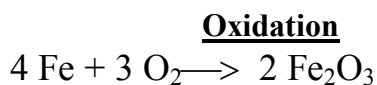
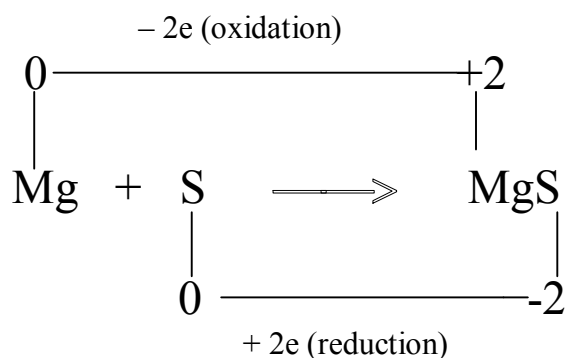


OXIDATION-REDUCTION REACTIONS
I. Traditional Meaning


A rxn in which an element combines with oxygen

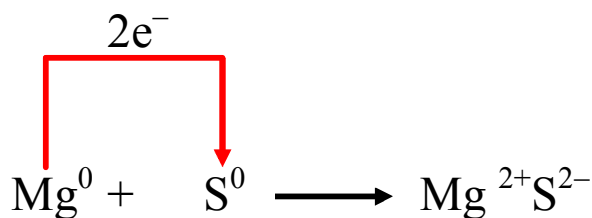


A rxn in which a metal is obtained from its oxide

II. Modern Meaning


Mg : - is **oxidized** (loses electrons)
 - causes the reduction of S
 - called **Reducing Agent**

S : - is **reduced** (gains electrons)
 - causes the oxidation of Mg
 - called **Oxidizing Agent**

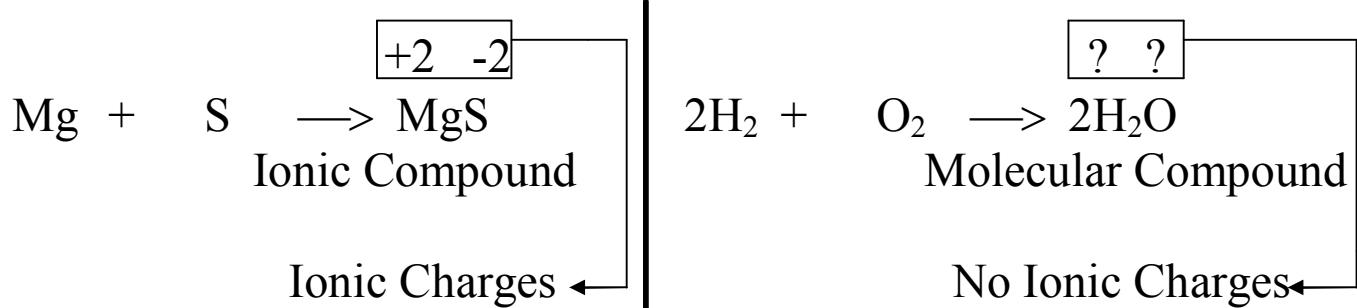


- Oxidation-Reduction** Rxns (Redox Rxns) can be represented by half-reactions:

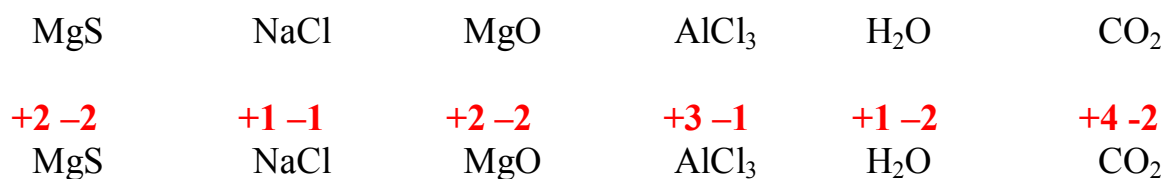
Oxidation Half-Reaction

Reduction Half-Reaction


OXIDATION NUMBERS (O.N.)



