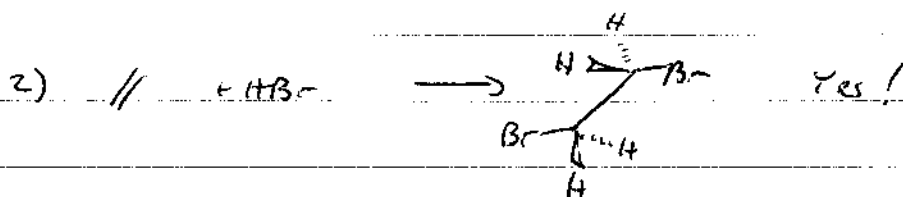
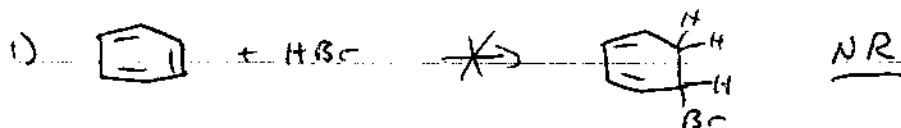


Ch 17

Reactions of Aromatic Compounds

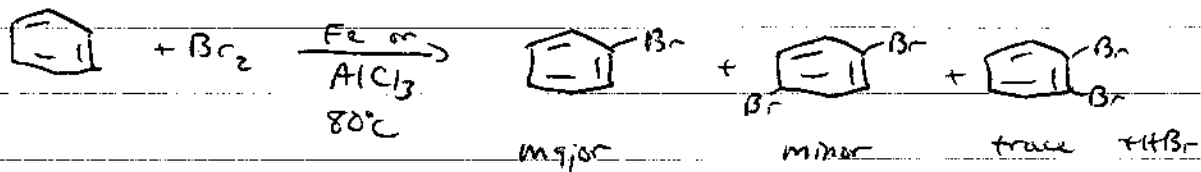
Electrophilic Substitution Rxns

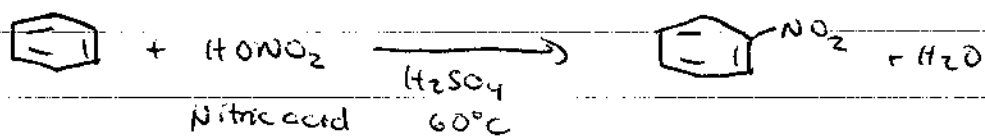


Why? Egn 1 \rightarrow lose aromaticity

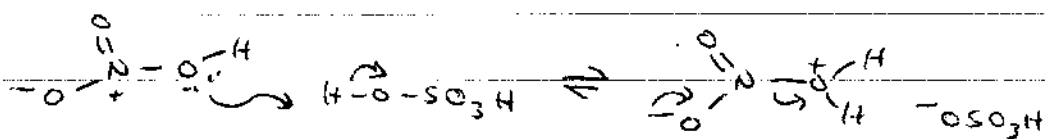
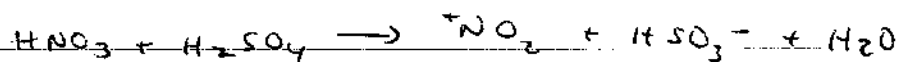
Egn 2 \rightarrow no problem

Instead,



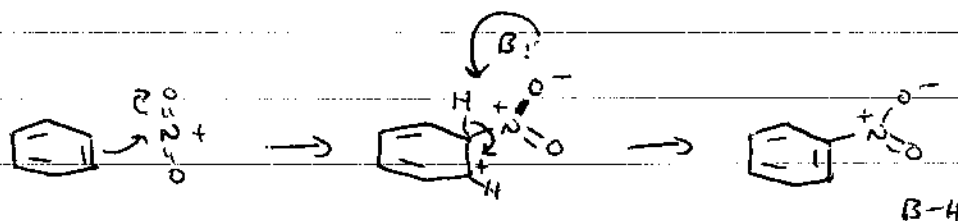
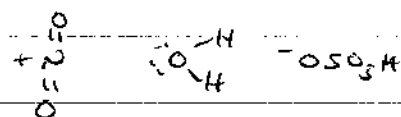


Mechanism



↓

Nitronium ion

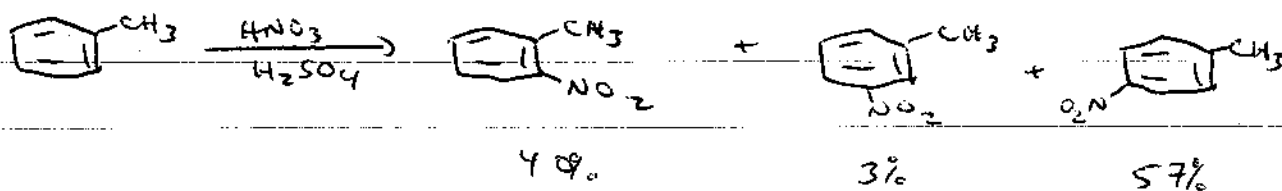
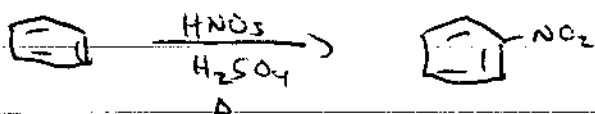


SUBSTITUTION RXN

Also,



Sulfonation Rxns are similar



Cc1ccccc1 25X faster than c1ccccc1 !

Why?

-CH₃ group activates aromatic ring to subst.

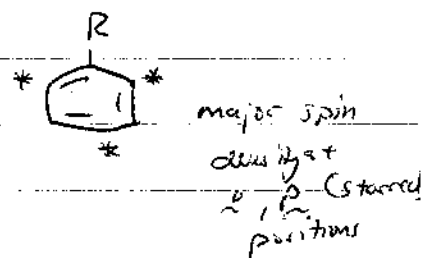
Ring Activating groups or ortho, para directing groups

EDG's ⇒ push e⁻ density onto ortho, para positions

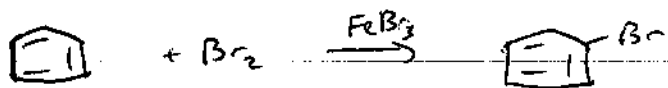
∴ electron poor Attacking groups more

likely to attack these e⁻ rich spots

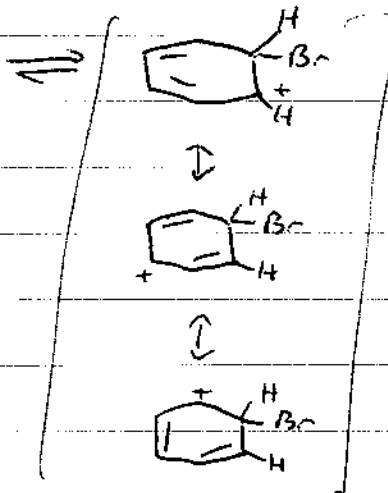
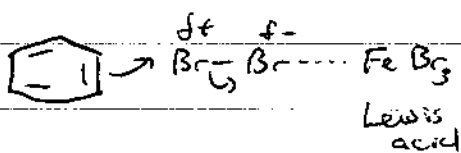
- ↑ increasing ability
- Ex -NR₂ (R = Alkyl, H, Ar)
 - OH
 - OCH₃
 - NH⁺C(=O)CH₃
 - O⁺C(=O)R
 - R = allyl, Aryl
 - Cl, Br, I



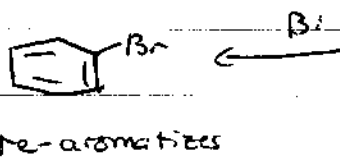
Thus



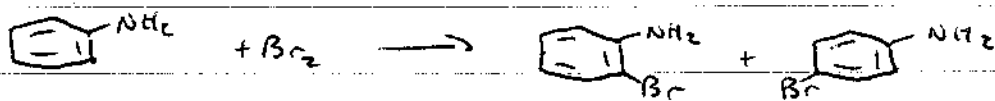
Mechanism



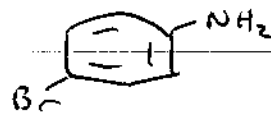
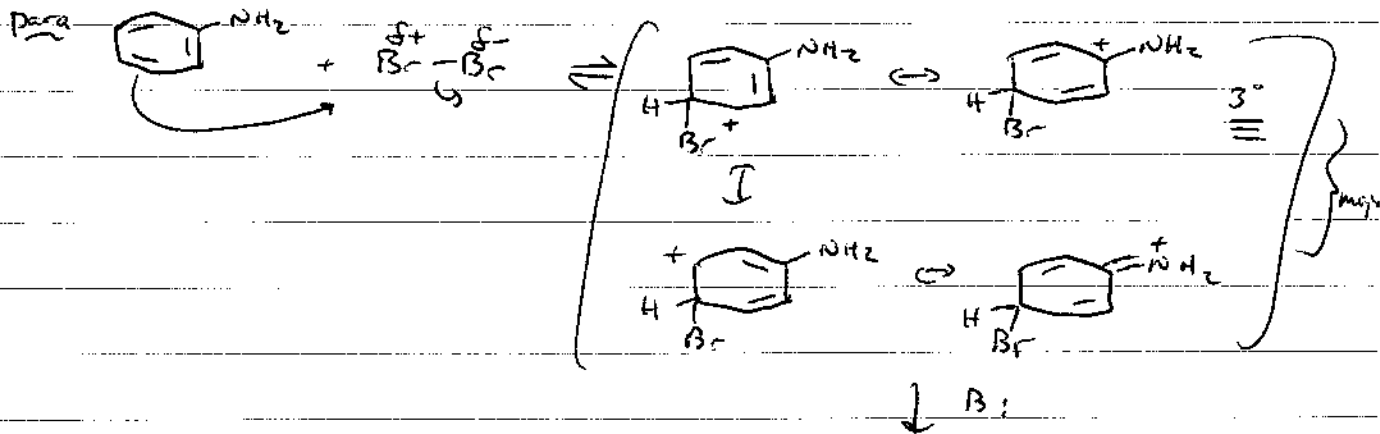
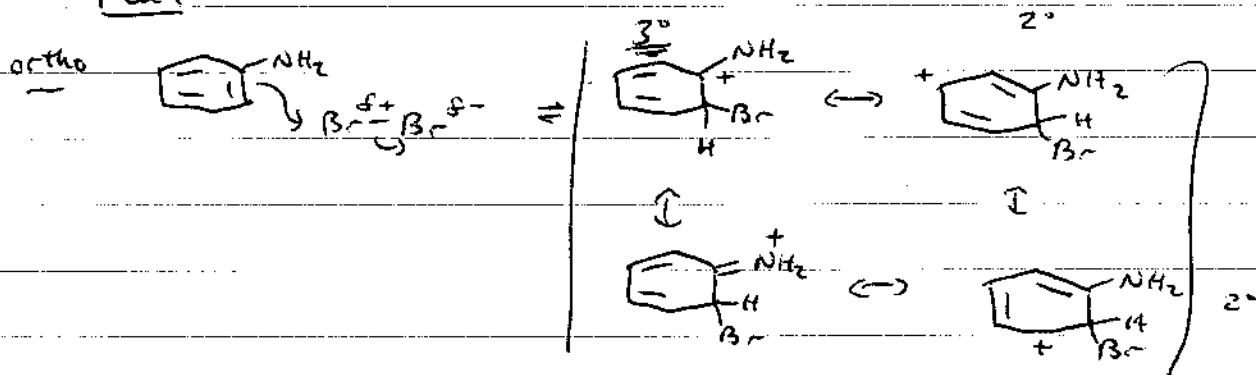
all are
2° carbons!

