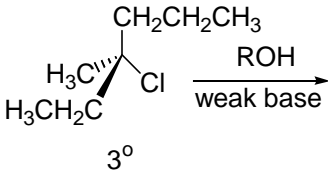
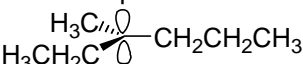
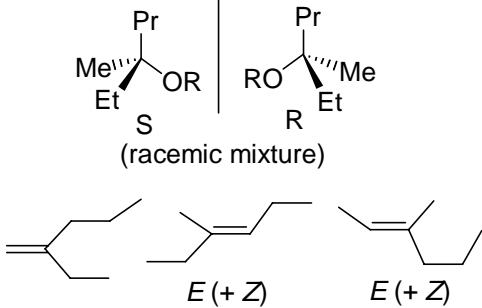
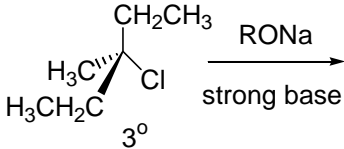
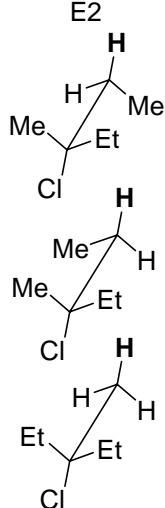
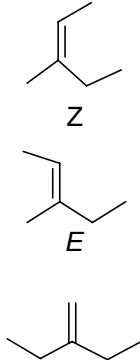
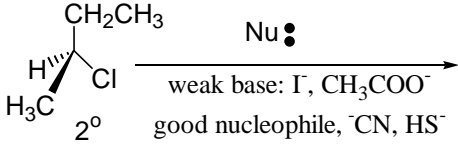
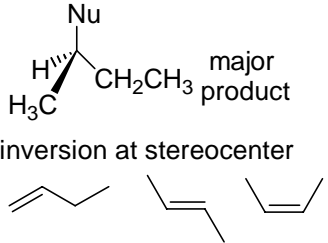
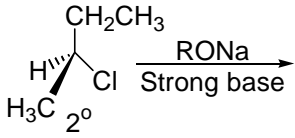
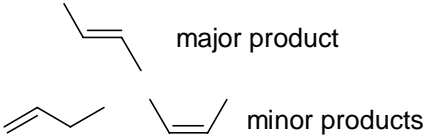
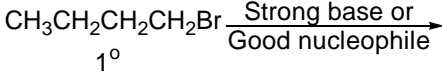
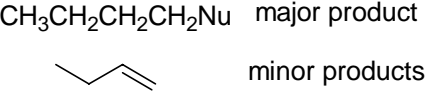
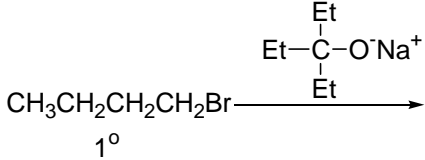
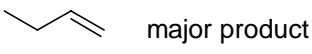
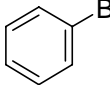
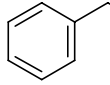
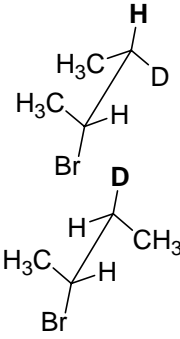
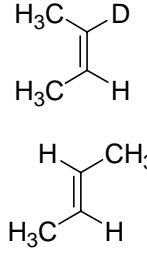
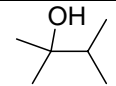




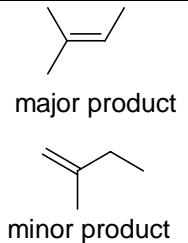
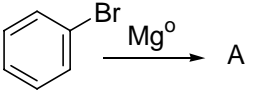
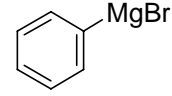
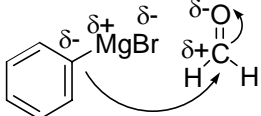
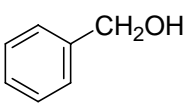
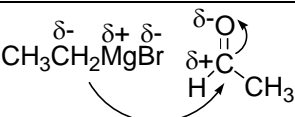
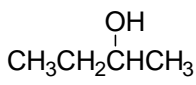
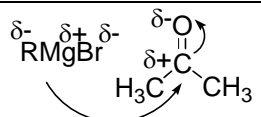
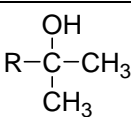
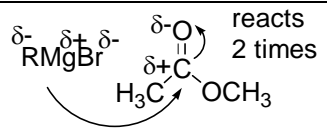
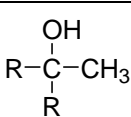
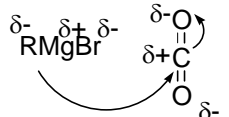
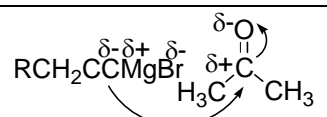
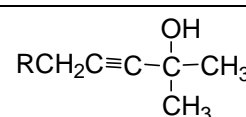
## Chemical Reactions Review

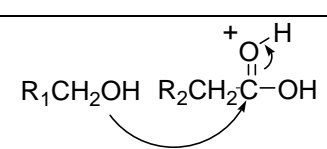
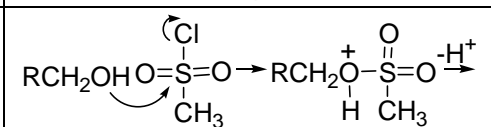
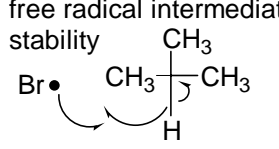
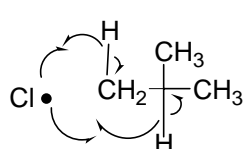
This is not a comprehensive list of reactions but is an excellent start.

Not all reactions are balanced and mechanisms are incomplete or shortened.

Question	Things to think about	Answer
 <p>3°</p>	$S_N1$ 	 <p>(racemic mixture)</p> <p><math>E(+Z)</math>      <math>E(+Z)</math></p>
 <p>3°</p>	$E2$ 	 <p><math>Z</math></p> <p><math>E</math></p>
 <p>2°</p> <p>weak base: <math>I^-</math>, <math>CH_3COO^-</math>      good nucleophile, <math>CN^-</math>, <math>HS^-</math>      aprotic solvent</p>	good nucleophiles that are not strong bases 2° carbon - aprotic solvent does not favour ionization $S_N2$ - favoured	 <p>major product</p> <p>inversion at stereocenter</p> <p><math>E2</math> - minor products</p>
 <p>2°</p> <p>Strong base</p>	all strong bases are good nucleophiles but 2° carbon - steric interaction $E2$ - favoured	 <p>major product</p> <p>minor products</p>
