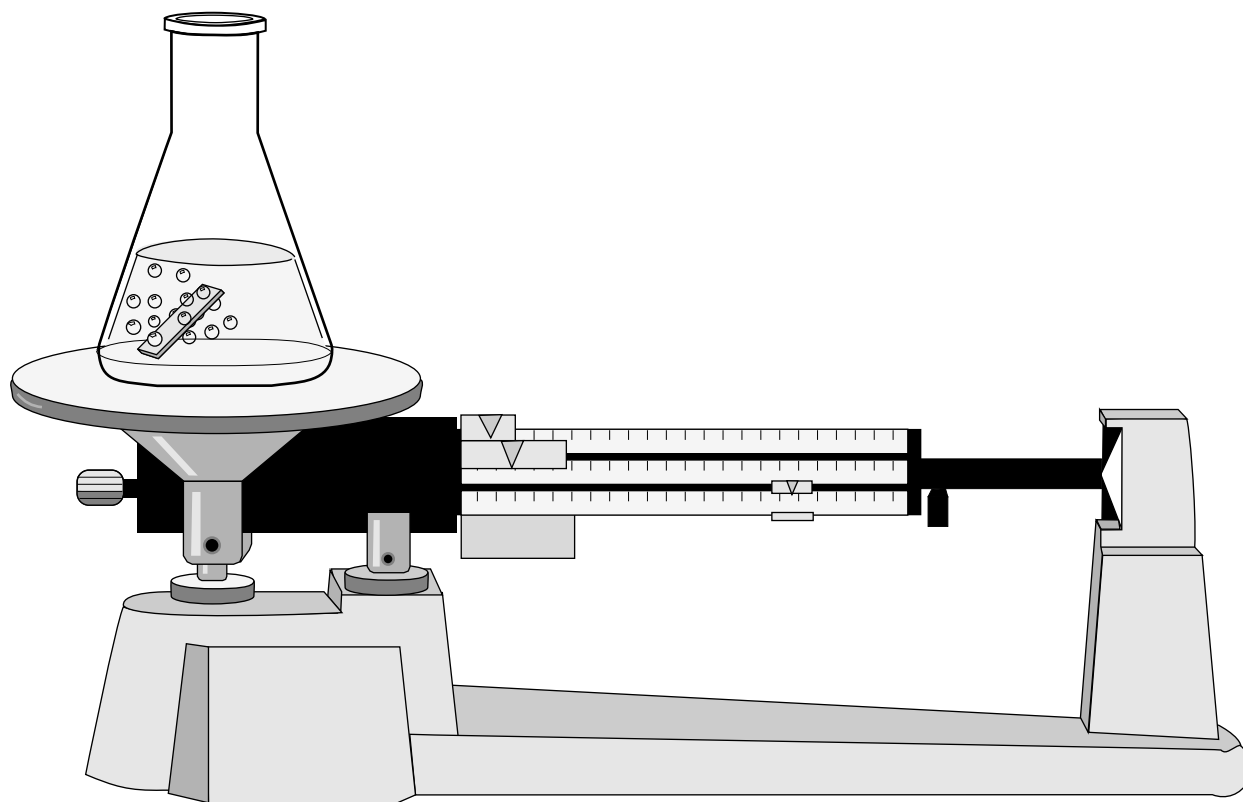


Data Booklet

CHEMISTRY 12

Work done in this booklet
will not be marked.



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REFERENCE

D.R. Lide, *CRC Handbook of Chemistry and Physics*, 80th edition, CRC Press, Boca Raton, 1999.

