

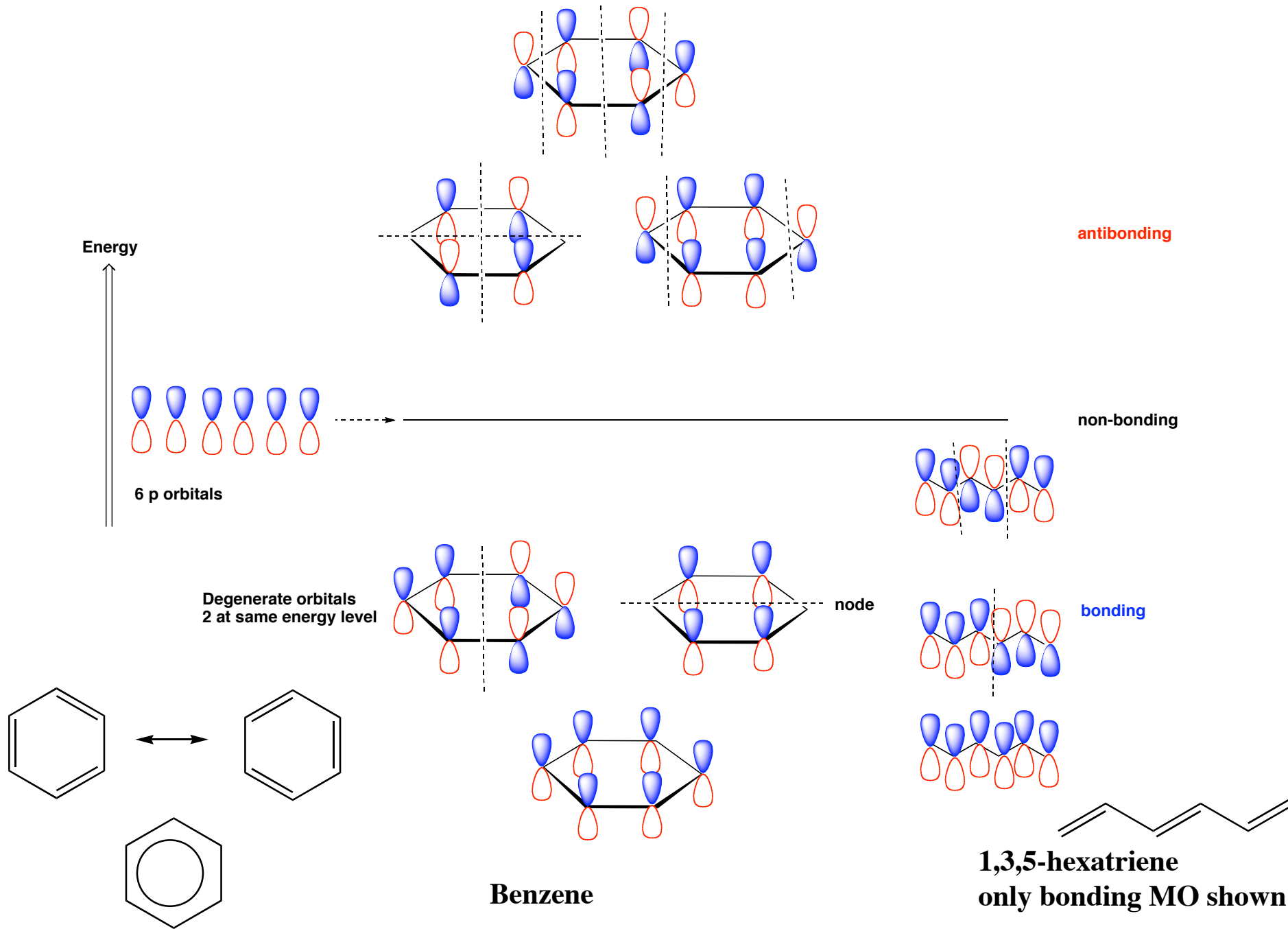
Aromatic Compounds

- Aromaticity
- Electrophilic aromatic subst. } Repetition
- Nucleophilic aromatic subst. (McM 7th ed, 16.7)
- Benzyne (McM 7th ed, 16.8)
- Reduction of aromatics (McM 7th ed, 16.10)

Alcohols, Phenols, Ethers

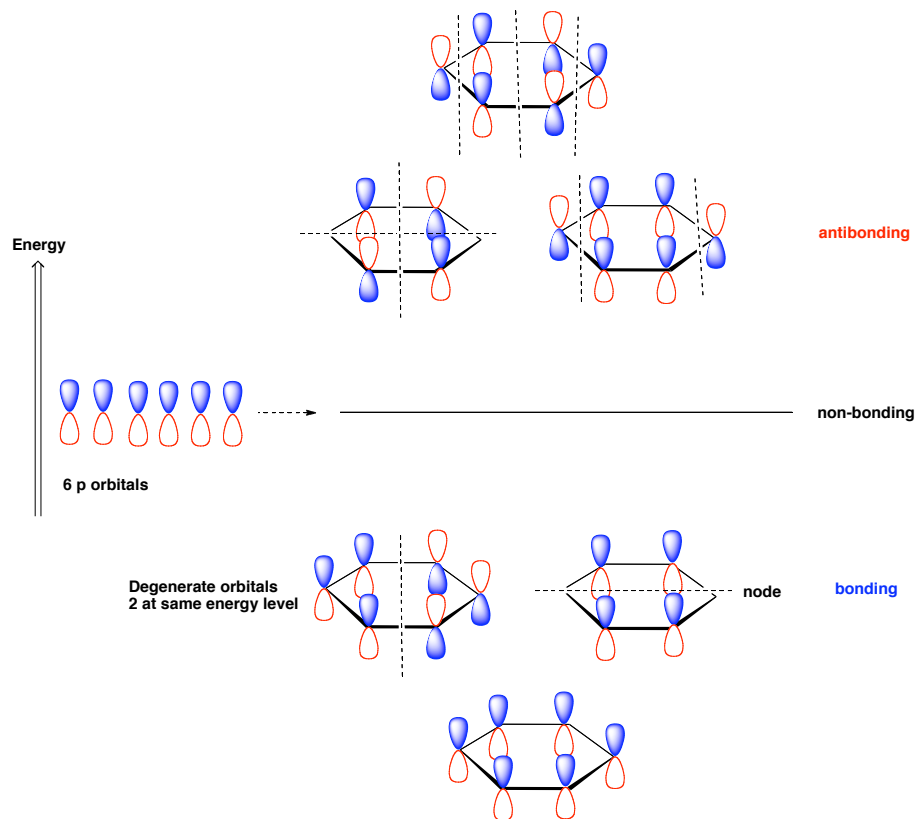
- Phenols (McM 7th ed, 17.9)
- Oxidation of alcohols and phenols (McM 7th ed, 17.7, 17.10)
- Protection groups (7th ed, 17.8)
- Cleavage of ethers (McM 7th ed, 18.3)

