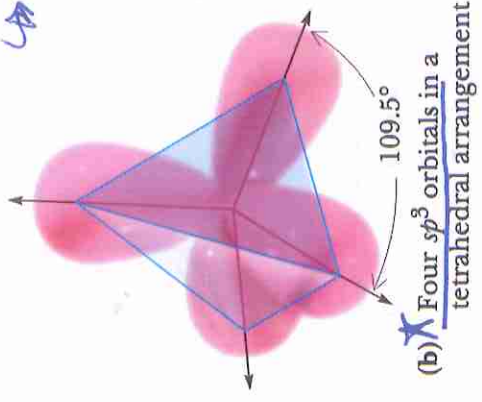


$\pi$ -Bonds  $\rightarrow$  overlapping 2p orbitals

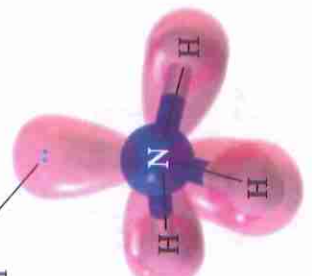
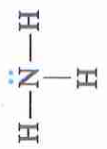
Think  $\left\{ \begin{array}{l} \sigma\text{-Bonds} \rightarrow \text{overlapping hybridized orbitals} \\ \pi\text{-Bonds} \rightarrow \text{overlapping } p \text{ atomic orbitals in various combinations to give } sp, sp^2, sp^3 \text{ hybridized orbitals} \end{array} \right.$

(see bottom right of this page)

$sp^3$   
 $\rightarrow$  No 2p orbital  
 $\hookrightarrow$  can't have a  $\pi$ -bond  
 $\hookrightarrow$  b/c  $\pi$ -bonds are from 2p orbitals!

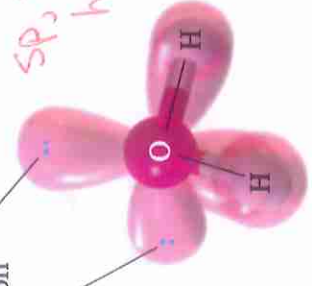


Unshared electron pair



Ammonia

Unshared electron pairs

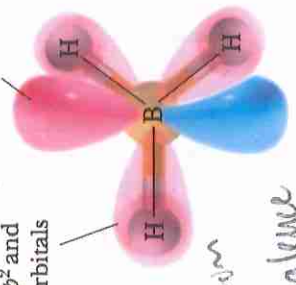


Water

$sp^2 \Rightarrow$  3 bonds using  $sp^2$  hybridized orbitals  
 $\rightarrow$  3  $\sigma$  bonds  $\rightarrow$  BH3, Carbocation  $\rightarrow$  empty 2p orbital  
 $\rightarrow$  2  $\sigma$  bonds using  $sp^2$  hybridized orbitals & 1  $\pi$  bond using 2p  
 (double bond)  
 $\downarrow$   
 $1 sp^2$  hybridized left over  $\hookrightarrow$



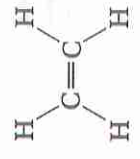
(b)  $\sigma$  bonds formed by the overlap of  $sp^2$  and 1s orbitals



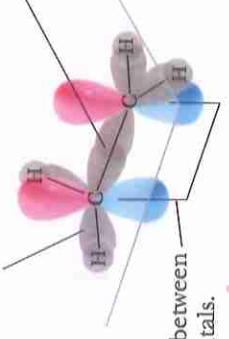
Borane

Carbocation  
 6 valence e<sup>-</sup>  
 $\hookrightarrow$  empty 2p

$sp$  orbitals overlapping =  $\pi$ -way



(b) Four C-H  $\sigma$  bonds form from overlap of a C  $sp^2$  and a H 1s orbital. See one here.



