

Chemistry Data Booklet

Higher and Advanced Higher

For use in National Qualification Courses
leading to the 2007 examinations and beyond.

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Relative Atomic Masses of Selected Elements

| Element | Symbol | Relative atomic mass |
|-----------|--------|----------------------|
| Aluminium | Al | 27.0 |
| Antimony | Sb | 121.8 |
| Argon | Ar | 40.0 |
| Arsenic | As | 74.9 |
| Barium | Ba | 137.3 |
| Beryllium | Be | 9.0 |
| Bismuth | Bi | 209.0 |
| Boron | B | 10.8 |
| Bromine | Br | 79.9 |
| Cadmium | Cd | 112.4 |
| Calcium | Ca | 40.0 |
| Carbon | C | 12.0 |
| Cerium | Ce | 140.1 |
| Caesium | Cs | 132.9 |
| Chlorine | Cl | 35.5 |
| Chromium | Cr | 52.0 |
| Cobalt | Co | 58.9 |
| Copper | Cu | 63.5 |
| Fluorine | F | 19.0 |
| Gallium | Ga | 69.7 |
| Germanium | Ge | 72.6 |
| Gold | Au | 197.0 |
| Hafnium | Hf | 178.5 |
| Helium | He | 4.0 |
| Hydrogen | H | 1.0 |
| Indium | In | 114.8 |
| Iodine | I | 126.9 |
| Iridium | Ir | 192.2 |
| Iron | Fe | 55.8 |
| Krypton | Kr | 83.8 |
| Lead | Pb | 207.2 |
| Lithium | Li | 6.9 |
| Magnesium | Mg | 24.3 |
| Manganese | Mn | 54.9 |
| Mercury | Hg | 200.6 |

| Element | Symbol | Relative atomic mass |
|------------|--------|----------------------|
| Molybdenum | Mo | 95.9 |
| Neon | Ne | 20.2 |
| Nickel | Ni | 58.7 |
| Niobium | Nb | 92.9 |
| Nitrogen | N | 14.0 |
| Osmium | Os | 190.2 |
| Oxygen | O | 16.0 |
| Palladium | Pd | 106.4 |
| Phosphorus | P | 31.0 |
| Platinum | Pt | 195.1 |
| Potassium | K | 39.1 |
| Rhenium | Re | 186.2 |
| Rhodium | Rh | 102.9 |
| Rubidium | Rb | 85.5 |
| Ruthenium | Ru | 101.1 |
| Scandium | Sc | 45.0 |
| Selenium | Se | 79.0 |
| Silicon | Si | 28.1 |
| Silver | Ag | 107.9 |
| Sodium | Na | 23.0 |
| Strontium | Sr | 87.6 |
| Sulphur | S | 32.1 |
| Tantalum | Ta | 181.0 |
| Tellurium | Te | 127.6 |
| Thallium | Tl | 204.4 |
| Thorium | Th | 232.0 |
| Tin | Sn | 118.7 |
| Titanium | Ti | 47.9 |
| Tungsten | W | 183.9 |
| Uranium | U | 238.0 |
| Vanadium | V | 51.0 |
| Xenon | Xe | 131.3 |
| Zinc | Zn | 65.4 |
| Zirconium | Zr | 91.2 |

Electron Arrangements of Elements

Group 1
2

| | |
|----|-----------------------|
| 1 | H Hydrogen |
| 3 | Li Lithium |
| 11 | Na Sodium |
| 19 | K Potassium |
| 37 | Rb Rubidium |
| 55 | Cs Caesium |
| 87 | Fr Francium |

Group 3
4
5
6
7
0

| | |
|----|----------------------|
| 2 | He Helium |
| 10 | Ne Neon |
| 18 | Ar Argon |
| 36 | Kr Krypton |
| 54 | Xe Xenon |
| 86 | Rn Radon |

Key

| |
|----------------------|
| Atomic number |
| Symbol |
| Electron arrangement |
| Name |

Group 1
2

| | |
|----|------------------------|
| 2 | Be Beryllium |
| 12 | Mg Magnesium |
| 20 | Ca Calcium |
| 38 | Sr Strontium |
| 56 | Ba Barium |
| 88 | Ra Radium |

Group 3
4
5
6
7
0

| | |
|-----|------------------------|
| 5 | B Boron |
| 13 | Al Aluminium |
| 31 | Ga Gallium |
| 49 | In Indium |
| 81 | Tl Thallium |
| 101 | Bi Bismuth |
| 127 | Po Polonium |
| 153 | At Astatine |
| 171 | Fr Francium |

Group 3
4
5
6
7
0

| | |
|-----|--------------------------|
| 6 | C Carbon |
| 14 | Si Silicon |
| 32 | Ge Germanium |
| 50 | Sn Tin |
| 82 | Pb Lead |
| 112 | Cn Copernicium |
| 138 | Fl Flerovium |
| 164 | Uu Ununquadium |
| 181 | Ubn Unbibium |

Group 3
4
5
6
7
0

| | |
|-----|---------------------------|
| 7 | N Nitrogen |
| 15 | P Phosphorus |
| 33 | As Arsenic |
| 51 | Sb Antimony |
| 83 | Bi Bismuth |
| 115 | Mc Moscovium |
| 133 | Nh Nihonium |
| 151 | Uue Ununseptium |
| 169 | Uub Unbibium |

Group 3
4
5
6
7
0

| | |
|-----|---------------------------|
| 8 | O Oxygen |
| 16 | S Sulphur |
| 34 | Se Selenium |
| 52 | Te Tellurium |
| 84 | Po Polonium |
| 116 | Lv Livermorium |
| 134 | Uuo Ununoctium |
| 152 | Uuq Ununquadium |
| 170 | Uub Unbibium |

Group 3
4
5
6
7
0

| | |
|-----|---------------------------|
| 9 | F Fluorine |
| 17 | Cl Chlorine |
| 35 | Br Bromine |
| 53 | I Iodine |
| 85 | At Astatine |
| 117 | Ts Tennessine |
| 135 | Uuh Ununhexium |
| 153 | Uuq Ununquadium |
| 171 | Uub Unbibium |

Group 3
4
5
6
7
0

| | |
|-----|------------------------|
| 10 | Ne Neon |
| 18 | Ar Argon |
| 36 | Kr Krypton |
| 54 | Xe Xenon |
| 86 | Rn Radon |
| 118 | Og Oganesson |

Transition Elements

| | | | | | | | | | | | | | | | | | | | |
|----|------------------------|-----|----------------------------|-----|-----------------------|-----|-------------------------|-----|-------------------------|-----|------------------------|-----|-------------------------|-----|---------------------------|-----|--------------------------|-----|--------------------------|
| 21 | Sc Scandium | 22 | Ti Titanium | 23 | V Vanadium | 24 | Cr Chromium | 25 | Mn Manganese | 26 | Fe Iron | 27 | Co Cobalt | 28 | Ni Nickel | 29 | Cu Copper | 30 | Zn Zinc |
| 39 | Y Yttrium | 40 | Zr Zirconium | 41 | Nb Niobium | 42 | Mo Molybdenum | 43 | Tc Technetium | 44 | Ru Ruthenium | 45 | Rh Rhodium | 46 | Pd Palladium | 47 | Ag Silver | 48 | Cd Cadmium |
| 57 | La Lanthanum | 72 | Hf Hafnium | 73 | Ta Tantalum | 74 | W Tungsten | 75 | Re Rhenium | 76 | Os Osmium | 77 | Ir Iridium | 78 | Pt Platinum | 79 | Au Gold | 80 | Hg Mercury |
| 89 | 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 |