 <p>1°</p> <p>Strong base or      Good nucleophile</p>	1° carbon little steric interaction $S_N2$ - favoured	 <p>major product</p> <p>minor products</p>
 <p>1°</p>	1° carbon but the strong base is bulky lots of steric interaction $S_N2$ - unlikely to occur $E2$ - favoured	 <p>major product</p>

$\text{CH}_3\text{Br} \xrightarrow[\text{Good nucleophile}]{\text{Strong base or}}$	no $\beta$ carbons - no E2	$\text{CH}_3\text{Nu}$
$\begin{array}{c} \text{H}_3\text{C} \\   \\ \text{C}=\text{C} \\   \quad   \\ \text{H} \quad \text{Br} \end{array} \xrightarrow[\text{good nucleophile}]{\text{Strong base or}}$	vinyl halide $\text{sp}^2$ short strong bond	no reaction
 $\xrightarrow[\text{good nucleophile}]{\text{Strong base or}}$	aryl halide $\text{sp}^2$ short strong bond	no reaction
$\begin{array}{c} \text{H}_3\text{C} \\   \\ \text{C}=\text{C} \\   \quad   \\ \text{H} \quad \text{CH}_2\text{Br} \end{array} \text{ fast } \text{S}_{\text{N}}1 \text{ and } \text{S}_{\text{N}}2 \text{ why?}$	$\text{S}_{\text{N}}1$ - resonance stabilized carbocation intermediate $\text{S}_{\text{N}}2$ - stabilized transition state through hyperconjugation	
 $\text{ fast } \text{S}_{\text{N}}1 \text{ and } \text{S}_{\text{N}}2 \text{ why?}$	$\text{S}_{\text{N}}1$ - resonance stabilized carbocation intermediate $\text{S}_{\text{N}}2$ - stabilized transition state through hyperconjugation	
What is the order for decreasing stability of a carbocation, why?	1) resonance stability of benzylic and allylic 2) hyperconjugation of alkanes	benzylic $\geq$ allylic $>$ $3^\circ > 2^\circ > 1^\circ >$ methyl
What is the order for decreasing stability of alkenes, why?	hyperconjugation	$(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_3)_2 > \text{CH}_3\text{CH}=\text{CHCH}_3 > \text{CH}_3\text{CH}=\text{CH}_2 > \text{CH}_2=\text{CH}_2$
What is the order of decreasing reactivity in a $\text{S}_{\text{N}}2$ reaction, why?	1) hyperconjugation of T.S. benzylic and allylic 2) steric interaction	benzylic $\geq$ allylic $>$ methyl $> 1^\circ > 2^\circ > 3^\circ$
What is the order of decreasing reactivity in a $\text{S}_{\text{N}}1$ reaction, why?	Stability of intermediate 1) Resonance stabilization benzylic and allylic 2) hyperconjugation	benzylic $\geq$ allylic $>$ $3^\circ > 2^\circ > 1^\circ >$ methyl