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 Hydrogen 1.0 | <div style="display: flex; justify-content: space-between; align-items: center;"> 14 • Atomic Number </div> <div style="display: flex; justify-content: space-between; align-items: center;"> Si • Symbol </div> <div style="display: flex; justify-content: space-between; align-items: center;"> Silicon • Name </div> <div style="display: flex; justify-content: space-between; align-items: center;"> 28.1 • Atomic Mass </div> | | | | | | | | | | | | | | | | 2 He Helium 4.0 | | | | | | | | | | | | | | | | | |
| 3 Li Lithium 6.9 | | | | | | | | | | | | | | | | | 4 Be Beryllium 9.0 | 11 Na Sodium 23.0 | 12 Mg Magnesium 24.3 | 19 K Potassium 39.1 | 20 Ca Calcium 40.1 | 21 Sc Scandium 45.0 | 22 Ti Titanium 47.9 | 23 V Vanadium 50.9 | 24 Cr Chromium 52.0 | 25 Mn Manganese 54.9 | 26 Fe Iron 55.8 | 27 Co Cobalt 58.9 | 28 Ni Nickel 58.7 | 29 Cu Copper 63.5 | 30 Zn Zinc 65.4 | 31 Ga Gallium 69.7 | 32 Ge Germanium 72.6 | 33 As Arsenic 74.9 |
| 37 Rb Rubidium 85.5 | 38 Sr Strontium 87.6 | 39 Y Yttrium 88.9 | 40 Zr Zirconium 91.2 | 41 Nb Niobium 92.9 | 42 Mo Molybdenum 95.9 | 43 Tc Technetium (98) | 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 Cesium 132.9 | 56 Ba Barium 137.3 | 57 La Lanthanum 138.9 | 58 Ce Cerium 140.1 | 59 Pr Praseodymium 140.9 | 60 Nd Neodymium 144.2 | 61 Pm Promethium (145) | 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 |
| 87 Fr Francium (223) | 88 Ra Radium (226) | 89 Ac Actinium (227) | 90 Rf Rutherfordium (261) | 91 Db Dubnium (262) | 92 Sg Seaborgium (263) | 93 Bh Bohrium (262) | 94 Hs Hassium (265) | 95 Mt Meitnerium (266) | 96 Lr Lawrencium (262) | 97 U Uranium 238.0 | 98 Np Neptunium (237) | 99 Pu Plutonium (244) | 100 Am Americium (243) | 101 Cm Curium (247) | 102 Bk Berkelium (247) | 103 Cf Californium (251) | 104 Es Einsteinium (252) | 105 Fm Fermium (257) | 106 Md Mendelevium (258) | 107 No Nobelium (259) | 108 Lr Lawrencium (262) | 109 Uu Ununennium (289) | 110 Uub Ununbium (288) | 111 Uut Ununtrium (288) | 112 Uuq Ununquadium (289) | 113 Uuq Ununquadium (288) | 114 Uuq Ununquadium (289) | 115 Uup Ununpentium (288) | 116 Uuq Ununquadium (289) | 117 Uuh Ununheptium (289) | 118 Uuo Ununoctium (289) | 119 Uuh Ununheptium (288) | 120 Uuo Ununoctium (289) | |

Based on mass of C₁₂ at 12.00.

Values in parentheses are the masses of the most stable or best known isotopes for elements which do not occur naturally.

ATOMIC MASSES OF THE ELEMENTS

*Based on mass of C¹² at 12.00.
Values in parentheses are the mass number of the most stable or best
known isotopes for elements that do not occur naturally.*