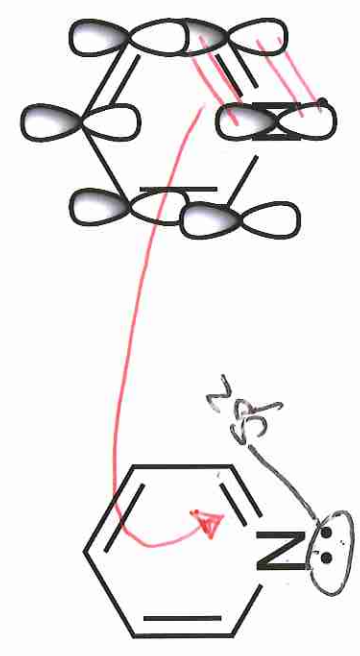
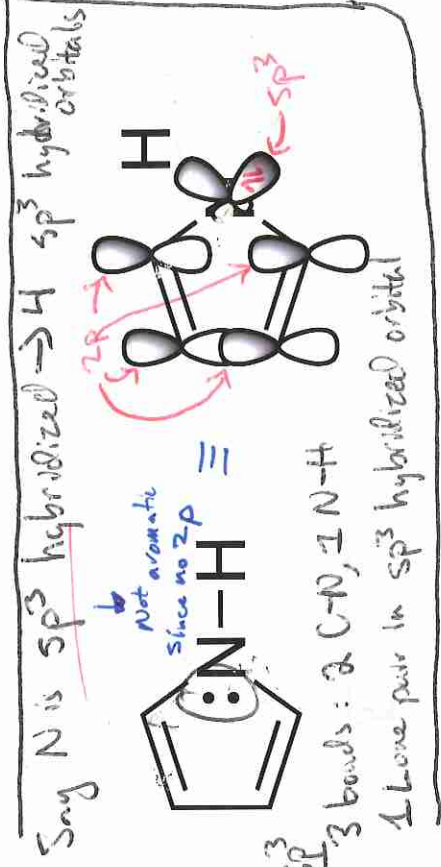
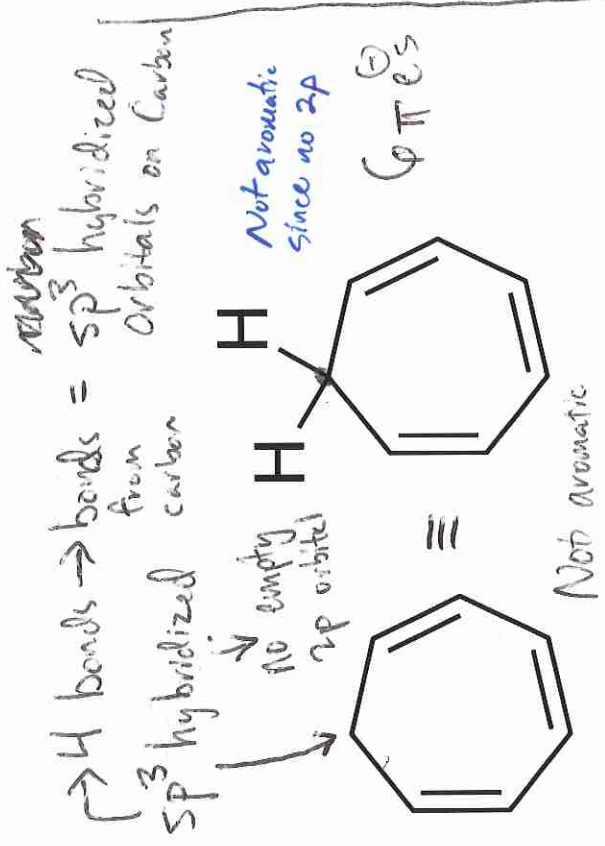
A  $\pi$  bond forms between these two 2p orbitals.