Lanthanides

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----|------------------------|----|----------------------|----|---------------------------|----|------------------------|----|-------------------------|----|------------------------|----|------------------------|----|-------------------------|----|------------------------|----|--------------------------|----|--------------------------|-----|----------------------|-----|--------------------------|-----|------------------------|-----|-------------------------|
| 57 | La Lanthanum | 58 | Ce Cerium | 59 | Pr Praseodymium | 60 | Nd Neodymium | 61 | Pm Promethium | 62 | Sm Samarium | 63 | Eu Europium | 64 | Gd Gadolinium | 65 | Tb Terbium | 66 | Dy Dysprosium | 67 | Ho Holmium | 68 | Er Erbium | 69 | Tm Thulium | 70 | Yb Ytterbium | 71 | Lu Lutetium |
| 89 | Ac Actinium | 90 | Th Thorium | 91 | Pa Protactinium | 92 | U 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 |

Actinides

Densities of Selected Elements

Group 1
2

| | |
|--------------------------|-------------------------|
| 1 Hydrogen 0-00009 | 4 Beryllium 1-85 |
| 3 Lithium 0-53 | 12 Magnesium 1-74 |
| 11 Sodium 0-97 | 20 Calcium 1-54 |
| 37 Rubidium 1-53 | 38 Strontium 2-60 |
| 55 Caesium 1-93 | 56 Barium 3-51 |

Key

| |
|---|
| Atomic number Name of element Density/g cm ⁻³ <i>measured at s.t.p.</i> |
|---|

Group 3
4
5
6
7
0

| | | | | | |
|-------------------------|-------------------------|--------------------------|-------------------------|--------------------------|-------------------------|
| 5 Boron 2-34 | 6 Carbon * | 7 Nitrogen 0-0013 | 8 Oxygen 0-0014 | 9 Fluorine 0-0017 | 10 Neon 0-0009 |
| 13 Aluminium 2-70 | 14 Silicon 2-33 | 15 Phosphorus 1-82 | 16 Sulphur 2-07 | 17 Chlorine 0-0032 | 18 Argon 0-0018 |
| 31 Gallium 5-90 | 32 Germanium 5-35 | 33 Arsenic 5-73 | 34 Selenium 4-81 | 35 Bromine 3-12 | 36 Krypton 0-0037 |
| 49 Indium 7-31 | 50 Tin 7-28 | 51 Antimony 6-68 | 52 Tellurium 6-25 | 53 Iodine 4-93 | 54 Xenon 0-0059 |
| 81 Thallium 11-8 | 82 Lead 11-3 | 83 Bismuth 9-80 | 84 Polonium 9-4 | 85 Astatine - | 86 Radon 0-0097 |

| | | | | | | | | | |
|-------------------------|-------------------------|------------------------|--------------------------|--------------------------|-------------------------|-----------------------|-------------------------|----------------------|-----------------------|
| 21 Scandium 2-99 | 22 Titanium 4-50 | 23 Vanadium 5-96 | 24 Chromium 7-20 | 25 Manganese 7-20 | 26 Iron 7-86 | 27 Cobalt 8-90 | 28 Nickel 8-90 | 29 Copper 8-92 | 30 Zinc 7-14 |
| 39 Yttrium 4-47 | 40 Zirconium 6-52 | 41 Niobium 8-57 | 42 Molybdenum 10-2 | 43 Technetium 11-5 | 44 Ruthenium 12-3 | 45 Rhodium 12-4 | 46 Palladium 12-0 | 47 Silver 10-5 | 48 Cadmium 8-64 |
| 57 Lanthanum 6-15 | 72 Hafnium 13-3 | 73 Tantalum 16-6 | 74 Tungsten 19-4 | 75 Rhenium 20-5 | 76 Osmium 22-5 | 77 Iridium 22-4 | 78 Platinum 21-5 | 79 Gold 19-3 | 80 Mercury 13-6 |

*The density of carbon as graphite is 2.25 g cm⁻³.

The density of carbon as diamond is 3.51 g cm⁻³.

Melting and Boiling Points of Selected Elements

Group 1
2

| | | | |
|----|-----------|------|------|
| 1 | Hydrogen | -259 | -253 |
| 3 | Lithium | 181 | 1342 |
| | | 1342 | 2471 |
| 11 | Sodium | 98 | 883 |
| | | 883 | 1090 |
| 12 | Magnesium | 649 | |
| 20 | Calcium | 842 | 1484 |
| 37 | Rubidium | 38 | 688 |
| | | 38 | 1384 |
| 55 | Caesium | 28 | 671 |
| | | 28 | 1640 |

Key

| |
|------------------|
| Atomic number |
| Name of element |
| Melting point/°C |
| Boiling Point/°C |

Group 3
4
5
6
7
0

| | | | |
|----|------------|------|------|
| 5 | Boron | 2300 | 4000 |
| | | 2300 | 4000 |
| 13 | Aluminium | 660 | 2467 |
| | | 660 | 2467 |
| 14 | Silicon | 1410 | 2355 |
| | | 1410 | 2355 |
| 15 | Phosphorus | 44 | 280 |
| | | 44 | 280 |
| 16 | Sulphur | 113 | 445 |
| | | 113 | 445 |
| 31 | Gallium | 30 | 2403 |
| | | 30 | 2403 |
| 32 | Germanium | 937 | 2830 |
| | | 937 | 2830 |
| 33 | Arsenic | *817 | *613 |
| | | *817 | *613 |
| 34 | Selenium | 217 | 685 |
| | | 217 | 685 |
| 49 | Indium | 157 | 2080 |
| | | 157 | 2080 |
| 50 | Tin | 232 | 2602 |
| | | 232 | 2602 |
| 51 | Antimony | 631 | 1750 |
| | | 631 | 1750 |
| 52 | Tellurium | 452 | 988 |
| | | 452 | 988 |
| 81 | Thallium | 304 | 1457 |
| | | 304 | 1457 |
| 82 | Lead | 328 | 1749 |
| | | 328 | 1749 |
| 83 | Bismuth | 271 | 1560 |
| | | 271 | 1560 |
| 84 | Polonium | 254 | 962 |
| | | 254 | 962 |
| 85 | Astatine | 302 | |
| | | 302 | |
| 86 | Radon | -71 | -62 |
| | | -71 | -62 |

