H2 CHEMISTRY 9729

Organic Chemistry Notes

FEBRUARY 23, 2020

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Victoria Junior College
2018-2019

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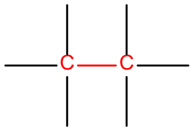
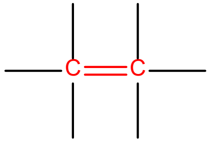
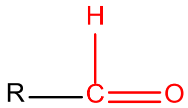
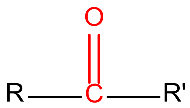
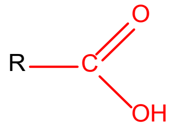
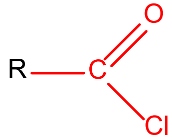
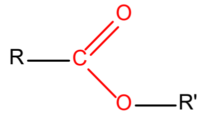
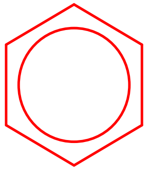
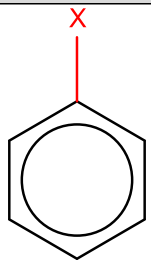
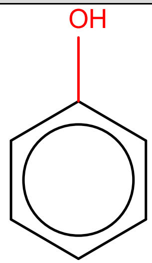
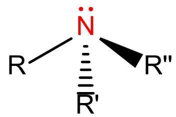
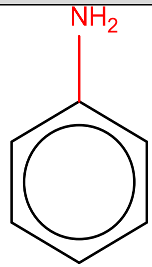
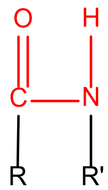
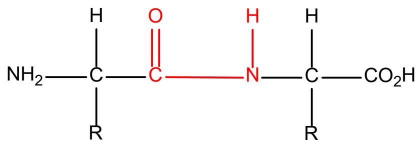
			Hydroxyls	Carbonyls				
Alkanes	Alkenes	Halogeno-alkanes	Alcohols	Aldehydes	Ketones	Carboxylic acids	Acyl chloride	Ester
		R—X	R—OH					
Free radical substitution Combustion	Combustion Reduction Oxidation Electrophilic addition	Elimination Nucleophilic substitution	Acid-metal Nucleophilic substitution Condensation (elimination) Oxidation	Nucleophilic addition Condensation Reduction Oxidation Iodoform test	Nucleophilic addition Condensation Reduction Iodoform test	Acid-metal Acid-base Condensation Conversion to acyl chloride Reduction De-carboxylation	Hydrolysis Condensation	Acid hydrolysis Alkaline hydrolysis
	Arenes	Halogenoarenes	Phenols	Amines	Phenylamines	Amides	Proteins	
								
	Addition Electrophilic substitution	Hydrolysis Nucleophilic substitution	Acid-metal Acid-base Nucleophilic substitution Electrophilic substitution	Neutralisation Nucleophilic substitution Condensation	Neutralisation Nucleophilic substitution Condensation Electrophilic substitution	Acid hydrolysis Alkaline hydrolysis Reduction	Acid-base catalysed hydrolysis Enzymatic hydrolysis	

Markonikov's rule: For unsymmetrical alkenes, the electrophile will go to the carbon with the greater number of hydrogen bonded to it. This is to produce a more stable carbocation.

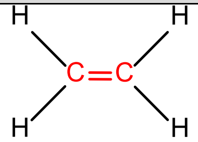
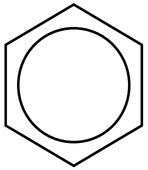
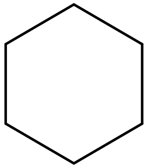
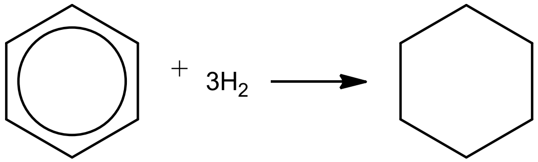
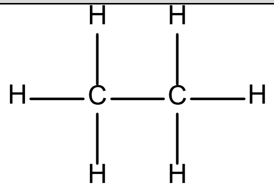
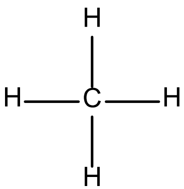
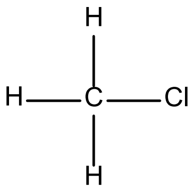
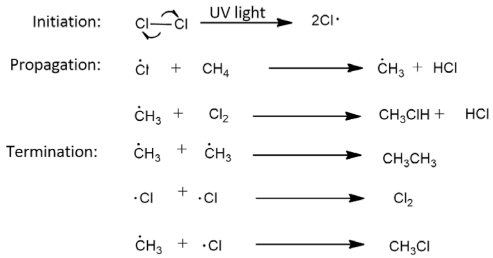
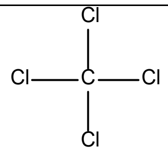
Functional groups attached to *benzylic carbons* (the first carbon bonded directly to the benzene ring) can undergo the same reactions as if they were not bonded to a benzene ring.

Phenol (-OH) and *Phenylamine* (-NH_2) groups are very activating groups. Hence, reactions that used to need a catalyst do not need a catalyst anymore.

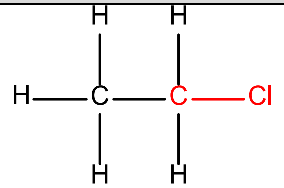
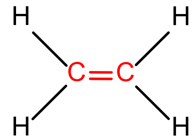
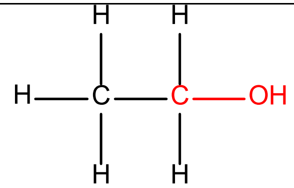
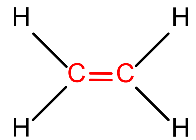
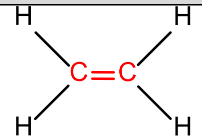
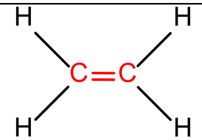
Methanoic acid (HCOOH) and ethandioic acid (HO_2C-CO_2H) are unstable in the presence of acidified $KMnO_4$ and will be oxidised to CO_2 and H_2O.

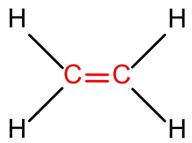
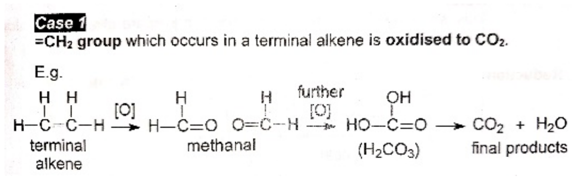
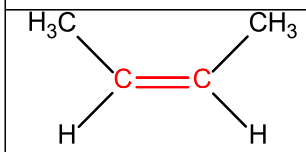
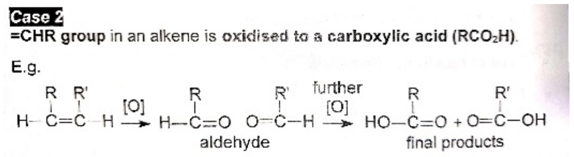
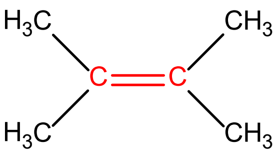
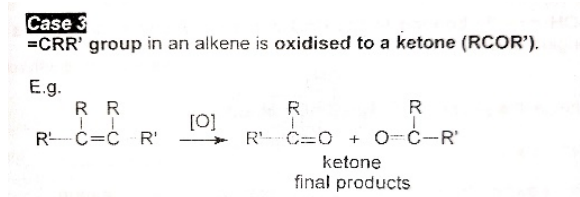
Note: Always specify the medium and the reactants.
Note: Nu refers to Nucleophile, E refers to Electrophile and X is a Halogen.

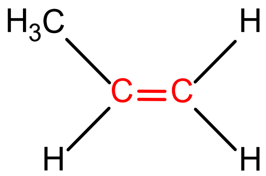
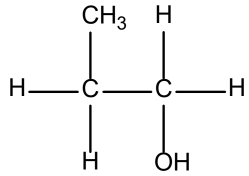
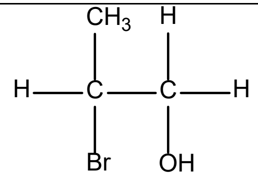
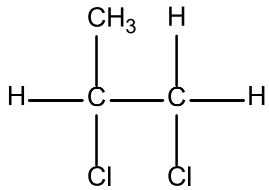
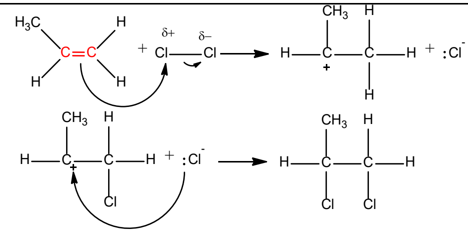
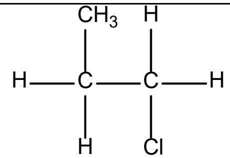
ALKANES

Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Reduction (alkene)	 ethene	H_2 gas, Ni catalyst, heat OR H_2 gas, Pt or Pd catalyst, r.t.p.	CH_3CH_3	$C_2H_4 + H_2 \rightarrow C_2H_6$	Produces alkanes C-C
Addition (benzene)	 benzene	H_2, Ni, 150°C, high pressure	 cyclohexane C_6H_{12}		Produces cyclohexane
REACTIONS					
Combustion	 ethane	Limited O_2, heat	CO (g) + H_2O (g)	$C_2H_6 + 5/2O_2 \rightarrow 2CO + 3H_2O$	
		Excess O_2, heat	CO_2 (g) + H_2O (g)	$C_2H_6 + 7/2O_2 \rightarrow 2CO + 3H_2O$	
Free Radical Substitution	 methane	Limited Cl_2 (g) or Br_2 (g), UV light	 chloroethane		Produces halogenoalkanes R-X
		Excess Cl_2 (g) or Br_2 (g), UV light	 tetrachloromethane	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ $CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$ $CH_2Cl_2 + Cl_2 \rightarrow CHCl_3 + HCl$ $CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$	

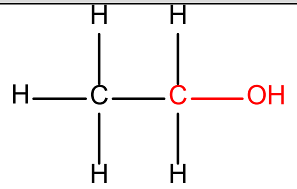
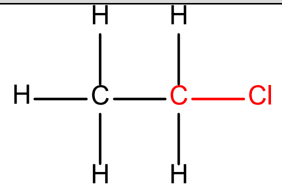
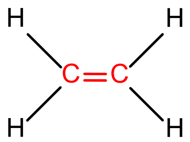
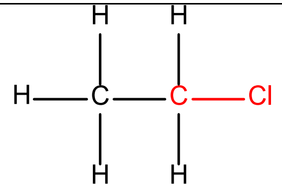
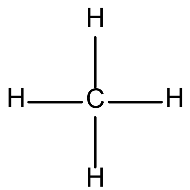
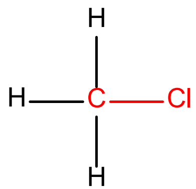
ALKENES

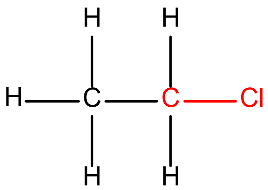
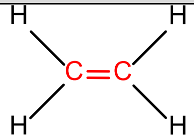
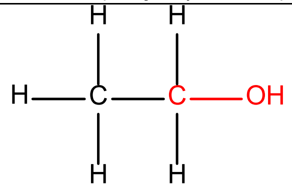
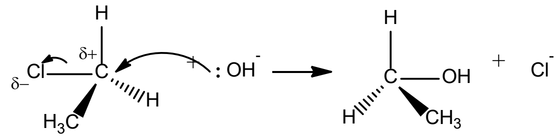
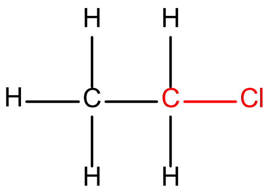
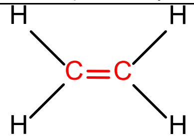
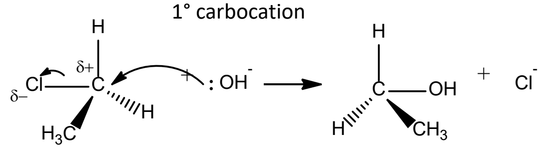
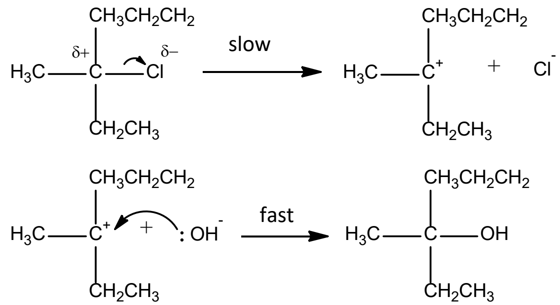
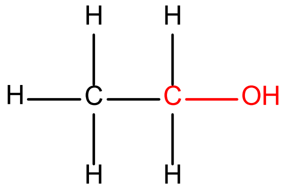
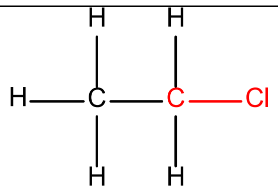
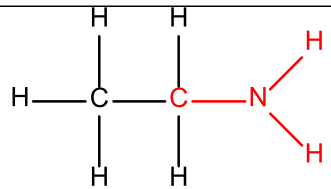
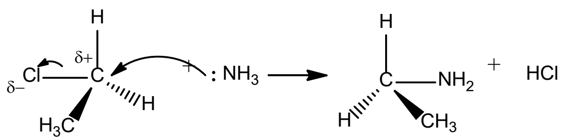
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Elimination (halogeno-alkane)	 chloroethane	NaOH in ethanol, heat	 ethane (major product)	$CH_3CH_2Cl \rightarrow CH_2{=}CH_2 + HCl$	Produces alkenes
Condensation or elimination (alcohol)	 ethanol	Excess conc. H_2SO_4, heat	 ethene	$C_2H_5OH \rightarrow CH_2{=}CH_2 + H_2O$	Produces alkenes
REACTIONS					
Combustion	 ethene	Limited O_2, heat	CO (g) + H_2O (g)	$C_2H_4 + 2O_2 \rightarrow 2CO + 2H_2O$	
		Excess O_2, heat	CO_2 (g) + H_2O (g)	$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$	
Reduction	 ethene	H_2 gas, Ni catalyst, heat OR H_2 gas, Pt or Pd catalyst, r.t.p.	CH_3CH_3	$C_2H_4 + H_2 \rightarrow C_2H_6$	Produces alkanes

