**STANDARD REDUCTION POTENTIALS (In water solution @ 298 K)**

**­Reduction Half-Reaction SRP (measured in volts)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Li+1(aq)+ e-1 | 🡺 | Li(s) |  | - 3.05 |
| Cs+1(aq)+ e-1 | 🡺 | Cs(s) |  | - 2.92 |
| K+1(aq)+ e-1 | 🡺 | K(s) |  | - 2.92 |
| Rb+1(aq)+ e-1 | 🡺 | Rb(s) |  | - 2.92 |
| Ba+2(aq)+ 2e-1 | 🡺 | Ba(s) |  | - 2.90 |
| Na+1(aq)+ e-1 | 🡺 | Na(s) |  | - 2.71 |
| Mg+2(aq) + 2 e-1 | 🡺 | Mg(s) |  | - 2.37 |
| Al+3(aq)+ 3e-1 | 🡺 | Al(s) |  | - 1.66 |
| Mn+2(aq)+ 2e-1 | 🡺 | Mn(s) |  | - 1.18 |
| **2 H2O+ 2e-1** | **🡺** | **H2(g) + 2 OH-1(aq)** |  | **- 0.83** |
| Zn+2(aq)+ 2e-1 | 🡺 | Zn(s) |  | - 0.76 |
| Cr+3(aq)+ 3e-1 | 🡺 | Cr(s) |  | - 0.74 |
| Fe+2(aq)+ 2e-1 | 🡺 | Fe(s) |  | - 0.44 |
| Cr+2(aq)+ 2e-1 | 🡺 | Cr(s) |  | - 0.41 |
| Cd+2(aq)+ 2e-1 | 🡺 | Cd(s) |  | - 0.40 |
| PbSO4(aq) + 2 e-1 | 🡺 | Pb(s) + SO42-(aq) |  | - 0.36 |
| Tl+1(aq)+ e-1 | 🡺 | Tl(s) |  | - 0.34 |
| Co+2(aq)+ 2e-1 | 🡺 | Co(s) |  | - 0.28 |
| Ni+2(aq)+2 e-1 | 🡺 | Ni(s) |  | - 0.25 |
| AgI(s)+ e-1 | 🡺 | Ag(s) + I-1(aq) |  | - 0.15 |
| Sn+2(aq)+ 2 e-1 | 🡺 | Sn(s) |  | - 0.14 |
| Pb+2(aq)+ 2 e-1 | 🡺 | Pb(s) |  | - 0.13 |
| **2 H+1(aq) + 2 e-1** | **🡺** | **H2(g)** |  |  **0.00** |
| AgBr(s)+ e-1 | 🡺 | Ag(s) + Br-1(aq) |  | + 0.10 |
| S(s) + 2 H+1(aq) + 2 e-1 | 🡺 | H2S(aq) |  | + 0.14 |
| Sn+4(aq)+ 2 e-1 | 🡺 | Sn+2(aq) |  | + 0.15 |
| Sn+4(aq)+ 2 e-1 | 🡺 | Sn+2(aq) |  | + 0.15 |
| SO42-(aq) + 4 H+1(aq) + 2 e-1 | 🡺 | SO2(g) + H2O(liq) |  | + 0.14 |
| Cu+2(aq) + 2 e-1 | 🡺 | Cu(s) |  | + 0.34 |
| Sn+4(aq) + 2 e-1 | 🡺 | Sn+2(aq) |  | + 0.15 |
| Cu+2(aq) + e-1 | 🡺 | Cu+1(aq) |  | + 0.15 |
| Cu+1(aq) + e-1 | 🡺 | Cu(s) |  | + 0.52 |
| I2(s)+ 2 e-1 | 🡺 | 2 I-1(aq) |  | + 0.53 |
| Fe+3(aq) + e-1 | 🡺 | Fe+2(aq) |  | + 0.77 |
| Hg2+2(aq) + 2 e-1 | 🡺 | 2 Hg (liq) |  | + 0.79 |
| Ag+1(aq) + e-1 | 🡺 | Ag(s) |  | + 0.80 |
| 2 Hg+2(aq) + 2 e-1 | 🡺 | Hg2+2(aq) |  | + 0.92 |
| NO31-(aq) + 4 H+1(aq) + 3 e-1 | 🡺 | NO(g) + 2 H2O(liq) |  | + 0.96 |
| AuCl4 1-(aq) + 3 e-1 | 🡺 | Au(s) + 4 Cl-1(aq) |  | + 1.00 |
| Br2(liq) + 2 e-1 | 🡺 | 2 Br-1(aq) |  | + 1.07 |
| **O2(g) + 4 H+1(aq) + 4 e-1** | **🡺**  | **2 H2O(liq)** |  | **+ 1.23** |
| MnO2(s) + 4 H+1(aq) +2 e-1 | 🡺 | Mn+2(aq) + 2 H2O(liq) |  | + 1.23 |
| Cr2O72-(aq) + 14 H+1(aq) +6 e-1 | 🡺 | 2 Cr+3(aq)+ 7 H2O(liq) |  | + 1.33 |
| Cl2(g) + 2 e-1 | 🡺 | 2 Cl-1(aq) |  | + 1.36 |
| ClO31-(aq) + 6 H+1(aq) +5 e-1 | 🡺 | ½ Cl2(g) + 3 H2O(liq) |  | + 1.47 |
| Au+3(aq) + 3 e-1 | 🡺 | Au(s) |  | + 1.50 |
| PbO2(s)+SO42-(aq) + 4 H+1(aq)+2 e-1 | 🡺 | PbSO4(s) + 2 H2O(liq) |  | + 1.68 |
| F2(g) + 2 e-1 | 🡺 | 2 F-1(aq) |  | + 2.87 |

