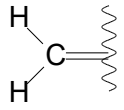
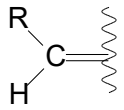
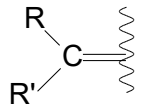
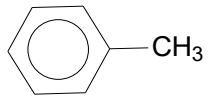
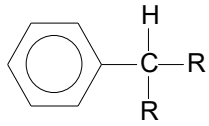
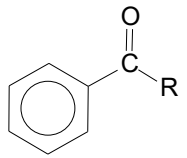
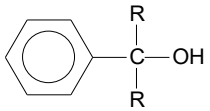
1. Types of Organic reaction you need to know

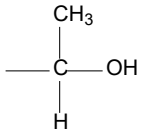
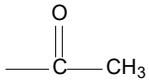
Types of reaction	Sub Reaction	Comments
Substitution (carbon centre is saturated/ resonance stabilised)	*Free Radical Substitution*	Homolytic fission of alkane leading to unpaired eln. H2 Topic: Alkane
	Electrophilic Substitution	Electrophilic: reacting carbon-centre is eln rich; thus it attacks electrophile. H2 Topic: Arene
	Nucleophilic Substitution	Nucleophilic: reacting carbon centre is eln poor; thus attacked by nucleophile. H2 Topic: Halogenoalkane
Addition (carbon centre is unsaturated)	*Electrophilic Addition*	Electrophilic: C=C double bond is eln rich, thus it attacks electrophile. H2 Topic: Alkene
	Nucleophilic Addition	Nucleophilic: reacting carbon centre is eln poor, thus attacked by nucleophile. H2 Topic: Carbonyl compound
Oxidation		Either increase in O atom/ decrease in H atom/ increase in OS
Reduction		Either decrease in O atom/increase in H atom/ decrease in OS
Acid base reaction	Bronsted Lowry	Bronsted Acid donates H^+. Bronsted Base accepts H^+
	Lewis	Lewis acid accepts eln pair; Lewis base donates eln pair
Hydrolysis		Reaction whereby a molecule is cleaved into two molecules by H_2O. Eg: Esters hydrolysis, Amide hydrolysis, Acid chlorides hydrolysis, Nitrile hydrolysis.
Condensation		Reaction between *two functional groups* to eliminate a small molecule such as water or ammonia. (one of these molecules involve a −C=O group) Eg. Carboxylic acid + alcohol, acid chloride + ammonia, etc)
Elimination		Reaction to remove a small molecule from an organic molecule (eg. Removal of HX from halogenoalkane; H_2O from alcohol)
Precipitation		Chemical reaction that cause formation of solid from two aq. Soln.

*** for reactions in italic, you need to know the mechanism.*

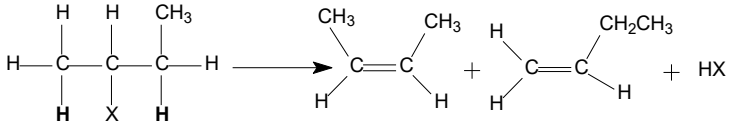
2. Common reagents for synthesis

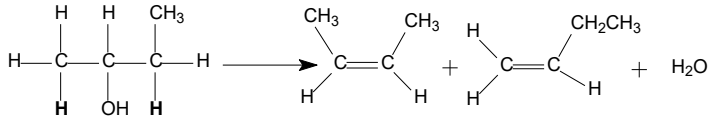
Reagents & Condition	Type of reaction	Functional group	Observations	Products	√ ?
Section A: Oxidation					
$KMnO_4$ with H_2SO_4 (aq), heat **Or $KMnO_4$ with NaOH, heat, followed by acidification**	Oxidation (Oxidative cleavage)	 Terminal alkene	Decolourisation of purple soln; Effervescence observed.	CO_2 + H_2O	
			Decolourisation of purple soln	RCO_2H formed. $CH_3CH=CH_2$ + 5[O] → CH_3CO_2H + H_2O + CO_2 Note: So if elucidation abt vigorous oxidation of alkene shows an increase of 2 O, the alkene contains this feature.	
				Ketone formed. $(CH_3)_2C=CH_2$ + 4[O] → $(CH_3)_2CO$ + H_2O + CO_2 Note: So if elucidation abt vigorous oxidation of alkene shows an increase of 1 O, the alkene contains this feature.	
$KMnO_4$ with H_2SO_4 (aq), heat	Oxidation (Side chain oxidation- occurs when C directly bonded to benzene ring has *a H or O directly attached*)			Benzoic acid formed. $C_6H_5CH_3$ + 3[O] → $C_6H_5CO_2H$ + H_2O	
			Decolourisation of purple soln; Effervescence observed.	Benzoic acid formed. The rest of the chain get oxidised to CO_2 & H_2O unless question says otherwise	
				Benzoic acid formed. $C_6H_5COCH_3$ + 4[O] → $C_6H_5CO_2H$ + H_2O + CO_2 Note: Likely to be hinted by the question	