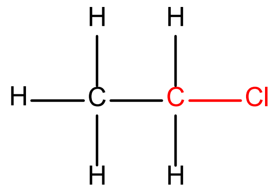
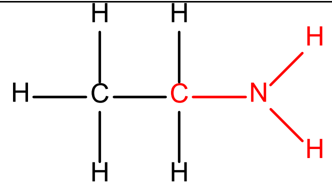
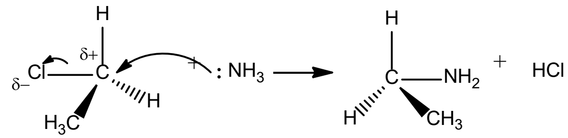
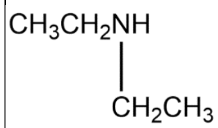
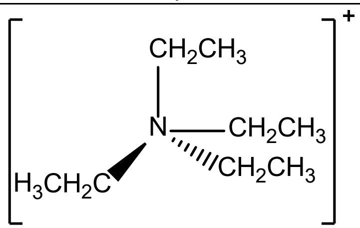
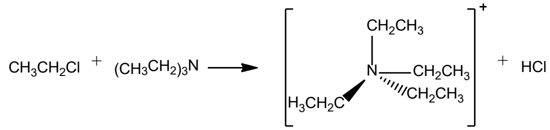
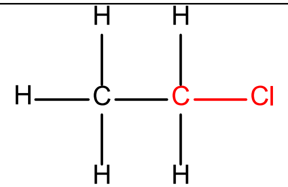
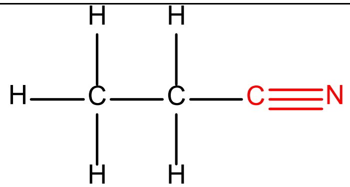
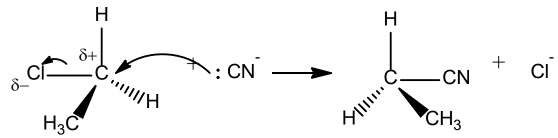
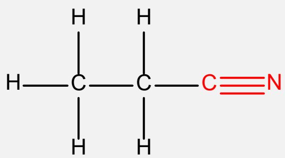
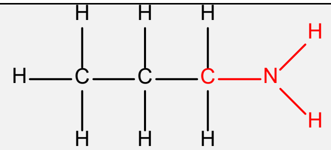
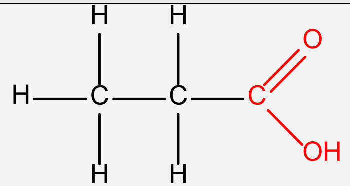
Oxidation	 ethene $=CH_2$ group	$KMnO_4$ in acidic medium, heat	CO_2 (g) + H_2O (g)		
		$KMnO_4$ in alkaline medium, heat	CO_3^{2-} + H_2O		
	 but-2-ene $=CHR$ group	$KMnO_4$ in H_2SO_4, heat	CH_3COOH		Produces carboxylic acids
		$KMnO_4$ in H_2SO_4, heat	$CH_3COO^-Na^+$		
	 dimethylbut-2-ene $=CRR'$ group	$KMnO_4$ in H_2SO_4, heat	CH_3COCH_3		Produces ketones
		$KMnO_4$ in NaOH, heat	CH_3COCH_3		

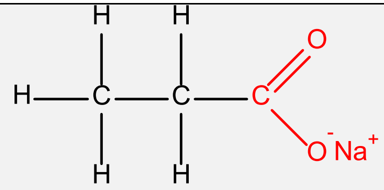
Electrophilic addition	 prop-2-ene	Cold conc. H_2SO_4, followed by water with heating		$CH_2{=}CH_2 + H_2O \rightarrow CH_3CH_2OH$	Produces alcohols
		Steam, high temperature, high pressure, acid catalyst			
		Br_2 in water, r.t.p.		$CH_3CH{=}CH_2 + Br_2 + H_2O \rightarrow CH_3CHBrCH_2OH$ (major)	
				$CH_3CH{=}CH_2 + Br_2 \rightarrow CH_3CHBrCH_2Br$ (minor)	
		X_2 in CCl_4, r.t.p.			
		HX in water, r.t.p.		$CH_3CH{=}CH_2 + HCl \rightarrow CH_3CH_2CH_2Cl$	Produces halogenoalkanes

HALOGENOALKANES

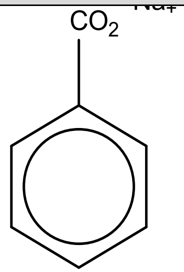
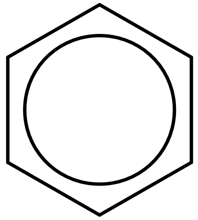
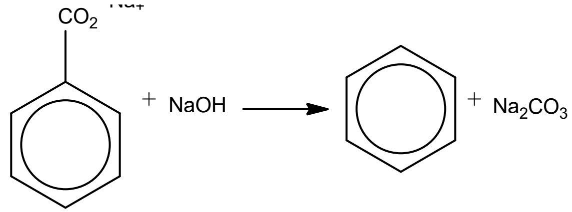
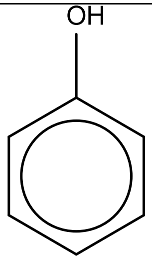
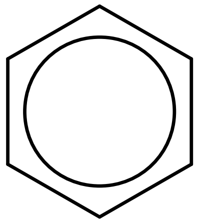
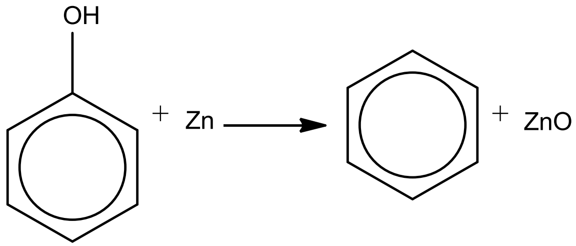
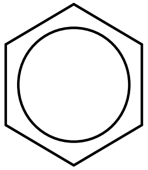
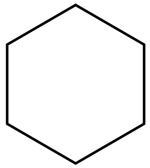
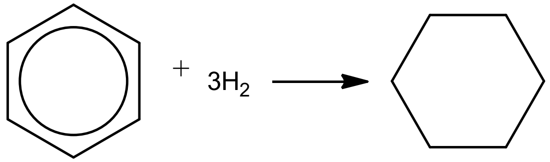
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Nucleophilic substitution (alcohol)	 ethanol	HCl or HBr, heat	 chloroethane	$C_2H_5OH + HCl \rightarrow C_2H_5Cl + H_2O$	
		$SOCl_2$, heat		$C_2H_5OH + SOCl_2 \rightarrow C_2H_5Cl + SO_2 + HCl$	
		PX_3, heat		$3C_2H_5OH + PCl_3 \rightarrow 3C_2H_5Cl + H_3PO_4$	
		PCl_5, r.t.p.		$C_2H_5OH + PCl_5 \rightarrow C_2H_5Cl + POCl_3 + HCl$	
Electrophilic addition (alkene)	 ethene	HX in water, r.t.p.	 chloroethane	$CH_2{=}CH_2 + HCl \rightarrow CH_3CH_2Cl$	
Free Radical Substitution (alkane)	 methane	Limited Cl_2 (g) or Br_2 (g), UV light	 chloromethane	Initiation: $Cl{-}Cl \xrightarrow{\text{UV light}} 2Cl\cdot$ Propagation: $\dot{Cl} + CH_4 \rightarrow \dot{C}H_3 + HCl$ $\dot{C}H_3 + Cl_2 \rightarrow CH_3ClH + HCl$ Termination: $\dot{C}H_3 + \dot{C}H_3 \rightarrow CH_3CH_3$ $\cdot Cl + \cdot Cl \rightarrow Cl_2$ $\dot{C}H_3 + \cdot Cl \rightarrow CH_3Cl$	Produces halogenoalkanes

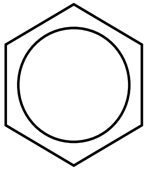
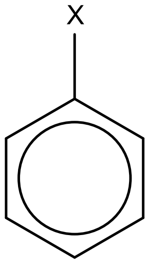
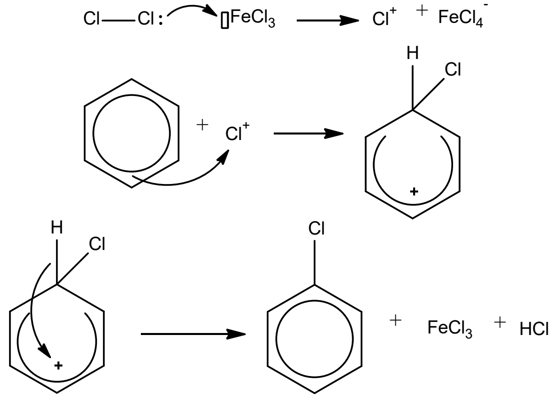
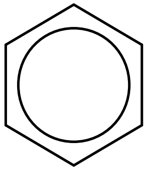
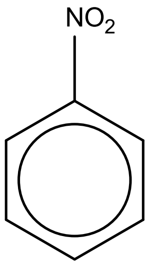
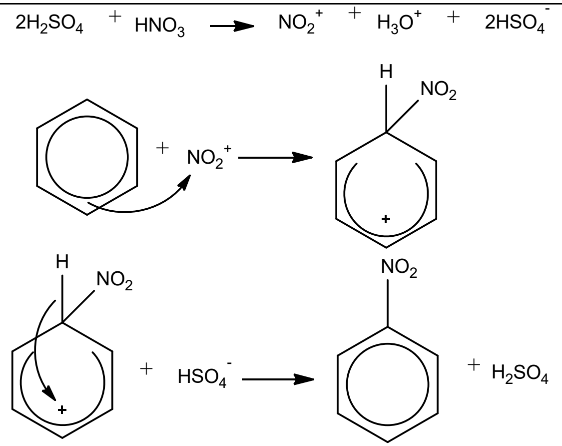
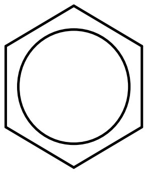
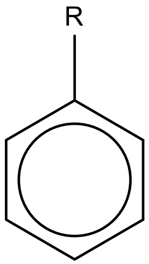
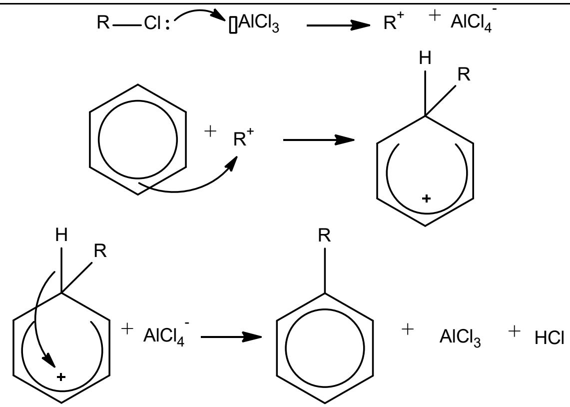
REACTIONS					
Elimination	 chloroethane	NaOH in ethanol, heat	 ethene (major product)	$CH_3CH_2Cl \rightarrow CH_2{=}CH_2 + HCl$	Produces alkenes
			 CH_3CH_2OH (minor product)		Produces alcohols
Nucleophilic substitution	 chloroethane	NaOH in water, heat	 ethene (minor product)	S_N2 mechanism 1° carbocation  S_N1 mechanism 3° carbocation 	Produces alcohols Distinguishing test for halogen: Acidify with HNO_3 (aq), followed by $AgNO_3$ (aq)
			 CH_3CH_2OH (major product)		
Nucleophilic substitution	 chloroethane	excess NH_3 in ethanol, heat under pressure in a sealed tube	 $CH_3CH_2NH_2$		

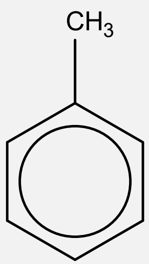
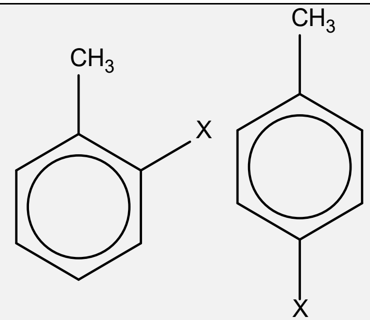
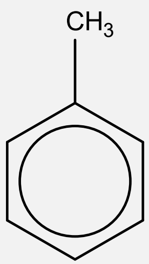
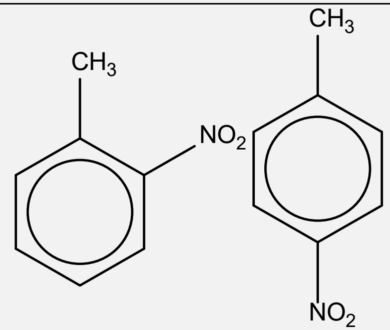
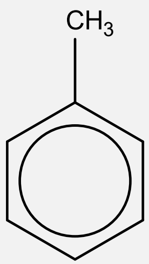
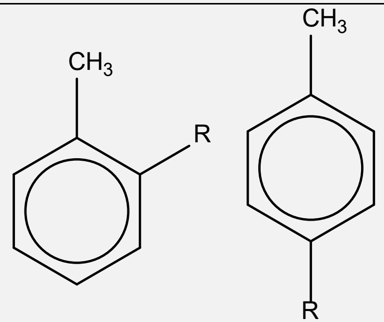
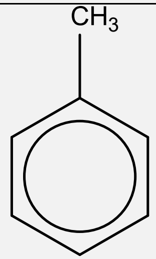
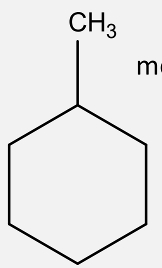
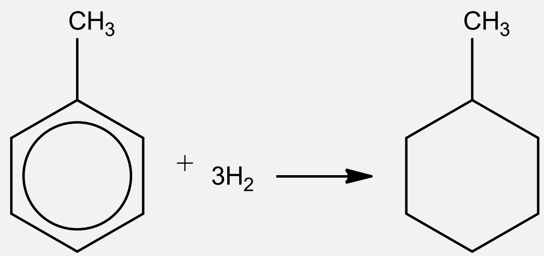
Nucleophilic substitution	 chloroethane	limited NH_3 in ethanol, heat under pressure in a sealed tube	 $CH_3CH_2NH_2$ primary amine		Produces amines. Multiple substitution occurs because the product is also a nucleophile.
			 secondary amine	$CH_3CH_2Cl + CH_3CH_2NH_2 \rightarrow (CH_3CH_2)_2N + HCl$	
			$(CH_3CH_2)_3N$ tertiary amine	$CH_3CH_2Cl + (CH_3CH_2)_2N \rightarrow (CH_3CH_2)_3N + HCl$	
					