| Element | Symbol | Atomic Number | Atomic Mass | Element | Symbol | Atomic Number | Atomic Mass |
|-------------|--------|---------------|-------------|---------------|--------|---------------|-------------|
| Actinium | Ac | 89 | (227) | Mercury | Hg | 80 | 200.6 |
| Aluminum | Al | 13 | 27.0 | Molybdenum | Mo | 42 | 95.9 |
| Americium | Am | 95 | (243) | Neodymium | Nd | 60 | 144.2 |
| Antimony | Sb | 51 | 121.8 | Neon | Ne | 10 | 20.2 |
| Argon | Ar | 18 | 39.9 | Neptunium | Np | 93 | (237) |
| Arsenic | As | 33 | 74.9 | Nickel | Ni | 28 | 58.7 |
| Astatine | At | 85 | (210) | Niobium | Nb | 41 | 92.9 |
| Barium | Ba | 56 | 137.3 | Nitrogen | N | 7 | 14.0 |
| Berkelium | Bk | 97 | (247) | Nobelium | No | 102 | (259) |
| Beryllium | Be | 4 | 9.0 | Osmium | Os | 76 | 190.2 |
| Bismuth | Bi | 83 | 209.0 | Oxygen | O | 8 | 16.0 |
| Boron | B | 5 | 10.8 | Palladium | Pd | 46 | 106.4 |
| Bromine | Br | 35 | 79.9 | Phosphorus | P | 15 | 31.0 |
| Cadmium | Cd | 48 | 112.4 | Platinum | Pt | 78 | 195.1 |
| Calcium | Ca | 20 | 40.1 | Plutonium | Pu | 94 | (244) |
| Californium | Cf | 98 | (251) | Polonium | Po | 84 | (209) |
| Carbon | C | 6 | 12.0 | Potassium | K | 19 | 39.1 |
| Cerium | Ce | 58 | 140.1 | Praseodymium | Pr | 59 | 140.9 |
| Cesium | Cs | 55 | 132.9 | Promethium | Pm | 61 | (145) |
| Chlorine | Cl | 17 | 35.5 | Protactinium | Pa | 91 | 231.0 |
| Chromium | Cr | 24 | 52.0 | Radium | Ra | 88 | (226) |
| Cobalt | Co | 27 | 58.9 | Radon | Rn | 86 | (222) |
| Copper | Cu | 29 | 63.5 | Rhenium | Re | 75 | 186.2 |
| Curium | Cm | 96 | (247) | Rhodium | Rh | 45 | 102.9 |
| Dubnium | Db | 105 | (262) | Rubidium | Rb | 37 | 85.5 |
| Dysprosium | Dy | 66 | 162.5 | Ruthenium | Ru | 44 | 101.1 |
| Einsteinium | Es | 99 | (252) | Rutherfordium | Rf | 104 | (261) |
| Erbium | Er | 68 | 167.3 | Samarium | Sm | 62 | 150.4 |
| Europium | Eu | 63 | 152.0 | Scandium | Sc | 21 | 45.0 |
| Fermium | Fm | 100 | (257) | Selenium | Se | 34 | 79.0 |
| Fluorine | F | 9 | 19.0 | Silicon | Si | 14 | 28.1 |
| Francium | Fr | 87 | (223) | Silver | Ag | 47 | 107.9 |
| Gadolinium | Gd | 64 | 157.3 | Sodium | Na | 11 | 23.0 |
| Gallium | Ga | 31 | 69.7 | Strontium | Sr | 38 | 87.6 |
| Germanium | Ge | 32 | 72.6 | Sulphur | S | 16 | 32.1 |
| Gold | Au | 79 | 197.0 | Tantalum | Ta | 73 | 180.9 |
| Hafnium | Hf | 72 | 178.5 | Technetium | Tc | 43 | (98) |
| Helium | He | 2 | 4.0 | Tellurium | Te | 52 | 127.6 |
| Holmium | Ho | 67 | 164.9 | Terbium | Tb | 65 | 158.9 |
| Hydrogen | H | 1 | 1.0 | Thallium | Tl | 81 | 204.4 |
| Indium | In | 49 | 114.8 | Thorium | Th | 90 | 232.0 |
| Iodine | I | 53 | 126.9 | Thulium | Tm | 69 | 168.9 |
| Iridium | Ir | 77 | 192.2 | Tin | Sn | 50 | 118.7 |
| Iron | Fe | 26 | 55.8 | Titanium | Ti | 22 | 47.9 |
| Krypton | Kr | 36 | 83.8 | Tungsten | W | 74 | 183.8 |
| Lanthanum | La | 57 | 138.9 | Uranium | U | 92 | 238.0 |
| Lawrencium | Lr | 103 | (262) | Vanadium | V | 23 | 50.9 |
| Lead | Pb | 82 | 207.2 | Xenon | Xe | 54 | 131.3 |
| Lithium | Li | 3 | 6.9 | Ytterbium | Yb | 70 | 173.0 |
| Lutetium | Lu | 71 | 175.0 | Yttrium | Y | 39 | 88.9 |
| Magnesium | Mg | 12 | 24.3 | Zinc | Zn | 30 | 65.4 |
| Manganese | Mn | 25 | 54.9 | Zirconium | Zr | 40 | 91.2 |
| Mendelevium | Md | 101 | (258) | | | | |

NAMES, FORMULAE, AND CHARGES OF SOME COMMON IONS

* *Aqueous solutions are readily oxidized by air.*

** *Not stable in aqueous solutions.*

| Positive Ions (Cations) | | | |
|------------------------------------|------------------------|--------------------|--------------------------|
| Al^{3+} | Aluminum | Pb^{4+} | Lead(IV), plumbic |
| NH_4^+ | Ammonium | Li^+ | Lithium |
| Ba^{2+} | Barium | Mg^{2+} | Magnesium |
| Ca^{2+} | Calcium | Mn^{2+} | Manganese(II), manganous |
| Cr^{2+} | Chromium(II), chromous | Mn^{4+} | Manganese(IV) |
| Cr^{3+} | Chromium(III), chromic | Hg_2^{2+} | Mercury(I)*, mercurous |
| Cu^+ | Copper(I)*, cuprous | Hg^{2+} | Mercury(II), mercuric |
| Cu^{2+} | Copper(II), cupric | K^+ | Potassium |
| H^+ | Hydrogen | Ag^+ | Silver |
| H_3O^+ | Hydronium | Na^+ | Sodium |
| Fe^{2+} | Iron(II)*, ferrous | Sn^{2+} | Tin(II)*, stannous |
| Fe^{3+} | Iron(III), ferric | Sn^{4+} | Tin(IV), stannic |
| Pb^{2+} | Lead(II), plumbous | Zn^{2+} | Zinc |