$\pi$ -Bond

one pair must be in  $sp^2$  hybridized orbital

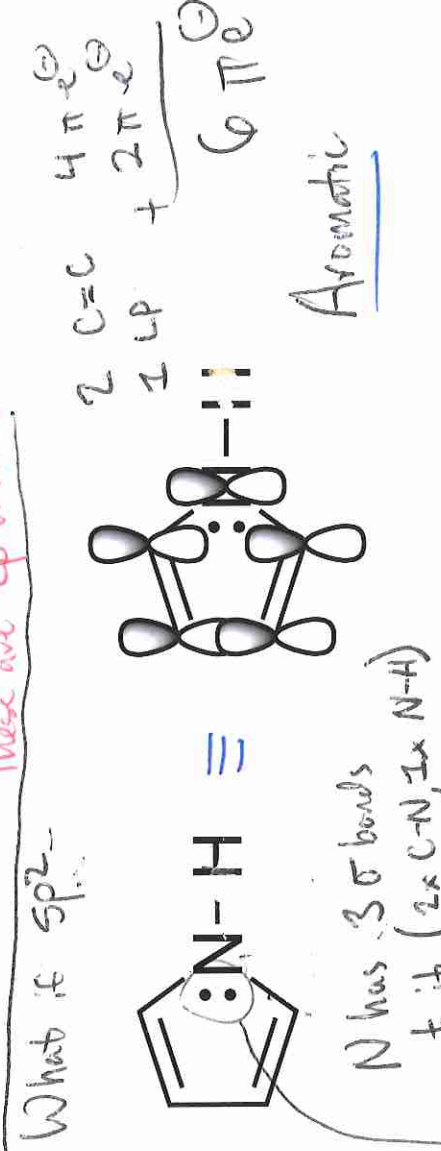
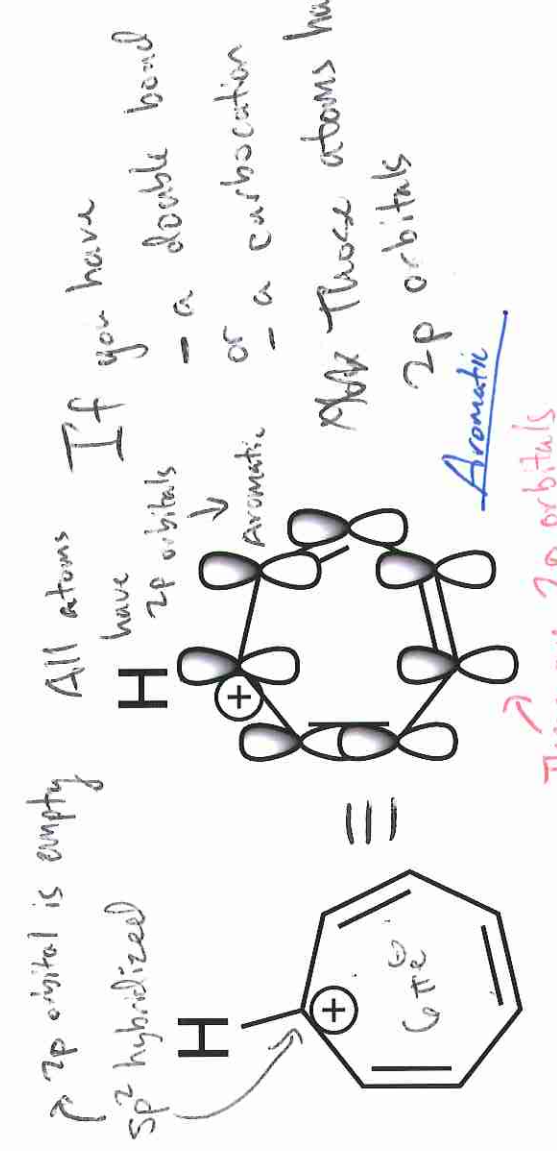
A C-C  $\sigma$  bond forms from overlap of two  $sp^2$  orbitals.

$\sigma$ -Bond



Since N has a double bond on it → it has to have a 2p orbital ( $sp^2$  hybridized)

Any time there's a double bond, a 2p orbital is being used in that  $\pi$ -bond



N has 3  $\sigma$  bonds to it (2x C-N, 1x N-H)

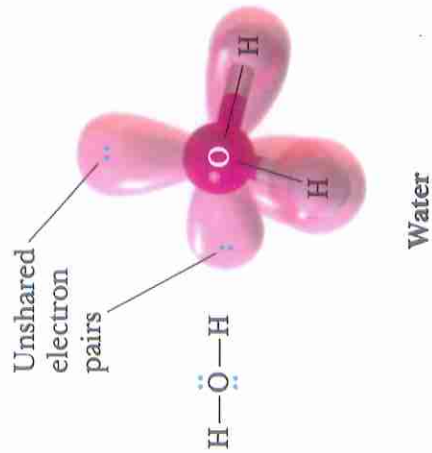
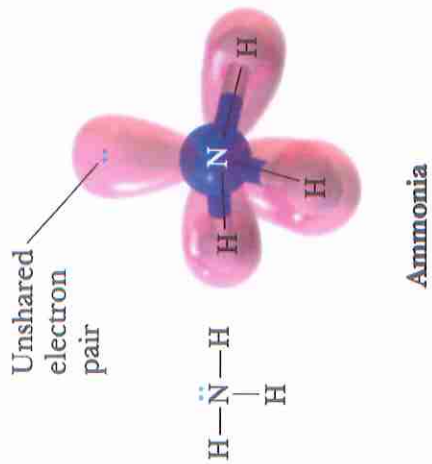
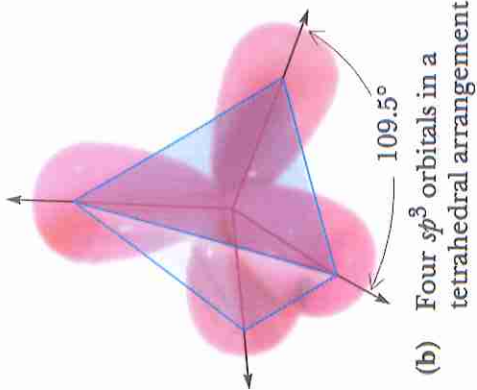
↓

All bonds use all 3  $sp^2$  hybrid orbitals

3

↳ Lone pair must be in 2p orbital

# sp<sup>3</sup>



# sp<sup>2</sup>

