## Standard Reduction Potentials at 25 °C

| Half-reaction | | | E°(volts) |
|---|---|---|---|
| $F_2(g) + 2\ e^-$ | $\rightleftharpoons$ | $2\ F^-(aq)$ | + 2.89 |
| $H_2O_2(aq) + 2\ H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $2\ H_2O(\ell)$ | + 1.76 |
| $PbO_2(s) + SO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $PbSO_4(s) + 2\ H_2O(\ell)$ | + 1.69 |
| $2\ HC\ell O(aq) + 2\ H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $C\ell_2(g) + 2\ H_2O(\ell)$ | + 1.63 |
| $MnO_4^-(aq) + 8\ H^+(aq) + 5\ e^-$ | $\rightleftharpoons$ | $Mn^{2+}(aq) + 4\ H_2O(\ell)$ | + 1.51 |
| $Au^{3+}(aq) + 3\ e^-$ | $\rightleftharpoons$ | $Au(s)$ | + 1.50 |
| $HC\ell O(aq) + H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $C\ell^-(aq) + H_2O(\ell)$ | + 1.49 |
| $PbO_2(s) + 4\ H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Pb^{2+}(aq) + 2\ H_2O(\ell)$ | + 1.46 |
| $C\ell_2(g) + 2\ e^-$ | $\rightleftharpoons$ | $2\ C\ell^-(aq)$ | + 1.36 |
| $Cr_2O_7^{2-}(aq) + 14\ H^+(aq) + 6\ e^-$ | $\rightleftharpoons$ | $2\ Cr^{3+}(aq) + 7\ H_2O(\ell)$ | + 1.36 |
| $O_2(g) + 4\ H^+(aq) + 4\ e^-$ | $\rightleftharpoons$ | $2\ H_2O(\ell)$ | + 1.23 |
| $Br_2(\ell) + 2\ e^-$ | $\rightleftharpoons$ | $2\ Br^-(aq)$ | + 1.08 |
| $Ag^+(aq) + e^-$ | $\rightleftharpoons$ | $Ag(s)$ | + 0.80 |
| $Fe^{3+}(aq) + e^-$ | $\rightleftharpoons$ | $Fe^{2+}(aq)$ | + 0.77 |
| $O_2(g) + 2\ H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $H_2O_2(aq)$ | + 0.70 |
| $I_2(s) + 2\ e^-$ | $\rightleftharpoons$ | $2\ I^-(aq)$ | + 0.54 |
| $O_2(g) + 2\ H_2O(\ell) + 4\ e^-$ | $\rightleftharpoons$ | $4\ OH^-(aq)$ | + 0.40 |
| $Cu^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Cu(s)$ | + 0.34 |
| $S(s) + 2\ H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $H_2S(aq)$ | + 0.17 |
| $2\ H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $H_2(g)$ | 0 exactly |
| $Pb^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Pb(s)$ | – 0.13 |
| $Sn^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Sn(s)$ | – 0.14 |
| $Ni^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Ni(s)$ | – 0.24 |
| $Co^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Co(s)$ | – 0.28 |
| $PbSO_4(s) + 2\ e^-$ | $\rightleftharpoons$ | $Pb(s) + SO_4^{2-}(aq)$ | – 0.36 |
| $Cd^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Cd(s)$ | – 0.40 |
| $2\ CO_2(g) + 2\ H^+(aq) + 2\ e^-$ | $\rightleftharpoons$ | $H_2C_2O_4(aq)$ | – 0.43 |
| $Fe^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Fe(s)$ | – 0.44 |
| $Cr^{3+}(aq) + 3\ e^-$ | $\rightleftharpoons$ | $Cr(s)$ | – 0.74 |
| $Zn^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Zn(s)$ | – 0.76 |
| $2\ H_2O(\ell) + 2\ e^-$ | $\rightleftharpoons$ | $H_2(g) + 2\ OH^-(aq)$ | – 0.83 |
| $Mn^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Mn(s)$ | – 1.18 |
| $A\ell^{3+}(aq) + 3\ e^-$ | $\rightleftharpoons$ | $A\ell(s)$ | – 1.68 |
| $Mg^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Mg(s)$ | – 2.36 |
| $Na^+(aq) + e^-$ | $\rightleftharpoons$ | $Na(s)$ | – 2.71 |
| $Ca^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Ca(s)$ | – 2.87 |
| $Sr^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Sr(s)$ | – 2.90 |
| $Ba^{2+}(aq) + 2\ e^-$ | $\rightleftharpoons$ | $Ba(s)$ | – 2.91 |
| $K^+(aq) + e^-$ | $\rightleftharpoons$ | $K(s)$ | – 2.94 |

