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Support Pack | Grade 12

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Physical Sciences

Chemistry information sheets

This support pack for the **Chemistry section** of the **Physical Sciences Grade 12 CAPS curriculum** provides revision of important basic information and concepts that learners need to know to successfully cope with Chemistry at Grade 12 level. Learners can work through these individually at home or these could form the basis of a catch-up class or online lesson. You have permission to print or photocopy this document or distribute it electronically via email or WhatsApp.

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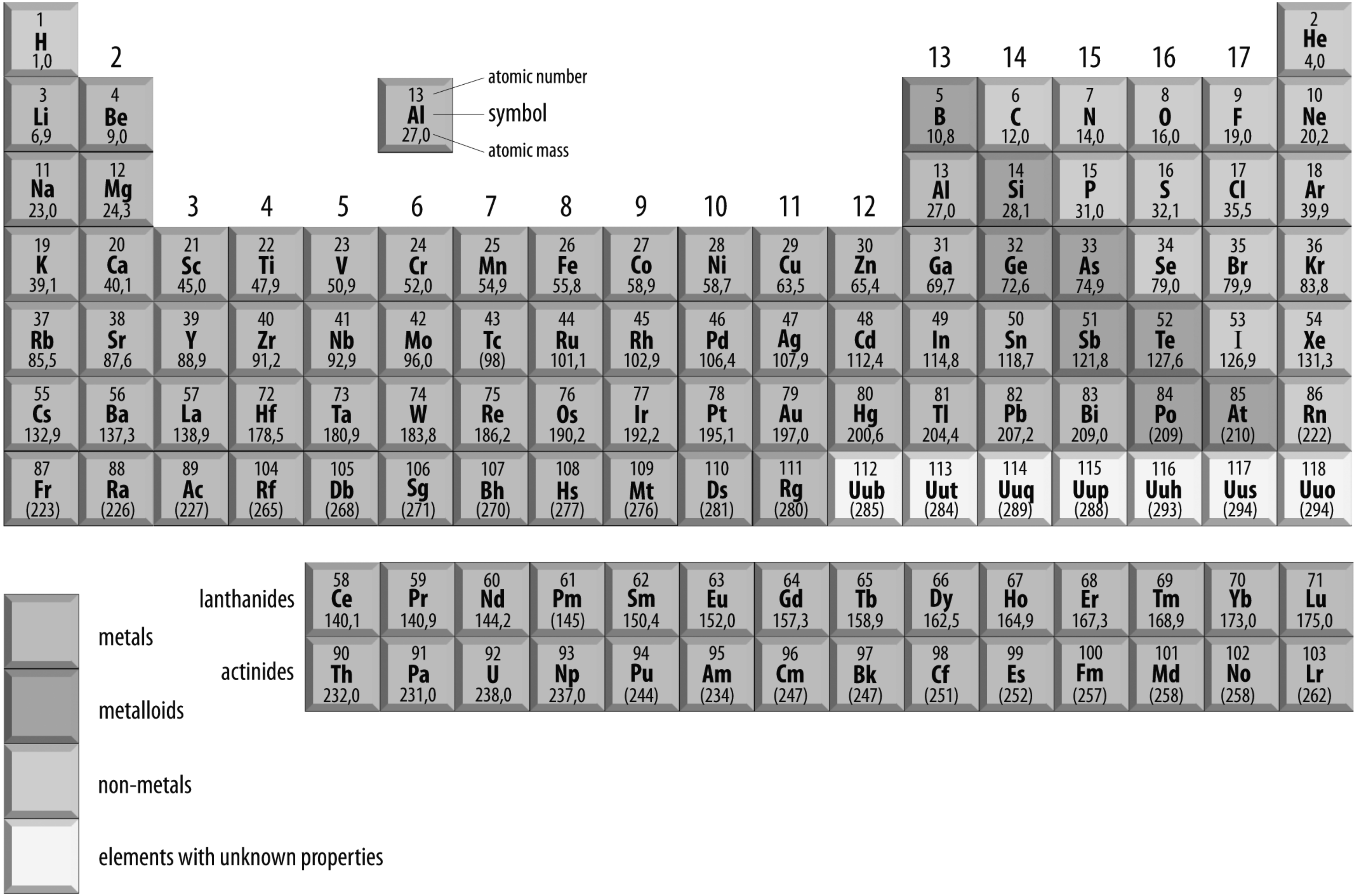
The Periodic Table of the Elements



