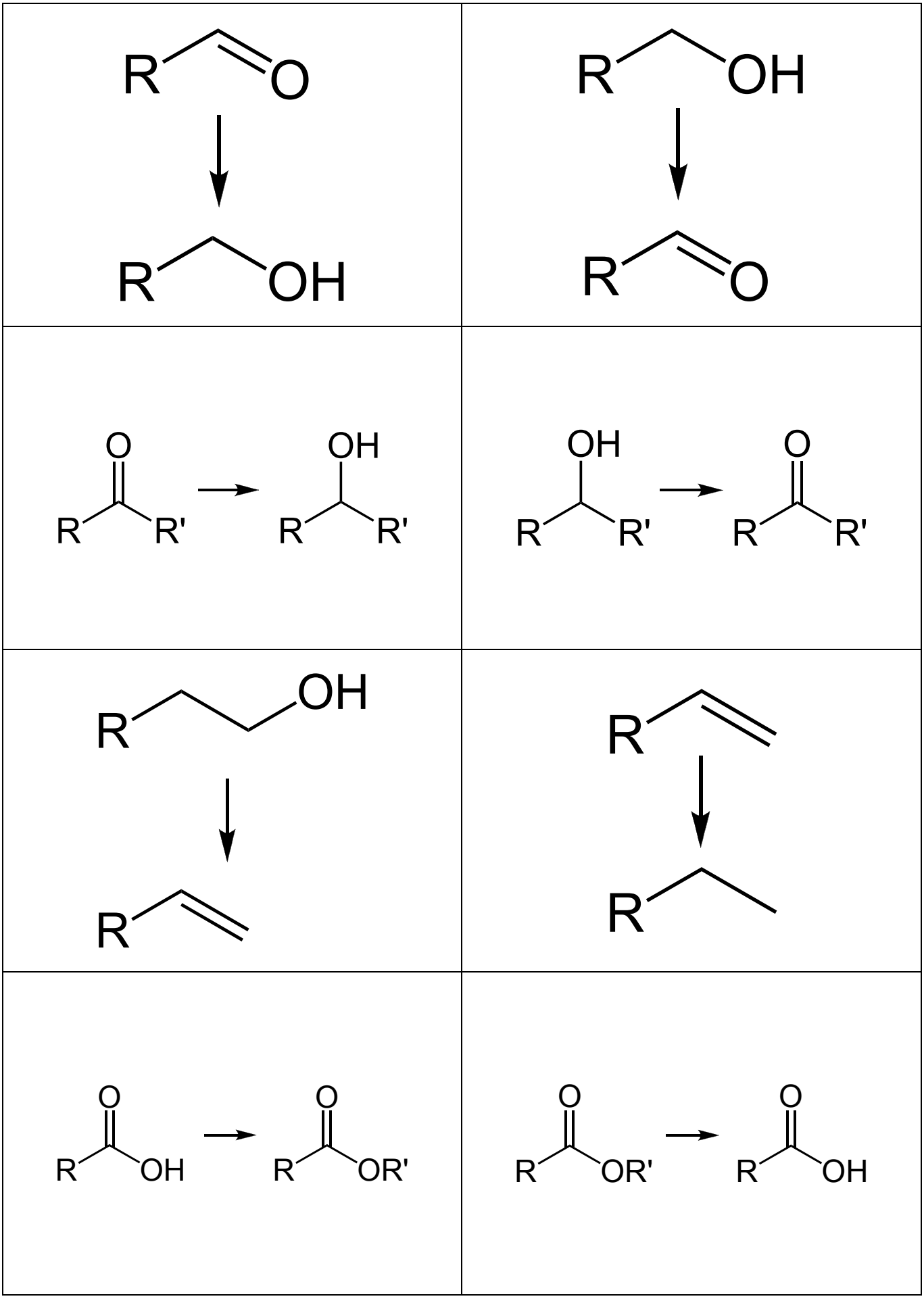

R
O
R
OH
R
OH
R
O
O
R
R'
OH
R
R'
OH
R
R'
O
R
R'
OH
R
OH
R
R
R
O
R
OH
O
R
OR'
O
R
OR'
O
R
OH

Oxidation
converts 1° alcohols to aldehydes

$Cr_2O_7^{2-}$, H^+, reflux

Reduction
converts aldehydes to 1° alcohols

$NaBH_4$
sodium borohydride /
sodium tetrahydridoborate(III)