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

Government of **Western Australia**
**Curriculum Council**

WACE
Western Australian Certificate of Education

# CHEMISTRY DATA SHEET

# 2012



This document is valid for teaching and examining until 31 December 2012.

2011/38829(v2) *Chemistry Data Sheet revised December 2011*

## 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 6.941 | 4 **Be** beryllium 9.012 | | | | | | | | | | | 5 **B** boron 10.81 | 6 **C** carbon 12.01 | 7 **N** nitrogen 14.01 | 8 **O** oxygen 16.00 | 9 **F** fluorine 19.00 | 10 **Ne** neon 20.18 |
| 11 **Na** sodium 22.99 | 12 **Mg** magnesium 24.31 | | | | | | | | | | | 13 **Aℓ** aluminium 26.98 | 14 **Si** silicon 28.09 | 15 **P** phosphorus 30.97 | 16 **S** sulfur 32.06 | 17 **Cℓ** chlorine 35.45 | 18 **Ar** argon 39.95 |
| 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 | | | | | | |

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 (January 2011 version)]

## Solubility rules for ionic solids in water

### Soluble in water

| Soluble | Exceptions | |
|---|---|---|
| | **Insoluble** | **Slightly soluble** |
| Most chlorides | $AgC\ell$ | $PbC\ell_2$ |
| Most bromides | AgBr | $PbBr_2$ |
| Most iodides | AgI, $PbI_2$ | |
| All nitrates | No exceptions | |
| All ethanoates | | |
| Most sulfates | $SrSO_4$, $BaSO_4$, $PbSO_4$ | $CaSO_4$, $Ag_2SO_4$ |

### Insoluble in water

| Insoluble | Exceptions | |
|---|---|---|
| | **Soluble** | **Slightly soluble** |
| Most hydroxides | NaOH, KOH, $Ba(OH)_2$ (note: $NH_4OH$ and AgOH do not exist) | $Ca(OH)_2$, $Sr(OH)_2$ |
| Most carbonates | $Na_2CO_3$, $K_2CO_3$, $(NH_4)_2CO_3$ | |
| Most phosphates | $Na_3PO_4$, $K_3PO_4$, $(NH_4)_3PO_4$ | |
| Most sulfides | $Na_2S$, $K_2S$, $(NH_4)_2S$ | |

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

## 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 $\text{ppm} = \frac{\text{mass of solute (mg)}}{\text{mass of solution (kg)}}$

pH of a solution $\text{pH} = -\log [H^+]$

## 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 = $6.022 \times 10^{23}$ $mol^{-1}$
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, $K_w = 1.00 \times 10^{-14}$

## Colours of selected ionic 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 | State | Colour |
|---|---|---|
| copper | solid | salmon pink |
| gold | solid | yellow |
| nitrogen dioxide | gas | brown |
| sulfur | solid | yellow |

### 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 |

### Coloured halogens

| Halogen | Colour of free element |
|---|---|
| $F_2(g)$ | yellow |
| $C\ell_2(g)$ | greenish-yellow |
| $Br_2(\ell)$ | red |
| $I_2(s)$ | purple |

| Halogen | Colour of halogen in aqueous solution |
|---|---|
| $C\ell_2(aq)$ | pale yellow |
| $Br_2(aq)$ | orange |
| $I_2(aq)$ | brown |

| Halogen | Colour of halogen in organic solvent |
|---|---|
| $Br_2$ | red |
| $I_2$ | purple |