

附錄 半反應之標準還原電位 (25°C)

標準還原電位 Standard reduction potentials

| 半反應 Half-reaction | $E^{\circ}(\text{V})$ |
|---|-----------------------|
| $3\text{N}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{HN}_3$ | -3.1 |
| $\text{Li}^+ + \text{e}^- \rightleftharpoons \text{Li}$ | -3.045 |
| $\text{Rb}^+ + \text{e}^- \rightleftharpoons \text{Rb}$ | -2.925 |
| $\text{K}^+ + \text{e}^- \rightleftharpoons \text{K}$ | -2.924 |
| $\text{Cs}^+ + \text{e}^- \rightleftharpoons \text{Cs}$ | -2.923 |
| $\text{Ba}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ba}$ | -2.90 |
| $\text{Sr}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sr}$ | -2.89 |
| $\text{Ca}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ca}$ | -2.76 |
| $\text{Na}^+ + \text{e}^- \rightleftharpoons \text{Na}$ | -2.7109 |
| $\text{Mg}(\text{OH})_2 + 2\text{e}^- \rightleftharpoons \text{Mg} + 2\text{OH}^-$ | -2.69 |
| $\text{Mg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mg}$ | -2.375 |
| $\text{H}_2 + 2\text{e}^- \rightleftharpoons 2\text{H}^-$ | -2.23 |
| $\text{Al}^{3+} + 3\text{e}^- \rightleftharpoons \text{Al} (0.1 \text{ M NaOH})$ | -1.706 |
| $\text{Be}^{2+} + 2\text{e}^- \rightleftharpoons \text{Be}$ | -1.70 |
| $\text{Ti}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ti}$ | -1.63 |
| $\text{Zn}(\text{CN})_4^{2-} + 2\text{e}^- \rightleftharpoons \text{Zn} + 4\text{CN}^-$ | -1.26 |
| $\text{Zn}(\text{NH}_3)_4^{2+} + 2\text{e}^- \rightleftharpoons \text{Zn} + 4\text{NH}_3$ | -1.04 |
| $\text{Mn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mn}$ | -1.029 |
| $\text{SO}_4^{2-} + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{SO}_3^{2-} + 2\text{OH}^-$ | -0.92 |
| $\text{Cr}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cr}$ | -0.91 |
| $\text{TiO}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{Ti} + 2\text{H}_2\text{O}$ | -0.87 |
| $2\text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{H}_2 + 2\text{OH}^-$ | -0.8277 |
| $\text{Zn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Zn}$ | -0.7628 |
| $\text{Cr}^{3+} + 3\text{e}^- \rightleftharpoons \text{Cr}$ | -0.74 |
| $2\text{SO}_3^{2-} + 3\text{H}_2\text{O} + 4\text{e}^- \rightleftharpoons \text{S}_2\text{O}_3^{2-} + 6\text{OH}^-$ | -0.58 |
| $\text{PbO} + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{Pb} + 2\text{OH}^-$ | -0.576 |
| $\text{Ga}^{3+} + 3\text{e}^- \rightleftharpoons \text{Ga}$ | -0.560 |
| $\text{S} + 2\text{e}^- \rightleftharpoons \text{S}^{2-}$ | -0.508 |
| $2\text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{C}_2\text{O}_4$ | -0.49 |
| $\text{Ni}(\text{NH}_3)_6^{2+} + 2\text{e}^- \rightleftharpoons \text{Ni} + 6\text{NH}_3$ | -0.48 |
| $\text{Co}(\text{NH}_3)_6^{2+} + 2\text{e}^- \rightleftharpoons \text{Co} + 6\text{NH}_3$ | -0.422 |
| $\text{Cr}^{3+} + \text{e}^- \rightleftharpoons \text{Cr}^{2+}$ | -0.41 |
| $\text{Fe}^{2+} + 2\text{e}^- \rightleftharpoons \text{Fe}$ | -0.409 |
| $\text{Cd}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cd}$ | -0.4026 |
| $\text{PbSO}_4 + 2\text{e}^- \rightleftharpoons \text{Pb} + \text{SO}_4^{2-}$ | -0.356 |
| $\text{In}^{3+} + 3\text{e}^- \rightleftharpoons \text{In}$ | -0.338 |
| $\text{Tl}^+ + \text{e}^- \rightleftharpoons \text{Tl}$ | -0.3363 |
| $\text{Ag}(\text{CN})_2^- + \text{e}^- \rightleftharpoons \text{Ag} + 2\text{CN}^-$ | -0.31 |
| $\text{Co}^{2+} + 2\text{e}^- \rightleftharpoons \text{Co}$ | -0.28 |
| $\text{H}_3\text{PO}_4 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_3\text{PO}_3 + \text{H}_2\text{O}$ | -0.276 |
| $\text{Ni}^{2+} + 2\text{e}^- \rightleftharpoons \text{Ni}$ | -0.23 |

