SUMMARY OF ORGANIC REACTIONS

SECTION 1 - ALIPHATIC

Aldehydes and ketones

Type of reaction	**Mechanism**
1. **oxidation** (aldehydes only): aldehyde → carboxylic acid reagents: potassium dichromate ($K_2Cr_2O_7$) in sulphuric acid (H_2SO_4) conditions: warm under reflux equation: R-CHO + [O] → R-COOH observation: orange to green to distinguish between aldehydes and ketones: either: add Fehling's solution and heat observation: blue solution to brick red precipitate equation: $R\text{-}CHO + 4OH^- + 2Cu^{2+} \rightarrow R\text{-}COOH + Cu_2O + 2H_2O$ or: add Tollen's reagent and heat observation: colourless solution to silver mirror equation: $R\text{-}CHO + 2[Ag(NH_3)_2]^+ + H_2O \rightarrow RCOOH + 2Ag + 4NH_3 + 2H^+$	n/a
2. **reduction**: carbonyl → alcohol reagents: $NaBH_4(aq)$ conditions: room temperature equation: $R_1\text{-}CO\text{-}R_2 + 2[H] \rightarrow R_1\text{-}CH(OH)\text{-}R_2$	Nucleophilic addition (required)
3. **addition of HCN**: carbonyl → hydroxynitrile reagents: NaCN and HCl(aq) conditions: room temperature equation: $R_1\text{-}CO\text{-}R_2 + HCN \rightarrow R_1\text{-}C(CN)(OH)\text{-}R_2$	Nucleophilic addition (required)

Carboxylic acids and their salts

Type of reaction	**Mechanism**
1. **acid-base** a) **carboxylic acids with sodium hydroxide** reagent: NaOH conditions: room temperature equation: $R\text{-}COOH(aq) + NaOH(aq) \rightarrow R\text{-}COO^-Na^+(aq) + H_2O(l)$ b) **carboxylic acids with sodium carbonate** reagent: Na_2CO_3 conditions: room temperature equation: $2R\text{-}COOH(aq) + Na_2CO_3(aq) \rightarrow 2R\text{-}COO^-Na^+(aq) + CO_2(g) + H_2O(l)$ observations: colourless gas evolved which turns limewater milky c) **carboxylate salts with acids** reagent: HCl(aq) conditions: room temperature equation: $R\text{-}COO^-(aq) + H^+(aq) \rightarrow R\text{-}COOH(aq)$	n/a
2. **esterification** reagents: any alcohol, concentrated sulphuric acid catalyst conditions: heat and reflux equation: $R_1\text{-}COOH + R_2OH == R_1\text{-}COOR_2 + H_2O$	Nucleophilic addition/ Elimination (not required)

Esters

Type of reaction	**Mechanism**
hydrolysis a) **acid hydrolysis** reagent: concentrated H_2SO_4 conditions: heat under reflux equation: $R_1\text{-}COOR_2 + H_2O == R_1\text{-}COOH + R_2OH$ b) **alkaline hydrolysis (saponification)** reagent: NaOH(aq) conditions: heat under reflux equation: $R_1\text{-}COOR_2 + NaOH == R_1\text{-}COO^-Na^+ + R_2OH$	n/a

Acyl chlorides and acid anhydrides

Type of reaction	**Mechanism**
1. acylation using acyl chlorides a) **with water** (to make carboxylic acids) conditions: room temperature equation: R-COCl + H_2O → R-COOH + HCl observation: white misty fumes b) **with ammonia** (to make amides) conditions: room temperature equation: R-COCl + NH_3 → R-$CONH_2$ + HCl observation: white misty fumes c) **with alcohols** (to make esters) conditions: room temperature equation: R_1-COCl + R_2-OH → R_1-$COOR_2$ + HCl observation: white misty fumes d) **with primary amines** (to make N-substituted amides) conditions: room temperature equation: R_1-COCl + R_2-NH_2 → R_1-$CONHR_2$ + HCl observation: white misty fumes	Nucleophilic addition-elimination (required)
2. acylation using acid anhydrides a) **with water** (to make carboxylic acids) conditions: room temperature equation: R_1-COOCO-R_2 + H_2O → R_1-COOH + R_2-COOH b) **with ammonia** (to make amides) conditions: room temperature equation: R_1-COOCO-R_2 + NH_3 → R_1-$CONH_2$ + R_2-COOH c) **with alcohols** (to make esters) conditions: room temperature equation: R_1-COOCO-R_2 + R_3-OH → R_1-COO-R_3 + R_2-COOH d) **with primary amines** (to make N-substituted amides) conditions: room temperature equation: R_1-COOCO-R_2 + R_3-NH_2 → R_1-CONH-R_3 + R_2-COOH	Nucleophilic addition-elimination (not required)

