is 0.0 °C and 100.0 kPa

Equilibrium constant for water at 25 °C, K_w = 1.00 × 10⁻¹⁴

Solubility rules for ionic solids in water

Soluble in water

Soluble	Exceptions	
	Insoluble	Slightly soluble
Most chlorides	AgCl	PbCl ₂
Most bromides	AgBr	PbBr ₂
Most iodides	AgI, PbI ₂	
All nitrates	No exceptions	
All ethanoates		
Most sulfates	SrSO ₄ , BaSO ₄ , PbSO ₄	CaSO ₄ , Ag ₂ SO ₄

Insoluble in water

Insoluble	Exceptions	
	Soluble	Slightly soluble
Most hydroxides	NaOH, KOH, Ba(OH) ₂ NH ₄ OH*, AgOH**	Ca(OH) ₂ , Sr(OH) ₂
Most carbonates	Na ₂ CO ₃ , K ₂ CO ₃ , (NH ₄) ₂ CO ₃	
Most phosphates	Na ₃ PO ₄ , K ₃ PO ₄ , (NH ₄) ₃ PO ₄	
Most sulfides	Na ₂ S, K ₂ S, (NH ₄) ₂ S	

* NH₃ dissolves in water to form both NH₃ (aq) and NH₄⁺(aq)/OH⁻(aq)

** Ag⁺(aq) reacts with OH⁻(aq) to form insoluble Ag₂O

Soluble = more than 0.1 mole dissolves per litre

Slightly soluble = between 0.01 and 0.1 mole dissolves per litre

Insoluble = less than 0.01 mole dissolves per litre

Colours of selected substances

In general, ionic solids have the same colour as that of any coloured ion they contain. Two colourless ions in general produce a white solid. Selected exceptions to these two basic rules are noted below.

Ionic Solid	Colour
copper(II) carbonate	green
copper(II) chloride	green
copper(II) oxide	black
copper(II) sulfide	black
lead(II) iodide	yellow
lead(II) sulfide	grey
manganese(IV) oxide	black
silver carbonate	yellow
silver iodide	pale yellow
silver oxide	brown
silver sulfide	black

Other coloured substances

Most gases and liquids are colourless, and most metals are silvery or grey. Selected exceptions to these basic rules are noted below.

Substance	Colour
copper(s)	salmon pink
gold(s)	yellow
nitrogen dioxide(g)	brown
sulfur(s)	yellow

Coloured halogens

Halogen	Colour of free element
$F_2(g)$	yellow
$Cl_2(g)$	greenish-yellow
$Br_2(l)$	red
$I_2(g)$	purple

Halogen	Colour of halogen in aqueous solution
$Cl_2(aq)$	pale yellow
$Br_2(aq)$	orange
$I_2(aq)$	brown

Halogen	Colour of halogen in organic solvent
Br_2	red
I_2	purple

Coloured ions in aqueous solution

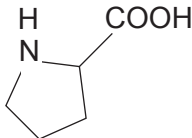
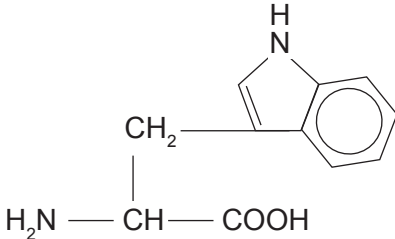
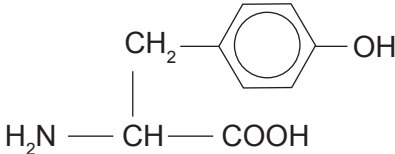
Cation	Colour
Cr^{3+}	deep green
Co^{2+}	pink
Cu^{2+}	blue
Fe^{2+}	pale green
Fe^{3+}	pale brown
Mn^{2+}	pale pink
Ni^{2+}	green

Anion	Colour
CrO_4^{2-}	yellow
$Cr_2O_7^{2-}$	orange
MnO_4^-	purple

α -amino acids

Name	Symbol	Structure
alanine	Ala	$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
arginine	Arg	$\begin{array}{c} \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{NH} - \text{C}(=\text{NH}) - \text{NH}_2 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
asparagine	Asn	$\begin{array}{c} \text{O} \\ \\ \text{CH}_2 - \text{C} - \text{NH}_2 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
aspartic acid	Asp	$\begin{array}{c} \text{CH}_2 - \text{COOH} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
cysteine	Cys	$\begin{array}{c} \text{CH}_2 - \text{SH} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
glutamine	Gln	$\begin{array}{c} \text{O} \\ \\ \text{CH}_2 - \text{CH}_2 - \text{C} - \text{NH}_2 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
glutamic acid	Glu	$\begin{array}{c} \text{CH}_2 - \text{CH}_2 - \text{COOH} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
glycine	Gly	$\text{H}_2\text{N} - \text{CH}_2 - \text{COOH}$
histidine	His	$\begin{array}{c} \text{CH}_2 - \text{C}_4\text{H}_3\text{N}_2 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
isoleucine	Ile	$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH}_3 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$

α -amino acids

Name	Symbol	Structure
leucine	Leu	$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_3 \\ \\ \text{CH}_2 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
lysine	Lys	$\begin{array}{c} \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{NH}_2 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
methionine	Met	$\begin{array}{c} \text{CH}_2 - \text{CH}_2 - \text{S} - \text{CH}_3 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
phenylalanine	Phe	$\begin{array}{c} \text{CH}_2 - \text{C}_6\text{H}_5 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
proline	Pro	
serine	Ser	$\begin{array}{c} \text{CH}_2 - \text{OH} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
threonine	Thr	$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{OH} \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$
tryptophan	Trp	
tyrosine	Tyr	
valine	Val	$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_3 \\ \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$