**Relative Strengths of Acids and Bases (Acid Dissociation or Ionization Values)**

 **Acid Conjugate Base**

 **Name Formula KA Name Formula**

Perchloric acid HClO4 ~1010 Perchlorate ion ClO4-1

Hydroiodic acid HI ~1010 Iodide ion I-1

Hydrobromic acid HBr ~109 Bromide ion Br-1

Hydrochloric acid HCl ~107 Chloride ion Cl-1

Sulfuric acid \* H2SO4 ~103 Bisulfate ion HSO4-1

Nitric acid HNO3 ~102 Nitrate ion NO3-1

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Hydronium ion H3O+1 or H+1 56 Water H2O

Bisulfate ion HSO4-1 1.2 x 10-2 Sulfate ion SO4-2

Sulfurous acid H2SO3 1.2 x 10-2 Bisulfite ion HSO3-1

Phosphoric acid H3PO4 7.5 x 10-3 Dihydrogen phosphate ion H2 PO4-2

Hexaaquairon(III) ion Fe(H2O)63+ 9 x 10-4 Fe(H2O)5OH2+

Hydrofluoric acid HF 7.2 x 10-4 Fluoride ion F-1

Nitrous acid HNO2 4.5 x 10-4 Nitrite ion NO2-1

Acetic acid HC2H3O2 1.8 x 10-5 Acetate ion C2H3O2-1

Hexaaquaaluminum ion Al(H2O)63+ 7 x 10-6 Al(H2O)5OH2+

Carbonic acid H2CO3 4.3 x 10-7 Bicarbonate ion HCO3-1

Bisulfite ion HSO3-1 2.8 x 10-7 Sulfite ion SO3-2

Hydrosulfuric acid H2S1.0 x 10-7 Bisulfide ion HS-1

Dihydrogen phosphate ion H2PO4-1 6.2 x 10-8 Monohydrogen phosphate ion HPO4-2

Phenolphthalein HPhth 3 x 10-9 Phenolphthalein ion Phth-1

Ammonium ion NH4+1 5.6 x 10-10 Ammonia NH3

Hydrocyanic acid HCN 4.0 x 10-10 Cyanide ion CN-1

Hexaaquairon(II) ion Fe(H2O)62+ 3 x 10-10 Fe(H2O)5OH1+

Bicarbonate ion HCO3-14.7 x 10-11 Carbonate ion CO3-2

Hydrogen peroxide H2O2 2.4 x 10-12 Hydroperoxide ion HO2-1

Monohydrogen phosphate ion HPO4-21.0 x 10-12 Phosphate ion PO4-3

Bisulfide ion HS-11.3 x 10-13 Sulfide ion S-2

Water H2O1.8 x 10-16 Hydroxide ion OH-1

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Methanol CH3OH ~10-16 Methoxide ion CH3O-1

Ammonia NH3 ~10-35 Amide ion NH2-1

Hydroxide ion OH-1 ~10-36 Oxide ion O-2

Hydrogen H2 ~10-36 Hydride ion H-1

Amide ion NH2-1 very weak Imide ion NH-2

Imide ion NH-2 very weak Nitride ion N-3

Methane CH4 ~10-58 Methide ion CH3-1

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**Solubility Rules:**

**(If a 0.10-molar aqueous solution can be prepared, the substance is considered to be “soluble”.)**

**1. All nitrates, acetates, and chlorates are soluble.**

**2. All chlorides, bromides, and iodides are soluble except with Ag+1, Hg2+2, and Pb+2.**

**3. All sulfates are soluble except with Sr+2, Ba+2, Hg2+2, Hg+2, and Pb+2.**

**(With Ag+1 and Ca+2, only slightly soluble.)**

**4. All carbonates, chromates, sulfites, and phosphates are insoluble, except those of the I-A family and the ammonium ion (NH4+1).**

**5. All hydroxides are insoluble, except those of the I-A and the lower II-A family.**

**6. All sulfides are insoluble, except those of the I-A and the II-A family. Many decompose.**

**7. Salts containing a I-A metal or the ammonium ion (NH4+1) are soluble.**