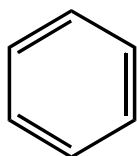
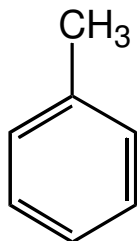


# AROMÁS SZÉNHYDROGÉNEK

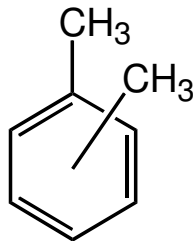
## Elnevezés



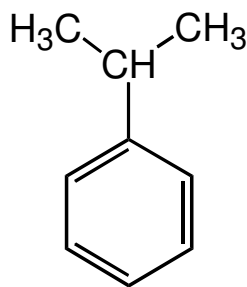
benzol



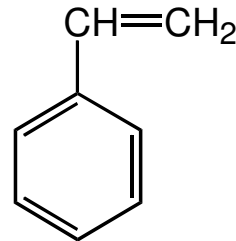
toluol



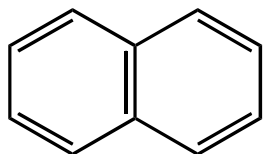
xilol (o, m, p)



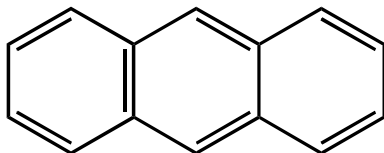
kumol



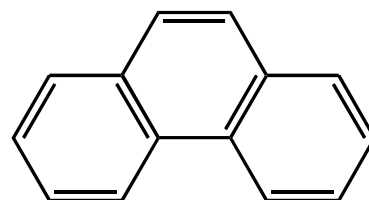
sztírol



naftalin

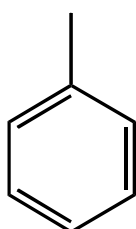


antracén

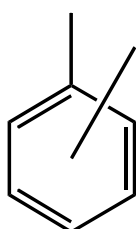


fenantrén

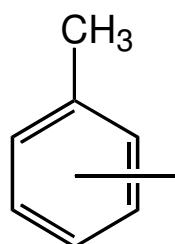
## Csoportnevek



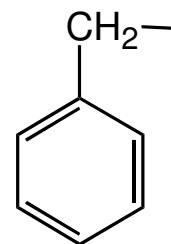
fenil



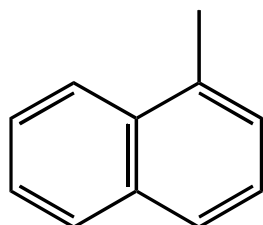
fenilén (o,m,p)



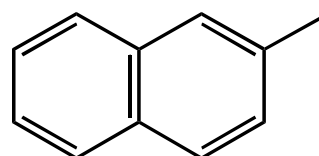
tolil (o,m,p)



benzil

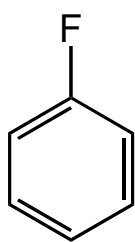


1-naftil

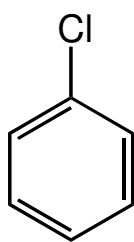


2-naftil

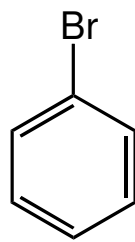
## Szubsztituált benzolszármazékok



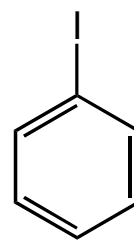
fluorbenzol



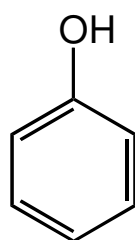
klórbenzol



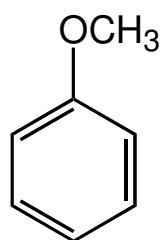
brómbenzol



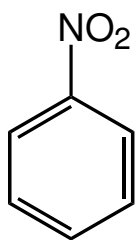
jódbenzol



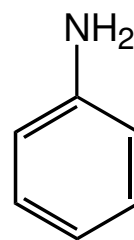
fenol



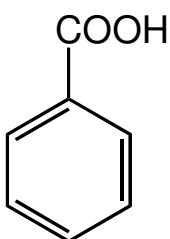
anizol



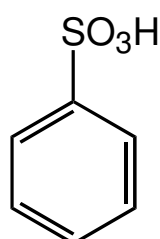
nitrobenzol



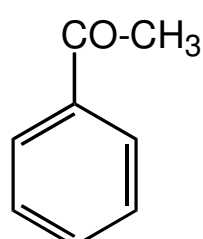
anilin



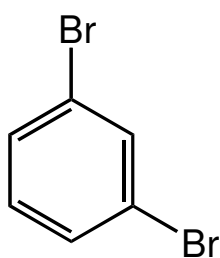
benzoesav



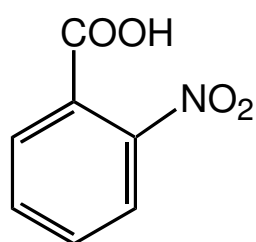
benzolszulfonsav



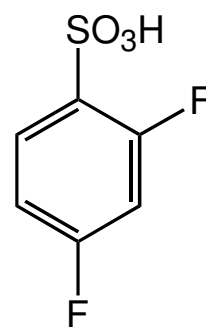
acetofenon



1,3-dibrómbenzol  
m-dibrómbenzol



2-nitrobenzoesav  
o-nitrobenzoesav

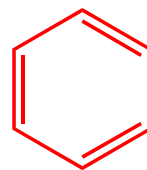


2,4-difluorbenzolszulfonsav

## A benzol szerkezete

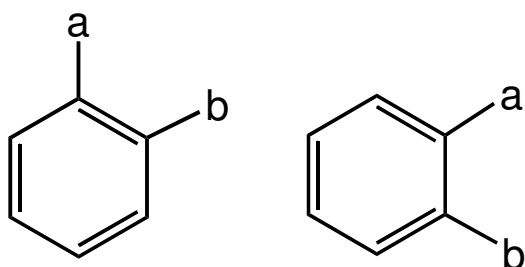
A) összegképlet:  $C_6H_6$

egyféle  $C_6H_5-X$



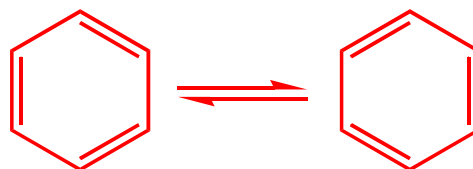
Kekule, 1865

B)



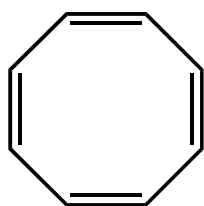
nincs két izomer

csökkent mértékű telítetlenség



Kekule, 1872

C)



ciklooktatetraén

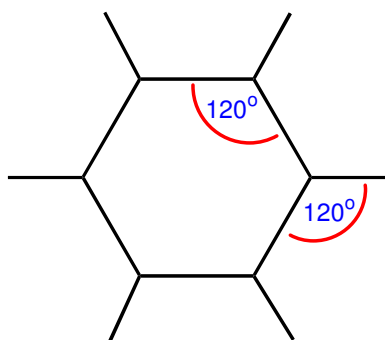
Willstätter, 1911

nem aromás!

(konjugált polialkén)

# A benzol tulajdonságai

## A) Szimmetrikus szerkezet



C—C  
alkán

kötéshossz (pm)

154

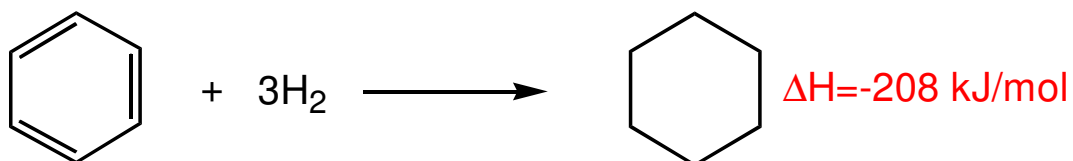
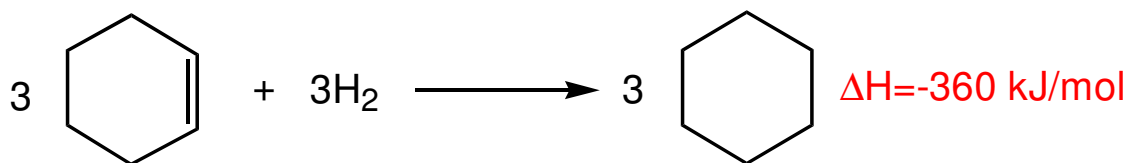
C≡≡C  
benzol

139

C=C  
alkén

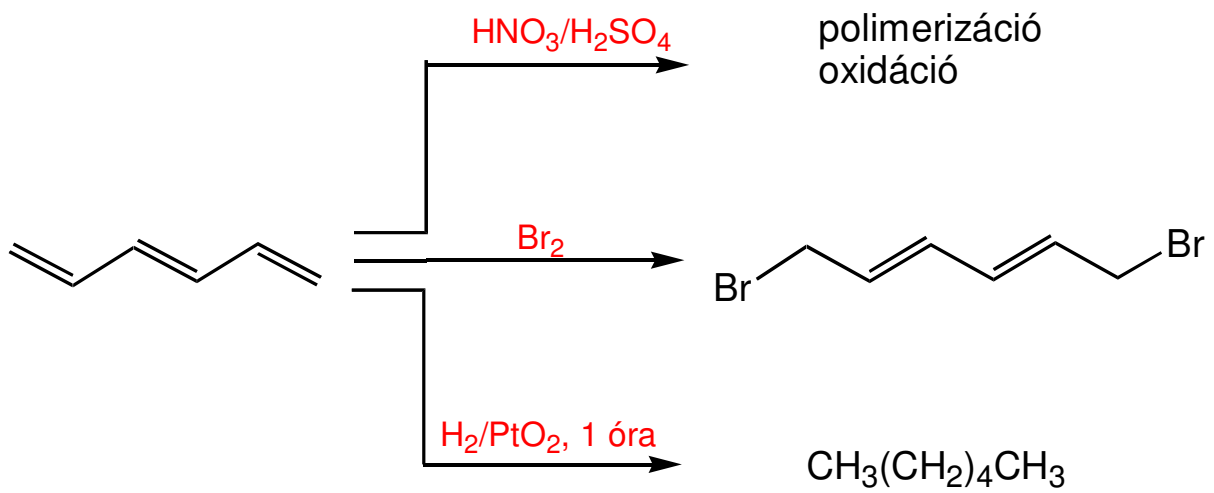
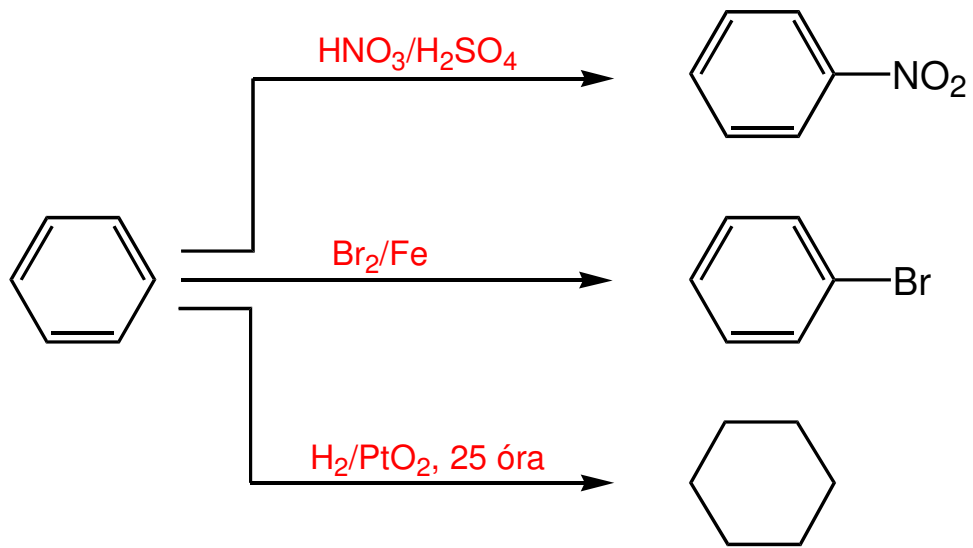
134

## B) Termodinamikai stabilitás



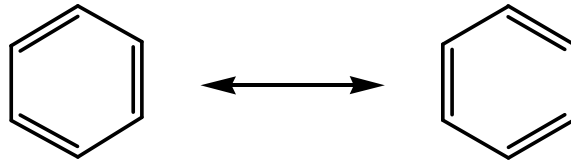
stabilizációs energia = 152 kJ/mol

### C) Reaktivitás

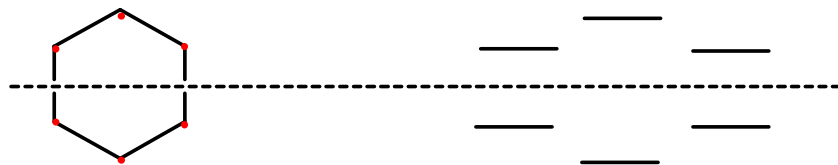
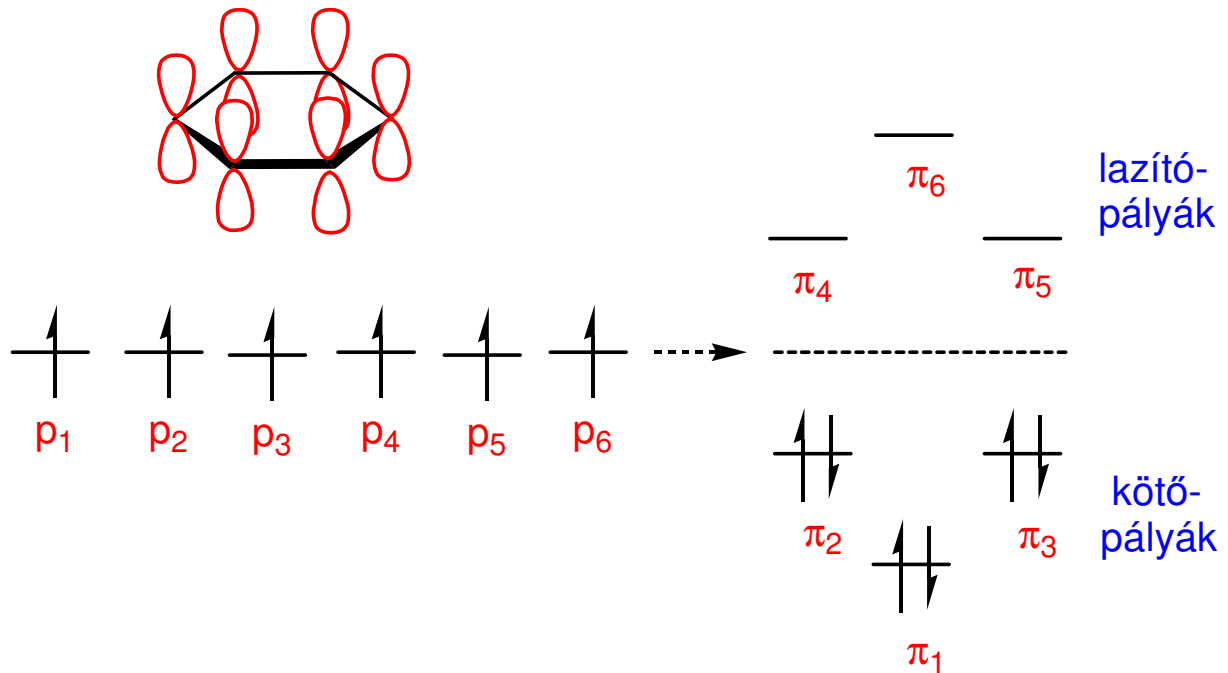


