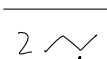
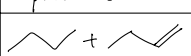
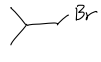
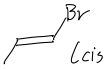
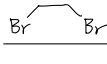
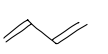
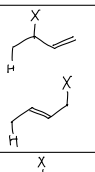
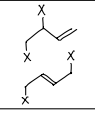
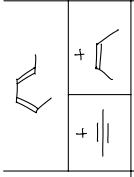
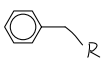
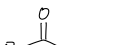
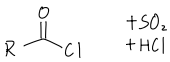
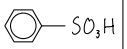
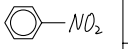
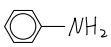
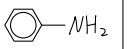
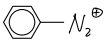
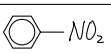
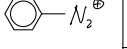
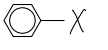
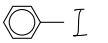
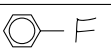
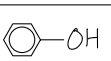
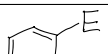
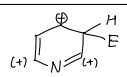
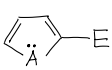
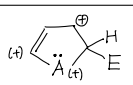
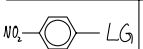
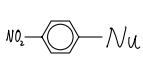
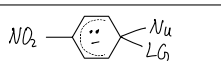
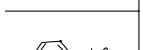
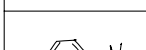
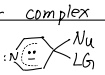
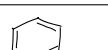
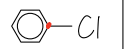
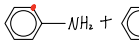
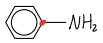
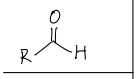
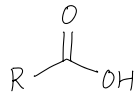
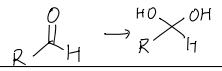
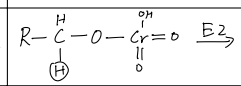
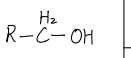
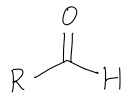
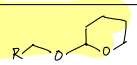
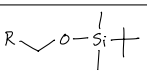
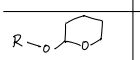
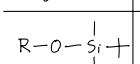
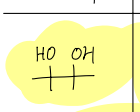
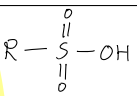
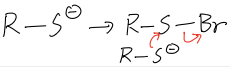
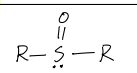
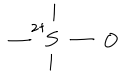
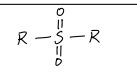
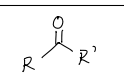
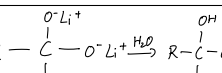
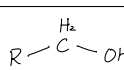
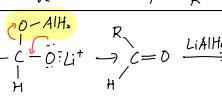
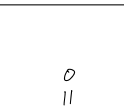
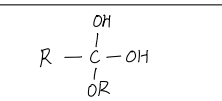
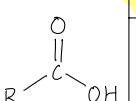
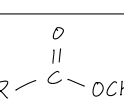
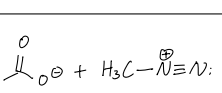
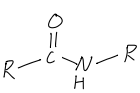
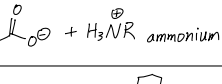
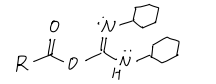
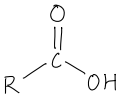
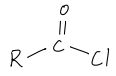
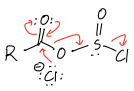
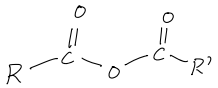
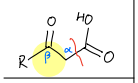
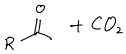
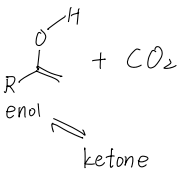
