

!All Organic Reactions with Conditions!

Type of Reaction	Reaction Name	Conditions	Example Equation	
Alkanes				
Reduction	Preparation by Hydrogenation of Alkenes/ Cracking	Ni 140° OR Pt/Pd r.t.	$R'R''=R'''R'''' + H_2 \xrightarrow{Ni + \Delta} R'R''HC-CHR'''R''''$	
Free Radical Substitution	Free Radical Substitution Mechanism	Exc. Cl UV	$\begin{array}{l} \text{Initiation: } \{Cl_2 \xrightarrow{uv} 2Cl\bullet\} \\ \text{Propagation: } \left\{ \begin{array}{l} Cl\bullet + CH_4 \rightarrow \bullet CH_3 + HCl \\ \bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet \\ 2Cl\bullet \rightarrow Cl_2 \end{array} \right\} \\ \text{Termination: } \left\{ \begin{array}{l} 2\bullet CH_3 \rightarrow H_3C-CH_3 \\ \bullet CH_3 + Cl\bullet \rightarrow CH_3Cl \end{array} \right\} \\ \hline \text{Overall: } Cl_2 + CH_4 \xrightarrow{uv} CH_3Cl + HCl \end{array}$	Types of Substitutions $\begin{array}{l} CH_4 + Cl_2 \rightarrow CH_3Cl + HCl \\ CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl \\ CH_2Cl_2 + Cl_2 \rightarrow CHCl_3 + HCl \\ CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl \end{array}$
Alkenes				
Elimination	Preparation of Alkene/ Dehydration of Alcohol	Excess c. H ₂ SO ₄ 170° Al ₂ O ₃ 300–350°	$RH_2C-CH_2OH \xrightarrow{H_2SO_4 \text{ at } 170^\circ} RHC=CH_2 + H_2O$	
	Dehydrohalogenation of Halogenoalkanes (Markovnikov Involved)	NaOH _(alc) Reflux	$\begin{array}{l} RHXC-CH_3 \xrightarrow{NaOH_{(alc)}} RHC=CH_2 + NaX + H_2O \\ RHXC-CH_3 \xrightarrow{NaOH_{(aq)}} RCH(OH)-CH_3 + NaX \end{array}$	
EA	Hydrohalogenation of Alkenes (Markovnikov Involved)	HX r.t.	$H_2C=CH_2 + HX \xrightarrow{RTP} H_3C-CH_2X$	
	Halogenation of Alkenes in CCl ₄	X ₂ in CCl ₄ r.t. Decolor from red-brown Br in CCl ₄	$H_2C=CH_2 + X_2 \xrightarrow{RTP+CCl_4} H_2XC-CH_2X$	
	Halogenation of Alkenes in H ₂ O	X ₂ in H ₂ O r.t. Decolor from red-brown Br _(aq)	$H_2C=CH_2 + X_2 + H_2O \xrightarrow{RTP} H_2XC-CH_2OH + HX$	
	Hydration of Alkenes	c. H ₂ SO ₄ H ₂ O Δ	$H_2C=CH_2 + H_2O \xrightarrow{H_2SO_4 \text{ with } \Delta + \text{water}} H_3C-CH_2OH$	
Reduction	Hydrogenation of Alkenes	H ₂ Pt/Pd; r.t. or Ni; 140°	$H_2C=CH_2 + H_2 \xrightarrow{Pt/Pd \text{ at } RTP / Ni \text{ at } 140^\circ} H_3C-CH_3$	

