# RedOx

Oxidation Reduction

**Old definition** – Limited to Carbon & oxygen

Oxidation – gain of oxygen or loss of hydrogen

Ex $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

oxidation

Reduction – gain hydrogen or loss of oxygen

Ex

Reduction

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

**Broad Definition**

Oxidation – The loss of $e^-$

Reduction – Gain of $e^-$

Oxidation is Loss OiL

Reduction is Gain RiG

We need a book keeping system for $e^-$

Book keep system → Oxidation number

## Rules for assigning oxidation numbers

- All elements in their elemental state have oxidation number Ø

Ex $\overset{\emptyset}{Na}$ $\overset{\emptyset}{Pb}$ $\overset{\emptyset}{N_2}$ $\overset{\emptyset}{O_2}$ $\overset{\emptyset}{H_2}$ $\overset{\emptyset}{S_8}$

- The oxidation number on a monatomic ion is the same as the charge state

Ex $\overset{+1}{Na^+}$ $\overset{+4}{Pb^{4+}}$ $\overset{-3}{N^{3-}}$ $\overset{-2}{O^{2-}}$ $\overset{+6}{Cr^{6+}}$ ← ox # ← Charges

Oxidation # Charge then value +6

Charge State value then charge 6+

- Combined hydrogen (Covalent hydrogen) is always +1 $\overset{+1}{CH_4}$

- Combined Oxygen (Covalent Oxygen) is always −2 except peroxide(-O-O-) where peroxide oxygen is −1

$\overset{-2}{CO_2}$ $\overset{-1}{H}-\overset{-1}{O}-\overset{-1}{O}-H$

- Combined Fluorine (Covalent fluorine) is always -1

$\overset{-1}{CF_4}$

* - The sum of the oxidation numbers in a covalent compound must add to ∅ zero or for a polyatomic ion the sum must be equal to the charge state on the polyatomic ion.

Ex

$\overset{?\ -1}{CF_4}$

$C + 4F = \emptyset$

$C + 4(-1) = \emptyset$

$C - 4 = 0$

$C = +4$

$\overset{+4\ -1}{CF_4}$ ← oxidation #'s

$\overset{?\ +1}{CH_4}$

$C + 4H = \emptyset$

$C + 4(+1) = \emptyset$

$C + 4 = \emptyset$

$C = -4$

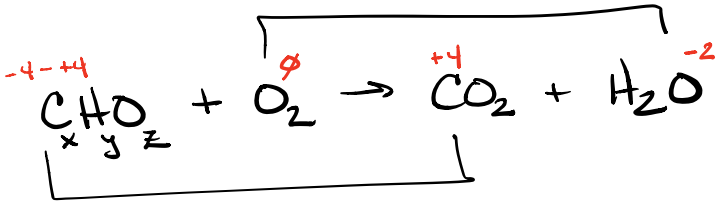
$\overset{-4\ +1}{CH_4}$

$Na^{+}$ not $Na^{+1}$

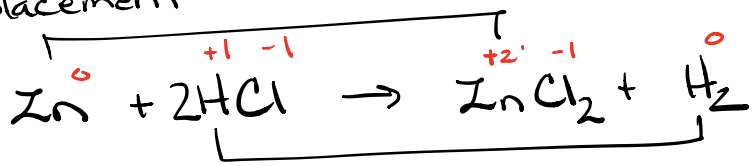
$\overset{\text{ox \#}}{\overset{+1}{Na^{+}}}$ ← charge state

## Redox Rxns

- Combustion




- Single Replacement




- Combination & Decomposition (Frequently but not always Redox)