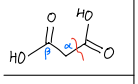
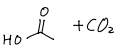
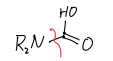
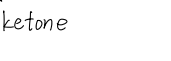
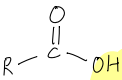
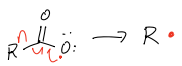
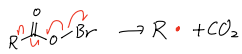
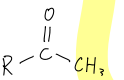
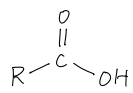
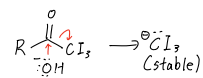
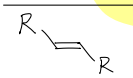
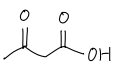
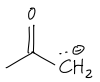
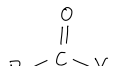
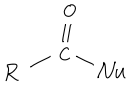
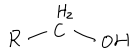
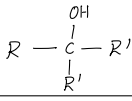
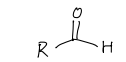
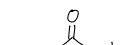
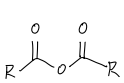
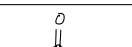
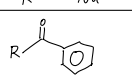
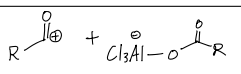
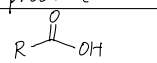
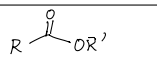
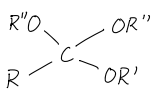
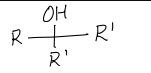
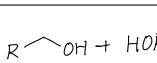
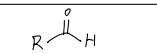
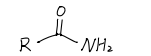
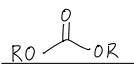
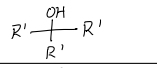
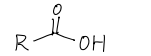
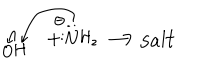
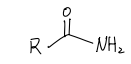
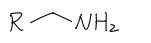
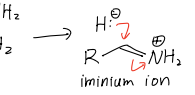
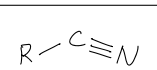
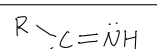
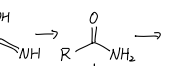
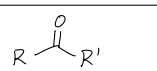
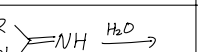
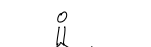
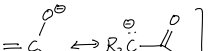
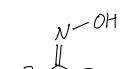
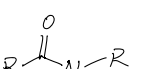
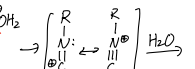
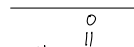
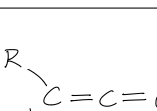
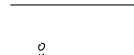
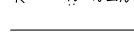
reactant	reagent	product	selectivity	mechanism	intermediate	$C^{\oplus}$ shift ?	comments
	H_3O^+		Markovnikov		$C^{\oplus}$	✓	
	HX			~	$C^{\oplus}$	✓	
				trans ?	cyclic	X	hard to stop
	(excess)			~	cyclic → $C^{\oplus}$	?	Geminal
	H_2 Pd/C			syn	attach to metal	X	
							
	$Pd/CaCO_3/Pb$ (Lindlar)			cis			
	Na/NH_3			trans	solvated e^- → radical anion → weaken C≡C	X	trans  more stable
	X_2 CCl_4			anti	cyclic	X	Vicinal
	Nu:		Nu: Markovnikov		breaks weaker bond		
	(excess)				?		not as favored
	1. $Hg(OAc)_2$/ H_2O 2. $NaBH_4$		Markovnikov	anti	cyclic	X	
				(trans)			tautomerization
	1. BH_3 2. H_2O_2/OH^-		anti-Markovnikov	syn	concerted partial bonds	X	
				(trans/syn)			tautomerization
	1. O_3 2. Zn/H_2O or $(CH_3)_2S$ or H_2/Pd (red)				cyclic		aldehyde
	2. H_2O_2 (oxi.)						carboxylic acid