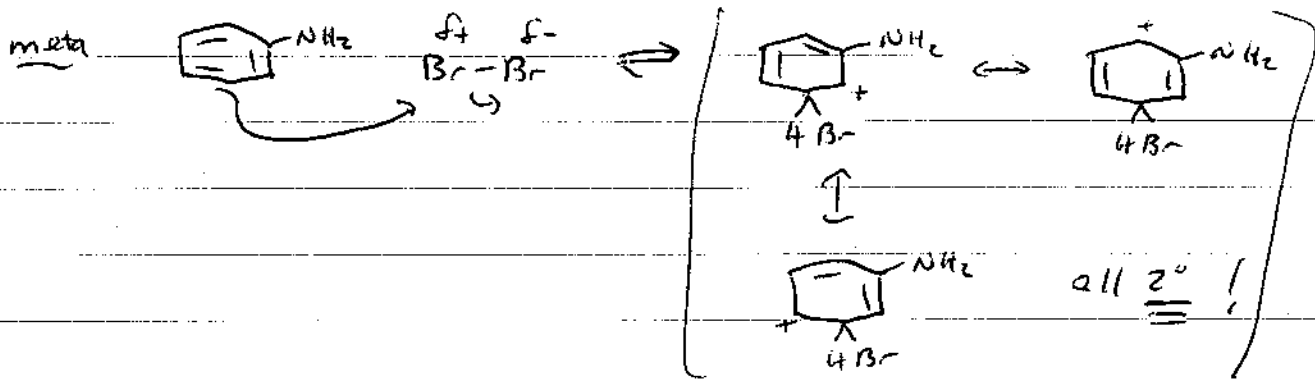


Subst. Rxns of Aromatic Groups w/ Ring Activating Groups



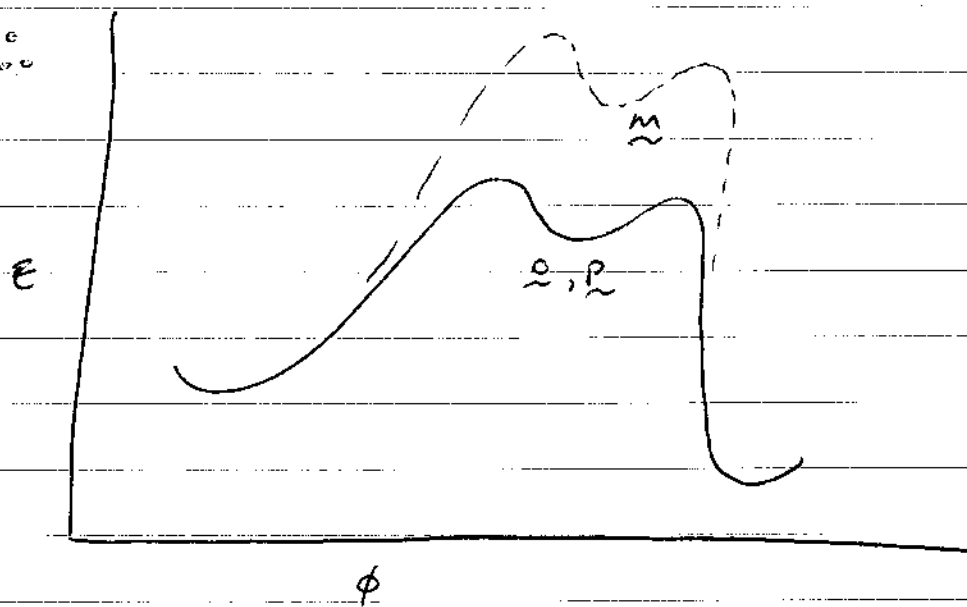
Mech



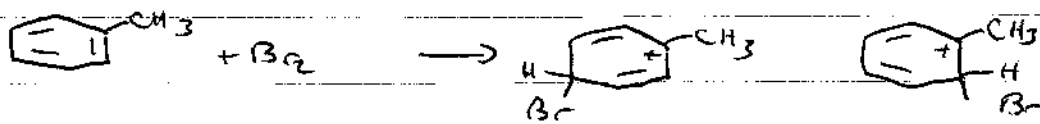


ONLY 3 Resonance structures!

↓ B:

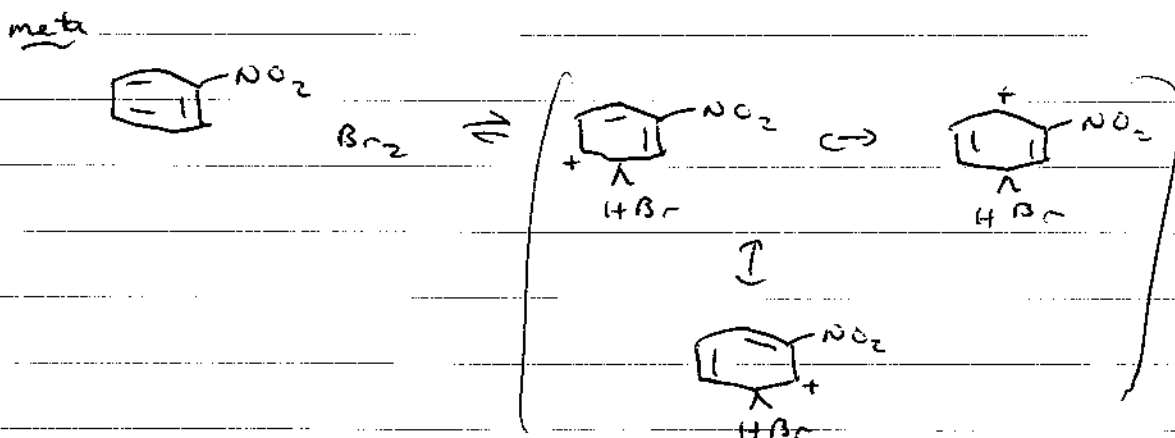
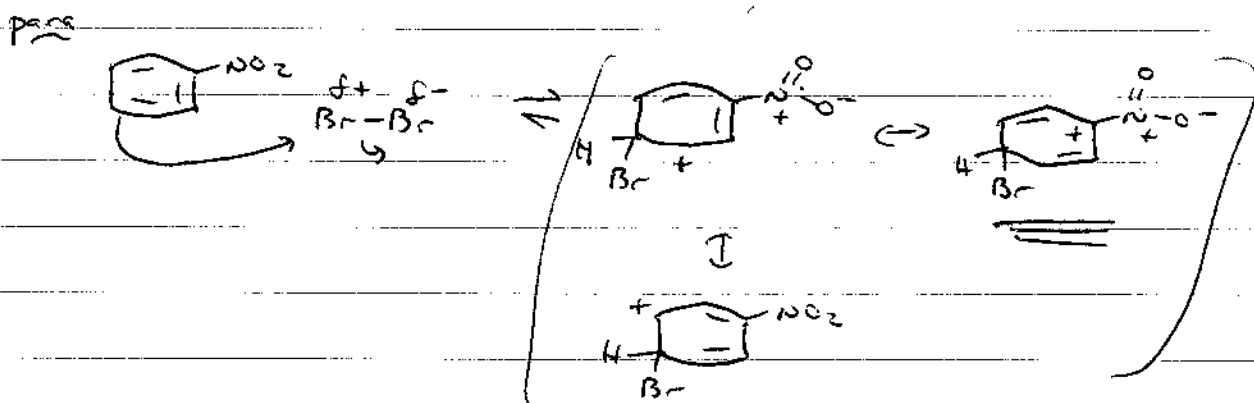
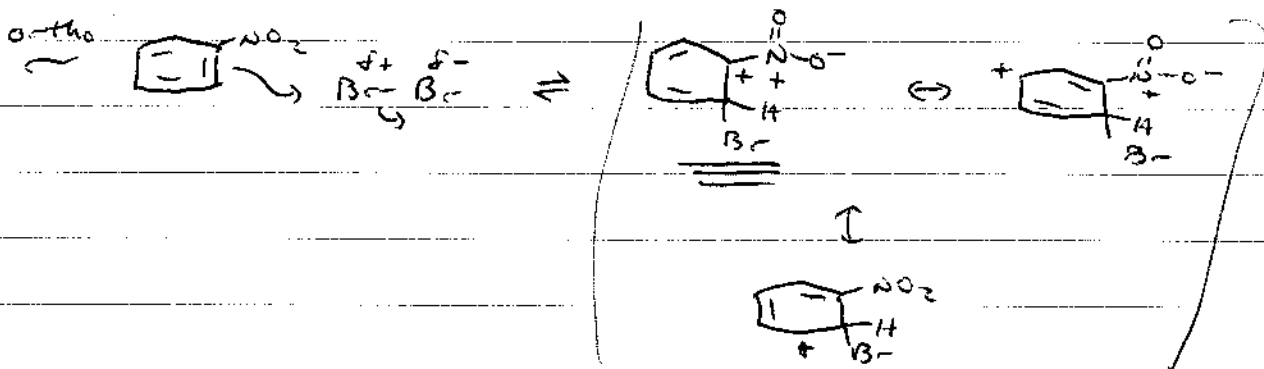
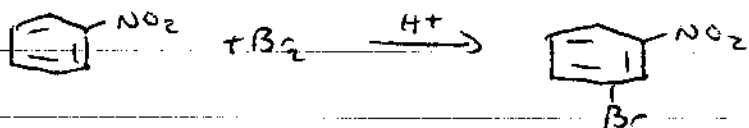


