

- | |
|--|
| <ol style="list-style-type: none">1. Oxidation Numbers2. Electron gain and loss3. Agents |
|--|

Electrochemistry is the study of the **interchange of chemical and electrical energy**.

- Reactions with electron transfers are commonly called **oxidation-reduction reactions (redox reactions)**
- Not all reactions involve an electron transfer!

Oxidation Numbers

Oxidation number is the real or apparent **charge** of an atom or ion. Also called **"combining capacity"**.

Rules for Assigning Oxidation Numbers (simplified):

1. Atoms in elemental form have a charge of zero

ex. Na, O₂

2. Oxygen always has a charge of = -2

3. Hydrogen always has a charge of = +1

4. Oxidation numbers in a neutral compound must add up to zero

ex. $\begin{matrix} +1 & -1 \\ \text{H} & \text{Cl} \end{matrix}$

$$\boxed{\text{H} = +1 \quad \text{Cl} = -1}$$

5. Oxidation numbers in a polyatomic ion must add up to its given charge

ex. $\begin{matrix} +5 & -2 & & \\ \text{P} & \text{O} & 4 & 3- \\ +5 & -8 & & \times 4 \end{matrix}$

$$\boxed{\text{O} = -2 \quad \text{P} = +5}$$

6. Follow regular rules when assigning charges

ex. $\begin{matrix} +2 & -1 & & \\ \text{Mg} & \text{F} & 2 & \\ +2 & -2 & & \times 2 \end{matrix}$

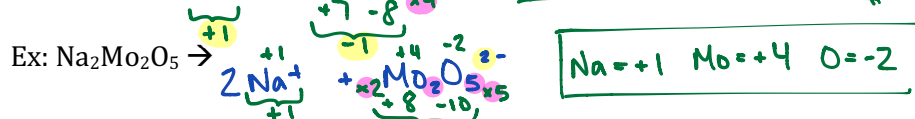
$$\boxed{\text{Mg} = +2 \quad \text{F} = -1}$$

7. The more electronegative element should have a negative charge

re: Chem II
it is "hungry" for electrons

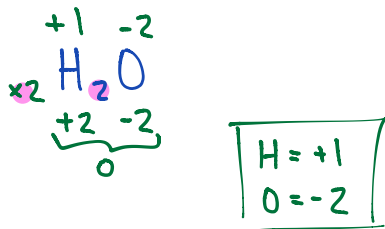
Hint!!

It might be helpful to break up a compound in a dissociation equation first!

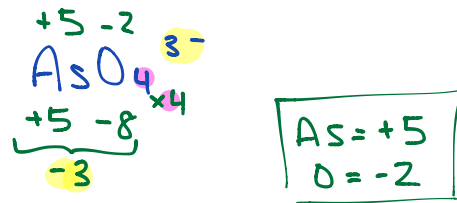


Example: Assign the oxidation number of each atom in the following species

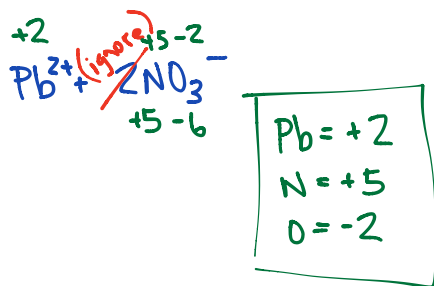
a) H_2O



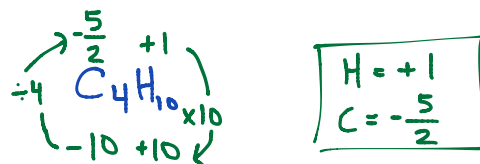
b) AsO_4^{3-}



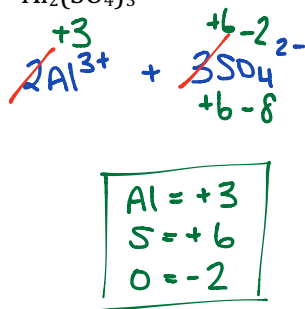
c) $\text{Pb}(\text{NO}_3)_2$



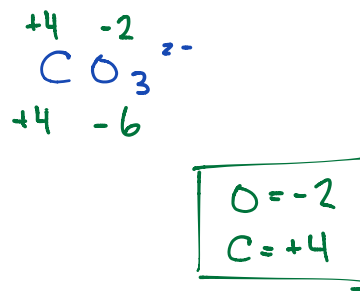
d) C_4H_{10}



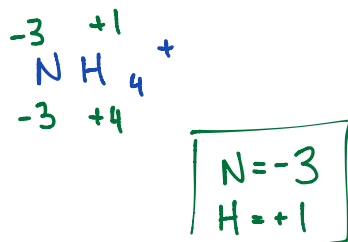
e) $\text{Al}_2(\text{SO}_4)_3$



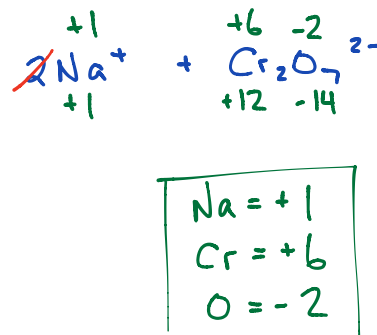
f) CO_3^{2-}



g) NH_4^+



h) $\text{Na}_2\text{Cr}_2\text{O}_7$



MORE PRACTICE!

Determine the oxidation number for **each atom** in the following compounds:

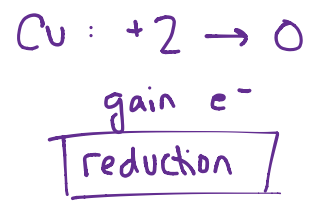
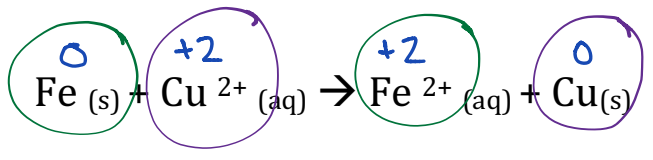
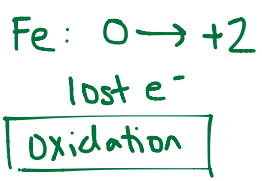
F_2 0	Fe_2O_3 $+3 -2$	$CaCO_3$ $+2 +4 -2$ $Ca^{2+} + CO_3^{2-}$	BrO_2^- $+3 -2$
PbI_2 $+2 -1$	H_2 0	$S_2O_3^{2-}$ $+2 -2$	CN^- $+2 -3$
ZnO $+2 -2$	NH_4OH $-3 +1 + -2 +1$ $NH_4^+ + OH^-$ $N = -3$ $H = +1$ $O = -2$	P_4 0	Cs_2O_2 $+2 -2$
$S_2O_8^{2-}$ $+7 -2$	N_2H_4 $-2 +1$	MnO_4^- $+7 -2$	PO_3^{3-} $+3 -2$
N_2O_5 $+5 -2$	WBr_4 $+4 -1$	K_2S $+1 -2$	SeO_3^{2-} $+4 -2$
SF_6 $+6 -1$	NO_2 $+4 -2$	MnO_2^- $+3 -2$	$Na_2Mo_2O_5$ $+1 +4 -2$
$NaNO_3$ $+1 +5 -2$ $Na^+ + NO_3^-$	H_2CO $+1 -2$	OH^- $-2 +1$	Cl_2O $+1 -2$
O_3 0	Ba_2XeO_4 $+2 +4 -2$	PCl_3 $+3 -1$	P_2O_5 $+5 -2$
U_3O_8 $+16/3 -2$	Pb 0	$ZnBr_2$ $+2 -1$	$S_2O_3^{2-}$ $+2 -2$
$(NH_4)_2SeO_4$ $2NH_4^+ + SeO_4^{2-}$ $-3 +1 +6 -2$	CH_3OH $C = -2$ $H = +1$ $O = -2$ $CH_3^+ + OH^-$ $-2 +1 -2 +1$	$LiAlH_4$ $-1 -3 +1$	CH_3COO^- $O = -2$ $H = +1$ $C = 0$
$FeCl_3$ $+3 -1$	$(NH_4)_2C_2O_4$ $2NH_4^+ + C_2O_4^{2-}$ $-3 +1 +3 -2$	BF_3 $+3 -1$	SiO_4^{4-} $+4 -2$

Electron gain and loss

LEO says GER

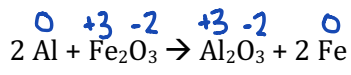
OIL RIG

Loss e^-	Gain e^-
<ul style="list-style-type: none"> Oxidation number increases Called "oxidation" 	<ul style="list-style-type: none"> Oxidation number decreases Called "reduction"
<p>L OSS</p> <p>E lectrons more \oplus</p> <p>Oxidation</p>	<p>G ain</p> <p>E lectrons more \ominus</p> <p>Reduction</p>
<p>Oxidation</p> <p>IS</p> <p>LOSS</p>	<p>Reduction</p> <p>IS</p> <p>Gain</p>



Practice:

Consider the following reaction:



Determine the oxidation numbers for each atom and write the value on top of the element in the reaction.

- Are electrons gained or lost by each iron (III) ion? gain e^-
 - How many? $3e^-$
- Are electrons gained or lost by each Al atom? lost e^-
 - How many? $3e^-$
- How many electrons were transferred in total during the reaction? 3 (from Al to Fe)
- What happened to the oxide ion, O^{2-} during the reaction?
The oxidation number stayed the same - neither reduced/oxidized

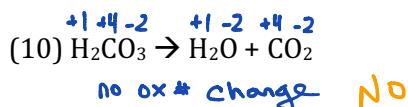
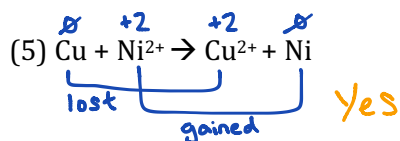
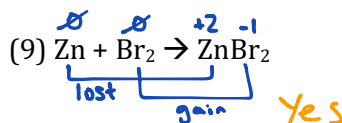
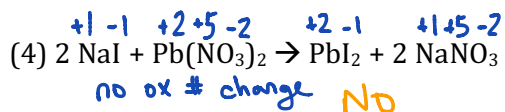
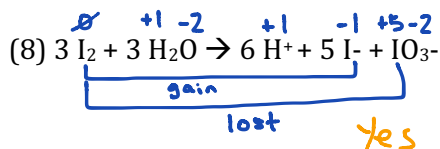
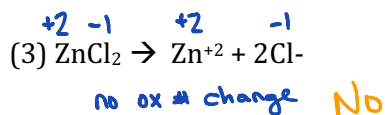
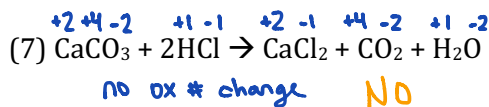
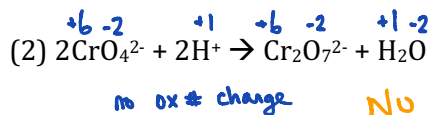
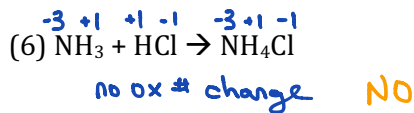
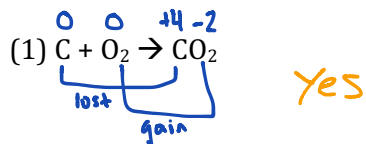
★ The number of electrons lost by the species being oxidized must always equal the number of electrons gained by the species being reduced. ★

Practice:

1. Consider the following reactions. For each reaction:

a) Determine the **oxidation number** for each of the atoms.

b) Identify if the reaction is a **redox** reaction. (**reduction/oxidation**) → must have ox # change



2. When $\overset{+6}{MnO_4}^{2-}$ undergoes **oxidation**, it may form: loss $e^- \rightarrow$ ox # ↑

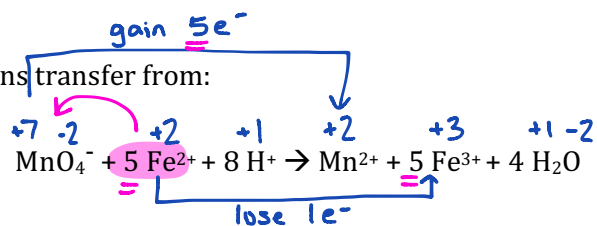
A. $\overset{+2}{MnO}$

B. $\overset{+6}{MnO_3}$

C. $\overset{+7}{MnO_4}^-$

D. $\overset{+3}{Mn_2O_3}$

3. During the reaction, electrons transfer from:



A. Fe^{3+} to Fe^{2+}

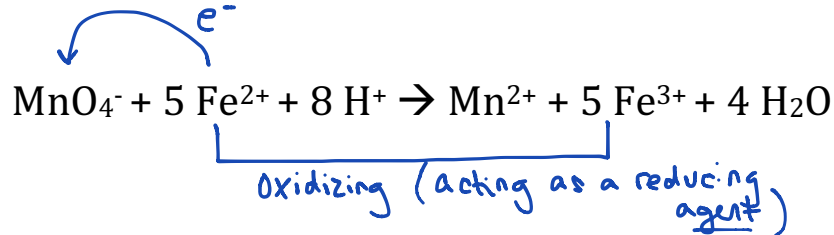
B. Fe^{2+} to MnO_4^-

C. MnO_4^- to Fe^{2+}

D. MnO_4^- to Mn^{2+}

Agents

Another way of looking at it is that one species **causes** the electron loss or gain. A species that is being oxidized causes the other species to gain electrons and be reduced.

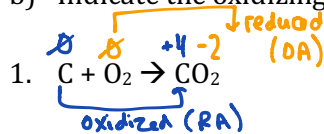


A substance that is reduced acts as an Oxidizing agent. (OA)

A substance that is oxidized acts as a Reducing agent. (RA)

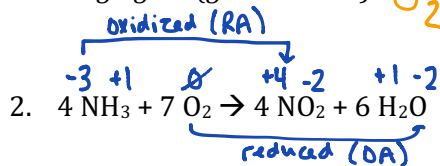
Practice:

- Assign oxidation numbers to all atoms in the equation.
- Indicate the oxidizing and reducing agents in each of the following reactions.



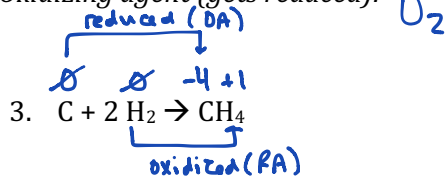
Oxidizing agent (gets reduced): O₂

Reducing Agent (gets oxidized): C



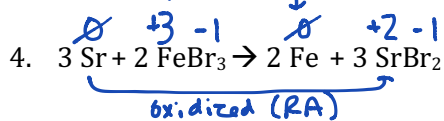
Oxidizing agent (gets reduced): O₂

Reducing Agent (gets oxidized): NH₃



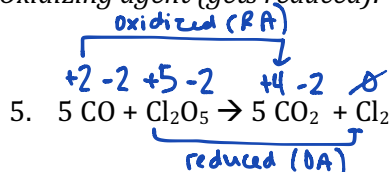
Oxidizing agent (gets reduced): C

Reducing Agent (gets oxidized): H₂



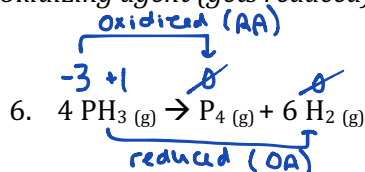
Oxidizing agent (gets reduced): FeBr₃

Reducing Agent (gets oxidized): Sr



Oxidizing agent (gets reduced): Cl₂O₅

Reducing Agent (gets oxidized): CO



Oxidizing agent (gets reduced): PH₃

Reducing Agent (gets oxidized): PH₃

Worksheet