Polarity of molecules

Electronégativity of a chemical element

Introduced in 1835 by Swedish chemist Jöns Jacob Berzelius, then improved by American scientist Linus Pauling, an element's electronegativity characterizes its ability to attract electrons to itself when a bond is formed. The electronegativity of an element is ⍰. It is a unitless number that varies between 0.7 and 4.

H 2,1																He
Li 1,0	Be 1,6											B 2,0	C 2,5	N 3,0	O 3,5	F 4,0	Ne
Na 0,9	Mg 1,2											Al 1,5	Si 1,8	P 2,1	S 2,5	Cl 3,0	Ar
K 0,8	Ca 1,0	Sc 1,3	Ti 1,5	V 1,6	Cr 1,6	Mn 1,5	Fe 1,8	Co 1,9	Ni 1,9	Cu 1,9	Zn 1,6	Ga 1,6	Ge 1,8	As 2,0	Se 2,4	Br 2,8	Kr
Rb 0,8	Sr 1,0	Y 1,2	Zr 1,4	Nb 1,6	Mo 1,8	Tc 1,9	Ru 2,2	Rh 2,2	Pd 2,2	Ag 1,9	Cd 1,7	In 1,7	Sn 1,8	Sb 1,9	Te 2,1	I 2,5	Xe
Cs 0,7	Ba 0,9	La 1,0	Hf 1,3	Ta 1,5	W 1,7	Re 1,9	Os 2,2	Ir 2,2	Pt 2,2	Au 2,4	Hg 1,9	Tl 1,8	Pb 1,9	Bi 1,9	Po 2,0	At 2,1	Rn

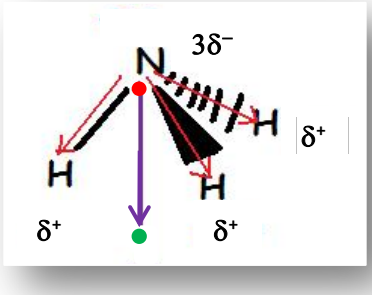
Polarization of a covalent bond

When the electronegativity of two bonded elements is different ($\Delta\chi > 0.4$), the electrons forming the bond can be found mainly around the most electronegative element: the electron cloud is not symmetrically shaped around the two elements.
The most electronegative element is slightly negatively charged, δ^-, and the least electronegative is slightly positively charged, δ^+.
The bond is said to be polarized.

Note: A bond between two identical elements, or between two elements with similar electronegativity ($\Delta\chi < 0.4$), like carbon C ($\chi = 2.5$) and hydrogen H ($\chi = 2.1$), is not polarised.

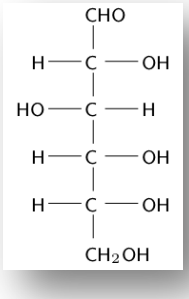
Polar molecules

A molecule is electrically neutral overall, but it can have a slightly negative pole, N (barycenter (or center of symmetry) of negative charges) and a slightly positive pole, P (barycenter (or center of symmetry) of positive charges) that are not confused. The molecule is said to be polarized. It forms an electric dipole characterized by a vector $\overrightarrow{NP}$.

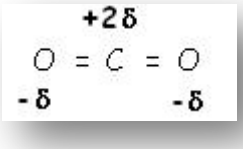


● : N, barycenter of negative charges
● : P, barycentre of positive charges
→ : Vector $\overrightarrow{NP}$

A molecule with polarized bonds does not imply that it is polar. If there is a center of symmetry for polarized bonds, then the barycenters of negative and positive charges are the same. The molecule is apolar.

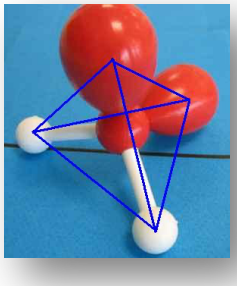


Although it has two polarized bonds, the carbon dioxide molecule has one center of symmetry. It is therefore apolar (the barycentre of positive and negative charges are both on C).



The glucose molecule presents multiple polarized bonds, and doesn't show any center of symetry. It is a polar molecule.

Water, a polar molecule



Due to the two non-bonding pairs around the oxygen atom, the water molecule is bend.
Oxygen is more electronegative than Hydrogen. Therefore, H has a slightly positive charge while O has a slightly negative charge. The O-H bond is polarized.

The barycenter of positive charges (between the 2 H) is different from the barycenter of negative charges (O) ⇒ La molécule d'eau est polaire.