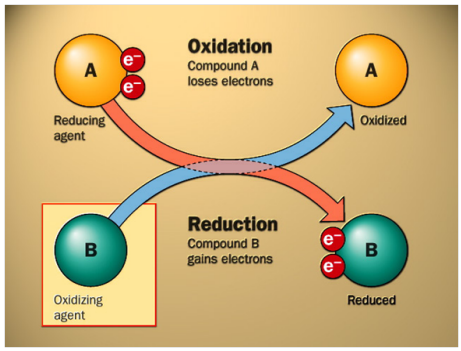
4.9 - 4.10 Oxidation/ Reduction Reactions



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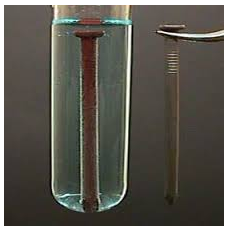
Demo:

Iron is replaced by copper:

$Fe_{(s)} + CuSO_{4(aq)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$



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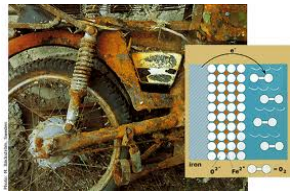
Oxidation

Colloquially, 'oxidation' means reacting with O_2.
In chemistry, oxidation = loss of electrons (symbol = e^-).
In the demo, iron lost e^-:

Half-reaction*: $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2\ e^-$

Thus, it was oxidized.

* A half-reaction shows a reactant losing or gaining electrons.



Oxidation

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Reduction

Reduction: gaining e^-.

The oxidation number (charge) is reduced, hence the term reduction.

In our demo, e^- were gained by copper:

Half-reaction: $Cu^{2+}_{(aq)} + 2\ e^- \rightarrow Cu_{(s)}$

Since copper's charge lowered from +2 to zero: it underwent reduction.

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Oxidation-Reduction (Redox) Reactions

Def: Reaction involving e^- transfer.
No oxidation w/o reduction!
Oxidizing Agent (oxidizer): Oxidizes another chemical. It accepts e^-, so is reduced.

Reducing Agent (reducer): Reduces oxidizer's charge by giving it e^-. The reducer is oxidized.

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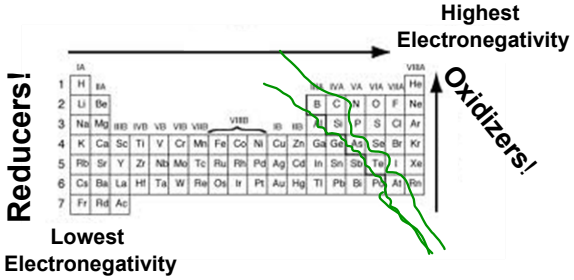
Redox and Electronegativity

Electronegativity: the attraction an element has for the electrons of another element. It drives redox chemistry. Metals = good reducers; Non-metals = good oxidizers.



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How to Assign Charge: 5 Rules

1. Pure elements (polyatomic too: N_2, O_3) = 0.
2. Oxide (O^{2-}) always = -2; peroxide (O_2^{2-}) = -1
   Fluoride (F^-) always = -1.
3. 1st group, including hydrogen (covalent compounds only) = +1. Ex: Na^+ = +1.
   2nd group metals = +2. Ex: Ca^{2+} = +2.
4. Total charge in neutral compounds is 0.
   Ex: H_2SO_4 has net charge of 0.
5. Total charge of all ions = superscript.
   Cl^- = -1 charge. Ex: SO_4^{2-} has net charge of -2.
   Use Accountant Method to determine unknown elements in polyatomic ions.

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1. Accountant Method Guided Example: HNO_2

Accountants use The Bottom Line; this technique determines charges in complex species. Do HNO_2.

1. Draw 'Bottom Line': HNO_2
2. Put overall charge at end of Line: $HNO_2 = 0$
3. Place rule-based charges above elements: $\overset{+1\ ?\ -2}{HNO_2} = 0$
4. Multiply charges by subscripts: $\overset{+1\ ?\ -2}{HNO_2}$ → $+1+?-4 = 0$
5. Solve for missing information: $\overset{+1\ +3\ -2}{HNO_2}$ → $+1+3-4 = 0$

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2. Oxidation Number Example

Determine each elements' oxidation number:

Au^{3+} CO_2 Rb

N_2O_5 ClO_3^- S_8

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3. Oxidizer Example

Assign charges to each atom, $\overset{0}{N_{2(g)}} + \overset{0}{3H_{2(g)}} \rightarrow \overset{-3\ +1}{2\ NH_{3(g)}}$ then link changed elements with tie lines showing oxidation number change.

-3

$N_{2(g)} + 3H_{2(g)} \rightarrow 2\ NH_{3(g)}$

+1

What charge changes charge happen, and which reactant is the oxidizer? How many electrons are transferred?

Nitrogen gains 3 e^- : change = -3.

Hydrogen loses 1 e^-: change = +1.

Nitrogen = oxidizer - it was reduced (absorbed e^-).

Six electrons went from hydrogen to nitrogen.

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4. Balance this Tough Problem!

__P + __H_2O + __HNO_3 ⟶ __H_3PO_4 + __NO

Answer Later!

May 2-11:36 AM

Redox Balancing Procedure

1. Assign oxidation numbers only to elements that change.
2. Link changing elements with tie lines, and indicate what their charge change is.
3. Add coefficients to equalize charge by swapping charge changes - this produces the lowest common multiple.
4. Balance non-changed elements by inspection.
5. Reduce coefficients if possible.

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4. Tough Problem Again!

$P + H_2O + HNO_3 \longrightarrow H_3PO_4 + NO$

1. Determine oxidation numbers:

$\overset{0}{P} + H_2O + \overset{+5}{H}\overset{+5}{N}O_3 \longrightarrow \overset{+5}{H_3}\overset{+2}{P}O_4 + \overset{+2}{N}O$

Change: +5

2. Link and report changes: **Change: -3**
3. Swap charges and write as coefficients:

$3P + H_2O + 5HNO_3 \longrightarrow 3H_3PO_4 + 5NO$

4. Balance the rest by inspection:

$3P + 2H_2O + 5HNO_3 \longrightarrow 3H_3PO_4 + 5NO$

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5. Ionic Example

Sometimes it is useful to only write ions that are involved in the reaction.

$ClO_4^- + HBr \rightarrow Cl^- + Br_2 + H_2O$

1. Assign oxidation numbers to changing elements:

$\overset{+7\ -2}{ClO_4^-} + \overset{+1\ -1}{HBr} \rightarrow \overset{-1}{Cl^-} + \overset{0}{Br_2} + \overset{+1\ -2}{H_2O}$

2. Link and report changes with tie lines:

$ClO_4^- + HBr \rightarrow Cl^- + Br_2 + H_2O$

-8 +1

Changes: Cl = -8 Br = +1 (need 8)

3. Write coefficients by swapping charge changes:

$ClO_4^- + 8\ HBr \rightarrow Cl^- + 4\ Br_2 + H_2O$

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5. Ionic Example

4. Balance the rest by inspection

$ClO_4^- + 8HBr \rightarrow Cl^- + 4Br_2 + 4H_2O$

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Homework

4.9 - 4.10 Problems in your Booklet
Due: Next Class.

Prepare for test Monday, 9/30

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