Alkyl groups - same



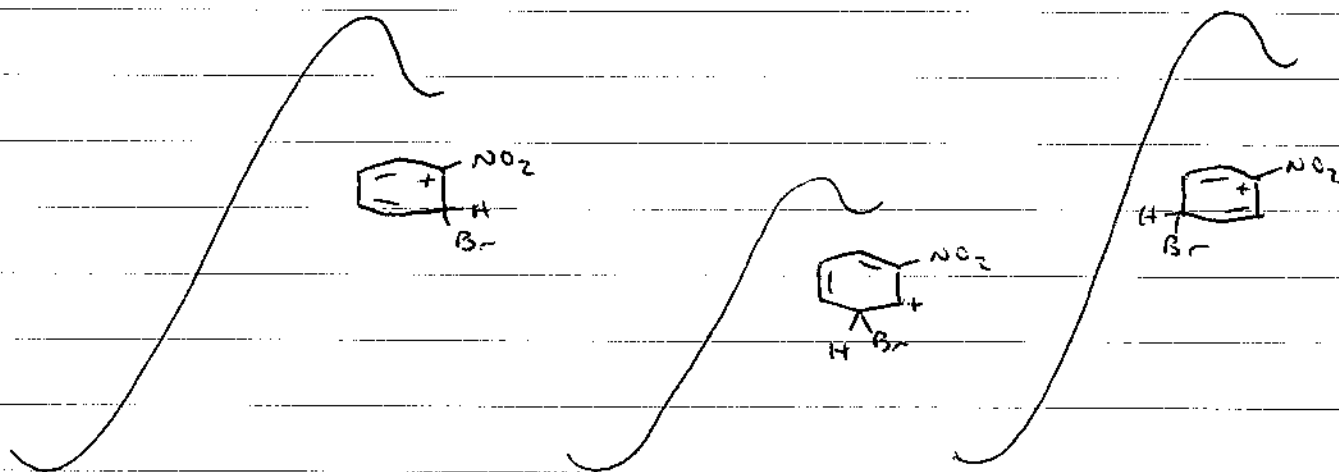
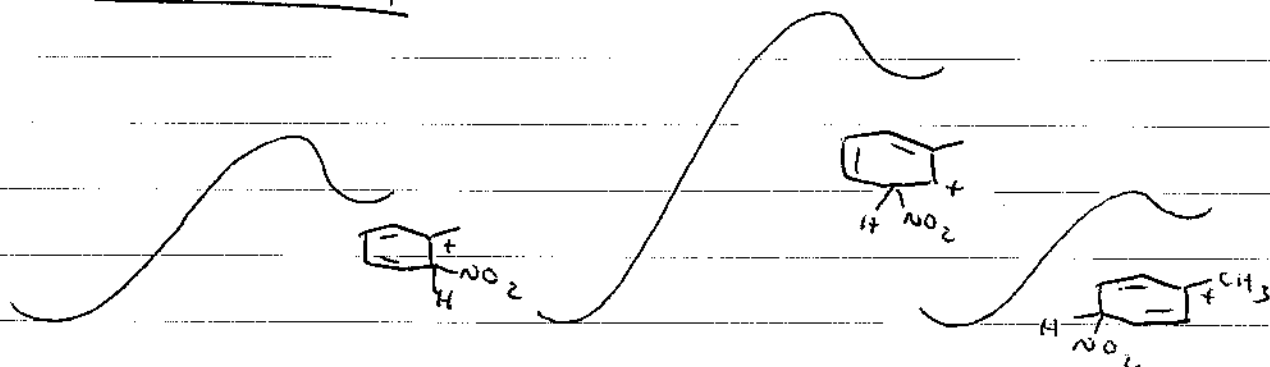
Major resonance forms

Orientation in Electrophilic Aromatic Subst. w / RING DEACTIVATING GROUPS



NONE has 2 "+" charges side by side
 so NONE stabilize BUT none
de stabilize either!

Relative Intermediate energies



ortho

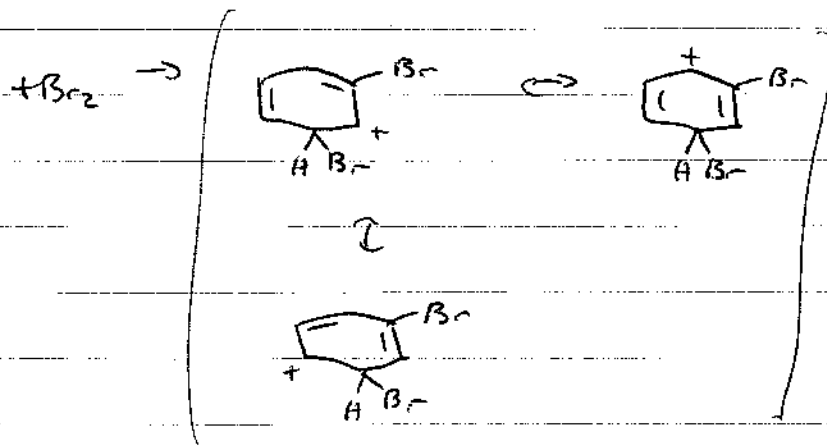
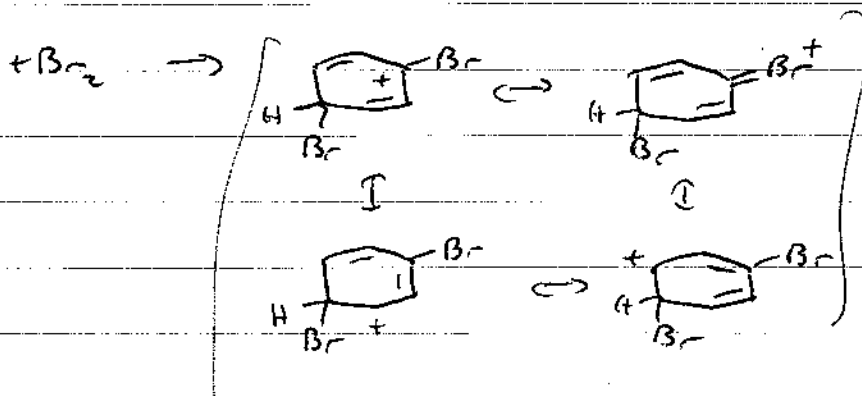
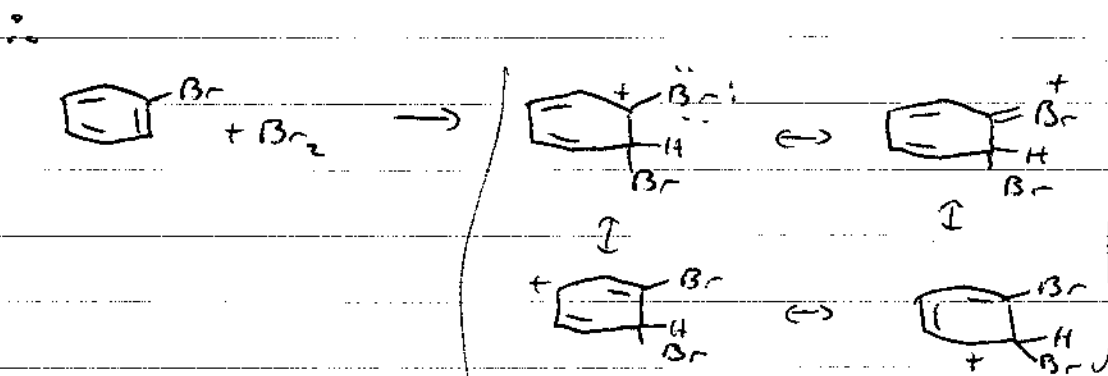
meta

para

Haloaromatic molecules

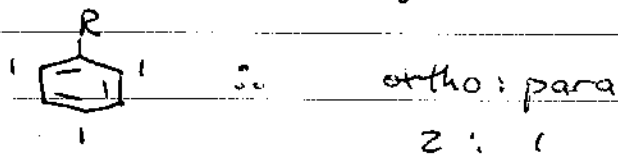
- electron w/drawing \Rightarrow \therefore deactivating

However, non-bonding e^- can stabilize "+" charge

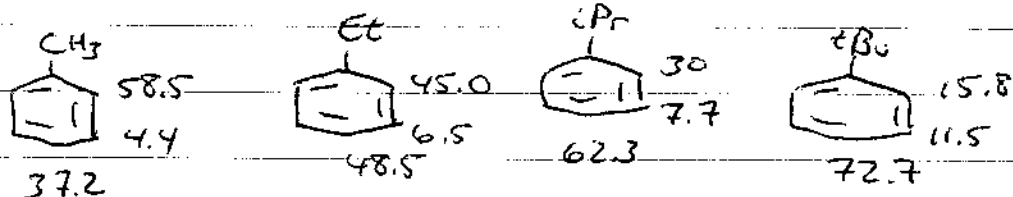


ortho, para preferred

Steric Effects: Reality

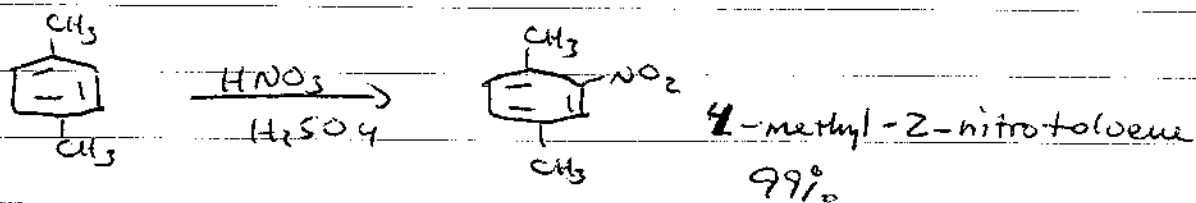


Actually, para position gets more subst.

