



## Week 12 Handouts

***The Golden Rules of Organic Chemistry***

Your goal should be to understand, not memorize, the material presented in your organic chemistry course. The following principles should be learned as you begin your study of organic chemistry, then used as a solid foundation for building your understanding throughout the course. These simple ideas explain a great deal about the structures and properties of organic molecules, as well as the characteristic ways in which they react. Thoroughly understanding the following three key principles and related ideas will allow you to develop an intuitive feel for organic chemistry that avoids the necessity of resorting to the far less effective use of extensive memorization.

***A. Predicting Structure and Bonding***

1. In most stable molecules, all the atoms will have filled valence shells.
2. Five- and six-membered rings are the most stable.
3. There are two possible arrangements of four different groups around a tetrahedral atom.

***B. Predicting Stability and Properties***

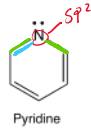
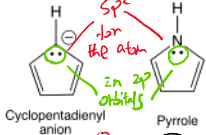
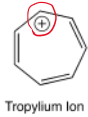
4. The most important question in organic chemistry is "Where are the electrons?"
5. Delocalization of charge over a larger area is stabilizing.
6. Delocalization of unpaired electron density over a larger area is stabilizing.
7. Delocalization of pi electron density over a larger area is stabilizing.

***C. Predicting Reactions***

8. Reactions will occur if the products are more stable than the reactants and the energy barrier is low enough.
9. Functional groups react the same in different molecules.
10. A reaction mechanism describes the sequence of steps occurring during a reaction.
11. Most bond-making steps in reaction mechanisms involve nucleophiles reacting with electrophiles.

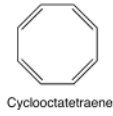
**Hückel's Aromaticity Criteria**

- 1) All atoms have to be  $sp^2$
- 2) flat
- 3) monocyclic - single ring
- 4) There are  $4n+2$   $\pi$  e<sup>-</sup>



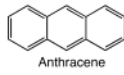
$3(C) \Rightarrow 6\pi e^-$

$2(C) \Rightarrow 4e^-$   
 $1(\text{lobe pair}) \Rightarrow 2e^-$

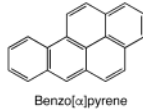


Antiaromatic

Aromatic



$\Rightarrow$

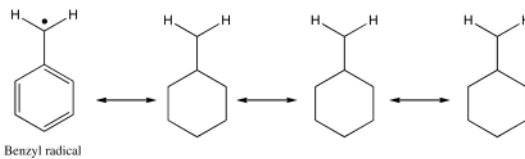
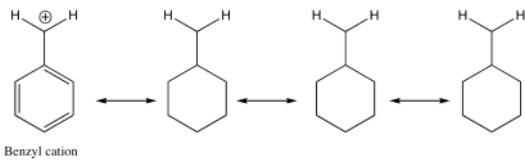
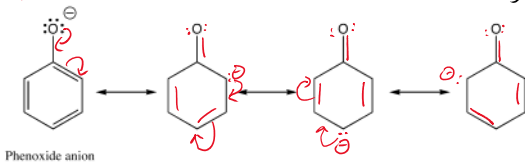


Determine which orbital the lone pair stays in:

- 1) Determine the hybridization state of the atom;
- 2) Count the hybridized and  $2p$  orbitals used

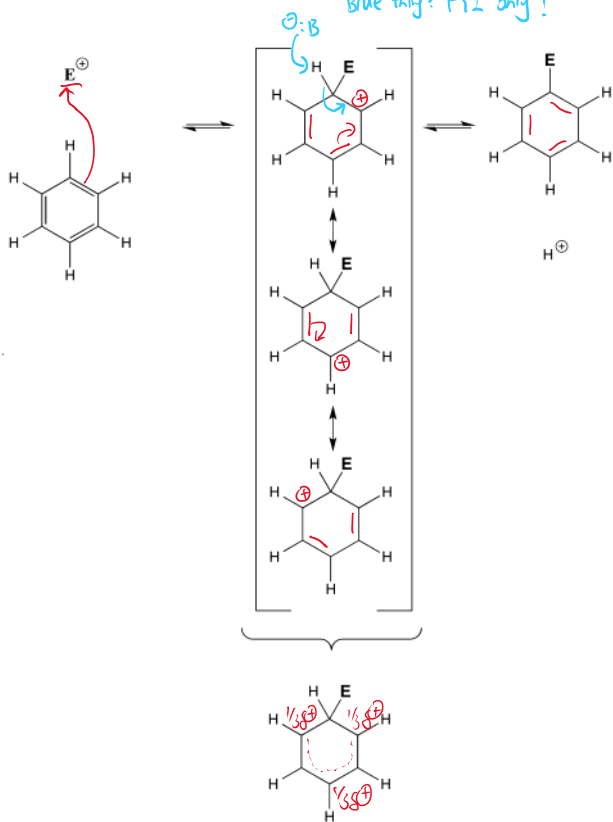
**Aromatic resonance stabilization of charged species**

- charges can be distributed across multiple atoms  $\rightarrow$  stabilizing!
- certain positions will have more partial charges than the rest  $\rightarrow$  "directing effect"



EAS → Electrophilic Atomic Substitution

Blue thing: FIZ only!