Oxidation
converts 2° alcohols to ketones

$Cr_2O_7^{2-}$, H^+, reflux

Reduction
converts ketones to 2° alcohols

$NaBH_4$
sodium borohydride /
sodium tetrahydridoborate(III)

Addition
(hydrogenation)
converts alkenes to alkanes

$H_2(g)$
finely powdered Ni catalyst
150 °C, 5 atm

(or Pt, room temp., 1 atm)

Elimination
(dehydration)
converts 1° or 2° alcohols to alkenes

$Al_2O_3(s)$, 300 °C

or

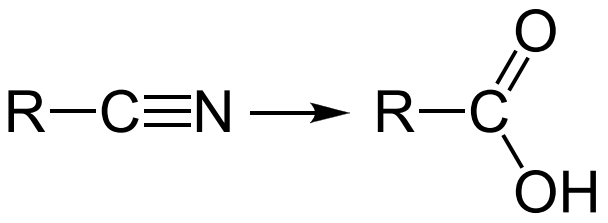
conc. H_2SO_4, reflux followed by H_2O

Ester hydrolysis
converts esters to carboxylic acids and alcohols

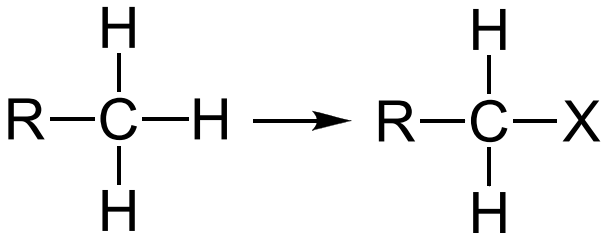
H^+, H_2O
reflux

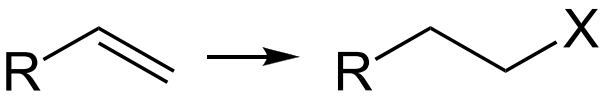
Esterification
converts carboxylic acids and alcohols to esters