Oxidation	In/Complete Combustion	$O_2 \parallel \Delta$	$C_2H_4 + 3O_2 \xrightarrow{\Delta} 2CO_2 + 2H_2O$ $C_2H_4 + 2O_2 \xrightarrow{\Delta} 2CO + 2H_2O$ $C_2H_4 + O_2 \xrightarrow{\Delta} 2C + 2H_2O$
	Hydroxylation/Diol Formation	Alkaline/Dil. $KMnO_4 \parallel$ Cold \parallel Purple decolors to Brown ppt = MnO_2	$H_2C=CH_2 + [O] + H_2O \rightarrow H_2OHC-CH_2OH$
Halogenoalkanes			
ES	Preparation from Alcohols	$PX_3 \parallel$ Reflux $PCl_5 \parallel$ r.t. $SOCl_2 \parallel$ Reflux* HX	$3ROH + PX_3 \xrightarrow{reflux} 3RX + H_3PO_4$ $ROH + PX_5 \xrightarrow{RTP} RX + HX + POX_3$ $ROH + SOCl_2 \xrightarrow{RTP} RX + HX + SO_2$ $ROH + HX \rightarrow RX + H_2O$
EA	Preparation from Alkenes / Hydrohalogenation of Alkenes	$HX \parallel$ r.t.	$RH_2C=CH_2 + HX \xrightarrow{RTP} RH_2XC-CH_3$
Nuc Substitution	Alkaline Hydrolysis/ Formation of Alcohol	$NaOH_{(aq)} \parallel$ Under reflux	$RX \xrightarrow{NaOH(aq)} ROH + X^-$
	Formation of Nitriles	$KCN_{(alc)} \parallel$ Reflux	$RX + CN^- \xrightarrow{NaOH(alc)} RCN + X^-$
Hydrolysis	Further Carboxylic Acid Formation	$H^+_{(aq)} \parallel \Delta$	$RCN \xrightarrow{H^+ + \Delta} RCOOH + NH_4^+$
Reduction	Further Amine Formation	$LiAlH_4$ in dry ether \parallel r.t. + H_2O	$RCN + 4[H] \xrightarrow{RTP} RCH_2NH_2 + NH_4^+$
Nuc Substitution	Amine Formation	Excess $NH_{3(alc)} \parallel \Delta \parallel$ Pressure in Sealed Tube	$RX + NH_3 \xrightarrow{\Delta} RNH_2 + HX$ <p>Note: Excess RX forms higher order amines</p>
Elimination favored: <ul style="list-style-type: none"> Δ $\uparrow [NaOH]$ Solvent=Ethanol Substitution favored: <ul style="list-style-type: none"> Solvent = H_2O 	S_N2 1° Halogenoalkanes	Polar Aprotic Solvents (contain no H atoms connected directly to an EN atom. Not capable of H-bonding)	$H_3C-CH_2X + OH^- \xrightarrow{slow} H_2C(OH)-CH_3 + X^-$
	S_N1 3° Halogenoalkanes	Polar Protic Solvents (capable of hydrogen H-bonding.)	$C(RR'R'')X \xrightarrow{slow} C^+(RR'R'') + X^- \xrightarrow{fast+OH^-} C(RR'R'')OH$
Elimination	(follows Markovnikov)	$NaOH_{(alc)} \parallel$ Under reflux	$H_3C-CH_2X + NaOH \xrightarrow{NaOH(aq)} H_2C=CH_2 + NaBr + H_2O$

Alcohols				
Hydration	Preparation from	Alkenes	Cold c. H ₂ SO ₄ H ₂ O Δ	$H_2C=CH_2 \xrightarrow{\text{Cold c. H}_2\text{SO}_4} H_3C-CH_2-OSO_3H \xrightarrow{\text{Water}+\Delta} H_3C-CH_2OH$
NS		Alkaline Hydrolysis of Halogenoalkanes	NaOH _(alc) Reflux	$RX \xrightarrow{\text{NaOH(alc)}} ROH + X^-$
Reduction		Reduction of Carboxylic Acids	LiAlH ₄ in dry ether r.t. + H ₂ O OR NaBH ₄ (alc) OR H ₂ /Pt/Pd; r.t. or H ₂ /Ni; 140° Na _(alc)	$RCOOH + 4[H] \xrightarrow{RTP} RCH_2OH + H_2O$
		Reduction of Aldehydes → 1° Alcohols		$RCHO + 4[H] \xrightarrow{RTP} RCH_2OH$
		Reduction of Ketones → 2° Alcohols		$RR'C=O + 4[H] \xrightarrow{RTP} RR'CH-OH$
Nuc Substitution	Formation of Haloalkanes		Reflux ZnCl ₂ in case of X=Cl	$ROH + HX \rightarrow RX + H_2O$
Redox	Reaction with Na		Reactive Metal	$2ROH + 2Na \rightarrow 2RO^-Na^+ + H_2$
Oxidation	Oxidation of 1° Alcohols		Alc → Aldehyde = Distillation	$RCH_2OH \xrightarrow{[O] \text{ and Distil}} RCH=O \xrightarrow{[O] \text{ and Reflux}} RCOOH$
	Oxidation of 2° Alcohols (No 3° as alpha carbon does not have H atoms)		Alc → Carboxylic acid = Reflux Alc → Ketone = Reflux	$RR'CHOH \xrightarrow{[O] + Reflux} RR'C=O$ [O] can be MnO ₄ ⁻ OR Cr ₂ O ₇ ²⁻ /H ⁺
Elimination	Dehydration to Alkenes (follows Zaitsev=More Alkyl groups=major)		Excess c. H ₂ SO ₄ 170° Al ₂ O ₃ 300–350°	$RH_2C-CH_2OH \xrightarrow{\text{H}_2\text{SO}_4 \text{ at } 170^\circ} RHC=CH_2 + H_2O$
Esterification	Acylation (Ester Formation) with Carboxylic Acids		c. H ₂ SO ₄ Δ	$RCOOH + R'OH \xrightleftharpoons{\text{c.H}_2\text{SO}_4+\Delta} RCO-OR' + H_2O$
Esterification	Acylation (Ester Formation) with Acyl Chlorides		r.t.	$RCO-Cl + R'OH \rightarrow RCO-OR' + HCl$