- OXIDATION NUMBERS are assigned numbers based on the assumption that all compounds are ionic

IN AN IONIC COMPOUND

O.N. = Ionic Charge

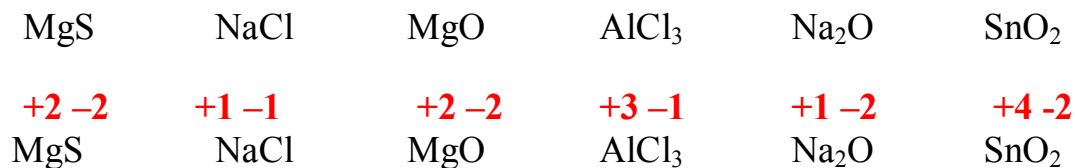
**+1 -2**IN A MOLECULAR COMPOUNDO.N. = "Assumed" Ionic Charge
(assume that the compound is ionic)**+2 -2**

RULES FOR ASSIGNING O.N.'s

1. O.N. of any element in its free, uncombined state = 0



2. O.N. of any monoatomic ion = Charge of the Ion



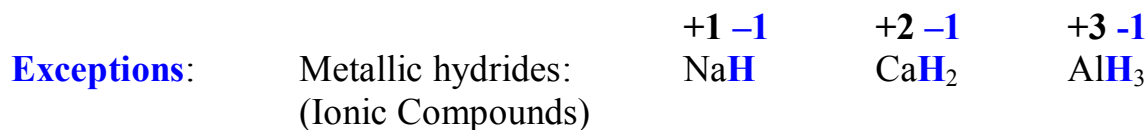
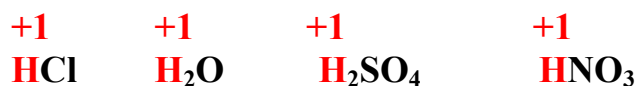
3. O.N. of Oxygen in any compound = -2



4. In Molecular Compounds, the negative ON is assigned to the atom that is more to the right and higher up on the Periodic Table



5. O.N. of Hydrogen in any compound = +1



6. The Sum of all the O.N.'s of all atoms in a compound = 0

$+1 \text{ ? } -2$ H_2SO_4	$+1 \text{ ? } -2$ H_2SO_3	$+1 \text{ ? } -2$ HNO_3	$+1 \text{ ? } -2$ HNO_2
$+2 \text{ (?) } - 8 = 0$	$+2 \text{ (?) } - 6 = 0$	$+1 \text{ (?) } - 6 = 0$	$+1 \text{ (?) } - 4 = 0$
O.N. of S = +6	O.N. of S = +4	O.N. of N = +5	O.N. of N = +3

Examples:

(A) Calculate O.N. of **Cl** in the following Compounds:

HCl	HClO	HClO₂	HClO₃	HClO₄
$+1 \text{ ?}$	$+1 \text{ ? } -2$	$+1 \text{ ? } -2$	$+1 \text{ ? } -2$	$+1 \text{ ? } -2$
HCl	HClO	HClO₂	HClO₃	HClO₄
-1	+1	_____	_____	_____

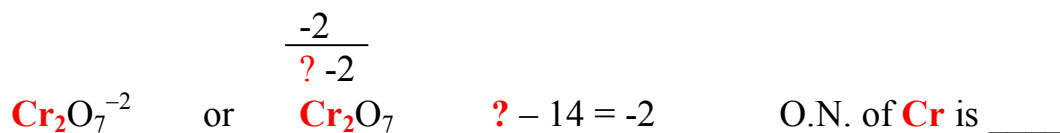
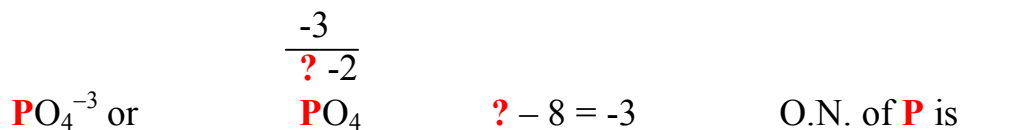
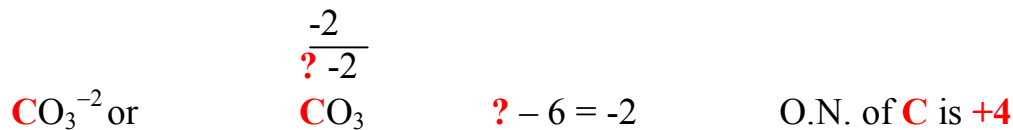
OXIDATION NUMBER INCREASES