| | | | |
|----|------------|------|------|
| 21 | Scandium | 1541 | 2831 |
| | | 1541 | 2831 |
| 22 | Titanium | 1660 | 3287 |
| | | 1660 | 3287 |
| 23 | Vanadium | 1890 | 3380 |
| | | 1890 | 3380 |
| 24 | Chromium | 1857 | 2672 |
| | | 1857 | 2672 |
| 25 | Manganese | 1244 | 1962 |
| | | 1244 | 1962 |
| 26 | Iron | 1535 | 2730 |
| | | 1535 | 2730 |
| 27 | Cobalt | 1495 | 2927 |
| | | 1495 | 2927 |
| 28 | Nickel | 1453 | 2913 |
| | | 1453 | 2913 |
| 29 | Copper | 1083 | 2567 |
| | | 1083 | 2567 |
| 30 | Zinc | 420 | 907 |
| | | 420 | 907 |
| 39 | Yttrium | 1522 | 3338 |
| | | 1522 | 3338 |
| 40 | Zirconium | 1852 | 4377 |
| | | 1852 | 4377 |
| 41 | Niobium | 2477 | 4742 |
| | | 2477 | 4742 |
| 42 | Molybdenum | 2623 | 4639 |
| | | 2623 | 4639 |
| 43 | Technetium | 2157 | 4265 |
| | | 2157 | 4265 |
| 44 | Ruthenium | 2310 | 3900 |
| | | 2310 | 3900 |
| 45 | Rhodium | 1966 | 3695 |
| | | 1966 | 3695 |
| 46 | Palladium | 1552 | 2963 |
| | | 1552 | 2963 |
| 47 | Silver | 962 | 2212 |
| | | 962 | 2212 |
| 48 | Cadmium | 321 | 765 |
| | | 321 | 765 |
| 72 | Hafnium | 2227 | 4602 |
| | | 2227 | 4602 |
| 73 | Tantalum | 2996 | 5425 |
| | | 2996 | 5425 |
| 74 | Tungsten | 3410 | 5660 |
| | | 3410 | 5660 |
| 75 | Rhenium | 3180 | 5627 |
| | | 3180 | 5627 |
| 76 | Osmium | 3033 | 5012 |
| | | 3033 | 5012 |
| 77 | Iridium | 2410 | 4130 |
| | | 2410 | 4130 |
| 78 | Platinum | 1772 | 3827 |
| | | 1772 | 3827 |
| 79 | Gold | 1064 | 2856 |
| | | 1064 | 2856 |
| 80 | Mercury | -39 | 357 |
| | | -39 | 357 |

* not at standard pressure

† Sublimes.

Covalent Radii of Selected Elements

Group 1
2

| | |
|------------------------|------------------------|
| 1 Hydrogen 37 | 4 Beryllium 129 |
| 3 Lithium 134 | 12 Magnesium 145 |
| 19 Potassium 196 | 20 Calcium 174 |
| 37 Rubidium 216 | 38 Strontium 191 |
| 55 Caesium 235 | 56 Barium 198 |

Group 3
4
5
6
7

| | | | | |
|------------------------|------------------------|-------------------------|------------------------|-----------------------|
| 5 Boron 90 | 6 Carbon 77 | 7 Nitrogen 75 | 8 Oxygen 73 | 9 Fluorine 71 |
| 13 Aluminium 130 | 14 Silicon 117 | 15 Phosphorus 110 | 16 Sulphur 102 | 17 Chlorine 99 |
| 31 Gallium 120 | 32 Germanium 122 | 33 Arsenic 121 | 34 Selenium 117 | 35 Bromine 114 |
| 49 Indium 150 | 50 Tin 140 | 51 Antimony 143 | 52 Tellurium 135 | 53 Iodine 133 |
| 81 Thallium 157 | 82 Lead 155 | 83 Bismuth 151 | 84 Polonium - | 85 Astatine 140 |

Key

| |
|--|
| Atomic number Name of element Covalent radius/pm |
|--|

| | | | | | | | | | |
|------------------------|------------------------|-----------------------|-------------------------|------------------------|------------------------|----------------------|------------------------|---------------------|----------------------|
| 21 Scandium 141 | 22 Titanium 132 | 23 Vanadium 122 | 24 Chromium 119 | 25 Manganese 116 | 26 Iron 114 | 27 Cobalt 114 | 28 Nickel 113 | 29 Copper 118 | 30 Zinc 120 |
| 39 Yttrium 162 | 40 Zirconium 147 | 41 Niobium 133 | 42 Molybdenum 127 | 43 Technetium - | 44 Ruthenium 122 | 45 Rhodium 122 | 46 Palladium 126 | 47 Silver 136 | 48 Cadmium 140 |
| 57 Lanthanum 169 | 72 Hafnium 142 | 73 Tantalum 133 | 74 Tungsten 131 | 75 Rhenium 128 | 76 Osmium 126 | 77 Iridium 124 | 78 Platinum 127 | 79 Gold 130 | 80 Mercury 141 |

Melting and Boiling Points of Selected Oxides

| Element | Formula of oxide | mp/°C | bp/°C |
|------------|--------------------------------|-------------------|-----------------|
| hydrogen | H ₂ O | 0 | 100 |
| lithium | Li ₂ O | sublimes at 1200 | |
| beryllium | BeO | 2530 | 3900 |
| boron | B ₂ O ₃ | 450 | 1860 |
| carbon | CO ₂ | sublimes at -78.5 | |
| nitrogen | N ₂ O ₂ | -9 | 21 |
| fluorine | F ₂ O | -224 | -145 |
| sodium | Na ₂ O | sublimes at 1275 | |
| magnesium | MgO | 2852 | 3600 |
| aluminium | Al ₂ O ₃ | 2072 | 2980 |
| silicon | SiO ₂ | 1610 | 2230 |
| phosphorus | P ₄ O ₁₀ | sublimes at 300 | |
| sulphur | SO ₂ | -72.7 | -10 |
| chlorine | Cl ₂ O | -20 | decomposes at 4 |
| potassium | K ₂ O | decomposes at 350 | |
| calcium | CaO | 2614 | 2850 |

Melting and Boiling Points of Selected Chlorides

| Element | Formula of chloride | mp/°C | bp/°C |
|------------|---------------------------------|-----------------|------------------|
| lithium | LiCl | 605 | 1350 |
| beryllium | BeCl ₂ | 405 | 520 |
| boron | BCl ₃ | -107 | 12.5 |
| carbon | CCl ₄ | -23 | 76.8 |
| nitrogen | NCl ₃ | -40 | 71 |
| fluorine | FCl | -154 | -101 |
| sodium | NaCl | 801 | 1413 |
| magnesium | MgCl ₂ | 714 | 1412 |
| aluminium | Al ₂ Cl ₆ | sublimes at 178 | |
| silicon | SiCl ₄ | -70 | 57.6 |
| phosphorus | PCl ₃ | -112 | 75.5 |
| sulphur | SCl ₂ | -78 | decomposes at 59 |
| potassium | KCl | 770 | 1680 |
| calcium | CaCl ₂ | 782 | >1600 |