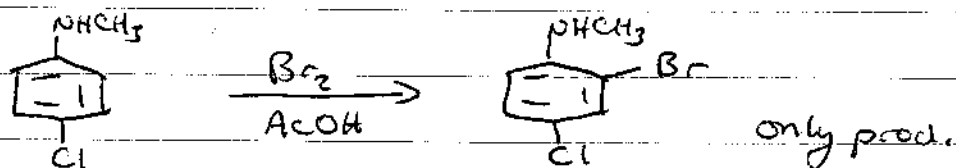


also, large electrophiles favor para position

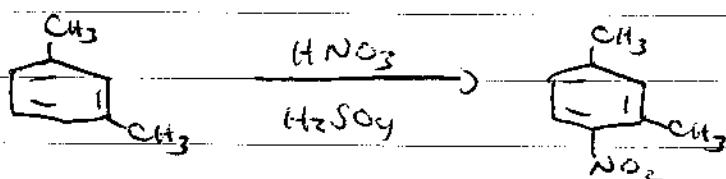
Effects of more than one substituent



Both Me groups direct ortho/para

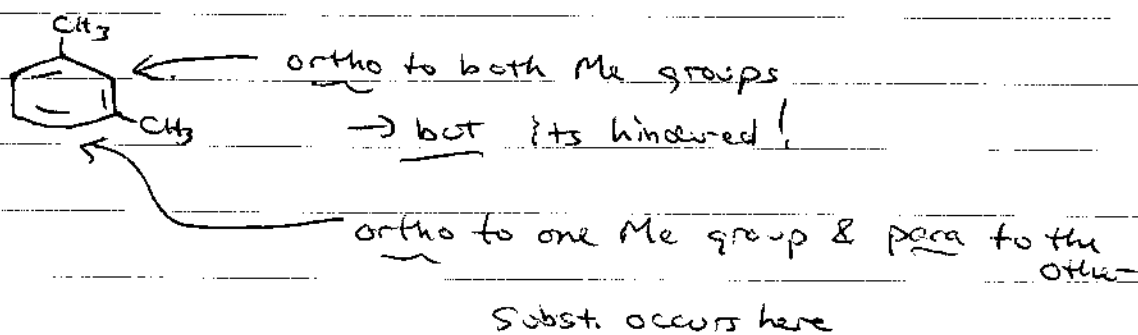


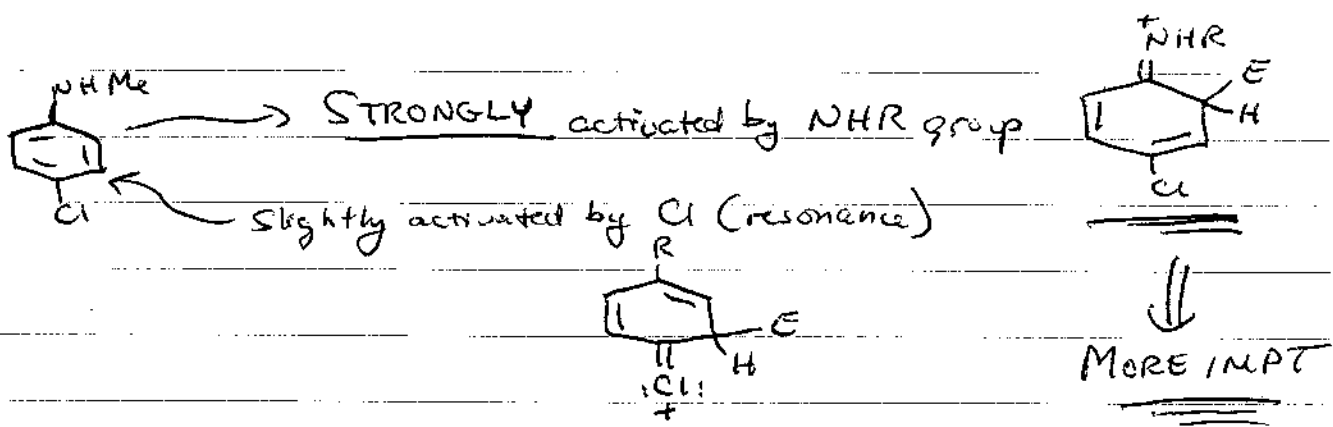
- NHR group is ortho/para directing
- Cl is not directing to meta attack



Me-groups are ortho/para directing

Ok, what is going on?



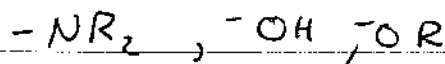


Can generalize,

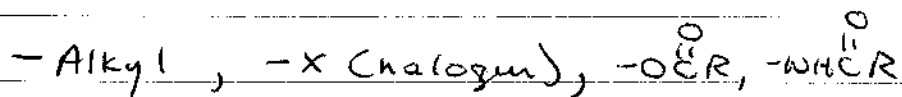
— Activating groups are stronger directors than deactivating groups

Can separate directing groups into 3 classes:

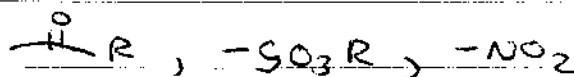
1) Strong ortho/para directors

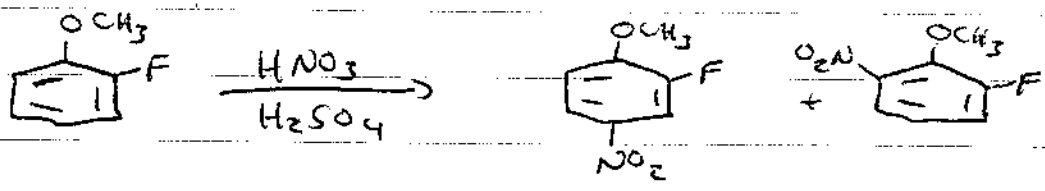


2) Moderate ortho/para directors



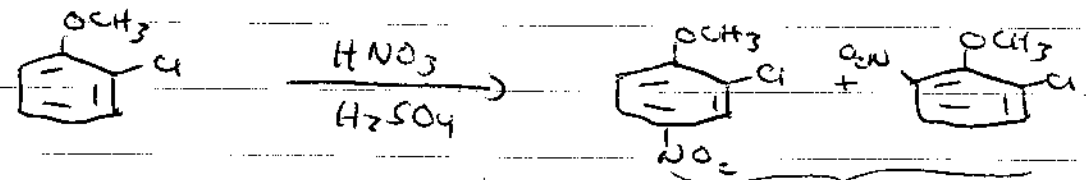
3) All meta directors (deactivating groups)





CH_3O - o,p - directing
 F - m - directing

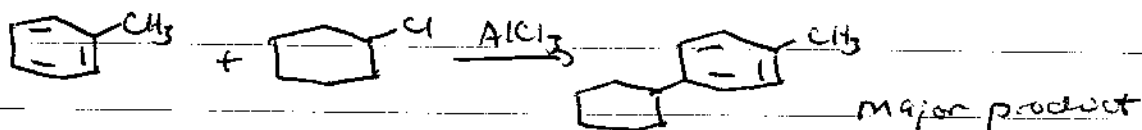
What if the two directing groups compete?



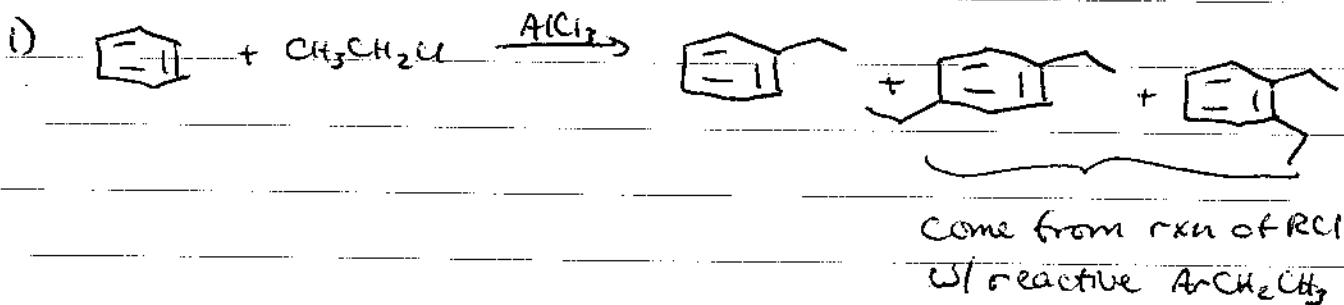
- OCH_3 o,p directing (strongly) major products
 - Cl o,p directing (weak)