Aldehydes & Ketones (Carbonyl Compounds)			
Oxidation	Preparation from Alcohol	Alc—> Aldehyde = Distillation Alc —> Ketone = Reflux [O] can be MnO ₄ ⁻ OR Cr ₂ O ₇ ²⁻ /H ⁺ (orange to green)	$RCH_2OH \xrightarrow{[O] \text{ and Distil}} RCH=O$ $RR'CHOH \xrightarrow{[O] \text{ and Reflux}} RR'C=O$
Reduction	Reduction of Aldehydes —> 1° Alcohols	LiAlH ₄ in dry ether r.t. + H ₂ O OR NaBH ₄ (alc) OR H ₂ /Pt/Pd r.t. or H ₂ /Ni 140° OR Na(alc)	$RCHO + 4[H] \xrightarrow{RTP} RCH_2OH$
	Reduction of Ketones—> 2° Alcohols		$RR'C=O + 4[H] \xrightarrow{RTP} RR'CH-OH$
Carboxylic Acids, Esters, Acyl Chlorides and Anhydrides			
Oxidation	Preparation of Carboxylic Acids from Oxidation of 1° Alcohol	MnO ₄ ⁻ / H ⁺ OR Cr ₂ O ₇ ²⁻ /H ⁺ Δ Reflux	$RCH_2OH + 2[O] \xrightarrow{\Delta / Reflux} RCOOH + H_2O$
	Preparation of Carboxylic Acids from Oxidation of Aldehydes		$RCH=O + [O] \xrightarrow{\Delta / Reflux} RCOOH$
Hydrolysis (Acidic/Basic)	Preparation of Carboxylic Acids from Hydrolysis of Nitriles	dil. H ₂ SO ₄ / HCl Δ Reflux	$RCN + 2H_2O + H^+ \xrightarrow{reflux} RCOOH + NH_4^+$
		NaOH(aq) followed by dil. H ₂ SO ₄ / HCl Δ Reflux	$RCN + 2H_2O + OH^- \xrightarrow{reflux} RCOO^- + NH_3$ $RCOO^- \xrightarrow{H^+} RCOOH$
Acid-Base Reaction	Formation of Carboxylate Salts	—	$RCOOH + NaOH \rightarrow RCOO^-Na^+ + H_2O$ $2RCOOH + Na_2CO_3 \rightarrow 2RCOO^-Na^+ + CO_2 + H_2O$ $RCOOH + Na \rightarrow RCOO^-Na^+ + \frac{1}{2}H_2$
Esterification	Formation of Esters	c. H ₂ SO ₄ Reflux	$RCOOH + R'OH \xrightleftharpoons{c.H_2SO_4+Reflux} RCO-OR' + H_2O$
Nuc Substitution	Formation of Acyl Chlorides	SOCl ₂ * or PCl ₅ r.t.	$RCOOH + PCl_5 \xrightarrow{RTP} RCOCl + HCl + POCl_3$ $RCOOH + SOCl_2 \xrightarrow{RTP} RCOCl + HCl + SO_2^*$
Reduction Hydrolysis	Reduction to 1° Alcohols	LiAlH ₄ in dry ether r.t. + H ₂ O	$RCOOH + 4[H] \xrightarrow{RTP} RCH_2OH + H_2O$

