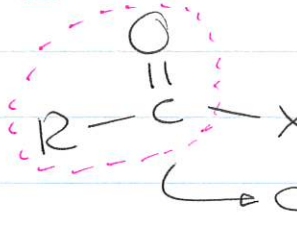
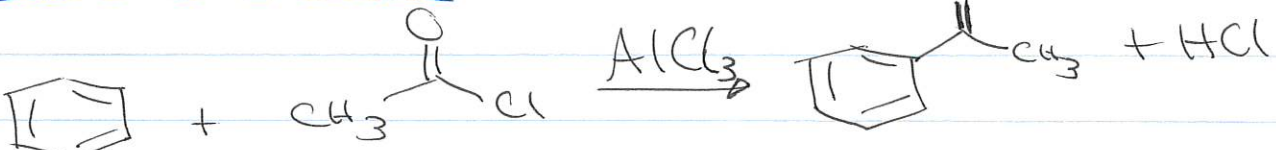
32

Friedel-Crafts Acylation



↳ acyl group

General RXN

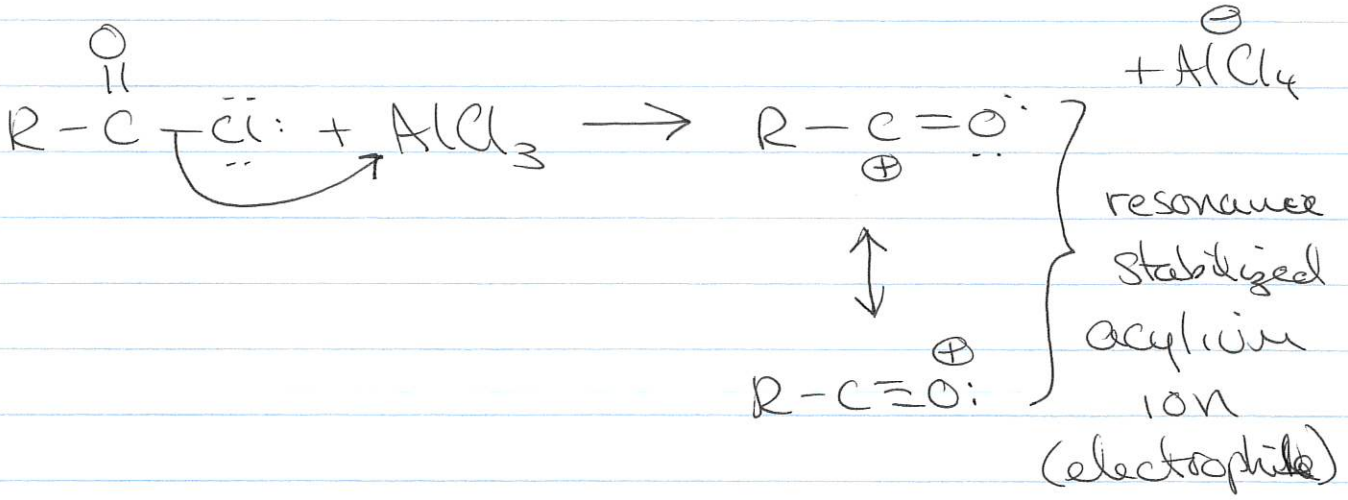


acetyl chloride

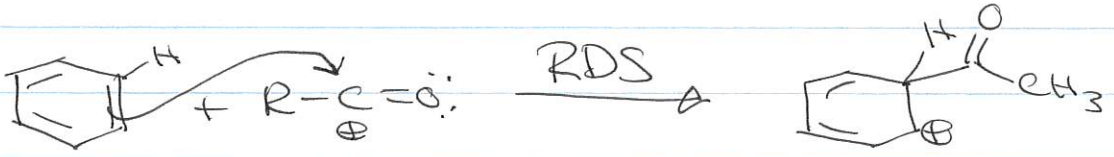
general name: acyl chloride

Mechanism:

Step 1: Generation of the Electrophile

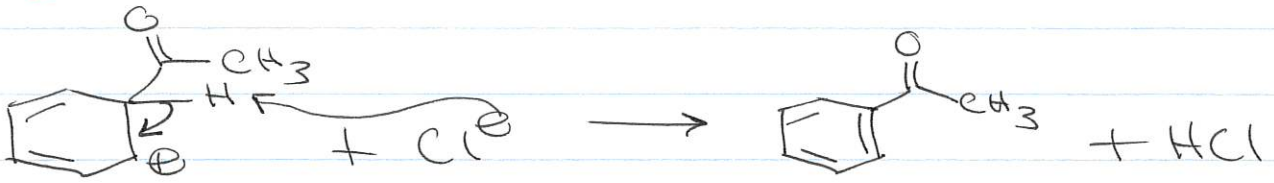


Step 2: Attack on Electrophile



resonance stabilized

Step 3: Loss of Proton: Rearomatization



Advantages of Friedel-Crafts Acylations

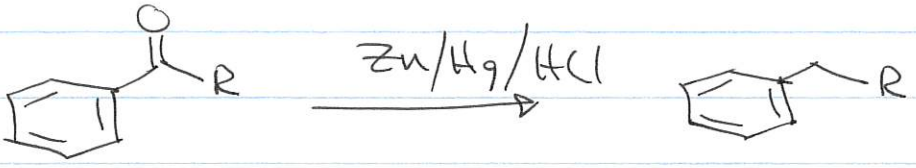
A) Polyacylation does not occur.

B) Rearrangement of the acylium ion does not occur.

C) Acyl group is much easier to modify than is an alkyl group.

D) Acyl group can be converted to an alkyl group.

