Oxidation number (ON)

In a covalent bond, the electrons (always 2 in number) are not shared equally. This depends on the difference in electronegativity between the two atoms forming the bond. Oxidation numbers refer to the number of charges an atom in a molecule would have if all the bonds were broken.

Example: $H{-}O{-}H \longrightarrow H^{+} \quad O^{2-} \quad H^{+}$

- It is a way to keep track of the electrons in an oxidation−reduction reaction (redox).
- The term "oxidation state" is mostly used for ionic compounds where the species have a real charge.
- A compound (molecule or ion) is said to be **oxidized** if its **oxidation number increases** in a reaction.
- On the other hand, if a compound is **reduced,** its **oxidation number decreases** in a reaction.

$$\underset{(+3)}{Fe^{3+}} + e^{-} \longrightarrow \underset{(+2)}{Fe^{2+}}$$

ON decreases

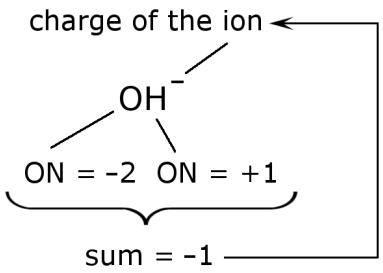
reduction

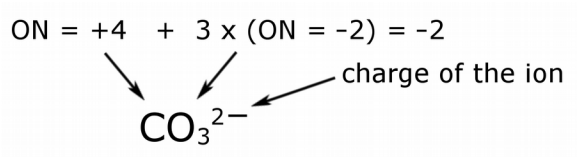
species	Oxidation number	example	exception
pure elements	0	O_2, Li, Cu, F_2	
single ions	valence	$Fe^{3+} = +3$, $S^{2-} = -2$	
F in compounds	−1	HF, SF_6	
O in compounds	−2	H_2O, CO, NO_2	peroxide H_2O_2: ON = −1
H in compounds	+1	H_2O, HF	Hydride MH: ON = −1
Cl, Br, I in compounds	−1	HCl, CH_3Cl	ON variable if O and F are present.

The sum of all the ON of the atoms present in a compound = 0.

The sum of all the ON of the atoms in an ion = charge of the ion.

Example:





Exercises

Find the oxidation number of the underlined atom in each of the following compounds:

a. $\underline{C}O$

b. $Li_3\underline{N}$

c. $\underline{NaH}$

d. $\underline{N}_2O_4$

e. $\underline{N}O_2$

f. $\underline{Ni}(OH)_2$

g. $H\underline{Cl}O_4$

h. $\underline{N}H_4^+$

I. $\underline{Si}F_2O$

j. $\underline{Ir}O_4^+$

k. $\underline{Cl}O_2^-$

l. $\underline{U}O_2^{2+}$

m. $[\underline{Fe}(CN)_6]^{3-}$ *(see hint)*

n. $(NH_4)_2\underline{S}O_3$

o. $\underline{Fe}_3O_4$

Hint: $[\underline{Fe}(CN)_6]^{3-}$ *None of these atoms in this ion are listed in the oxidation number determination table. However, the "CN" group is the cyanide ion "CN^-", with a charge of −1.*

$\underline{Fe}_3O_4$ *A fractional oxidation number is possible since this compound contains both Fe^{2+} and Fe^{3+} ions but in different proportions.*

For each of the following reaction (half-reaction), use the change of the oxidation number to indicate if the reaction is a reduction or an oxidation.

p. $H_2 \rightarrow 2H^+$

q. $V^{5+} \rightarrow V^{3+}$

r. $SF_6 \rightarrow SF_3$

s. $NO_3^- \rightarrow NO_2$

t. $S_2O_3^{2-} \rightarrow SO_4^{2-}$

Answers:

a. C = +2

b. N = −3

c. H = −1

d. N = +4

e. N = +4

f. Ni = +2

g. Cl = +7

h. N = −3

I. Si = +4

j. Ir = +9

k. Cl = +3

l. U = +6

m. Fe = +3

n. S = +4

o. Fe = +8/3 or $+2.\overline{6}$

p. oxidation: ON(H) 0 → +1

q. reduction: ON(V) +5 → +3

r. reduction: ON(S) +6 → +3 , ON(F) unchanged.

s. reduction: ON(N) +5 → +4 , ON(O) unchanged.

t. oxidation: ON(S) +2 → +6 , ON(O) unchanged.