	2. ~ (oxi or red)						always carboxylic acid
	$R-\ddot{N}-\ddot{N}=\ddot{N}$						work for all 1,3-dipole
	1. $KMnO_4$ 2. H_2O/OH^-			syn	similar to 1,3-dipole	X	
	1. OsO_4 2. H_2O/Na_2SO_3						
	CH_2N_2 $h\nu(\Delta)$		add to more sub.	syn (singlet) mix (triplet)	carbene $:CH_2$ (or X_2)	X	
	CHX_3 $KOC(CH_3)_3$						
	CF_3CO_3H (or mCPBA)			syn	last O added rest becomes carboxylic acid	X	
	HNu $H_2Nu^{\oplus}$		Markovnikov	anti	prot. → SN2-like → deprot.	X	better resonance
	$:Nu^{\ominus}$		anti-Markovnikov		SN2 → prot.		less hindrance
	1. RMgX ether 2. H_2O		R anti-Markovnikov	syn	Mg add	X	less hindrance: R-Li also good
	1. $RCu(CN)Li_2$ 2. H_2O						good for C=O
	1. $LiAlH_4$ ether 2. H_2O		H anti-Markovnikov	anti			

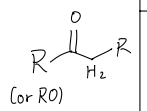
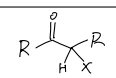
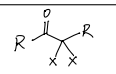
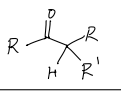
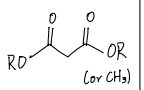
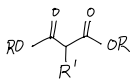
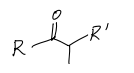
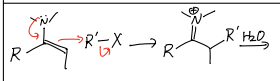
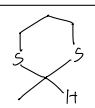
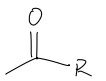
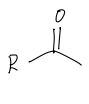
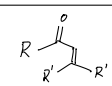
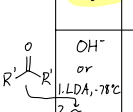
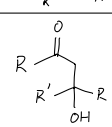
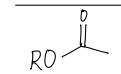
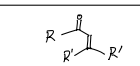
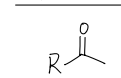
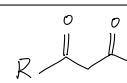
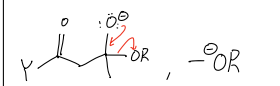
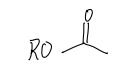
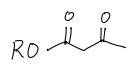
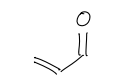
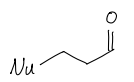
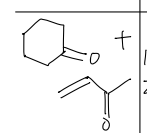
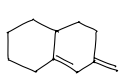
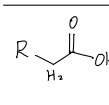
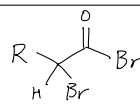
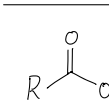
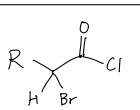
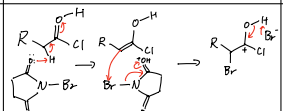
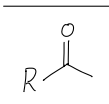
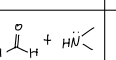
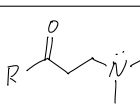
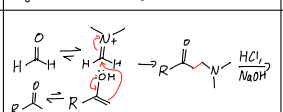
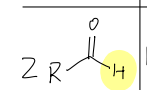
reactant	reagent	product	selectivity (o/m/p)	mechanism	intermediate	C⊕ shift ?	comments
2 							inefficient
		$H_3C\cdot$ + 					
	H–Br IV· hν		anti-Markovnikov		C·	✓	Br only
	H–Br IV· hν −70°C	 (cis/trans)	anti-Markovnikov		vinyl C·		Br only
	(excess)		anti-M x2		C·		vicinal
	CX_4 IV· hν		anti-M ?		C·	X	X = Cl, Br
	X_2 (dilute) hν		mostly more subbed (~M)		C·	X	Br more selective
	NBS hν trace HBr		allylic			✓	X_2 conc. must be low, or will be polar addition
	KNH_2 NH_3		?				2 x E_2
	1. KNH_2 NH_3 2. H_2O		terminal alkyne				⇌
	HX −70°C	 (1,2) + (1,4)	Markovnikov; kinetic: 1,2 thermodynamic: 1,4	syn	 cyclic		
	X_2 −70°C						S_N1'
	△	 (1 enant.) (1 enant.)	endo preferred	syn	(concerted)	X	diene in s-cis, ⇌
	1. $KMnO_4$ (or $H_2Cr_2O_7$) 2. H_3O^+/H_2O						No 3° R!