$\begin{array}{c} \text{CH}_3 \\   \\ \text{H}-\text{C}-\text{D} \\   \\ \text{H}-\text{C}-\text{Br} \\   \\ \text{CH}_3 \end{array} \xrightarrow[\text{CH}_3\text{CH}_2\text{OH}]{\text{CH}_3\text{CH}_2\text{ONa}}$	 E2 favoured	
$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3-\text{C}-\text{CH}=\text{CH}_2 \\   \\ \text{CH}_3 \end{array} \xrightarrow[25^\circ\text{C}]{\text{H}_2\text{SO}_4/\text{H}_2\text{O}}$	base - alkene formation of carbocation rearrangements $\text{H}_2\text{O}$ present - nucleophile	 major product but some alkenes likely
$\begin{array}{c} \text{CH}_3 \text{ OH} \\   \quad   \\ \text{CH}_3-\text{C}-\text{C}-\text{CH}_3 \\   \quad   \\ \text{H} \quad \text{H} \end{array} \xrightarrow[25^\circ\text{C}]{\text{HBr}}$	base - OH $\text{H}_2\text{O}$ is a good leaving group carbocation rearrangements the conjugate base of the acid is a good nucleophile ( $\text{S}_{\text{N}}1$ )	 major product  minor product

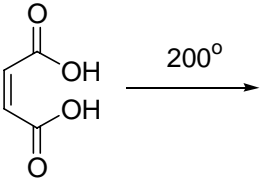
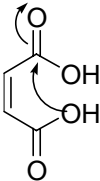
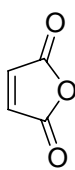
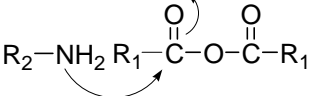
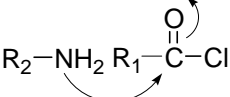
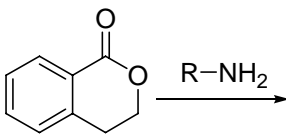
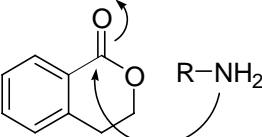
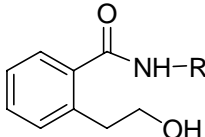
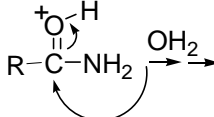
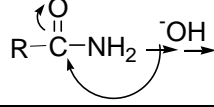
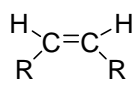
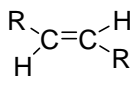
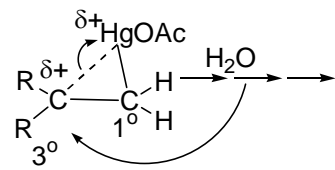
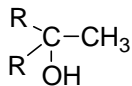
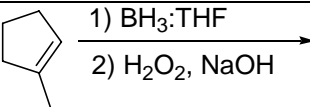
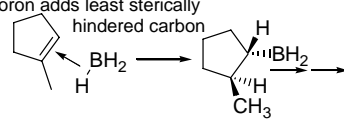
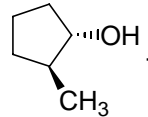
$\begin{array}{c} \text{CH}_3 \text{ OH} \\   \quad   \\ \text{CH}_3 - \text{C} - \text{CH}_3 \\   \quad   \\ \text{H} \quad \text{H} \end{array} \xrightarrow[80^\circ\text{C}]{85\% \text{ H}_2\text{SO}_4}$	base - OH H <sub>2</sub> O is a good leaving group carbocation rearrangements Conjugate base - poor nucleophile There is no appreciable amounts of H <sub>2</sub> O present (E1)	
	Grignard Reagent	
$\text{A} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{HCOH}}$		
$\text{CH}_3\text{CH}_2\text{MgBr} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{H}_3\text{CCOH}}$		
$\text{RMgX} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{H}_3\text{CCOCH}_3}$		
$\text{RMgX} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{H}_3\text{CCOOCH}_3}$		