# A BENZOL ELEKTRONSZERKEZETE

## VB módszer

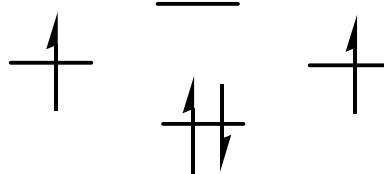
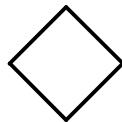
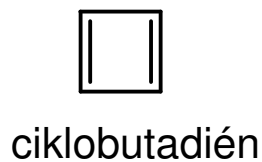


## MO módszer

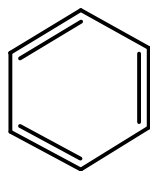


# Monociklusos aromás rendszerek

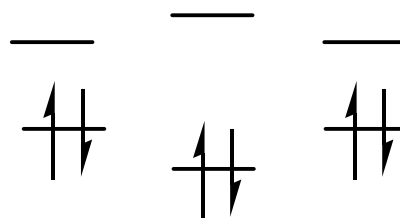
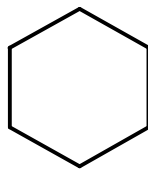
## A) Páros számú szénatom (annulének)



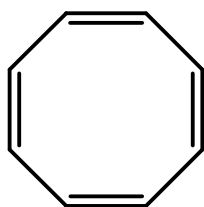
antiaromás



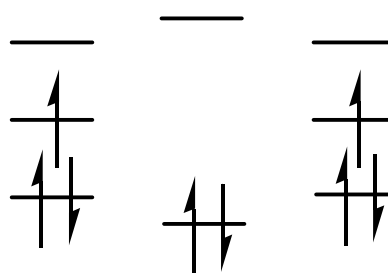
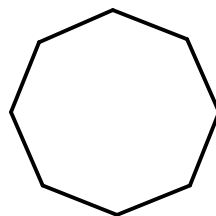
benzol



aromás



ciklooktatetraén



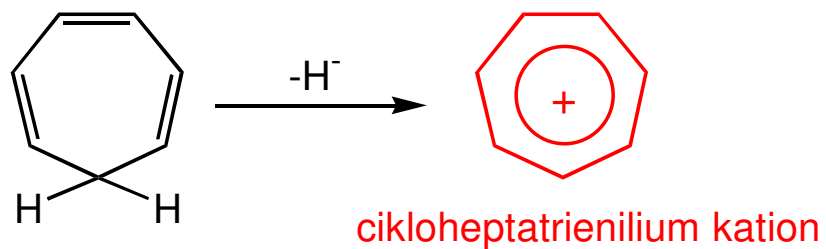
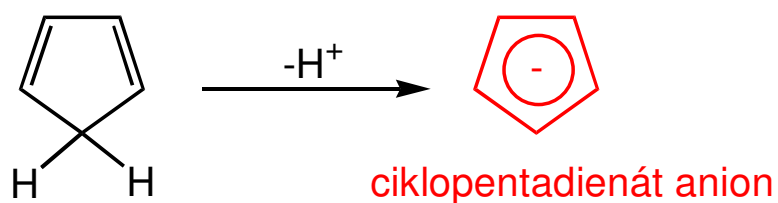
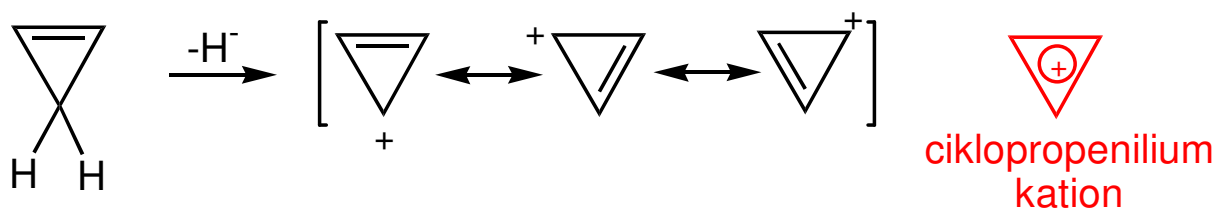
antiaromás

**Aromaticitás feltételei:** planáris gyűrű

folytonos konjugáció

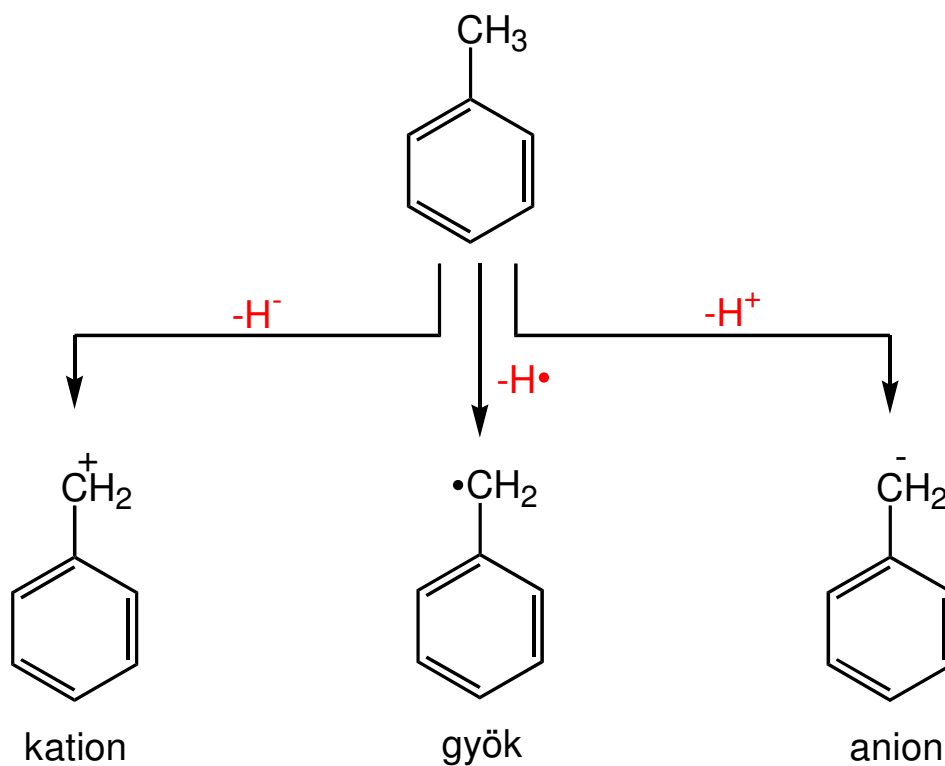
$4n+2$   $\pi$  elektron (Hückel szabály)