				Benzoic acid formed. Note: Likely to be hinted by the question	
	Oxidation	Aldehydes, 1° and 2°alcohols	Decolourisation of purple soln	Aldehyde → carboxylic acid 1° alcohol → carboxylic acid 2° alcohol → ketone 3° alcohol → no [O] Note: If elucidation shows a gain of 1 O atom during oxidation => likelihood is 1° alcohol	
		Methanoic acid Ethanedioic acid	Decolourisation of purple soln Effervescence observed.	CO_2 + H_2O produced	
Dilute $KMnO_4$ with NaOH (aq)	Mild Oxidation	Alkenes	Decolourisation of purple soln Formation of brown MnO_2	Alkene → Diol $CH_2{=}CH_2 + H_2O + [O] \rightarrow CH_2(OH)CH_2OH$	
$K_2Cr_2O_7$ with H_2SO_4 (aq), Heat,	Oxidation	Aldehydes, 1° and 2°alcohols	Orange soln turns green	Aldehyde → carboxylic acid 1° alcohol → carboxylic acid (with reflux) 1° alcohol → aldehyde (with distillation) 2° alcohol → ketone	
Tollen's reagent (ammonical solution of silver nitrate), **Warm**		Aldehydes	Silver mirror formed.	Ag^+ reduced to Ag $RCHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow RCO_2^- + 2Ag + 4NH_3 + 2H_2O$	
Fehling's Soln (alkaline solution of Copper(II) tartrate), **warm**		**Aliphatic** Aldehydes only	Reddish brown soln formed.	Cu^{2+} reduced to Cu^+ in Cu_2O $RCHO + 2\,Cu^{2+} + 5OH^- \rightarrow RCO_2^- + Cu_2O + 3H_2O$	
I_2(aq) with NaOH, Warm		Ethanol/Alcohols with the structural feature	Yellow crystals of triiodomethane (CHI_3) formed.	$RCH(OH)CH_3 + 4I_2 + 6OH^- \rightarrow RCO_2^- + CHI_3 + 5I^- + 5H_2O$ $RCOCH_3 + 3I_2 + 4OH^- \rightarrow RCO_2^- + CHI_3 + 3I^- + 3H_2O$	

		 Or ethanal/ketones with the structural feature 		Synthesis to ***decrease carbon chain by 1 C***.	
Section B: Reduction					
H_2(g) with Ni catalyst	Reduction	Alkenes Aldehydes Ketones Nitriles	-	Alkene → Alkane Aldehyde → 1° alcohol Ketone → 2° alcohol * 1 mol of H_2 reacts with 1 mol of the above Nitrile → Amine * 2 mol of H_2 reacts with 1 mol of the above	
LiA/H_4 in dry ether	Reduction	Aldehydes Ketones Nitriles Carboxylic acids Amides		Aldehyde → 1° alcohol Ketone → 2° alcohol Nitrile → Amine Carboxylic acid → 1° alcohol Amide → Amine + H_2O 1. $RCONH_2$ + 4[H] → RCH_2NH_2 (1° amine) + H_2O 2. RCONHR + 4[H] → RCH_2NHR(2° amine) + H_2O 3. $RCONR_2$ + 4[H] → RCH_2NR_2 (3° amine) + H_2O Note: LiA/H_4 only reduce polar bonds, but not nitrobenzene. *It may reduce esters to alcohols,* ***if question give context.***	
Sn with concentrated HCl, heat **Followed by aq. NaOH,**		Nitrobenzenes		Phenylamine produced.	