| Negative Ions (Anions) | | | |
|-----------------------------------|---------------------------------|-----------------------------|------------------------|
| Br^- | Bromide | OH^- | Hydroxide |
| CO_3^{2-} | Carbonate | ClO^- | Hypochlorite |
| ClO_3^- | Chlorate | I^- | Iodide |
| Cl^- | Chloride | HPO_4^{2-} | Monohydrogen phosphate |
| ClO_2^- | Chlorite | NO_3^- | Nitrate |
| CrO_4^{2-} | Chromate | NO_2^- | Nitrite |
| CN^- | Cyanide | $\text{C}_2\text{O}_4^{2-}$ | Oxalate |
| $\text{Cr}_2\text{O}_7^{2-}$ | Dichromate | O^{2-} | Oxide** |
| H_2PO_4^- | Dihydrogen phosphate | ClO_4^- | Perchlorate |
| CH_3COO^- | Ethanoate, acetate | MnO_4^- | Permanganate |
| F^- | Fluoride | PO_4^{3-} | Phosphate |
| HCO_3^- | Hydrogen carbonate, bicarbonate | SO_4^{2-} | Sulphate |
| HC_2O_4^- | Hydrogen oxalate, binoxalate | S^{2-} | Sulphide |
| HSO_4^- | Hydrogen sulphate, bisulphate | SO_3^{2-} | Sulphite |
| HS^- | Hydrogen sulphide, bisulphide | SCN^- | Thiocyanate |
| HSO_3^- | Hydrogen sulphite, bisulphite | | |

SOLUBILITY OF COMMON COMPOUNDS IN WATER

The term soluble here means > 0.1 mol/L at 25°C.

| Negative Ions (Anions) | Positive Ions (Cations) | Solubility of Compounds |
|---|---|----------------------------|
| All | Alkali ions: Li ⁺ , Na ⁺ , K ⁺ , Rb ⁺ , Cs ⁺ , Fr ⁺ | Soluble |
| All | Hydrogen ion: H ⁺ | Soluble |
| All | Ammonium ion: NH ₄ ⁺ | Soluble |
| Nitrate, NO ₃ ⁻ | All | Soluble |
| Chloride, Cl ⁻ or Bromide, Br ⁻ or Iodide, I ⁻ | All others | Soluble |
| | Ag ⁺ , Pb ²⁺ , Cu ⁺ | Low Solubility |
| Sulphate, SO ₄ ²⁻ | All others | Soluble |
| | Ag ⁺ , Ca ²⁺ , Sr ²⁺ , Ba ²⁺ , Pb ²⁺ | Low Solubility |
| Sulphide, S ²⁻ | Alkali ions, H ⁺ , NH ₄ ⁺ , Be ²⁺ , Mg ²⁺ , Ca ²⁺ , Sr ²⁺ , Ba ²⁺ | Soluble |
| | All others | Low Solubility |
| Hydroxide, OH ⁻ | Alkali ions, H ⁺ , NH ₄ ⁺ , Sr ²⁺ | Soluble |
| | All others | Low Solubility |
| Phosphate, PO ₄ ³⁻ or Carbonate, CO ₃ ²⁻ or Sulphite, SO ₃ ²⁻ | Alkali ions, H ⁺ , NH ₄ ⁺ | Soluble |
| | All others | Low Solubility |