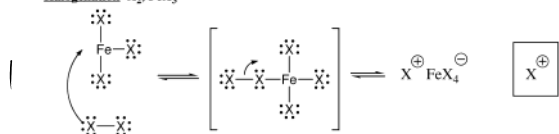


scope of the electrophile:

Reagents

Halogenation  $X_2, FeX_3$

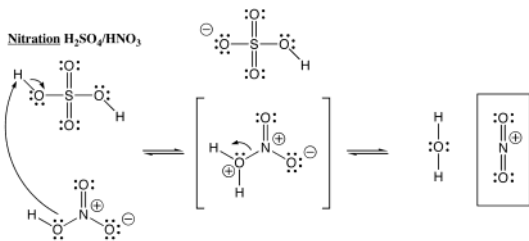
Wicked strong electrophile  $E^+$



$X = Br, Cl \Rightarrow$  can't mix and match

2

Nitration  $H_2SO_4/HNO_3$



3

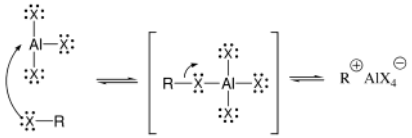
Sulfonation  $H_2SO_4/SO_3$



Fuming sulfuric acid contains both of the above reagents, the  $SO_3$  is the important one

Reagents

Friedel-Crafts Alkylation R-X, AlX<sub>3</sub>



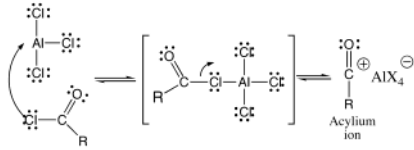
X = Br, Cl

Wicked strong electrophile

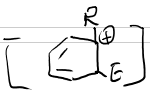


Note this is a carbocation, so it will rearrange if it is a primary or a rearrangement-prone secondary cation

Friedel-Crafts Acylation RCOCl, AlCl<sub>3</sub>

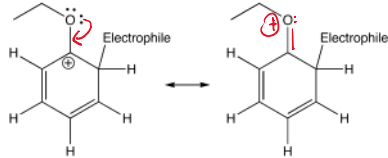


Other notes: 1) It is hard to stop the Friedel-Crafts alkylation after one alkyl group adds (because alkyl groups are "good", that is, activating), but it can be done. 2) Neither Friedel-Crafts reaction works if there is already an electron withdrawing (bad) group on the ring.



Arenium ion **stabilizing** interactions

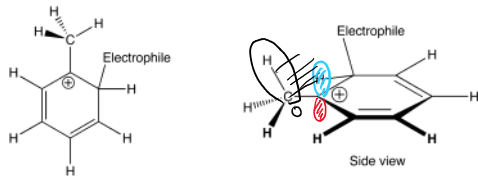
A) **Pi donation**, a resonance effect for atoms with lone pairs attached to the ring



f OR "GOOD"

activating, donating

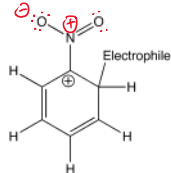
B) **Hyperconjugation** for alkyl groups attached to the ring



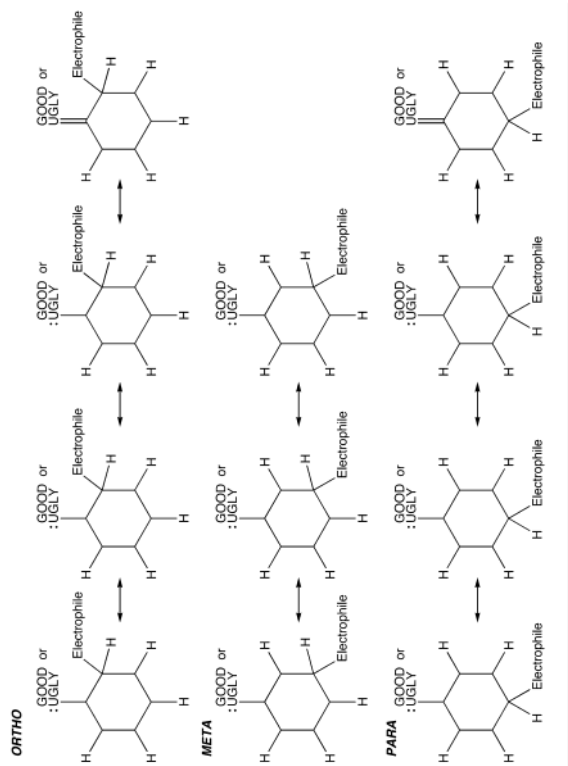
f CH<sub>3</sub> "GOOD"