The stronger directing group wins

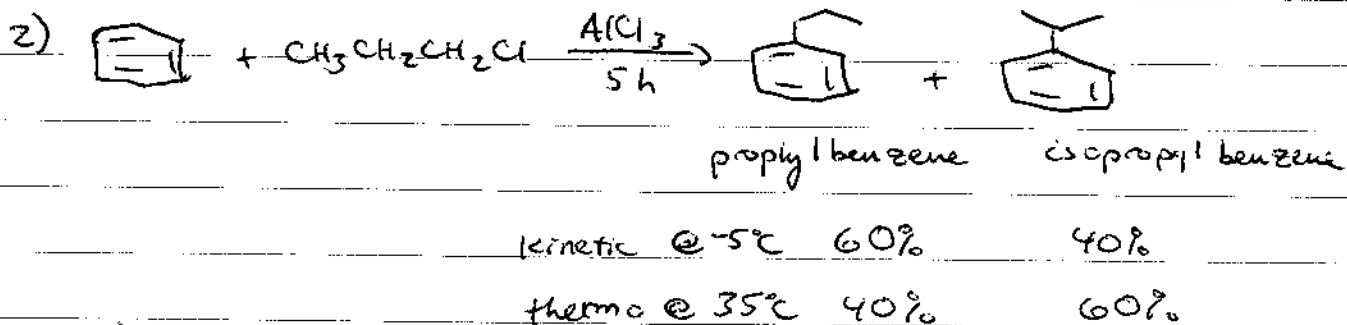
Also,



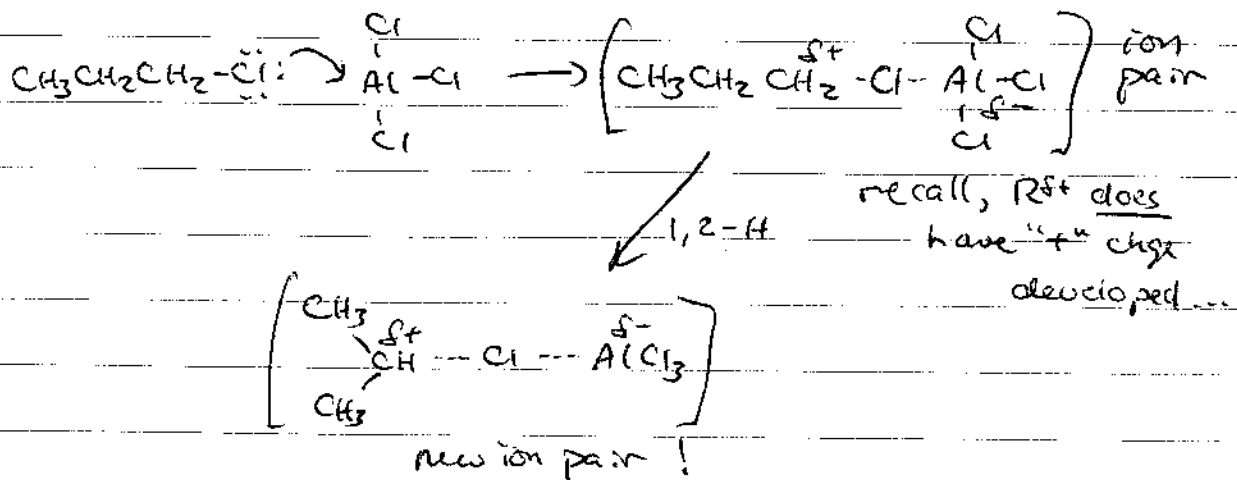
Limitations of F-C Rxn



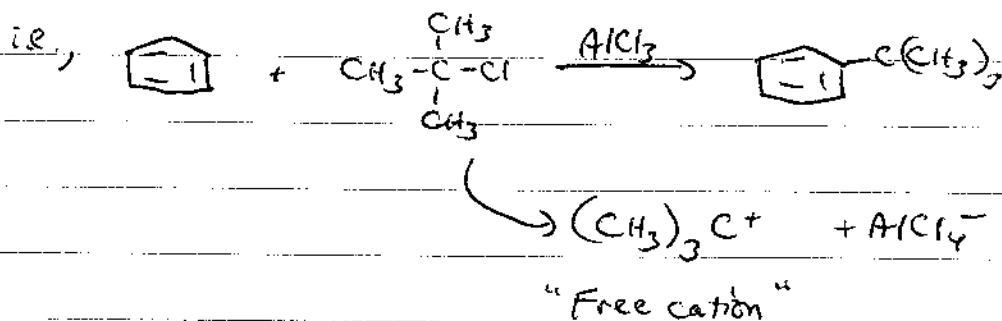
∴ multiple substitutions are likely



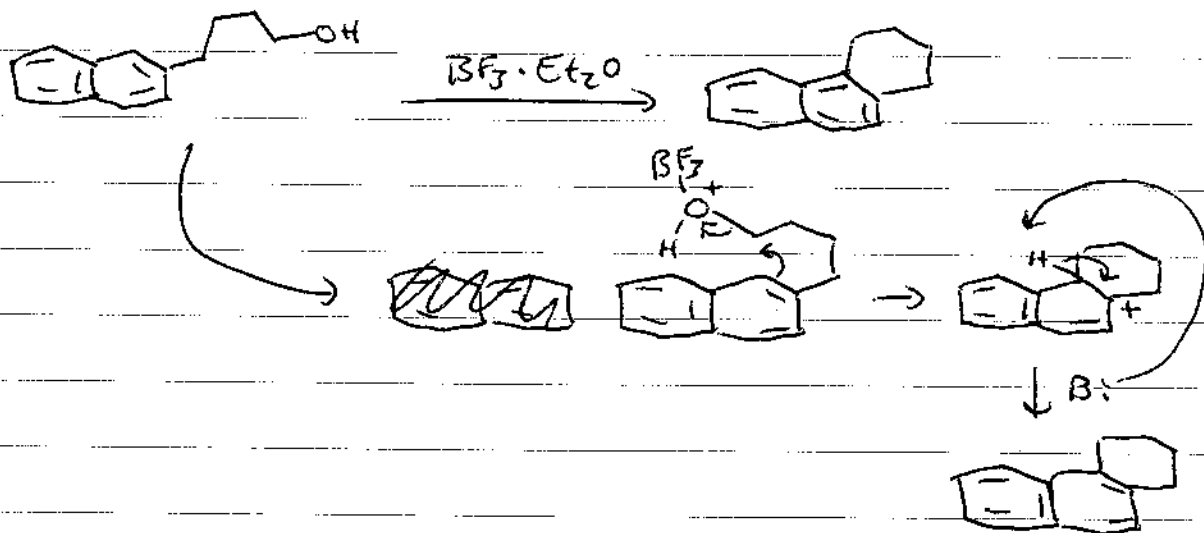
AlCl₃ - Lewis acid catalyst:



Can avoid by using molecules that form 2° or 3° cations



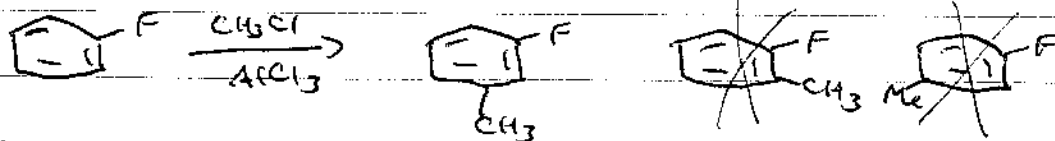
also



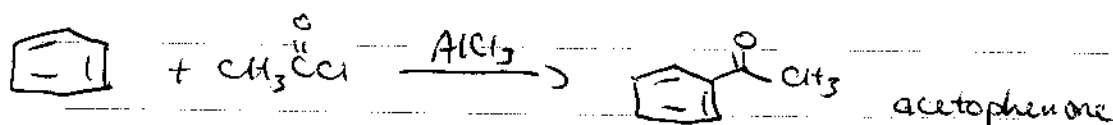
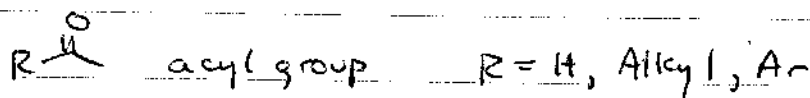
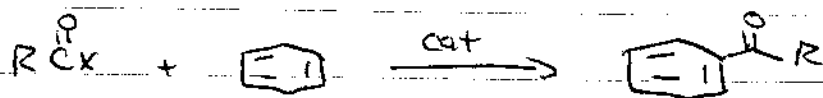
Finally

3) if have a meta-directing group on a ring \rightarrow difficult to put where you want

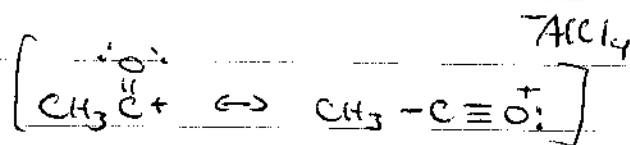
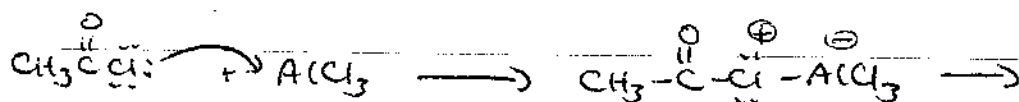
i.e.,



Friedel-Crafts Acylation

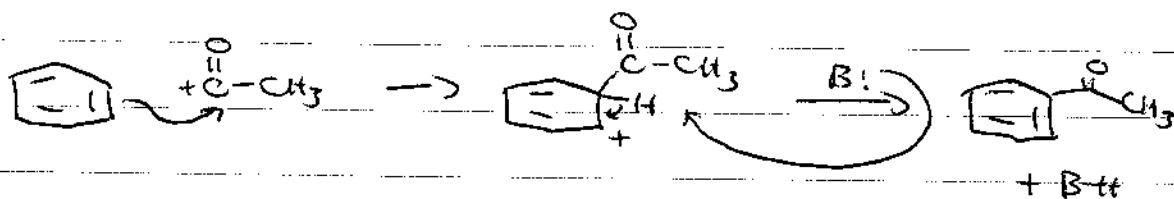


Mechanism

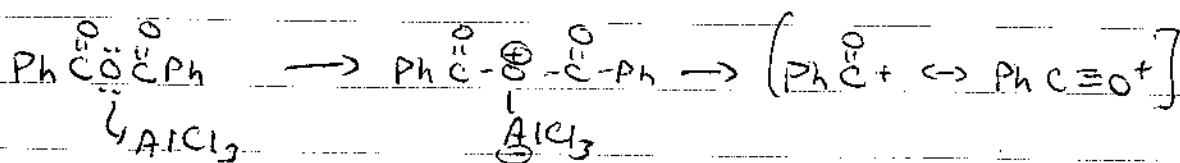


good resonance structures

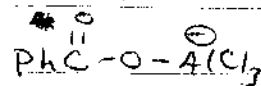
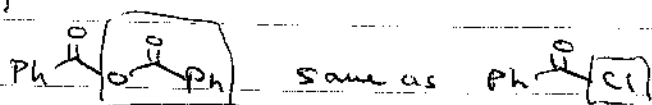
Now,



