Heteronuclear Bond Polarity

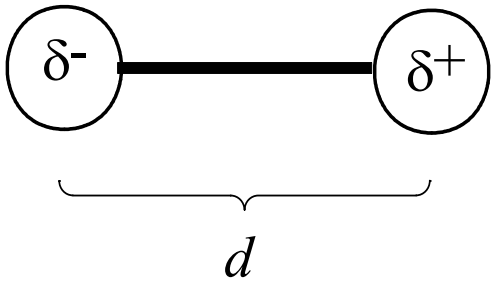
- All heteronuclear bonds have some polarity.

- When two different atoms have the same value of electronegativity the bond is very nearly pure covalent and the polarity is very small, *but there is still some polarity*.

Comparison of N and Cl Electronegativity on Different Electronegativity Scales

Scale	Basis	χ_N	χ_{Cl}	$\Delta\chi_{N-Cl}$
Original Pauling	*D*	3.0	3.0	0
Recalculated Pauling	*D*	3.04	3.16	–0.12
Allred-Rochow	*Z**	3.07	2.83	+0.24

Dipole Moment of a Diatomic Molecule



dipole moment = $\mu = \delta d$

Units: debye (D) = 3.34×10^{-3} C@m

Molecule	μ	Molecule	μ
H-H	0 D	H-F	1.82 D
F-F	0 D	H-Cl	1.08 D
Cl-Cl	0 D	H-I	0.44 D

Dipole Moments of Polyatomic Molecules

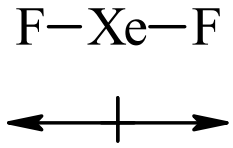
- For polyatomic molecules, molecular polarity depends on both *shape* and *composition*.

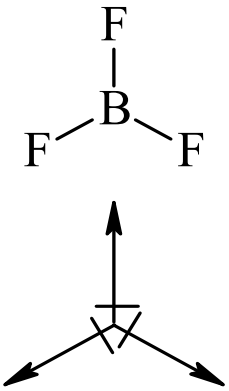
- A molecule is nonpolar when all individual bond polarities are counterbalanced by other *identical* bond polarities.

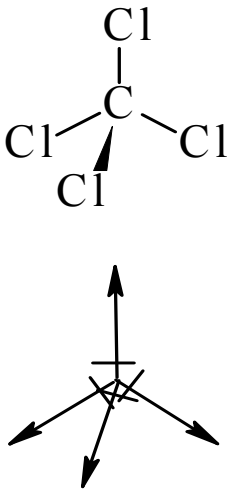
- A molecule is polar when any one of its individual bond polarities is not counterbalanced by identical bond polarities.
  - Lack of counter balancing polarities may result from a less symmetrical shape. (*Shape*)
  - Lack of counterbalancing polarities may result from a unique bond in the molecule with different bond strength or to a different element. (*Composition*)

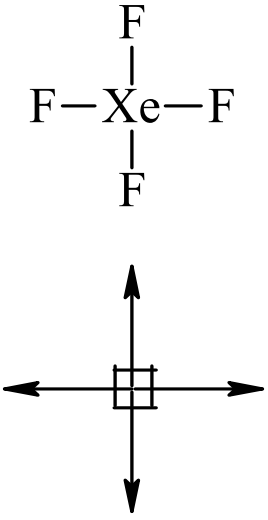
Nonpolar Polyatomic Molecules

- In highly symmetric binary molecules, individual bond polarities may cancel, leaving the molecule with no net dipole moment.



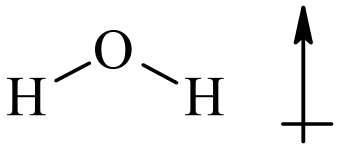




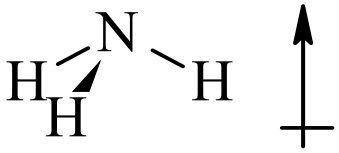


Polar Polyatomic Molecules

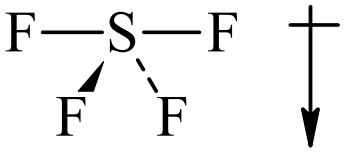
- If a binary molecule has a geometry that gives it a sense of up and down or right and left it is polar.



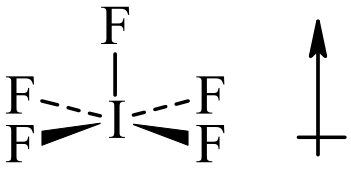
$\mu = 1.85$ D



$\mu = 1.47$ D



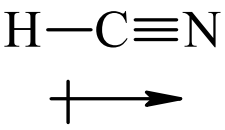
$\mu = 0.632$ D



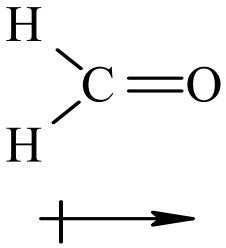
$\mu = 2.18$ D

More Complex Molecules

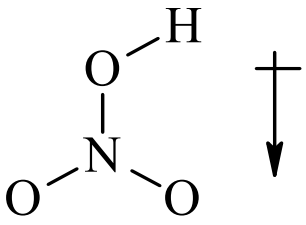
- If a ternary molecule has its bonds asymmetrically arranged, it may be polar even though its shape would be nonpolar for a binary molecule.



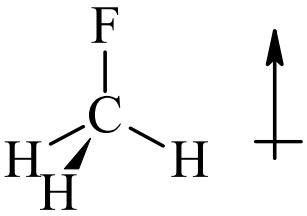
$\mu = 2.98$ D



$\mu = 2.33$ D



$\mu = 2.17$ D



$\mu = 1.85$ D