$\text{RMgX} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{CO}_2}$		RCOOH
$\text{RCH}_2\text{CCH} \xrightarrow{\text{RCH}_2\text{MgBr}} \text{A}$	an sp <sup>3</sup> carbon with a negative charge is a stronger base than a sp carbon	RCH <sub>2</sub> CCMgBr + RCH <sub>3</sub>
$\text{A} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{H}_3\text{CCOCH}_3}$		
$\text{R}_1\text{MgX} + \text{R}_2\text{OH} \longrightarrow$	a carbon with a negative charge is a stronger base than on oxygen with a negative charge	$\text{R}_2\text{O}^- + \text{MgX} + \text{R}_1\text{H}$
What is the difference between LiAlH <sub>4</sub> and NaBH <sub>4</sub>	LiAlH <sub>4</sub> will reduce carboxylic acids, esters, ketones and aldehydes NaBH <sub>4</sub> will only reduce ketones and aldehydes	
$\text{R}_1 - \overset{\text{O}}{\parallel} \text{C} - \text{OR}_2 \xrightarrow[2) \text{H}_2\text{O}]{1) \text{LiAlH}_4/\text{Et}_2\text{O}}$	reduction	R <sub>1</sub> CH <sub>2</sub> OH + R <sub>2</sub> OH
$\text{R} - \overset{\text{O}}{\parallel} \text{C} - \text{H} \xrightarrow[\text{H}_2\text{O}]{\text{NaBH}_4}$	reduction	RCH <sub>2</sub> OH

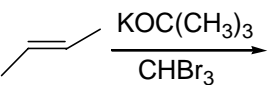
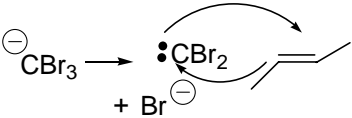
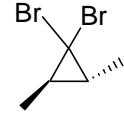
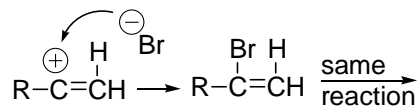
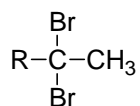
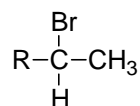
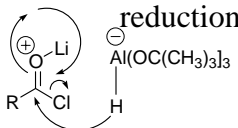
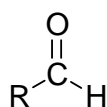
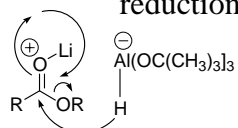
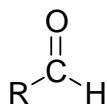
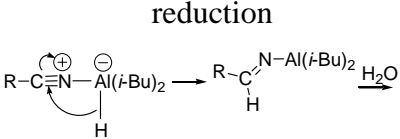
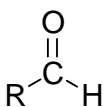
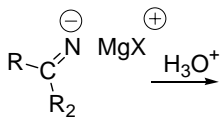
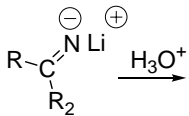
$\text{R}_1-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}_2 \xrightarrow[\text{H}_2\text{O}]{\text{NaBH}_4}$	reduction	$\text{R}_1-\overset{\text{OH}}{\text{C}}-\text{R}_2$
$\text{RCH}_2\text{OH} \xrightarrow[\text{(or Na}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4)]{\text{H}_2\text{CrO}_4}$	oxidation	$\text{RCOOH}$
$\text{RCH}_2\text{OH} \xrightarrow{\text{PCC}}$	partial oxidation	$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$
$\text{R}_1-\overset{\text{OH}}{\underset{\text{H}}{\text{C}}}-\text{R}_2 \xrightarrow[\text{NaOH}]{\text{H}_2\text{CrO}_4 \text{ or } \text{KMnO}_4}$	oxidation	$\text{R}_1-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}_2$
