Standard Cells and Cell Potentials - pgs 627-631

- A **standard cell** is a voltaic cell in which each half-cell contains all entities shown in the half-reaction equation at SATP conditions, with a concentration of 1.0 mol/L for the aqueous solutions

$$\underset{}{Zn(s)} \mid \underset{1.0\,mol/L}{Zn^{2+}(aq)} \parallel \underset{1.0\,mol/L}{Cr_2O_7^{2-}(aq)}, \underset{1.0\,mol/L}{H^+(aq)}, \underset{1.0\,mol/L}{Cr^{3+}(aq)} \mid C(s) \quad \text{at SATP}$$

- The standard cell potential, ***E°*<u>cell</u>**, is the voltage produced by the cell, operating under standard conditions

- $E°_{cell}$ represents the energy difference between the cathode and the anode. (think waterfall)

- The degree sign (°) indicates that standard 1.0 mol/L and SATP conditions apply

- A standard reduction potential, ***E°<u>r</u>***, represents the ability of a standard half-cell to attract electrons, thus undergoing a reduction

- The half-cell with the greater attraction for electrons - that is, the one with the more positive reduction potential ($E°_r$) - gains electrons from the half-cell with the lower reduction potential

- The standard cell potential is the difference between the reduction potentials of the two standard half-cells

voltage

$$E°_{cell} = \underset{\substack{\text{cathode} \\ \text{SOA}}}{E°_r} - \underset{\substack{\text{anode} \\ \text{SRA}}}{E°_r}$$

Draw the cell below and label all the necessary parts. Calculate the cell potential for the cell below

$$\underset{}{Zn(s)} \mid \underset{1.0\,mol/L}{Zn^{2+}(aq)} \parallel \underset{1.0\,mol/L}{Cr_2O_7^{2-}(aq)}, \underset{1.0\,mol/L}{H^+(aq)}, \underset{1.0\,mol/L}{Cr^{3+}(aq)} \mid C(s) \quad \text{at SATP}$$

http://www.boardworks.co.uk/media/4bc9cf15/A-Level%20Chemistry/redox_5_hydrogen_electrode_animation.swf

<u>Standard Hydrogen Half-Cell</u>

- It is impossible to determine experimentally the reduction potential of a single half-cell because electron transfer requires both an oxidizing agent and a reducing agent

- To assign values for standard reduction potentials (E^o_r), we measure the "reducing" strength of all possible half cells relative to an accepted, standard half-cell.

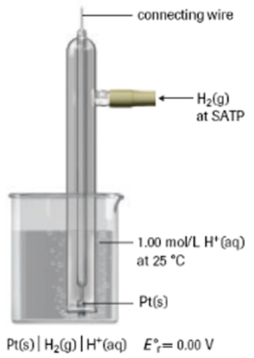
- The half-cell used for this purpose is the standard **<u>hydrogen</u>** half-cell

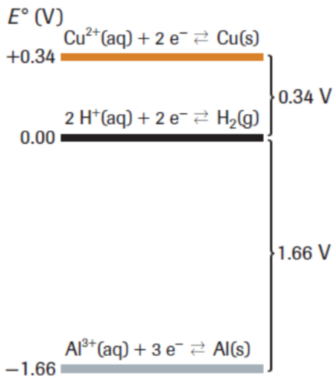
- A half-cell that is chosen as a reference and arbitrarily assigned a reduction potential of exactly zero volts, is called a **<u>reference</u>** half-cell.

- The standard hydrogen half-cell consists of

  - an inert platinum electrode immersed in a 1.00 mol/L solution of hydrogen ions

  - hydrogen gas at a pressure of 100 kPa bubbling over the electrode





- Because we have assigned the hydrogen half-cell a reduction potential (E^o_r) of zero, we can now assign values to the other half cells by connecting them to the hydrogen half cell and calculating the cell potential.

$$E^o_{cell} = E^o_{r\ \text{cathode}} - E^o_{r\ \text{anode}}$$

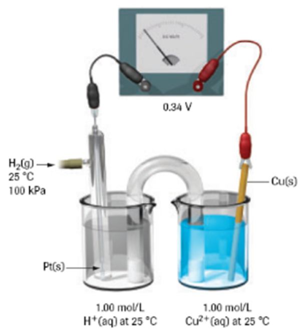


Figure 7
A copper–hydrogen standard cell

- A reduction potential that has a **positive** value means that the oxidizing agent is a stronger oxidizing agent than hydrogen ions.

- A reduction potential that has a **negative value** means that the oxidizing agent is a weaker oxidizing agent than hydrogen ions

- We can measure the standard reduction potential of a half-cell by constructing a standard cell using a hydrogen reference half-cell and the half-cell whose reduction potential you want to measure

http://www.boardworks.co.uk/a-level-chemistry_507/product-samples

Learning Tip

A voltmeter has two terminals, positive (red) and negative (black). Connect these to the electrodes of any cell so that the voltmeter gives a positive reading. Whatever electrode is connected to the positive terminal will be the cathode, and the other electrode will be the anode.