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| $2\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{S}_2\text{O}_6^{2-} + 2\text{H}_2\text{O}$ | -0.224 |
| $\text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{HCO}_2\text{H}$ | -0.20 |
| $\text{O}_2 + 2\text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}_2 + 2\text{OH}^-$ | -0.146 |
| $\text{Sn}^{2+} + 2\text{e}^- \rightleftharpoons \text{Sn}$ | -0.1364 |
| $\text{Pb}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pb}$ | -0.1263 |
| $\text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e}^- \rightleftharpoons \text{Cr}(\text{OH})_3 + 5\text{OH}^-$ | -0.12 |
| $\text{WO}_3 + 6\text{H}^+ + 6\text{e}^- \rightleftharpoons \text{W} + 3\text{H}_2\text{O}$ | -0.09 |
| $\text{Ru}^{3+} + \text{e}^- \rightleftharpoons \text{Ru}^{2+}$ | -0.08 |
| $\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{HO}_2^- + \text{OH}^-$ | -0.076 |
| $\text{Fe}^{3+} + 3\text{e}^- \rightleftharpoons \text{Fe}$ | -0.036 |
| $2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$ | 0 |
| $\text{NO}_3^- + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{NO}_2^- + 2\text{OH}^-$ | 0.01 |
| $\text{AgBr} + \text{e}^- \rightleftharpoons \text{Ag} + \text{Br}^-$ | 0.0713 |
| $\text{S}_4\text{O}_6^{2-} + 2\text{e}^- \rightleftharpoons 2\text{S}_2\text{O}_3^{2-}$ | 0.0895 |
| $\text{Sn}^{4+} + 2\text{e}^- \rightleftharpoons \text{Sn}^{2+}$ | 0.15 |
| $\text{Cu}^{2+} + \text{e}^- \rightleftharpoons \text{Cu}^+$ | 0.158 |
| $\text{ClO}_4^- + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{ClO}_3^- + 2\text{OH}^-$ | 0.17 |
| $\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$ | 0.20 |
| $\text{AgCl} + \text{e}^- \rightleftharpoons \text{Ag} + \text{Cl}^-$ | 0.2223 |
| $\text{IO}_3^- + 3\text{H}_2\text{O} + 6\text{e}^- \rightleftharpoons \text{I}^- + 6\text{OH}^-$ | 0.26 |
| $\text{Hg}_2\text{Cl}_2 + 2\text{e}^- \rightleftharpoons 2\text{Hg} + 2\text{Cl}^-$ | 0.2682 |
| $\text{Cu}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cu}$ | 0.3402 |
| $\text{ClO}_3^- + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{ClO}_2^- + 2\text{OH}^-$ | 0.35 |
| $\text{Ag}(\text{NH}_3)_2^+ + \text{e}^- \rightleftharpoons \text{Ag} + 2\text{NH}_3$ | 0.373 |
| $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightleftharpoons 4\text{OH}^-$ | 0.401 |
| $\text{H}_2\text{SO}_3 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{S} + 3\text{H}_2\text{O}$ | 0.45 |
| $\text{HgCl}_4^{2-} + 2\text{e}^- \rightleftharpoons \text{Hg} + 4\text{Cl}^-$ | 0.48 |
| $\text{Cu}^+ + \text{e}^- \rightleftharpoons \text{Cu}$ | 0.522 |
| $\text{I}_3^- + 2\text{e}^- \rightleftharpoons 3\text{I}^-$ | 0.5338 |
| $\text{I}_2 + 2\text{e}^- \rightleftharpoons 2\text{I}^-$ | 0.535 |
| $\text{MnO}_4^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightleftharpoons \text{MnO}_2 + 4\text{OH}^-$ | 0.588 |
| $\text{ClO}_2^- + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{ClO}^- + 2\text{OH}^-$ | 0.59 |
| $\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2\text{O}_2$ | 0.682 |
| $\text{Fe}^{3+} + \text{e}^- \rightleftharpoons \text{Fe}^{2+}$ | 0.770 |
| $\text{Hg}_2^{2+} + 2\text{e}^- \rightleftharpoons 2\text{Hg}$ | 0.7961 |
| $\text{Ag}^+ + \text{e}^- \rightleftharpoons \text{Ag}$ | 0.7996 |
| $\text{Hg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Hg}$ | 0.851 |
| $\text{H}_2\text{O}_2 + 2\text{e}^- \rightleftharpoons 2\text{OH}^-$ | 0.88 |
| $\text{ClO}^- + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{Cl}^- + 2\text{OH}^-$ | 0.89 |
| $2\text{Hg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Hg}_2^{2+}$ | 0.905 |
| $\text{NO}_3^- + 3\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{HNO}_2 + \text{H}_2\text{O}$ | 0.94 |
| $\text{ClO}_2 + \text{e}^- \rightleftharpoons \text{ClO}_2^-$ | 0.95 |
| $\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{NO} + 2\text{H}_2\text{O}$ | 0.96 |
| $\text{Pd}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pd}$ | 0.987 |
| $\text{HNO}_2 + \text{H}^+ + \text{e}^- \rightleftharpoons \text{NO} + \text{H}_2\text{O}$ | 0.99 |
| $\text{IO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightleftharpoons \text{I}^- + 3\text{H}_2\text{O}$ | 1.085 |