(B) Calculate O.N. of Mn in KMnO₄

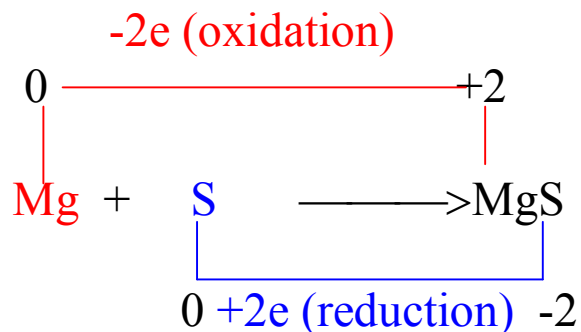


7. The Sum of O.N.'s of all atoms in a polyatomic ion = Charge of the ion



OXIDATION-REDUCTION REACTIONS

- Redox reactions are rxns in which the O.N.'s of at least 2 elements change



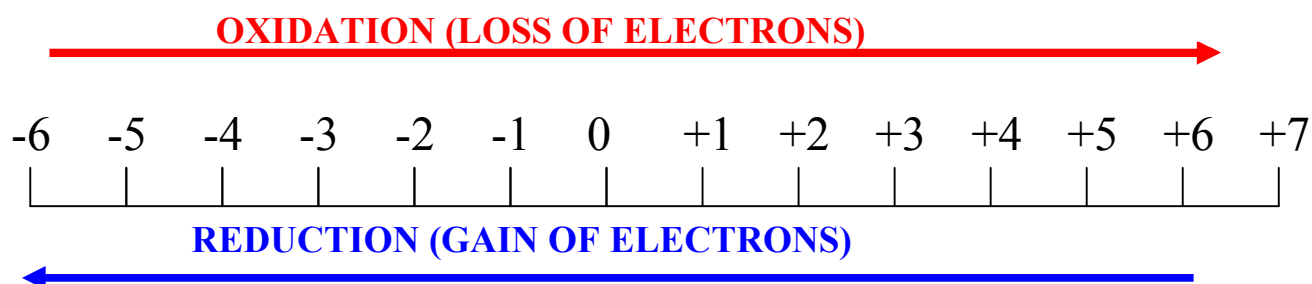
In General

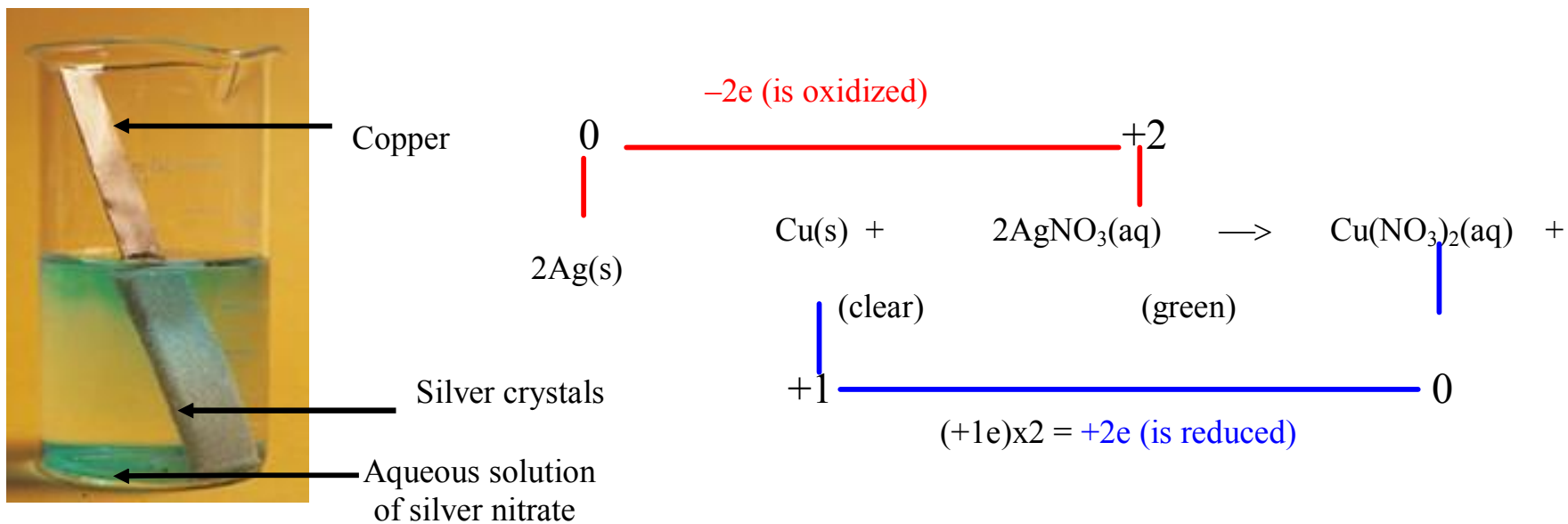
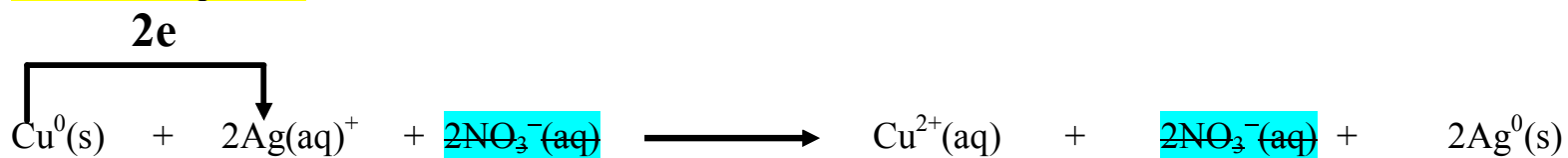
An element that is oxidized: (Mg)

- loses electrons
- its O.N. increases
- is the Reducing Agent

An element that is reduced: (S)

- gains electrons
- its O.N. is reduced
- is the Oxidizing Agent



Example 1:**Total Ionic Equation:****Net Ionic Equation:**

HALF-REACTIONS

- Redox Reactions are discussed (sometimes balanced) by writing two Half – Reactions:

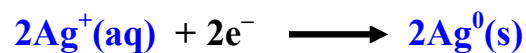
OXIDATION HALF-REACTION

- involves loss of electrons
- increase in Oxidation Number



REDUCTION HALF-REACTION

- involves gain of electrons
- decrease in Oxidation Number



NOTE:

Number of electrons
lost in
Oxidation reaction

=

Number of electrons
gained in
Reduction reaction

CONCLUSION:

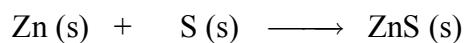
Oxidation–Reduction (Redox) Reactions

- are reactions in which the Oxidation Numbers of at least two elements change
- involve transfer of electrons:

- from : the element that is oxidized (called **Reducing Agent**)
- to: the element that is reduced (called **Oxidizing Agent**)

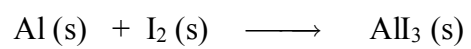
Example 2:

Determine the oxidized and reduced species and write half-reactions for the reaction of zinc and sulfur to form zinc sulfide:



Example 3:

Determine the oxidized and reduced species and write half-reactions for the reaction of aluminum and iodine to form zinc aluminum iodine:

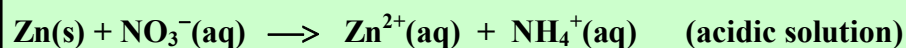


BALANCING REDOX REACTIONS IN ACIDIC & BASIC SOLUTIONS

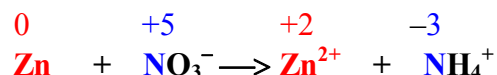
- When balancing redox reactions, the following must be observed:
 - Atoms must balance
 - Nr. of electrons lost = Nr. of electrons gained
 - Net charges of ions on both sides of the equation must balance

1. Acidic Solution (H^+ ions and H_2O molecules may be added as needed)

Balance the following redox reaction that takes place in acidic solution:



Step 1: Assign oxidation numbers and determine the oxidized and reduced species and number of electrons involved.



Step 2: Set up half-reactions.

- Oxidation loses electrons (write as product)
- Reduction gains electrons (write as reactant)

Oxidation half-reaction	Reduction half-reaction
$\text{Zn} \rightarrow \text{Zn}^{2+} + 2 \text{e}^-$	$\text{NO}_3^- + 8 \text{e}^- \rightarrow \text{NH}_4^+$

Step 3: Balance atoms; H_2O molecules and H^+ ions may be added as needed

Oxidation half-reaction	Reduction half-reaction
$\text{Zn} \rightarrow \text{Zn}^{2+} + 2 \text{e}^-$ (balanced; no action needed)	$\text{NO}_3^- + 8 \text{e}^- \rightarrow \text{NH}_4^+$ Balance O atoms by adding H_2O molecules: $\text{NO}_3^- + 8 \text{e}^- \rightarrow \text{NH}_4^+ + 3 \text{H}_2\text{O}$ Balance H atoms by adding H^+ ions: $\text{NO}_3^- + 10 \text{H}^+ + 8 \text{e}^- \rightarrow \text{NH}_4^+ + 3 \text{H}_2\text{O}$

- **Check to see that atoms and charges are balanced for each half-reaction,**

Step 4: Equalize loss and gain of electrons.

Oxidation half-reaction	Reduction half-reaction
$[\text{Zn} \rightarrow \text{Zn}^{2+} + 2 \text{e}^{-}] \times 4$ $4 \text{Zn} \rightarrow 4 \text{Zn}^{2+} + 8 \text{e}^{-}$	$[\text{NO}_3^{-} + 10 \text{H}^{+} + 8 \text{e}^{-} \rightarrow \text{NH}_4^{+} + 3 \text{H}_2\text{O}] \times 1$ $\text{NO}_3^{-} + 10 \text{H}^{+} + 8 \text{e}^{-} \rightarrow \text{NH}_4^{+} + 3 \text{H}_2\text{O}$

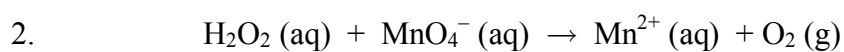
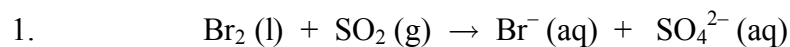
Step 5: Add up half-reactions and cancel electrons.



- Check to see that atoms and charges are balanced for the overall reaction

Examples:

Balance the following redox reaction in acidic solution:



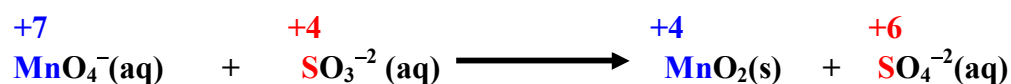
2. Basic Solution (OH^- ions and H_2O molecules may be added as needed)

Basic Idea: O and H will be balanced as though the solution were acidic
 In a later step, the acidic solution will be converted to a basic solution

Balance the following redox reaction that takes place in basic solution:



Step 1: Assign oxidation numbers and determine the oxidized and reduced species and number of electrons involved.