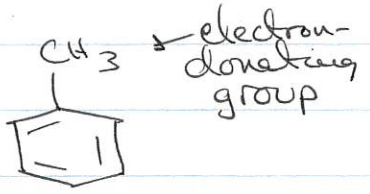
Clemmensen Reduction

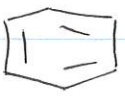


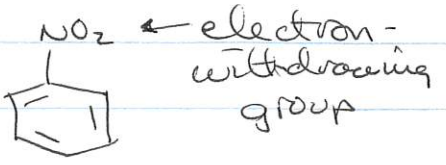
- we therefore have access to the Friedel-Crafts alkylation products, without the limitations of the alkylation rxn.

Substituent Effects & How They Effect Rxns

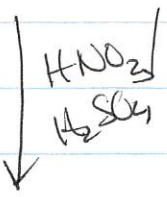
- substituents on the aromatic ring have an effect how fast rxns will occur & also the position of substitution.

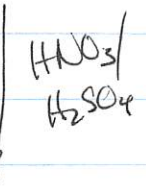


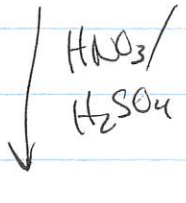


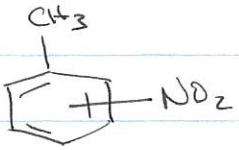


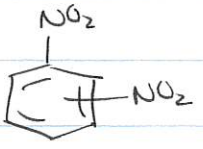
rel. rate: 25 | 1 | 10^{-4}











	Stat.	Obs.
ortho	40%	59%
meta	40%	4%
para	20%	37%

	Stat	Obs
ortho	40%	6%
meta	40%	93%
para	20%	1%

- different substituents can cause a rxn rate to increase or decrease, depending upon the nature of the group.
(electron-donating vs. electron-withdrawing)

General Theory of Substituent Effects

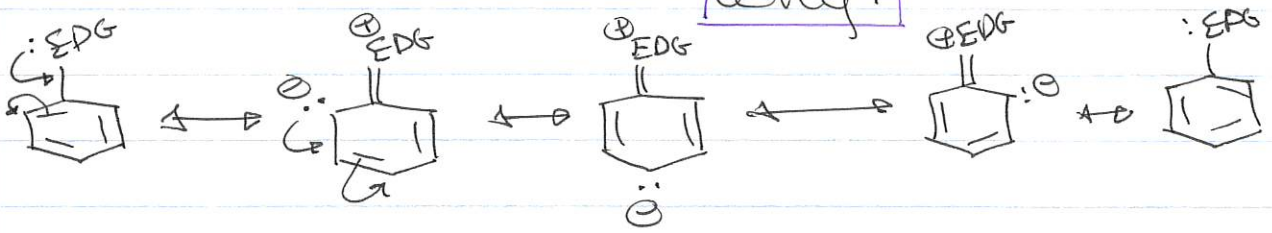
Electron-withdrawing groups = meta directors

Electron-donating groups → ortho/para directors.

Electron-donating Groups

– ortho/para directors

Why?

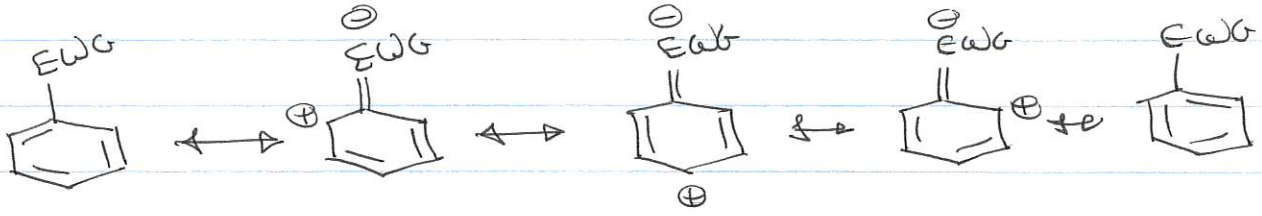


- electron-donating ability results in greater electron density at the ortho & para positions.
  - so rxn occurs more quickly b/c more electron density.
  - sub. tends to add to ortho/para positions due to greater electron density.

Electron-withdrawing Groups

– meta-directors

Why?



- electron withdrawing ability of the group leads to less electron-density on the ortho/para positions.

- thus the meta position has greater electron density relative to the ortho/para positions.

Classification of Substituents

ortho/para directors

strong activators

- $-\ddot{N}H_2$ (amino)
- $-\ddot{O}H$ (hydroxyl)

moderate activators

- $-\ddot{N}H-\overset{\overset{O}{\|}}{C}-CH_3$ (amide)
- $-\ddot{O}-\overset{\overset{O}{\|}}{C}-CH_3$ (ester)
- $-\ddot{O}-R$ (alkoxy)

weak activator

- $-CH_3$ alkyl
-  phenyl

Meta Directors

strong deactivator

- $-NO_2$ (nitro)
- $-\overset{\oplus}{N}R_3$ (ammonium)
- $-CX_3$ (trihalomethyl)

moderate deactivator

- $-C\equiv N$ (nitrile)
- $-SO_3H$ (sulfonic acid)
- $-\overset{\overset{O}{\|}}{C}H$ (aldehyde)
- $-\overset{\overset{O}{\|}}{C}-R$ (ketone)
- $-\overset{\overset{O}{\|}}{C}-OH$ (carboxy)

Weakly Deactivating but ortho/para directors

$-\ddot{F}:$ $-\ddot{Cl}:$ $-\ddot{Br}:$ $-\ddot{I}:$

- halides seem like they should be electron withdrawing (meta-directors) but they have a dual nature.