	1. Na/NH_3 EtOH 2. H_2O		e⁻ draw; e⁻ donate		 (1 resonance)		
	H_2/Rh (or Pt oxides) CH_3CH_2OH △/pressure						acid group also reduced to OH
	D_3O^+ D_2O						Can poly add
	SO_3 H_2SO_4		(m)				
	HNO_3 H_2SO_4		(m)				
	$NO_2^{\oplus}BF_4^{\ominus}$ −20°C						
	X_2 FeX_3		(o/p)	S_EAr	$X-\overset{\oplus}{X}-\overset{\ominus}{Fe}X_3$		
	R–X AlX_3		(o/p)		$C^{\oplus}$ for 2°, 3° $R-\overset{\oplus}{X}-\overset{\ominus}{AlX_3}$ for 1°, Me partial bonds	✓	
	 $AlCl_3$		(m)		$AlCl_4^{\ominus} + R-\overset{\oplus}{C}=O$	X	$AlCl_3$ used to hydrolyze, not only catalyst → $Al(OH)_3$

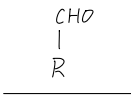
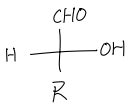
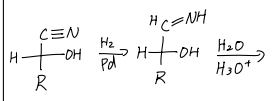
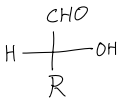
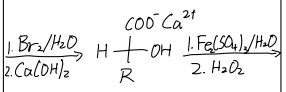
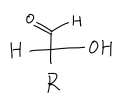
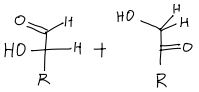
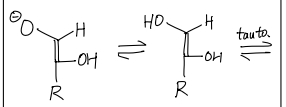
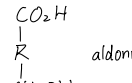
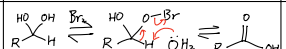
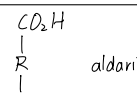
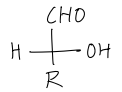
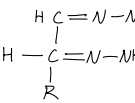
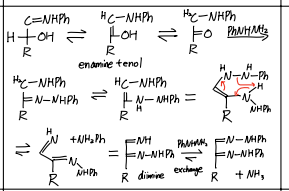
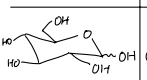
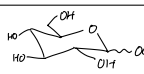
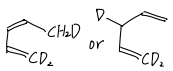
reactant	reagent	product	selectivity (current preferred site) (following o/p/m)	mechanism	intermediate	$C^{\oplus}$ shift ?	comments
	$Zn(Hg)/HCl$ $EtOH$		(o/p)				remove O
	H_2N-NH_2 KOH 						
							
	H_2O H_3O^+ $\triangle$						
	$H_2/Pd/C$ $EtOH$		(o/p)				
	1. Sn/HCl 2. $^-OH/H_2O$						
	$NaONO$ HCl			Lots of carbonyl ill	$2HONO \rightarrow ONONO$		
	CF_3CO_3H		(m)				
	CuX		(o/p)				X = Cl, Br, CN
	KI						
	HBF_4						
	H_2O H_2SO_4/Δ						
	H_3PO_2						
	$E^{\oplus}$		3	S_EAr			Slower than benzene 3° favored since no $\oplus$ on N.