Nucleophilic substitution	 chloroethane	NaCN in ethanol, heat	 $CH_3CH_2C{\equiv}N$		Produces nitriles for further reactions: see below
Reduction	 propane nitrile	$LiAlH_4$ in dry ether, followed by water, r.t.p.	 $CH_3CH_2CH_2NH_2$	$CH_3CH_2CN + 4[H] \rightarrow CH_3CH_2CH_2NH_2$	Produces amines
Acid hydrolysis		H_2SO_4 in water, heat	 CH_3CH_2COOH	$2CH_3CH_2CN + 4H_2O + H_2SO_4 \rightarrow 2CH_3CH_2COOH + (NH_4)_2SO_4$	Produces carboxylic acids

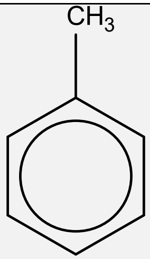
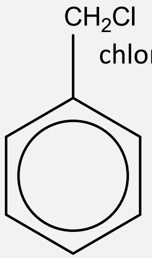
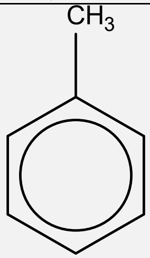
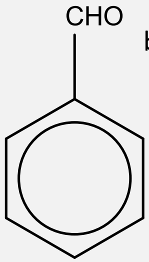
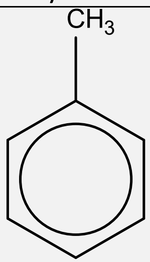
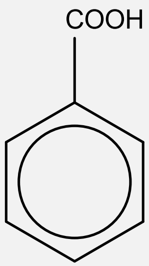
Alkaline hydrolysis		NaOH in water, heat	 $CH_3CH_2COO^-Na^+$	$CH_3CH_2CN + H_2O + NaOH \rightarrow CH_3CH_2COO^-Na^+ + NH_3$	

ARENES

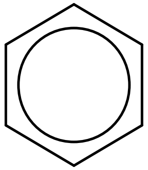
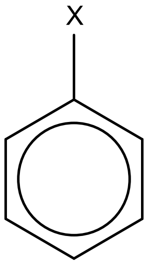
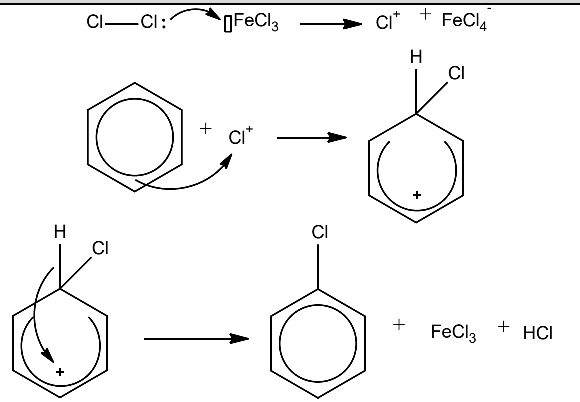
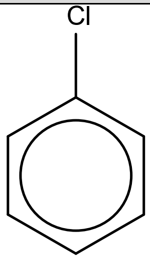
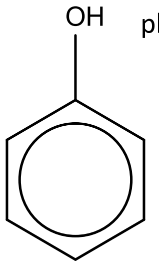
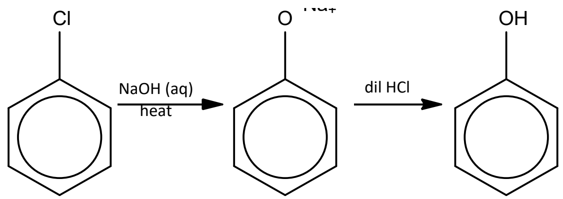
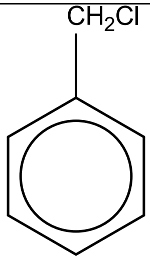
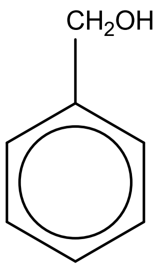
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
			PREPARATION		
De-carboxylation	 sodium benzoate	NaOH, heat			
Reduction (phenol)	 phenol	Zn metal, heat			
			REACTIONS		
Addition	 benzene	H_2, Ni, 150°C, high pressure	 cyclohexane		Produces cyclohexane

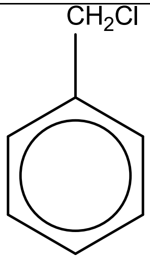
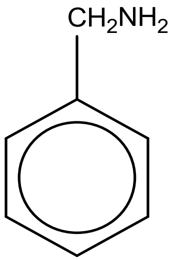
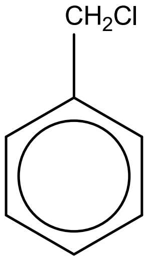
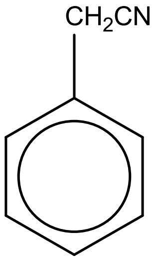
Electrophilic substitution	 benzene	Br_2 or Cl_2, anhydrous $FeBr_3$ or $FeCl_3$, r.t.p.	 halogenoarene		Prolonged conditions produce 1,2-dihalide and 1,4-dihalide Produces halogenoarenes
Electrophilic substitution	 benzene	conc. HNO_3, conc. H_2SO_4, heat at 60°C	 nitrobenzene		Excessive temperatures lead to multiple substitution of NO_2^+
Electrophilic substitution	 benzene	RCl or RBr, anhydrous $AlCl_3$ or BF_3, r.t.p.	 alkyl-substituted benzene		Produces methylbenzene for further reactions: see below

Electrophilic substitution	 methylbenzene	Br_2 or Cl_2, anhydrous $FeBr_3$ or $FeCl_3$, r.t.p.		Similar to benzene	
Electrophilic substitution	 methylbenzene	conc. HNO_3, conc. H_2SO_4, heat at 30°C		Similar to benzene	Temperature needed is reduced as CH_3 is an *activating* group.
Electrophilic substitution	 methylbenzene	RCl or RBr, anhydrous $AlCl_3$ or BF_3, r.t.p.		Similar to benzene	
Ring addition	 methylbenzene	H_2, Ni, 150°C, high pressure	 methylcyclohexane		

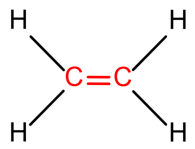
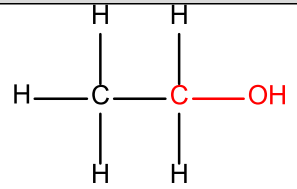
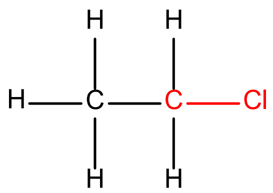
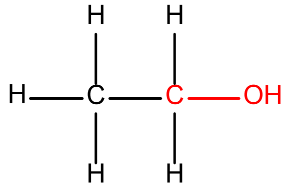
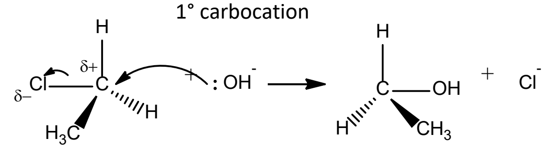
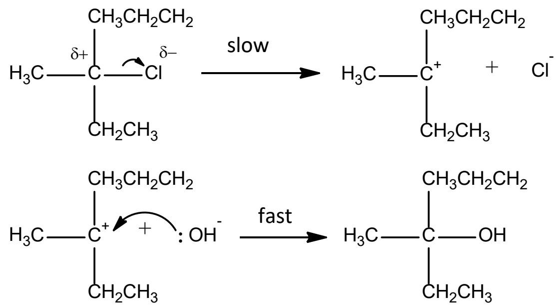
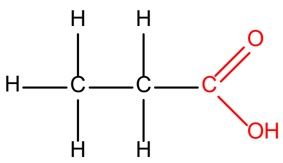
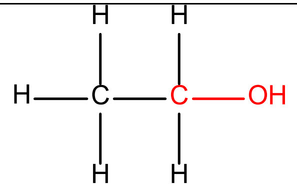
Side-chain substitution (free radical substitution)	 methylbenzene	Cl_2 or Br_2, UV light	 chloromethylbenzene	Similar to alkanes	
Side-chain oxidation (weak)	 methylbenzene	CrO_2Cl_2 or MnO_2, 65% H_2SO_4	 benzaldehyde	-	*temperature is not given in notes
Side-chain oxidation (strong)	 methylbenzene	$KMnO_4$ (aq), H_2SO_4 (aq), heat under reflux	 benzoic acid	-	Reaction only occurs on presence of benzylic hydrogen Produces benzoic acid

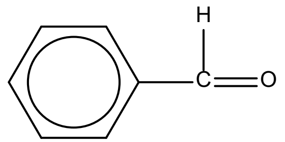
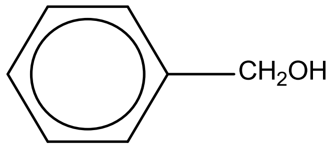
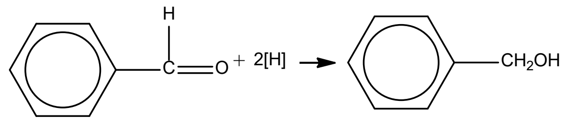
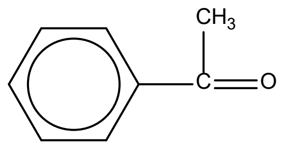
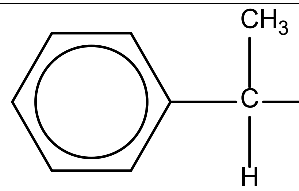
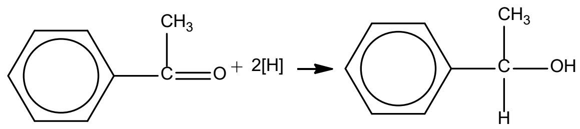
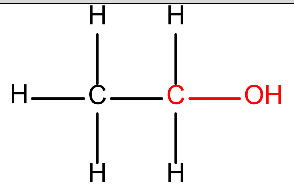
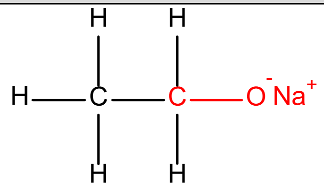
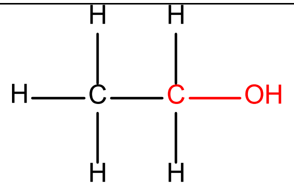
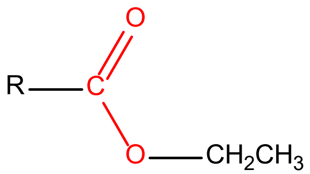
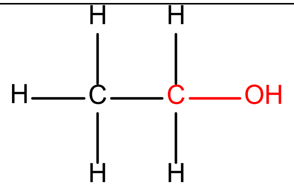
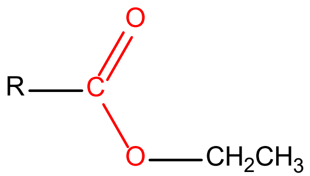
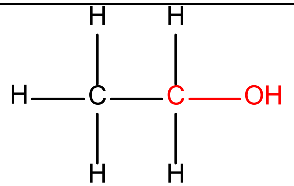
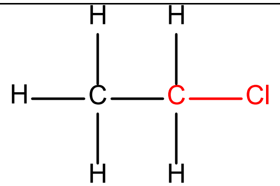
HALOGENOARENES

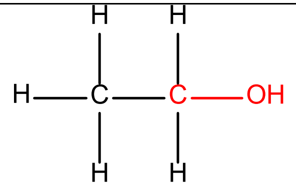
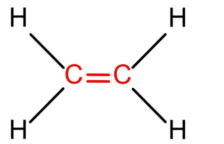
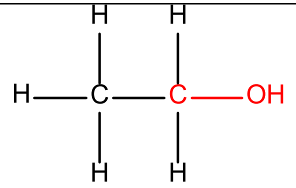
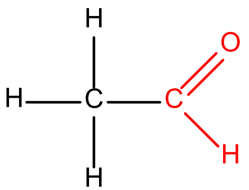
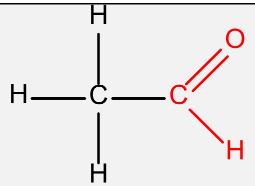
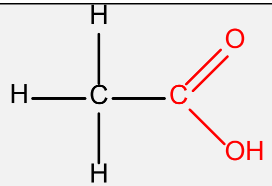
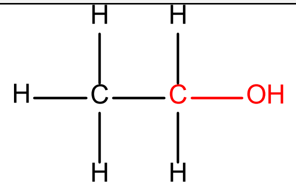
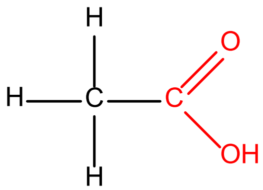
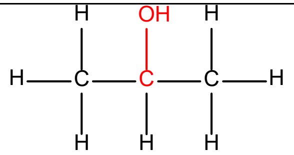
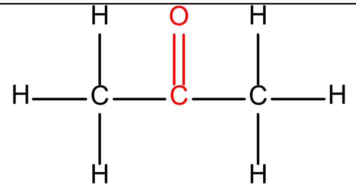
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Electrophilic substitution (benzene)	 benzene	Br_2 or Cl_2, anhydrous $FeBr_3$ or $FeCl_3$, r.t.p.	 halogenoarene		
REACTIONS					
Hydrolysis	 chlorobenzene	NaOH (aq), 360°C, 150 atm followed by dilute HCl	 phenol		Produces phenols
Nucleophilic substitution	 chloromethylbenzene	NaOH in water, heat		Similar to halogenoalkanes	Does not occur with chlorine directly bonded to benzene ring