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1,0																	2 **He** 4,0
3 **Li** 6,9	4 **Be** 9,0											5 **B** 10,8	6 **C** 12,0	7 **N** 14,0	8 **O** 16,0	9 **F** 19,0	10 **Ne** 20,2
11 **Na** 23,0	12 **Mg** 24,3											13 **Al** 27,0	14 **Si** 28,1	15 **P** 31,0	16 **S** 32,1	17 **Cl** 35,5	18 **Ar** 39,9
19 **K** 39,1	20 **Ca** 40,1	21 **Sc** 45,0	22 **Ti** 47,9	23 **V** 50,9	24 **Cr** 52,0	25 **Mn** 54,9	26 **Fe** 55,8	27 **Co** 58,9	28 **Ni** 58,7	29 **Cu** 63,5	30 **Zn** 65,4	31 **Ga** 69,7	32 **Ge** 72,6	33 **As** 74,9	34 **Se** 79,0	35 **Br** 79,9	36 **Kr** 83,8
37 **Rb** 85,5	38 **Sr** 87,6	39 **Y** 88,9	40 **Zr** 91,2	41 **Nb** 92,9	42 **Mo** 96,0	43 **Tc** (98)	44 **Ru** 101,1	45 **Rh** 102,9	46 **Pd** 106,4	47 **Ag** 107,9	48 **Cd** 112,4	49 **In** 114,8	50 **Sn** 118,7	51 **Sb** 121,8	52 **Te** 127,6	53 I 126,9	54 **Xe** 131,3
55 **Cs** 132,9	56 **Ba** 137,3	57 **La** 138,9	72 **Hf** 178,5	73 **Ta** 180,9	74 **W** 183,8	75 **Re** 186,2	76 **Os** 190,2	77 **Ir** 192,2	78 **Pt** 195,1	79 **Au** 197,0	80 **Hg** 200,6	81 **Tl** 204,4	82 **Pb** 207,2	83 **Bi** 209,0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (271)	107 **Bh** (270)	108 **Hs** (277)	109 **Mt** (276)	110 **Ds** (281)	111 **Rg** (280)	112 **Uub** (285)	113 **Uut** (284)	114 **Uuq** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

13
Al
27,0

atomic number

symbol

atomic mass

lanthanides	58 **Ce** 140,1	59 **Pr** 140,9	60 **Nd** 144,2	61 **Pm** (145)	62 **Sm** 150,4	63 **Eu** 152,0	64 **Gd** 157,3	65 **Tb** 158,9	66 **Dy** 162,5	67 **Ho** 164,9	68 **Er** 167,3	69 **Tm** 168,9	70 **Yb** 173,0	71 **Lu** 175,0
actinides	90 **Th** 232,0	91 **Pa** 231,0	92 **U** 238,0	93 **Np** 237,0	94 **Pu** (244)	95 **Am** (234)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (258)	103 **Lr** (262)

metals

metalloids

non-metals

elements with unknown properties

Table of Standard Reduction Potentials

The Table of Standard Reduction Potentials is provided.

- All the half-reactions are written as reductions.
- All the substances on the left of the double arrows are oxidising agents.
- All the substances on the right of the double arrows are reducing agents.
- Reduction half-reactions are read from left to right.
- Oxidation half-reactions are read from right to left.
- For a spontaneous reaction, the stronger oxidising agent will react with the stronger reducing agent.
- We use the Table of Standard Reduction Potentials to calculate the voltage supplied by a particular combination of half-cells.

  $E^\circ_{\text{cell}} = E^\circ_{\text{oxidising agent}} - E^\circ_{\text{reducing agent}}$

  or $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$
- A positive E°_{cell} value indicates a spontaneous reaction.

Example

The E°_{cell} value for the standard Zn | Cu cell is:

Oxidising agent (Cu^{2+}): $Cu^{2+} + 2e^- \rightarrow Cu$ $\quad E^\circ = +0{,}34$ V

Reducing agent (Zn): $Zn(s) \rightarrow Zn^{2+} + 2e^-$ $\quad E^\circ = -0{,}76$ V

$$\begin{aligned}E^\circ_{\text{cell}} &= E^\circ_{\text{oxidising agent}} - E^\circ_{\text{reducing agent}}\\ &= (+0{,}34) - (-0{,}76)\\ &= +0{,}34 + 0{,}76\\ &= +1{,}10 \text{ V}\end{aligned}$$

A redox reaction always consists of two half-reactions: one for oxidation and one for reduction. We use the Table of Standard Reduction Potentials to write a balanced ionic equation for a redox reaction by following these steps:

Step 1: Identify the reactants on the list. One reactant must be an oxidising agent and the other a reducing agent.