MO orbitals benzene - aromaticity



Criteria for Aromaticity (Hückel)

- (Monocyclic) ring
- Planar
- No of π -electrons in conjugation $4n+2$ ($n: 0, 1, 2, \dots$)



Benzene:

The 3 bonding MOs are filled

Filled shell of MOs

(cf. filled shell of atomic orbitals noble gasses)

Less than 6 π -electrons:

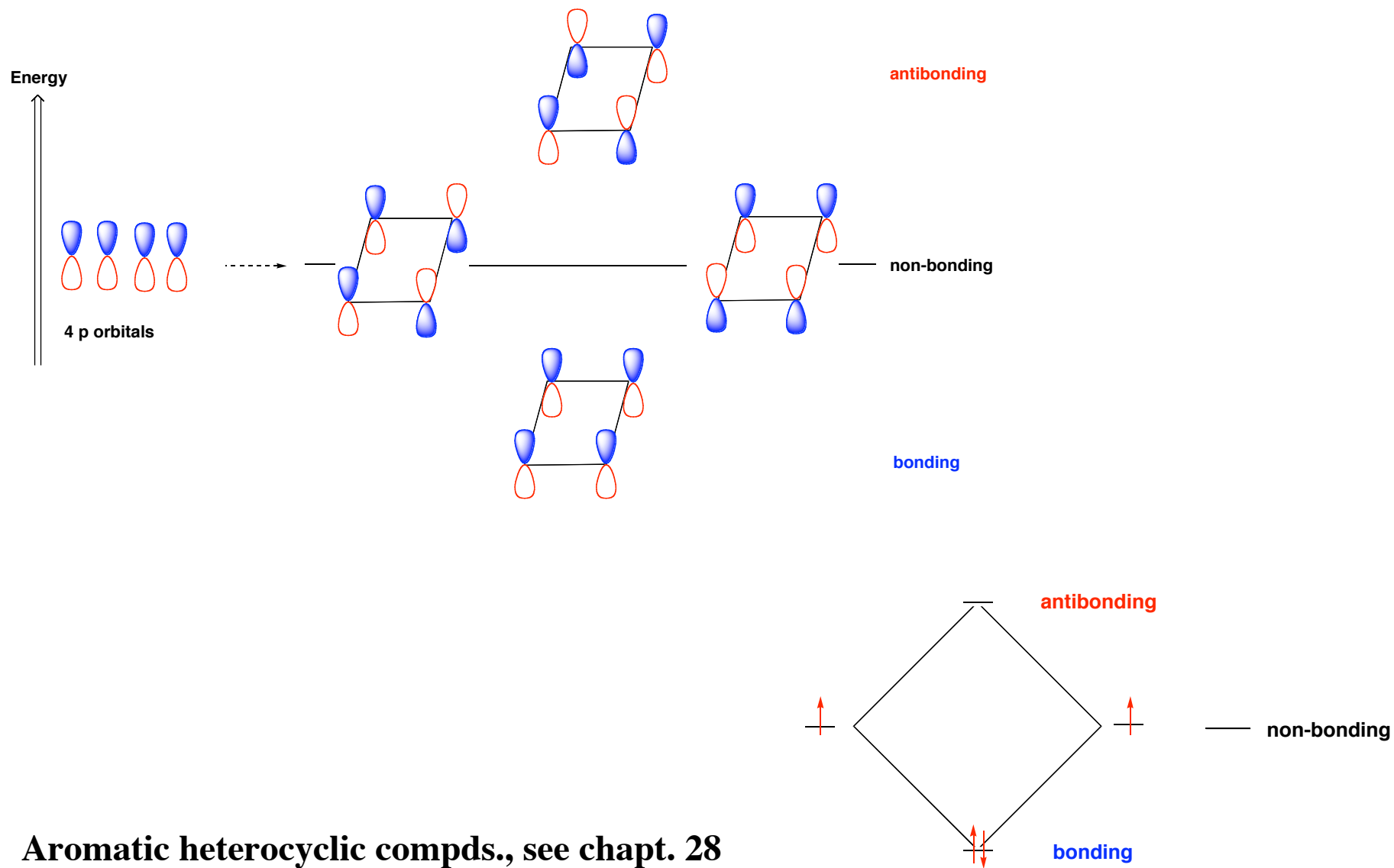
Half-filled orbital(s) - radical character

More than 6:

Electron in antibonding orbitals

Unstable, high-energy species

Ex. of an anti-aromatic compound - Cyclobutadiene

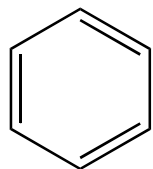


Aromatic heterocyclic compds., see chapt. 28

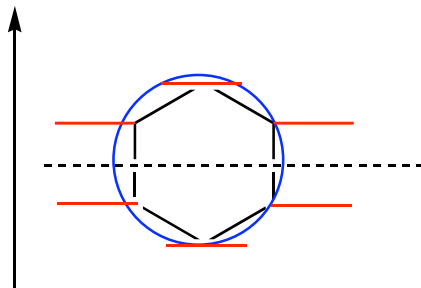
Frost circles / Frost devices (not in McM)

How to find rel. energies of MO for planar, cyclic, fully conjug. compds. (aromatic compds?)
No math. involved

Benzene



Energy



3 antibonding MO (2 degenerate)

3 bonding MO (2 degenerate)

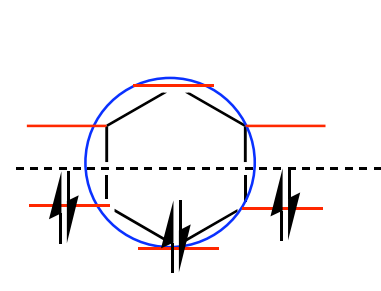
Hexagon inside circle
Vertex (corner) down