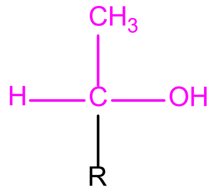
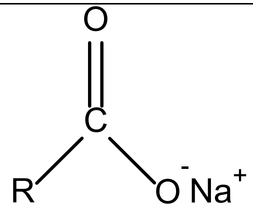
Nucleophilic substitution	 chloromethylbenzene	excess NH_3 in ethanol, heat under pressure in a sealed tube		Similar to halogenoalkanes	Does not occur with chlorine directly bonded to benzene ring
Nucleophilic substitution	 chloromethylbenzene	NaCN in ethanol, heat		Similar to halogenoalkanes	Does not occur with chlorine directly bonded to benzene ring Undergoes the same step-up reactions as halogenoalkanes

HYDROXYLS (ALIPHATIC)

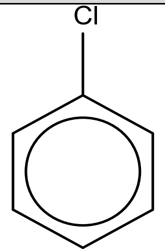
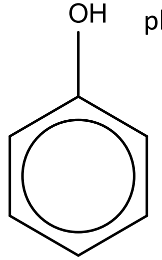
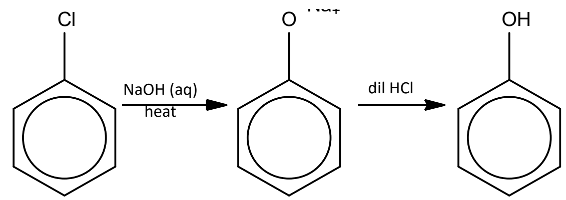
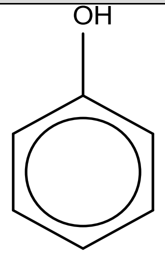
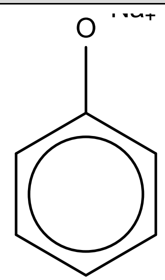
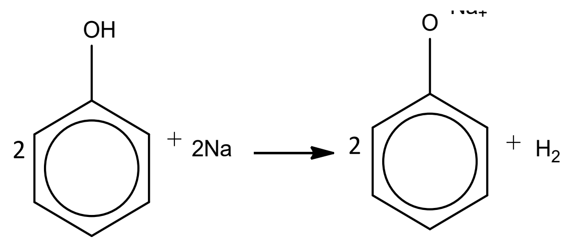
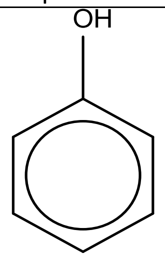
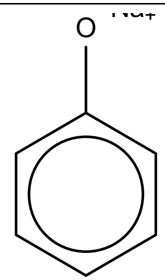
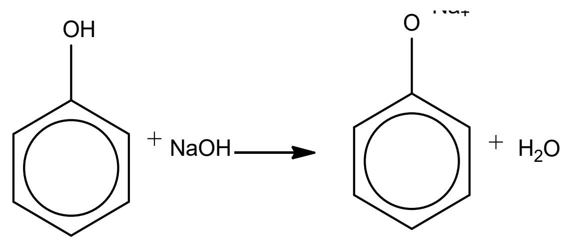
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Electrophilic addition (alkene)	 ethene	Cold conc. H_2SO_4, followed by water with heating	 CH_3CH_2OH	$CH_2{=}CH_2 + H_2O \rightarrow CH_3CH_2OH$	
Nucleophilic substitution (halogeno-alkane)	 chloroethane	NaOH in water, heat	 CH_3CH_2OH (major product)	S_N2 mechanism 1° carbocation  S_N1 mechanism 3° carbocation 	
Reduction (carboxylic acid)	 ethanoic acid	$LiAlH_4$ in dry ether, followed by hydrolysis, r.t.p.	 ethanol	$CH_3CO_2H + 4[H] \rightarrow CH_3CH_2OH + H_2O$	Produces primary alcohols

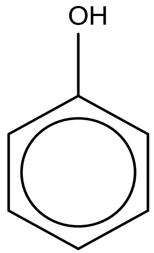
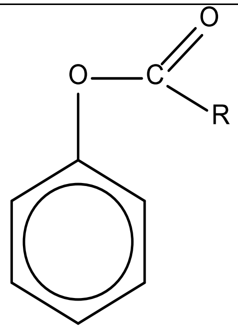
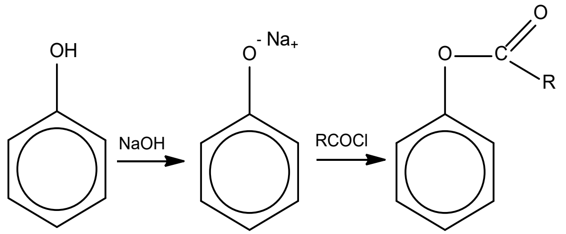
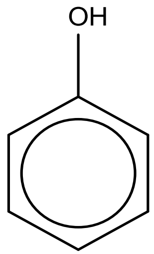
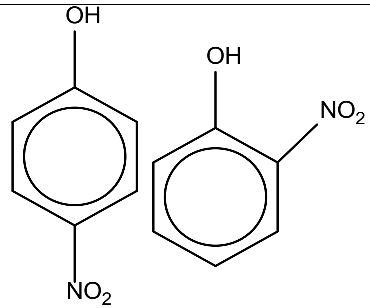
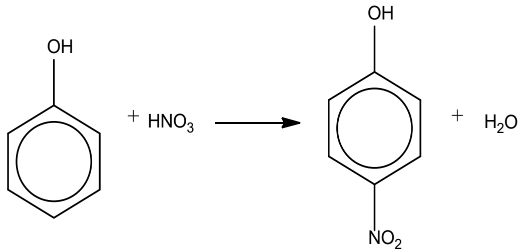
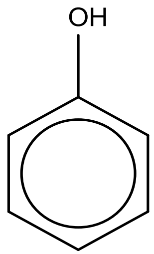
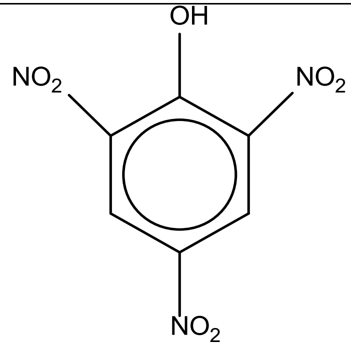
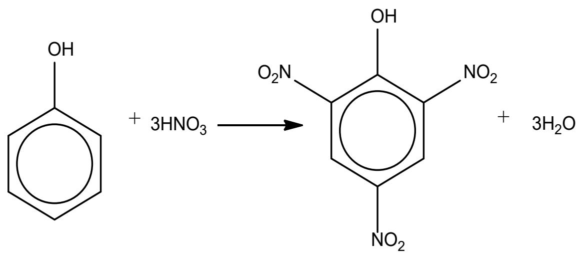
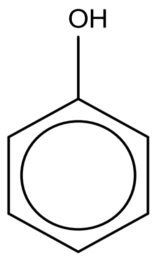
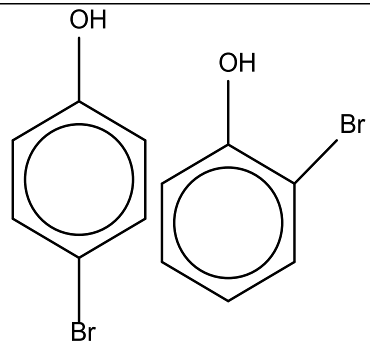
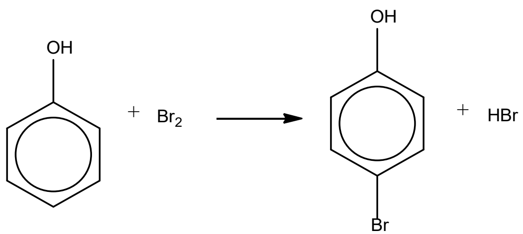
Reduction (aldehyde)	 benzyaldehyde	$LiAlH_4$ in dry ether followed by hydrolysis, r.t.p.	 phenylmethanol		Produces primary alcohols
Reduction (ketone)		$LiAlH_4$ in dry ether followed by hydrolysis, r.t.p.			Produces secondary alcohol
REACTIONS					
Acid-metal or redox	 ethanol	Na metal, r.t.p.		$2C_2H_5OH + 2Na \rightarrow 2C_2H_5O^-Na^+ + H_2$	Effervescence of H_2 observed
Nucleophilic substitution	 ethanol	$R\text{-}CO_2H$, conc H_2SO_4, heat		$C_2H_5OH + RCO_2H \rightleftharpoons RCO_2CH_2CH_3 + H_2O$	Produces esters
Nucleophilic substitution	 ethanol	R-COCl, r.t.p.		$C_2H_5OH + RCOCl \rightarrow RCO_2CH_2CH_3 + HCl$	Produces esters (favoured method)
Nucleophilic substitution	 ethanol	HCl or HBr, heat	 chloroethane	$C_2H_5OH + HCl \rightarrow CH_3CH_2Cl + H_2O$	Produces halogenoalkanes
		$SOCl_2$, heat		$C_2H_5OH + SOCl_2 \rightarrow CH_3CH_2Cl + SO_2 + HCl$	
		PX_3, heat		$3C_2H_5OH + PCl_3 \rightarrow 3\ CH_3CH_2Cl + H_3PO_4$	
		PCl_5, r.t.p.		$C_2H_5OH + PCl_5 \rightarrow CH_3CH_2Cl + POCl_3 + HCl$	

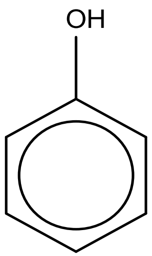
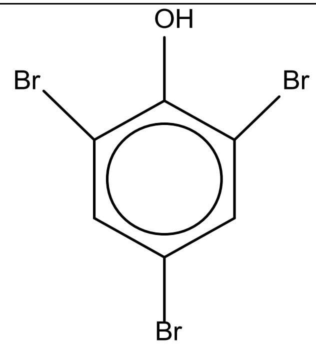
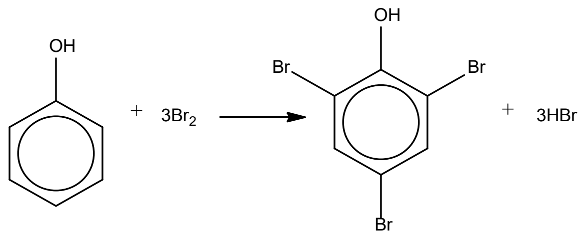
Condensation or elimination	 ethanol	Excess conc. H_2SO_4, heat	 ethene	$C_2H_5OH \rightarrow CH_2{=}CH_2 + H_2O$	Produces alkenes
Oxidation (mild)	 ethanol 1° alcohol	Acidified $K_2Cr_2O_7$ distil	 CH_3CHO	$CH_3CH_2OH + [O] \rightarrow CH_3CHO + H_2O$	Must write distil in exam. Produces aldehyde. Can be further oxidised: see below
Oxidation (mild)	 ethanal	Acidified $K_2Cr_2O_7$, reflux	 CH_3COOH	$CH_3CHO + [O] \rightarrow CH_3COOH$	Must write reflux in exam. Produces carboxylic acid
Oxidation (strong)	 ethanol 1° alcohol	Acidified $KMnO_4$, heat	 CH_3COOH	$CH_3CH_2OH + 2[O] \rightarrow CH_3COOH + H_2O$	Produces carboxylic acid
Oxidation (strong)	 propan-2-ol 2° alcohol	Acidified $KMnO_4$, heat	 CH_3COCH	$CH_3CH(OH)CH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$	Produces ketones

Iodoform test		Iodine and aqueous NaOH, warm		$CH_3CH_2OH + 4I_2 + 6OH^- \rightarrow CH_3COO^- + 5I^- + 5H_2O + CHI_3$	Ethanol is the only 1° alcohol to give positive iodoform test.