			Other reducing agents can't be used as reduction is more difficult	$\left[RCOCH_2\textbf{COOH} + 2[H] \xrightarrow{NaBH_4(alc)} RCH(OH)CH_2\textbf{COOH} \right]$
Esterification	Acyl Chlorides +	Alcohols	r.t.	$RCO-Cl + R'OH \rightarrow RCO-OR' + HCl$ Name: R'-yl R-oate
Nuc Addition		Ammonia		$RCOCl + NH_3 \rightarrow RCONH_2 + HCl$
		1° Amines		$RCOCl + R'NH_2 \rightarrow RCONHR' + HCl$ Name: N-R'-yl R-amide
Hydrolysis		Water		$RCOCl + H_2O \rightarrow RCOOH + HCl$
Esterification	Preparation of Esters from Carboxylic Acids + Alcohols		c. H ₂ SO ₄ Δ	$RCOOH + R'OH \xrightleftharpoons{c.H_2SO_4+\Delta} RCO-OR' + H_2O$
	Preparation of Esters from Acyl Chlorides + Alcohols		r.t.	$RCO-Cl + R'OH \rightarrow RCO-OR' + HCl$
Hydrolysis	Hydrolysis of Esters (Acidic)		dil. H ₂ SO ₄ / HCl Reflux	$RCOOR' + H_2O \xrightleftharpoons{H^++Reflux} RCOOH + R'OH$
	Hydrolysis of Esters (Alkaline)		NaOH _(aq) followed by Alcohol/ Carboxylate Salt Reflux	$RCOOR' + NaOH \xrightarrow{reflux} RCOO^-Na^+ + R'OH$ $RCOO^-Na^+ \xrightarrow{H^+} RCOOH + Na^+$
Benzene				
ES	Nitration of Benzene		c. H ₂ SO ₄ c. HNO ₃ >60°	<div>$2H_2SO_4 + HNO_3 \xrightarrow{\Delta} NO_2^+ + 2HSO_4^- + H_3O^+$<p style="text-align: center;">ortho meta para</p></div>

ES	Bromination of Benzene	$\text{Br}_2 \parallel \text{Fe} \mid \text{FeBr}_3$	
Free Radical Substitution	Chlorination of Benzene	Limited $\text{Cl}_2 \parallel \text{UV}$	
Oxidation	Oxidation of Alkylbenzene to Carboxylic Acid	$\text{MnO}_4^- / \text{H}^+ \parallel \Delta$ OR $\text{MnO}_4^- / \text{OH}^- \parallel \Delta \parallel \text{H}^+$	<p style="text-align: center;"><i>Alkylbenzene</i> <i>Benzoic acid</i></p>

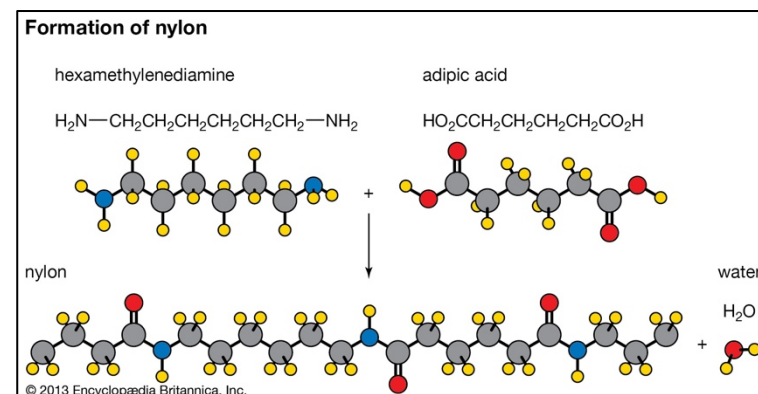
Extra Notes

Nucleophilic substitution — a nucleophile (contains a lone pair + negative charge) attacking a molecule that is electron deficient. This is prevalent in halogenoalkanes due to the polar bond.

