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NEET, JEE Main and Class 12 boards

All Name Reactions of Class 12 Organic Chemistry

38 name reactions and rules, chapter by chapter in the order of the NCERT book: the equation, the reagent and conditions, and the one point the exam asks about each. Then 12 named tests in one table and a quiz of 14 questions.

Haloalkanes and haloarenes 10

Finkelstein reaction

$$\mathrm{R{-}X + NaI \xrightarrow{\text{dry acetone}} R{-}I + NaX}$$

Halogen exchange by the S_N2 path; X is Cl or Br. NaCl and NaBr do not dissolve in dry acetone, so they precipitate and pull the reaction forward. The usual way to make alkyl iodides.

Swarts reaction

$$\mathrm{CH_3{-}Br + AgF \longrightarrow CH_3{-}F + AgBr}$$

Halogen exchange with a metal fluoride: AgF, $\mathrm{Hg_2F_2}$, $\mathrm{CoF_2}$ or $\mathrm{SbF_3}$. The usual way to make alkyl fluorides.

Wurtz reaction

$$\mathrm{2\,R{-}X + 2\,Na \xrightarrow{\text{dry ether}} R{-}R + 2\,NaX}$$

Joins two alkyl groups, so the alkane has twice the carbon atoms. Good only for symmetrical alkanes: two different halides give a mixture of three alkanes. Methane cannot be made this way.

More: What is the Wurtz reaction and why is it not good for odd-carbon alkanes?

Wurtz–Fittig reaction

$$\mathrm{C_6H_5{-}X + R{-}X + 2\,Na \xrightarrow{\text{dry ether}} C_6H_5{-}R + 2\,NaX}$$

An aryl halide and an alkyl halide with sodium give an alkylbenzene.

Fittig reaction

$$\mathrm{2\,C_6H_5{-}X + 2\,Na \xrightarrow{\text{dry ether}} C_6H_5{-}C_6H_5 + 2\,NaX}$$

Two molecules of an aryl halide with sodium give biphenyl.

Sandmeyer reaction

$$\mathrm{C_6H_5N_2{}^+Cl^- \xrightarrow{CuCl/HCl} C_6H_5Cl + N_2}$$
$$\mathrm{C_6H_5N_2{}^+Cl^- \xrightarrow{CuBr/HBr} C_6H_5Br + N_2}$$
$$\mathrm{C_6H_5N_2{}^+Cl^- \xrightarrow{CuCN/KCN} C_6H_5CN + N_2}$$

Replaces the diazonium group by Cl, Br or CN with the copper(I) salt. Iodobenzene needs only KI, and fluorobenzene needs $\mathrm{HBF_4}$; neither of those is a Sandmeyer reaction.

More: What is the difference between Sandmeyer and Gattermann reactions?

Gattermann reaction

$$\mathrm{C_6H_5N_2^+Cl^-} \xrightarrow{\mathrm{Cu/HCl}} \mathrm{C_6H_5Cl + N_2}$$

Copper powder with HCl or HBr in place of the copper(I) salt. The products are the same as in the Sandmeyer reaction, but the yield is lower.

Balz–Schiemann reaction

$$\mathrm{C_6H_5N_2^+Cl^-} \xrightarrow{\mathrm{HBF_4}} \mathrm{C_6H_5N_2^+BF_4^-}$$
$$\mathrm{C_6H_5N_2^+BF_4^-} \xrightarrow{\Delta} \mathrm{C_6H_5F + BF_3 + N_2}$$

The way to put fluorine on a benzene ring: the diazonium fluoroborate is precipitated and then heated.

Friedel–Crafts alkylation and acylation

$$\mathrm{C_6H_6 + CH_3Cl} \xrightarrow[\text{anhydrous}]{\mathrm{AlCl_3}} \mathrm{C_6H_5CH_3 + HCl}$$
$$\mathrm{C_6H_6 + CH_3COCl} \xrightarrow[\text{anhydrous}]{\mathrm{AlCl_3}} \mathrm{C_6H_5COCH_3 + HCl}$$

Electrophilic substitution; anhydrous $\mathrm{AlCl_3}$ makes the carbocation or the acylium ion. Alkylation can rearrange and can add more than one alkyl group; acylation does neither. Nitrobenzene does not react, and aniline fails because it forms a salt with $\mathrm{AlCl_3}$.

More: Why does aniline not undergo Friedel-Crafts reaction?

Dow's process

$$\mathrm{C_6H_5Cl + 2\,NaOH} \xrightarrow[\text{300 atm}]{\text{623 K}} \mathrm{C_6H_5ONa + NaCl + H_2O}$$

Chlorobenzene resists nucleophiles, hence the drastic conditions. Acidifying the sodium phenoxide gives phenol.