Melting and Boiling Points of Selected Organic Compounds

| Name of compound | mp/°C | bp/°C |
|------------------|--------|-------|
| methane | -182.5 | -164 |
| ethane | -183 | -89 |
| propane | -190 | -42 |
| butane | -138 | -1 |
| pentane | -130 | 36 |
| hexane | -95 | 69 |
| heptane | -91 | 98 |
| octane | -57 | 126 |
| cyclobutane | -50 | 12 |
| cyclopentane | -94 | 49 |
| cyclohexane | 7 | 81 |
| ethene | -169 | -104 |
| propene | -185 | -47 |
| but-1-ene | -185 | -6 |
| pent-1-ene | -138 | 30 |
| hex-1-ene | -140 | 63 |
| benzene | 6 | 80 |

| Name of compound | mp/°C | bp/°C |
|------------------|-------|-------|
| methanol | -94 | 65 |
| ethanol | -117 | 79 |
| propan-1-ol | -127 | 97 |
| propan-2-ol | -90 | 82 |
| butan-1-ol | -90 | 117 |
| butan-2-ol | -100 | 100 |
| methanal | -92 | -21 |
| ethanal | -121 | 21 |
| propanal | -81 | 49 |
| butanal | -99 | 76 |
| propanone | -95 | 56 |
| butanone | -86 | 80 |
| methanoic acid | 8 | 101 |
| ethanoic acid | 17 | 118 |
| propanoic acid | -21 | 141 |
| butanoic acid | -4 | 164 |
| methoxyethane | -113 | 7 |
| ethoxyethane | -116 | 34.5 |

Solubilities of Selected Compounds in Water

The table shows how some compounds behave in cold water

| | | |
|----|--------------------|--|
| vs | means very soluble | (a solubility greater than 10 g l^{-1}) |
| s | means soluble | (a solubility of between 1 and 10 g l^{-1}) |
| i | means insoluble | (a solubility of less than 1 g l^{-1}) |
| – | no data | |

| | bromide | carbonate | chloride | iodide | nitrate | phosphate | sulphate | oxide | hydroxide |
|-------------------|---------|-----------|----------|--------|---------|-----------|----------|-------|-----------|
| aluminium | vs | i | vs | vs | vs | i | vs | i | i |
| ammonium | vs | vs | vs | vs | vs | vs | vs | – | – |
| barium | vs | i | vs | vs | vs | i | i | vs | vs |
| calcium | vs | i | vs | vs | vs | i | s | s | s |
| copper(II) | vs | i | vs | – | vs | i | vs | i | i |
| iron(II) | vs | i | vs | vs | vs | i | vs | i | i |
| iron(III) | vs | – | vs | – | vs | i | vs | i | i |
| lead(II) | s | i | s | i | vs | i | i | i | i |
| lithium | vs | vs | vs | vs | vs | i | vs | vs | vs |
| magnesium | vs | i | vs | vs | vs | i | vs | i | i |
| nickel | vs | i | vs | vs | vs | i | vs | i | i |
| potassium | vs | vs | vs | vs | vs | vs | vs | vs | vs |
| silver | i | i | i | i | vs | i | s | i | – |
| sodium | vs | vs | vs | vs | vs | vs | vs | vs | vs |
| tin(II) | vs | i | vs | s | – | i | vs | i | i |
| zinc | vs | i | vs | vs | vs | i | vs | i | i |

Note: Some of the compounds in the table hydrolyse significantly in water.

Formulae of Selected Ions Containing More Than One Kind of Atom

| one positive | | one negative | | two negative | | three negative | |
|--------------|-----------------|-------------------|---------------------------|--------------|------------------------------|----------------|--------------------|
| Ion | Formula | Ion | Formula | Ion | Formula | Ion | Formula |
| ammonium | NH_4^+ | ethanoate | CH_3COO^- | carbonate | CO_3^{2-} | phosphate | PO_4^{3-} |
| | | hydrogencarbonate | HCO_3^- | chromate | CrO_4^{2-} | | |
| | | hydrogensulphate | HSO_4^- | dichromate | $\text{Cr}_2\text{O}_7^{2-}$ | | |
| | | hydrogensulphite | HSO_3^- | sulphate | SO_4^{2-} | | |
| | | hydroxide | OH^- | sulphite | SO_3^{2-} | | |
| | | nitrate | NO_3^- | thiosulphate | $\text{S}_2\text{O}_3^{2-}$ | | |
| | | permanganate | MnO_4^- | | | | |

Radioactive Decay Series

Note: In both tables γ emissions have been omitted.

Table 1 (Plutonium-Uranium)

| Element | Symbol | Mass Number | Atomic Number | Type of Radiation | Half-life Period |
|--------------|--------|-------------|---------------|-------------------|------------------------------|
| plutonium | Pu | 242 | 94 | α | 3.79×10^5 years |
| uranium | U | 238 | 92 | α | 4.51×10^9 years |
| thorium | Th | 234 | 90 | β | 24.1 days |
| protactinium | Pa | 234 | 91 | β | 6.75 hours |
| uranium | U | 234 | 92 | α | 2.47×10^5 years |
| thorium | Th | 230 | 90 | α | 8.0×10^4 years |
| radium | Ra | 226 | 88 | α | 1.62×10^3 years |
| radon | Rn | 222 | 86 | α | 3.82 days |
| polonium | Po | 218 | 84 | α | 3.05 minutes |
| lead | Pb | 214 | 82 | β | 26.8 minutes |
| bismuth | Bi | 214 | 83 | β | 19.7 minutes |
| polonium | Po | 214 | 84 | α | 1.6×10^{-4} seconds |
| thallium | Tl | 210 | 81 | β | 1.3 minutes |
| lead | Pb | 210 | 82 | β | 21 years |
| bismuth | Bi | 210 | 83 | β | 5.01 days |
| polonium | Po | 210 | 84 | α | 138 days |
| lead | Pb | 206 | 82 | stable | |

Table 2 (Thorium)

| Element | Symbol | Mass Number | Atomic Number | Type of Radiation | Half-life Period |
|----------|--------|-------------|---------------|-------------------|-------------------------------|
| thorium | Th | 232 | 90 | α | 1.41×10^{10} years |
| radium | Ra | 228 | 88 | β | 5.8 years |
| actinium | Ac | 228 | 89 | β | 6.13 hours |
| thorium | Th | 228 | 90 | α | 1.91 years |
| radium | Ra | 224 | 88 | α | 3.64 days |
| radon | Rn | 220 | 86 | α | 55 seconds |
| polonium | Po | 216 | 84 | α | 0.15 seconds |
| lead | Pb | 212 | 82 | β | 10.6 hours |
| bismuth | Bi | 212 | 83 | β | 60.6 minutes |
| polonium | Po | 212 | 84 | α | 3.04×10^{-7} seconds |
| thallium | Tl | 208 | 81 | β | 3.10 minutes |
| lead | Pb | 208 | 82 | stable | |

Enthalpies of Formation and Combustion of Selected Substances

| Substance | Standard enthalpy of formation /kJ mol ⁻¹ | Standard enthalpy of combustion /kJ mol ⁻¹ |
|-------------------|---|--|
| hydrogen | – | –286 |
| carbon (graphite) | – | –394 |
| sulphur (rhombic) | – | –297 |
| methane | –75 | –891 |
| ethane | –85 | –1560 |
| propane | –104 | –2220 |
| butane | –125 | –2877 |
| benzene | 49 | –3268 |
| ethene | 52 | –1411 |
| ethyne | 227 | –1300 |
| methanol | –239 | –727 |
| ethanol | –278 | –1367 |
| propan-1-ol | –306 | –2020 |
| methanoic acid | –409 | –255 |
| ethanoic acid | –487 | –876 |