## A) Páratlan számú szénatom (aromás ionok)

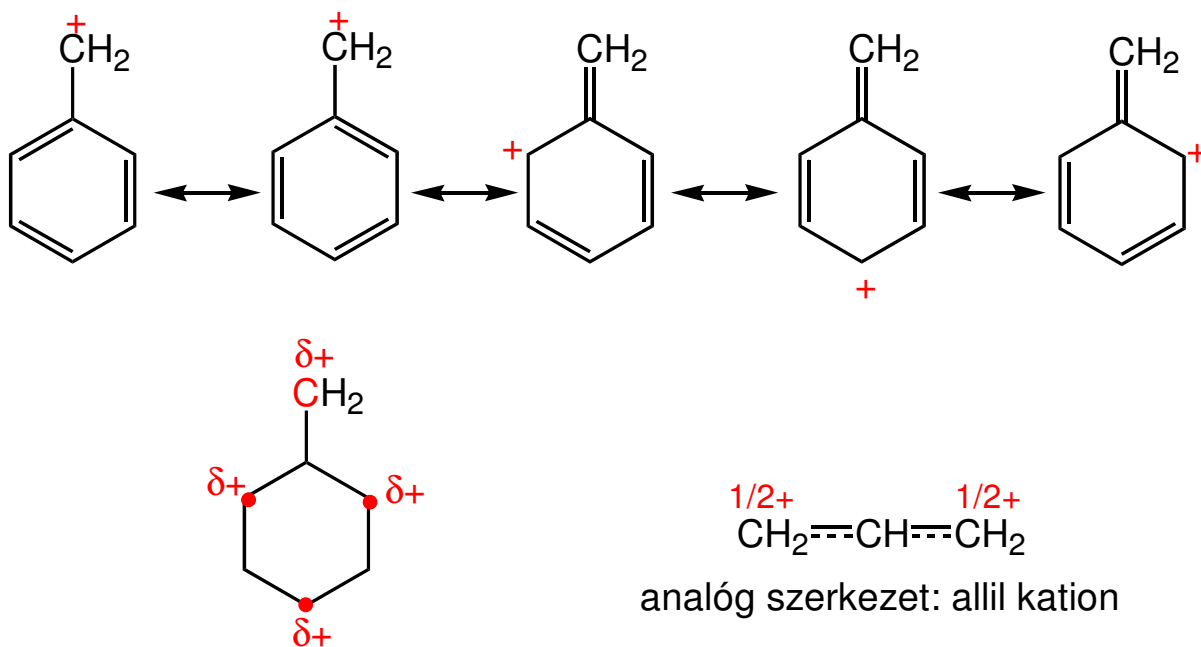




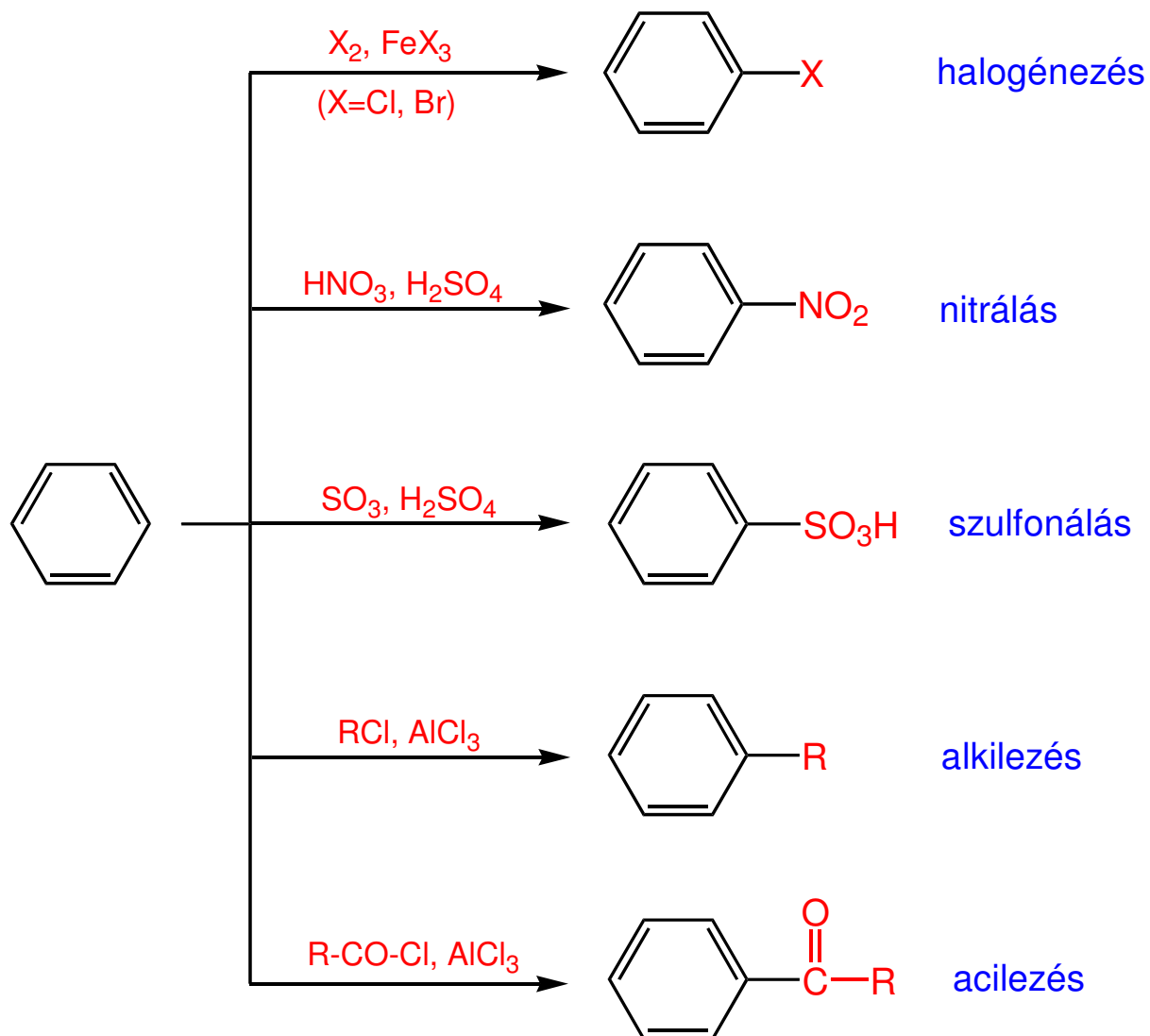
## Benzil-rendszerek



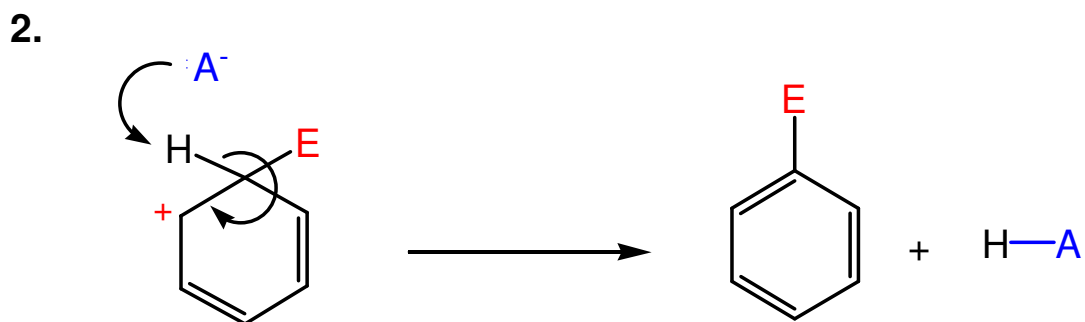
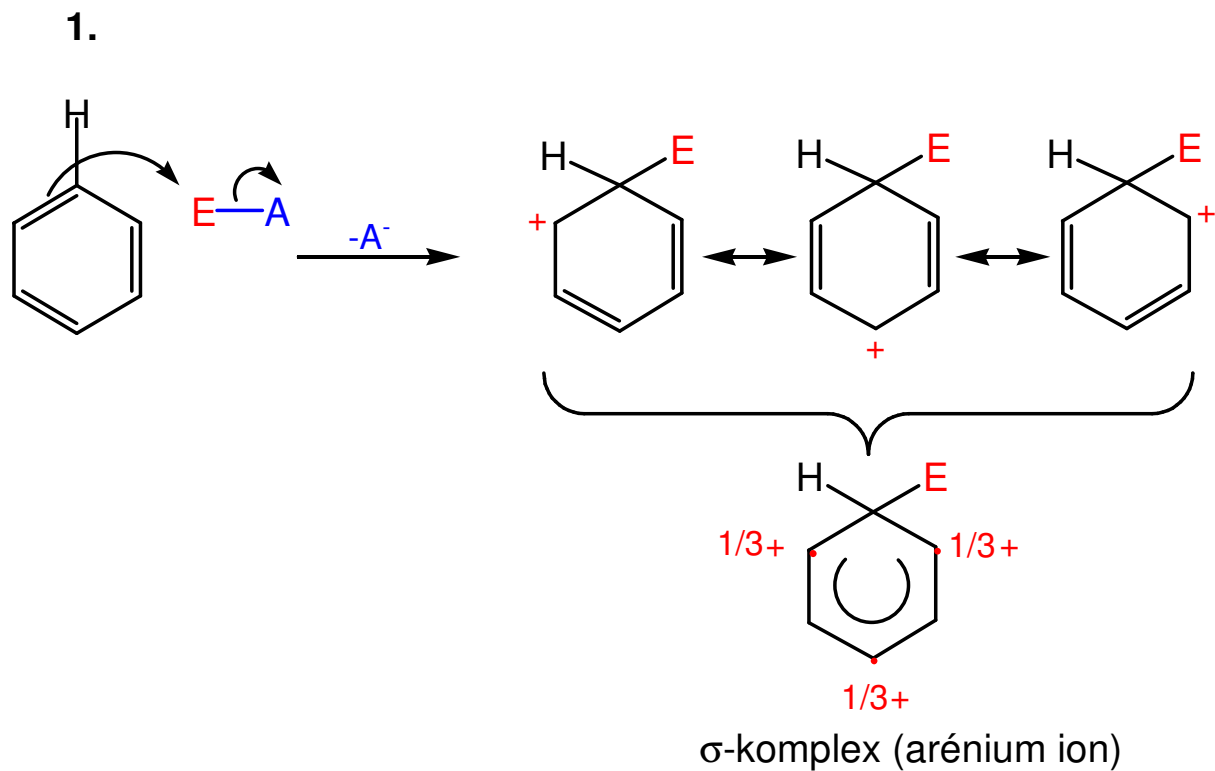
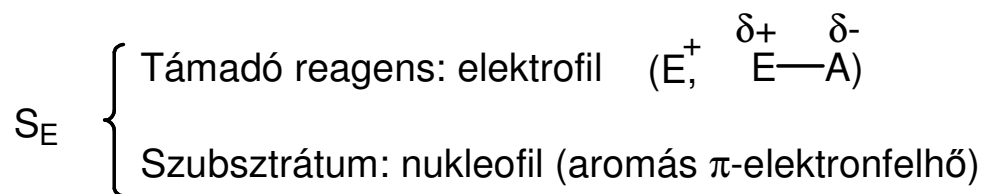
## Benzil kation

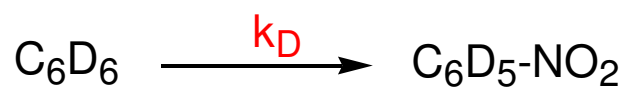
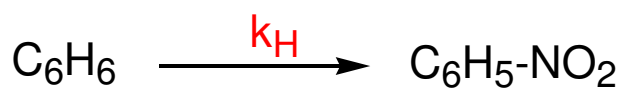
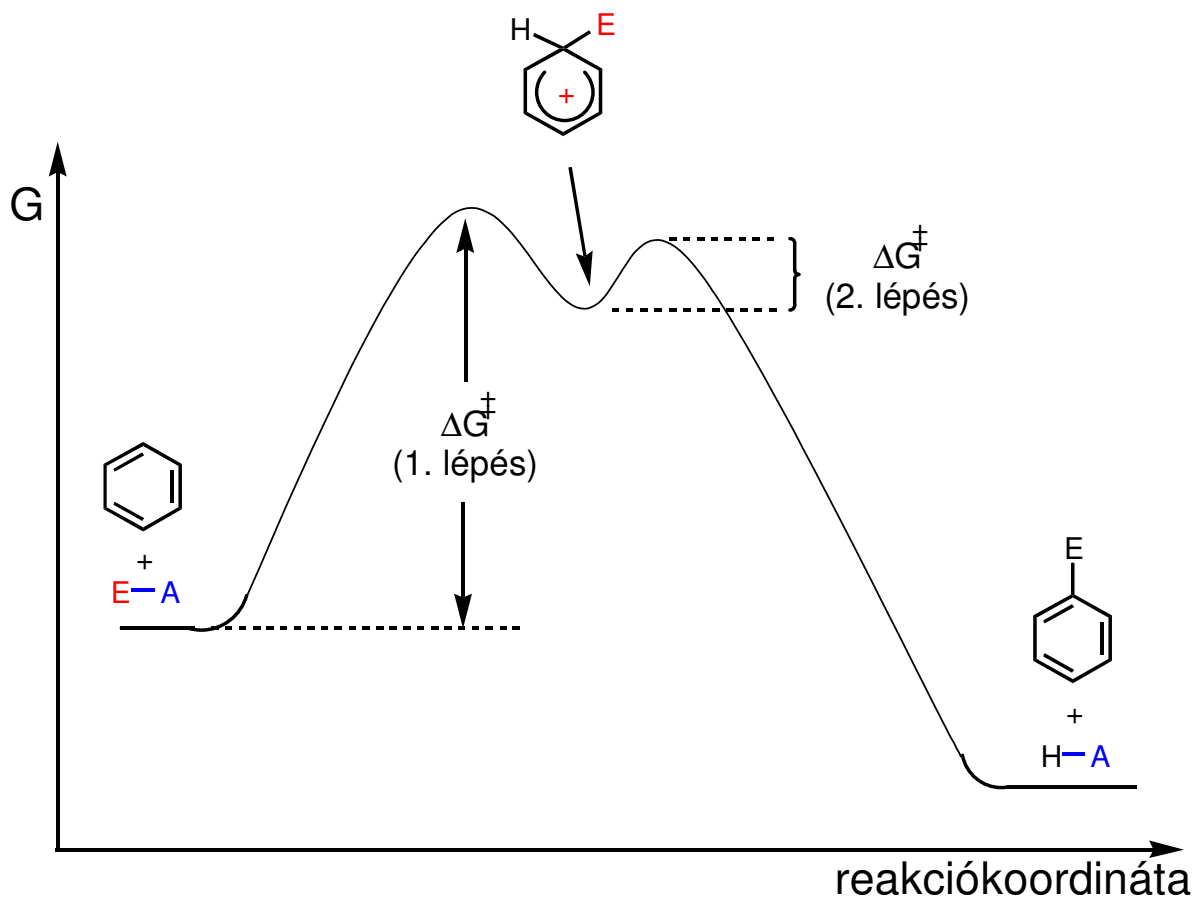


## A benzol szubsztitúciós reakciói



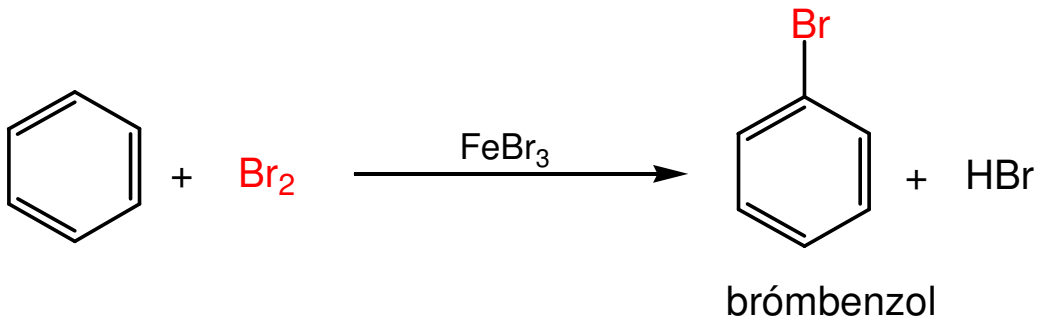
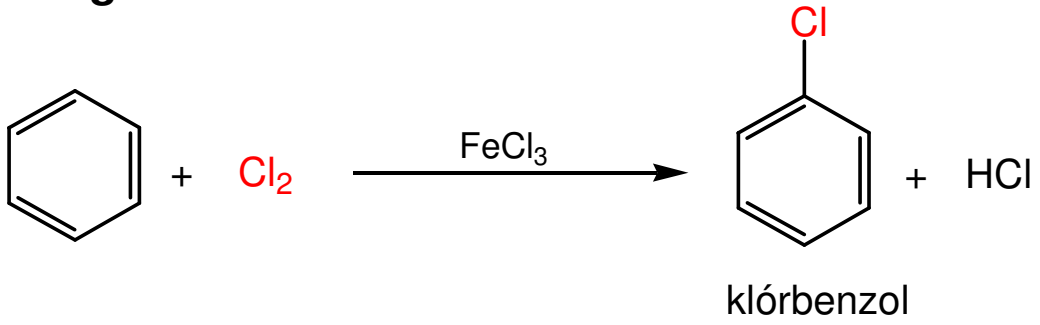
## Az aromás elektrofil szubsztitúció mechanizmusa



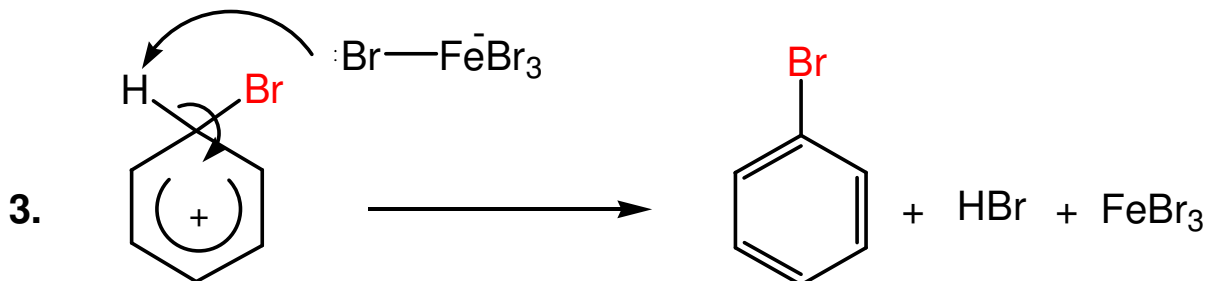
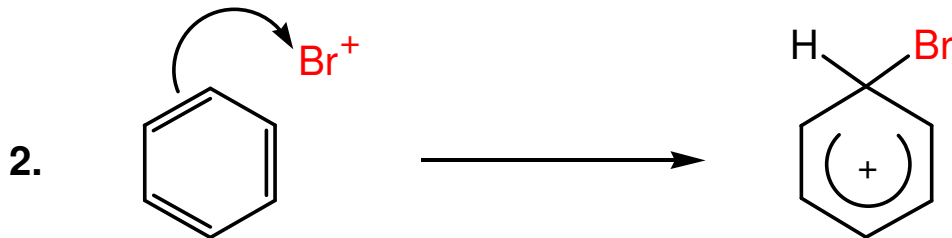
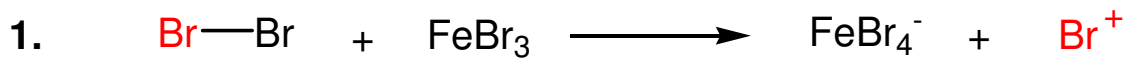


$$k_H = k_D$$

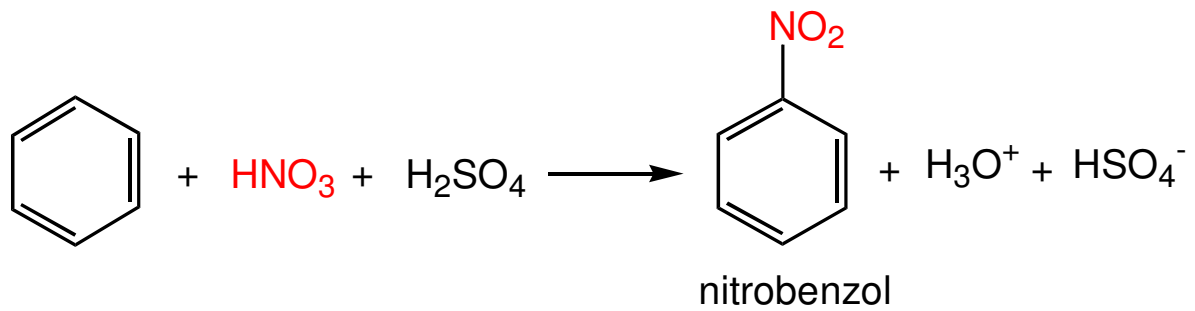
## Halogénezés



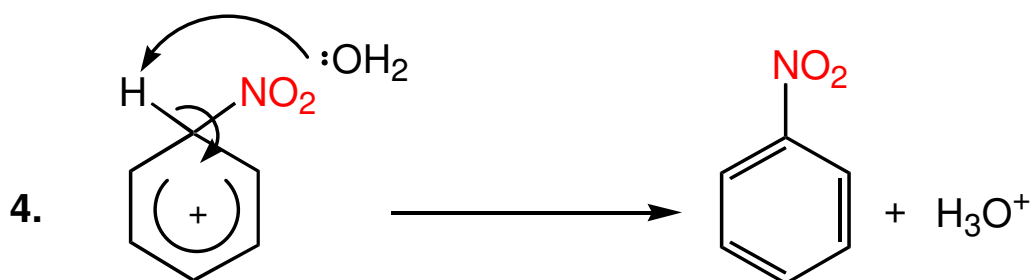
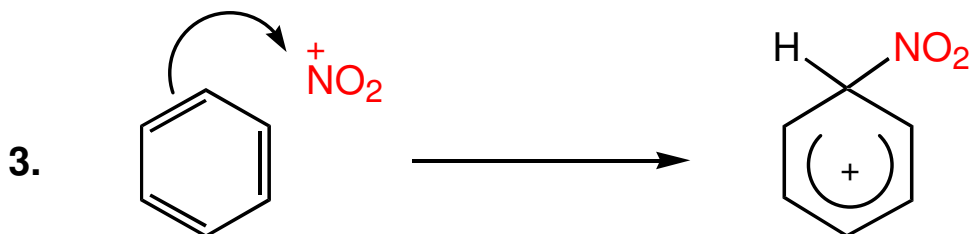
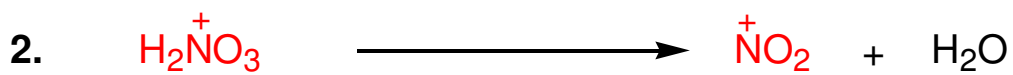
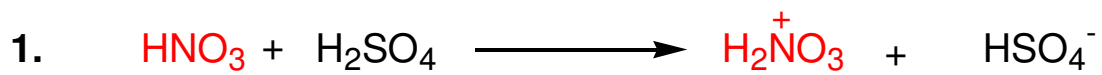
## Mechanizmus



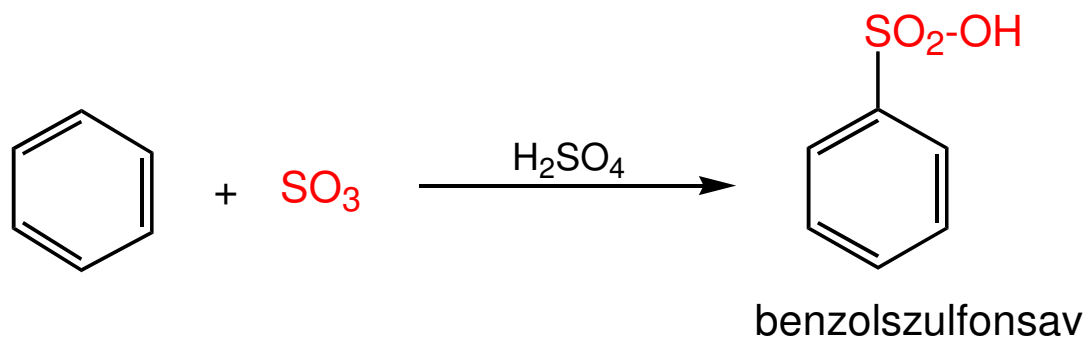
## Nitrálás



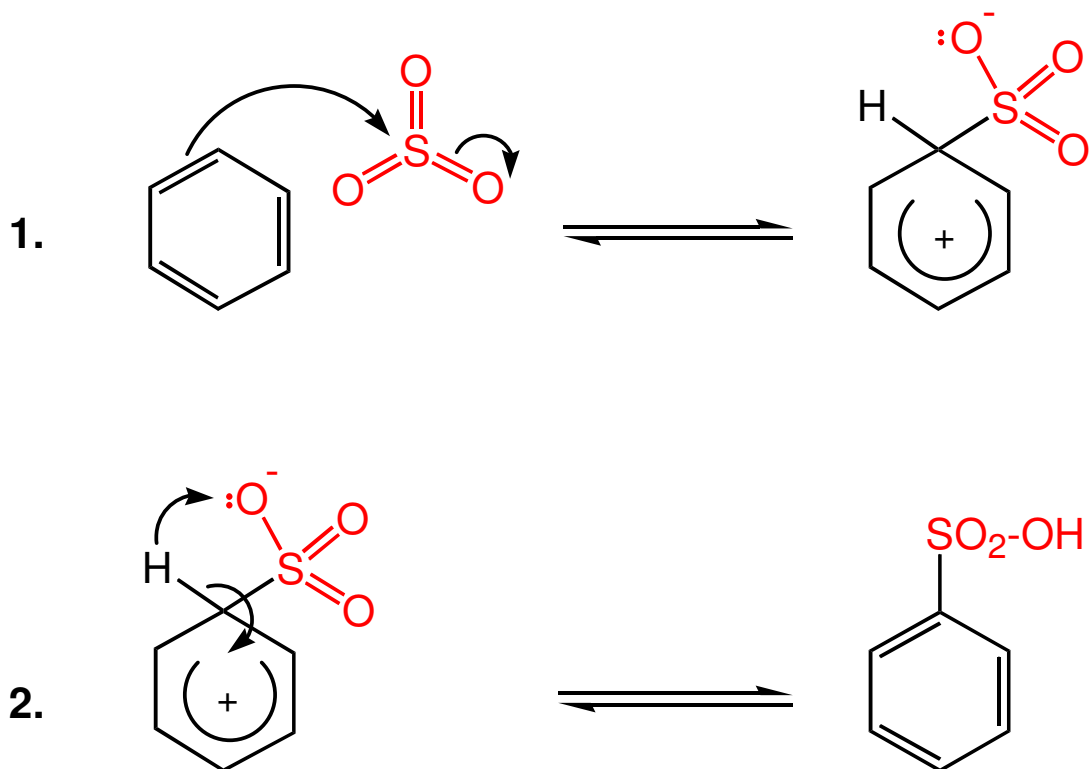
## Mechanizmus



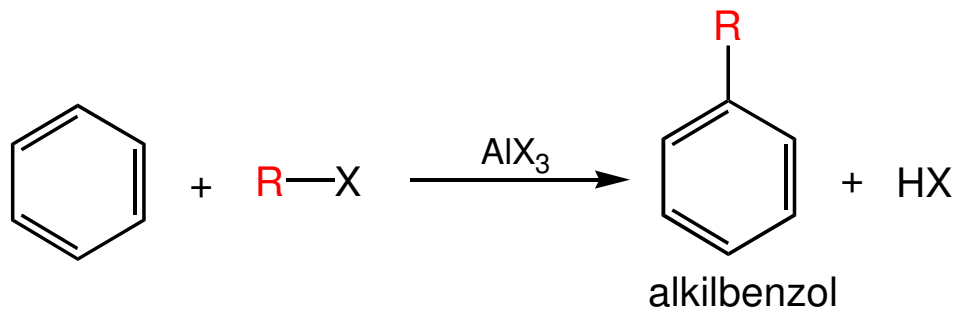
## Szulfonálás



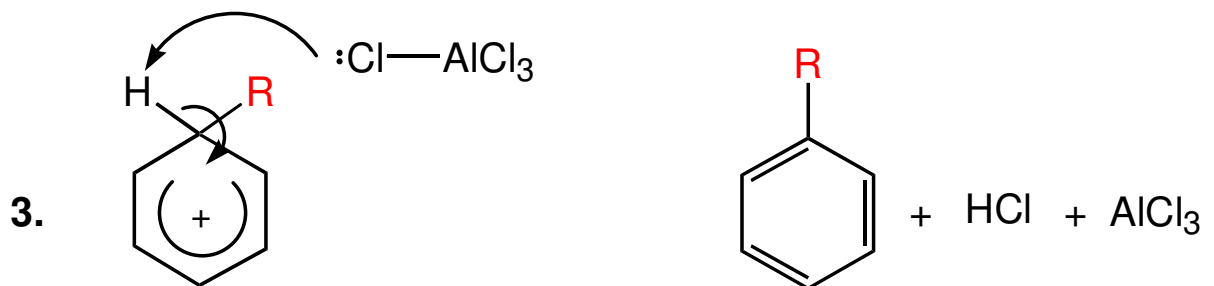
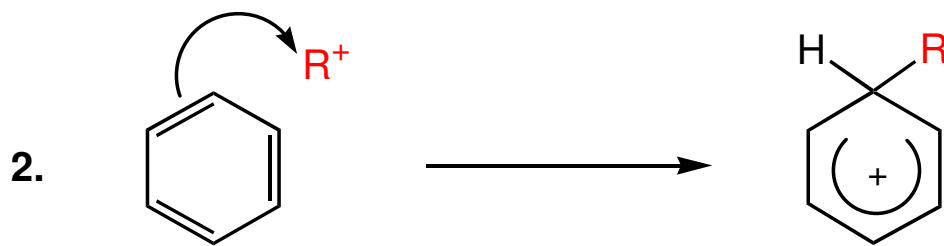
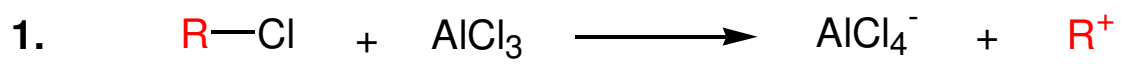
## Mechanizmus



## Friedel-Crafts alkilezés

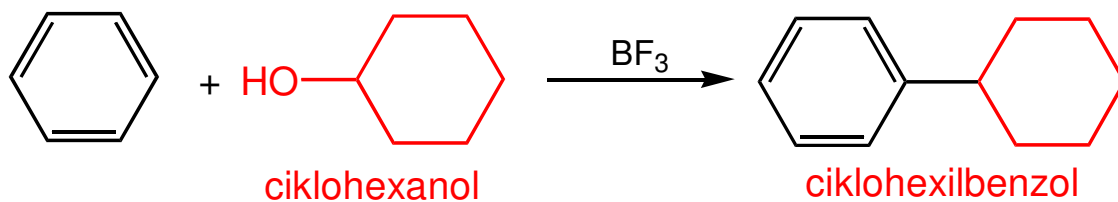
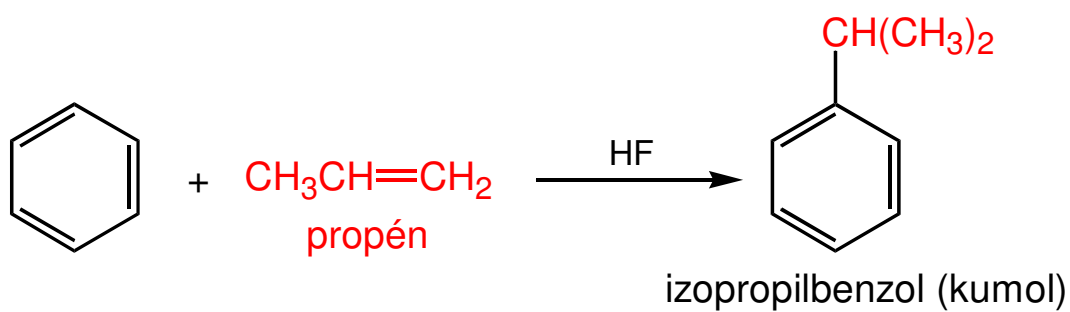


### Mechanizmus



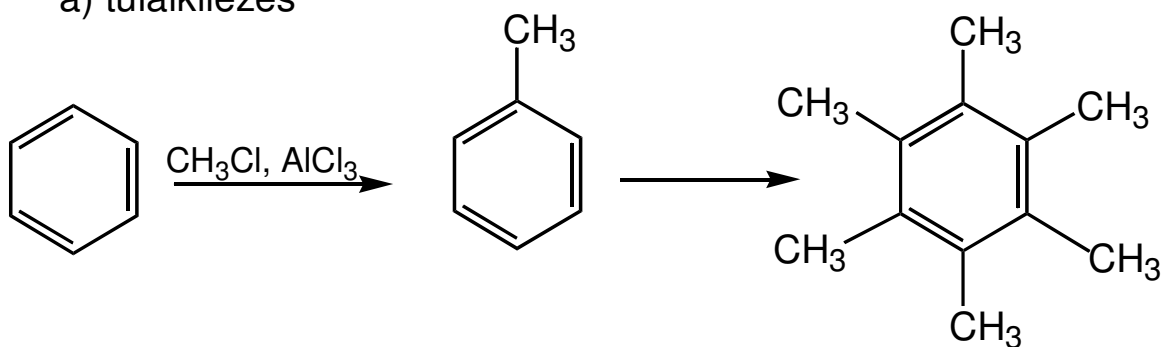


## Alkilezés alkénnel, alkoholokkal

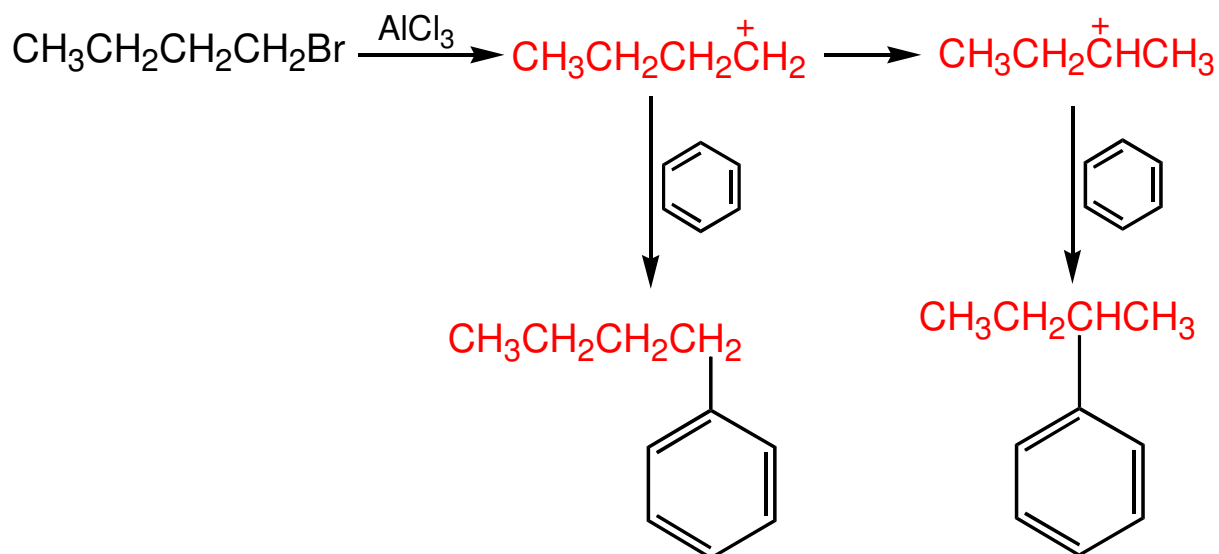


## Bonyodalmak

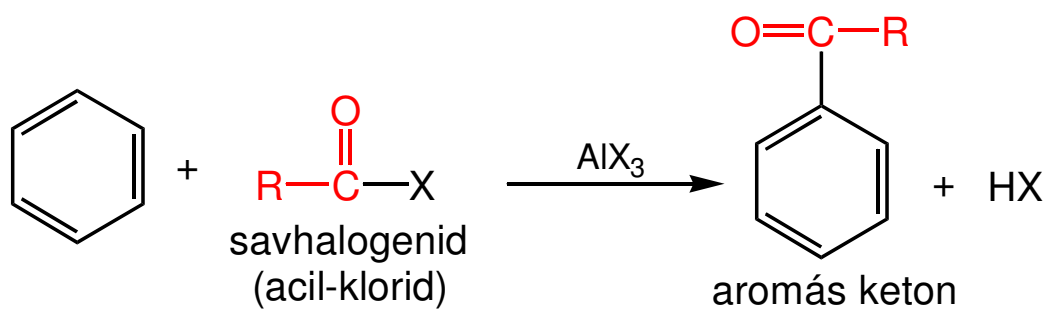
a) túlalkilezés



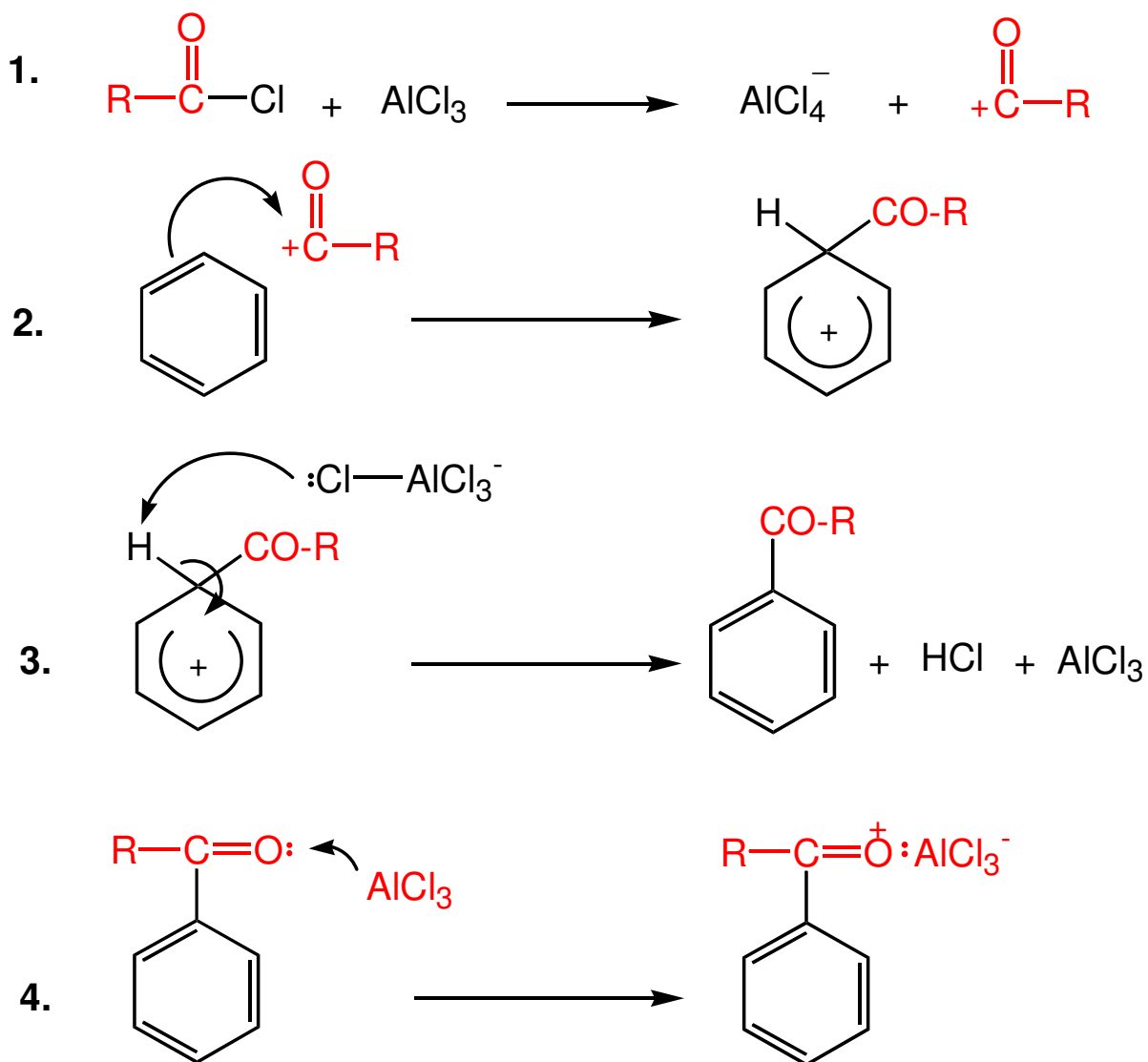
b) keveréktermék



## Friedel-Crafts acilezés

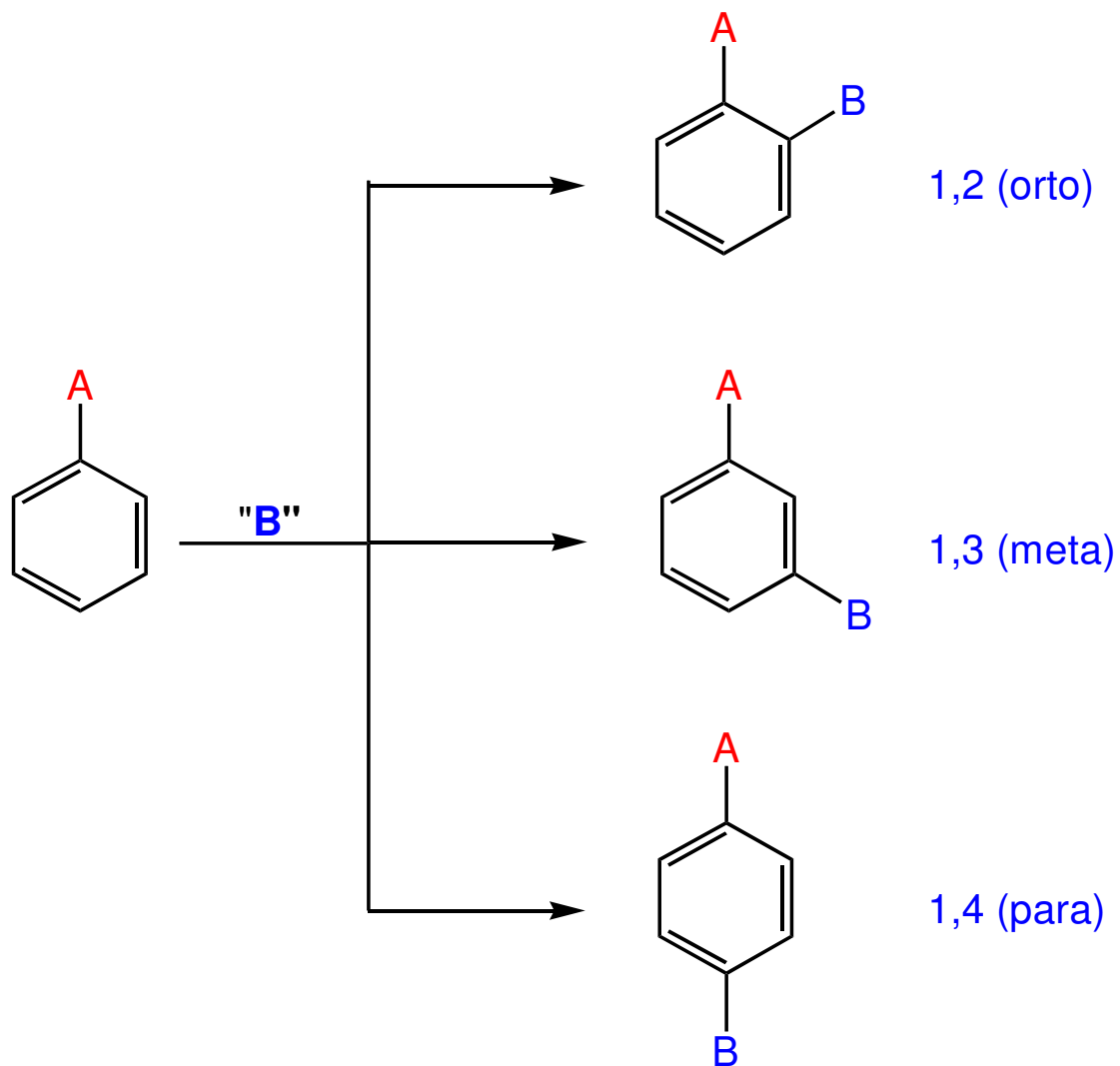


## Mechanizmus

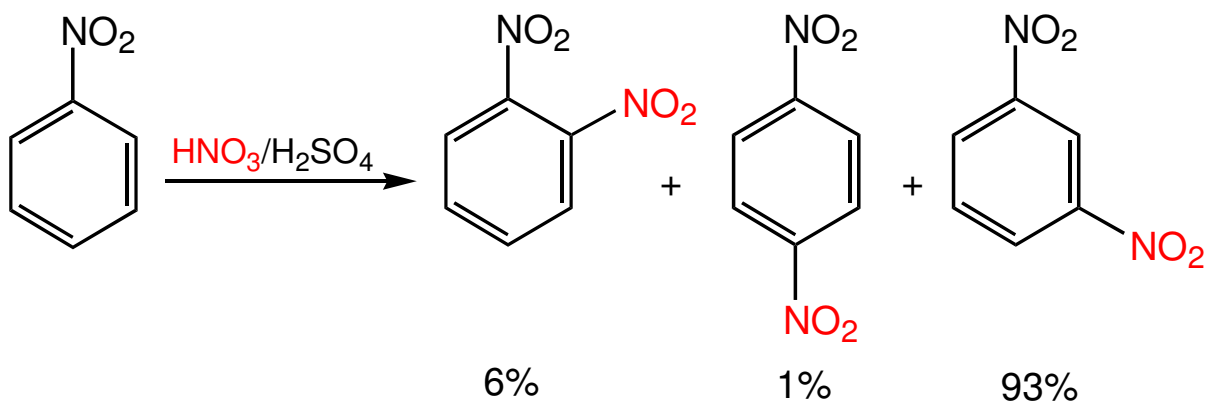
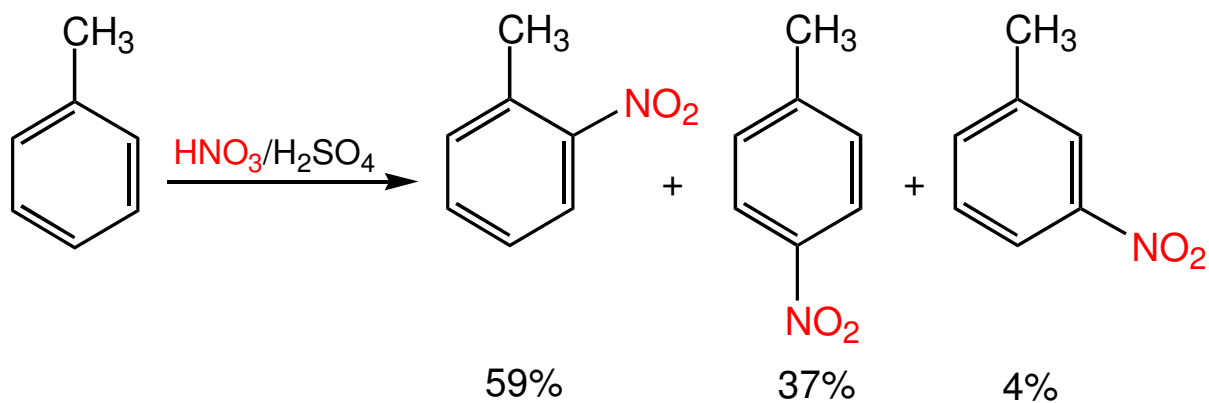


# Aromás elektrofil szubsztitúció: reaktivitás és irányítás

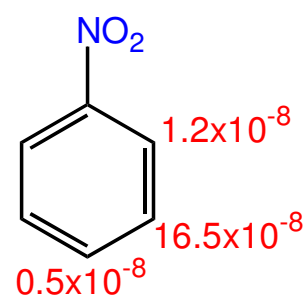
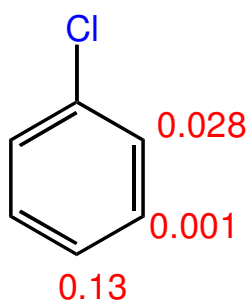
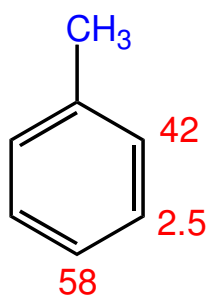
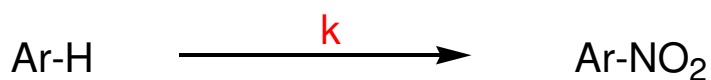
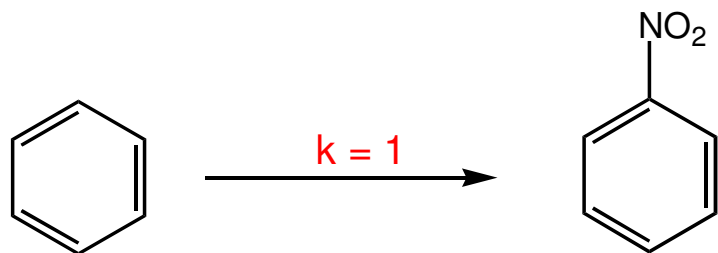
Diszubsztituált benzolszármazékok



Hová?



Milyen sebességgel?



$\text{CH}_3$ : aktivál, o-, p-irányítás

$\text{Cl}$ : dezaktivál, o-, p-irányítás

$\text{NO}_2$ : erősen dezaktivál, m-irányítás

## orto-, para-irányító

## meta-irányító

### aktivál

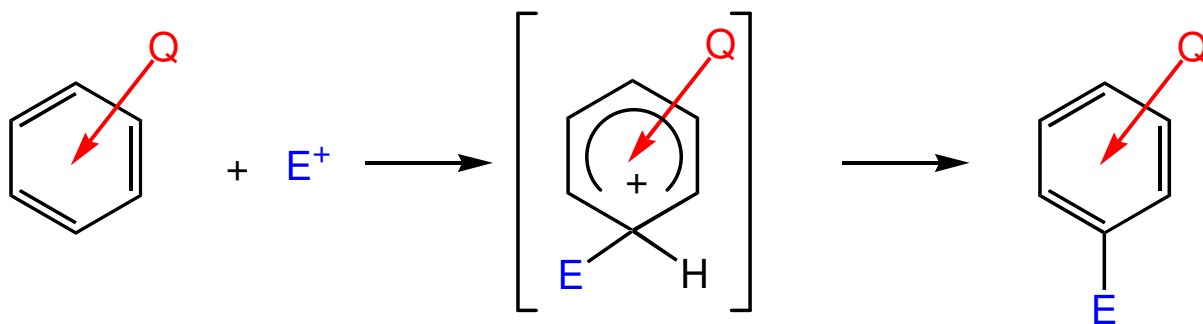
- R (alkil)
- Ar (aril)
- OH
- OR
- NH<sub>2</sub>
- NHR
- NR<sub>2</sub>
- NH-CO-R

### dezaktivál

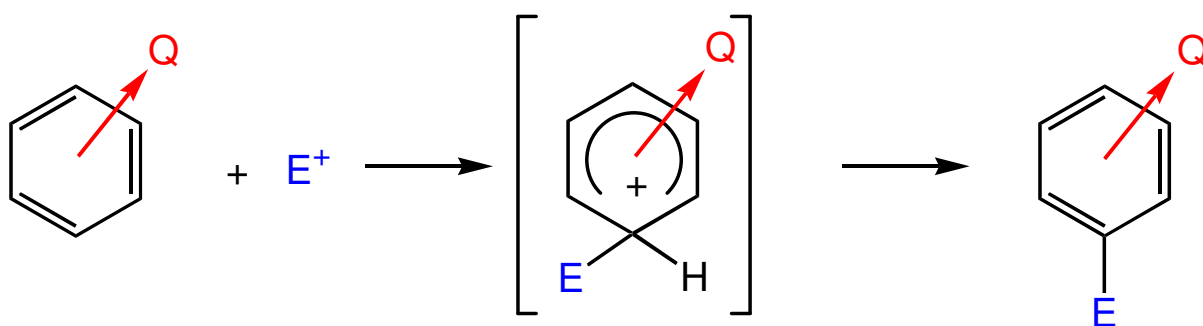
- F
- Cl
- Br
- I

### erősen dezaktivál

- NO<sub>2</sub>
- NH<sub>3</sub><sup>+</sup>
- NR<sub>3</sub><sup>+</sup>
- SO<sub>3</sub>H
- CX<sub>3</sub>
- CHO
- CO-R
- COOH
- COOR

