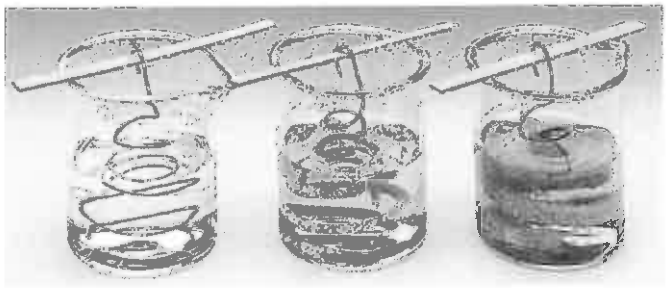
Redox Reactions & Electrochemistry

Oxidation and Reduction

Examples of Oxidation and Reduction Reactions

- oxidation of carbohydrates to water and carbon dioxide in your body.
- All combustion and corrosion processes.
- Rust, bleach

When copper wire is placed in an aqueous solution of silver nitrate:



The reaction between copper and silver nitrate solution

$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$

Ionic Equation:

$Cu_{(s)} + 2Ag^{+}_{(aq)} + 2NO_3^{-}{}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2NO_3^{-}{}_{(aq)} + 2Ag_{(s)}$

Removing Spectator Ions:

$Cu_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$

This is a redox reaction.

LEO the lion says GER!
losing e^- is oxid
gaining e^- is reduct
OR
OIL RIG
oxid is losing e^-
reduct is gaining e^-

Any reaction in which electrons are lost is called an oxidation reaction. A reaction that involves the gain of electrons is called a reduction reaction.

The element that undergoes oxidation is the reducing agent.
The element that undergoes reduction is the oxidizing agent.

In the above example: Cu loses e^- & is oxidized (reducing agent)
Ag gains e^- & is reduced (oxidizing agent)

Oxidation and reduction must take place concurrently, therefore they are called redox reactions.

Electronegativity and Oxidation Numbers

Metals have low electronegativities, ΔE and tend to lose electrons to other atoms, and are hard to oxidize. Those with high ΔEs accept electrons and are reduced. (aka nonmetals)

We can keep track of the electrons by assigning oxidation numbers to the various atoms. The oxidation number tells us how many electrons an atom in a compound would gain or lose.

Determining Oxidation Numbers

Rule 1: The Elements

- The oxidation number of a pure element is 0. eg. $Cu_{(s)}$, $Cl_{2(g)}$

Rule 2: Simple Ion Charge = Oxidation Number

Assigning oxidation numbers to most ions is the ion charge.

- the ions of Group I metals are assigned the oxidation number +1.
- the ions of Group 2 metals are assigned the oxidation number +2.

eg. Na^{+1}, Mg^{+2}, Cl^{-1}, O^{-2}

Rule 3: Hydrogen

- Hydrogen is assigned the oxidation number +1 in all compounds except in metal hydrides where it is assigned the number −1. eg. CaH_2

Rule 4: Oxygen

- Oxygen is assigned the oxidation number −2, except in peroxides like hydrogen peroxide where it is assigned −1, and in OF_2 where is is assigned a +2 (eg H_2O_2)

Rule 5: Covalent Compounds

In compounds that do not contain hydrogen or oxygen, the more electronegative element is assigned the oxidation number it would have in an ionic compound.

- In sulfur dichloride, SCl_2, chlorine has a higher electronegativity so it is assigned −1 and sulfur is assigned +2.

Rule 6: Compounds

The sum of the oxidation numbers in a compound is zero.

- The sum of oxidation numbers in NaCl is (+1) + (-1) = 0
- The sum of oxidation numbers in H_2O is 2(+1) + (-2) = 0

Rule 7: Polyatomic Ions

The sum of the oxidation numbers of the elements in a polyatomic ion must equal the ion charge.

Example: Carbonate ion CO_3^{-2}

Oxygen is assigned the oxidation number -2. There are three oxygen atoms in the formula so the total negative charge is -6. Since the carbonate ion has a charge of -2, the oxidation number of carbon must be +4

Examples:

1) What are the oxidation numbers of each element in calcium chloride?

$^{+2}Ca^{-1}Cl_2$

2) What are the oxidation numbers of iron in the two iron oxides, FeO and Fe_2O_3 ?

$^{+2}Fe^{-2}O$ $\quad$ $^{+3}Fe_2^{-2}O_3$ Do O first

+6 -6 = 0

3) What are the oxidation numbers of the elements in H_2O ?

$^{+1}H_2^{-2}O$

+2 -2 = 0

4) What are the oxidation numbers of the elements in CO_2 ?

$^{+4}C^{-2}O_2$

+4 -4 = 0

5) What are the oxidation numbers of the elements in $S_2O_3^{-2}$?

$^{+2}S_2^{-2}O_3^{-2}$

+4 -6 = -2

6) Is the following reaction a Redox reaction? Show your work.

$$2\,NaBr_{(aq)} + Cl_{2(g)} \rightarrow 2\,NaCl_{(aq)} + Br_{2(aq)}$$

Na: +1 to +1 no change
Br: -1 to 0 loses $1e^-$
Cl: 0 to -1 gains $1e^-$

yes; change in oxid #

7) Is the following reaction a Redox reaction? Show your work.

$$2\,Na + Cl_2 \rightarrow 2NaCl$$

Na: 0 to +1 loses $1e^-$
Cl: 0 to -1 gains $1e^-$

yes; change in oxid #

8) Identify the oxidizing agent and reducing agent in each of the following:

a) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

H: 0 to +1 loses $1e^-$ Oxidation ∴ reducing agent
O: 0 to -2 gains $2e^-$ reduction ∴ oxidizing agent

b) $Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$

+1 -6 +2 +5-6 -4

Cu: 0 to +2 loses $2e^-$ oxidation ∴ reducing agent
N: +5 to +4 gains $1e^-$ reduction ∴ oxidizing agent