Haloalkanes and haloarenes JEE Main PYQ with solutions

Alcohols, phenols and ethers 5

Kolbe's reaction

$$\mathrm{C_6H_5ONa} \xrightarrow[\text{400 K, 4 to 7 atm}]{\mathrm{CO_2}} \mathrm{C_6H_4(OH)COONa}$$
$$\mathrm{C_6H_4(OH)COONa} \xrightarrow{\mathrm{H^+}} \mathrm{C_6H_4(OH)COOH}$$

Sodium phenoxide and carbon dioxide give 2-hydroxybenzoic acid (salicylic acid). The phenoxide ion is used because it is more reactive than phenol towards the weak electrophile $\mathrm{CO_2}$.

More: What are the Reimer-Tiemann and Kolbe reactions of phenol?

Reimer–Tiemann reaction

$$\mathrm{C_6H_5OH} \xrightarrow[\text{340 K, then acid}]{\mathrm{CHCl_3 + NaOH\,(aq)}} \mathrm{C_6H_4(OH)CHO}$$

Puts a CHO group ortho to the OH of phenol: the product is 2-hydroxybenzaldehyde (salicylaldehyde). The electrophile is dichlorocarbene, $:\mathrm{CCl_2}$. With $\mathrm{CCl_4}$ in place of $\mathrm{CHCl_3}$ the product is salicylic acid.

Williamson synthesis

$$\mathrm{R{-}X + R'{-}ONa \longrightarrow R{-}O{-}R' + NaX}$$

The alkoxide ion attacks the alkyl halide by the S_N2 path, so the halide must be primary. A tertiary halide gives an alkene instead. For tert-butyl methyl ether use $\mathrm{CH_3Br}$ with $\mathrm{(CH_3)_3CONa}$, never the other way round.

More: In Williamson synthesis, which alkyl halide and alkoxide should be used?

Esterification

$$\mathrm{RCOOH + R'OH \overset{H^+}{\rightleftharpoons} RCOOR' + H_2O}$$

Reversible and acid catalysed. Concentrated $\mathrm{H_2SO_4}$ also removes the water, which shifts the equilibrium towards the ester.

Cumene process

$$\mathrm{C_6H_5CH(CH_3)_2 \xrightarrow{O_2} C_6H_5C(CH_3)_2OOH}$$

$$\mathrm{C_6H_5C(CH_3)_2OOH \xrightarrow[H_2O]{H^+} C_6H_5OH + CH_3COCH_3}$$

The industrial route to phenol. Air oxidises cumene (isopropylbenzene) to cumene hydroperoxide, and dilute acid splits it into phenol and acetone.

Alcohols, phenols and ethers JEE Main PYQ with solutions

Aldehydes, ketones and carboxylic acids 13

Rosenmund reduction

$$\mathrm{RCOCl + H_2 \xrightarrow{Pd/BaSO_4} RCHO + HCl}$$

Acyl chloride to aldehyde. Barium sulphate poisons the palladium, so the aldehyde is not reduced further to the alcohol.

More: What are the Rosenmund, Stephen, Etard and Gattermann-Koch reactions?

Stephen reaction

$$\mathrm{RCN + SnCl_2 + HCl \longrightarrow RCH{=}NH \xrightarrow{H_3O^+} RCHO}$$

Nitrile to aldehyde. The nitrile is reduced to an imine, which is then hydrolysed.

Etard reaction

$$\mathrm{C_6H_5CH_3 \xrightarrow[CS_2]{CrO_2Cl_2} \text{chromium complex} \xrightarrow{H_3O^+} C_6H_5CHO}$$

Chromyl chloride oxidises the methyl group of toluene only as far as the aldehyde. $\mathrm{KMnO_4}$ would go on to benzoic acid.

Gattermann–Koch reaction

$$\mathrm{C_6H_6 + CO + HCl \xrightarrow[\text{anhydrous}]{AlCl_3/CuCl} C_6H_5CHO}$$

Puts a CHO group on benzene with carbon monoxide and hydrogen chloride.

Clemmensen reduction

$$\mathrm{R{-}CO{-}R' \xrightarrow[\text{conc. HCl}]{\mathrm{Zn{-}Hg}} R{-}CH_2{-}R'}$$

Carbonyl group to $\mathrm{CH_2}$ in acid. Use it when the molecule is stable to acid.

More: What is the difference between Clemmensen and Wolff-Kishner reduction?

Wolff-Kishner reduction

$$\mathrm{R{-}CO{-}R' \xrightarrow{NH_2NH_2} R{-}C(=NNH_2){-}R'}$$
$$\mathrm{R{-}C(=NNH_2){-}R' \xrightarrow[\text{glycol, heat}]{KOH} R{-}CH_2{-}R' + N_2}$$

Carbonyl group to $\mathrm{CH_2}$ in base, through the hydrazone. Use it when the molecule is sensitive to acid.

