Standard Reduction Potential

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The standard reduction potential is the tendency for a chemical species to be reduced, and is measured in volts at standard conditions. The more positive the potential is the more likely it will be reduced.

Introduction

The standard reduction potential is in a category known as the standard cell potentials or standard electrode potentials. The standard cell potential is the potential difference between the cathode and anode. For more information view Cell Potentials. The standard potentials are all measured at 298 K, 1 atm, and with 1 M solutions.

Standard Reduction Potentials

As stated above, the standard reduction potential is the likelihood that a species will be reduced. It is written in the form of a reduction half reaction. An example can be seen below where "A" is a generic element and C is the charge.

- Standard Reduction Potential

$$A^{C+}(1M) + C * e^{-} \rightarrow A(s)$$

- Copper's Standard Reduction Potential

$$Cu^{2+}(1M) + 3 * e^{-} \rightarrow Cu(s) \quad E^{\circ}_{0(reduction)} = +0.340V$$

Standard Oxidation Potentials

The standard oxidation potential is much like the standard reduction potential. It is the tendency for a species to be *oxidized* at standard conditions. It is also written in the form of a half reaction, and an example is shown below.

- Standard Oxidation Potential (SOP) under standard conditions:

$$A(s) \rightarrow A^{c+} + Ce^{-}$$

Copper's Standard Oxidation Potential

$$Cu(s) \rightarrow Cu^{2+} + 2e^{-}$$

$$E^{0}_{o}(SOP) = -0.34V$$

The standard oxidation potential and the standard reduction potential are opposite in sign to each other for the same chemical species.

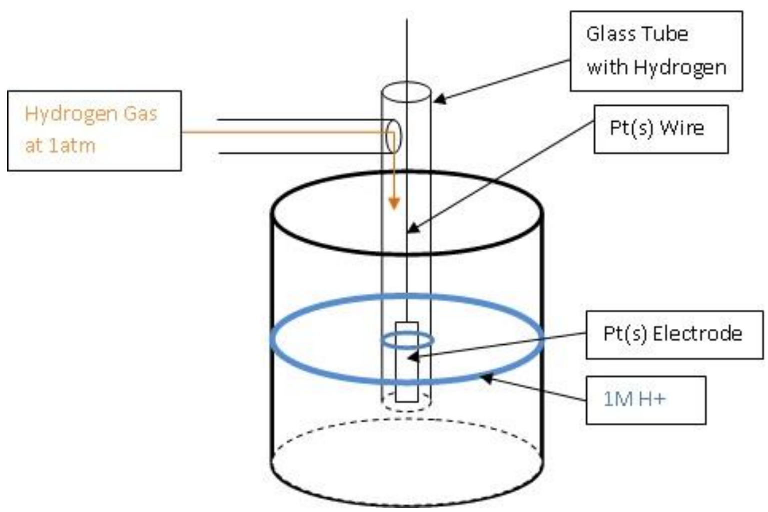
- Relation Between Standard Reduction Potential (SRP) and the Standard Oxidation Potential (SOP)

$$E^{0}_{o}(SRP) = -E^{0}_{o}(SOP)$$

How are Standard Reduction Potentials Experimentally Determined

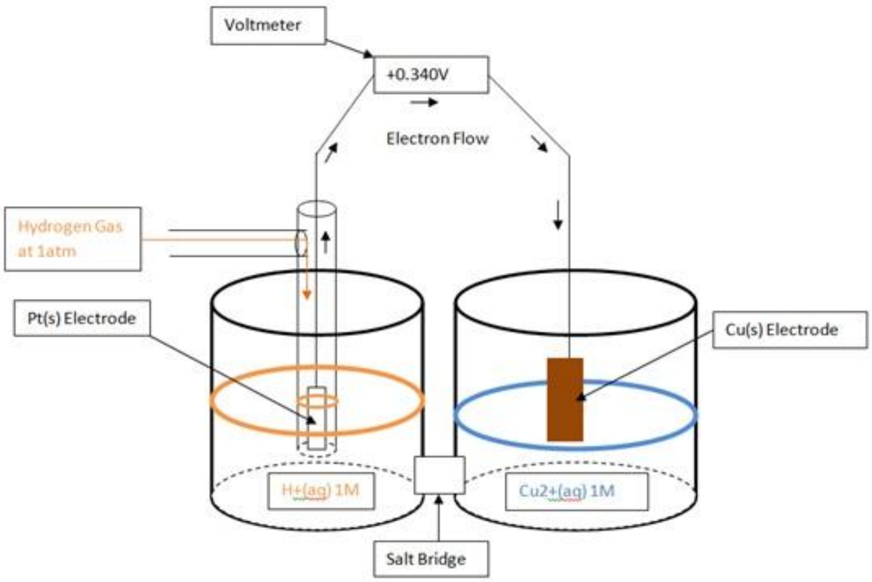
Standard reduction or oxidation potentials can be determined using a SHE (standard hydrogen electrode).

