Bonding motifs for common atoms in organic compounds

Page 1 – Intro & Carbon

Start: diatomics → AX_n (central, terminal; n = 2 to 6) → Organic Molecules

Lewis structures ↑ VB ↑ (theory VSEPR)

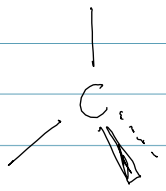
Bonding motifs

of bonds & bond orders
# of l.p.
bonding geometry ⇒ angles
formal charge
hybridization (VB theory)
octet rule ✓

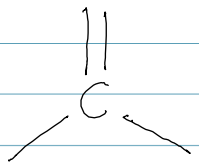
Carbon

- central atom ← bonded to ≥ 2 atoms
- no formal charge
- no lone pairs
- total 4 bonds (σ + π)

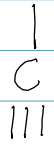
Most common



tetrahedral
~109°
σ from sp^3
↑ 2s ↑ (2px, 2py, 2pz)



trigonal planar
120°
σ from sp^2
p orbital ⇒ π bond



linear
180°
σ from sp
2 p orbitals make π bonds

Rare

linear
180°
σ from sp
2 p orbitals make π bonds (one on each end)

Bond motifs in organic compounds

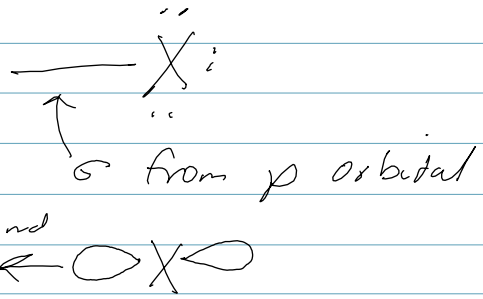
page 2: Hydrogen & Halogens

Inorganic carbon: CO_2, CN^-, CCl_4

Organic: at least one C–H bond

Hydrogen: always terminal
one bond (σ – 1s orbital from H)
formal charge zero

Halogens: always terminal
F, Cl, Br, I single bond



hybridization energy is +

" needed for central atoms ⇒ correct angles

" not needed for terminal atoms

Bottom line X = H, F, Cl, Br, I
terminal
no formal charges
← rare exceptions

Bonding motifs in Organic compounds

Page 3 - Nitrogen

Mostly formal charge = 0 ∴ single lone pair
three bonds

trigonal pyramidal
< 109.5° (105-108°)

≈ sp^3 (25% s / 75% p)

lone pair (34% s / 66% p)

bonds (22% s / 78% p)

smaller bond angles ⟸ lessened s character

bent
< 120° (~118°)

≈ sp^2

p orbital
form π bond

$:N\equiv$

terminal

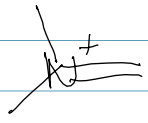
lone pair : 2s

bonds : 2p

σ + 2π bonds

N most likely element to have + formal charge

4 bonds, No lone pairs



$-\overset{\oplus}{N}\equiv$

Very Rare $N^{\ominus}$

$:\ddot{N}^{\ominus}-$

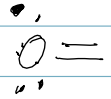
sp^3

Bonding Motifs in Organic Compounds

Page 4 – Oxygen and Sulfur

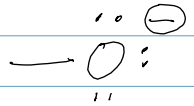
Oxygen most common: no f.c.
two bonds
two l.p.

sp^3
$\approx 105°$



terminal
VB: no hybridization
σ & π bonds from p orbitals

lone pair: remaining p & s

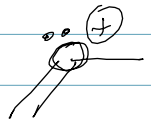
Most likely to be ⊖ 

σ bond of p orbital on O

Can be ⊕ 

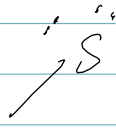
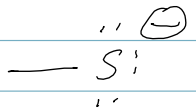
trigonal pyramidal

eg H_3O^+



bent

Sulfur

Most common  or 

Rare: EC exceeds 8 in organics

Later: functional groups