Aldol condensation

$$\mathrm{2\,CH_3CHO \overset{\text{dil. NaOH}}{\rightleftharpoons} CH_3CH(OH)CH_2CHO}$$
$$\mathrm{CH_3CH(OH)CH_2CHO \xrightarrow[-H_2O]{\Delta} CH_3CH{=}CHCHO}$$

Needs at least one alpha hydrogen. Dilute alkali gives the aldol, 3-hydroxybutanal from ethanal; heating removes water and gives but-2-enal. Ketones give ketols in the same way.

More: Which compounds give aldol condensation and which give the Cannizzaro reaction?

Cross aldol condensation (Claisen-Schmidt)

$$\mathrm{C_6H_5CHO + CH_3COC_6H_5 \xrightarrow[293\ K]{\text{dil. NaOH}} C_6H_5CH{=}CHCOC_6H_5 + H_2O}$$

Benzaldehyde has no alpha hydrogen, so it can only accept the enolate of the ketone. Product: 1,3-diphenylprop-2-en-1-one (benzalacetophenone).

Cannizzaro reaction

$$\mathrm{2\,HCHO + KOH \longrightarrow CH_3OH + HCOOK}$$
$$\mathrm{2\,C_6H_5CHO + NaOH \longrightarrow C_6H_5CH_2OH + C_6H_5COONa}$$

Given by aldehydes with no alpha hydrogen, in concentrated alkali. It is a disproportionation: one molecule is reduced to the alcohol and one is oxidised to the salt of the acid.

Haloform reaction

$$\mathrm{RCOCH_3 + 3\,NaOX \longrightarrow RCOONa + CHX_3 + 2\,NaOH}$$

Given by methyl ketones and by compounds with the $\mathrm{CH_3CH(OH)^-}$ group, which are first oxidised to $\mathrm{CH_3CO^-}$. With $\mathrm{I_2}$ and NaOH the yellow precipitate of iodoform is the test. The acid formed has one carbon less.

More: Which compounds give the haloform (iodoform) test?

Hell-Volhard-Zelinsky (HVZ) reaction

$$\mathrm{RCH_2COOH \xrightarrow[\text{then } H_2O]{X_2+\text{red P}} RCH(X)COOH}$$

Puts Cl or Br on the alpha carbon of a carboxylic acid. The acid must have an alpha hydrogen.

Kolbe's electrolysis

$$2\,CH_3COONa + 2\,H_2O \xrightarrow{\text{electrolysis}} C_2H_6 + 2\,CO_2 + H_2 + 2\,NaOH$$

Electrolysis of the sodium or potassium salt of a carboxylic acid. The alkane and CO_2 form at the anode and hydrogen at the cathode. Two alkyl groups join, so methane cannot be made.

Decarboxylation with soda lime

$$RCOONa + NaOH \xrightarrow[\Delta]{CaO} RH + Na_2CO_3$$

The alkane has one carbon less than the acid.

Aldehydes, ketones and carboxylic acids JEE Main PYQ with solutions

Amines 5

Hoffmann bromamide degradation

$$RCONH_2 + Br_2 + 4\,NaOH \longrightarrow RNH_2 + Na_2CO_3 + 2\,NaBr + 2\,H_2O$$

Amide to primary amine with one carbon less. The alkyl or aryl group moves from the carbonyl carbon to nitrogen. Also spelt Hofmann.

More: What is the Hofmann bromamide degradation reaction?

Gabriel phthalimide synthesis

$$C_6H_4(CO)_2NH \xrightarrow{KOH} C_6H_4(CO)_2NK \xrightarrow{R-X} C_6H_4(CO)_2NR$$
$$C_6H_4(CO)_2NR \xrightarrow{NaOH\,(aq)} RNH_2 + C_6H_4(COONa)_2$$

Gives a pure primary aliphatic amine. Aniline cannot be made, because aryl halides do not undergo nucleophilic substitution with the phthalimide anion.

More: Why can aromatic primary amines not be prepared by Gabriel phthalimide synthesis?

Carbylamine reaction

$$RNH_2 + CHCl_3 + 3\,KOH \xrightarrow{\Delta} RNC + 3\,KCl + 3\,H_2O$$

Only primary amines, aliphatic or aromatic, give the foul-smelling isocyanide, so it is the test for a primary amine. The KOH is alcoholic.

More: What is the carbylamine reaction? Which amines give it?