Step 2: First write the reactants underneath each other and then write the rest of the equation from the list. The reduction reaction must be the forward reaction and the oxidation reaction must be the reverse reaction. Use only forward arrows in redox reactions.

Step 3: Multiply the half-reactions with coefficients to get equal numbers of electrons.

Step 4: Cancel the electrons as well as any H^+ ions and H_2O that might appear on both sides of the arrow.

Step 5: Add the half-reactions and write down the complete balanced ionic equation.

Step 6: Add the spectator ions to balance all the charges in the ionic equation.

Worked example 1

Write a balanced ionic equation for the preparation of nitrogen dioxide by reacting concentrated nitric acid with copper.

Solution

Steps 1 & 2: $NO_3^- + 2H^+ + e^- \rightarrow NO_2 + H_2O$ Step 3: ×2

$Cu \rightarrow Cu^{2+} + 2e^-$

Step 4: $2NO_3^- + 4H^+ + \cancel{2e^-} \rightarrow 2NO_2 + 2H_2O$

$Cu \rightarrow Cu^{2+} + \cancel{2e^-}$

Step 5: $2NO_3^- + 4H^+ + Cu \rightarrow 2NO_2 + 2H_2O + Cu^{2+}$

Equilibrium and *E*° values

- The tendency to reach equilibrium drives an electrochemical reaction. The larger the E°_{cell} value is, the further the reaction is from equilibrium.
- The E° values are at standard conditions. A cell that starts off under standard conditions will have ionic concentrations of 1 $mol \cdot dm^{-3}$. As the reactions progress, the ionic concentrations will decrease as the reactants are used up and products are formed. The cell potential becomes smaller. Finally, the cell potential will reach zero, and the reaction stops. At this point the reaction is at equilibrium, no electrons flow and the cell has gone flat.
- When E°_{cell} is very small, changes in the concentrations and temperature can change the direction of the reaction. An increase in ion concentration favours the forward reaction and the equilibrium shifts to the right. A normally non-spontaneous reaction with a negative E° value can then take place spontaneously.

The Table of Standard Reduction Potentials

Table A

Increasing oxidising ability

Half-reactions			E° (V)
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+2,87
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+1,82
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+1,52
$Cl_2(g) + 2e^-$	$\rightleftharpoons$	$2Cl^-$	+1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+1,33
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+1,28
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+1,23
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+1,06
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+0,96
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+0,80
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+0,78
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+0,78
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+0,77
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+0,68
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+0,54
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+0,52
$SO_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$S + 2H_2O$	+0,45
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+0,40
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+0,34
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+0,17
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+0,16
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+0,15
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+0,14
$2H^+ + 2e^-$	$\rightleftharpoons$	$H_2(g)$	0,00
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	−0,04
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	−0,13
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	−0,14
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	−0,25
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	−0,28
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	−0,40
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	−0,41
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	−0,44
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	−0,74
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	−0,74
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	−0,76
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	−0,83
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	−1,18
$Al^{3+} + 3e^-$	$\rightleftharpoons$	Al	−1,66
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	−2,37
$Na^+ + e^-$	$\rightleftharpoons$	Na	−2,71
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	−2,87
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	−2,90
$K^+ + e^-$	$\rightleftharpoons$	K	−2,92
$Li^+ + e^-$	$\rightleftharpoons$	Li	−3,04

Increasing reducing ability

Table B

Increasing oxidising ability

Half-reactions			E° (V)
$Li^+ + e^-$	$\rightleftharpoons$	Li	−3,04
$K^+ + e^-$	$\rightleftharpoons$	K	−2,92
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	−2,90
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	−2,87
$Na^+ + e^-$	$\rightleftharpoons$	Na	−2,71
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	−2,37
$Al^{3+} + 3e^-$	$\rightleftharpoons$	Al	−1,66
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	−1,18
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	−0,83
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	−0,76
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	−0,74
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	−0,74
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	−0,44
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	−0,41
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	−0,40
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	−0,28
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	−0,25
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	−0,14
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	−0,13
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	−0,04
$2H^+ + 2e^-$	$\rightleftharpoons$	$H_2(g)$	0,00
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+0,14
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+0,15
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+0,16
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+0,17
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+0,34
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+0,40
$SO_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$S + 2H_2O$	+0,45
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+0,52
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+0,54
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+0,68
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+0,77
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+0,78
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+0,78
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+0,80
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+0,96
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+1,06
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+1,23
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+1,28
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+1,33
$Cl_2(g) + 2e^-$	$\rightleftharpoons$	$2Cl^-$	+1,36
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+1,52
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+1,82
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+2,87