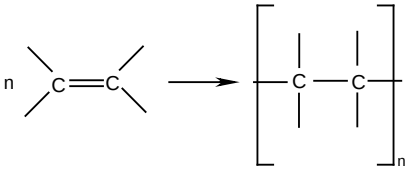
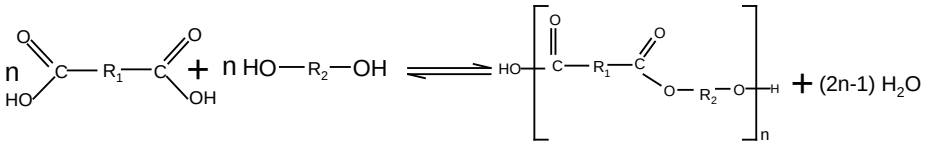
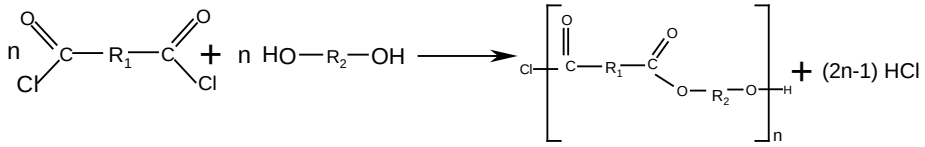
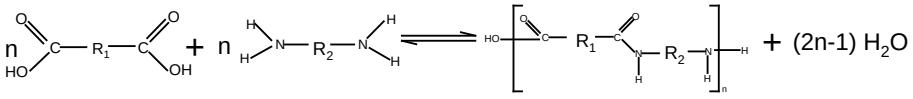
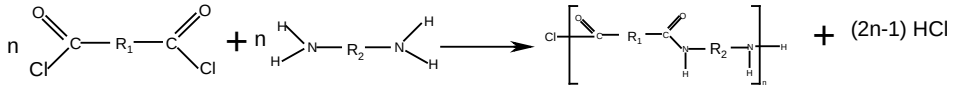
Amines

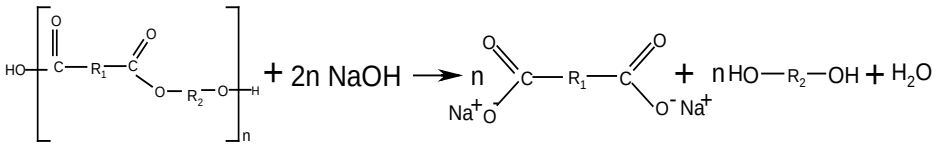
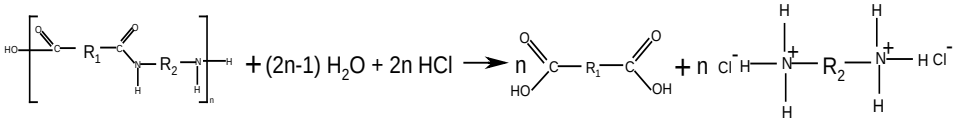
Type of reaction	Mechanism
1. **haloalkane → primary amine** reagents: haloalkane and excess ammonia conditions: heat equation: $R\text{-}X + 2NH_3 \rightarrow R\text{-}NH_2 + NH_4X$ or reagent: haloalkane and ammonia (1:1 ratio) conditions: heat equation: $R\text{-}X + NH_3 \rightarrow R\text{-}NH_2 + HX$ 2. **haloalkane → secondary amine** reagents: haloalkane and ammonia (2:1 ratio) conditions: heat equation: $2R\text{-}X + NH_3 \rightarrow R\text{-}NH\text{-}R + HX$ or reagents: haloalkane and primary amine conditions: heat equation: $R_1\text{-}X + R_2\text{-}NH_2 \rightarrow R_1\text{-}NH\text{-}R_2 + HX$ 3. **haloalkane → tertiary amine** reagents: haloalkane and ammonia (3:1 ratio) conditions: heat equation: $3R\text{-}X + NH_3 \rightarrow R_3N + HX$ or reagents: haloalkane and secondary amine conditions: heat equation: $R_1\text{-}X + R_2\text{-}NH\text{-}R_3 \rightarrow R_1R_2R_3N + HX$ 4. **haloalkane → quartenary ammonium salt** reagents: haloalkane and ammonia (4:1 ratio) conditions: heat equation: $4R\text{-}X + NH_3 \rightarrow [R_4N]^+X^-$ or reagents: haloalkane and secondary amine conditions: heat equation: $R_1\text{-}X + R_2R_3R_4N \rightarrow [R_1R_2R_3R_4N]^+X^-$	Nucleophilic substitution (required)
2. **reduction**: nitrile → primary amine reagents: $LiAlH_4$ in dry ether conditions: room temperature equation: $R\text{-}CN + 4[H] \rightarrow R\text{-}CH_2NH_2$	n/a
3. **acid-base**: a) amines with acids equations: $R_1\text{-}NH_2 + HCl \rightarrow R_1\text{-}NH_3Cl$ $R_1R_2\text{-}NH + HCl \rightarrow R_1R_2\text{-}NH_2Cl$ $R_1R_2R_3\text{-}N + HCl \rightarrow R_1R_2R_3\text{-}NHCl$ b) alkyl ammonium salts with alkalis equations: $R_1\text{-}NH_3Cl + NaOH \rightarrow R_1\text{-}NH_2 + NaCl + H_2O$ $R_1R_2\text{-}NH_2Cl + NaOH \rightarrow R_1R_2\text{-}NH + NaCl + H_2O$ $R_1R_2R_3\text{-}NHCl + NaOH \rightarrow R_1R_2R_3\text{-}N + NaCl + H_2O$	n/a