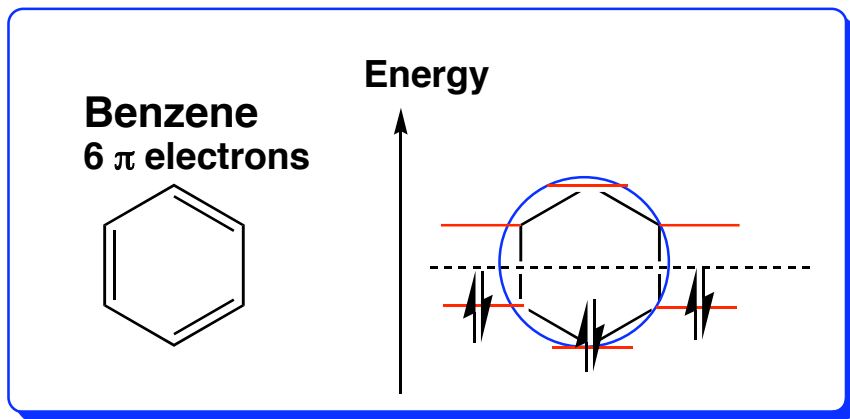
Molecular orbitals

----- Level of a non-bonding MO

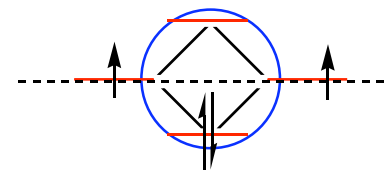
6 π -electrons in 3 bonding MO

Energy



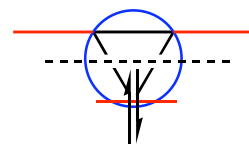
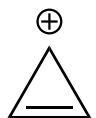


Cyclobutadiene
4 π electrons



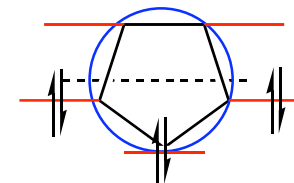
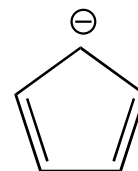
Diradical

Cyclopropenium cation
2 π -electrons



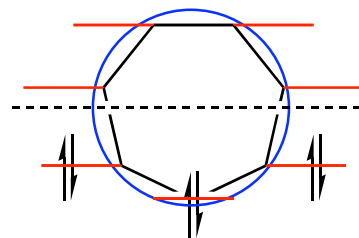
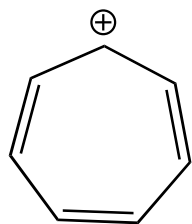
All π electrons in the bonding MO

Cyclopentadienyl anion
6 π -electrons



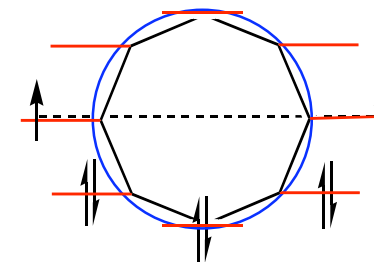
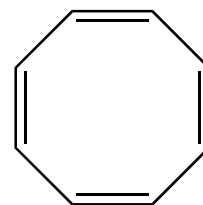
All π electrons in the bonding MO

Tropylium cation
6 π -electrons



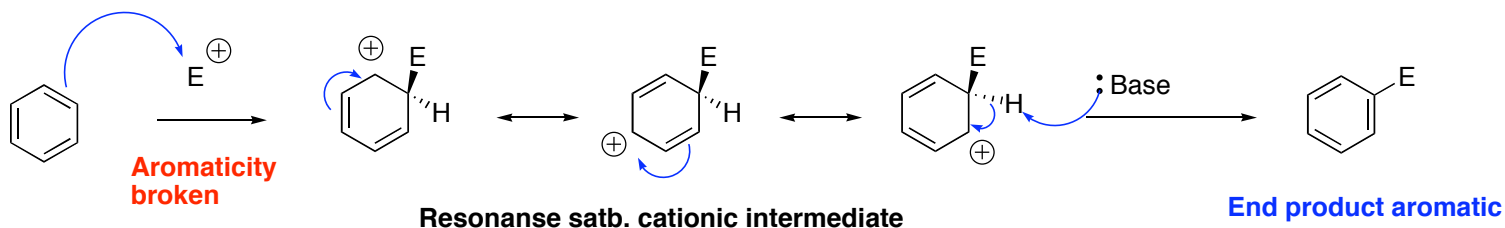
All π electrons in the bonding MO

Cyclooctatetraene
8 π -electrons



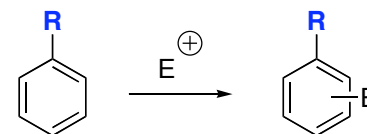
Diradical

Electrophilic Aromatic Substitution and Substituent Effects



1. step \approx 1. step in E-fil add. to alkene

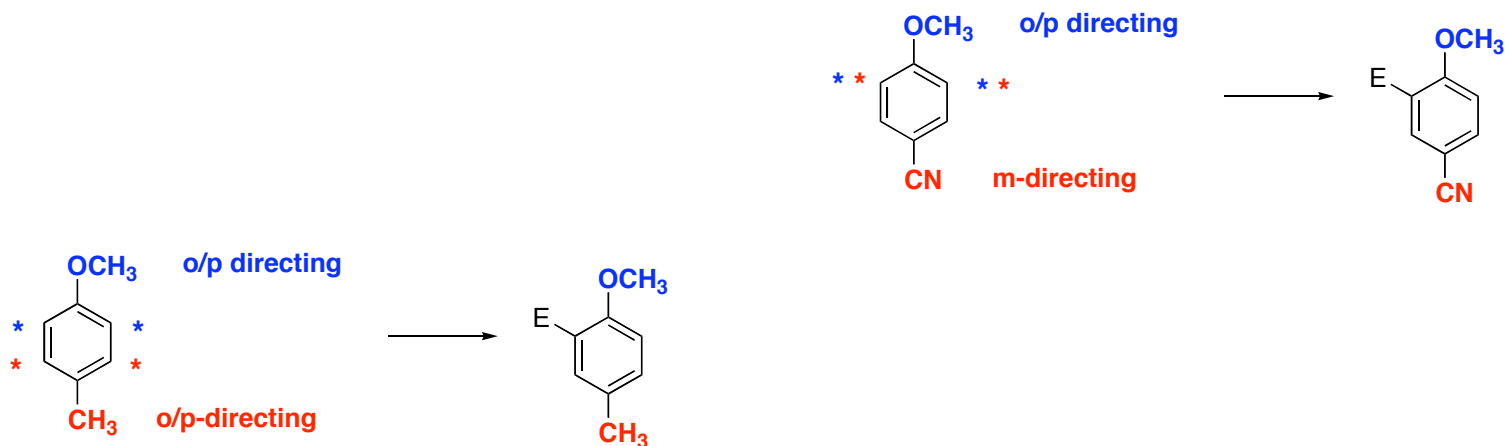
- Halogenation (bromination)
- Nitration
- Sulfonation
- Alkylation (Friedel Craft)
- Acylation (Friedel Craft)□



