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Metals tend to lose electrons.

Na ⇌ Na⁺ + e⁻

Non-metals tend to gain electrons.

Cl⁻ + e⁻ ⇌ Cl⁻

Reducing agents

Oxidizing agents

We use the Oxidation State to keep track of the number of electrons that have been gained or lost by an element.
Electronegativity, symbol $\chi$, is a chemical property that describes the ability of an atom to attract electrons (or electron density) towards itself in a covalent bond (Pauling, 1932).

Electronegativity cannot be directly measured and must be calculated from other atomic or molecular properties. As it is usually calculated, it is not strictly an atomic property, but rather a property of an atom in a molecule.

$$\chi_A - \chi_B = (\text{eV})^{-1/2} \sqrt{E_d(AB) - [E_d(AA) + E_d(BB)]/2}$$

PAULING

$E_d(\text{HBr})=3.79 \text{ eV}; E_d(\text{H}_2)=4.52 \text{ eV}; E_d(\text{Br}_2)=2.00 \text{ eV}$

$\chi_{\text{Br}} - \chi_{\text{H}}=0.73$

$\chi_{\text{H}}=2.20$ by definition

$1 \text{ eV} = 1.60217653(14) \times 10^{-19} \text{ J} = 96.48538(2) \text{ kJ/mole}$
# PAULING ELECTRONEGATIVITY

Atomic radius decreases → Ionization energy increases → Electronegativity increases →

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Periodic table of electronegativity using the Pauling scale
MULLIKAN (ABSOLUTE) ELECTRONEGATIVITY

\[ \chi = \frac{(\text{IE} + \text{EA})}{2} \text{ (kJ/mol)} \]

- \text{IE} - (First) Ionization Energy \((X \rightarrow X^+ + e^-)\)
- \text{EA} - Electron Affinity \((X^- \rightarrow X + e^-)\)
IE - (First) Ionization Energy
EA - ELECTRON AFFINITY

[Periodic Table Image]
The correlation between Mulliken electronegativities (x-axis, in kJ/mol) and Pauling electronegativities (y-axis).
The OXIDATION STATE or OXIDATION NUMBER is the real or hypothetical, integer or fractional charge an atom in a neutral or charged formula would acquire following:

(a) the conventional attribution of all the bonding electrons in a bond to the more electronegative atom;

(b) the equipartition of the bonding electrons between atoms with the same electronegativity.

Lithium hydride LiH

\[ \chi_{\text{H}} = 2.20; \chi_{\text{Li}} = 0.98 \]

\[ \chi_{\text{H}} > \chi_{\text{Li}} \]

\[ \text{OS}(\text{Li}) = +1 \]

\[ \text{OS}(\text{H}) = -1 \]

Ammonia \( \text{NH}_3 \)

\[ \chi_{\text{N}} = 3.04; \chi_{\text{H}} = 2.20 \]

\[ \chi_{\text{N}} > \chi_{\text{H}} \]

\[ \text{OS}(\text{N}) = -3 \]

\[ \text{OS}(\text{H}) = +1 \]
Rules for Oxidation States

1. The oxidation state (OS) of an individual atom in a free element is 0.
2. The total of the OS in all atoms in:
   i. Neutral species is 0.
   ii. Ionic species is equal to the charge on the ion.
3. In their compounds, the alkali metals and the alkaline earths have OS of +1 and +2 respectively.
4. In compounds the OS of fluorine is always –1
5. In compounds, the OS of hydrogen is usually +1 (exception: hydrides, -1)
6. In compounds, the OS of oxygen is usually –2 (exceptions: peroxides, -1; superoxides, -1/2; oxygen fluoride, F2O, +2).
7. In binary (two-element) compounds with metals:
   i. Halogens have OS of –1,
   ii. Group 16 have OS of –2 and
   iii. Group 15 have OS of –3.
Anions (-Q): Groups 15, 16, 17 (VA, VIA, VIIA)
Cations (+Q): Groups 1, 2, 3 (IA, IIA, IIIA)
Assigning Oxidation States.

What is the oxidation state of the underlined element in each of the following? a) P₄; b) Al₂O₃; c) MnO₄⁻; d) NaH

a) P₄ is an element. \( P \text{ OS} = 0 \).

b) Al₂O₃: O is –2. O₃ is –6. Since \((+6)/2=(+3)\), Al OS = +3.


d) NaH: net charge = 0, rule 3 beats rule 5, Na OS = +1 and H OS = -1.