Arenium ion **destabilizing** interaction

A) **Inductive effect** of electronegative atoms or groups attached to the ring

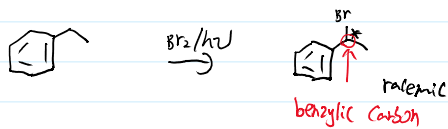


f NO<sub>2</sub> "BAD" deactivating withdrawing

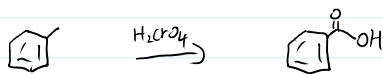


Reactions :

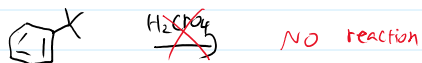
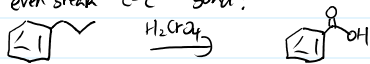
1. Free radical bromination:



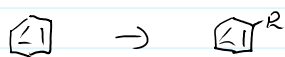
2. Oxidation



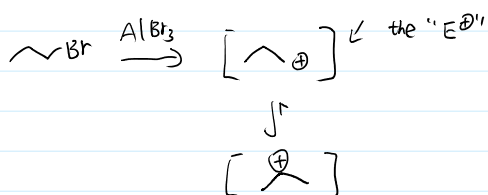
can even break C-C bond!

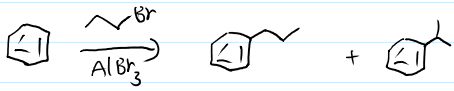


Friedel - Crafts Alkylation

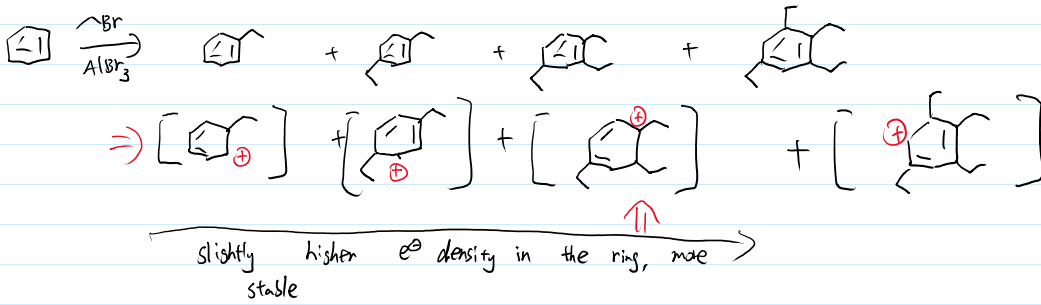


1) It involves carbocation  $\rightarrow$  can rearrange

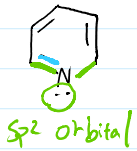




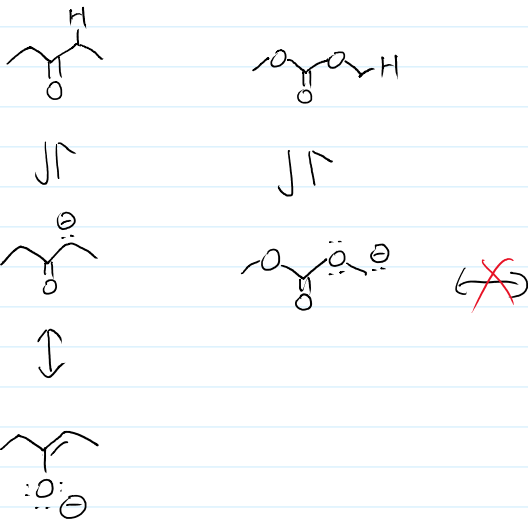
2) Alkyl group is GOOD group → Activate, → overreact



- Adding one alkyl group makes adding the next one easier (activating)
- Because alkyl groups help stabilize the arenium ion intermediate.



- N is sp<sup>2</sup> hybridized
- It has  $\begin{cases} 3 \text{ sp}^2 \text{ hybridized orbitals} \\ 1 \text{ 2p orbital} \end{cases}$
- recall  $\begin{cases} \sigma\text{-bonds formed by hybridized orbitals} \\ \pi\text{-bonds formed by 2p orbitals} \end{cases}$



sp<sup>2</sup> hybridized O-atom