$A + B \rightarrow C$ Combination

$A \rightarrow B + C$ Decomposition

# Polyatomic Example

? -2

$PO_4^{3-}$ ← Charge State

Phosphate Ion

Charge State →

$P + 4O = -3$

$P + 4(-2) = -3$

$P - 8 = -3$

$P = +5$

ox #'s

+5 -2

Charge State →

$PO_4^{3-}$

$P + 4O =$

$+5 + 4(-2) =$

$5 - 8 = -3$

? -2

$SO_4^{2-}$

$S + 4O = -2$

$S + 4(-2) = -2$

$S - 8 = -2$

$S = +6$

ox #'s

+6 -2

Charge State →

$SO_4^{2-}$

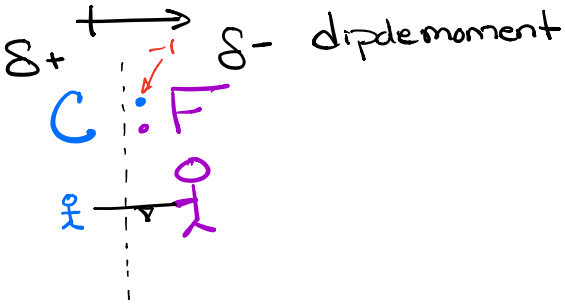
Molecule (covalent) $\emptyset$ ← Charge State

Polyatomic $\#-$ ← Charge State

Covalent so ≅ Charges

C – F

EN 2.5 4.0




Ox #'s allow for tracking when there are no charges

+1 -1

C F

Reduction

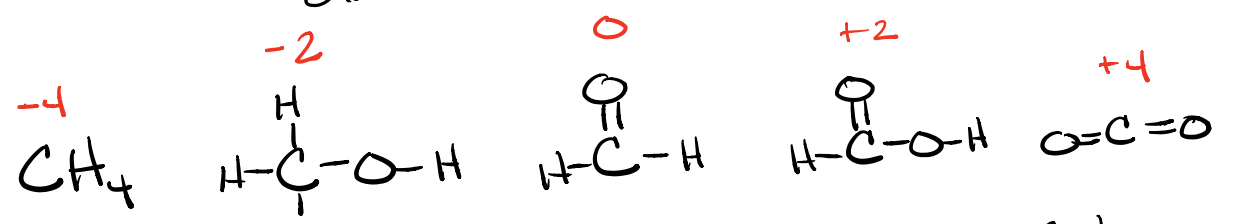
← Adding of Hydrogen & loss of Oxygen

Reduction is gain $e^-$

oxidation

Adding Oxygen to Carbon (loss of hydrogen) →

Oxidation is Loss $e^-$




? +1 -2

$CH_4O$

$C + 4(1) + (-2) = 0$

$C + 4 - 2 = 0$

$C + 2 = 0$

$C = -2$

$$\overset{?\ +1}{2C_2H_6} + 7\overset{0}{O_2} \rightarrow 4\overset{?\ -2}{CO_2} + 6\overset{+1\ -2}{H_2O}$$

$2C + 6H = 0$

$2C + 6(+1) = 0$

$2C + 6 = 0$

$2C = -6$

$C = -3$

$C + 2O = 0$

$C + 2(-2) = 0$

$C - 4 = 0$

$C = +4$

Reduction half Reaction

Oxygen have gained $e^-$ has been Reduced

$$\overset{-3\ +1}{2C_2H_6} + 7\overset{0}{O_2} \rightarrow \overset{+4\ -2}{4CO_2} + \overset{+1\ -2}{6H_2O}$$

oxidation half Rxn

Carbon has lost $e^-$ and has been oxidized

$O_2$ is oxygen in it's elemental state is diatomic

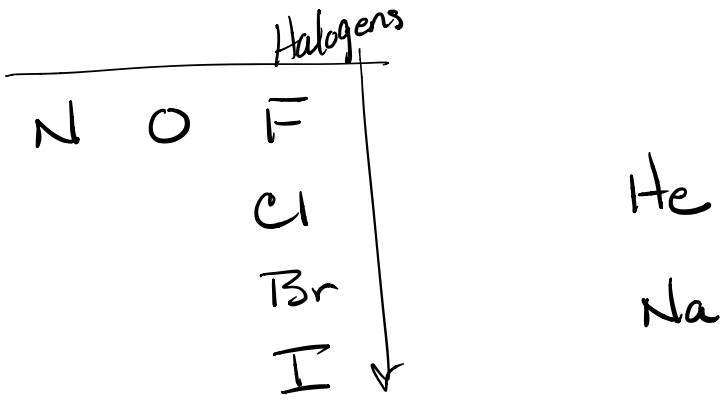
| $O$ | $O^{2-}$ | $O_2$ |
|---|---|---|
| oxygen atom | oxide ion | oxygen gas |