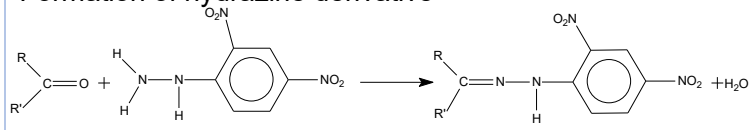
				Note: NaOH is added in 2nd step to neutralise $C_6H_5NH_3^+$ to liberate phenylamine.	
Section C: Reaction with Na/NaOH/$NaHCO_3$/Na_2CO_3					
Na(s)	Redox reaction	Alcohols Phenols Carboxylic acids	Effervescence of H_2 gas	ROH + Na → RO^-Na^+ + ½ H_2 C_6H_5OH + Na → $C_6H_5O^-Na^+$ + ½ H_2 CH_3CO_2H + Na → $CH_3CO_2^-Na^+$ + ½ H_2 Note: **½ mol of H_2** liberated per mol of the organic molecule Na is oxidised, H is reduced.	
NaOH (aq)	Acid base reaction	Phenols Carboxylic acids	Partition of phenols and carboxylic acids from organic layer into the aq. Layer	Phenols → Phenoxide + water Carboxylic acids → Carboxylate salts + water.	
NaOH(aq), heat	Nucleophilic Substitution/ or alkaline hydrolysis	Halogenoalkanes (where X= Cl, Br, I)	-	Alcohols RX + OH^- → ROH + X^- To distinguish the diff halogenoalkanes, Dil HNO_3 is added to remove the xs. NaOH, cooled and $AgNO_3$ added in to precipitate AgX AgCl: White ppt AgBr: Cream ppt AgI: Yellow ppt	
	Alkaline hydrolysis	Amides	Pungent alkaline gas liberated that turn moist red litmus blue	Ammonia/ Amine produced with carboxylate salt $RCONH_2$ + OH^- → RCO_2^- + NH_3 RCONHR + OH^- → RCO_2^- + NH_2R (NH_2R might exist as a gas, either CH_3NH_2 or hinted by qns)	

		Nitriles		$RCN + OH^- + H_2O \rightarrow RCO_2^- + NH_3$	
		Esters	-	Carboxylate salt and alcohol (or phenoxide salt) Note: 1. phenol deprotonate in presence of aq. NaOH to give phenoxide salt. 2. As water is used in hydrolysis, if need to carry out subsequent test to verify the starting compound is indeed ester, cannot use reagents such as PCl_5, $SOCl_2$ etc as they will get destroyed by the moisture from hydrolysis.	
Na_2CO_3(aq), **$NaHCO_3$(aq)**	Acid-base reaction	Carboxylic acids Acyl Halides (where X= Cl, Br)	Effervescence	Carboxylic acid → Carboxylate salt + CO_2 + H_2O CH_3COX → Carboxylate salt + NaX + H_2O	
NaOH (ethanol), heat	Elimination	Halogenoalkanes		Alkene  (Both cis/trans) Note: Elimination is only possible if halogen and hydrogen atom are attached on adjacent carbons.	
Section D: Hydrolysis					
Dilute acids (HCl, HNO_3, H_2SO_4), Heat	Acid Hydrolysis	Nitriles Amides Esters		$RCN + H^+ + 2H_2O \rightarrow RCO_2H + NH_4^+$ $RCONH_2 + H^+ + H_2O \rightarrow RCO_2H + NH_4^+$ $RCO_2R' + H_2O \rightarrow RCO_2H + R'OH$	
H_2O (l)	Hydrolysis	Acyl Halides (where X= Cl, Br)	**White fumes	Carboxylic acid and hydrogen halides	

				**Note: White fume is observed only with dropwise addition of water, else HCl will dissolve and is no longer observed. Hence, choose another method for distinguishing test if possible.	
$AgNO_3$ (aq)	Hydrolysis followed by precipitation		AgCl= White ppt AgBr= Cream ppt	Silver halides ppt No need to add OH^- or H^+ as acid halides hydrolyses readily in water.	
Section E: Reaction with Conc Acid					
H_2O(g) with H_3PO_4 catalyst or Cold Conc. H_2SO_4 followed by water, heat	Electrophilic Addition	Alkene		Alcohol Note: Apply Markonikov's rule (Add H to the C containing more no. of H in C=C to get the more stable carbocation)	
Concentrated H_3PO_4 catalyst and heat Or Excess conc H_2SO_4, heat	Elimination	Alcohols		Alkene:  Note: Only possible if -OH and hydrogen atom are attached on adjacent carbons.	
Conc. H_2SO_4, heat with reflux	Condensation	Alcohols Carboxylic acid		$RCO_2H + R'OH \rightleftharpoons RCO_2R' + H_2O$ Conc. H_2SO_4 used as a dehydrating agent as well as a catalyst. Reaction does **not** proceed with phenol.	
Conc. HNO_3 **(with Conc. H_2SO_4)** **50°C - Benzene** **30°C- alkylbenzene**	Electrophilic substitution	Benzene, Alkyl Substituted benzene ring		Nitrobenzene or alkyl nitrobenzene In the reaction, the electrophile is $^+NO_2$	