Selected Bond and Mean Bond Enthalpies

Bond Enthalpies

| Bond | Enthalpy /kJ mol ⁻¹ |
|---------|-----------------------------------|
| H – H | 432 |
| O = O | 497 |
| N ≡ N | 941 |
| F – F | 155 |
| Cl – Cl | 243 |
| Br – Br | 194 |
| I – I | 149 |
| H – F | 569 |
| H – Cl | 428 |
| H – Br | 362 |
| H – I | 295 |

Mean Bond Enthalpies

| Bond | Mean Enthalpy /kJ mol ⁻¹ |
|-----------------------|--|
| Si – Si | 222 |
| C – C | 346 |
| C = C | 602 |
| C ≡ C | 835 |
| C ⋯ C (aromatic) } | 519 |
| H – O | 458 |
| H – N | 387 |
| C – H | 414 |
| C – O | 358 |
| C = O | 798 |
| C – F | 486 |
| C – Cl | 326 |
| C – Br | 285 |
| C – I | 213 |

Enthalpy of Sublimation of Carbon

The energy required to convert 1 mole solid carbon into 1 mole gaseous carbon atoms is 715 kJ at 298 K (25°C). The equation is

$$\text{C(s)} \rightarrow \text{C(g)} \quad \Delta H = 715 \text{ kJ}$$

Ionisation Energies and Electronegativities of Selected Elements

Notes: The first ionisation energy for an element E refers to the reaction $E(g) \rightarrow E^+(g) + e^-$; the second ionisation energy refers to $E^+(g) \rightarrow E^{2+}(g) + e^-$; etc.

| Element | Symbol | Ionisation Energies/kJ mol ⁻¹ | | | | Electro-negativity (Pauling scale) |
|------------|--------|--|--------|-------|--------|------------------------------------|
| | | First | Second | Third | Fourth | |
| hydrogen | H | 1311 | – | – | – | 2.2 |
| helium | He | 2380 | 5260 | – | – | – |
| lithium | Li | 526 | 7310 | 11800 | – | 1.0 |
| beryllium | Be | 905 | 1770 | 14800 | – | 1.5 |
| boron | B | 807 | 2440 | 3660 | 25000 | 2.0 |
| carbon | C | 1090 | 2360 | 4640 | 6220 | 2.5 |
| nitrogen | N | 1410 | 2860 | 4580 | 7470 | 3.0 |
| oxygen | O | 1320 | 3400 | 5320 | 7470 | 3.5 |
| fluorine | F | 1690 | 3380 | 6060 | 8410 | 4.0 |
| neon | Ne | 2090 | 3960 | 6140 | 9360 | – |
| sodium | Na | 502 | 4560 | 6920 | 9540 | 0.9 |
| magnesium | Mg | 744 | 1460 | 7750 | 10500 | 1.2 |
| aluminium | Al | 584 | 1830 | 2760 | 11600 | 1.5 |
| silicon | Si | 792 | 1590 | 3250 | 4350 | 1.9 |
| phosphorus | P | 1020 | 1920 | 2930 | 4950 | 2.2 |
| sulphur | S | 1010 | 2260 | 3380 | 4560 | 2.5 |
| chlorine | Cl | 1260 | 2310 | 3840 | 5160 | 3.0 |
| argon | Ar | 1530 | 2670 | 3950 | 5770 | – |
| potassium | K | 425 | 3060 | 4440 | 5880 | 0.8 |
| calcium | Ca | 596 | 1160 | 4930 | 6470 | 1.0 |
| scandium | Sc | 637 | 1250 | 2410 | 7130 | 1.3 |
| titanium | Ti | 664 | 1320 | 2670 | 4170 | 1.5 |
| vanadium | V | 656 | 1430 | 2850 | 4600 | 1.6 |
| chromium | Cr | 659 | 1600 | 3000 | 4800 | 1.6 |
| manganese | Mn | 723 | 1520 | 3270 | 5000 | 1.5 |
| iron | Fe | 766 | 1570 | 2970 | 5480 | 1.8 |
| cobalt | Co | 764 | 1660 | 3250 | – | 1.8 |
| nickel | Ni | 743 | 1770 | 3410 | 5400 | 1.9 |
| copper | Cu | 751 | 1970 | 3570 | 5700 | 1.9 |
| zinc | Zn | 913 | 1740 | 3850 | 5990 | 1.6 |
| arsenic | As | 947 | 1798 | 2736 | 4838 | 2.2 |
| bromine | Br | 1150 | 2100 | 3480 | 4560 | 2.8 |
| rubidium | Rb | 409 | 2670 | 3880 | – | 0.8 |
| strontium | Sr | 556 | 1080 | 4120 | 5500 | 1.0 |
| silver | Ag | 731 | 2073 | 3361 | – | 1.9 |
| tin | Sn | 709 | 1412 | 2942 | 3930 | 1.8 |
| antimony | Sb | 834 | 1595 | 2439 | 4265 | 2.1 |
| iodine | I | 1020 | 1850 | 2040 | – | 2.6 |
| caesium | Cs | 382 | 2440 | – | – | 0.8 |
| barium | Ba | 509 | 979 | 3420 | – | 0.9 |
| gold | Au | 890 | 1979 | – | – | 2.4 |
| lead | Pb | 716 | 1450 | 3081 | 4084 | 1.8 |

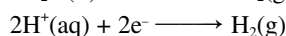
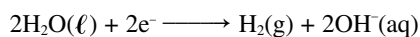
Electrochemical Series: Standard Reduction Potentials

Note: The data given below are reduction potentials applicable to standard state conditions.

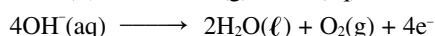
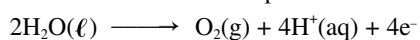
| Reaction | E°/V |
|---|-------------|
| $\text{Li}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Li}(\text{s})$ | -3.02 |
| $\text{Cs}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Cs}(\text{s})$ | -2.92 |
| $\text{Rb}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Rb}(\text{s})$ | -2.92 |
| $\text{K}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{K}(\text{s})$ | -2.92 |
| $\text{Sr}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Sr}(\text{s})$ | -2.89 |
| $\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Ca}(\text{s})$ | -2.76 |
| $\text{Na}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Na}(\text{s})$ | -2.71 |
| $\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Mg}(\text{s})$ | -2.37 |
| $\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightleftharpoons \text{Al}(\text{s})$ | -1.68 |
| $2\text{H}_2\text{O}(\ell) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ | -0.83 |
| $\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Zn}(\text{s})$ | -0.76 |
| $\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightleftharpoons \text{Cr}(\text{s})$ | -0.74 |
| $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$ | -0.44 |
| $\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Ni}(\text{s})$ | -0.23 |
| $\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Sn}(\text{s})$ | -0.14 |
| $\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Pb}(\text{s})$ | -0.13 |
| $\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$ | -0.04 |
| $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$ | 0.00 |
| $\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+}(\text{aq})$ | 0.15 |
| $\text{Cu}^{2+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Cu}^+(\text{aq})$ | 0.15 |
| $\text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\ell)$ | 0.17 |
| $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$ | 0.34 |
| $\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\ell) + 4\text{e}^- \rightleftharpoons 4\text{OH}^-(\text{aq})$ | 0.40 |
| $\text{I}_2(\text{s}) + 2\text{e}^- \rightleftharpoons 2\text{I}^-(\text{aq})$ | 0.54 |
| $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$ | 0.77 |
| $\text{Ag}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Ag}(\text{s})$ | 0.80 |
| $\text{Hg}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Hg}(\ell)$ | 0.85 |
| $\text{Br}_2(\ell) + 2\text{e}^- \rightleftharpoons 2\text{Br}^-(\text{aq})$ | 1.07 |
| $\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}(\ell)$ | 1.23 |
| $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\ell)$ | 1.33 |
| $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$ | 1.36 |
| $\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\ell)$ | 1.51 |
| $\text{F}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{F}^-(\text{aq})$ | 2.87 |