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|--|-----------------------|
| $\text{Br}_2(\text{aq}) + 2\text{e}^- \rightleftharpoons 2\text{Br}^-$ | 1.087 |
| $\text{Cr}^{6+} + 3\text{e}^- \rightleftharpoons \text{Cr}^{3+}$ | 1.10 |
| $\text{ClO}_3^- + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{ClO}_2^- + \text{H}_2\text{O}$ | 1.15 |
| $\text{ClO}_4^- + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{ClO}_3^- + \text{H}_2\text{O}$ | 1.19 |
| $2\text{IO}_3^- + 12\text{H}^+ + 10\text{e}^- \rightleftharpoons \text{I}_2 + 6\text{H}_2\text{O}$ | 1.19 |
| $\text{HCrO}_4^- + 7\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{Cr}^{3+} + 4\text{H}_2\text{O}$ | 1.195 |
| $\text{Pt}^{2+} + 2\text{e}^- \rightleftharpoons \text{Pt}$ | 1.2 |
| $\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 2\text{H}_2\text{O}$ | 1.208 |
| $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$ | 1.229 |
| $\text{O}_3 + \text{H}_2\text{O} + 2\text{e}^- \rightleftharpoons \text{O}_2 + 2\text{OH}^-$ | 1.24 |
| $\text{Tl}^{3+} + 2\text{e}^- \rightleftharpoons \text{Tl}^+$ | 1.247 |
| $\text{ClO}_2 + \text{H}^+ + \text{e}^- \rightleftharpoons \text{HClO}_2$ | 1.27 |
| $2\text{HNO}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{N}_2\text{O} + 3\text{H}_2\text{O}$ | 1.27 |
| $\text{Au}^{3+} + 2\text{e}^- \rightleftharpoons \text{Au}^+$ | 1.29 |
| $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$ | 1.33 |
| $\text{ClO}_4^- + 8\text{H}^+ + 7\text{e}^- \rightleftharpoons 1/2\text{Cl}_2 + 4\text{H}_2\text{O}$ | 1.34 |
| $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-$ | 1.3583 |
| $\text{ClO}_4^- + 8\text{H}^+ + 8\text{e}^- \rightleftharpoons \text{Cl}^- + 4\text{H}_2\text{O}$ | 1.37 |
| $\text{Au}^{3+} + 3\text{e}^- \rightleftharpoons \text{Au}$ | 1.42 |
| $\text{ClO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightleftharpoons \text{Cl}^- + 3\text{H}_2\text{O}$ | 1.45 |
| $\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Pb}^{2+} + 2\text{H}_2\text{O}$ | 1.467 |
| $2\text{ClO}_3^- + 12\text{H}^+ + 10\text{e}^- \rightleftharpoons \text{Cl}_2 + 6\text{H}_2\text{O}$ | 1.47 |
| $\text{HClO} + \text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Cl}^- + \text{H}_2\text{O}$ | 1.49 |
| $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+} + 4\text{H}_2\text{O}$ | 1.491 |
| $\text{HClO}_2 + 3\text{H}^+ + 4\text{e}^- \rightleftharpoons \text{Cl}^- + 2\text{H}_2\text{O}$ | 1.56 |
| $2\text{NO} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{N}_2\text{O} + \text{H}_2\text{O}$ | 1.59 |
| $2\text{HClO}_2 + 6\text{H}^+ + 6\text{e}^- \rightleftharpoons \text{Cl}_2 + 4\text{H}_2\text{O}$ | 1.63 |
| $2\text{HClO} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{Cl}_2 + 2\text{H}_2\text{O}$ | 1.63 |
| $\text{HClO}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{HClO} + \text{H}_2\text{O}$ | 1.64 |
| $\text{MnO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightleftharpoons \text{MnO}_2 + 2\text{H}_2\text{O}$ | 1.679 |
| $\text{Au}^+ + \text{e}^- \rightleftharpoons \text{Au}$ | 1.68 |
| $\text{PbO}_2 + \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{PbSO}_4 + 2\text{H}_2\text{O}$ | 1.685 |
| $\text{N}_2\text{O} + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{N}_2 + \text{H}_2\text{O}$ | 1.77 |
| $\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$ | 1.776 |
| $\text{Co}^{3+} + \text{e}^- \rightleftharpoons \text{Co}^{2+}$ | 1.842 |
| $\text{S}_2\text{O}_8^{2-} + 2\text{e}^- \rightleftharpoons 2\text{SO}_4^{2-}$ | 2.05 |
| $\text{O}_3(\text{g}) + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{O}_2(\text{g}) + \text{H}_2\text{O}$ | 2.07 |
| $\text{F}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{HF}(\text{aq})$ | 3.03 |

錄自：Bodner, G. M.; Pardue, H. L. *Chemistry-An Experimental Science*; 2nd ed.,
John Wiley & Sons, Inc.: New York, 1995.