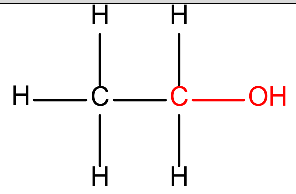
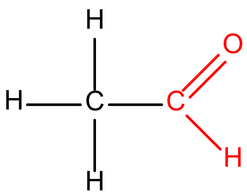
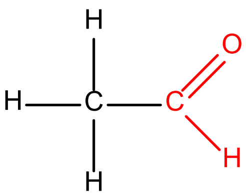
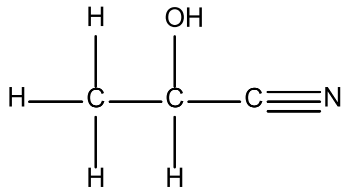
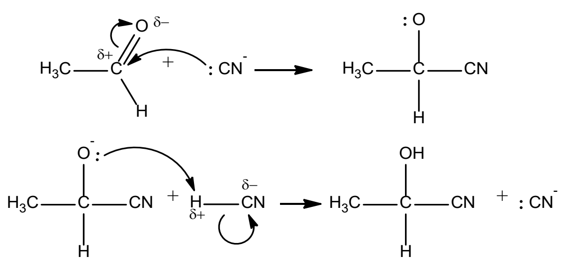
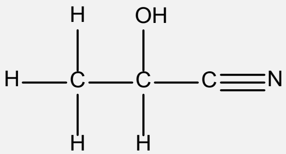
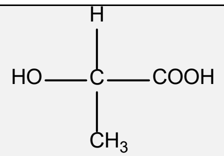
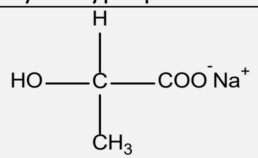
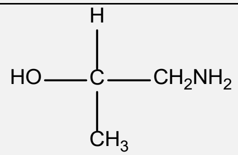
HYDROXYLS (AROMATIC)

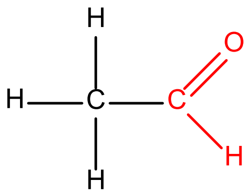
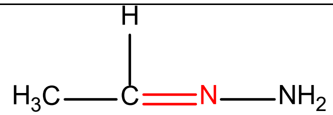
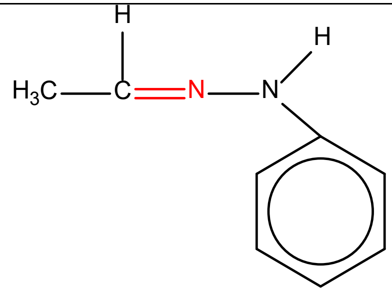
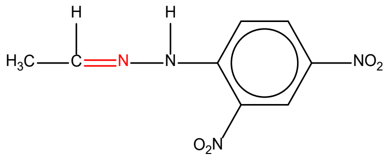
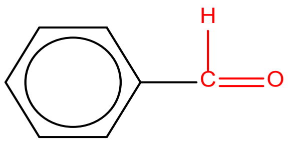
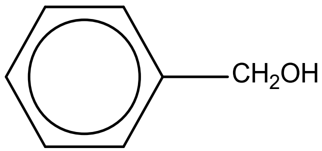
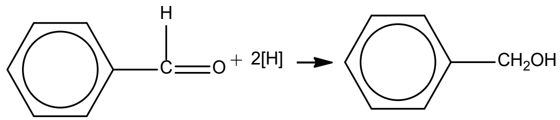
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Hydrolysis (halogeno-arene)	 chlorobenzene	NaOH (aq), 360°C, 150atm followed by dilute HCl	 phenol		
REACTIONS					
Acid-metal or redox	 phenol	Na metal, r.t.p.			
Acid-base	 phenol	NaOH (aq), r.t.p.			Alcohols do not react with NaOH, only phenols do Reason: phenol salt is more stable

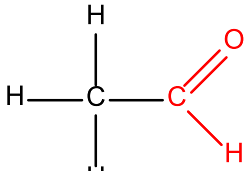
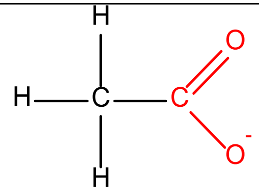
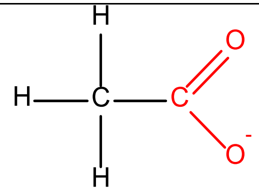
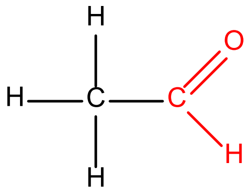
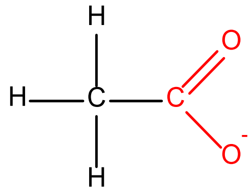
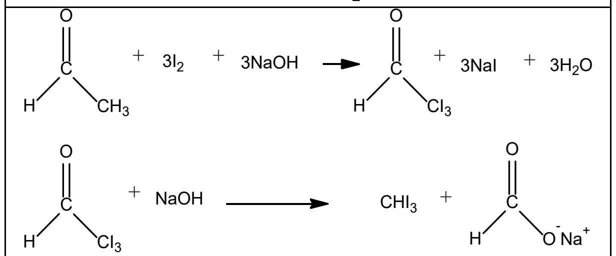
Nucleophilic substitution or condensation	 phenol	R-COCl in NaOH (aq), r.t.p.			Produces esters
Electrophilic substitution	 phenol	Dilute HNO_3, r.t.p.			Mono-substitution
Electrophilic substitution	 phenol	Concentrated HNO_3, r.t.p.			tri-substitution
Electrophilic substitution	 phenol	Liquid Cl_2 or Br_2, r.t.p.			Mono-substitution

Electrophilic substitution	 phenol	Aqueous Cl_2 or Br_2, r.t.p.			tri-substitution

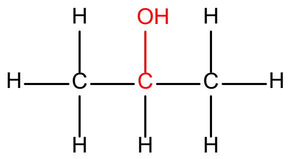
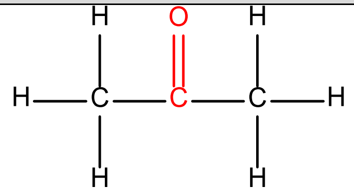
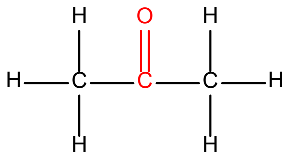
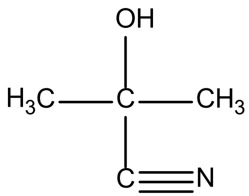
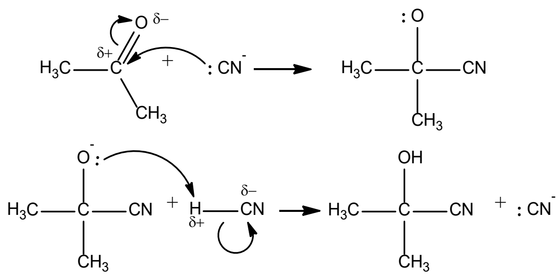
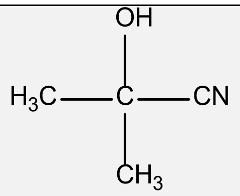
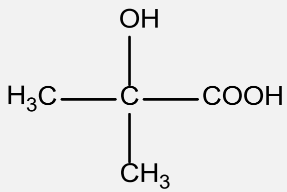
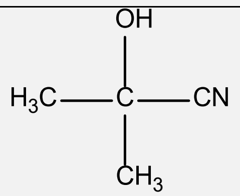
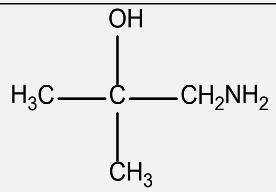
CARBONYLS (ALDEHYDES)

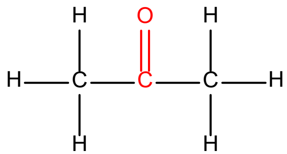
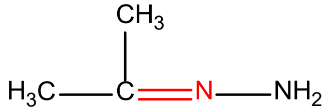
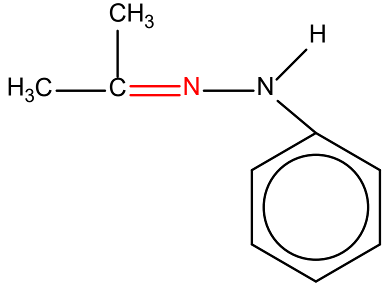
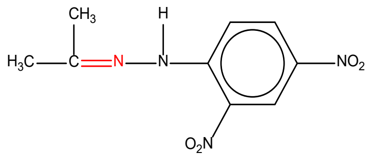
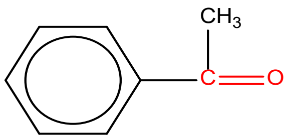
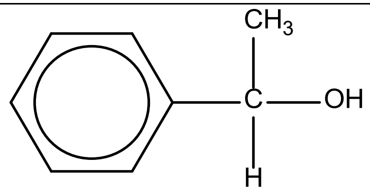
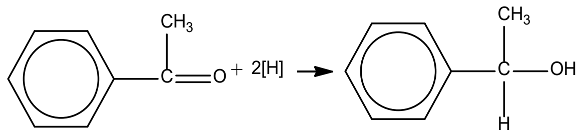
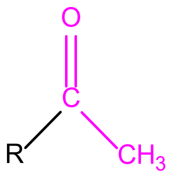
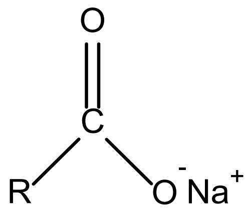
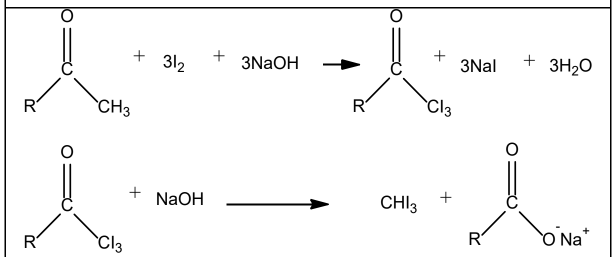
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Oxidation (mild) (primary alcohol)	 ethanol 1° alcohol	Acidified $K_2Cr_2O_7$ distil	 CH_3CHO	$CH_3CH_2OH + [O] \rightarrow CH_3CHO + H_2O$	
REACTIONS					
Nucleophilic addition	 ethanal	CN^-, r.t.p. HCN with trace amounts of base, r.t.p.	 $CH_3CH(OH)CN$		Produces racemic mixture Produces nitriles for further reactions: see below
Acid hydrolysis	 2-hydroxypropanenitrile	H_2SO_4 in H_2O, heat	 2-hydroxypropanoic acid	-	
Base hydrolysis		NaOH in H_2O, heat			
Reduction		$LiAlH_4$ in dry ether, followed by water, r.t.p.	 amino-propan-2-ol	-	

Condensation	 ethanal	Hydrazine $H_2N\text{-}NH_2$, r.t.p.		$CH_3CHO + H_2N\text{-}NH_2 \rightarrow CH_3CH\text{=}N\text{-}NH_2 + H_2O$	Brady's reagent (2,4-DNPH) gives orange ppt. Can be used to identify carbonyl compounds. (2,4-**D**o**N**ot**P**ee**H**ere - Goh Wei Ren 18S411)
		Phenylhydrazine $H_2N\text{-}NHC_6H_5$, r.t.p.		$CH_3CHO + H_2N\text{-}NHC_6H_5 \rightarrow CH_3CH\text{=}N\text{-}NHC_6H_5$ + H_2O	
		2,4-dinitrophenyl Hydrazine, r.t.p. 2,4-DNPH, r.t.p. Bradys' reagent, r.t.p.		$CH_3CHO + H_2N\text{-}NHC_6H_3(NO_2)_2 \rightarrow$ $CH_3CH\text{=}N\text{-}NHC_6H_3(NO_2)$ + H_2O	
Reduction	 benzyaldehyde	$LiAlH_4$ in dry ether followed by hydrolysis, r.t.p. $NaBH_4$ in ethanol, r.t.p. H_2, Pt catalyst, r.t.p.	 phenylmethanol		Produces primary alcohols

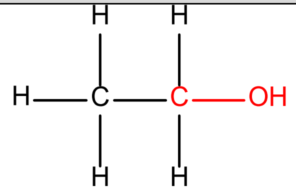
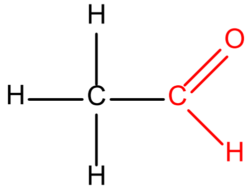
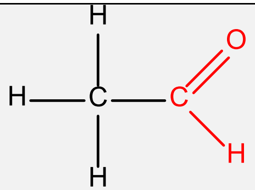
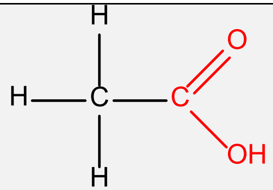
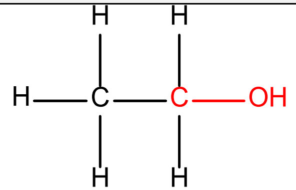
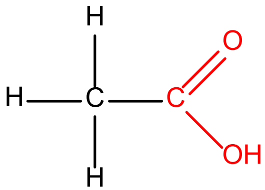
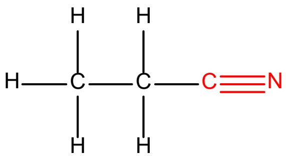
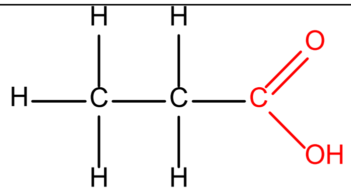
Oxidation	 ethanal	acidified $KMnO_4$, heat	-	-	Purple solution is decolorised to colorless
		acidified $K_2Cr_2O_7$, heat	-	-	Distinguishing tests for aldehyde vs ketone. Orange solution turns green
		Tollens' reagent, $Ag(NH_3)_2^+$ solution, warm		$CH_3CHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow CH_3CO_2^- + 4NH_3 + 2Ag + 2H_2O$	Silver mirror precipitated
		Fehling's solution, Alkaline $CuSO_4$and potassium sodium tartrate, warm ($KNaC_4H_4O_6{\cdot}4H_2O$)		$CH_3CHO + 2Cu^{2+} + 5OH^- \rightarrow CH_3CO_2^- + Cu_2O + 3H_2O$	Brick red ppt produced
Iodoform test	 ethanal	Iodine and aqueous NaOH, warm		$CH_3CHO + 3I_2 + 4NaOH \rightarrow CH_3CO_2^-Na^+ + CHI_3 + 3NaI + 3H_2O$ 	R-$COCH_3$ gives positive iodoform test. Note: for aldehydes, only ethanal gives positive test Pale yellow ppt produced