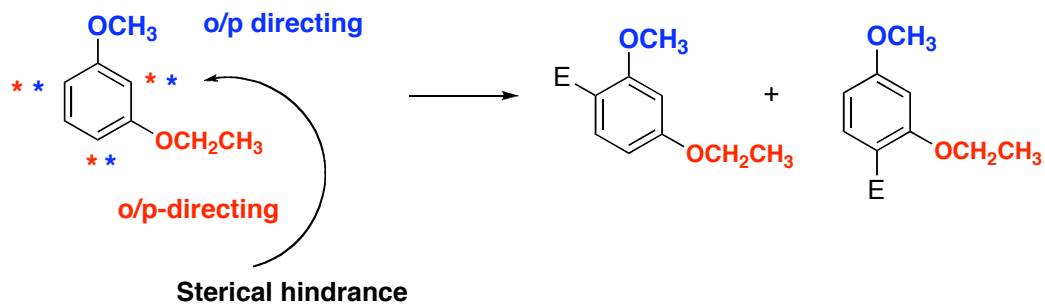
R influence:

- Reactivity
- Regiochemistry

Regiochemistry in E-fil aromatic subst of disubst. benzene derivs.



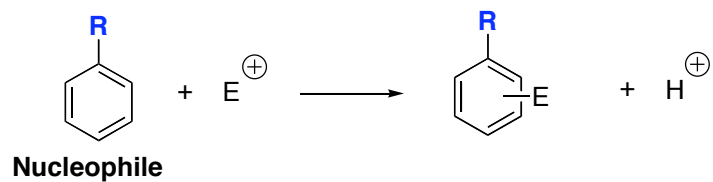
Resonance effects more powerful than inductive effects



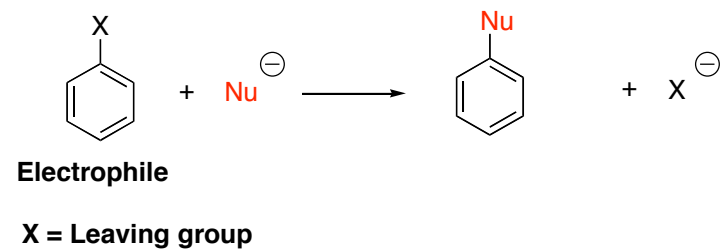
Synth of trisubst. benzene deriv. - Planning of a good reaction sequence

Nucleophilic Aromatic Substitution

E-fil Ar subst



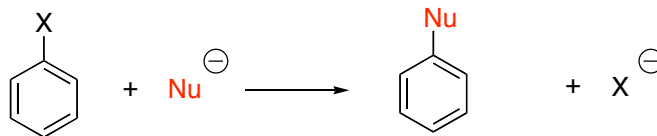
Nu-fil Ar subst



More common on π -deficient heterocycles, see chapt 28

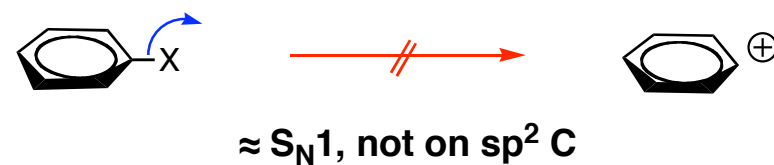
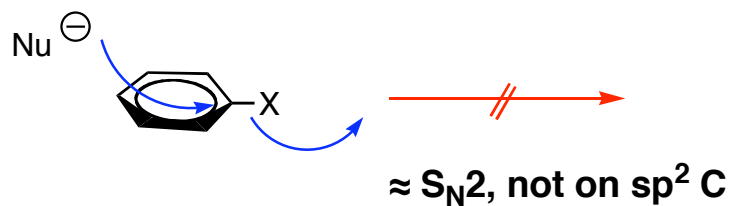
Not like S_N2 (or S_N1)

Nu-phil Ar subst



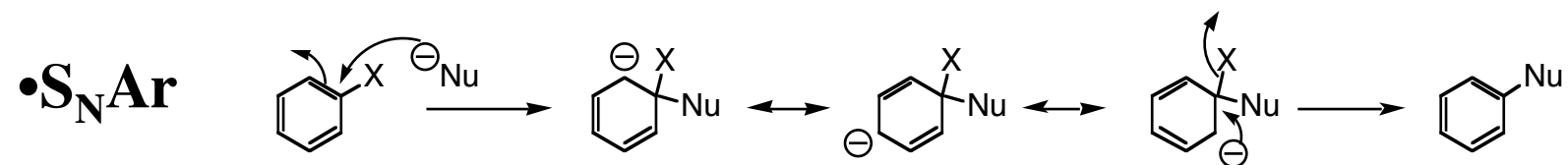
Electrophile

X = Leaving group



(but NB! diazotation, amine chapt.)

Mechanisms:



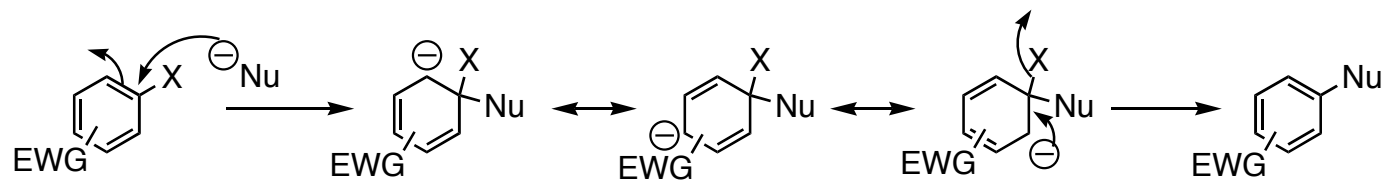
• S_N1 : Via diazonium salts (See amine chapter)

• **Benzyne**

• (SRN1: Involves radicals)

• (VNS: Vicarious nucl. Subst.)