			2				Faster than benzene more C share $\oplus$ w/ A (:A = :NH , :O , :S)
	$:Nu^{\ominus}$ HNu		NO_2 on o/p	S_NAr			At least one NO_2
					Meisenheimer complex		
			2/4				ipso attack
	1. KNH_2 NH_3 2. H_2O	 $+H_2\uparrow$	2 (intra H-bond)				1. loss of $H^{\ominus}$ Also R–Li → R adds to 2-
	KNH_2 NH_3	 + 			 (benzyne)		
	H_2O H_3O^+ or OH^-		Less hindered ✓ α-e^- drawing group ✓ resonance X				$\overset{H_2O}{\rightleftharpoons}$ gem-diol
	ROH ROH_2^+ or RO^-						Hemiacetal Not isolable, except for ring
							Acetal Protect C=O from base excess ROH → ← excess H_2O
	1. $NaCN$ 2. H_3O^+						
	1. $NaHSO_3$ 2. H_3O^+						
	RNH_2 H_3O^+		[1°]				imine
	R_2NH H_3O^+		[2°] (3° no rxn)	add → E2			enamine (less stable)
	1. $R-Li$ ($R-MgX$) 2. H_3O^+						H_2O destroys organometallic. Needs to apply separately
	$LiAlH_4$						Irreversible
	$NaBH_4$						
	$(Ph)_3P=CR_2$				(oxophosphetane)		Wittig rxn Reverse of ozonolysis

reactant	reagent	product	selectivity [#°]	mechanism	intermediate	C⊕ shift ?	comments
	Na_2CrO_4 ($Na_2Cr_2O_7$) H_3O^+						2° OH → ketone 1° OH → aldehyde → acid
			[1~2°]				
	HNO_3		[1°]				[O] also = RuO_4
	$KMnO_4$		[1-2°]				further oxidize to acid (?)
	CrO_3 pyridine	(if careful,)	[1-2°]	add → E2			
	PCC		[1-2°]				No $-_2O$ in reagent, so aldehyde can't hydrate
	MnO_2		[allylic/benzylic]				
	DMSO []/ ClCOCOCl/ $:NEt_3$		[1-2°]	intramolecular E2			
							OH protecting group
							
	H_2O H_3O^+	$R-OH$					Regenerate OH
	$^+NH_4$ F^-						
	HIO_4/ H_2SO_4	2 			Cyclic		
R-SH	HNO_3						S gets oxidized, not C, as in alcohol
	Br_2 base (or I_2)	R-S-S-R		S_N2			$KHCO_3$ deprots RS-H.
R-S-R	ROOH						RSOR / RSO_2R tetrahedral  preferred
	(excess)						
2 R-Li	CuBr	R_2CuLi					
R-X	R'_2CuLi	$R-R'$ + $R'-Cu$ + $Li-X$	[R is 1°/2°]	S_N2 ?	$R:^\ominus$		R-Li, R-MgX strong B:⊖, not Nu:⊖
	$LiAlH_4$	$R-H$			$H:^\ominus$		
	$LiHB(Et)_3$						
	1. 2 R'-Li 2. H_2O						acid deprot. first. Then R'-Li add Dianion has no good LG → must ketone
	1. $LiAlH_4$ 2. H_2O			add → elim			Aldehyde as intermediate, but will reduce again. $^-OAlH_2$ is a good LG
	excess R'OH $R'OH_2$			add → elim			ana. hemiacetal can poly can be intra (lactone)
	1. NaOH 2 R'-LG			S_N2			
	CH_2N_2		methyl ester only				
	$R'NH_2$ intense △				 ammonium salt		intense heat
	$R'NH_2$ DCC			add → elim.			Change LG (OH) can poly can be intra (lactam)

reactant	reagent	product	preference	mechanism	intermediate	C⊕ shift ?	comments
	$SOCl_2$			add→ elim			ana. $R-OH \xrightarrow{SOCl_2} R-Cl$
	PCl_5						
	1. NaOH 2. 			add → elim			
	DCC (or P_2O_5)						(dehydrating reagents)
	△ (melt)						cyclic anhydride
	△			intramolecular Diels-Alder-like			β-keto acid → ketone
							malonic acid → acid
		ROH + CO_2					monoester of c. acid → alcohol diester stable, since no H to lose
		$R_2NH + CO_2$					 stable, also no H
	1. NaOH 2. electrochemical oxidation	$R-R + CO_2$		radical			Kolbe electrolysis
	1. Ag_2O 2. Br_2 △	$R-Br$					Hunsdiecker rxn. Chain
	1. I_2 NaOH (or Br_2) 2. H_3O^+ H_2O		Methyl ketone only	add→ elim			Haloform rxn I makes H more acidic
	$KMnO_4$ / 18-Crown-6/H_3O^+						Like ozonolysis
CO_2	1. R-MgBr 2. H_3O^+ H_2O						
	1. LDA 2. CO_2 3. H_3O^+ H_2O						
	$Nu^{\ominus}$:			add elim			Nu: = H_2O, HOR, NHR_2, $N_3^{\ominus}$, $^{\ominus}CN$, $RCOO^{\ominus}$, $^{\ominus}CH_2N_2^{\oplus}$
	1. $LiAlH_4$ 2. H_2O			add/elim → add			
	1. $2R'MgBr$ 2. H_2O						2 eq.