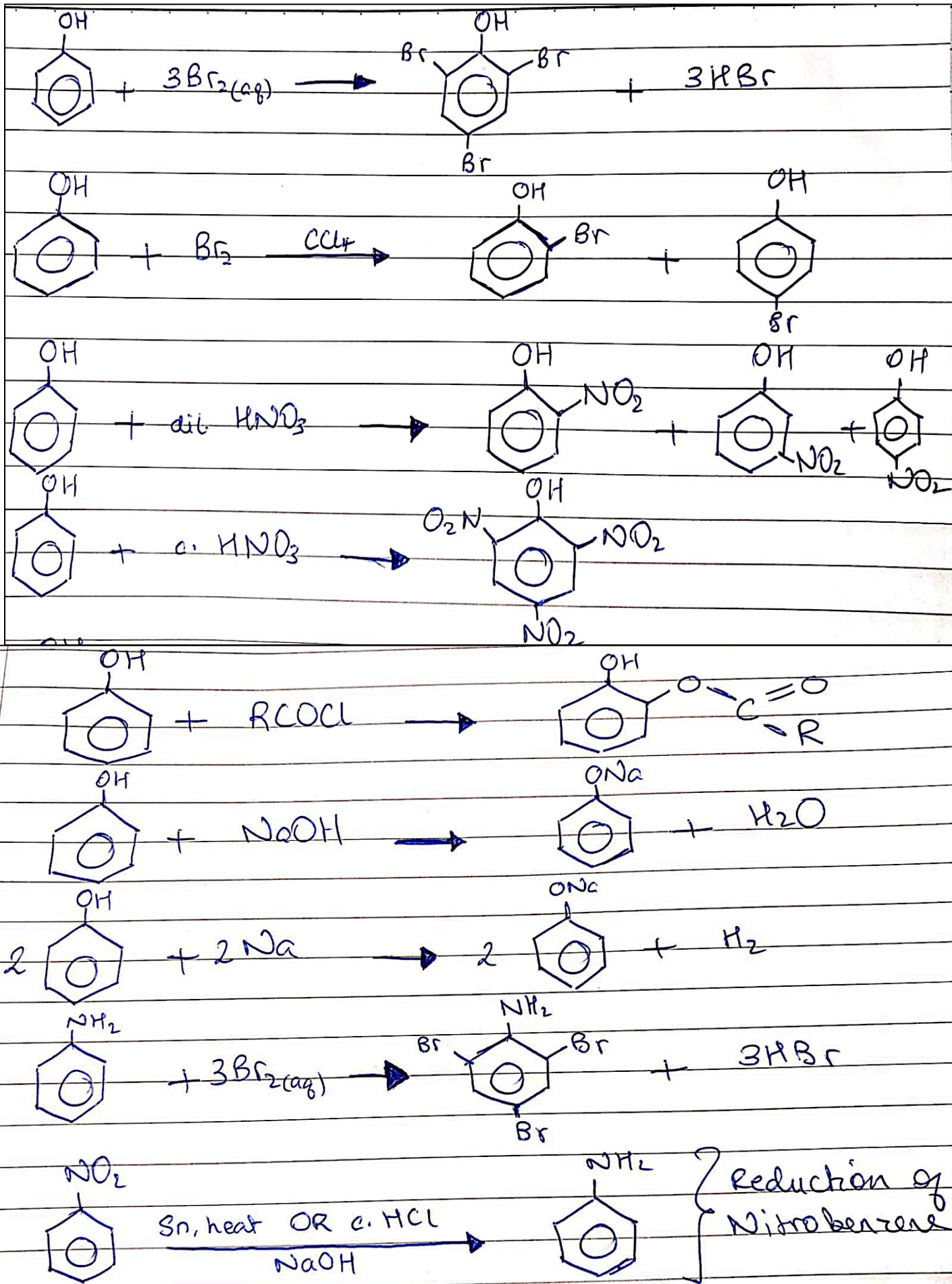
Electrophilic addition — when electrophiles (electron deficient/cations) molecules are combined with another molecule. And usually this happens with alkenes. Alkenes have a double bond where pi bonds are present, and here it is dense in electrons.

Polymerization — is the merging of several alkenes.

- Monomers \rightarrow Polymers which are huge molecules with repeating units Ethene \rightarrow Polyethene.
 - The double bonds are broken from ethene and actually a really long chain of alkane is formed. Propene \rightarrow Polypropylene
- Condensation polymerization can only happen when there are two reactive functional groups. You must form chains on both ends! But addition polymerization require double bond(s).



Further Reactions



Key:

|| - And

| - Or