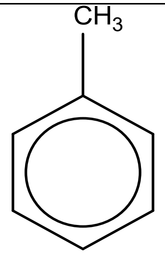
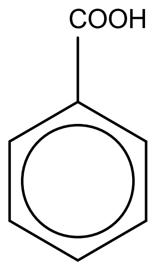
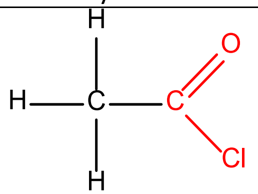
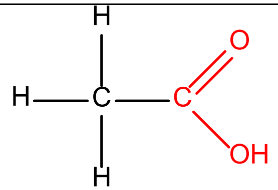
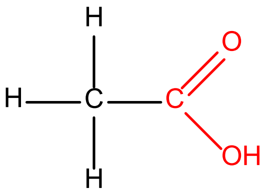
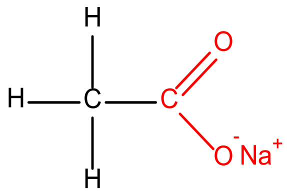
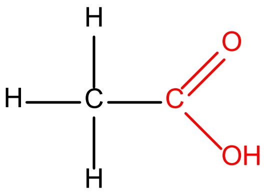
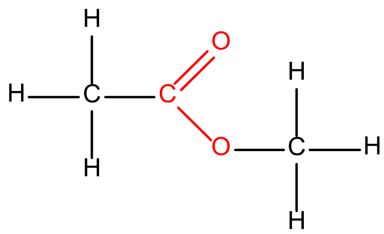
CARBONYLS (KETONES)

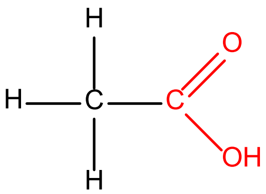
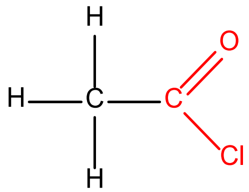
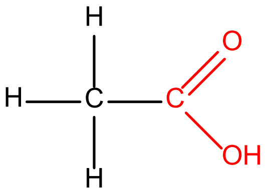
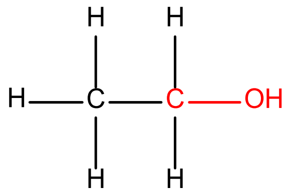
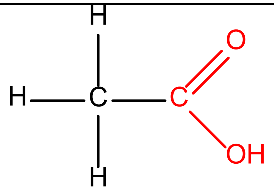
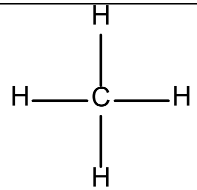
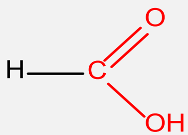
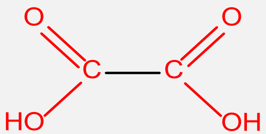
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Oxidation (secondary alcohol)	 propan-2-ol	$K_2Cr_2O_7$ in H_2SO_4, reflux	 propan-2-one	$CH_3CH(OH)CH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$	
REACTIONS					
Nucleophilic addition	 propan-2-one	HCN with trace amounts of base (NaOH or NaCN), r.t.p.	 $CH_3CH(OH)CNCH_3$		Produces racemic mixture Produces nitriles for further reactions: see below
Hydrolysis		H_2SO_4 in H_2O, heat		-	
Reduction		$LiAlH_4$ in dry ether, r.t.p.		-	

Condensation	 propan-2-one	Hydrazine $H_2N\text{-}NH_2$, r.t.p.		$CH_3COCH_3 + H_2N\text{-}NH_2 \rightarrow (CH_3)_2C\text{=}N\text{-}NH_2 + H_2O$	Brady's reagent gives orange ppt. Can be used to identify carbonyl compounds
		Phenylhydrazine $H_2N\text{-}NHC_6H_5$, r.t.p.		$CH_3COCH_3 + H_2N\text{-}NHC_6H_5 \rightarrow (CH_3)_2C\text{=}N\text{-}NHC_6H_5 + H_2O$	
		2,4-dinitrophenyl Hydrazine, r.t.p.		$CH_3COCH_3 + H_2N\text{-}NHC_6H_3(NO_2)_2 \rightarrow (CH_3)_2C\text{=}N\text{-}NHC_6H_3(NO_2)_3 + H_2O$	
		2,4-DNPH, r.t.p.			
		Bradys' reagent, r.t.p.			
Reduction		$LiAlH_4$ in dry ether followed by hydrolysis, r.t.p.			Produces secondary alcohol
Iodoform test	 Any ketone with $-COCH_3$ group (pink)	Iodine and aqueous NaOH, warm		$RCOCH_3 + 3I_2 + 4NaOH \rightarrow RCO_2^-Na^+ + CHI_3 + 3NaI + 3H_2O$	
					

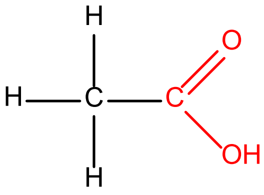
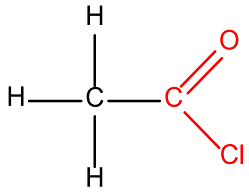
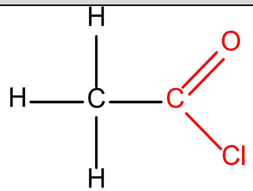
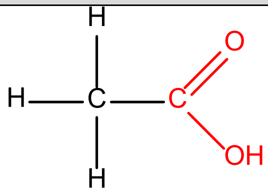
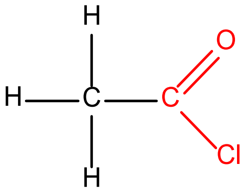
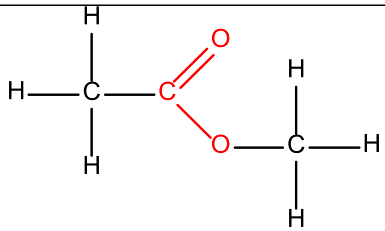
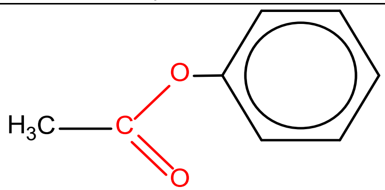
CARBONYLS (CARBOXYLIC ACIDS)

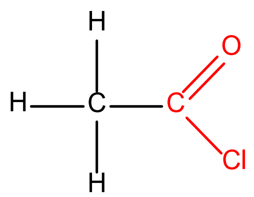
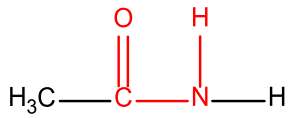
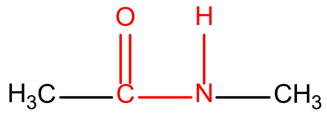
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Oxidation (mild) (alcohol)	 ethanol 1° alcohol	Acidified $K_2Cr_2O_7$ distil	 CH_3CHO	$CH_3CH_2OH + [O] \rightarrow CH_3CHO + H_2O$	Must write distil in exam. Produces aldehyde. Can be further oxidised: see below
Oxidation (mild) (aldehyde)	 ethanal	Acidified $K_2Cr_2O_7$, reflux	 CH_3COOH	$CH_3CHO + [O] \rightarrow CH_3COOH$	Must write reflux in exam. Produces carboxylic acid
Oxidation (strong) (alcohol)	 ethanol 1° alcohol	Acidified $KMnO_4$, heat	 CH_3COOH	$CH_3CH_2OH + 2[O] \rightarrow CH_3COOH + H_2O$	Produces carboxylic acid
Acid hydrolysis (nitrile)	 propane nitrile	H_2SO_4 in water, heat	 CH_3CH_2COOH	$2CH_3CH_2CN + 4H_2O + H_2SO_4 \rightarrow 2CH_3CH_2COOH + (NH_4)_2SO_4$	Produces carboxylic acids

Side-chain oxidation (strong) (methylbenzene)	 methylbenzene	$KMnO_4$ (aq), H_2SO_4 (aq), heat under reflux	 benzoic acid	-	
Hydrolysis (acyl chloride)	 ethanoyl chloride	water, r.t.p.	 ethanoic acid	$CH_3COCl + H_2O \rightarrow CH_3CO_2H + HCl$	Produces carboxylic acids
REACTIONS					
Acid-metal	 ethanoic acid	Na metal, r.t.p.	 sodium ethanoate	$CH_3CO_2H + Na \rightarrow CH_3CO_2^-Na^+ + \frac{1}{2} H_2$	
Acid-base		NaOH, r.t.p.		$CH_3CO_2H + NaOH \rightarrow CH_3CO_2^-Na^+ + H_2O$	
		$NaHCO_3$, r.t.p.		$CH_3CO_2H + NaHCO_3 \rightarrow CH_3CO_2^-Na^+ + H_2O + CO_2$	Distinguishing test for carboxylic acids (alcohols/phenols do not react)
		Na_2CO_3, r.t.p.		$2CH_3CO_2H + Na_2CO_3 \rightarrow 2CH_3CO_2^-Na^+ + H_2O + CO_2$	
Esterification / condensation	 ethanoic acid	R-OH (e.g. CH_3OH), concentrated H_2SO_4 catalyst, reflux	 methyl ethanoate	$CH_3CO_2H + CH_3OH \rightleftharpoons CH_3CO_2CH_3 + H_2O$	Produces esters

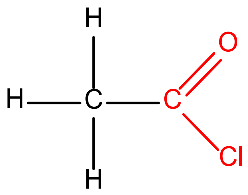
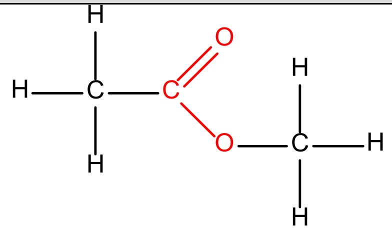
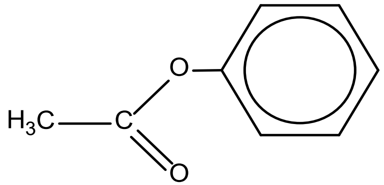
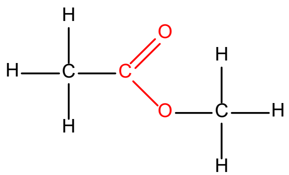
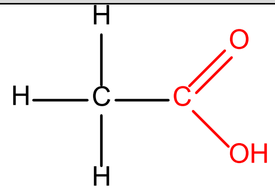
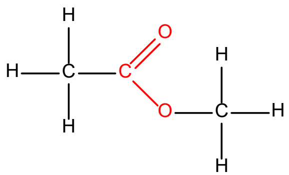
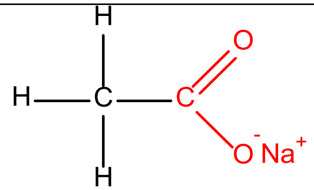
Conversion to acyl chloride	 ethanoic acid	PCl_5, r.t.p.	 ethanoyl chloride	$3CH_3CO_2H + PCl_3 \rightarrow 3CH_3COCl + H_3PO_4$	
		PCl_3, reflux		$CH_3CO_2H + PCl_5 \rightarrow CH_3COCl + HCl\ (g) + POCl_3$	
		$SOCl_2$, reflux		$CH_3CO_2H + SOCl_2 \rightarrow 3CH_3COCl + HCl\ (g) + SO_2\ (g)$	Preferred reaction
Reduction	 ethanoic acid	$LiAlH_4$ in dry ether, r.t.p.	 ethanol	$CH_3CO_2H + 4[H] \rightarrow CH_3CH_2OH + H_2O$	Produces primary alcohols
De-carboxylation	 ethanoic acid	Soda lime (CaO / NaOH mixture), reflux	 methane	$CH_3CO_2H + NaOH \rightarrow CH_3CO_2^-Na^+ + H_2O$ $CH_3CO_2^-Na^+ + NaOH \rightarrow CH_4 + Na_2CO_3$ Overall: $CH_3CO_2H + 2NaOH \rightarrow CH_4 + Na_2CO_3 + H_2O$	Produces alkanes
Dehydration (special)	 methanoic acid	Excess concentrated H_2SO_4, reflux	-	$HCO_2H \rightarrow H_2O + CO$	Unstable in presence of hot $KMnO_4$
Oxidation (special)		H_2SO_4 (aq), $KMnO_4$ (aq), reflux	-	$HCO_2H + [O] \rightarrow H_2O + CO_2$	
Dehydration (special)	 ethanedioic acid	Excess concentrated H_2SO_4, reflux	-	$H_2C_2O_4 \rightarrow H_2O + CO + CO_2$	
Oxidation (special)		H_2SO_4 (aq), $KMnO_4$ (aq), reflux	-	$H_2C_2O_4 + [O] \rightarrow H_2O + 2CO_2$	

CARBONYLS (ACYL CHLORIDES)

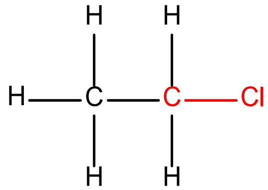
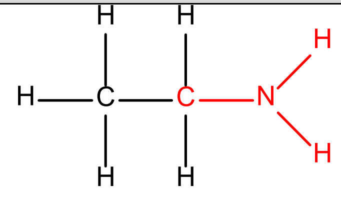
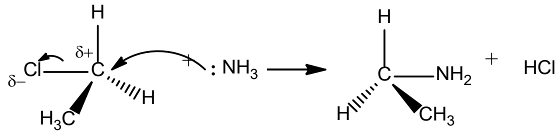
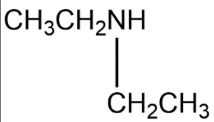
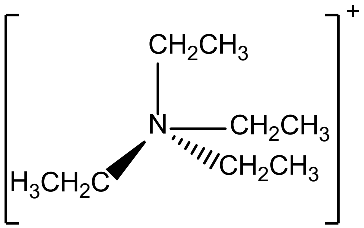
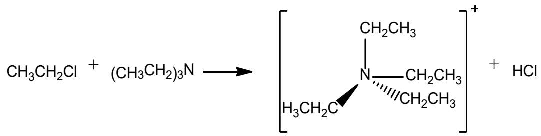
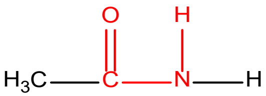
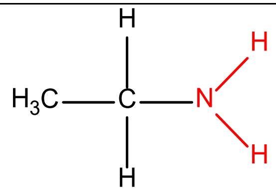
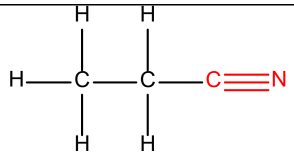
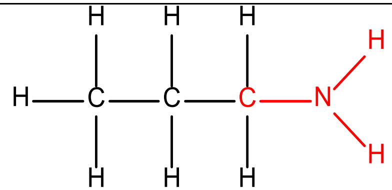
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Conversion to acyl chloride (carboxylic acid)	 ethanoic acid	PCl_5, r.t.p.	 ethanoyl chloride	$3CH_3CO_2H + PCl_3 \rightarrow 3CH_3COCl + H_3PO_4$	
		PCl_3, reflux		$CH_3CO_2H + PCl_5 \rightarrow CH_3COCl + HCl\ (g) + POCl_3$	
		$SOCl_2$, reflux		$CH_3CO_2H + SOCl_2 \rightarrow 3CH_3COCl + HCl\ (g) + SO_2\ (g)$	Preferred reaction as the 2 gases are easily removed
REACTIONS					
Hydrolysis	 ethanoyl chloride	water, r.t.p.	 ethanoic acid	$CH_3COCl + H_2O \rightarrow CH_3CO_2H + HCl$	Produces carboxylic acids
Condensation	 ethanoyl chloride	R-OH (e.g. CH_3OH), r.t.p.	 methyl ethanoate	$CH_3COCl + CH_3OH \rightarrow CH_3COOCH_3 + HCl$	Produces esters
Condensation		C_6H_5OH, NaOH (aq), r.t.p.		$C_6H_5OH + NaOH \rightarrow C_6H_5O^-Na^+ + H_2O$ $CH_3COCl + C_6H_5O^-Na^+ \rightarrow CH_3COOC_6H_5 + NaCl$	Produces esters NaOH produces the stronger nucleophile $C_6H_5O^-Na^+$