Electrolysis of Water

Reduction reactions at the negative electrode



Oxidation reactions at the positive electrode



Dissociation Constants of Selected Species

| Equilibrium in aqueous solution | | | | $K_a/\text{mol l}^{-1}$ | $\text{p}K_a$ |
|---------------------------------|---|----------------------|---|-------------------------|---------------|
| methanoic acid | HCOOH | \rightleftharpoons | $\text{H}^+ + \text{HCOO}^-$ | 1.8×10^{-4} | 3.75 |
| ethanoic acid | CH_3COOH | \rightleftharpoons | $\text{H}^+ + \text{CH}_3\text{COO}^-$ | 1.7×10^{-5} | 4.76 |
| propanoic acid | $\text{CH}_3\text{CH}_2\text{COOH}$ | \rightleftharpoons | $\text{H}^+ + \text{CH}_3\text{CH}_2\text{COO}^-$ | 1.3×10^{-5} | 4.87 |
| butanoic acid | $\text{CH}_3(\text{CH}_2)_2\text{COOH}$ | \rightleftharpoons | $\text{H}^+ + \text{CH}_3(\text{CH}_2)_2\text{COO}^-$ | 1.5×10^{-5} | 4.83 |
| benzoic acid | $\text{C}_6\text{H}_5\text{COOH}$ | \rightleftharpoons | $\text{H}^+ + \text{C}_6\text{H}_5\text{COO}^-$ | 6.3×10^{-5} | 4.20 |
| phenol | $\text{C}_6\text{H}_5\text{OH}$ | \rightleftharpoons | $\text{H}^+ + \text{C}_6\text{H}_5\text{O}^-$ | 1.0×10^{-10} | 9.99 |
| hydrofluoric acid | HF | \rightleftharpoons | $\text{H}^+ + \text{F}^-$ | 6.8×10^{-4} | 3.17 |
| boric acid | H_3BO_3 | \rightleftharpoons | $\text{H}^+ + \text{H}_2\text{BO}_3^-$ | 5.4×10^{-10} | 9.27 |
| hydrocyanic acid | HCN | \rightleftharpoons | $\text{H}^+ + \text{CN}^-$ | 6.2×10^{-10} | 9.21 |
| carbonic acid | $\text{H}_2\text{O} + \text{CO}_2$ | \rightleftharpoons | $\text{H}^+ + \text{HCO}_3^-$ | 4.5×10^{-7} | 6.35 |
| hydrogencarbonate ion | HCO_3^- | \rightleftharpoons | $\text{H}^+ + \text{CO}_3^{2-}$ | 4.7×10^{-11} | 10.33 |
| sulphurous acid | H_2SO_3 | \rightleftharpoons | $\text{H}^+ + \text{HSO}_3^-$ | 1.4×10^{-2} | 1.85 |
| hydrogensulphite ion | HSO_3^- | \rightleftharpoons | $\text{H}^+ + \text{SO}_3^{2-}$ | 6.3×10^{-8} | 7.19 |
| hydrogen sulphide | H_2S | \rightleftharpoons | $\text{H}^+ + \text{HS}^-$ | 8.9×10^{-8} | 7.05 |
| hydrogensulphide ion | HS^- | \rightleftharpoons | $\text{H}^+ + \text{S}^{2-}$ | 1.3×10^{-4} | 13.90 |
| phosphoric acid | H_3PO_4 | \rightleftharpoons | $\text{H}^+ + \text{H}_2\text{PO}_4^-$ | 6.9×10^{-3} | 2.16 |
| dihydrogenphosphate ion | H_2PO_4^- | \rightleftharpoons | $\text{H}^+ + \text{HPO}_4^{2-}$ | 6.2×10^{-8} | 7.21 |
| hydrogenphosphate ion | HPO_4^{2-} | \rightleftharpoons | $\text{H}^+ + \text{PO}_4^{3-}$ | 4.8×10^{-13} | 12.32 |
| ammonium ion | NH_4^+ | \rightleftharpoons | $\text{H}^+ + \text{NH}_3$ | 5.8×10^{-10} | 9.24 |
| methylammonium ion | CH_3NH_3^+ | \rightleftharpoons | $\text{H}^+ + \text{CH}_3\text{NH}_2$ | 2.2×10^{-11} | 10.66 |
| phenylammonium ion | $\text{C}_6\text{H}_5\text{NH}_3^+$ | \rightleftharpoons | $\text{H}^+ + \text{C}_6\text{H}_5\text{NH}_2$ | 1.3×10^{-5} | 4.87 |

Infra-red Correlation Table

| Wave number range/cm ⁻¹ | Type of compound | Infra-red absorption due to |
|------------------------------------|--|--|
| 3570 – 3200 | alcohols and phenols | hydrogen bonded O – H stretch |
| 3650 – 3590 | alcohols and phenols | not hydrogen bonded O – H stretch |
| 3500 – 3300 | amine, not hydrogen bonded | N – H stretch |
| 3300 | alkyne | C – H stretch in C ≡ C – H |
| 3095 – 3010 | alkene | C – H stretch in C = C – H |
| 3100 – 3000 | benzene ring | C – H stretch |
| 2962 – 2853 | alkane | C – H stretch |
| 2900 – 2820 | aldehyde | C – H stretch in –CHO |
| 2775 – 2700 | aldehyde | C – H stretch in –CHO |
| 3500 – 2500 | carboxylic acid | hydrogen bonded O – H stretch in –COOH |
| 2260 – 2215 | nitriles | C ≡ N stretch |
| 2260 – 2100 | alkynes | C ≡ C stretch |
| 1750 – 1735 | ester | C = O stretch |
| 1740 – 1720 | aldehyde | C = O stretch |
| 1730 – 1717 | aromatic ester | C = O stretch |
| 1725 – 1700 | carboxylic acid | C = O stretch |
| 1700 – 1680 | aromatic and alkyl ketones } aromatic carboxylic acid } | C = O stretch |
| 1680 – 1620 | alkene | C = C stretch |
| 1600, 1580, 1500 and 1450 | benzene ring | C ≡ C (aromatic) stretch |
| 1485 – 1340 | alkane | C – H bend |
| 1275 – 1200 | aromatic ether | C – O stretch |
| 1150 – 1070 | alkyl ether | C – O stretch |

Spectral Lines and Flame Colours

Gas Discharge Lamps

| Element | Wavelength/nm | Colour |
|-----------------------------|---------------|---------------|
| hydrogen (Balmer series) | 656 | red |
| | 486 | blue-green |
| | 434 | blue-green |
| | 410 | violet |
| | 397 | ultra-violet |
| | 389 | ultra-violet |
| helium | 706 | red |
| | 667 | red |
| | 588 | orange-yellow |