Standard Reduction Potentials at 25 °C

Half-reaction	E°(volts)
$\text{F}_2(\text{g}) + 2 \text{e}^- \rightleftharpoons 2 \text{F}^-(\text{aq})$	+ 2.89
$\text{H}_2\text{O}_2(\text{aq}) + 2 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons 2 \text{H}_2\text{O}(\ell)$	+ 1.76
$\text{PbO}_2(\text{s}) + \text{SO}_4^{2-}(\text{aq}) + 4 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{PbSO}_4(\text{s}) + 2 \text{H}_2\text{O}(\ell)$	+ 1.69
$2 \text{HClO}(\text{aq}) + 2 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Cl}_2(\text{g}) + 2 \text{H}_2\text{O}(\ell)$	+ 1.63
$\text{MnO}_4^-(\text{aq}) + 8 \text{H}^+(\text{aq}) + 5 \text{e}^- \rightleftharpoons \text{Mn}^{2+}(\text{aq}) + 4 \text{H}_2\text{O}(\ell)$	+ 1.51
$\text{Au}^{3+}(\text{aq}) + 3 \text{e}^- \rightleftharpoons \text{Au}(\text{s})$	+ 1.50
$\text{HClO}(\text{aq}) + \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Cl}^-(\text{aq}) + \text{H}_2\text{O}(\ell)$	+ 1.49
$\text{PbO}_2(\text{s}) + 4 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Pb}^{2+}(\text{aq}) + 2 \text{H}_2\text{O}(\ell)$	+ 1.46
$\text{Cl}_2(\text{g}) + 2 \text{e}^- \rightleftharpoons 2 \text{Cl}^-(\text{aq})$	+ 1.36
$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14 \text{H}^+(\text{aq}) + 6 \text{e}^- \rightleftharpoons 2 \text{Cr}^{3+}(\text{aq}) + 7 \text{H}_2\text{O}(\ell)$	+ 1.36
$\text{O}_2(\text{g}) + 4 \text{H}^+(\text{aq}) + 4 \text{e}^- \rightleftharpoons 2 \text{H}_2\text{O}(\ell)$	+ 1.23
$\text{Br}_2(\ell) + 2 \text{e}^- \rightleftharpoons 2 \text{Br}^-(\text{aq})$	+ 1.08
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Ag}(\text{s})$	+ 0.80
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$	+ 0.77
$\text{O}_2(\text{g}) + 2 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{H}_2\text{O}_2(\text{aq})$	+ 0.70
$\text{I}_2(\text{s}) + 2 \text{e}^- \rightleftharpoons 2 \text{I}^-(\text{aq})$	+ 0.54
$\text{O}_2(\text{g}) + 2 \text{H}_2\text{O}(\ell) + 4 \text{e}^- \rightleftharpoons 4 \text{OH}^-(\text{aq})$	+ 0.40
$\text{Cu}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Cu}(\text{s})$	+ 0.34
$\text{S}(\text{s}) + 2 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{H}_2\text{S}(\text{aq})$	+ 0.17
$2 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{H}_2(\text{g})$	0 exactly
$\text{Pb}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Pb}(\text{s})$	− 0.13
$\text{Sn}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Sn}(\text{s})$	− 0.14
$\text{Ni}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Ni}(\text{s})$	− 0.24
$\text{Co}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Co}(\text{s})$	− 0.28
$\text{PbSO}_4(\text{s}) + 2 \text{e}^- \rightleftharpoons \text{Pb}(\text{s}) + \text{SO}_4^{2-}(\text{aq})$	− 0.36
$\text{Cd}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Cd}(\text{s})$	− 0.40
$2 \text{CO}_2(\text{g}) + 2 \text{H}^+(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{H}_2\text{C}_2\text{O}_4(\text{aq})$	− 0.43
$\text{Fe}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Fe}(\text{s})$	− 0.44
$\text{Cr}^{3+}(\text{aq}) + 3 \text{e}^- \rightleftharpoons \text{Cr}(\text{s})$	− 0.74
$\text{Zn}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Zn}(\text{s})$	− 0.76
$2 \text{H}_2\text{O}(\ell) + 2 \text{e}^- \rightleftharpoons \text{H}_2(\text{g}) + 2 \text{OH}^-(\text{aq})$	− 0.83
$\text{Mn}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Mn}(\text{s})$	− 1.18
$\text{Al}^{3+}(\text{aq}) + 3 \text{e}^- \rightleftharpoons \text{Al}(\text{s})$	− 1.68
$\text{Mg}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Mg}(\text{s})$	− 2.36
$\text{Na}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Na}(\text{s})$	− 2.71
$\text{Ca}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Ca}(\text{s})$	− 2.87
$\text{Sr}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Sr}(\text{s})$	− 2.90
$\text{Ba}^{2+}(\text{aq}) + 2 \text{e}^- \rightleftharpoons \text{Ba}(\text{s})$	− 2.91
$\text{K}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{K}(\text{s})$	− 2.94

[Data source: Aylward, G.H., & Findlay, T. (2008). *SI Chemical Data* (6th ed.). Queensland: John Wiley & Sons Australia, Ltd.]