•S_NAr



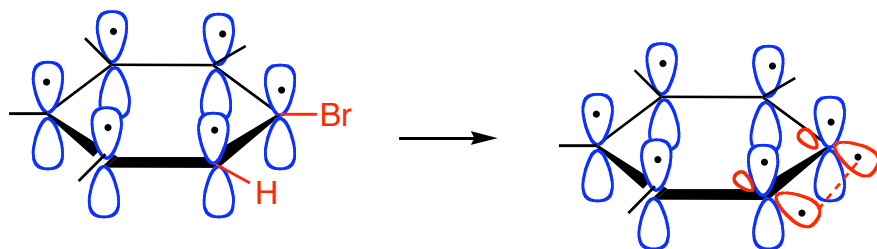
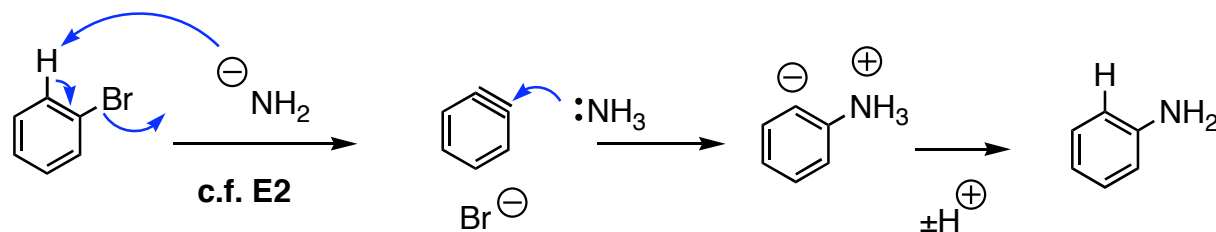
Only on electron deficient arenes (EWG o/p to X, Anion stabilizing effect)

(Aromatic heterocycles)

1st step rate limiting (Aromaticity broken)

X=F>Cl>Br>I

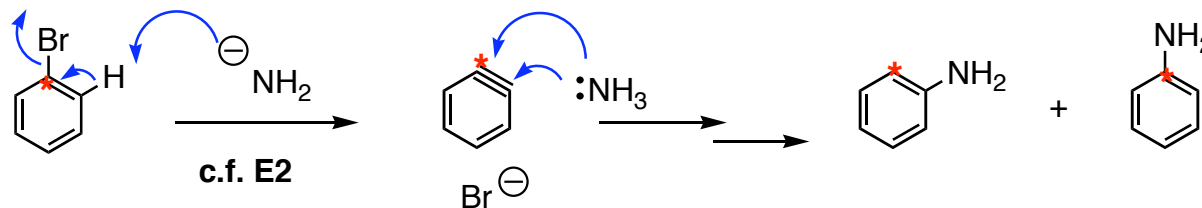
•Benzyne



“Triple bond” between sp^2 C
p-p overlap

sp^2 - sp^2 overlap - weak bond

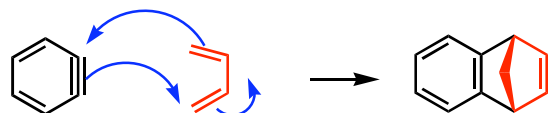
Benzyne unstable / reactive intermed.



Reactivity of benzyne:

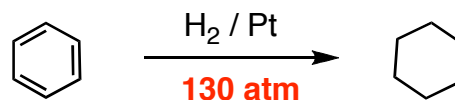
* ^{14}C

- Adds nucleophiles
- Dienophile in Diels Alder react.

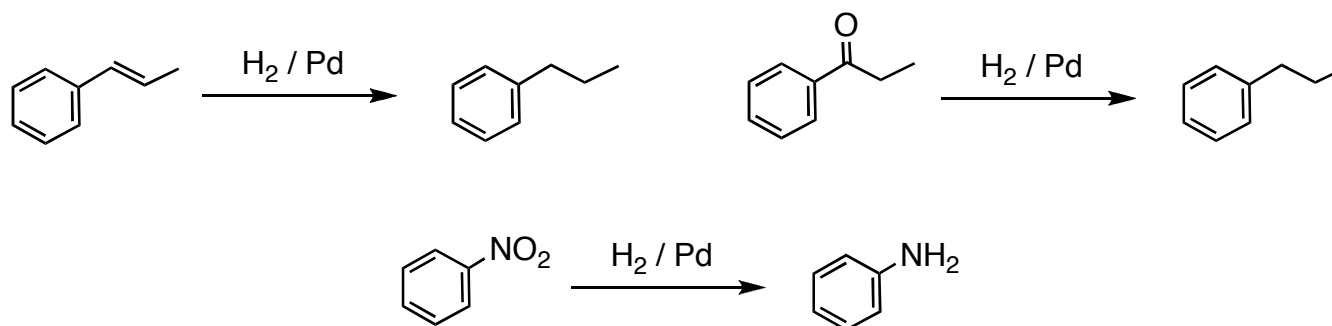


Reduction of aromatics

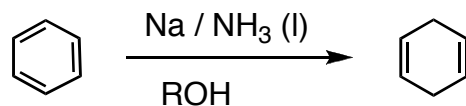
Aromatic rings reduced by some Pt-cat and high pressure



Selective red. of side chain functional groups

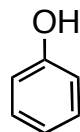


Partial reduction - Birch red. (not in McM)