Metal Vapour Lamps

| Element | Wavelength/nm | Colour |
|---------|----------------|--------------------|
| cadmium | 644 | red |
| | 509 | green |
| | 480 | blue |
| mercury | 579 } 577 } | yellow doublet |
| | 546 | green |
| | 436 | blue-violet |
| | 405 | violet |
| | 310 | ultra-violet |
| | sodium | 589.0 } 589.6 } |

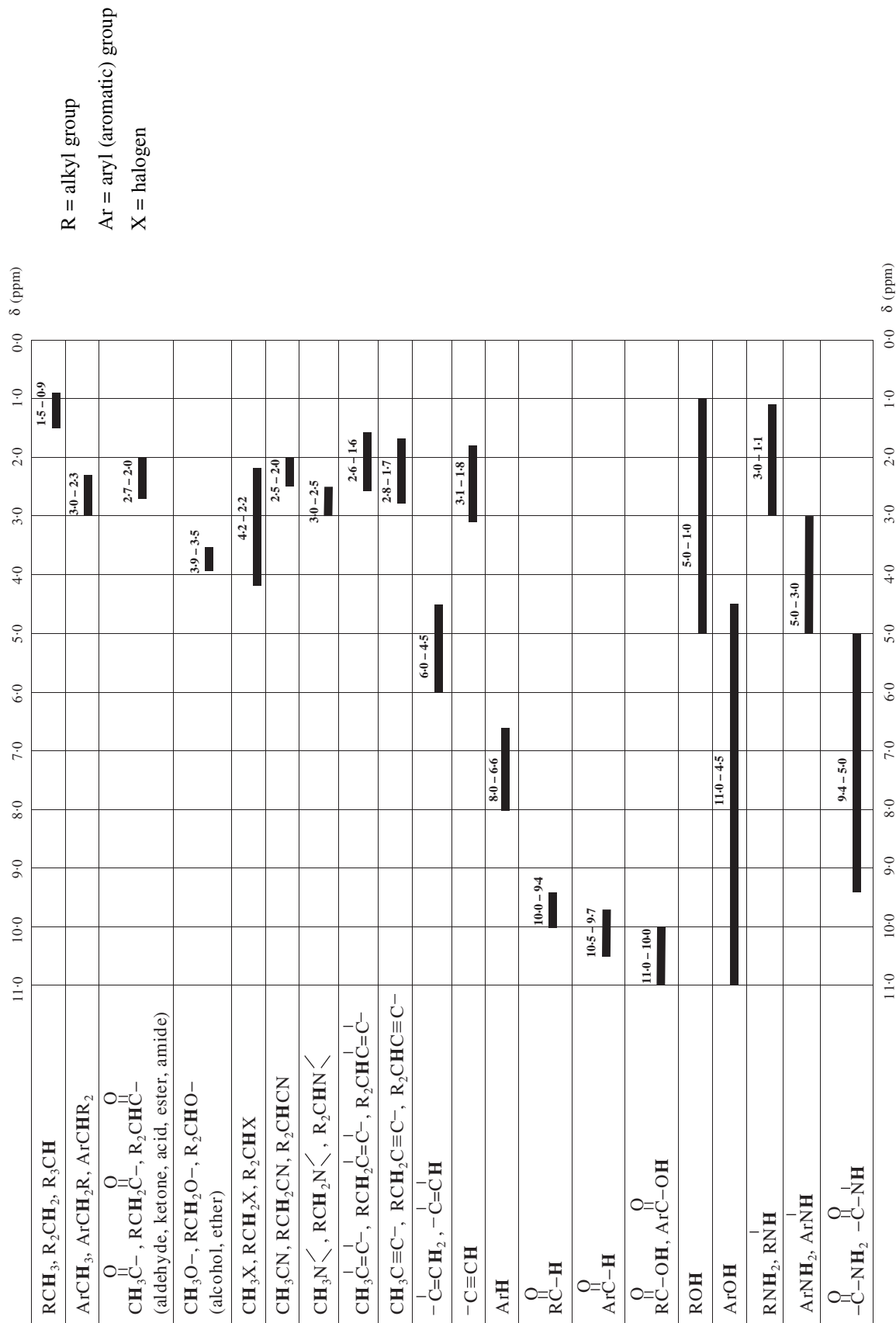
Flame Colours

Note: The data refers to prominent spectral lines.

| Element | Wavelength/nm | Colour |
|-----------|---------------|---------------|
| barium | 554 | green |
| calcium | 620 | orange-red |
| copper | 325 | blue-green |
| lithium | 671 | crimson |
| potassium | 405 | lilac |
| sodium | 589 | orange-yellow |
| strontium | 650 | red |

Proton NMR Spectra Correlation Chart

Note: Approximate chemical shift values of hydrogen atoms in different structural environments relative to tetramethylsilane (TMS) for which $\delta = 0$ ppm



Ionic Radii of Selected Ions

| Ion | Radius/pm |
|------------------|-----------|
| H ⁻ | 208 |
| Li ⁺ | 68 |
| Be ²⁺ | 31 |
| N ³⁻ | 142 |
| O ²⁻ | 136 |
| F ⁻ | 133 |
| Na ⁺ | 95 |
| Mg ²⁺ | 65 |
| Al ³⁺ | 50 |
| P ³⁻ | 198 |
| S ²⁻ | 184 |
| Cl ⁻ | 181 |
| K ⁺ | 133 |
| Ca ²⁺ | 100 |
| Ti ³⁺ | 67 |
| V ³⁺ | 64 |
| Cr ²⁺ | 73 |
| Cr ³⁺ | 62 |
| Mn ²⁺ | 67 |
| Fe ²⁺ | 61 |
| Fe ³⁺ | 55 |
| Co ²⁺ | 65 |
| Co ³⁺ | 55 |
| Ni ²⁺ | 69 |
| Cu ⁺ | 60 |
| Cu ²⁺ | 72 |
| Zn ²⁺ | 74 |
| Br ⁻ | 196 |
| Rb ⁺ | 161 |
| Sr ²⁺ | 126 |
| Ag ⁺ | 126 |
| Sn ²⁺ | 101 |
| I ⁻ | 220 |
| Cs ⁺ | 174 |
| Ba ²⁺ | 135 |
| Hg ²⁺ | 110 |
| Pb ²⁺ | 120 |