$\text{RCH}_2\text{OH} \xrightarrow[\text{NaOH}]{\text{KMnO}_4}$	oxidation	$\text{RCOOH}$
$\text{R}-\overset{\text{OH}}{\underset{\text{R}_3}{\text{C}}}-\text{R}_2 \xrightarrow[\text{NaOH}]{\text{KMnO}_4}$	3° alcohol	No Reaction
$\text{R}_1\text{CH}_2\text{OH} + \text{R}_2\text{CH}_2\overset{\text{O}}{\parallel}{\text{C}}-\text{OH} \xrightarrow{\text{conc H}_2\text{SO}_4}$		$\text{R}_1\text{CH}_2\overset{\text{O}}{\parallel}{\text{C}}\text{CH}_2\text{R}_2$
$\text{RCH}_2\text{OH} \xrightarrow[\text{or CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{Cl}]{\text{CH}_3\text{SO}_2\text{Cl}} \text{A}$		$\text{RCH}_2\text{O}-\overset{\text{O}}{\parallel}{\text{S}}(\text{O})-\text{CH}_3 + \text{Cl}^-$
react A with $\text{Nu}^\bullet$	$\text{S}_{\text{N}}2 \quad \text{Nu}^\bullet \curvearrowright \text{RCH}_2\text{O}-\overset{\text{O}}{\parallel}{\text{S}}(\text{O})-\text{CH}_3$	$\text{RCH}_2\text{Nu} + \overset{\ominus}{\text{O}}-\overset{\text{O}}{\parallel}{\text{S}}(\text{O})-\text{CH}_3$
What is the order for decreasing stability of free radicals, why?	same as carbocations allylic, benzylic - resonance alkyl groups - hyperconjugation	benzylic $\geq$ allylic $>$ $3^\circ > 2^\circ > 1^\circ >$ methyl
What is the selectivity difference between Cl and Br radicals?	Bromine is less reactive thus is more selective than chlorine. Bromination will predominately go through the most stable intermediate where as chlorination will give mixtures	
$\text{CH}_3-\overset{\text{CH}_3}{\underset{\text{H}}{\text{C}}}-\text{CH}_3 \xrightarrow[\text{hv}/120^\circ]{\text{Br}_2}$	think about the free radical intermediate stability 	$\text{CH}_3-\overset{\text{CH}_3}{\underset{\text{Br}}{\text{C}}}-\text{CH}_3$ approx. 100% $\text{CH}_3-\overset{\text{CH}_3}{\underset{\text{H}}{\text{C}}}-\text{CH}_2\text{Br}$ minor product
$\text{CH}_3-\overset{\text{CH}_3}{\underset{\text{H}}{\text{C}}}-\text{CH}_3 \xrightarrow[\text{hv}/25^\circ]{\text{Cl}_2}$	 think about the reactivity of the halogen radical	$\text{CH}_3-\overset{\text{CH}_3}{\underset{\text{Cl}}{\text{C}}}-\text{CH}_3$ approx. 2 $\text{CH}_3-\overset{\text{CH}_3}{\underset{\text{H}}{\text{C}}}-\text{CH}_2\text{Cl}$ : 3

		<p style="text-align: center;">racemic.</p> <p style="text-align: center;">This arises by abstraction of H• at C-2 giving a planar radical</p>
	<p style="text-align: center;">double E2</p>	<p style="text-align: center;"><math>R-C\equiv C-R</math></p>
	<p style="text-align: center;">double E2 also acidic proton</p>	<p style="text-align: center;"><math>R_1-C\equiv C^-Na^+</math></p>
<p style="text-align: center;">react A with <math>R_2CH_2Br</math></p>	<p style="text-align: center;"><math>S_N2</math></p>	<p style="text-align: center;"><math>R_1-C\equiv CCH_2R_2</math></p>
	<p style="text-align: center;">base - alkene conjugate base of acid good nucleophile Stability of carbocation</p>	
	<p style="text-align: center;">Free radical reaction Br radical attacks alkene Stability of radical intermediate</p>	<p style="text-align: center;"><math>RCH_2CH_2CH_2Br</math></p>
		<p style="text-align: center;">plus enantiomer</p>
		<p style="text-align: center;">enantiomers</p>
	<p style="text-align: center;">more positive carbon</p>	<p style="text-align: center;">plus enantiomer major product</p> <p style="text-align: center;">plus enantiomer</p>
	<p style="text-align: center;">hydrogens added from the surface of the catalyst - syn addition</p>	

$\begin{array}{c} R_1 \\ \diagdown \\ C=C \\ \diagup \\ R_2 \\   \\ H \\   \\ R_3 \end{array}$	$\begin{array}{c} R_1 \\ \diagdown \\ C=C \\ \diagup \\ R_2 \\   \\ H \\   \\ R_3 \end{array}$ oxidative cleavage workup reducing	$\begin{array}{c} O \\    \\ R_1-C-H \\   \\ H \end{array} + \begin{array}{c} O \\    \\ R_3-C-R_2 \end{array}$
$\begin{array}{c} R_1 \\ \diagdown \\ C=C \\ \diagup \\ R_2 \\   \\ H \\   \\ R_3 \end{array}$	$\begin{array}{c} R_1 \\ \diagdown \\ C=C \\ \diagup \\ R_2 \\   \\ H \\   \\ R_3 \end{array}$ oxidative cleavage workup oxidative	$\begin{array}{c} O \\    \\ R_1-C-OH \\   \\ H \end{array} + \begin{array}{c} O \\    \\ R_3-C-R_2 \end{array}$
$R-C\equiv C \xrightarrow{HCl}$	 base - alkyne then alkene stability of intermediate	$\begin{array}{c} Cl \\   \\ R-C-CH_3 \\   \\ Cl \end{array}$
$R-C\equiv C \xrightarrow{Br_2}$	bromination twice	$R-CBr_2-CHBr_2$
$R-C\equiv C \xrightarrow[HgSO_4]{H_2SO_4} A$	 OH <sub>2</sub>	$\begin{array}{c} OH \\   \\ R-C=C \\   \\ H \end{array}$ enol
$A \xrightarrow{\text{tautomerization}}$	 condensed mech	$\begin{array}{c} O \\    \\ R-C \end{array}$
$R-C(=O)-R_2 \xrightarrow[\text{Buffer}]{NaCN-HCN}$	 + O <sup>-</sup> H - CN	$\begin{array}{c} OH \\   \\ R-C-CN \\   \\ R_2 \end{array}$