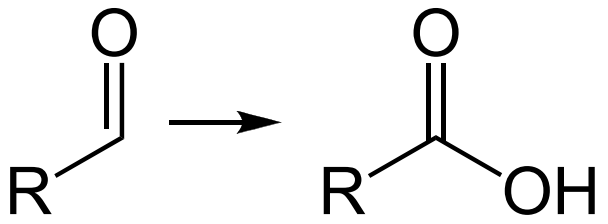
R'OH
conc. H_2SO_4 catalyst
reflux

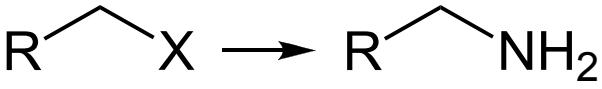

R–C≡N
R–C
O
OH

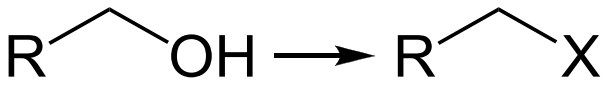

R–X
R–C≡N

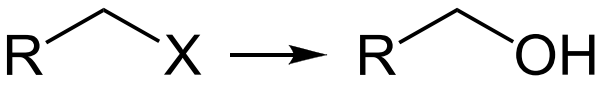

H
R–C–H
H
R–C–X
H
H


R
R
X

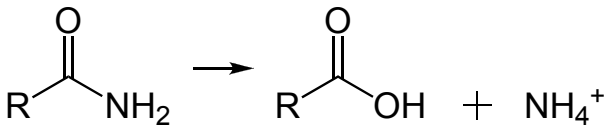

O
R
O
R
OH

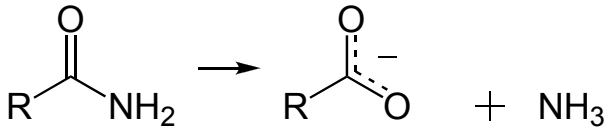

R
X
R
NH2

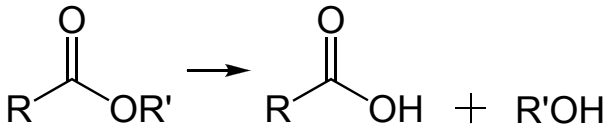

R
OH
R
X

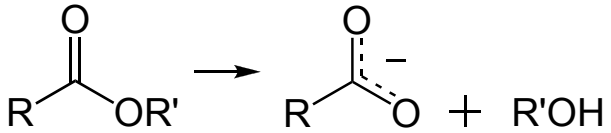

R
X
R
OH

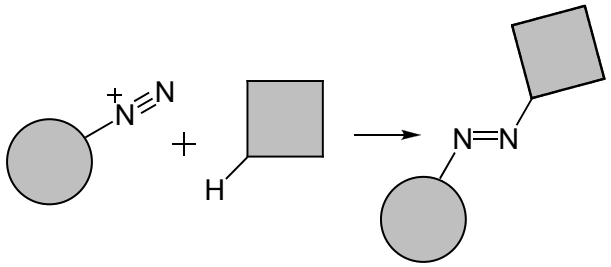
Nucleophilic substitution converts haloalkanes to nitriles NaCN in aqueous ethanol solution reflux	**Hydrolysis** converts nitriles to carboxylic acids $H^+(aq)$, H_2O, reflux
Electrophilic addition converts alkenes to haloalkanes conc. HX(aq) room temp.	**Radical substitution** converts alkanes to haloalkanes X_2, room temp. UV light (sunlight, hv)
Nucleophilic substitution converts haloalkanes to amines conc. $NH_3(aq)$ heat in a sealed tube	**Oxidation** converts aldehydes to carboxylic acids $Cr_2O_7^{2-}$, H^+, reflux
Nucleophilic substitution converts haloalkanes to alcohols NaOH(aq) reflux (or **hydrolysis:** $H_2O(l)$, slow)	**Nucleophilic substitution** converts alcohols to haloalkanes NaX(s) conc. $H_2SO_4(aq)$ reflux

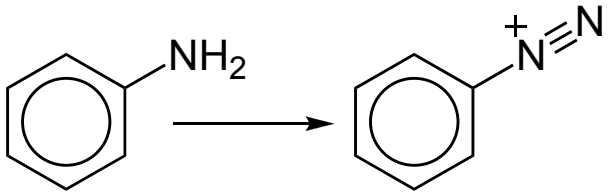

O
R
NH2
O
R
OH
+
NH4+

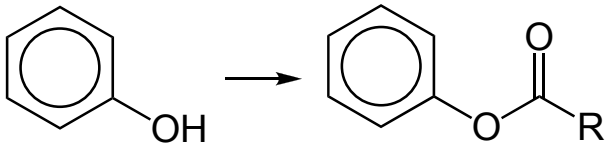

O
R
NH2
O
R
O
–
+
NH3

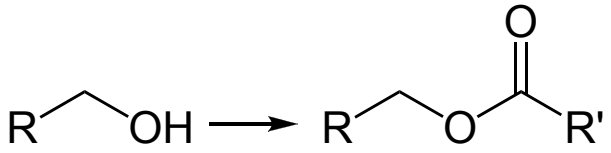

O
R
OR'
O
R
OH
+
R'OH


O
R
OR'
O
R
O
–
+
R'OH


+
N
N
+
H
N=N


NH2
+
N
N


OH
O
O
R


R
OH
R
O
O
R'

Alkali-catalysed amide hydrolysis

converts amides to carboxylate ions and ammonia

moderately conc.(4-6 M) NaOH
H_2O, reflux

Acid-catalysed amide hydrolysis

converts amides to carboxylic acids and ammonium ions

moderately conc. (4-6 M) H^+
H_2O, reflux

Alkali-catalysed ester hydrolysis

converts esters to carboxylate ions and alcohols

NaOH(aq)
H_2O, reflux

alkali-catalysed hydrolysis is often preferred because it goes to completion, unlike acid-catalysed hydrolysis