Step 2: Set up half-reactions.

- Oxidation loses electrons (write as product)
- Reduction gains electrons (write as reactant)

Oxidation half-reaction	Reduction half-reaction
$\text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-} + 2 \text{e}^-$	$\text{MnO}_4^- + 3 \text{e}^- \rightarrow \text{MnO}_2$

Step 3: Balance atoms; H_2O molecules and H^+ ions may be added as needed

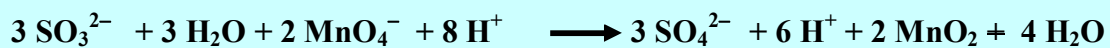
Oxidation half-reaction	Reduction half-reaction
$\text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-} + 2 \text{e}^-$	$\text{MnO}_4^- + 3 \text{e}^- \rightarrow \text{MnO}_2$
Balance O atoms by adding H_2O molecules: $\text{SO}_3^{2-} + \text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 2 \text{e}^-$	Balance O atoms by adding H_2O molecules: $\text{MnO}_4^- + 3 \text{e}^- \rightarrow \text{MnO}_2 + 2 \text{H}_2\text{O}$
Balance H atoms by adding H^+ ions: $\text{SO}_3^{2-} + \text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 2 \text{e}^- + 2 \text{H}^+$	Balance H atoms by adding H^+ ions: $\text{MnO}_4^- + 3 \text{e}^- + 4 \text{H}^+ \rightarrow \text{MnO}_2 + 2 \text{H}_2\text{O}$

- Check to see that atoms and charges are balanced for each half-reaction,

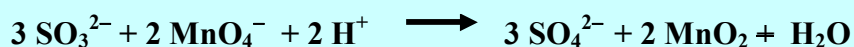
Step 4: Equalize loss and gain of electrons.

Oxidation half-reaction	Reduction half-reaction
$[\text{SO}_3^{2-} + \text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 2 \text{e}^- + 2 \text{H}^+] \times 3$	$[\text{MnO}_4^- + 3 \text{e}^- + 4 \text{H}^+ \rightarrow \text{MnO}_2 + 2 \text{H}_2\text{O}] \times 2$
$3 \text{SO}_3^{2-} + 3 \text{H}_2\text{O} \rightarrow 3 \text{SO}_4^{2-} + 6 \text{e}^- + 6 \text{H}^+$	$2 \text{MnO}_4^- + 6 \text{e}^- + 8 \text{H}^+ \rightarrow 2 \text{MnO}_2 + 4 \text{H}_2\text{O}$

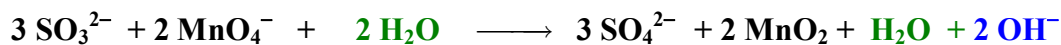
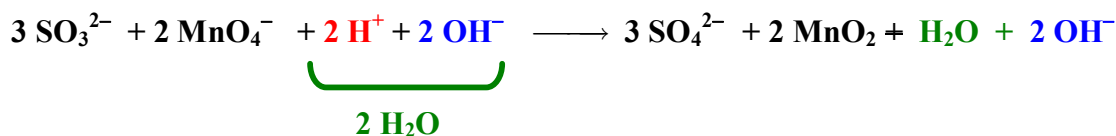
Step 5: Add up half-reactions and cancel electrons.



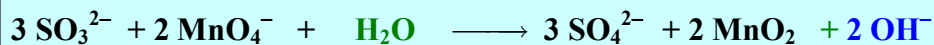
- Note that the H^+ ions and H_2O molecules may be canceled and the equation becomes:



Step 6: Add OH^- to cancel H^+ ion by forming H_2O molecules



- Cancel one more time the H_2O molecules:



- Check to see that atoms and charges are balanced for each half-reaction,

NOTE:

For an alternate method of balancing basic solutions see “Redox Review” on my website

Examples:

Balance the following redox reactions in basic solution:

