# CIE Chemistry A-Level

## Topic 23 - Organic Synthesis

## (A level only)

Flashcards

# In organic chemistry, what is a chiral centre?

In organic chemistry, what is a chiral centre?

A carbon atom attached to 4 different groups.

# What is a chiral molecule?

# What is a chiral molecule?

A molecule containing one or more chiral centres. It has no planes of symmetry.

# What are stereoisomers?

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Compounds with the same structural formula but a different arrangement of atoms in space.

# What are optical isomers?

# What are optical isomers?

Optical isomers are a type of stereoisomer.

Optical isomers are non-superimposable mirror images of each other. The pairs of optical isomers are called enantiomers.

Why does the synthesis of drugs often require the production of a single optical isomer?

Why does the synthesis of drugs often require the production of a single optical isomer?

- More effective.
- Fewer side effects.
- Reduces cost long term as money isn't wasted producing the optical isomer that is ineffective.

# List the typical reactions of alkanes

# List the typical reactions of alkanes

- Combustion.
- Free-radical substitution with $Br_2$ or $Cl_2$ to form halogenoalkanes.
- Cracking to form short chain alkenes and alkanes.

# List the typical reactions of alkenes

# List the typical reactions of alkenes

- Electrophilic addition: steam (forms alcohols), hydrogen halides (forms halogenoalkanes), halogens (forms dihalogenoalkanes) and hydrogen (forms alkanes).
- Oxidation with $H^+/MnO_4^-$ (forms diols).
- Addition polymerisation to form polymers.
- Combustion.

# List the typical reactions of halogenoalkanes

# List the typical reactions of halogenoalkanes

- Nucleophilic substitution: hydrolysis (forms alcohols), reaction with ethanolic cyanide (forms nitriles) and reaction with ammonia (forms primary amines).
- Elimination of hydrogen halide using ethanolic hydroxide ions (forms alkenes).

# List the typical reactions of alcohols

# List the typical reactions of alcohols

- Combustion.
- Substitution with hydrogen halides, sulfur dichloride oxide or phosphorus(III) halides (forms halogenoalkanes).
- Oxidation with $H^+/Cr_2O_7^{2-}$ (forms carboxylic acids).
- Dehydration using an acid catalyst (forms alkenes).
- Esterification with carboxylic acid or acyl chloride.

# What is produced when ethanol reacts with sodium?

What is produced when ethanol reacts with sodium?

Sodium ethoxide and hydrogen gas.

# List the typical reactions of aldehydes

# List the typical reactions of aldehydes

- Oxidation with $H^+/Cr_2O_7^{2-}$ (forms carboxylic acids).
- Reduction with $NaBH_4$ or $LiAlH_4$ (forms primary alcohols).
- Nucleophilic addition with HCN (forms hydroxynitriles).

# List the typical reactions of ketones

# List the typical reactions of ketones

- Reduction with $NaBH_4$ or $LiAlH_4$ (forms secondary alcohols).
- Nucleophilic addition with HCN (forms hydroxynitriles).

# List the typical reactions of carboxylic acids

# List the typical reactions of carboxylic acids

- Reaction with metals, alkalis or carbonates (forms a salt and an inorganic product).
- Esterification with alcohols.
- Reduction with $LiAlH_4$ (forms primary alcohols).
- Reaction with $SOCl_2$ (forms acyl chlorides, sulfur dioxide and hydrochloric acid).
- Reaction with phosphorus(V) chloride or phosphorus(III) chloride (forms acyl chlorides).

# What is produced when methanoic acid is oxidised using Fehling's or Tollens' reagent?

What is produced when methanoic acid is oxidised using Fehling's or Tollens' reagent?

Carbon dioxide and water

What is produced when ethanedioic acid is oxidised using acidified potassium manganate(VII)?

What is produced when ethanedioic acid is oxidised using acidified potassium manganate(VII)?

Water and carbon dioxide

# List the typical reactions of esters

# List the typical reactions of esters

- Acid hydrolysis (forms a carboxylic acid and an alcohol).
- Alkaline hydrolysis (forms a carboxylate salt and an alcohol).

# List the typical reactions of amines

# List the typical reactions of amines

- Reactions with acids to form a salt.
- React with carboxylic acids to form amides.

# List the typical reactions of nitriles

# List the typical reactions of nitriles

- Acid hydrolysis (forms a carboxylic acid and a salt).
- Alkaline hydrolysis (forms a carboxylate salt and ammonia).
- Reduction with $LiAlH_4$ to form an amine.

# List the typical reactions of arenes

# List the typical reactions of arenes

- Electrophilic substitution: with a halogen (forms chlorobenzene with $Cl_2$ or bromobenzene with $Br_2$), with nitric acid (forms nitrobenzene).
- Friedel-Crafts acylation and alkylation.
- Oxidation of a side chain (forms benzoic acid).
- Hydrogenation (forms cyclohexane).

# List the typical reactions of phenol

# List the typical reactions of phenol

- Reactions with strong bases (not acidic enough to react with carbonates).
- Reaction with sodium (forms sodium phenoxide and hydrogen gas).
- Reaction with diazonium salts (forms azo compounds).
- Electrophilic substitution: nitric acid (forms nitrophenol), bromine (forms bromophenol).

# List the typical reactions of acyl chlorides

# List the typical reactions of acyl chlorides

- Hydrolysis with water (forms carboxylic acids and HCl).
- Hydrolysis with sodium hydroxide (forms a carboxylate salt and water).
- Esterification with alcohols or phenol.
- Reaction with ammonia (forms an amide and HCl).
- Reaction with primary amide (forms an n-substituted amide).

# List the typical reactions of amides

# List the typical reactions of amides

- Acid hydrolysis (forms a carboxylic acid and ammonium ions).
- Alkaline hydrolysis (forms a carboxylate salt and ammonia or an amine).
- Reduction using $LiAlH_4$ (forms a primary amine).

# Describe the chemical test for an alkene

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Add bromine water. If a C=C bond is present, the orange solution will decolourise to form a colourless solution.

# Describe the chemical test for a halogenoalkane

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React with $AgNO_3(aq)$ and test the solubility of the precipitate in $NH_3(aq)$.

AgCl - white ppt soluble in dilute $NH_3$.
AgBr - cream ppt soluble in concentrated $NH_3$.
AgI - yellow ppt insoluble in $NH_3$.

# Describe the chemical test for an alcohol

# Describe the chemical test for an alcohol

React with $H^+/Cr_2O_7^{2-}$. If a primary or secondary alcohol is present, the colour will change from orange to green. There will be no colour change for tertiary alcohols.

# Describe the chemical tests for an aldehyde

# Describe the chemical tests for an aldehyde

- React with 2,4-DNPH. Yellow-orange ppt forms in the presence of a carbonyl.
- React with Tollens' reagent. Silver mirror is produced if an aldehyde is present.
- React with Fehling's solution. Blue solution forms a brick red ppt if an aldehyde is present.
- React with $H^+/Cr_2O_7^{2-}$. Orange solution turns green.

# Describe the chemical test for a ketone

# Describe the chemical test for a ketone

React with 2,4-DNPH. A yellow orange precipitate forms in the presence of a carbonyl.

# Describe the chemical test for a carboxylic acid

# Describe the chemical test for a carboxylic acid

React with a carbonate. If a carboxylic acid is present, the solution will effervesce and $CO_2$ will be produced.