Acid-catalysed ester hydrolysis

converts esters to carboxylic acids and alcohols

moderately conc. H_2SO_4(aq)
H_2O, reflux

Diazotisation

converts aryl amines to diazonium ions

$NaNO_2$(aq), dilute H^+
temp. < 5°C to avoid explosions

Diazo coupling

converts diazonium salts and coupling agents to azo compounds

temp. < 5°C to avoid explosions
(ice cold aqueous solutions)

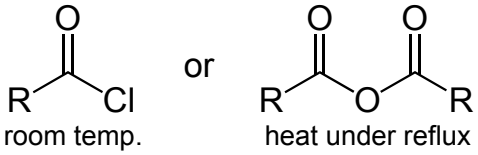
Esterification

converts alcohols to esters

R'COOH, conc. H_2SO_4 catalyst, reflux
or
(R'CO)$_2$O, heat under reflux
or
R'COCl, room temperature

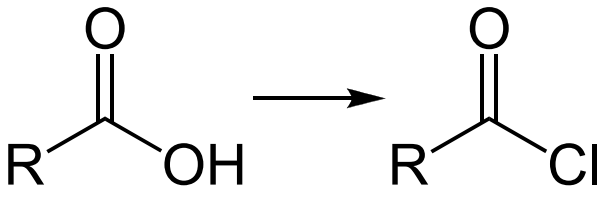
Acylation

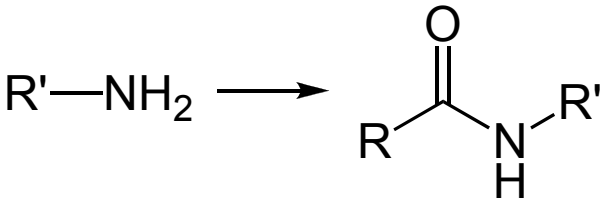
esterification of phenols to phenyl esters

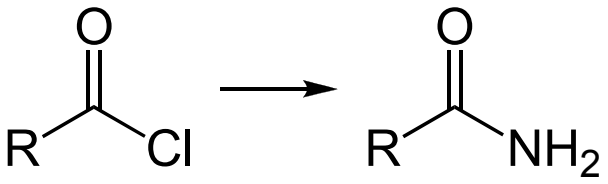


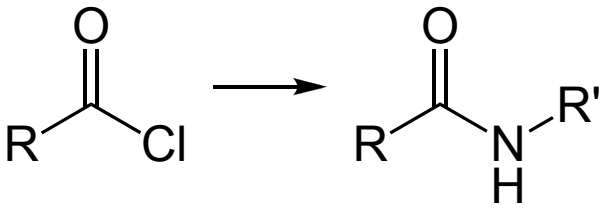
room temp. | heat under reflux

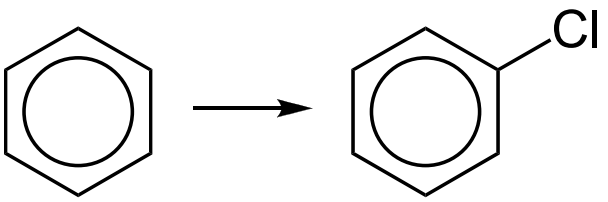
strictly anhydrous conditions
phenols cannot be esterified by carboxylic acids because phenols are too unreactive

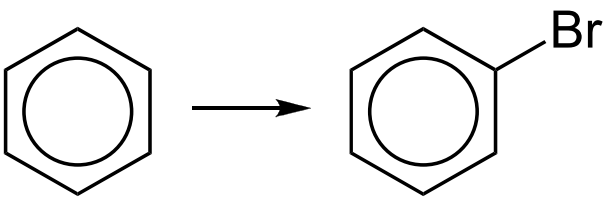

O
R
OH
O
R
Cl

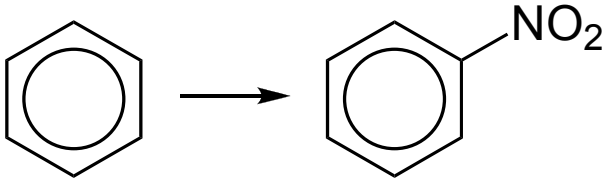

R'—NH2
O
R
N
H
R'