	1. $LiAl(OC(CH_3)_3)_3H$ 2. H_2O		aldehyde	add elim			bulky
	H_2/ Pd/Quinoline/S						Rosenmund reduction deactivated catalyst
	1. R'_2CuLi 2. H_2O		ketone				
	$Nu^{\ominus}$:			add elim			
	 /$AlCl_3$						F. C.

reactant	reagent	product	preference	mechanism	intermediate	C⊕ shift ?	comments
	H_2O (H_3O^+ (or OH^-))			add elim			ester hydrolysis
	HOR' ($H_2OR'^+$ (or OR'^-))						transesterification
	further HOR'' $H_2\overset{+}{O}R''$			add			ortho ester unstable. acetal/ketone / o.e. no resonance, but ester has
	1. $2\,R'MgBr$ 2. H_2O						2 eq.
	1. $LiAlH_4$ (or $NaBH_4$) 2. H_2O			add/elim → add			$NaBH_4$ won't work
	1. DIBAL-H 2. H_2O			add elim			DIBAL-H = 
	NH_3 ($NaNH_2$ (or NH_4Cl))						
	1. $3\,R'MgBr$ 2. H_2O						3 eq.
	H_2O H_2SO_4			add elim			slow, but irreversible
	1. $LiAlH_4$ 2. H_2O			add/elim → weird stuff			Gets NH_2, not OH! $NaBH_4$ won't work
	P_2O_5 △						dehydration
	$Nu:^-$			add			
	H_2O H_3O^+ (or OH^-)			add/elim X3			
$R-C\equiv N$	1. $R'MgBr$ 2. H_2O			add/elim → hydrolysis			Stop at ketone Imine has no LG, so survives till H_2O
	1. $LiAlH_4$ 2. H_2O						
	H_2 / Raney Ni						1° amine less reactive than =
$R_2C=C=O$	$Nu:^-$						sp C very reactive
	RCO_3H		H > 3° > 2° > 1° > 0°			X	Baeyer-Villiger
	H_2SO_4 / H_2O			backside attack			Beckman
	$:NR_3$		(3° N)				
	$h\nu$ / △ / Ag					X	Wolff carbene can add to = or insert between C—H Arndt-Eistert rxn: adds a C to R $RCO_2H \rightarrow 1.SOCl_2,\ 2.CH_2N_2,\ 3.\Delta/Ag,\ 4.H_2O$
	$h\nu$ / △						Curtius migration when lose N_2
	1. Br_2 2. H_2O/KOH	$R-NH_2$ $+CO_2+H_2O$					Hofmann isocyanate not isolable −1C
$O=C=\ddot{N}-R$	$Nu:^-$						very reactive

reactant	reagent	product	preference	mechanism	intermediate	C⊕ shift ?	comments
 (or RO)	D_2O D_3O^+ (or OD^-)				enol(ate)		Also racemerization
	X_2 H_3O^+			S_N2			Stops at mono
	X_2 ^-OH						All the way. If $CH_3 \rightarrow$ haloform
	1. LDA 2. $R'-X$		No 3° R				Works for aldehyde, ketone. For acid need 2 eq. LDA, +3. H_3O^+
 (or CH_3)	1. NaOR 2. $R'-X$						Then, 1. H_3O^+, 2. gentle $\Delta \rightarrow -CO_2$ $\rightarrow$ acid or ketone (malonic ester synthesis)
	1. $R'-X$ 2. H_2O H_3O^+		2° amine				Problem: >1 enamine may form
	1. BuLi THF 2. $R-X$ 3. H_3O^+ Hg^{2+}						3. RaNi $\rightarrow$ 
	H_3O^+		aldehyde ✓ receptor $\rightleftharpoons$ thermo product		enolate $\rightarrow$ add to C=O		Aldol
	 OH⁻ or 1. LDA, -78°C 2. ≥ 3. H_3O^+		If LDA, kinetic				Reversible Can be intra LDA stepwise to control enolate
	$RO^\ominus$						Knoevenagel Sometimes Nu: anion not enolate E.