Increasing reducing ability

Symbols of chemical elements and their names

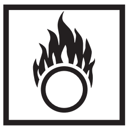
1	H	Hydrogen	38	Sr	Strontium	75	Re	Rhenium
2	He	Helium	39	Y	Yttrium	76	Os	Osmium
3	Li	Lithium	40	Zr	Zirconium	77	Ir	Iridium
4	Be	Beryllium	41	Nb	Niobium	78	Pt	Platinum
5	B	Boron	42	Mo	Molybdenum	79	Au	Gold
6	C	Carbon	43	Tc	Technetium	80	Hg	Mercury
7	N	Nitrogen	44	Ru	Ruthenium	81	Tl	Thallium
8	O	Oxygen	45	Rh	Rhodium	82	Pb	Lead
9	F	Fluorine	46	Pd	Palladium	83	Bi	Bismuth
10	Ne	Neon	47	Ag	Silver	84	Po	Polonium
11	Na	Sodium	48	Cd	Cadmium	85	At	Astatine
12	Mg	Magnesium	49	In	Indium	86	Rn	Radon
13	Al	Aluminium	50	Sn	Tin	87	Fr	Francium
14	Si	Silicon	51	Sb	Antimony	88	Ra	Radium
15	P	Phosphorus	52	Te	Tellurium	89	Ac	Actinium
16	S	Sulfur	53	I	Iodine	90	Th	Thorium
17	Cl	Chlorine	54	Xe	Xenon	91	Pa	Protactinium
18	Ar	Argon	55	Cs	Cesium	92	U	Uranium
19	K	Potassium	56	Ba	Barium	93	Np	Neptunium
20	Ca	Calcium	57	La	Lanthanum	94	Pu	Plutonium
21	Sc	Scandium	58	Ce	Cerium	95	Am	Americium
22	Ti	Titanium	59	Pr	Praseodymium	96	Cm	Curium
23	V	Vanadium	60	Nd	Neodymium	97	Bk	Berkelium
24	Cr	Chromium	61	Pm	Promethium	98	Cf	Californium
25	Mn	Manganese	62	Sm	Samarium	99	Es	Einsteinium
26	Fe	Iron	63	Eu	Europium	100	Fm	Fermium
27	Co	Cobalt	64	Gd	Gadolinium	101	Md	Mendelevium
28	Ni	Nickel	65	Tb	Terbium	102	No	Nobelium
29	Cu	Copper	66	Dy	Dysprosium	103	Lr	Lawrencium
30	Zn	Zinc	67	Ho	Holmium	104	Rf	Rutherfordium
31	Ga	Gallium	68	Er	Erbium	105	Db	Dubnium
32	Ge	Germanium	69	Tm	Thulium	106	Sg	Seaborgium
33	As	Arsenic	70	Yb	Ytterbium	107	Bh	Bohrium
34	Se	Selenium	71	Lu	Lutetium	108	Hs	Hassium
35	Br	Bromine	72	Hf	Hafnium	109	Mt	Meitnerium
36	Kr	Krypton	73	Ta	Tantalum	110	Ds	Darmstadtium
37	Rb	Rubidium	74	W	Tungsten	111	Rg	Roentgenium

Identifying harmful chemicals

The label on a chemical reagent bottle tells us if it is harmful or not. Precautions in handling harmful chemicals can be taken in advance to minimise accidents.

Study the following internationally used hazard symbols:

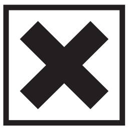
This symbol means that the chemical is highly flammable. It can catch fire easily and should not be left near an open flame. Methylated spirits is an example of a highly flammable chemical.



An oxidising substance contains oxygen that can cause other substances to burn more easily. Sodium chlorate releases oxygen when it reacts.

The symbol for toxic substances is the skull and crossbones because they can kill you. They must be handled with great care and only under supervision of the teacher.

Corrosive substances can burn your skin and eyes, and can burn holes in your clothes. Always use safety glasses when working with these chemicals. Many acids are corrosive.



Some substances can cause your skin to turn red or to blister. Certain dry powders can make you cough. These substances are called irritants. They are less dangerous than corrosive materials, but should still be handled with care.