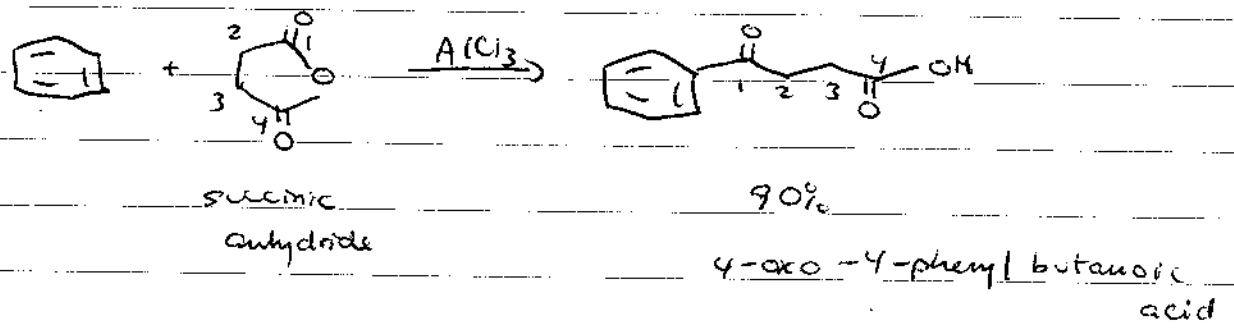
Can use Anhydrides as acylating agents also:



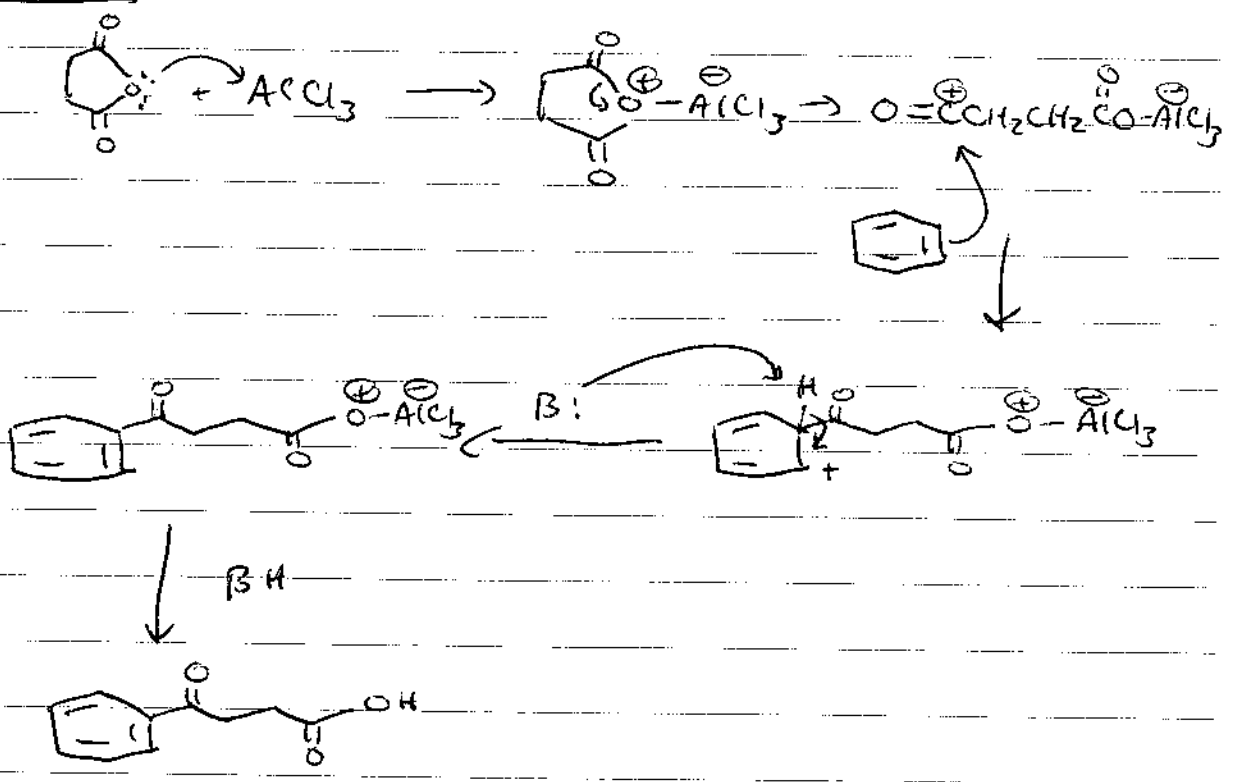
NOTICE!



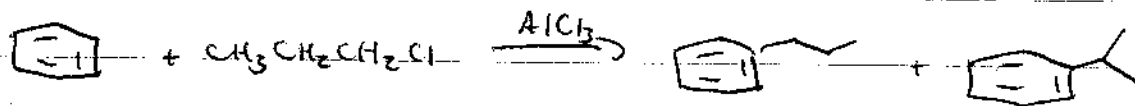
Another example...



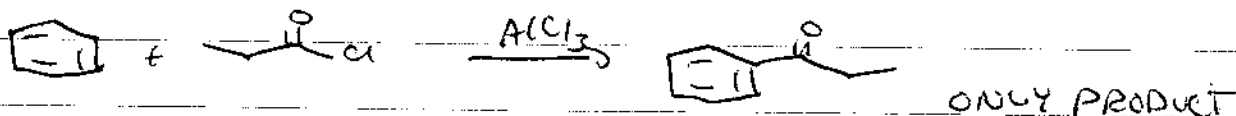
Mechanism



Advantages of Acylation over Alkylation



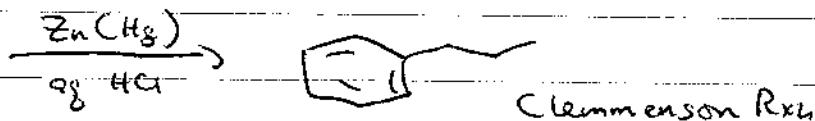
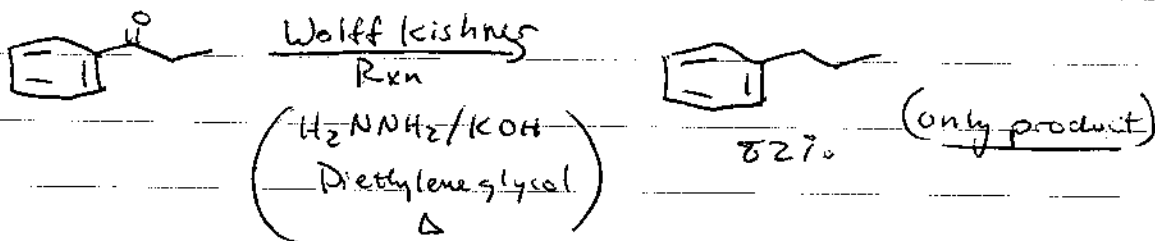
mixture of isomers



65% yield

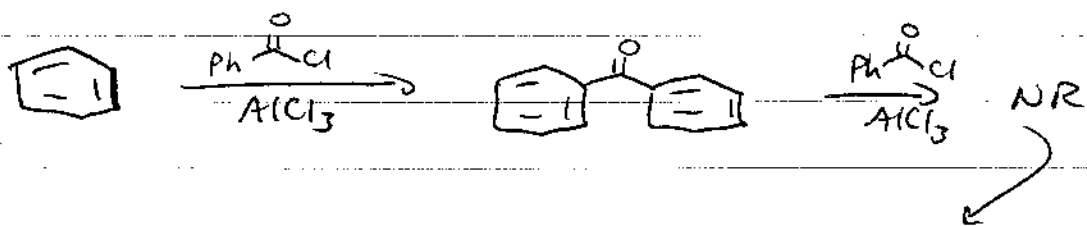
NOT the same?

But



NO SIDE PRODUCTS

Also,

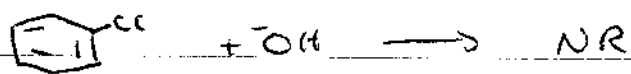


have deactivated the
ring to further subst.!
Wahoo!

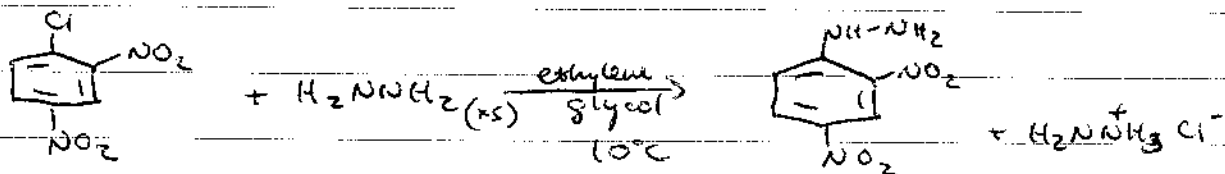
Skip 17-11C (Gatterman-Kohl Formylation)

Nucleophilic Aromatic Substitution Reactions

Activation of Aryl rings by e^- withdrawing groups



Attach strong e^- w/drawing groups though...