$R_1-C(=O)-H \xrightarrow[H^+]{R_2OH}$	 condensed mechanism	$\begin{array}{c} O-R_2 \\   \\ R-C-H \\   \\ O-R_2 \end{array} + H^+$
	 condensed mechanism same mech - H <sub>2</sub> O as above	
$R_1-C(=O)-R_2 \xrightarrow[H^+ \text{ Catalyst}]{G-NH_2}$	 - H <sub>2</sub> O - H <sup>+</sup>	$\begin{array}{c} N-G \\    \\ R_1-C-R_2 \end{array}$

$R-C\equiv N \xrightarrow{H_2SO_4 / H_2O}$	$R-\overset{+}{C}=\overset{+}{N}-H \xrightarrow{OH_2} R-\overset{+}{O}(\overset{+}{H})-C-NH_2 \xrightarrow{OH_2}$ <p style="text-align: center;">hydrolysis</p>	$RCOOH + NH_4^+$
$R-C\equiv N \xrightarrow{NaOH / H_2O}$	$R-C\equiv N \xrightarrow{^-OH} R-\overset{O}{\parallel}-C-NH_2 \xrightarrow{^-OH}$ <p style="text-align: center;">hydrolysis</p>	$RCOO^- + NH_3$
$R_1-\overset{O}{\parallel}-C-OR_2 \xrightarrow{H_2SO_4 / H_2O}$	$R_1-\overset{+}{O}(\overset{+}{H})-\overset{O}{\parallel}-C-OR_2 \xrightarrow{OH_2}$	$R_1COOH + R_2OH$
$R_1-\overset{O}{\parallel}-C-OR_2 \xrightarrow{NaOH / H_2O}$	$R_1-\overset{O}{\parallel}-C-OR_2 \xrightarrow{^-OH}$	$R_1COO^- + R_2O^-$
$R-\overset{O}{\parallel}-C-Cl \xrightarrow{H_2SO_4 / H_2O}$	$R-\overset{+}{O}(\overset{+}{H})-\overset{O}{\parallel}-C-Cl \xrightarrow{OH_2}$	$RCOOH + HCl$
$R-\overset{O}{\parallel}-C-Cl \xrightarrow{NaOH / H_2O}$	$R-\overset{O}{\parallel}-C-Cl \xrightarrow{^-OH}$	$RCOO^- + Cl^-$
$R_1-\overset{O}{\parallel}-C-OH \xrightarrow[R_3O^+]{R_2OH}$	$R_1-\overset{+}{O}(\overset{+}{H})-\overset{O}{\parallel}-C-OH \xrightarrow{HOR_2}$	$R_1\overset{O}{\parallel}-C-OR_2 + H_2O + H^+$
$R_1-\overset{O}{\parallel}-C-O-\overset{O}{\parallel}-C-R_1 \xrightarrow[R_3O^+]{R_2OH}$	$R_1-\overset{O}{\parallel}-C-O-\overset{+}{O}(\overset{+}{H})-\overset{O}{\parallel}-C-R_1 \xrightarrow{HOR_2}$	$R_1-\overset{O}{\parallel}-C-OR_2 + RCOOH + H^+$
$R_1-\overset{O}{\parallel}-C-Cl \xrightarrow[R_3O^+]{R_2OH}$	$R_1-\overset{+}{O}(\overset{+}{H})-\overset{O}{\parallel}-C-Cl \xrightarrow{HOR_2}$	$R_1-\overset{O}{\parallel}-C-OR_2 + HCl$
$R-\overset{O}{\parallel}-C-OH \xrightarrow{SOCl_2}$	$R-\overset{O}{\parallel}-C-OH \xrightarrow{Cl-\overset{O}{\parallel}-S-Cl} R-\overset{O}{\parallel}-C-O-\overset{O}{\parallel}-S-Cl \rightarrow R-\overset{O}{\parallel}-C-Cl + SO_2 + Cl^-$	$R-\overset{O}{\parallel}-C-Cl + SO_2 + Cl^-$
$R-\overset{O}{\parallel}-C-OH \xrightarrow{PCl_3}$	$R-\overset{O}{\parallel}-C-OH \xrightarrow{Cl-\overset{Cl}{\overset{Cl}{\text{P}}}-Cl} R-\overset{O}{\parallel}-C-O-\overset{Cl}{\overset{Cl}{\text{P}}}-Cl \rightarrow R-\overset{O}{\parallel}-C-Cl + H_3PO_4$	$R-\overset{O}{\parallel}-C-Cl + H_3PO_4$
