[TP] Based on the balanced reduction half-reaction, how many moles of electrons are consumed when 1 mole of $O_2(g)$ is reduced to hydrogen peroxide, $H_2O_2(aq)$?

20% 1. 1
20% 2. 2
20% 3. 3
20% 4. 4
20% 5. 6

Response Counter 10

Lecture 25 CH102 A1 (MWF 9:05 am)

Wednesday, March 29, 2017

Begin ch16: Electron transfer reactions and electrochemistry

- Electrochemistry in a nutshell
- Electrochemical cells harness spontaneity as electron flow
- Cell line notation
- Cell voltage, E_{cell}, and electrical energy
- What determines cell voltage, E_{cell}?

Next lecture: Continue ch16: What determines cell voltage, E_{cell}? Calculating standard cell voltage, $E°_{cell}$. Cell voltage versus spontaneity.

For oxidation numbers and balancing redox equations, please work through http://goo.gl/MMEUCs.

Electrochemistry in a nutshell

- Redox processes transfer electrons
- Redox processes evolve spontaneously to equilibrium
- Electron transfer can be harnessed as an electric current

[TP] Based on the balanced reduction half-reaction, how many moles of electrons are consumed when 1 mole of $O_2(g)$ is reduced to hydrogen peroxide, $H_2O_2(aq)$?

20% 1. 1
20% 2. 2
20% 3. 3
20% 4. 4
20% 5. 6

Response Counter 10

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[Quiz] Based on the balanced oxidation half-reaction, how many moles of electrons are released when 1 mole of NO(g) is oxidized to NO_3^-(aq)?

20% 1. 1
20% 2. 2
20% 3. 3
20% 4. 4
20% 5. 6

Response Counter 10

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Cu^{2+}(aq) oxidizes Zn(s)

Spontaneous flow of electrons from Zn to Cu

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

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

Harness in an electrochemical cell

$Zn(s)|\ Zn^{2+}(aq)\ ||Cu^{2+}(aq)|\ Cu(s)$

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Cu^{2+}(aq) oxidizes Zn(s) spontaneously

Sketch an electrochemical cell to harness the spontaneity of

$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$

$Zn(s)|\ Zn^{2+}(aq)\ ||Cu^{2+}(aq)|\ Cu(s)$

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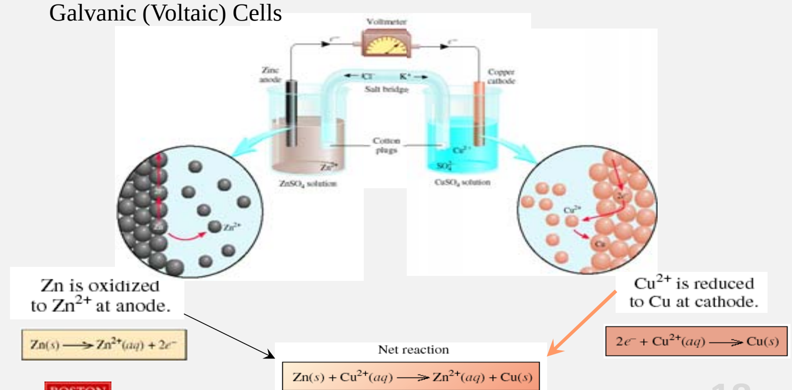
Galvanic (Voltaic) Cells



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Cell line notation (Tro, 4e, p 897)

$Zn(s)|\ Zn^{2+}(aq)\ ||Cu^{2+}(aq)|\ Cu(s)$

- Oxidation on left, "||" is salt bridge, reduction on right
- Phases separated by "|", same phases separated by ","
- If no solid, inert electrode (Pt or graphite)
- Left to right order matches flow of electrons

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Cell line notation (Tro, 4e, p 897)

$Fe(s)|\ Fe^{2+}(aq)\ ||MnO_4^{-}(aq),\ H^{+}(aq),\ Mn^{2+}(aq)|\ Pt(s)$

Write the half reactions …

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

$MnO_4^{-}(aq) + 5\ e^{-} + 8\ H^{+}(aq) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l)$

Sketch the cell (on your own).

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Cell voltage, E_{cell}, and electrical energy

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Cell voltage, E_{cell}, and electrical energy

Electron flow in a voltage E is able to provide electrical energy

w_e = electrical charge × voltage

In terms of moles of electrons that flow, n_e, the amount of charge is

electrical charge = $n_e \times F$

where F, known as the Faraday constant, is 96485 C/mol.

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Cell voltage, E_{cell}, and electrical energy

A typical physiological voltage is 0.150 V = 0.150 J/C.

The corresponding energy due to the transfer of 1.00 mol of electron is …

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Cell voltage, E_{cell}, and electrical energy

A typical physiological voltage is 0.150 V = 0.150 J/C.

The corresponding energy due to the transfer of 1.00 mol of electron is …

$$\begin{aligned} w_e &= \text{electrical charge} \times \text{voltage} = n_e\, F\, E_{cell} \\ &= 1.00\text{ mol} \times 0.150\text{ J/C} \times 96485\text{ C/mol} \\ &= 14.5\text{ kJ} \end{aligned}$$

This is a lot of energy!

While each electron contributes a small amount of energy, there are a lot of electrons in a mole!

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What determines cell voltage, E_{cell}?

The bigger, E_{cell}, the more energy than can be harnessed.

Two things determine , E_{cell}: enthalpy change and spontaneity

We will see that these two things together determine what is called the free energy change, ΔG, of the redox process.

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What determines cell voltage, E_{cell}?

By our convention that work done on the system corresponds to positive energy change, free energy change is defined with a negative sign …

$$\Delta G_{cell} = -n_e\, F\, E_{cell}$$

so that negative values of free energy change mean work is available to be done on the surrounding.

The term "free" energy change reflects the fact that ΔG is the energy available ('free') to do work.

In general, if $\Delta G_{cell} < 0$, that is, if $E_{cell} > 0$, then the redox process is able to provide energy to the surroundings.

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What determines cell voltage, E_{cell}?

We know spontaneity is determined by Q relative to K.

For now we can simplify things by arranging for $Q = 1$, typically by making reactants and products be in their standard state.

This arrangement defines what we call the standard free energy change,

$$\Delta G^\circ_{\text{cell}} = -n_e F E^\circ_{\text{cell}}$$

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