Figure (1) - Standard Hydrogen Electrode



Universally, hydrogen has been recognized as having reduction and oxidation potentials of zero. Therefore, when the standard reduction and oxidation potential of chemical species are measured, it is actually the difference in the potential from hydrogen. By using a galvanic cell in which one side is a SHE, and the other side is half cell of the unknown chemical species, the potential difference from hydrogen can be determined using a voltmeter. Standard reduction and oxidation potentials can both be determined in this fashion. When the standard reduction potential is determined, the unknown chemical species is being reduced while hydrogen is being oxidized, and when the standard oxidation potential is determined, the unknown chemical species is being oxidized while hydrogen is being reduced. The following diagrams show how a standard reduction potential is determined.

- Figure (2) - Determining the Standard Reduction Potential of Copper
- $Cu^{2+}(aq)+2e^{-} \rightarrow Cu(s)$ E= +0.34



How are Standard Reduction Potentials Applied

Standard reduction potentials are used to determine the standard cell potential. The standard reduction cell potential and the standard oxidation cell potential can be combined to determine the overall cell potential of a galvanic cell. The equations that relate these three potentials are shown below. For more information on this topic see Cell Potentials.

- Cell Potential

$$E^{\circ}_{Cell} = E^{\circ}_{0(reduction\ @Cathode)} + E^{\circ}_{0(oxidation\ @Anode)}$$

$$E^{\circ}_{Cell} = E^{\circ}_{0(reduction\ @Cathode)} - E^{\circ}_{0(Reduction\ @Anode)}$$

The Activity Series

When solving for the standard cell potential, the species oxidized and the species reduced must be identified. This can be done using an activity series. The table shown below is simply a table of standard reduction potentials in decreasing order. The species at the top have a greater likelihood of being reduced while the ones at the bottom have a greater likelihood of being oxidized. Therefore, when a species at the top is coupled with a species at the bottom, the one at the top will become reduced while the one at the bottom will become oxidized. Below is a table of standard reduction potentials.

Reduction Half-Reaction	Standard Reduction Potential (V)
$F_2(g)+2e^- \rightarrow 2F^-(aq)$	+2.87
$S_2O_8^{2-}(aq)+2e^- \rightarrow 2SO_4^{2-}(aq)$	+2.01
$O_2(g)+4H^+(aq)+4e^- \rightarrow 2H_2O(l)$	+1.23
$Br_2(l)+2e^- \rightarrow 2Br^+(aq)$	+1.09
$Ag^+(aq)+e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq)+e^- \rightarrow Fe^{2+}(aq)$	+0.77
$I_2(l)+2e^- \rightarrow 2I^+(aq)$	+0.54
$Cu^{2+}(aq)+2e^- \rightarrow Cu(s)$	+0.34
$Sn^{4+}(aq)+2e^- \rightarrow Sn^{2+}(aq)$	+0.15
$S(s)+2H^+(aq)+2e^- \rightarrow H_2S(g)$	+0.14
$2H^+(aq)+2e^- \rightarrow H_2(g)$	**0.00**
$Sn^{2+}(aq)+2e^- \rightarrow Sn(g)$	-0.14
$V^{3+}(aq)+e^- \rightarrow V^{2+}(aq)$	-0.26
$Fe^{2+}(aq)+2e^- \rightarrow Fe(s)$	-0.44
$Cr^{3+}(aq)+3e^- \rightarrow Cr(s)$	-0.74
$Zn^{2+}(aq)+2e^- \rightarrow Zn(s)$	-0.76
$Mn^{2+}(aq)+2e^- \rightarrow Mn(s)$	-1.18
$Na^+(aq)+e^- \rightarrow Na(s)$	-2.71
$Li^+(aq)+e^- \rightarrow Li(s)$	-3.04

References

1. Petrucci, Harwood, Herring, and Madura. General Chemistry: Principles and Modern Applications. 9th ed. Upper Saddle River, New Jersey: Pearson Education, 2007.
2. Zhumdal, Zhumdal. Chemistry. 7th ed. Boston, New Jersey: Massachusetts Houghton Miffle Company, 2007.

Outside Links

- Wikipedia - Standard Reduction Potentials
- CHP- Standard Reduction Potentials
- Youtube - SHE and Measuring Standard Reduction Potentials

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