$R_1-\overset{O}{\parallel}-C-Cl \xrightarrow{R_2-\overset{O}{\parallel}-C-ONa}$	$R_2-\overset{O}{\parallel}-C-O^- \xrightarrow{R_1-\overset{O}{\parallel}-C-Cl}$	$R_1-\overset{O}{\parallel}-C-O-\overset{O}{\parallel}-C-R_2 + NaCl$

		
$R_1-C(=O)-O-C(=O)-R_1 \xrightarrow{R_2-NH_2}$		$R_1-C(=O)-NH-R_2 + R_1COOH$
$R_1-C(=O)-Cl \xrightarrow{R_2-NH_2}$		$R_1-C(=O)-NH-R_2 + HCl$
		
$R-C(=O)-NH_2 \xrightarrow{H_2SO_4 / H_2O}$		$RCOOH + NH_4^+$
$R-C(=O)-NH_2 \xrightarrow{NaOH / H_2O}$		$RCOO^- + NH_3$
$R-C\equiv C-R \xrightarrow[\text{or } H_2, PdCaCO_3]{H_2/NiB(P-2)}$	Adds one equivalence of $H_2$ Syn addition	
$R-C\equiv C-R \xrightarrow[2) NH_4Cl]{1) Li, C_2H_5NH_2, -78^\circ C}$	anti addition occurs by formal addition of hydrogen to the opposite faces of the double bond	
$R-C=C-H \xrightarrow[2) NaBH_4, NaOH]{1) Hg(OAc)_2/THF}$		
	boron adds least sterically hindered carbon  Boron and H add from the same side	 + enantiomer

		
$\text{R}-\text{C}\equiv\text{CH} \xrightarrow{\text{HBr}}$		
$\text{R}-\text{C}\equiv\text{CH} \xrightarrow[\text{CH}_2\text{Cl}_2 \text{ (solvent)}]{\text{CH}_3\text{COBr/alumina, "HBr"}}$	Only reacts once	
$\text{R}-\text{C}\equiv\text{C}-\text{R}_2 \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{O}_3, 2) \text{HOAc}}$ <p>or 1) <math>\text{KMnO}_4</math> 2) <math>\text{H}_3\text{O}^+</math></p>	Oxidation of triple bond	$\text{RCO}_2\text{H} + \text{R}_2\text{CO}_2\text{H}$
$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{Cl} \xrightarrow[2) \text{H}_2\text{O}]{1) \text{LiAlH}(\text{O}t\text{-Bu})_3, -78^\circ\text{C}}$		
$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OR} \xrightarrow[2) \text{H}_2\text{O}]{1) \text{DIBAL-H}, -78^\circ\text{C}}$		
$\text{R}-\text{C}\equiv\text{N} \xrightarrow[2) \text{H}_2\text{O}]{1) \text{DIBAL-H}, -78^\circ\text{C}}$		
$\text{R}-\text{C}\equiv\text{N} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{R}_2\text{MgX}}$		$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}_2 + \text{NH}_4^+ + \text{Mg}^{2+} + \text{X}^-$
$\text{R}-\text{C}\equiv\text{N} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{R}_2\text{Li}}$		$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}_2 + \text{NH}_4^+ + \text{Li}^+$