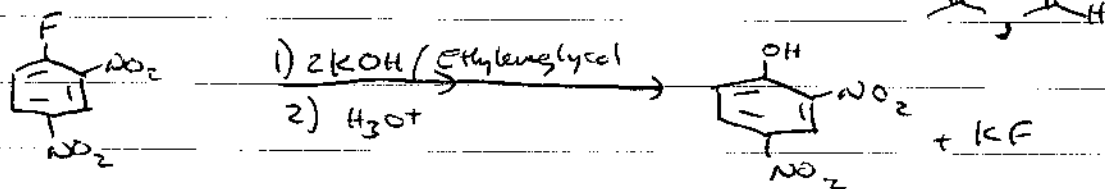


1-chloro-2,4-dinitrobenzene

2,4-dinitrophenyl
hydrazine

2,4-DNPH

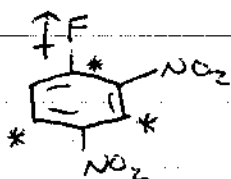
common derivative for



2,4-dinitrofluorobenzene

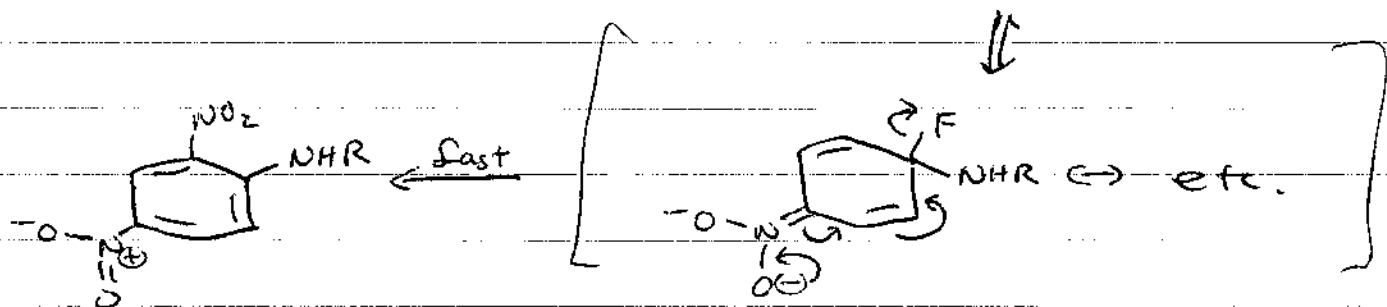
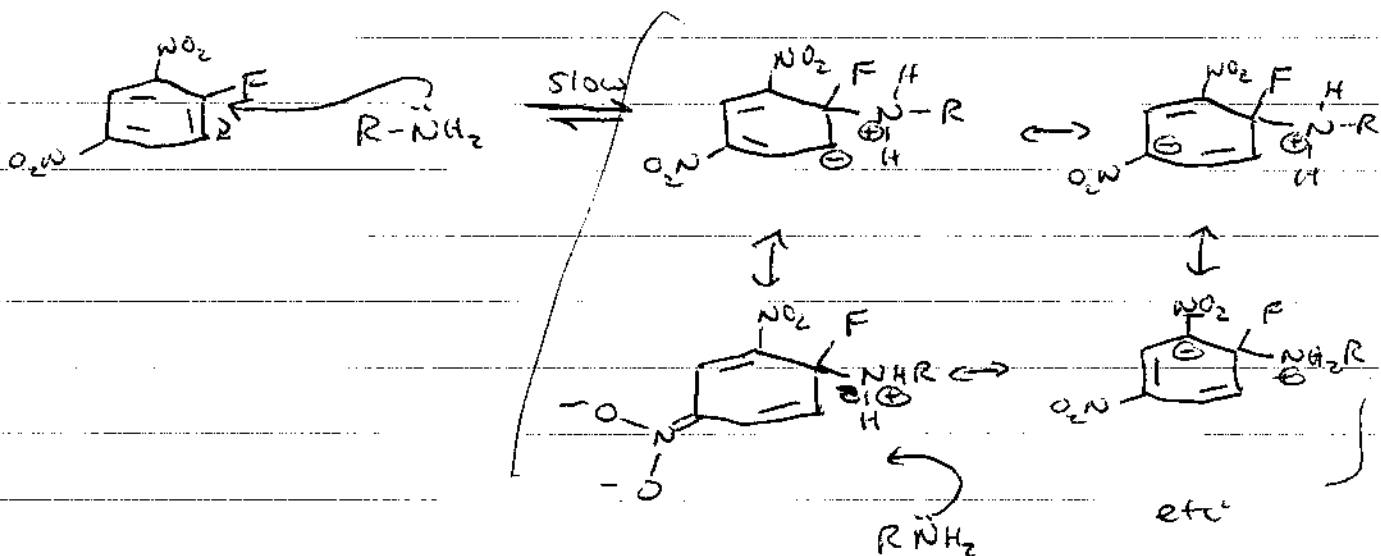
reacts v. rapidly
w/ amines, alkoxides, OH^-

Mechanism

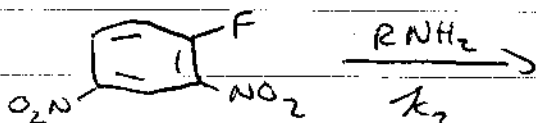
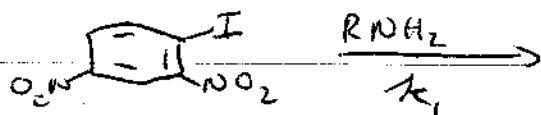


* e^- deficient sites

ALL groups are strong EWG's



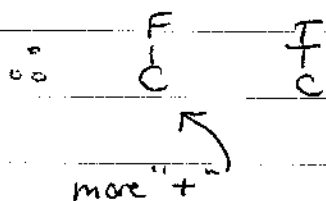
Interestingly,



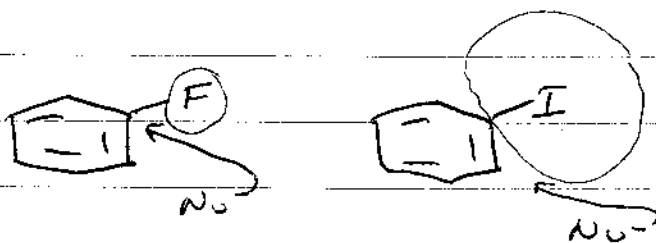
$$k_2 \gg k_1$$

Why ???

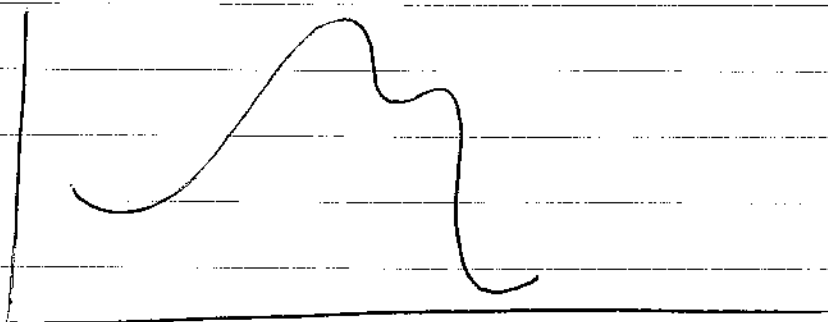
F is more electronegative than I



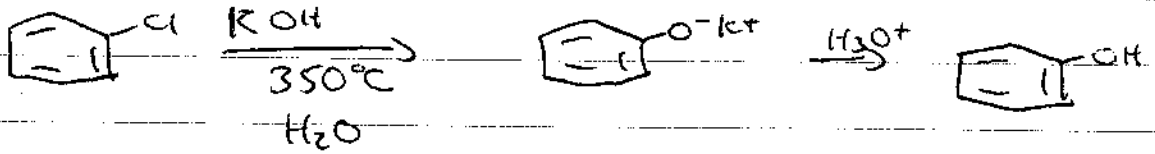
also



F smaller δ^+ easier approach

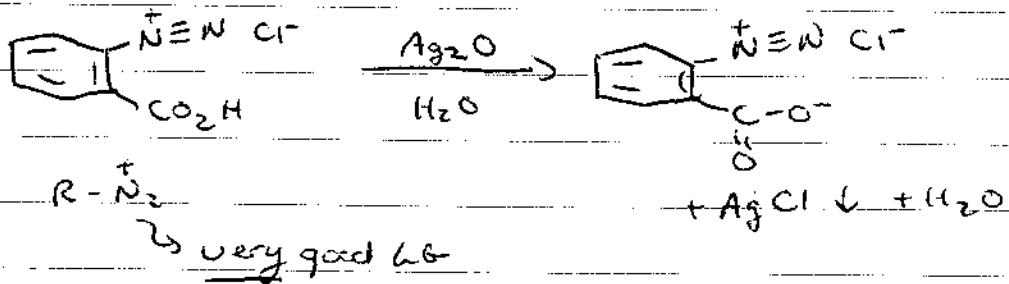


Benzynes

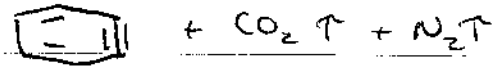


BUT, we just said this rxn doesn't work!
well, not at REASONABLE temps

Now, let's digress a second...



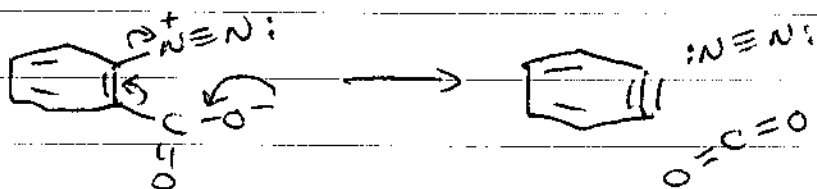
Benzene diazonium 2-carboxylate



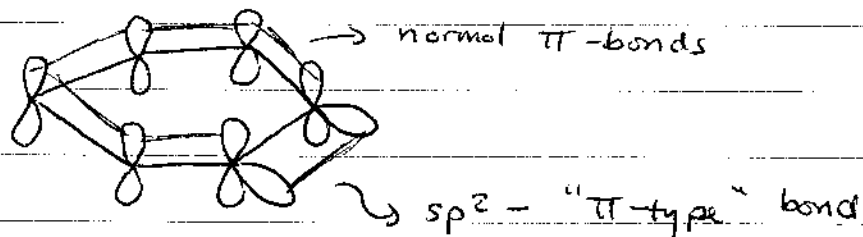
"Benzynes"

very reactive

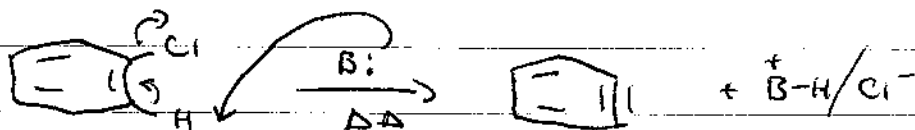
Mech of formation



Bonding in Benzyne - Triple bond?
Sort of ...

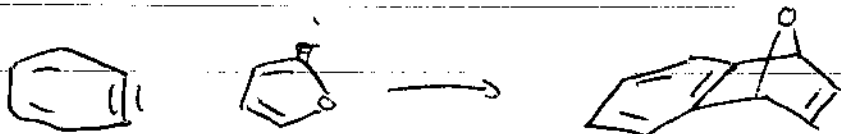


So ...