↑ does not exist in nature as a single atom

HOFBrINCl or BrINClHOF

In elemental state

$H_2$ $O_2$ $F_2$ $Br_2$ $I_2$ $N_2$ $Cl_2$




Ex

Reduction

Reduction is gain

$2Na^{0}_{(s)} + Cl_{2\,(g)}^{0} \longrightarrow 2NaCl^{+1\ -1}_{(s)}$

oxidation is loss

oxidation

$Na^+$ $Cl^-$

## Half Reactions

Loss as product

$Na \longrightarrow Na^+ + e^-$ oxidation half Rxn

$Cl_2 + 2e^- \longrightarrow 2Cl^-$ reduction half Rxn

gain as reactant

# Balancing RedOx done by Half Rxn

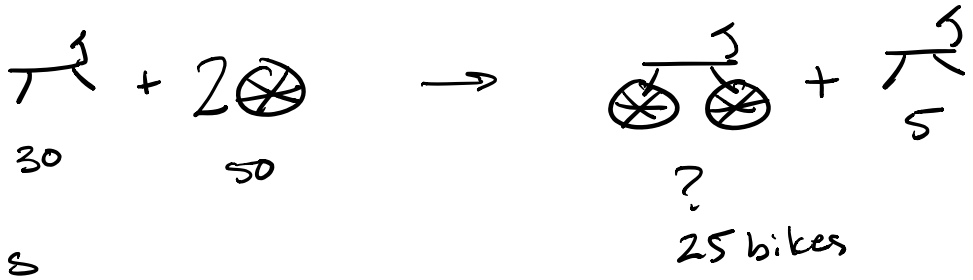
$$2\,Na \longrightarrow 2Na^{+} + 2e^{-}$$

$$+ \quad Cl_2 + 2e^{-} \longrightarrow 2Cl^{-}$$

$$2Na + Cl_2 + 2e^{-} \longrightarrow 2\,Na^{+} + 2\,Cl^{-} + 2e^{-}$$

$$\boxed{2\,Na + Cl_2 \rightarrow 2\,NaCl}$$

Balanced

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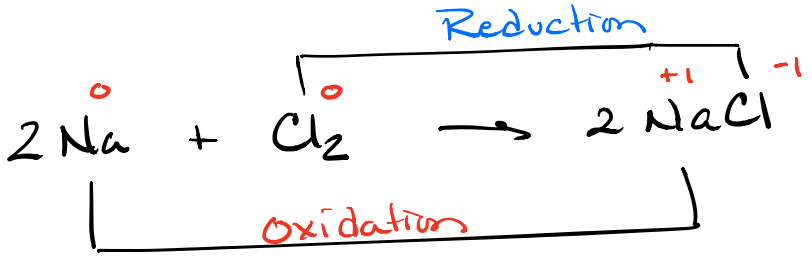
# Terminology




Reactants

Species being oxidized — Na metal

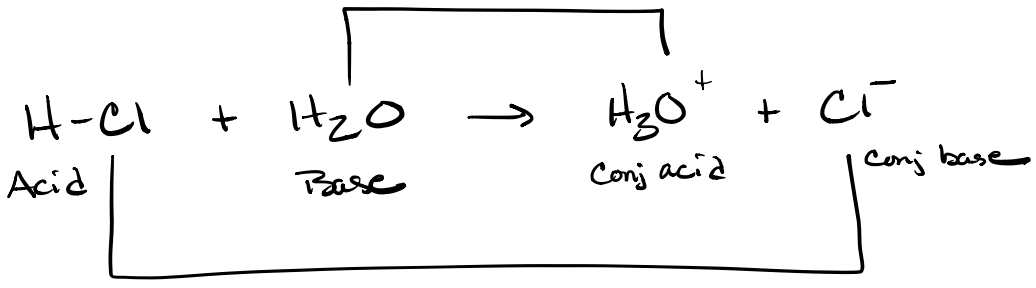
Species being reduced — $Cl_2$ gas

Oxidizing Agent (reagent) — $Cl_2$ gas

↖ The species causing the Sodium to be oxidized

Reducing Agent (reagent) — Na metal

↖ The species causing the $Cl_2$ to be reduced



Check to see if RedOx?
⟹ Looking for Changes in ox #

$\overset{+1\ -1}{HCl} + \overset{+1\ -2}{H_2O} \rightarrow \overset{+1\ -2}{H_3O^+} + \overset{-1}{Cl^-}$

H + Cl = 0
+1 + Cl = 0
Cl = -1

No Changes in oxidation # ⟹ not a RedOx Rxn

Acid/Base is the trading of $H^+$ = proton

RedOx is the trading of $e^-$

Acid/Base

$HC_2H_3O_2 + NaHCO_3 \rightarrow NaC_2H_3O_2 + H_2CO_3$

$HC_2H_3O_2$: acetic acid — Vinegar is 5% by mass acetic acid

$NaHCO_3$: Base — sodium bicarbonate — Baking Soda

$NaC_2H_3O_2$: salt

$H_2CO_3$: Carbonic acid

$\overset{+1\ +4\ -2}{H_2CO_3} \rightarrow \overset{+1\ -2}{H_2O_{(l)}} + \overset{+4\ -2}{CO_{2(g)}}$

not Redox but decomposition

$$2(+1) + C + 3(-2) = 0$$

$$2 + C - 6 = 0$$

$$C - 4 = 0$$

$$C = +4$$

$$1\,HC_2H_3O_2 \quad + 1\,NaHCO_3 \longrightarrow NaC_2H_3O_2 + H_2CO_3$$

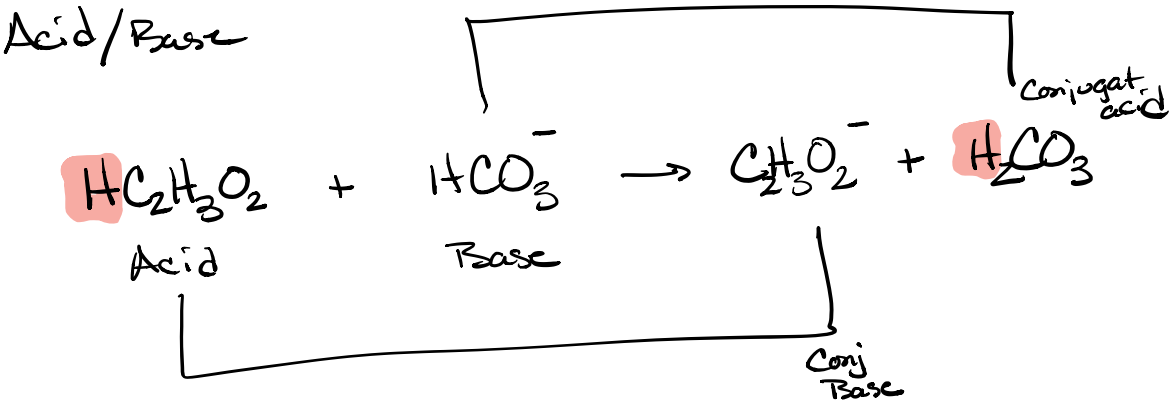
$HC_2H_3O_2$: ? , 5% by mass

$NaHCO_3$: 5.62 g

Road Map

g $NaHCO_3$ → moles $NaHCO_3$ → mole $HC_2H_3O_2$ → g $HC_2H_3O_2$ → (%) g vinegar → (density) mL vinegar

Acid/Base


Conjugat. acid
$HC_2H_3O_2$ + $HCO_3^-$ → $C_2H_3O_2^-$ + $H_2CO_3$
Acid
Base
Conj Base