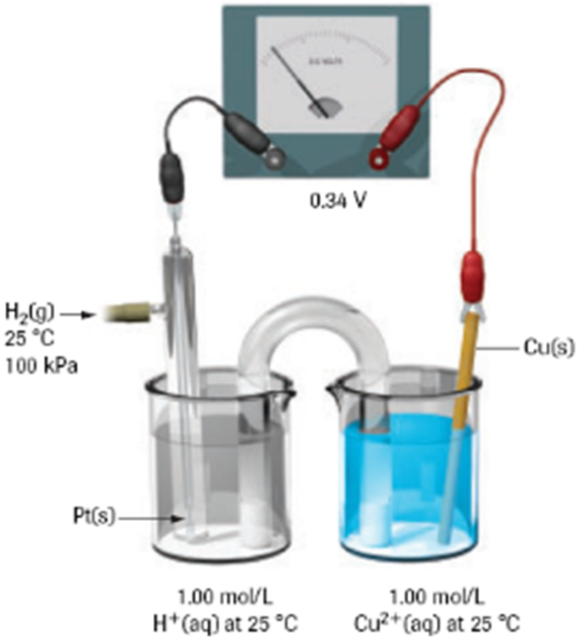


Figure 7
A copper-hydrogen standard cell

$$
\begin{array}{ll}
\text{cathode:} & Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s) \\
\text{anode:} & \underline{\qquad\qquad H_2(g) \rightarrow 2\,H^+(aq) + 2\,e^-} \\
\text{net:} & Cu^{2+}(aq) + H_2(g) \rightarrow Cu(s) + 2\,H^+(aq)
\end{array}
$$

$$
\begin{aligned}
E^\circ_{cell} &= \underset{\text{cathode}}{E^\circ_r} - \underset{\text{anode}}{E^\circ_r} \\
&= 0.34\ \text{V} - 0.00\ \text{V} \\
&= +0.34\ \text{V}
\end{aligned}
$$

SUMMARY ***Rules for Analyzing Standard Cells***

You can analyze a standard cell knowing the contents of both half-cells using one or more of the following steps:

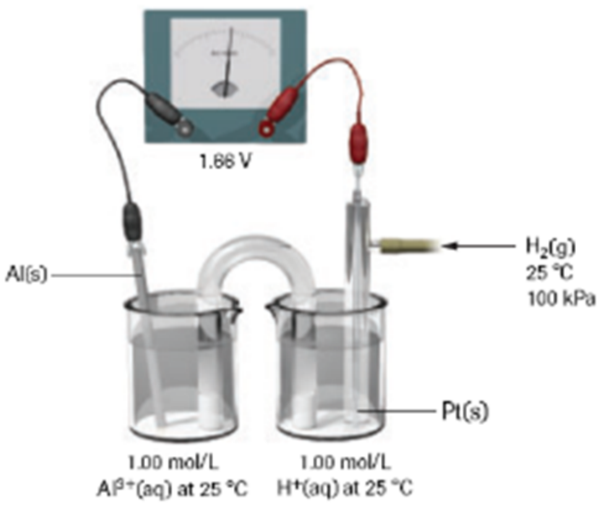
- Determine which electrode is the cathode. The cathode is the electrode where the strongest oxidizing agent present in the cell reacts, i.e., the oxidizing agent that is closest to the top on the left side of the redox table. If required, copy the reduction half-reaction for the strongest oxidizing agent and its reduction potential.

- Determine which electrode is the anode. The anode is the electrode where the strongest reducing agent present in the cell reacts, i.e., the reducing agent that is closest to the bottom on the right side of the redox table. If required, copy the oxidation half-reaction (reverse the half-reaction by reading from right to left) for the strongest reducing agent and its reduction potential.

- Determine the overall cell reaction. Balance the electrons for the two half-reaction equations (but do not change the $E°_r$) and add the half-reaction equations.
- Determine the standard cell potential, $E°_{cell}$, using the equation:

$$E°_{cell} = \underset{\text{cathode}}{E°_r} - \underset{\text{anode}}{E°_r}$$

Write the shorthand notation for this cell; determine the overall cell reaction and calculate the standard cell potential



Pracce Sheet 9

1. Draw and label a diagram for a voltaic cell constructed from some (not all) of the following materials. Write the half reacon and net reacon for your cell. Calculate the cell potenal of the cell you created.

strip of cadmium metal	voltmeter
strip of nickel metal	connecng wires
solid cadmium sulfate	glass U-tube
solid nickel(II) sulfate	coon
solid potassium sulfate	various beakers
dislled water	porous porcelain cup

2. Redesign the voltaic cell in queson 8 by changing at least one electrode and one electrolyte. The net reacon should remain the same for the redesigned cell.

3. A standard lead–dichromate cell is constructed. Write the cell notaon, label the electrodes, and calculate the standard cell potenal.