SOLUBILITY PRODUCT CONSTANTS AT 25°C

| Name | Formula | K_{sp} |
|---------------------|-----------------------------------|-----------------------|
| Barium carbonate | BaCO ₃ | 2.6×10^{-9} |
| Barium chromate | BaCrO ₄ | 1.2×10^{-10} |
| Barium sulphate | BaSO ₄ | 1.1×10^{-10} |
| Calcium carbonate | CaCO ₃ | 5.0×10^{-9} |
| Calcium oxalate | CaC ₂ O ₄ | 2.3×10^{-9} |
| Calcium sulphate | CaSO ₄ | 7.1×10^{-5} |
| Copper(I) iodide | CuI | 1.3×10^{-12} |
| Copper(II) iodate | Cu(IO ₃) ₂ | 6.9×10^{-8} |
| Copper(II) sulphide | CuS | 6.0×10^{-37} |
| Iron(II) hydroxide | Fe(OH) ₂ | 4.9×10^{-17} |
| Iron(II) sulphide | FeS | 6.0×10^{-19} |
| Iron(III) hydroxide | Fe(OH) ₃ | 2.6×10^{-39} |
| Lead(II) bromide | PbBr ₂ | 6.6×10^{-6} |
| Lead(II) chloride | PbCl ₂ | 1.2×10^{-5} |
| Lead(II) iodate | Pb(IO ₃) ₂ | 3.7×10^{-13} |
| Lead(II) iodide | PbI ₂ | 8.5×10^{-9} |
| Lead(II) sulphate | PbSO ₄ | 1.8×10^{-8} |
| Magnesium carbonate | MgCO ₃ | 6.8×10^{-6} |
| Magnesium hydroxide | Mg(OH) ₂ | 5.6×10^{-12} |
| Silver bromate | AgBrO ₃ | 5.3×10^{-5} |
| Silver bromide | AgBr | 5.4×10^{-13} |
| Silver carbonate | Ag ₂ CO ₃ | 8.5×10^{-12} |
| Silver chloride | AgCl | 1.8×10^{-10} |
| Silver chromate | Ag ₂ CrO ₄ | 1.1×10^{-12} |
| Silver iodate | AgIO ₃ | 3.2×10^{-8} |
| Silver iodide | AgI | 8.5×10^{-17} |
| Strontium carbonate | SrCO ₃ | 5.6×10^{-10} |
| Strontium fluoride | SrF ₂ | 4.3×10^{-9} |
| Strontium sulphate | SrSO ₄ | 3.4×10^{-7} |
| Zinc sulphide | ZnS | 2.0×10^{-25} |

RELATIVE STRENGTHS OF BRØNSTED-LOWRY ACIDS AND BASES
in aqueous solution at room temperature.