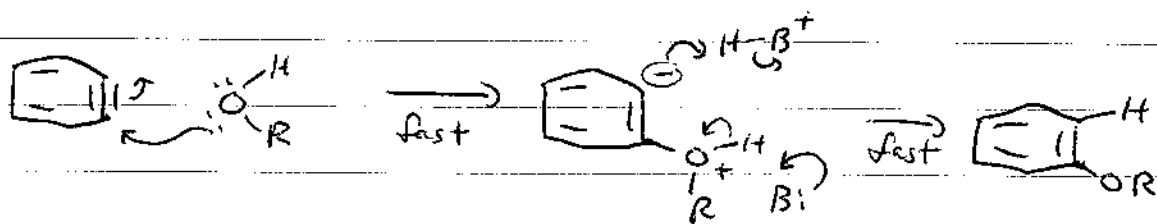


Reactions of benzyne

1) DA

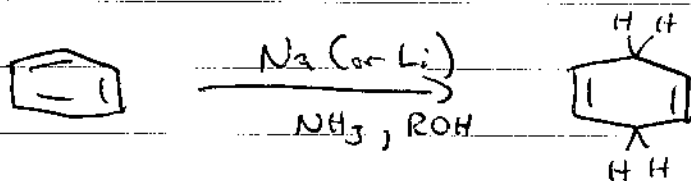


2) Nucleophilic Addn. Rxns

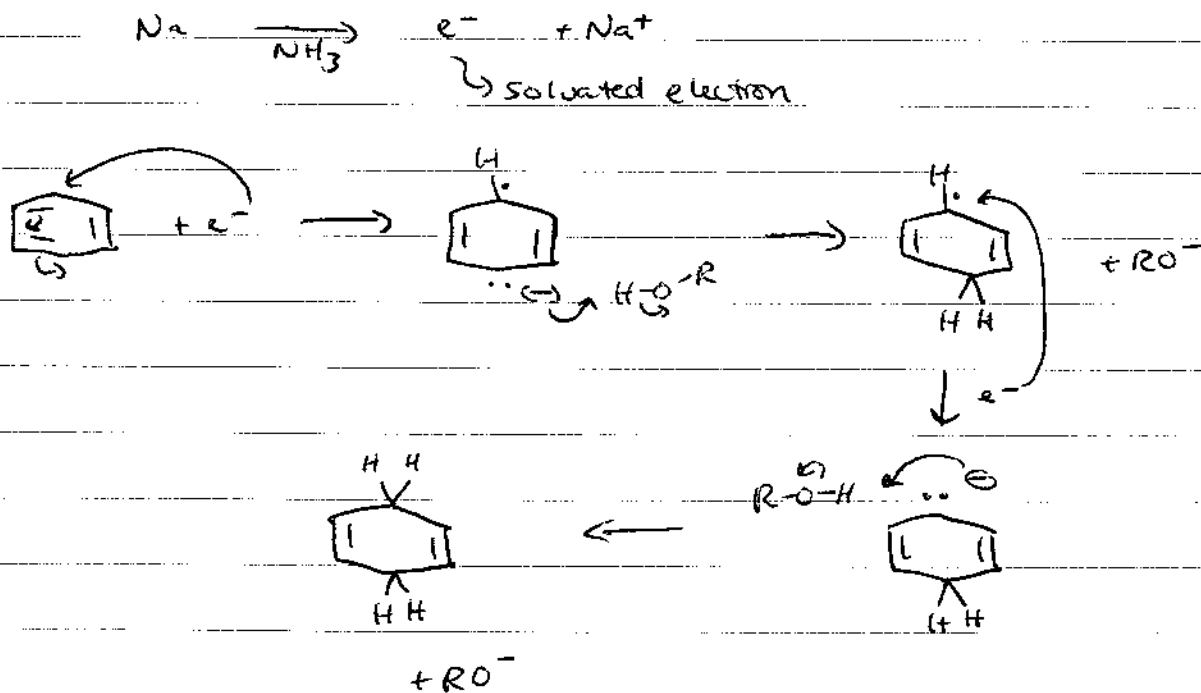


Skip 17.13 A, B

Birch Reduction

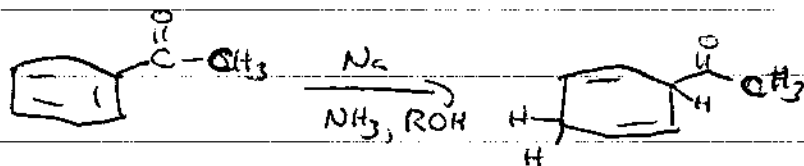


Mechanism

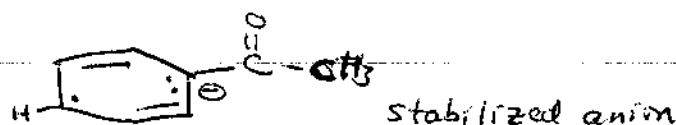


substituted benzenes: Birch Reduction

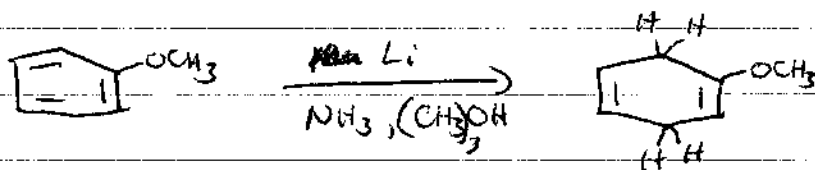
EWG substituents:



Why?

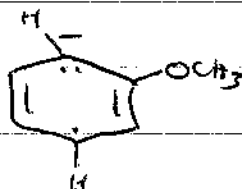


EDG substituents:



MeO group DESTABILIZES

" - "

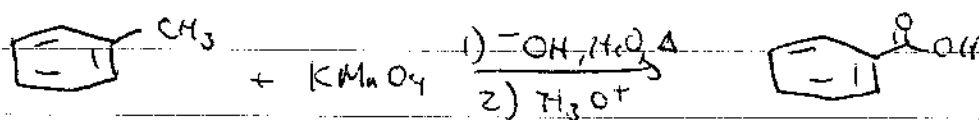
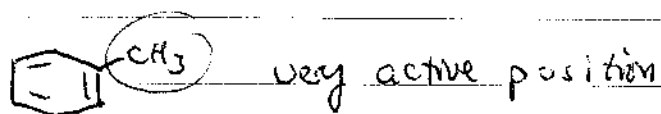


not as bad...

Notice, we use Li instead of Na

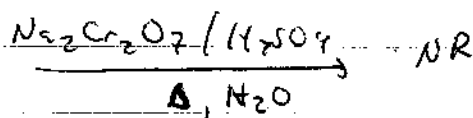
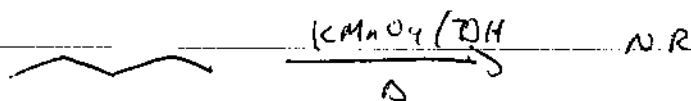
} stronger reducing agent

Side chain Oxidations in Arenes

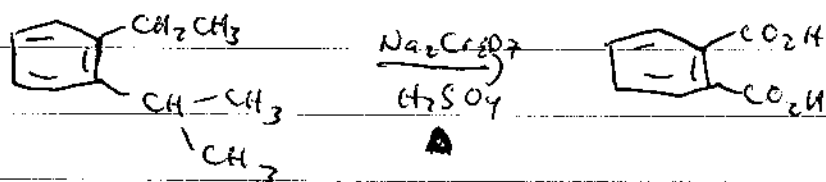


also can use $\text{Na}_2\text{Cr}_2\text{O}_7 / \text{H}_2\text{SO}_4 / \Delta / \text{H}_2\text{O}$

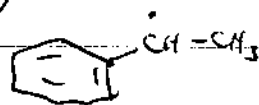
recall,



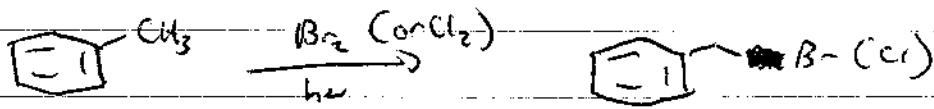
also,



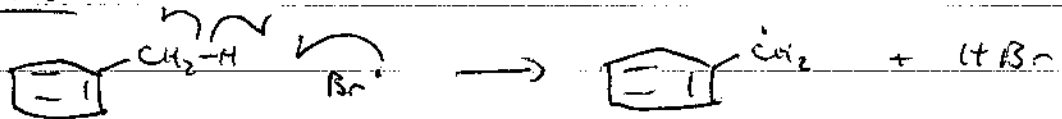
Mech. Probably involves



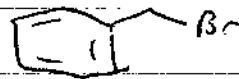
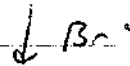
Benzylic radicals



Mech



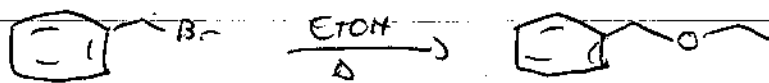
resonance stabilized!



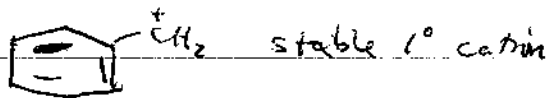
S_N1/S_N2 Rxns at benzylic carbons

S_N1 \rightarrow can go S_N1 if 2° halide/electrophile
1°

Thus,

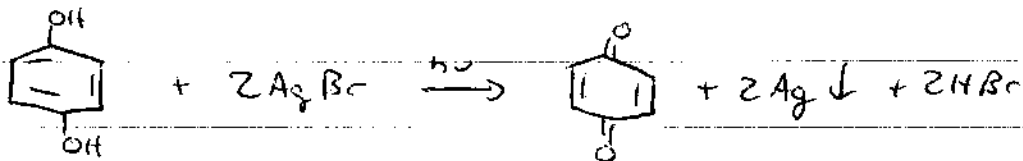
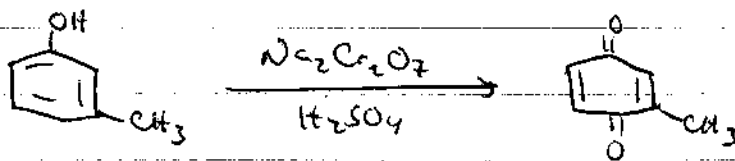


S_N1 mech



S_N2 also rapid...

Oxidations of Phenols



Photography!