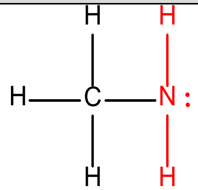
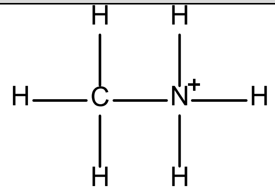
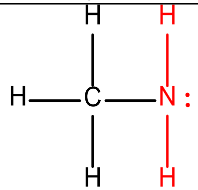
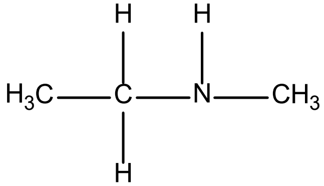
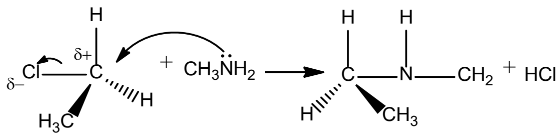
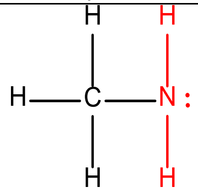
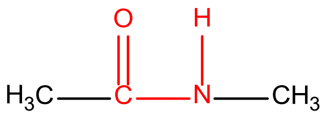
Condensation	 ethanoyl chloride	NH_3, r.t.p.		$CH_3COCl + NH_3 \rightarrow CH_3CO\text{-}NH_2 + HCl$ Excess ammonia: $CH_3COCl + 2NH_3 \rightarrow CH_3CO\text{-}NH_2 + NH_4Cl$	Produces amides
Condensation		$R\text{-}NH_2$ (e.g. CH_3NH_2), r.t.p.		$CH_3COCl + CH_3NH_2 \rightarrow CH_3CO\text{-}NHCH_3 + HCl$ Excess amine: $CH_3COCl + 2CH_3NH_2 \rightarrow CH_3CO\text{-}NHCH_3 + CH_3NH_3Cl$	Produces amides

CARBONYLS (ESTERS)

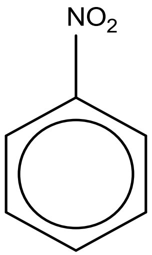
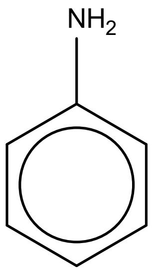
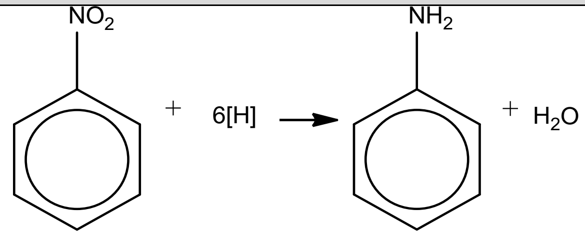
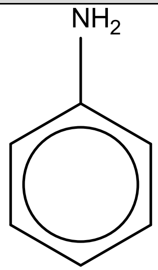
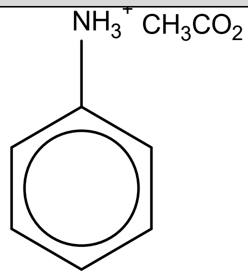
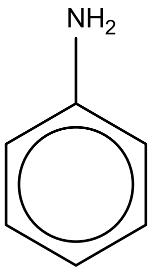
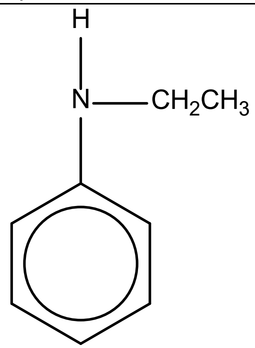
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Condensation (acyl chloride)	 ethanoyl chloride	R-OH (e.g. CH_3OH), r.t.p.	 methyl ethanoate	$CH_3COCl + CH_3OH \rightarrow CH_3COOCH_3 + HCl$	Produces esters
		C_6H_5OH, NaOH (aq), r.t.p.		$C_6H_5OH + NaOH \rightarrow C_6H_5O^-Na^+ + H_2O$ $CH_3COCl + C_6H_5O^-Na^+ \rightarrow CH_3COOC_6H_5 + NaCl$	Produces esters NaOH produces the stronger nucleophile $C_6H_5O^-Na^+$
REACTIONS					
Acid hydrolysis	 methyl ethanoate	H_2SO_4 (aq), reflux	 ethanoic acid	$CH_3COOCH_3 + H_2O \rightleftharpoons CH_3COOH + CH_3OH$	reversible
Alkaline hydrolysis	 methyl ethanoate	NaOH (aq), reflux	 sodium ethanoate	$CH_3COOCH_3 + NaOH \rightarrow CH_3COO^-Na^+ + CH_3OH$	not reversible as CH_3COO^- is resonance stabilized

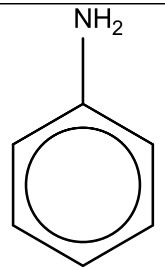
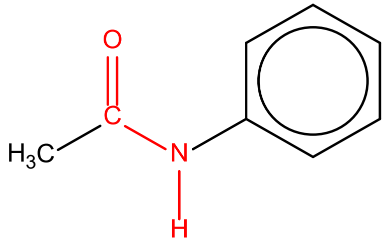
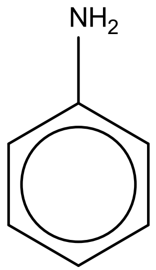
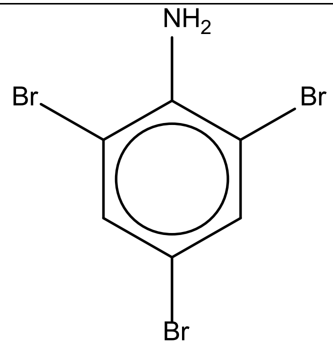
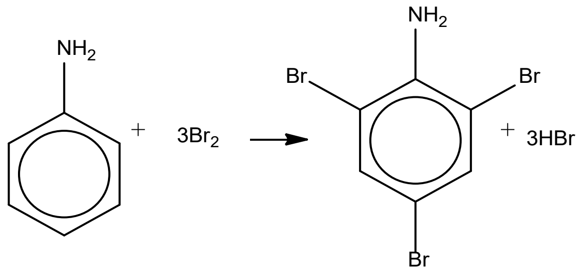
AMINES (ALIPHATIC)

Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Nucleophilic substitution (halogen-alkane)	 chloroethane	excess NH_3 in ethanol, heat under pressure in a sealed tube	 $CH_3CH_2NH_2$ primary amine		
			 secondary amine	$CH_3CH_2Cl + CH_3CH_2NH_2 \rightarrow (CH_3CH_2)_2NH + HCl$	
			$(CH_3CH_2)_3N$ tertiary amine	$CH_3CH_2Cl + (CH_3CH_2)_2N \rightarrow (CH_3CH_2)_3N + HCl$	
					
Reduction (amides)	 ethanamide	$LiAlH_4$ in dry ether, followed by hydrolysis, r.t.p.		$CH_3CONH_2 + 4[H] \rightarrow CH_3CH_2NH_2$	Produces primary amines
Reduction (nitriles)	 propane nitrile	$LiAlH_4$ in dry ether, followed by water, r.t.p.	 $CH_3CH_2CH_2NH_2$	$CH_3CH_2CN + 4[H] \rightarrow CH_3CH_2CH_2NH_2$	

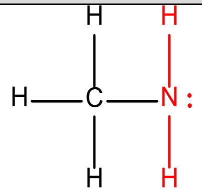
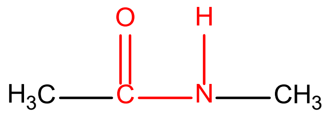
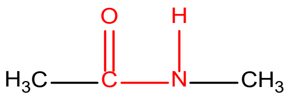
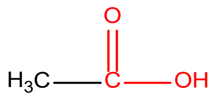
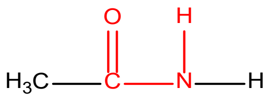
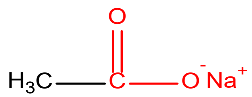
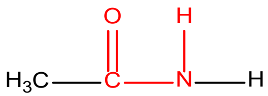
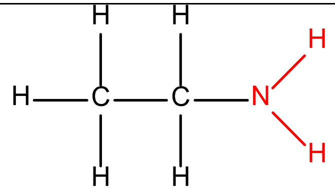
REACTIONS					
Neutralisation	 methylamine	Any acid (e.g. HCl), r.t.p.	 methylammonium chloride	$CH_3NH_2 + HCl \rightarrow CH_3NH_3^+Cl^-$	
Nucleophilic substitution (amine acting as attacking species)	 methylamine	RX (e.g. CH_3CH_2Cl), heat under pressure in a sealed tube (alcoholic amine)			Produces amines
Condensation	 methylamine	R-COCl (e.g. CH_3COCl), r.t.p.		$CH_3COCl + CH_3NH_2 \rightarrow CH_3CO\text{-}NHCH_3 + HCl$ Excess amine: $CH_3COCl + 2CH_3NH_2 \rightarrow CH_3CO\text{-}NHCH_3 + CH_3NH_3Cl$	Produces amides

AMINES (AROMATIC)

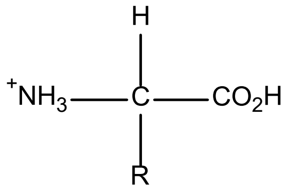
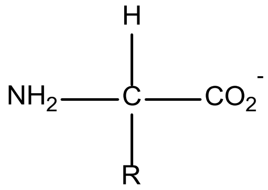
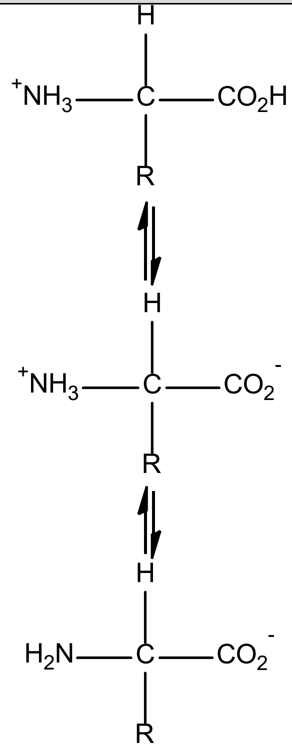
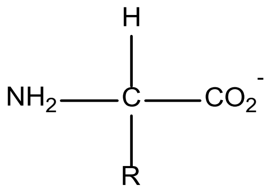
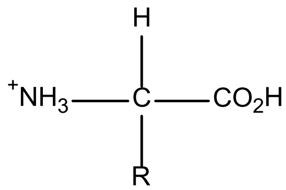
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Reduction (nitro-benzene)	 nitrobenzene	Sn and concentrated HCl, heat, followed by addition of alkali at r.t.p.	 phenylamine	 $C_6H_5NO_2 + 6H^+ + 3Sn \rightarrow C_6H_5NH_2 + 2H_2O + 3Sn^{2+}$	
REACTIONS					
Neutralisation	 phenylamine	Any acid (e.g. CH_3CO_2H), r.t.p.	 phenylammonium ethanoate	$C_6H_5NH_2 + CH_3CO_2H \rightarrow C_6H_5NH_3^+CH_3CO_2^-$	
Nucleophilic substitution (amine acting as attacking species)	 phenylamine	RX (e.g. CH_3CH_2Cl), heat under pressure in a sealed tube	 ethylphenylamine	$C_6H_5NH_2 + CH_3CH_2Cl \rightarrow C_6H_5NH(CH_2CH_3) + HCl$	

Condensation	 phenylamine	R-COCl (e.g. CH_3COCl), r.t.p.	 N-phenylethanamide	$C_6H_5NH_2 + CH_3COCl \rightarrow CH_3CONHC_6H_5 + HCl$	Produces amides
Electrophilic substitution	 phenylamine	Br_2 (aq), r.t.p.	 2,4,6-tribromophenylamine		Distinguishing test for phenylamine. Observation: orange bromine decolorises with formation of a white ppt.