Amino Acids

Type of reaction	**Mechanism**
1. **acid-base reactions of amino acids** a) with acids reagents: HCl conditions: room temperature equation: $R\text{-}CH(NH_2)\text{-}COOH + HCl \rightarrow R\text{-}CH(NH_3^+Cl^-)\text{-}COOH$ b) with alkalis reagents: NaOH conditions: room temperature equation: $R\text{-}CH(NH_2)\text{-}COOH + NaOH \rightarrow R\text{-}CH(NH_2)\text{-}COO^-Na^+ + H_2O$ 2. **condensation reactions of amino acids** conditions: DNA equation: $n\ R\text{-}CH(NH_2)\text{-}COOH \rightarrow H\text{-}(NHCRHCO)_n\text{-}OH + (n\text{-}1)\ H_2O$ 3. **hydrolysis of proteins** reagents: 6 $moldm^{-3}$ HCl conditions: heat, reflux equation: $H\text{-}(NHCRHCO)_n\text{-}OH + (n\text{-}1)\ H_2O + n\ HCl \rightarrow n\ R\text{-}CH(NH_3^+Cl^-)\text{-}COOH$	Nucleophilic addition-elimination (not required)

Polymers

Type of reaction	Mechanism
1. **Addition polymerisation (alkenes → polyalkenes)** conditions: high temperature, Ziegle-Natte catalyst equation:  2. **Condensation polymerisation** a) **polyesters** dicarboxylic acid + diol → polyester conditions: H_2SO_4, heat under reflux equation:  or diacyl chloride + diol → polyester conditions: room temperature equation:  b) **polyamides** dicarboxylic acid + diamine → polyamide conditions: warm, reflux equation:  or diacyl chloride + diamine → polyamide conditions: room temperature equation: 	Free radical addition (not required) Nucleophilic addition-elimination (not required)

3. **Hydrolysis of condensation polymers** a) **polyesters** reagents: NaOH(aq) conditions: heat equation:  b) **polyamides** reagents: HCl(aq) conditions: heat equation: 	n/a n/a

SECTION 2 – AROMATIC

Type of reaction	**Mechanism**
1. nitration (benzene → nitrobenzene) Reagent: conc HNO_3 in conc H_2SO_4 Conditions: 50-55^oC under reflux Equation: $C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$	Electrophilic substitution (required)
2. alkylation (benzene → alkylbenzene) Reagent: R-Cl with anyhdrous $AlCl_3$ Conditions: 50^oC under reflux Equation: $C_6H_6 + R\text{-}Cl \rightarrow C_6H_5\text{-}R + HCl$ OR Reagent: alkene with anhydrous $AlCl_3$ and HCl Equation: $C_6H_6 + R_1R_2C{=}CR_1R_2 \rightarrow C_6H_5CR_1R_2CR_3R_4$	Electrophilic substitution (required)
3. acylation (benzene → phenylketone) Reagent: R-COCl with anydrous $AlCl_3$ Conditions: 50^oC under reflux Equation: $C_6H_6 + R\text{-}COCl \rightarrow C_6H_5COR + HCl$	Electrophilic substitution (required)
4. reduction (nitrobenzene → phenylamine) Reagents: Sn in conc HCl Conditions: heat under reflux Equation: $C_6H_5NO_2 + 6[H] \rightarrow C_6H_5NH_2 + 2H_2O$	n/a