Diazotisation

$$C_6H_5NH_2 + NaNO_2 + 2\,HCl \xrightarrow{273\text{ to }278\text{ K}} C_6H_5N_2{}^+Cl^- + NaCl + 2\,H_2O$$

A primary aromatic amine with nitrous acid in the cold gives the diazonium salt. If the solution warms up, the salt decomposes to phenol.

More: What does H3PO2 do to a benzenediazonium salt?

Coupling reaction

$$C_6H_5N_2{}^+Cl^- + C_6H_5OH \xrightarrow{OH^-} C_6H_5{-}N{=}N{-}C_6H_4{-}OH + HCl$$

The diazonium ion is a weak electrophile and attacks the para position of phenol (in mild alkali) or of aniline (in mild acid). Phenol gives orange p-hydroxyazobenzene; aniline gives yellow p-aminoazobenzene.

Amines JEE Main PYQ with solutions

Hydrocarbons: Class 11 rules asked with these 5

Markovnikov's rule

$$\mathrm{CH_3-CH=CH_2 + HBr \longrightarrow CH_3-CHBr-CH_3}$$

The negative part of the reagent goes to the carbon with fewer hydrogen atoms, because the more stable carbocation forms first.

More: What are Markovnikov's rule and the anti-Markovnikov (peroxide) effect?

Peroxide effect (Kharasch effect, anti-Markovnikov addition)

$$\mathrm{CH_3-CH=CH_2 + HBr \xrightarrow{peroxide} CH_3-CH_2-CH_2Br}$$

A free radical chain reaction. It works only with HBr, not with HCl or HI.

Saytzeff (Zaitsev) rule

$$\mathrm{CH_3CH_2CH_2CHBrCH_3 \xrightarrow{alc.\ KOH} CH_3CH_2CH=CHCH_3}$$

In an elimination the main alkene is the one with more alkyl groups on the double bond. 2-Bromopentane gives pent-2-ene (81%) rather than pent-1-ene (19%).

More: What is the difference between Saytzeff and Hofmann products?

Ozonolysis

$$\mathrm{CH_3-CH=CH_2 \xrightarrow[Zn/H_2O]{O_3} CH_3CHO + HCHO}$$

Cuts the double bond and puts an oxygen atom on each carbon. To find the alkene, join the two carbonyl carbons.

More: How do you find the products of ozonolysis of an alkene?

Lindlar's catalyst, and sodium in liquid ammonia

An alkyne with $\mathrm{H_2}$ and Lindlar's catalyst (palladium on charcoal, partly deactivated) gives the cis alkene. An alkyne with sodium in liquid ammonia gives the trans alkene.

Hydrocarbons JEE Main PYQ with solutions

Named tests 12

The tests asked with the name reactions: the reagent, what gives the test, and what you see.

Test	Reagent	Given by	What you see
Lucas test	conc. HCl with anhydrous $\mathrm{ZnCl_2}$	Alcohols	Tertiary: turbidity at once. Secondary: within about 5 minutes. Primary: no turbidity at room temperature.
Iodoform test	$\mathrm{I_2}$ with NaOH	$\mathrm{CH_3CO^-}$ and $\mathrm{CH_3CH(OH)^-}$ compounds	Yellow precipitate of $\mathrm{CHI_3}$.
Tollens' test	Ammoniacal silver nitrate	Aldehydes, aliphatic and aromatic	Silver mirror.

Test	Reagent	Given by	What you see
Fehling's test	Fehling A ($CuSO_4$) with Fehling B (alkaline sodium potassium tartrate)	Aliphatic aldehydes; not aromatic aldehydes	Red-brown precipitate of Cu_2O.
2,4-DNP test	2,4-Dinitrophenylhydrazine	Aldehydes and ketones	Yellow, orange or red precipitate.
Sodium hydrogencarbonate test	$NaHCO_3$ solution	Carboxylic acids; not phenol	Brisk effervescence of CO_2.
Ferric chloride test	Neutral $FeCl_3$	Phenols	Violet colour.
Bromine water test	Br_2 in water	Phenol and aniline; alkenes and alkynes	White precipitate of the 2,4,6-tribromo compound from phenol or aniline; alkenes and alkynes discharge the colour.
Baeyer's test	Cold, dilute, alkaline $KMnO_4$	Alkenes and alkynes	The purple colour is discharged.
Carbylamine test	$CHCl_3$ with alcoholic KOH, heat	Primary amines	Foul smell of the isocyanide.
Hinsberg test	Benzenesulphonyl chloride, $C_6H_5SO_2Cl$	Primary and secondary amines	Primary: sulphonamide soluble in alkali. Secondary: sulphonamide insoluble in alkali. Tertiary: no reaction.
Azo dye test	$NaNO_2$ with HCl at 273 to 278 K, then alkaline 2-naphthol	Primary aromatic amines	Orange-red dye.

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