How can ethanoic acid be formed from chloroethane? Include any conditions and intermediates

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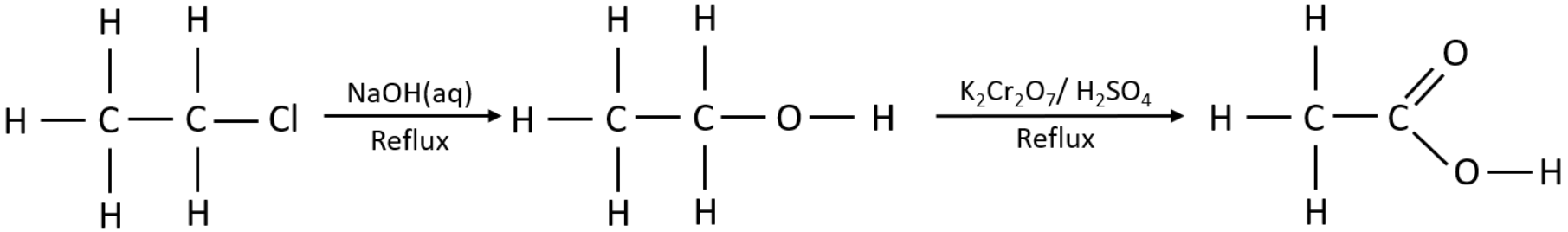


chloroethane ethanol ethanoic acid

# How can 2-propylamine be formed from propene? Include any conditions and intermediates

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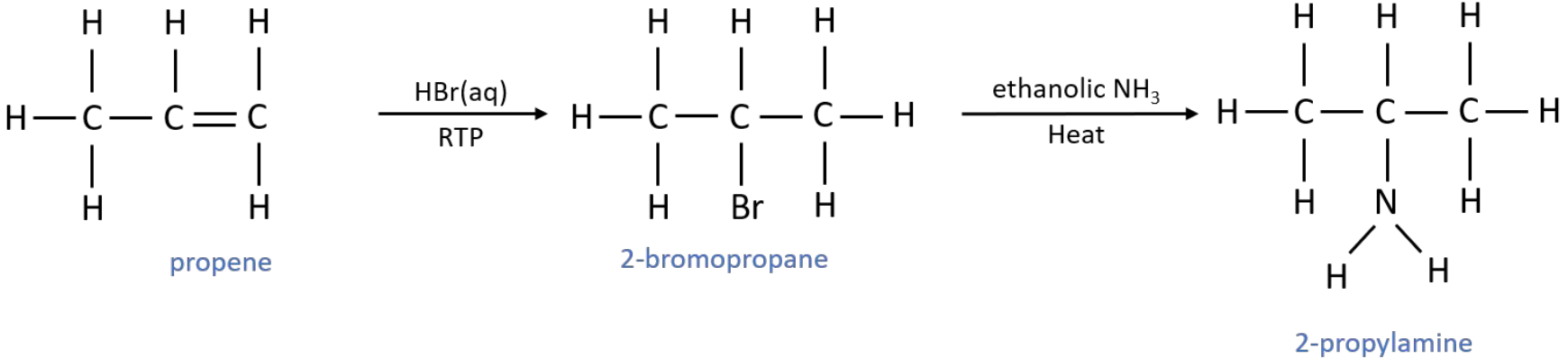

# What factors might be considered when analysing a synthetic route?

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- Type of reaction
- Reagents
- Atom economy
- By-products
- Conditions

What type of reaction is favoured when deciding which synthetic route to use?

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Addition reactions are much more sustainable than substitution or elimination reactions as they have no waste products.

A synthetic route is chosen to produce an organic compound. In terms of reagents, why might this route be favoured?

A synthetic route is chosen to produce an organic compound. In terms of reagents, why might this route be favoured?

- The reagents might be renewable.
- The reagents may have few safety concerns.

# How are by-products linked to the selection of a particular synthetic route?

How are by-products linked to the selection of a particular synthetic route?

A synthetic route with less harmful by-products is preferred as there would be fewer safety and environmental concerns. The process is more sustainable if the by-products can be used in another industry.

# What conditions are favoured for a synthetic route?

# What conditions are favoured for a synthetic route?

Conditions that are energy efficient and safe.