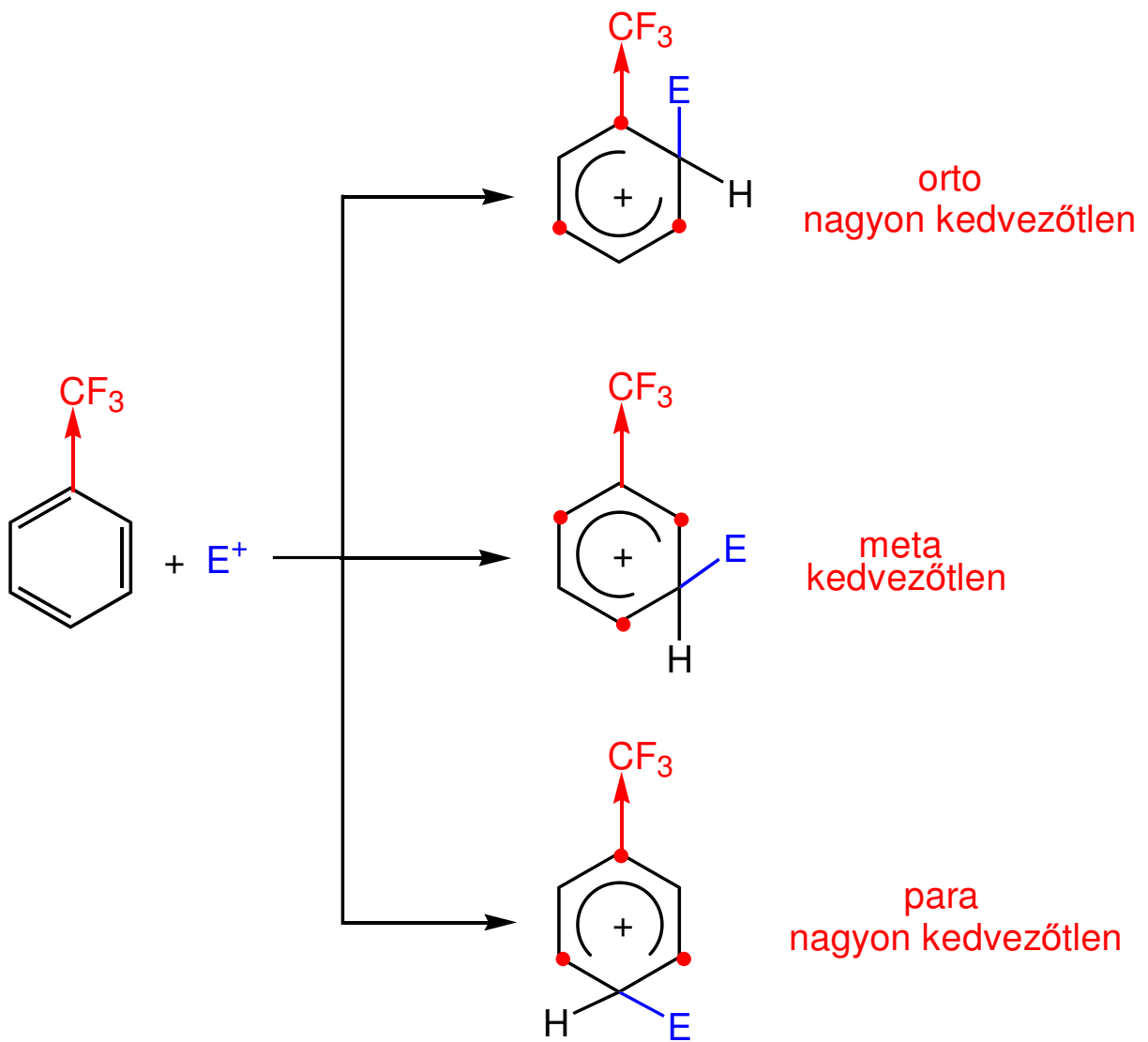


gyorsabb reakció

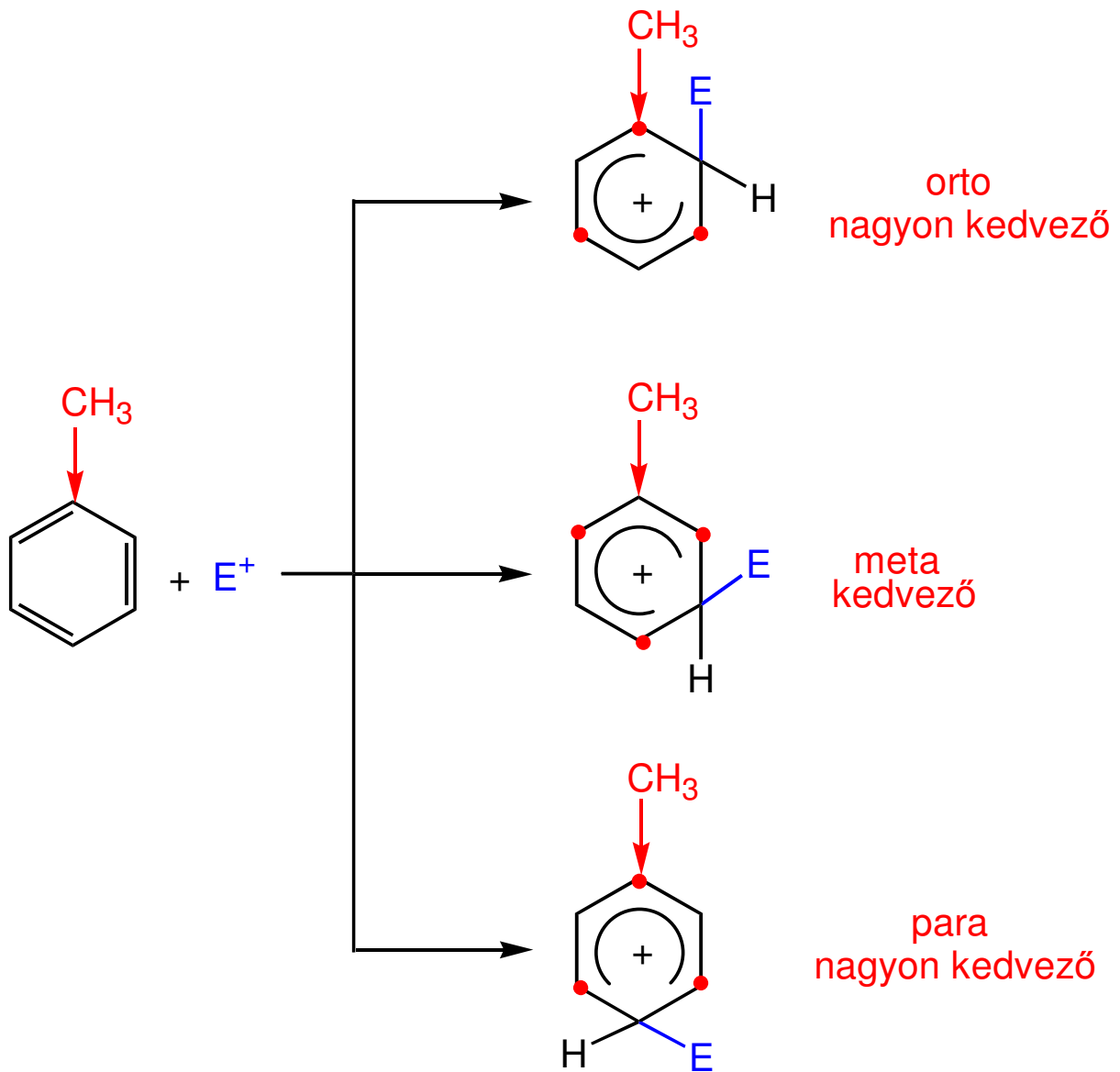


lassabb reakció

# -I hatású csoportok

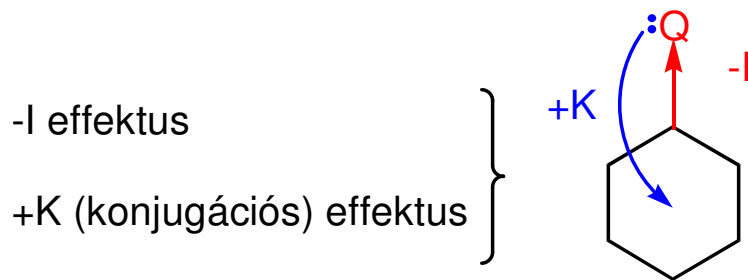


## +I effektusú csoportok

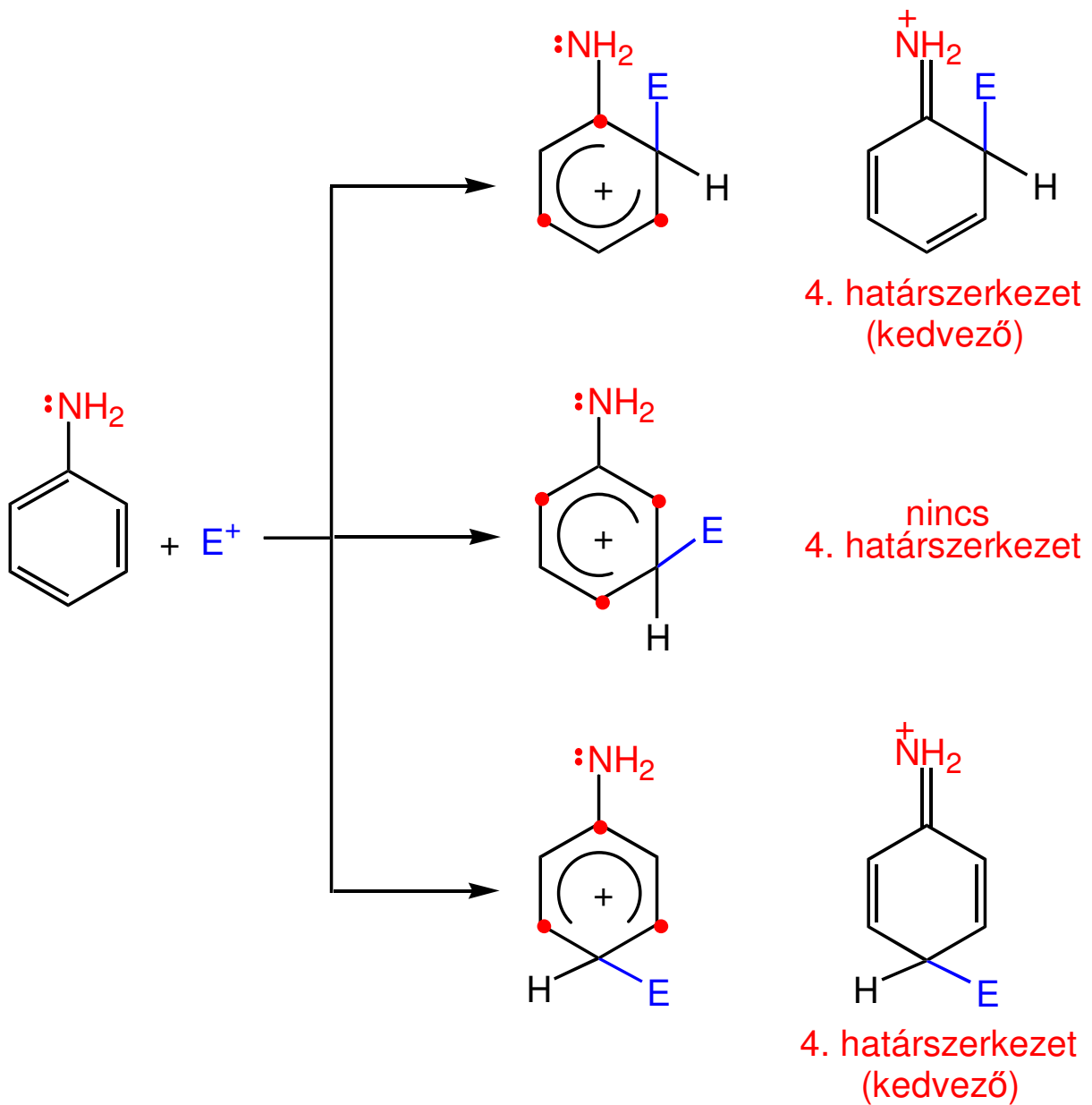




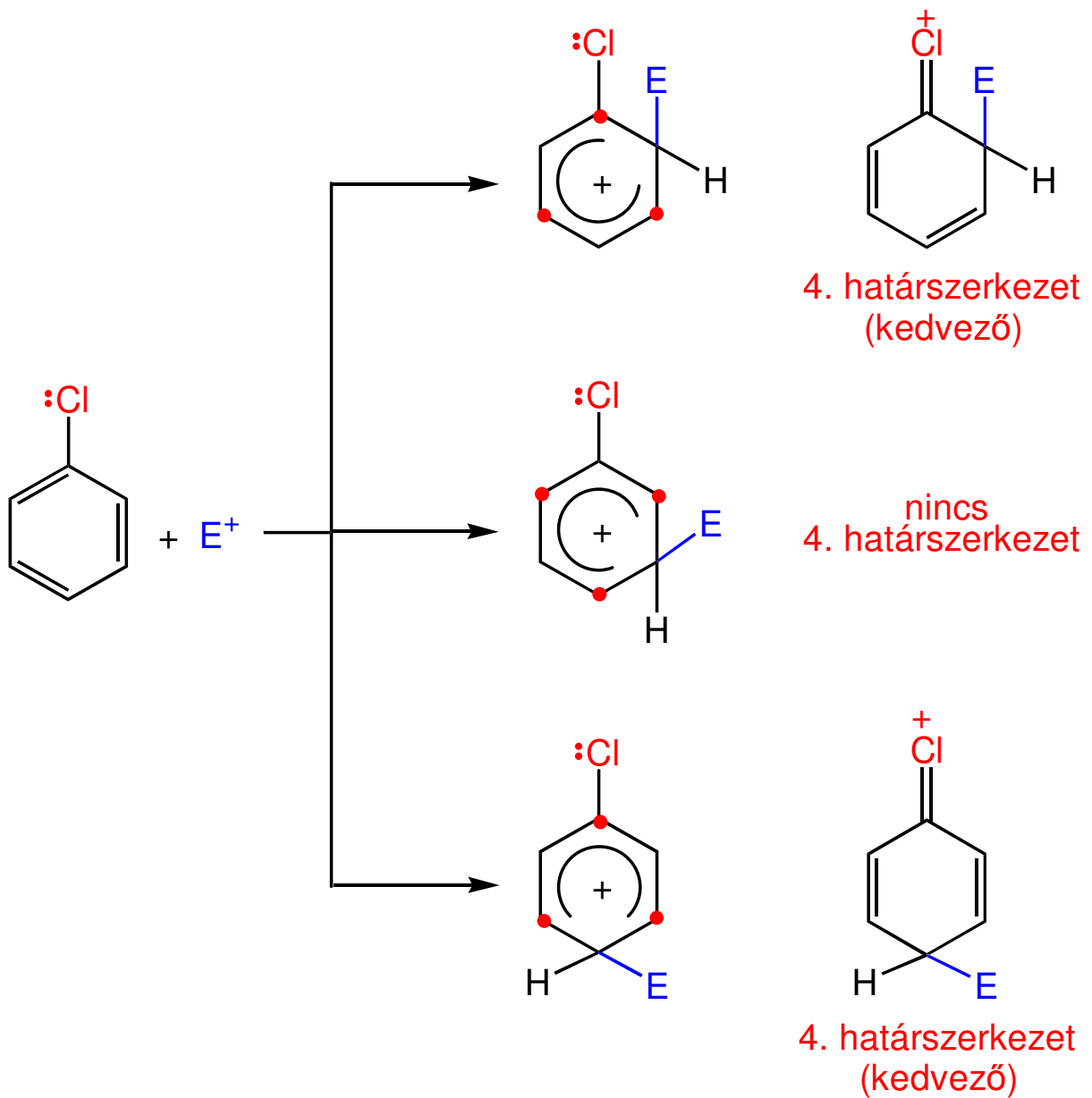
## Heteroatomok



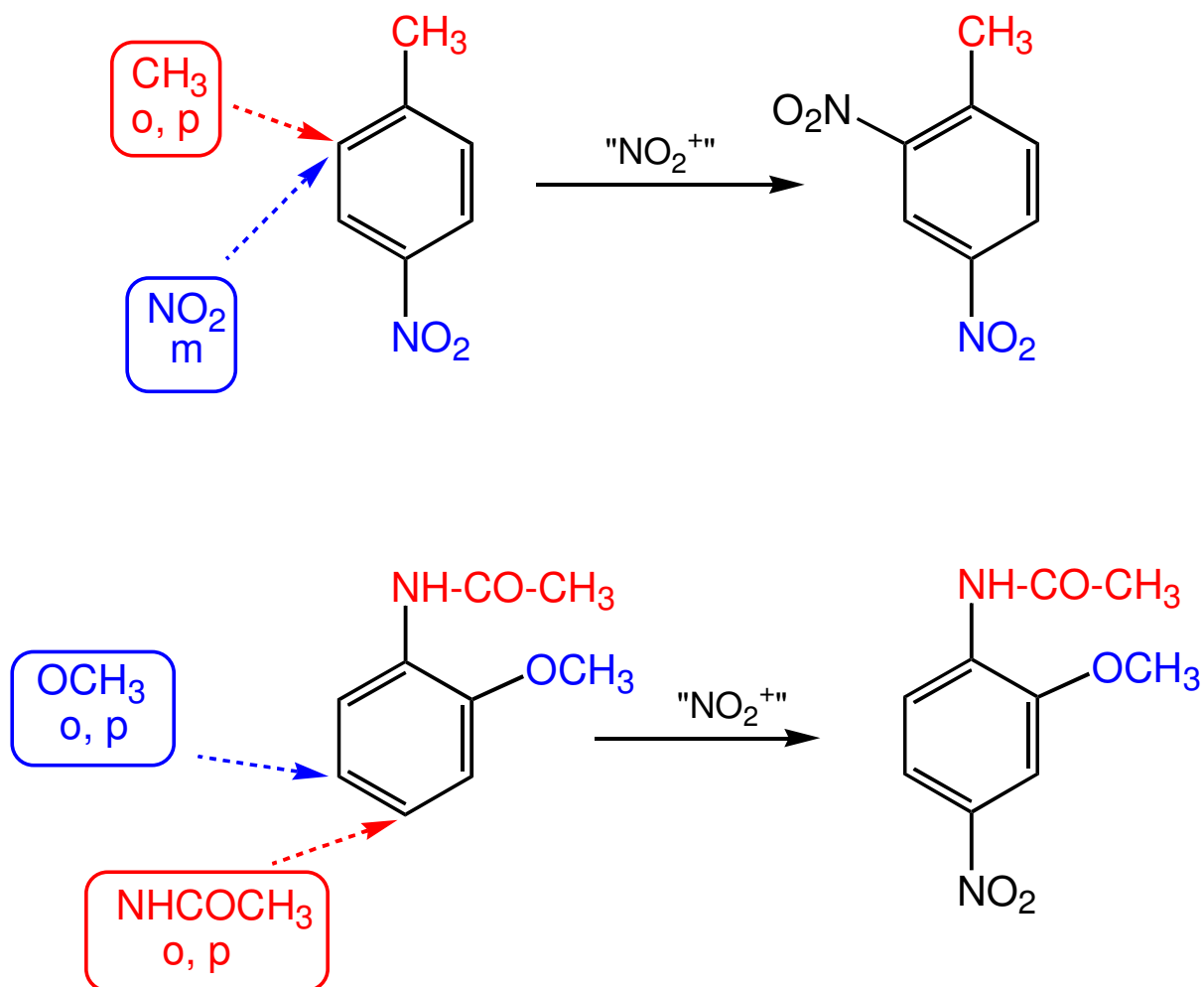
a) +K effektus: o-, p-irányítás; +K > -I : aktivál (pl. NH<sub>2</sub>, OH)



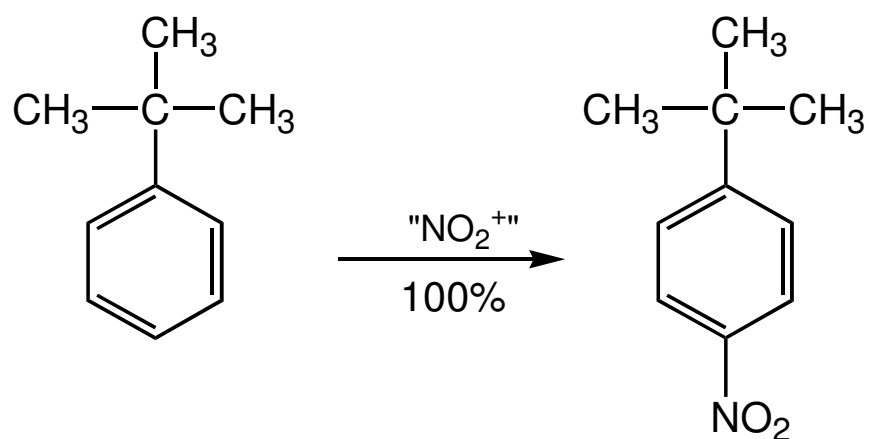
b) +K effektus: o-, p-irányítás; +K < -I : dezaktivál (F, Cl, Br, I)