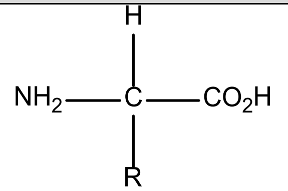
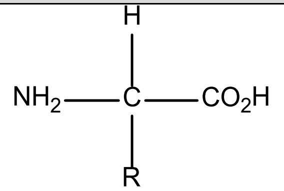
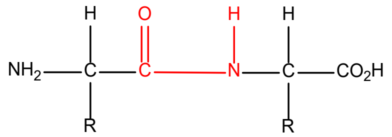
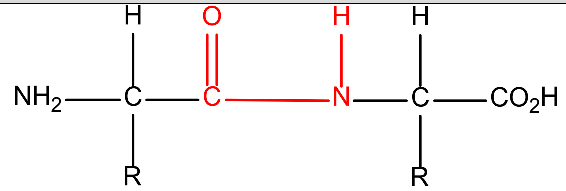
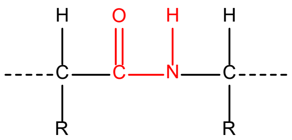
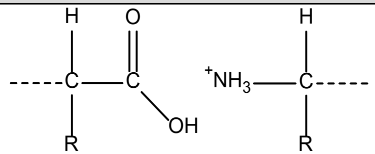
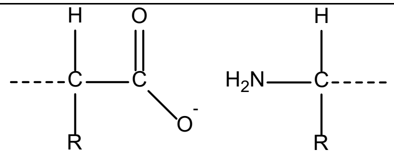
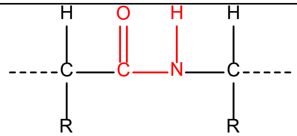
AMIDES

Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Condensation (amine)	 methylamine	R-COCl (e.g. CH_3COCl), r.t.p.		$CH_3COCl + CH_3NH_2 \rightarrow CH_3CO\text{-}NHCH_3 + HCl$ Excess amine: $CH_3COCl + 2CH_3NH_2 \rightarrow CH_3CO\text{-}NHCH_3 + CH_3NH_3Cl$	Produces amides
REACTIONS					
Acid hydrolysis		HCl (aq) / H_2SO_4 (aq), heat		$CH_3CONHCH_3 + H_2O + H^+ \rightarrow CH_3CO_2H + CH_3NH_3^+$	Produces carboxylic acid
Alkaline hydrolysis		NaOH (aq), heat		$CH_3CONH_2 + OH^- \rightarrow CH_3CO_2^- + NH_3$	Test for primary amide Pungent NH_3 gas produced
Reduction		$LiAlH_4$ in dry ether, followed by hydrolysis, r.t.p.		$CH_3CONH_2 + 4[H] \rightarrow CH_3CH_2NH_2$	Produces primary amines

AMINO ACIDS

Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
REACTIONS					
Adding acid to protonated amino acid	 High pH	Any acid	 Low pH		Order of deprotonation: α-carboxylic acid R-carboxylic acid α-amino acid R-amino acid
Adding alkali to fully deprotonated amino acid	 Low pH	Any base	 High pH		

PROTEINS

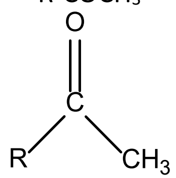
Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
PREPARATION					
Condensation (amino acid)					Dipeptide formation
REACTIONS					
Acid-base catalysed hydrolysis		Dilute acid, heat		-	-
		Dilute alkali, heat		-	-
Enzymatic hydrolysis		Enzyme, r.t.p.	Enzymes cleave at either the carboxylic end or amino acid end. The resulting fragment depends on the action of the enzyme.		

DISTINGUISHING TESTS (by functional group)

Test for	Reaction name	Reagents and Conditions	Observations (for X = …)	Notes
Alkene	Electrophilic addition	X_2 in water, r.t.p.	Cl_2: Pale yellow solution decolorises Br_2: Orange solution decolorises I_2: Brown solution decolorises	
Alkene	Oxidative cleavage	$KMnO_4$ (aq) in H_2SO_4 (aq), heat	Purple $KMnO_4$ decolorises [Terminal alkene: Effevescene of CO_2 gas that gives a white ppt with limewater]	
Halogeno-alkane R-X	Nucleophilic substitution	Add NaOH (aq), heat. Acidify with dilute HNO_3, followed by $AgNO_3$ (aq). Add NH_3 (aq)	Cl: White ppt produced Br: Pale yellow ppt produced I: Yellow ppt produced Cl: White ppt dissolves to form colorless solution Br: Cream ppt insoluble in dilute NH_3, soluble in concentrated NH_3 to form colorless solution	
Alcohol (1° and 2°)	Oxidation	$K_2Cr_2O_7$ (aq) in H_2SO_4 (aq), distill	1° and 2° alcohol: Orange solution turns green 3° alcohol: No observation	
		$K_2Cr_2O_7$ (aq) in H_2SO_4 (aq), reflux		
		$KMnO_4$ (aq) in H_2SO_4 (aq), heat	1° and 2° alcohol: Purple solution decolorises 3° alcohol: No observation	
Alcohol (1°, 2° and 3°)	Acid-metal	Na metal, r.t.p.	Effeverscene of H_2 observed	
Aldehyde	Condensation	Brady's reagent (2,4-DNPH)	Orange ppt produced	

Aldehyde	Oxidation	$K_2Cr_2O_7$ (aq) in H_2SO_4 (aq), reflux	Orange solution turns green	
		$KMnO_4$ (aq) in H_2SO_4 (aq), heat	Purple solution decolorises	
Aldehyde	Oxidation	Tollen's reagent $[Ag(NH_3)_2]^+$, warm	Silver mirror precipitated	
Aldehyde	Oxidation	Fehling's solution, warm	Brick red ppt produced Blue solution decolorises	
Ketone	Condensation	Brady's reagent (2,4-DNPH)	Orange ppt produced	
Aldehyde / ketone with $RCOCH_3$	Iodoform	I_2 in NaOH (aq), warm	Pale yellow ppt produced	Only ethanal gives positive iodoform test
Carboxylic acid	Acid-base	Na_2CO_3	Effevescene of CO_2 gas which produces a white ppt with limewater	Distinguish between **carboxylic acid** and **alcohol / phenol**
		$NaHCO_3$		
Amide (1°)	Alkaline hydrolysis	NaOH (aq), heat	Pungent NH_3 gas produced	

DISTINGUISHING TESTS (by reagent)

	Reagent	Reaction name	Positive test for	Observations (for X = …) to copy down	Notes
Reagents reactant with more than 1 functional group	$KMnO_4$ (aq) in H_2SO_4 (aq), heat or $KMnO_4$ (aq) in NaOH (aq), heat	Oxidative cleavage	Alkenes	Purple solution decolorises	
		Oxidation	1° and 2° alcohols Aldehydes		
			Benzene with side chain	Purple solution decolorises, white ppt produced	
	$K_2Cr_2O_7$ (aq) in H_2SO_4 (aq), heat or $KMnO_4$ (aq) in NaOH (aq), heat	Oxidation	1° and 2° alcohols Aldehydes	Orange solution turns green	
	Na metal / any metal	Acid-metal	Alcohol Phenol Carboxylic acid	Effevescene of H_2 which "pops" a lighted splint	
	X_2 (aq)	Electrophilic addition	Alkene	Cl_2: Pale yellow solution decolorises Br_2: Orange solution decolorises I_2: Brown solution decolorises	
		Electrophilic substitution	Phenol Phenylamine		
	Brady's reagent	Condensation	Aldehyde Ketone	Orange ppt produced	
	I_2 in NaOH, warm	Iodoform	R-$COCH_3$ 	Pale yellow ppt formed	
	Tollens' reagent $[Ag(NH_3)_2^+]$, warm	Oxidation	Aliphatic aldehyde Aromatic aldehyde	Silver mirror formed	

	Fehling's solution, warm	Oxidation	Aliphatic aldehyde	Brick red ppt formed	
	Na_2CO_3	Acid-base	Carboxylic acid	Effervescene of CO_2 which produces a white ppt with limewater	
	NaOH (aq), heat, followed by Dilute HNO_3, followed by $AgNO_3$ (aq), followed by NH_3 (aq) or conc. NH_3	Nucleophilic substitution	Halogenoalkanes	Cl: White ppt produced Br: Pale yellow ppt produced I: Yellow ppt produced Cl: White ppt dissolves to form colorless solution Br: Cream ppt insoluble in dilute NH_3, soluble in concentrated NH_3 to form colorless solution I: Yellow ppt insoluble in both dilute and concentrated NH_3	

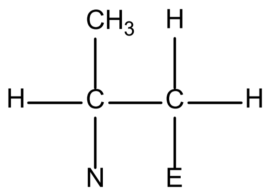
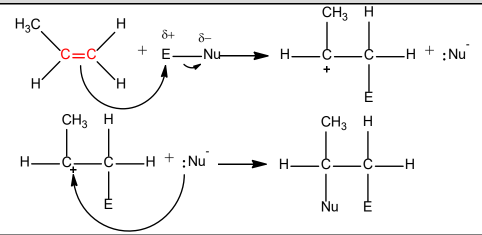
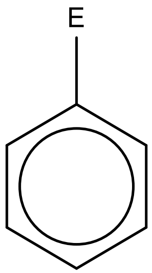
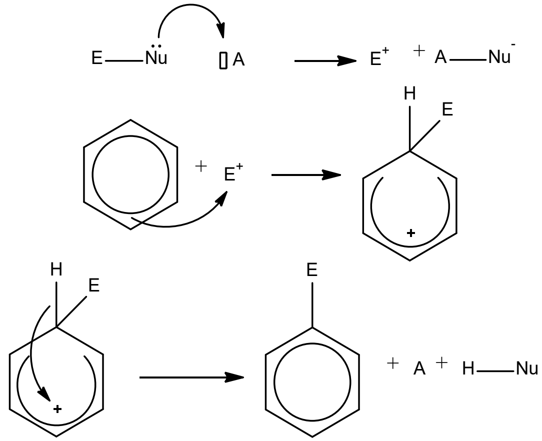
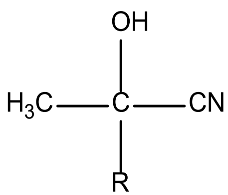
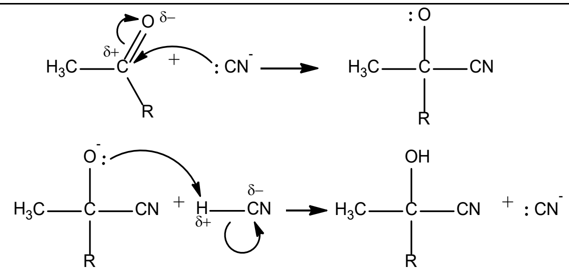
REDUCING AGENTS

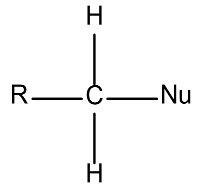
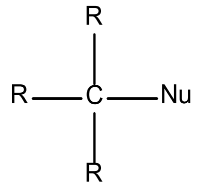
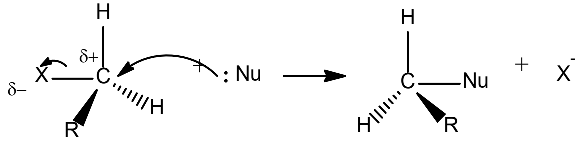
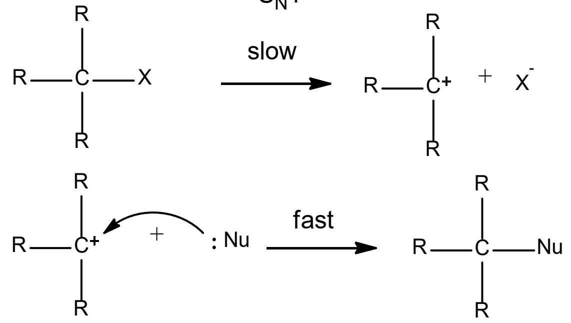
Reagent	Resulting compound from...							
	Alkene	Aldehyde	Ketone	Carboxylic acid	Acyl chloride	Ester	Amide	Nitrile
H_2, Ni catalyst, heat H_2, Pt or Pd catalyst, r.t.p.	Yes	Yes	Yes					Yes
$NaBH_4$ in methanol		Yes	Yes					
$LiAlH_4$ in dry ether		Yes	Yes	Yes	Yes	Yes	Yes	Yes
...produces...	alkane	1° alcohol	2° alcohol	1° alcohol	1° alcohol	2 1° alcohols	1° amine	1° amine

OXIDISING AGENTS

Reagent	Resulting compound from...							
	Alkene	Phenol	Alkylbenzene	1° and 2° alcohol	Aldehyde	Benzaldehyde	Methanoic acid	Ethanedioic acid
$KMnO_4$ (aq) in H_2SO_4 (aq), cold	Yes							
$KMnO_4$ (aq) in H_2SO_4 (aq), heat	Yes		Yes	Yes	Yes	Yes	Yes	Yes
K_2Cr_2O7 (aq) in H_2SO_4 (aq), heat				Yes	Yes	Yes		
Tollen's reagent $[Ag(NH_3)_2]^+$, warm					Yes	Yes		
Fehling's solution, warm						Yes		

REACTION MECHANISMS

Name of Reaction	Starting compound	Reagents and Conditions	Products	Reaction Mechanism / Chemical Equation	Notes
		REACTIONS			
Electrophilic addition	Alkenes	Cold conc. H_2SO_4, followed by water with heating Br_2 in water, r.t.p. X_2 in CCl_4, r.t.p. HX in water, r.t.p.			E = electrophilic Nu = nucleophile
Electrophilic substitution	Arenes and benzene derivatives (alkylbenzene, phenol, phenylamine)	Br_2 or Cl_2, anhydrous $FeBr_3$ or $FeCl_3$, r.t.p. conc. HNO_3, conc. H_2SO_4, heat at 60°C RCl or RBr, anhydrous $AlCl_3$ or BF_3, r.t.p.			A = acid catalyst
Nucleophilic addition	Aldehydes / Ketone	HCN with trace amounts of base, r.t.p.			R group = H R group = alkyl

Nucleophilic substitution	Halogenalkanes / Halogenoarenes	NaCN in ethanol, heat	S_N2  S_N1 	S_N2  S_N1 	
	Alcohols / Phenols	R-CO_2H, conc H_2SO_4, heat			
		R-COCl, r.t.p.			
		HCl or HBr, heat			
		$SOCl_2$, heat			
		PX_3, heat			
		PCl_5, r.t.p.			
	Amines / Phenylamines	RX (e.g. CH_3CH_2Cl), heat under pressure in a sealed tube (alcoholic amine)