	1. $NaNH_2$ (or LDA) 2.  3. H_3O^+		kinetic, less sub enolate		 , $-^\ominus OR$		Claisen Ketone enolate > ester
	1. NaOR 2.  3. H_3O^+						product not favored, but double α deprot. is irreversible until H_3O^+ Need leg. OR^-, Rs must match
	$Nu:^\ominus$						Michael Also can acid-cat. Preferred over C=O add, but not for $Nu:^\ominus = LiAlH_4$, $RMgBr$ yes for R_2CuLi, $RMgBr$/cat. CuI
	1. NaOEt/HOEt 2. KOH/H_2O				Michael $\rightarrow$ enolate trans $\rightarrow$ aldol $\rightarrow$ $-H_2O$		
	Br_2 / PBr_3			last S_N2	acid $\xrightarrow{PBr_3}$ a. bromide $\rightleftharpoons$ enol $\xrightarrow{Br_2}$ α-bromo a.b.		HVZ rxn a. bromide + H_2O/HOR/NH_3 $\rightleftharpoons$ α-bromo acid S_N2 reactive
	1. $SOCl_2$ 2. NBS HBr						
	1.  HCl 2. NaOH H_2O			aldol-like			Mannich β-amino ketone
	KOH H_2O		No α-H	$H:^\ominus$ trans			Cannizzaro
	$AlCl_3$						
	1. 2. H_2O		R' no α-H	$H:^\ominus$ trans			Al clamp
	Ph_3CLi DME		thermo				warm temp, weak base Also KH/BEt_3 $\rightarrow$

reactant	reagent	product	preference	mechanism	intermediate	$C^{\oplus}$ shift ?	comments
	1. NaCN H_2O 2. H_2 Pd 3. H_2O H_3O^+						Kilioni-Fischer Synthesis +C mix at C(2) poisoned catalyst
	1. Br_2/H_2O 2. $Ca(OH)_2$ 3. $Fe_2(SO_4)_3$/ H_2O/100°C 4. 30% H_2O_2			Unknown			Ruff degradation
	$Ca(OH)_2$ H_2O						Lobry de Bruijn-Alberda van Ekenstein
	Br_2/H_2O 0°C	 aldonic acid	aldehyde only				Mild
	$NaNO_2$/ HNO_3	 aldaric acid	aldehyde + 1°OH				More vigorous Also CrO_3 and $KMnO_4/H_3O^+$ Even more: $NaIO_4$
	3 $PhNHNH_2$ H_3O^+			enamine			Osazone No stereo at C(2)
	CH_3OH HCl		More stable $C^{\oplus}$ (anomeric)	S_N1			Acetal (glycoside (pyranoside, furanoside)) Stable under base, no Ether syn. Same for cat. HCl/H_2O
$RO-CH_2Ph$	H_2/Pd	$R-OH$					mild, protecting group
	$h\nu$ (or Δ)		4n: Δ con, $h\nu$ dis 4n+2: Δ dis, $h\nu$ con	conc.		X	Electrocyclic rxn
|| + || (general)			4n: ΔX, $h\nu$✓ 4n+2: Δ✓, $h\nu$X				Cycloaddition
							Sigmatropic rearrangement

THE END

Glad you've made it this far! The true journey of Orgo has just begun. Stay curious, stay synthesizing, and make your knowledge as boundless as your imagination :))