| Name of Acid | Acid | Base | K_a |
|---|--|---|-----------------------|
| Perchloric | HClO_4 | $\rightarrow \text{H}^+ + \text{ClO}_4^-$ | very large |
| Hydriodic | HI | $\rightarrow \text{H}^+ + \text{I}^-$ | very large |
| Hydrobromic | HBr | $\rightarrow \text{H}^+ + \text{Br}^-$ | very large |
| Hydrochloric | HCl | $\rightarrow \text{H}^+ + \text{Cl}^-$ | very large |
| Nitric | HNO_3 | $\rightarrow \text{H}^+ + \text{NO}_3^-$ | very large |
| Sulphuric | H_2SO_4 | $\rightarrow \text{H}^+ + \text{HSO}_4^-$ | very large |
| Hydronium Ion | H_3O^+ | $\rightleftharpoons \text{H}^+ + \text{H}_2\text{O}$ | 1.0 |
| Iodic | HIO_3 | $\rightleftharpoons \text{H}^+ + \text{IO}_3^-$ | 1.7×10^{-1} |
| Oxalic | $\text{H}_2\text{C}_2\text{O}_4$ | $\rightleftharpoons \text{H}^+ + \text{HC}_2\text{O}_4^-$ | 5.9×10^{-2} |
| Sulphurous ($\text{SO}_2 + \text{H}_2\text{O}$) | H_2SO_3 | $\rightleftharpoons \text{H}^+ + \text{HSO}_3^-$ | 1.5×10^{-2} |
| Hydrogen sulphate ion | HSO_4^- | $\rightleftharpoons \text{H}^+ + \text{SO}_4^{2-}$ | 1.2×10^{-2} |
| Phosphoric | H_3PO_4 | $\rightleftharpoons \text{H}^+ + \text{H}_2\text{PO}_4^-$ | 7.5×10^{-3} |
| Hexaaquoiron ion, iron(III) ion | $\text{Fe}(\text{H}_2\text{O})_6^{3+}$ | $\rightleftharpoons \text{H}^+ + \text{Fe}(\text{H}_2\text{O})_5(\text{OH})^{2+}$ | 6.0×10^{-3} |
| Citric | $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$ | $\rightleftharpoons \text{H}^+ + \text{H}_2\text{C}_6\text{H}_5\text{O}_7^-$ | 7.1×10^{-4} |
| Nitrous | HNO_2 | $\rightleftharpoons \text{H}^+ + \text{NO}_2^-$ | 4.6×10^{-4} |
| Hydrofluoric | HF | $\rightleftharpoons \text{H}^+ + \text{F}^-$ | 3.5×10^{-4} |
| Methanoic, formic | HCOOH | $\rightleftharpoons \text{H}^+ + \text{HCOO}^-$ | 1.8×10^{-4} |
| Hexaaquochromium ion, chromium(III) ion | $\text{Cr}(\text{H}_2\text{O})_6^{3+}$ | $\rightleftharpoons \text{H}^+ + \text{Cr}(\text{H}_2\text{O})_5(\text{OH})^{2+}$ | 1.5×10^{-4} |
| Benzoic | $\text{C}_6\text{H}_5\text{COOH}$ | $\rightleftharpoons \text{H}^+ + \text{C}_6\text{H}_5\text{COO}^-$ | 6.5×10^{-5} |
| Hydrogen oxalate ion | HC_2O_4^- | $\rightleftharpoons \text{H}^+ + \text{C}_2\text{O}_4^{2-}$ | 6.4×10^{-5} |
| Ethanoic, acetic | CH_3COOH | $\rightleftharpoons \text{H}^+ + \text{CH}_3\text{COO}^-$ | 1.8×10^{-5} |
| Dihydrogen citrate ion | $\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-$ | $\rightleftharpoons \text{H}^+ + \text{HC}_6\text{H}_5\text{O}_7^{2-}$ | 1.7×10^{-5} |
| Hexaaquoaluminum ion, aluminum ion | $\text{Al}(\text{H}_2\text{O})_6^{3+}$ | $\rightleftharpoons \text{H}^+ + \text{Al}(\text{H}_2\text{O})_5(\text{OH})^{2+}$ | 1.4×10^{-5} |
| Carbonic ($\text{CO}_2 + \text{H}_2\text{O}$) | H_2CO_3 | $\rightleftharpoons \text{H}^+ + \text{HCO}_3^-$ | 4.3×10^{-7} |
| Monohydrogen citrate ion | $\text{HC}_6\text{H}_5\text{O}_7^{2-}$ | $\rightleftharpoons \text{H}^+ + \text{C}_6\text{H}_5\text{O}_7^{3-}$ | 4.1×10^{-7} |
| Hydrogen sulphite ion | HSO_3^- | $\rightleftharpoons \text{H}^+ + \text{SO}_3^{2-}$ | 1.0×10^{-7} |
| Hydrogen sulphide | H_2S | $\rightleftharpoons \text{H}^+ + \text{HS}^-$ | 9.1×10^{-8} |
| Dihydrogen phosphate ion | H_2PO_4^- | $\rightleftharpoons \text{H}^+ + \text{HPO}_4^{2-}$ | 6.2×10^{-8} |
| Boric | H_3BO_3 | $\rightleftharpoons \text{H}^+ + \text{H}_2\text{BO}_3^-$ | 7.3×10^{-10} |
| Ammonium ion | NH_4^+ | $\rightleftharpoons \text{H}^+ + \text{NH}_3$ | 5.6×10^{-10} |
| Hydrocyanic | HCN | $\rightleftharpoons \text{H}^+ + \text{CN}^-$ | 4.9×10^{-10} |
| Phenol | $\text{C}_6\text{H}_5\text{OH}$ | $\rightleftharpoons \text{H}^+ + \text{C}_6\text{H}_5\text{O}^-$ | 1.3×10^{-10} |
| Hydrogen carbonate ion | HCO_3^- | $\rightleftharpoons \text{H}^+ + \text{CO}_3^{2-}$ | 5.6×10^{-11} |
| Hydrogen peroxide | H_2O_2 | $\rightleftharpoons \text{H}^+ + \text{HO}_2^-$ | 2.4×10^{-12} |
| Monohydrogen phosphate ion | HPO_4^{2-} | $\rightleftharpoons \text{H}^+ + \text{PO}_4^{3-}$ | 2.2×10^{-13} |
| Water | H_2O | $\rightleftharpoons \text{H}^+ + \text{OH}^-$ | 1.0×10^{-14} |
| Hydroxide ion | OH^- | $\leftarrow \text{H}^+ + \text{O}^{2-}$ | very small |
| Ammonia | NH_3 | $\leftarrow \text{H}^+ + \text{NH}_2^-$ | very small |