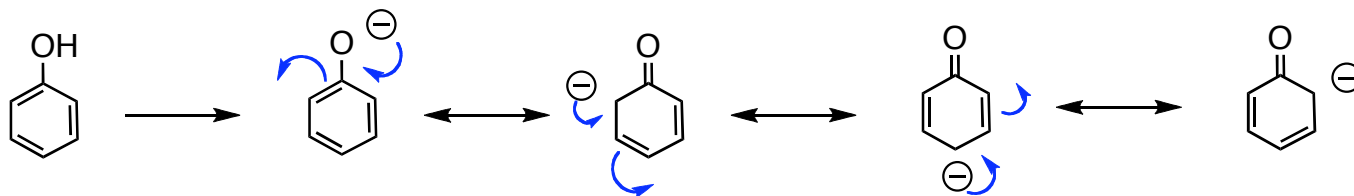


Mech. see http://en.wikipedia.org/wiki/Birch_reduction

Phenols

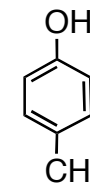


Acidity

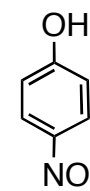


pKa = 10.0

CH₃OH: pKa = 15.5



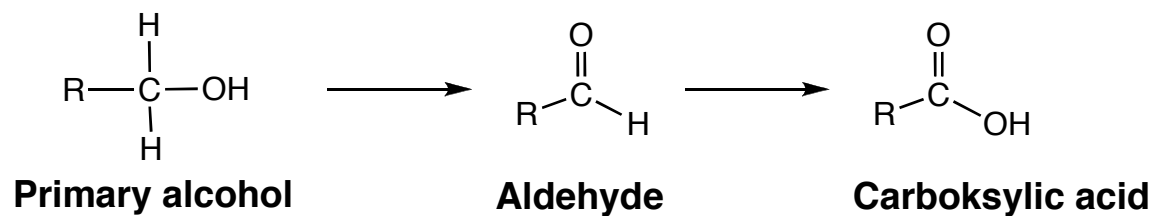
pKa = 10.2



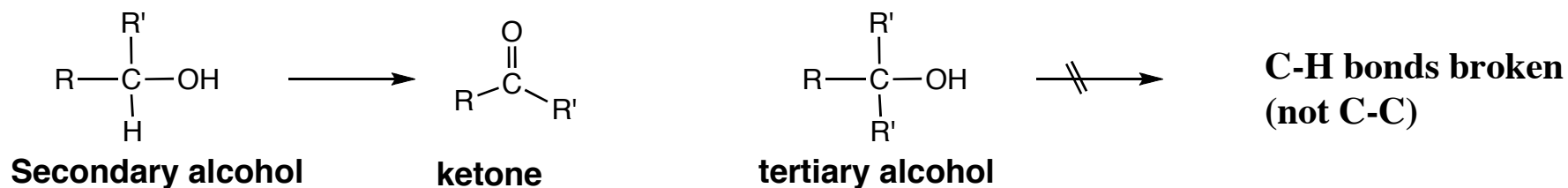
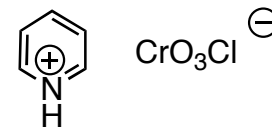
pKa = 7.15

E-fil Ar subst: Activating, o / p directing

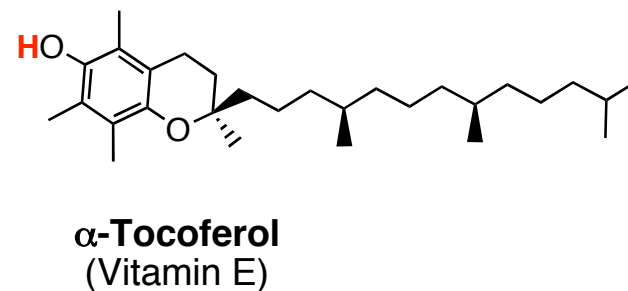
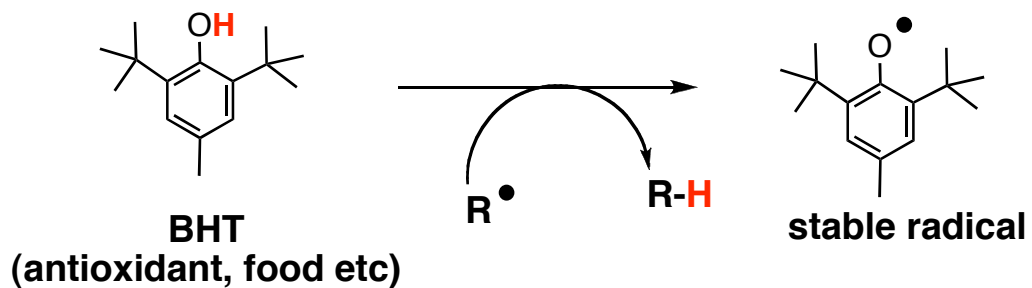
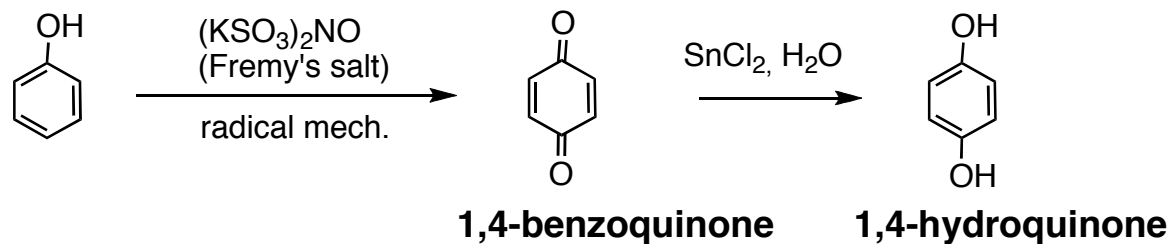
Oxidation of alcohols and phenols