Dilute HNO_3		Phenol (−OH group activate the ring)		Either 2-nitrophenol or 4-nitrophenol is obtained.	
Section F: Reaction with bromine/ halogen					
Br_2(l) in CCl_4	Electrophilic Addition	Alkenes	Decolourisation of reddish brown Br_2	Dibromo-alkane obtained.	
Br_2(l) UV Light	Free radical Substitution	Alkanes		Use limited Br_2 or excess alkane if mono-sub is preferred. If not, poly substitution will take place. Note: Avoid FRS as much as possible in synthesis, as a mixture of products can be expected.	
Br_2 (with $FeBr_3$/ A*l*Br_3) or C*l*$_2$ (with FeC*l*$_3$ or A*l*C*l*$_3$)	Electrophilic Substitution	Benzene Substituted Benzene		Mono-brominated benzene/ benzene derivative obtained. In the reaction, the electrophile is ^+Br	
Br_2 (aq)	Electrophilic Addition	Alkene	Decolourisation of orange Br_2	In *symmetrical alkene*, Bromohydrin formed as the major product $CH_2{=}CH_2 + Br_2$ (aq) → $CH_2(OH)CH_2Br + HBr$. Disubstituted bromine as the minor pdt. In *unsymmetrical alkene*, Br will add to the C(of the C=C double bond) with more no. of H while H_2O will act as the nucleophile in the 2nd step, to obtain the major product. $CH_3CH{=}CH_2 + Br_2$(aq) → $CH_3CH(OH)CH_2Br + HBr$	
	Electrophilic Substitution	Phenols Phenylamine	Decolourisation of orange Br_2 **Formation of white ppt	Tri-bromination has taken place. *2,4,6 tribromophenol or 2,4,6 triphenylamine obtained. Note: * the number of Br attached in the product tells you how many of the 2,4,6 sites are already occupied with a side chain.	

				** white ppt may be observed for large molecules, not necessarily just 2,4,6 tribromophenol or 2,4,6 triphenylamine No catalyst required due to strongly activating –OH and –NH_2 .	
Section G: Reaction with Ammonia/ amine/nitrogen containing reactants					
NH_3	Acid-base reaction	Carboxylic acids		Carboxylate salt obtained	
	Condensation/	Acid halides (where X= Cl, Br)	White fumes	Primary amide is obtained.	
NH_3 dissolved in ethanol, heat in a sealed tube	Nucleophilic substitution	Halogenoalkanes		When excess ammonia or limited halogenoalkane used; $2NH_3$+ RX → RNH_2 + NH_4X	
Amine dissolved in ethanol, heat)				When excess halogenoalkane used, further sub take place RNH_2 + RX → R_2NH + HX (1° amine → 2° amine) R_2NH + RX → R_3N + HX (2° amine → 3° amine) R_3N + RX → R_4N+ + HX (3° amine → 4° ammonium salt) Quarternary ammonium salt is possible as the end pdt.	
KCN/NaCN in ethanol, heat	Nucleophilic Substitution	Halogeoalkanes	-	Nitriles formed Note: step up reaction	
Trace amount of NaCN, HCN, cold (Alternative: Trace amt of NaOH, HCN)	Nucleophilic Addition	Aldehydes/ ketones	-	Formation of cyanonitrile. CH_3COCH_3 + HCN → $(CH_3)_2C(OH)CN$ Note: step up reaction, with an increase of one functional group	

2,4,Dinitrophenylhydrazine	Condensation	Aldehydes/ Ketones	Orange ppt formed	Formation of hydrazine derivative 	
Section H: Reaction with $HX/PX_3/PX_5$					
HBr (g) or HCl(g)	Electrophilic Addition	Alkenes	-	Halogenoalkanes obtained In unsymmetrical alkene, the H will add to the C(of the C=C double bond) with more no. of H while the X will add to the C with less no. of H to obtain the more stable carbocation intermediate.	
HBr (g)	Nucleophilic Substitution	Alcohols	-	Halogenoalkanes obtained.	
PCl_3 or PCl_5 or PBr_3 or $SOCl_2$ **Anhydrous conditions**		Alcohols Carboxylic acids	White fumes	Alcohol → halogenoalkanes $ROH + PCl_5 \rightarrow RCl + POCl_3 + HCl$ $ROH + PBr_3 \rightarrow RBr + H_3PO_3$ Carboxylic acid → Acid halides $RCO_2H + SOCl_2 \rightarrow RCOCl + SO_2 + HCl$	