ACID-BASE INDICATORS

| Indicator | pH Range in Which Colour Change Occurs | Colour Change as pH Increases |
|------------------|---|----------------------------------|
| Methyl violet | 0.0 – 1.6 | yellow to blue |
| Thymol blue | 1.2 – 2.8 | red to yellow |
| Orange IV | 1.4 – 2.8 | red to yellow |
| Methyl orange | 3.2 – 4.4 | red to yellow |
| Bromcresol green | 3.8 – 5.4 | yellow to blue |
| Methyl red | 4.8 – 6.0 | red to yellow |
| Chlorophenol red | 5.2 – 6.8 | yellow to red |
| Bromthymol blue | 6.0 – 7.6 | yellow to blue |
| Phenol red | 6.6 – 8.0 | yellow to red |
| Neutral red | 6.8 – 8.0 | red to amber |
| Thymol blue | 8.0 – 9.6 | yellow to blue |
| Phenolphthalein | 8.2 – 10.0 | colourless to pink |
| Thymolphthalein | 9.4 – 10.6 | colourless to blue |
| Alizarin yellow | 10.1 – 12.0 | yellow to red |
| Indigo carmine | 11.4 – 13.0 | blue to yellow |

STANDARD REDUCTION POTENTIALS OF HALF-CELLS

Ionic concentrations are at 1M in water at 25°C.