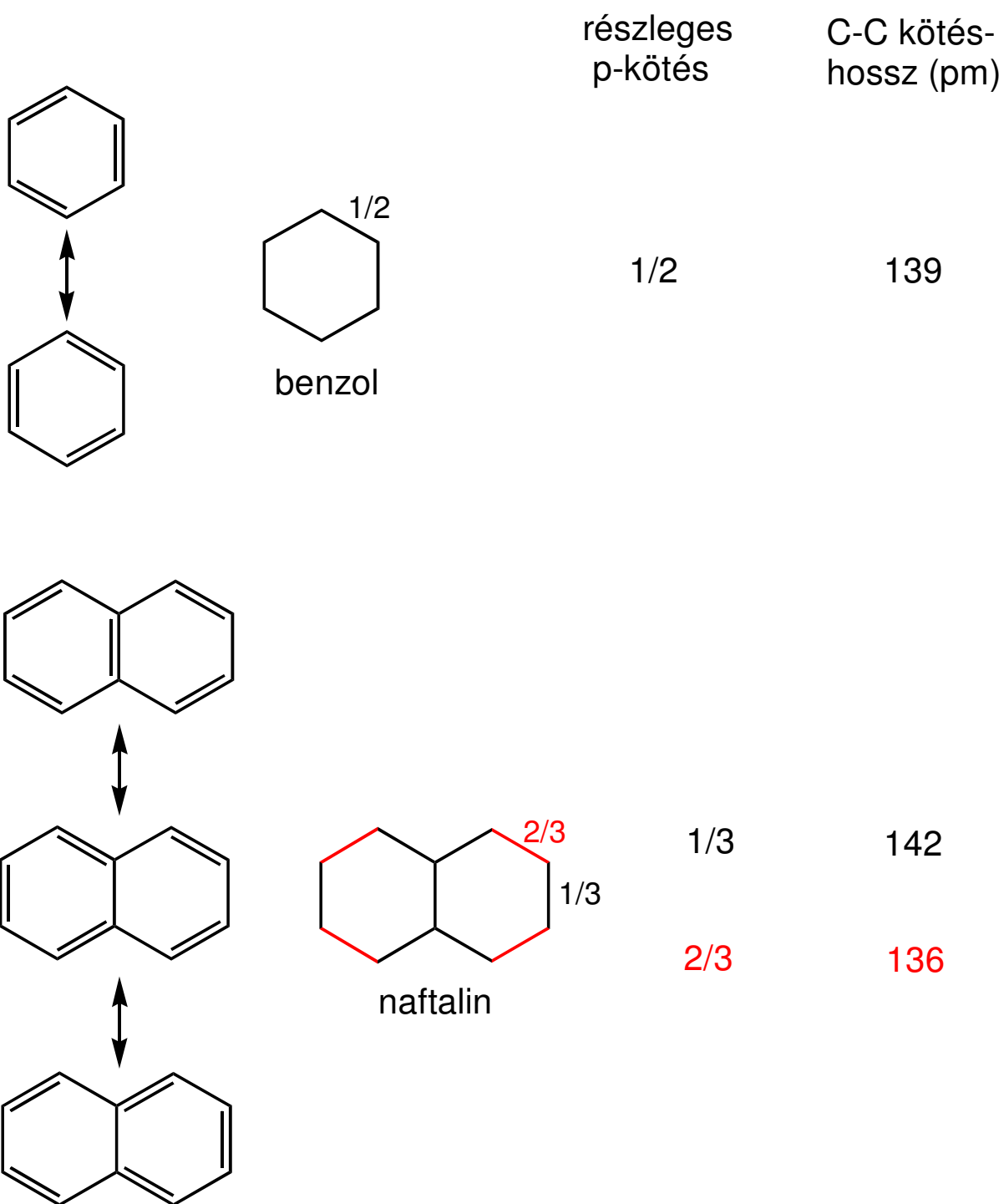
## Több szubsztituens irányító hatása



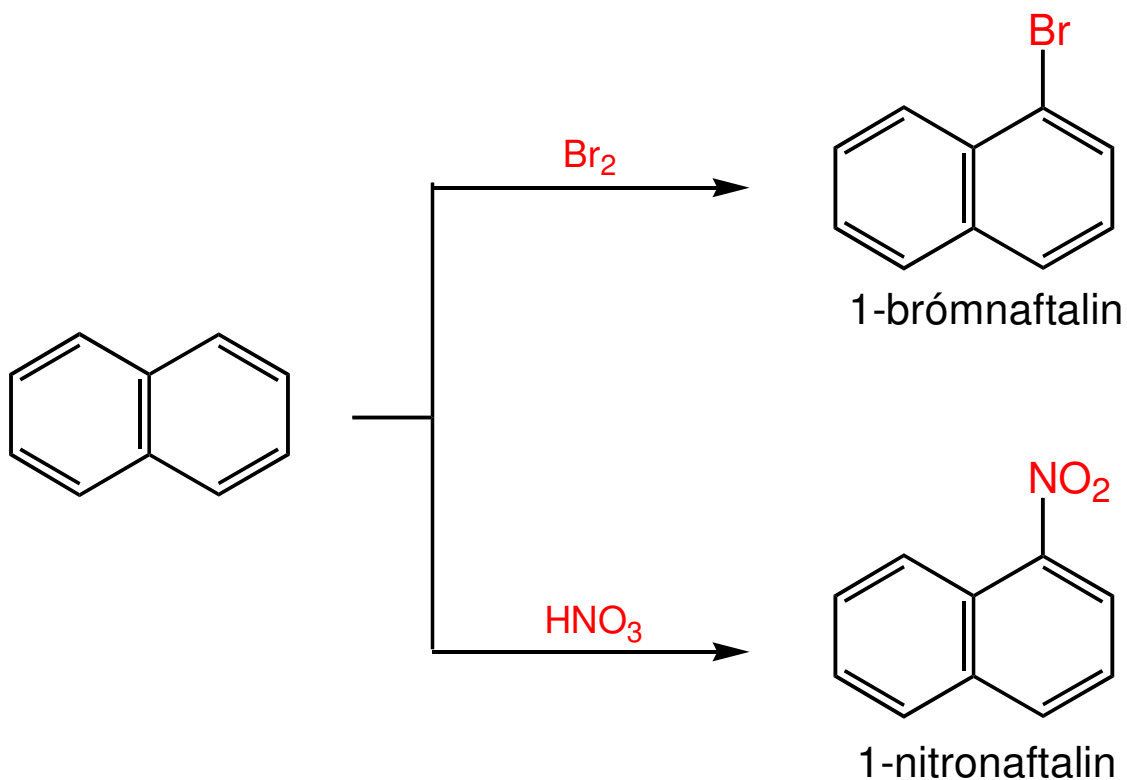
## Szterikus effektus



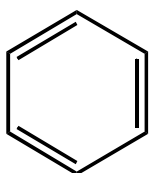
## A naftalin szerkezete



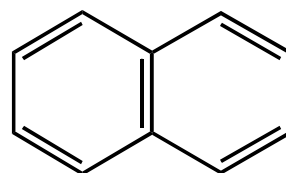
## A naftalin kémiai tulajdonságai



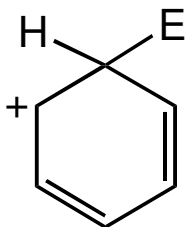
Reaktivitás ( $\text{S}_E$ )



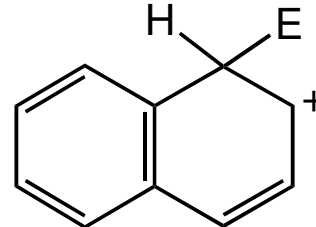
<



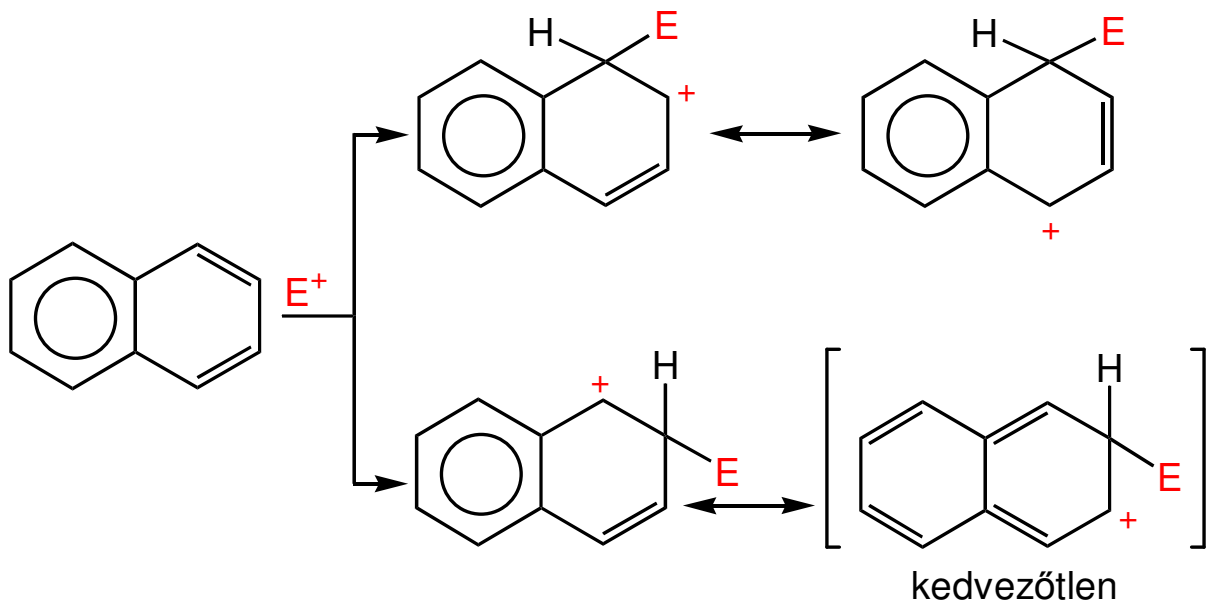
Stabilitás



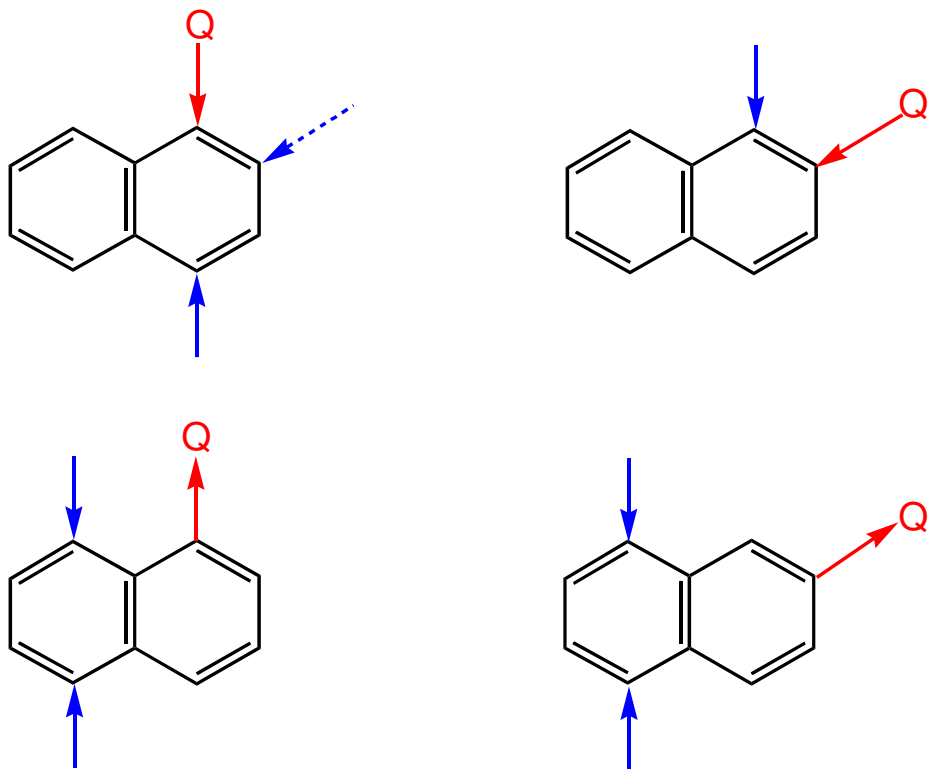
<



## Irányítás 1-es helyzetbe

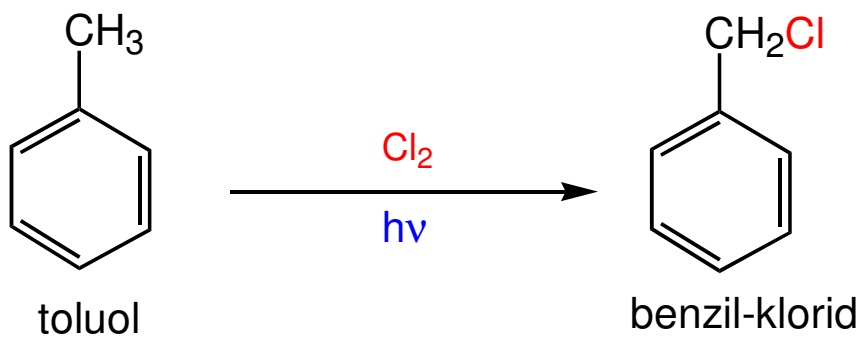


## Irányítás naftalin származékokban

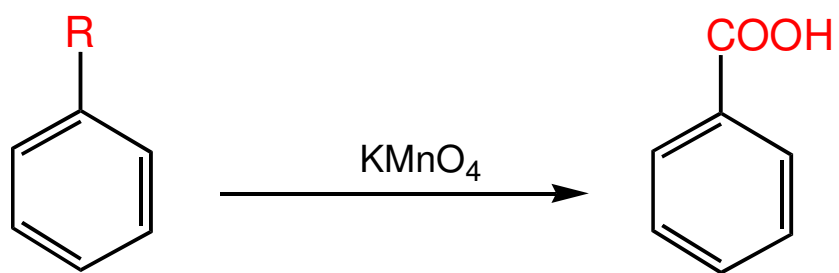


## Oldalláncban lejátszódó reakciók

### Halogénezés



### Oxidáció



R = pl. CH<sub>3</sub>, CH<sub>2</sub>CH<sub>3</sub>, CH(CH<sub>3</sub>)<sub>2</sub>, CH=CH<sub>2</sub>

## Redukciós reakciók