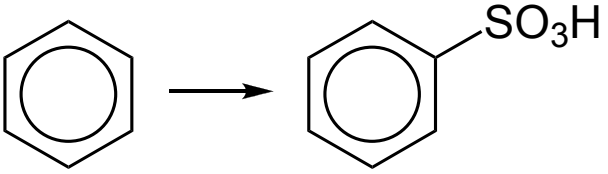

O
R
Cl
O
R
NH2


O
R
Cl
O
R
N
H
R'


Cl

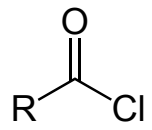

Br


NO2


SO3H

Acylation

converts primary amines to secondary amides



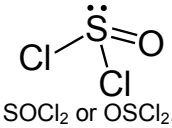
room temp.

strictly anhydrous conditions

Nucleophilic substitution

converts carboxylic acids to acyl chlorides

SCl_2O, reflux



SCl_2O is often written $SOCl_2$ or $OSCl_2$. It is most often called **thionyl chloride**, although its systematic name is *sulfur dichloride oxide.*

Acylation

converts acyl chlorides to secondary amides

$R'NH_2$
room temp.

strictly anhydrous conditions

Acylation

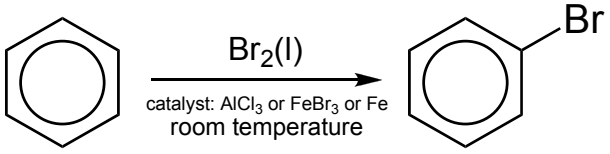
converts acyl chlorides to primary amides

conc. $NH_3(aq)$
room temp.

strictly anhydrous conditions

Electrophilic substitution

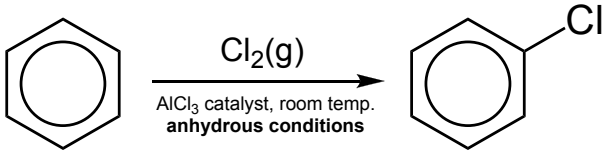
bromination converts arenes to bromoarenes



$FeBr_3$ or $AlCl_3$ helps polarize the Br_2 molecule, forming the electrophile Br^+, which then attacks the benzene ring.

Electrophilic substitution

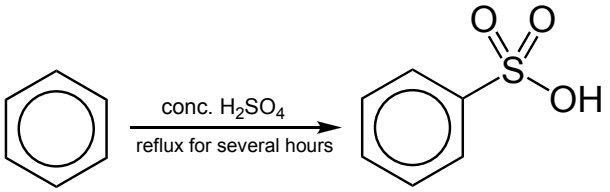
chlorination converts arenes to chloroarenes



$AlCl_3$ helps polarize the Cl_2 molecule, forming the electrophile Cl^+, which then attacks the benzene ring.

Electrophilic substitution

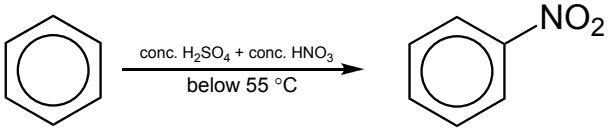
sulfonation converts arenes to arenesulfonic acids



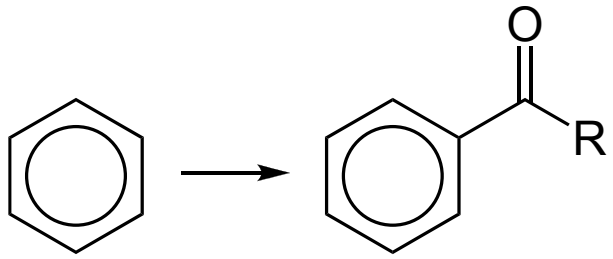
The electrophile in this reaction is probably SO_3, which is present in conc. $H_2SO_4(aq)$ in small quantities.