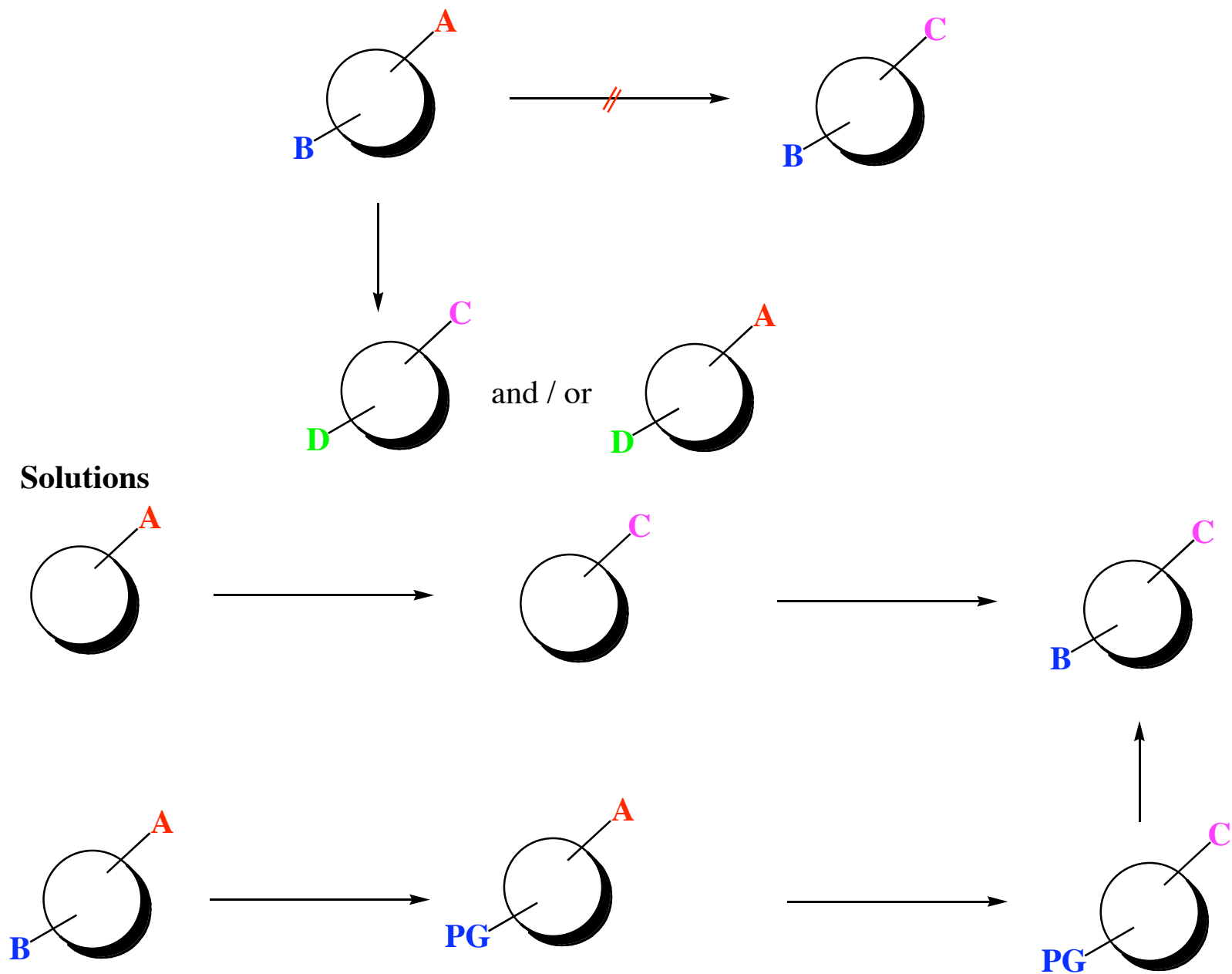
Selective oxidation to aldehyde ex. PCC



Phenol

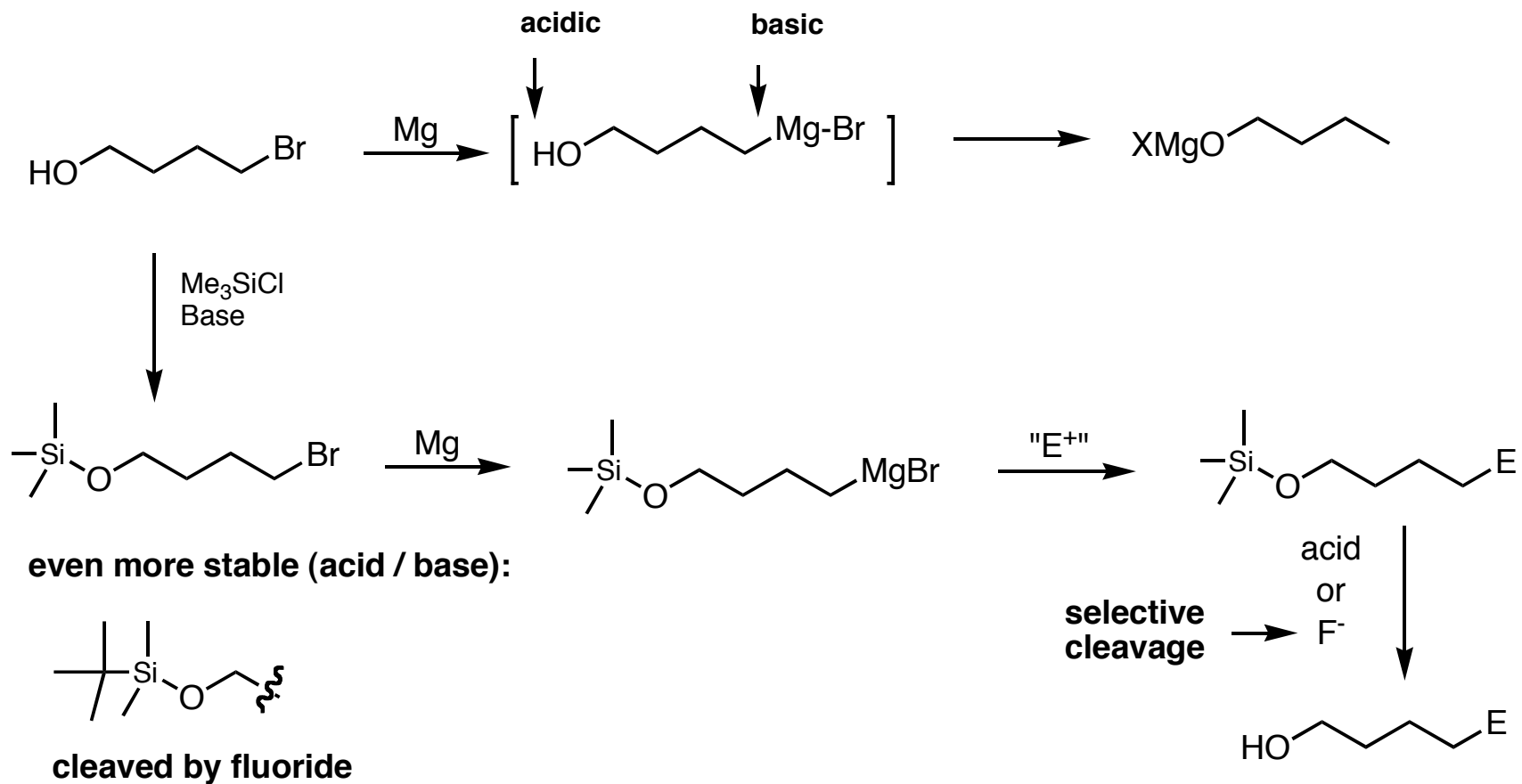


Protecting groups (PG) in organic synthesis

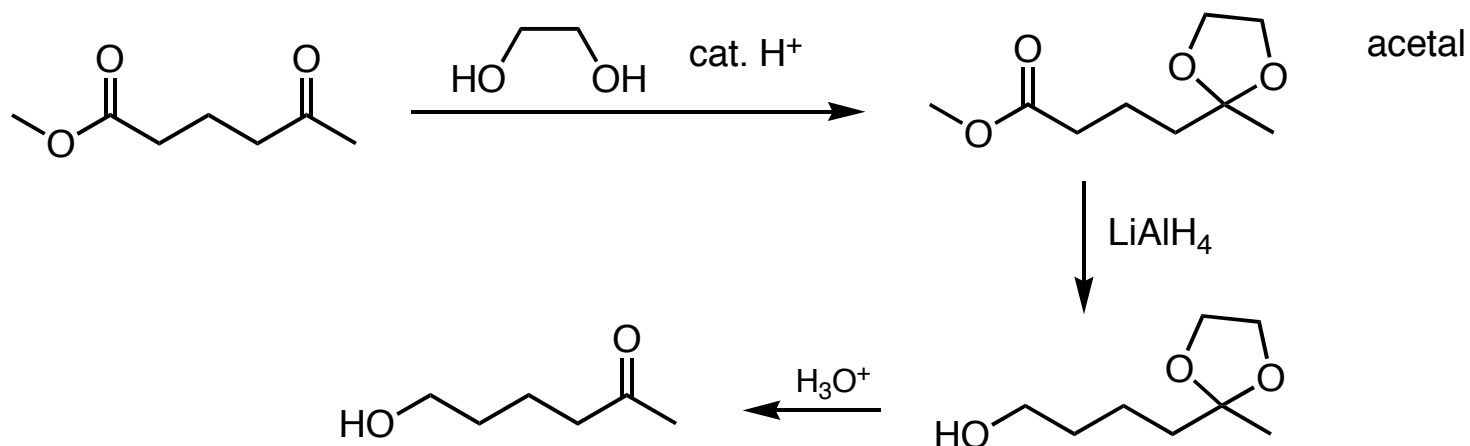
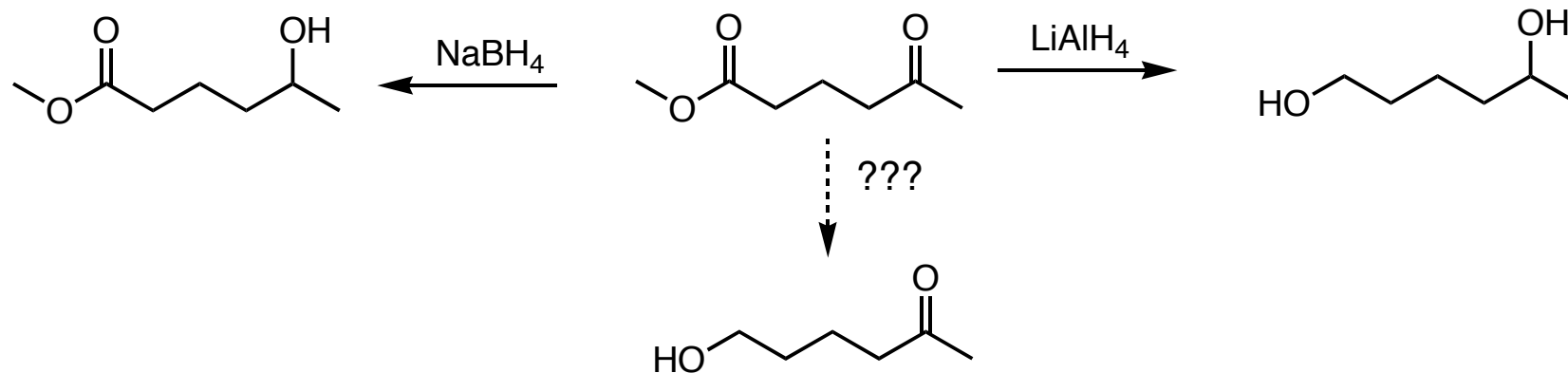


Examples

Protection of ROH



Protection of aldehydes / ketones

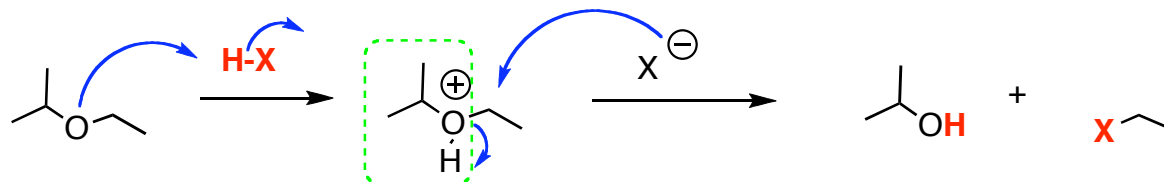


- Two extra steps