| | Oxidizing Agents | Reducing Agents | E° (Volts) | |
|---|--|---|---------------------------------|------|
| ↑ STRONG | $F_2(g) + 2e^-$ | $\rightleftharpoons 2F^-$ | +2.87 | WEAK |
| | $S_2O_8^{2-} + 2e^-$ | $\rightleftharpoons 2SO_4^{2-}$ | +2.01 | |
| | $H_2O_2 + 2H^+ + 2e^-$ | $\rightleftharpoons 2H_2O$ | +1.78 | |
| | $MnO_4^- + 8H^+ + 5e^-$ | $\rightleftharpoons Mn^{2+} + 4H_2O$ | +1.51 | |
| | $Au^{3+} + 3e^-$ | $\rightleftharpoons Au(s)$ | +1.50 | |
| | $BrO_3^- + 6H^+ + 5e^-$ | $\rightleftharpoons \frac{1}{2}Br_2(l) + 3H_2O$ | +1.48 | |
| | $ClO_4^- + 8H^+ + 8e^-$ | $\rightleftharpoons Cl^- + 4H_2O$ | +1.39 | |
| | $Cl_2(g) + 2e^-$ | $\rightleftharpoons 2Cl^-$ | +1.36 | |
| | $Cr_2O_7^{2-} + 14H^+ + 6e^-$ | $\rightleftharpoons 2Cr^{3+} + 7H_2O$ | +1.23 | |
| | $\frac{1}{2}O_2(g) + 2H^+ + 2e^-$ | $\rightleftharpoons H_2O$ | +1.23 | |
| $MnO_2(s) + 4H^+ + 2e^-$ | $\rightleftharpoons Mn^{2+} + 2H_2O$ | +1.22 | ← Overpotential Effect | |
| $IO_3^- + 6H^+ + 5e^-$ | $\rightleftharpoons \frac{1}{2}I_2(s) + 3H_2O$ | +1.20 | | |
| $Br_2(l) + 2e^-$ | $\rightleftharpoons 2Br^-$ | +1.09 | | |
| $AuCl_4^- + 3e^-$ | $\rightleftharpoons Au(s) + 4Cl^-$ | +1.00 | | |
| $NO_3^- + 4H^+ + 3e^-$ | $\rightleftharpoons NO(g) + 2H_2O$ | +0.96 | | |
| $Hg^{2+} + 2e^-$ | $\rightleftharpoons Hg(l)$ | +0.85 | | |
| $\frac{1}{2}O_2(g) + 2H^+(10^{-7}M) + 2e^-$ | $\rightleftharpoons H_2O$ | +0.82 | | |
| $2NO_3^- + 4H^+ + 2e^-$ | $\rightleftharpoons N_2O_4 + 2H_2O$ | +0.80 | | |
| $Ag^+ + e^-$ | $\rightleftharpoons Ag(s)$ | +0.80 | | |
| $\frac{1}{2}Hg_2^{2+} + e^-$ | $\rightleftharpoons Hg(l)$ | +0.80 | | |
| $Fe^{3+} + e^-$ | $\rightleftharpoons Fe^{2+}$ | +0.77 | ↓ STRENGTH OF REDUCING AGENT | |
| $O_2(g) + 2H^+ + 2e^-$ | $\rightleftharpoons H_2O_2$ | +0.70 | | |
| $MnO_4^- + 2H_2O + 3e^-$ | $\rightleftharpoons MnO_2(s) + 4OH^-$ | +0.60 | | |
| $I_2(s) + 2e^-$ | $\rightleftharpoons 2I^-$ | +0.54 | | |
| $Cu^+ + e^-$ | $\rightleftharpoons Cu(s)$ | +0.52 | | |
| $H_2SO_3 + 4H^+ + 4e^-$ | $\rightleftharpoons S(s) + 3H_2O$ | +0.45 | | |
| $Cu^{2+} + 2e^-$ | $\rightleftharpoons Cu(s)$ | +0.34 | | |
| $SO_4^{2-} + 4H^+ + 2e^-$ | $\rightleftharpoons H_2SO_3 + H_2O$ | +0.17 | | |
| $Cu^{2+} + e^-$ | $\rightleftharpoons Cu^+$ | +0.15 | | |
| $Sn^{4+} + 2e^-$ | $\rightleftharpoons Sn^{2+}$ | +0.15 | | |
| $S(s) + 2H^+ + 2e^-$ | $\rightleftharpoons H_2S(g)$ | +0.14 | | |
| $2H^+ + 2e^-$ | $\rightleftharpoons H_2(g)$ | +0.00 | | |
| $Pb^{2+} + 2e^-$ | $\rightleftharpoons Pb(s)$ | -0.13 | ← Overpotential Effect | |
| $Sn^{2+} + 2e^-$ | $\rightleftharpoons Sn(s)$ | -0.14 | | |
| $Ni^{2+} + 2e^-$ | $\rightleftharpoons Ni(s)$ | -0.26 | | |
| $H_3PO_4 + 2H^+ + 2e^-$ | $\rightleftharpoons H_3PO_3 + H_2O$ | -0.28 | | |
| $Co^{2+} + 2e^-$ | $\rightleftharpoons Co(s)$ | -0.28 | | |
| $Se(s) + 2H^+ + 2e^-$ | $\rightleftharpoons H_2Se$ | -0.40 | | |
| $Cr^{3+} + e^-$ | $\rightleftharpoons Cr^{2+}$ | -0.41 | | |
| $2H_2O + 2e^-$ | $\rightleftharpoons H_2 + 2OH^-(10^{-7}M)$ | -0.41 | | |
| $Fe^{2+} + 2e^-$ | $\rightleftharpoons Fe(s)$ | -0.45 | | |
| $Ag_2S(s) + 2e^-$ | $\rightleftharpoons 2Ag(s) + S^{2-}$ | -0.69 | | |
| $Cr^{3+} + 3e^-$ | $\rightleftharpoons Cr(s)$ | -0.74 | | |
| $Zn^{2+} + 2e^-$ | $\rightleftharpoons Zn(s)$ | -0.76 | | |
| $Te(s) + 2H^+ + 2e^-$ | $\rightleftharpoons H_2Te$ | -0.79 | | |
| $2H_2O + 2e^-$ | $\rightleftharpoons H_2(g) + 2OH^-$ | -0.83 | | |
| $Mn^{2+} + 2e^-$ | $\rightleftharpoons Mn(s)$ | -1.19 | | |
| $Al^{3+} + 3e^-$ | $\rightleftharpoons Al(s)$ | -1.66 | | |
| $Mg^{2+} + 2e^-$ | $\rightleftharpoons Mg(s)$ | -2.37 | | |
| $Na^+ + e^-$ | $\rightleftharpoons Na(s)$ | -2.71 | | |
| $Ca^{2+} + 2e^-$ | $\rightleftharpoons Ca(s)$ | -2.87 | | |
| $Sr^{2+} + 2e^-$ | $\rightleftharpoons Sr(s)$ | -2.89 | | |
| $Ba^{2+} + 2e^-$ | $\rightleftharpoons Ba(s)$ | -2.91 | | |
| $K^+ + e^-$ | $\rightleftharpoons K(s)$ | -2.93 | | |
| $Rb^+ + e^-$ | $\rightleftharpoons Rb(s)$ | -2.98 | | |
| $Cs^+ + e^-$ | $\rightleftharpoons Cs(s)$ | -3.03 | | |
| $Li^+ + e^-$ | $\rightleftharpoons Li(s)$ | -3.04 | | |