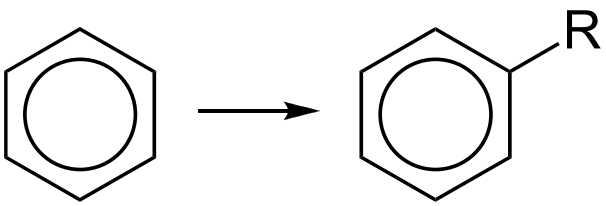
Electrophilic substitution

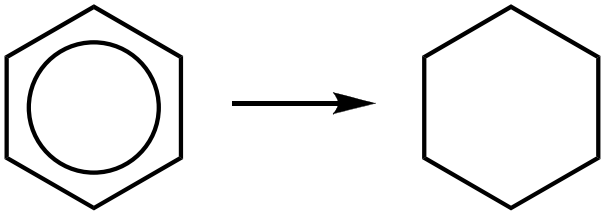
nitration converts arenes to nitroarenes

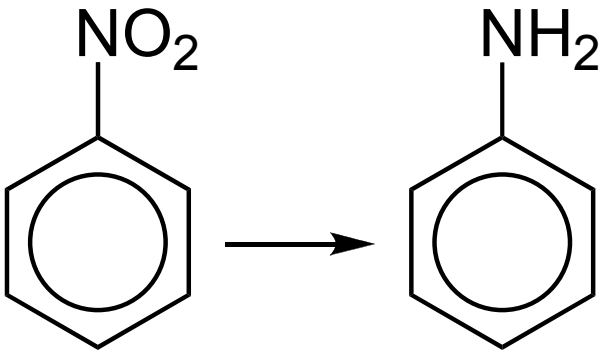


The combination of c. $H_2SO_4(aq)$ and c. $HNO_3(aq)$ is called a **nitrating mixture** and produces the electrophile NO_2^+, the nitronium ion, that attacks the benzene ring.


O
R

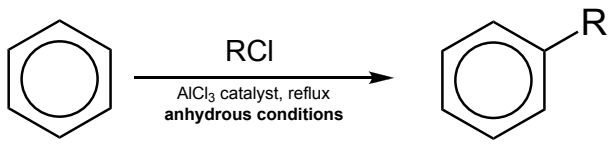

R




NO2
NH2

Electrophilic substitution

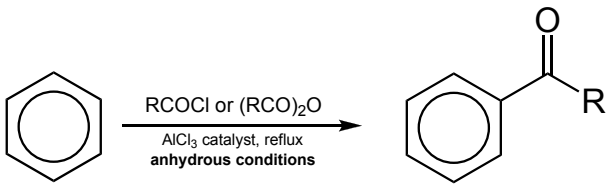
Friedel-Crafts alkylation converts arenes to alkylarenes



$AlCl_3$ helps polarize the RCl molecule, forming the electrophile R^+ which then attacks the benzene ring.

Electrophilic substitution

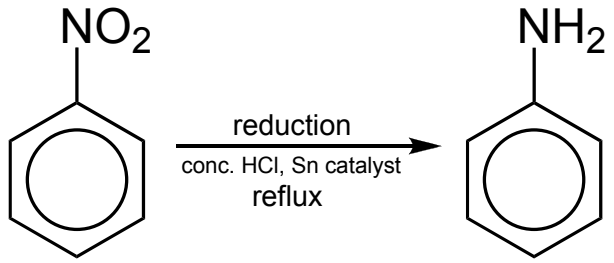
Friedel-Crafts acylation converts arenes to aryl ketones



$AlCl_3$ helps polarize the RCOCl or $(RCO)_2O$ molecule, forming the electrophile $[RCO]^+$, the acylium ion, which then attacks the benzene ring.

Reduction

converts nitroarenes to arylamines



Reduction

hydrogenation converts benzene to cyclohexane