- The protecting group course

Acidic cleavage of ethers

Cleavage by SN2 mech

(Ethers as prot. groups)

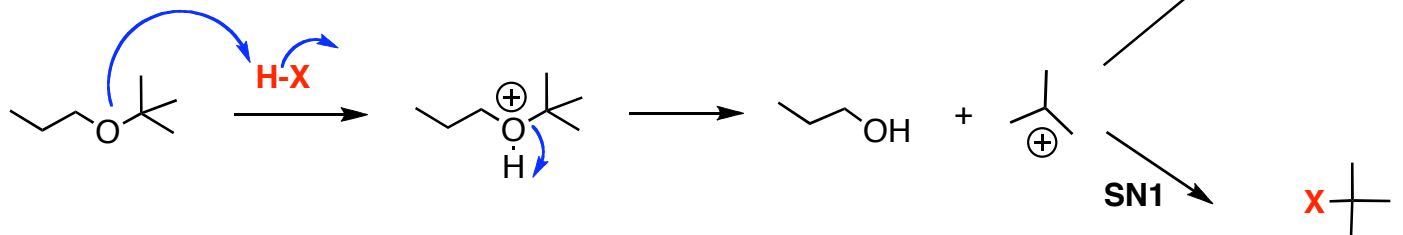


Attack on least sterically shielded C

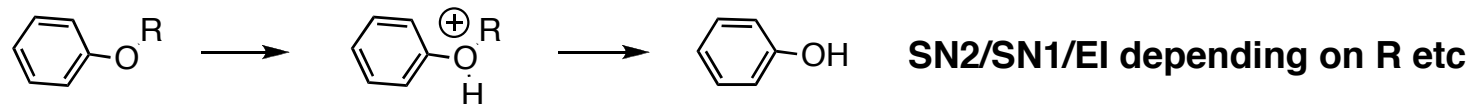
leaving group

Prim and sec alkyls

Cleavage by SN1 / E1 mechanisms



tert, allylic benzylic alkyls (stable carbocations)



SN2/SN1/E1 depending on R etc