Standard Entropy Values for Selected Substances

| Substance | Standard Entropy/J K ⁻¹ mol ⁻¹ |
|------------------------------------|--|
| H ₂ (g) | 131 |
| He(g) | 126 |
| Li(s) | 29 |
| B(s) | 5.9 |
| C(s) (graphite) | 5.7 |
| C(s) (diamond) | 2.4 |
| N ₂ (g) | 192 |
| O ₂ (g) | 205 |
| F ₂ (g) | 203 |
| Na(s) | 51 |
| Mg(s) | 33 |
| Al(s) | 28 |
| Si(s) | 19 |
| Cl ₂ (g) | 223 |
| K(s) | 65 |
| Ca(s) | 42 |
| Fe(s) | 27 |
| Ni(s) | 30 |
| Cu(s) | 33 |
| Br ₂ (ℓ) | 152 |
| Ag(s) | 43 |
| I ₂ (s) | 116 |
| Cs(s) | 85 |
| Ba(s) | 63 |
| Au(s) | 47 |
| Hg(ℓ) | 76 |
| H ₂ O(ℓ) | 70 |
| H ₂ O(g) | 189 |
| CO ₂ (g) | 214 |
| MgO(s) | 27 |
| Al ₂ O ₃ (s) | 51 |
| SO ₂ (g) | 248 |
| CaO(s) | 38 |
| BaO(s) | 72 |
| NaCl(s) | 72 |
| CaCl ₂ (s) | 108 |
| CsCl(s) | 99 |

**Standard Molar Enthalpies
of Atomisation of
Selected Elements**

| Element | $\Delta H^\circ/\text{kJ mol}^{-1}$ |
|---------|-------------------------------------|
| H | 216 |
| Li | 159 |
| Be | 326 |
| B | 565 |
| C | 715 |
| N | 471 |
| O | 249 |
| F | 78 |
| Na | 109 |
| Mg | 147 |
| Al | 330 |
| Si | 450 |
| P | 317 |
| S | 227 |
| Cl | 121 |
| K | 88 |
| Ca | 178 |
| Sc | 378 |
| Ti | 473 |
| V | 515 |
| Cr | 397 |
| Mn | 283 |
| Fe | 414 |
| Co | 427 |
| Ni | 430 |
| Cu | 337 |
| Zn | 130 |
| Br | 112 |
| Rb | 81 |
| Sr | 163 |
| Ag | 285 |
| Sn | 301 |
| I | 107 |
| Cs | 77 |
| Ba | 178 |

**Lattice Enthalpies
of Selected Compounds**

| Compound | Lattice Enthalpy/ kJ mol^{-1} |
|--------------------------------|--|
| Li ₂ O | -2799 |
| BeO | -4293 |
| Na ₂ O | -2481 |
| MgO | -3795 |
| Al ₂ O ₃ | -15916 |
| K ₂ O | -2238 |
| CaO | -3414 |
| FeO | -3795 |
| CoO | -3837 |
| NiO | -3908 |
| CuO | -4135 |
| ZnO | -4142 |
| SrO | -3217 |
| Ag ₂ O | -3002 |
| BaO | -3029 |
| LiCl | -834 |
| NaCl | -769 |
| MgCl ₂ | -2326 |
| KCl | -701 |
| CaCl ₂ | -2223 |
| CoCl ₂ | -2709 |
| NiCl ₂ | -2753 |
| CuCl | -921 |
| CuCl ₂ | -2774 |
| SrCl ₂ | -2127 |
| AgCl | -864 |
| BaCl ₂ | -2033 |
| LiF | -1030 |
| NaF | -910 |
| MgF ₂ | -2913 |
| KF | -808 |
| CaF ₂ | -2609 |
| NiF ₂ | -2845 |
| SrF ₂ | -2476 |
| AgF | -953 |
| BaF ₂ | -2341 |
| MgS | -3274 |
| CaS | -3002 |
| BaS | -2713 |
| NiS | -3528 |
| ZnS | -3692 |
| LiBr | -788 |
| NaBr | -732 |
| KBr | -671 |
| NiBr ₂ | -2699 |
| CuBr ₂ | -2711 |
| AgBr | -830 |

Electron Affinities of Selected Elements

| Element | Electron Affinity/kJ mol ⁻¹ |
|-------------------|--|
| H | -73 |
| O | -141 |
| (O ⁻) | +844 |
| F | -328 |
| S | -200 |
| (S ⁻) | +456 |
| Cl | -349 |
| Br | -325 |
| I | -295 |

The electron affinity for an element E refers to the reaction $E(g) + e^- \rightarrow E^-(g)$.

The second electron affinity refers to the reaction $E^-(g) + e^- \rightarrow E^{2-}(g)$.

Hydration Enthalpies of Selected Ions

| Ion | Hydration Enthalpy/kJ mol ⁻¹ |
|------------------|---|
| Li ⁺ | -520 |
| Na ⁺ | -405 |
| K ⁺ | -321 |
| Mg ²⁺ | -1920 |
| Al ³⁺ | -4690 |
| Ca ²⁺ | -1650 |
| Fe ²⁺ | -1950 |
| Fe ³⁺ | -4430 |
| Cu ²⁺ | -2100 |
| Zn ²⁺ | -2050 |
| Rb ⁺ | -300 |
| Sr ²⁺ | -1480 |
| Ag ⁺ | -464 |
| Cs ⁺ | -277 |
| Ba ²⁺ | -1360 |
| OH ⁻ | -460 |
| F ⁻ | -506 |
| Cl ⁻ | -364 |
| Br ⁻ | -337 |
| I ⁻ | -296 |

The hydration enthalpy for the ion of an element E refers to the changes represented by

$E^{n+}(g) \rightarrow E^{n+}(aq)$ and $E^{n-}(g) \rightarrow E^{n-}(aq)$.

Systeme Internationale (SI) Units

| Quantity | Name of Unit | Symbol |
|-------------------------------|----------------|--------|
| length | metre | m |
| mass | kilogram | kg |
| time | second | s |
| electric current | ampere | A |
| temperature | degree celsius | °C |
| energy | joule | J |
| electric charge | coulomb | C |
| electric potential difference | volt | V |
| amount of substance | mole | mol |

Physical Constants

| Quantity | Symbol | Value |
|--------------------------|--------|--|
| charge on electron | e^- | $1.60 \times 10^{-19} \text{ C}$ |
| Avogadro constant | L | $6.02 \times 10^{23} \text{ mol}^{-1}$ |
| Faraday constant | F | $9.65 \times 10^4 \text{ C mol}^{-1}$ |
| Planck constant | h | $6.63 \times 10^{-34} \text{ J s}$ |
| speed of light in vacuum | c | $3.00 \times 10^8 \text{ m s}^{-1}$ |

Properties of Water

| Quantity | Value |
|--|---|
| specific heat capacity of liquid water | $4.18 \text{ kJ kg}^{-1} \text{ }^\circ\text{C}^{-1}$ |
| ionic product of water | 10^{-14} at $24 \text{ }^\circ\text{C}$ |

SI Prefixes and Multiplication Factors

| SI Prefix | Symbol | Multiplication |
|-----------|--------|----------------|
| tera | T | 10^{12} |
| giga | G | 10^9 |
| mega | M | 10^6 |
| kilo | k | 10^3 |
| deci | d | 10^{-1} |
| centi | c | 10^{-2} |
| milli | m | 10^{-3} |
| micro | μ | 10^{-6} |
| nano | n | 10^{-9} |
| pico | p | 10^{-12} |

Conversion Factors

| For Volume | For Thermodynamic Temperature |
|---|-----------------------------------|
| $1 \text{ litre} = 1 \text{ dm}^3 = 1000 \text{ cm}^3$ $1000 \text{ litres} = 1000 \text{ dm}^3 = 1 \text{ m}^3$ | $0^\circ\text{C} = 273 \text{ K}$ |