

WJEC (Wales) Chemistry A-level

Topic 4.8 - Organic Synthesis and Analysis

Flashcards

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What factors might be considered when deciding on a synthesis route?



What factors might be considered when deciding on a synthesis route?

- Type of reaction
- Reagents
- Atom economy
- Byproducts
- Conditions



What condition is required for alkanes to undergo free radical substitution with halogens?



What condition is required for alkanes to undergo free radical substitution with halogens?

It is a photochemical reaction so the reaction requires ultraviolet light.



What different products can be produced when alkenes undergo electrophilic addition?



What different products can be produced when alkenes undergo electrophilic addition?

Reactant with alkene	Product
Hydrogen halide	Halogenoalkanes
Halogens	Di-halogenoalkanes
Hydrogen	Alkanes
Steam	Alcohols



Name the process in which alkenes can react to form polymers



Name the process in which alkenes can react to form polymers

Addition polymerisation



What reactant and conditions are required for a halogenoalkane to form a nitrile?



What reactant and conditions are required for a halogenoalkane to form a nitrile?

Reactant: Ethanolic KCN

Conditions: Warm, reflux setup



Name the mechanism and products formed when halogenoalkanes react with ammonia



Name the mechanism and products formed when halogenoalkanes react with ammonia

Mechanism: Nucleophilic substitution

Products: Amines



Name the two types of reactions between halogenoalkanes and hydroxides. How can you influence which reaction will occur?



Name the two types of reactions between halogenoalkanes and hydroxides. How can you influence which reaction will occur?

Nucleophilic substitution - produces alcohols.

Elimination - produces alkenes.

Aqueous conditions are required for the nucleophilic substitution reaction and anhydrous ethanolic conditions are required for the elimination reaction.



How can alcohols react to form alkenes?



How can alcohols react to form alkenes?

Alcohols can undergo dehydration with concentrated sulfuric acid (catalyst) to form alkenes. This is an elimination reaction.



What are the various products formed when alcohols react with acidified potassium dichromate(VI)?



What are the various products formed when alcohols react with acidified potassium dichromate(VI)?

Primary alcohols are oxidised to aldehydes and then to carboxylic acids.

Secondary alcohols are oxidised to ketones.

Tertiary alcohols do not undergo oxidation with acidified potassium dichromate(VI).



What are produced when alcohols reacts with carboxylic acids?



What are produced when alcohols reacts with carboxylic acids?

Esters



Give the reducing agent required for aldehydes and ketones to form alcohols



Give the reducing agent required for aldehydes and ketones to form alcohols

NaBH_4 in water with methanol



Give the reactants and mechanism name
for the formation of hydroxynitriles from
aldehydes



Give the reactants and mechanism name for the formation of hydroxynitriles from aldehydes

Reactants: Acidified KCN (usually a mix of KCN and H_2SO_4)

Mechanism name: Nucleophilic addition



Give the reducing agent required for
carboxylic acids to form alcohols



Give the reducing agent required for carboxylic acids to form alcohols



What are produced when nitriles undergo reduction with LiAlH_4 ?



What are produced when nitriles undergo reduction with LiAlH_4 ?

Amines



Give the reactants and mechanism name
for the formation of nitrobenzene from
benzene



Give the reactants and mechanism name for the formation of nitrobenzene from benzene

Reactants: Concentrated sulfuric acid and concentrated nitric acid

Mechanism name: Electrophilic substitution



How can arenes form benzoic acid?



How can arenes form benzoic acid?

Benzoic acid is produced when side chains on arenes undergo oxidation. Alkaline manganate(VII) followed by acidification is the most effective reagent.



What are produced when phenol reacts with diazonium salts?



What are produced when phenol reacts with diazonium salts?

Azo compounds



What is the product obtained when phenol reacts with nitric acid?



What is the product obtained when phenol reacts with nitric acid?

Nitrophenol



What different reactants are required for acyl chlorides to produce primary amides, N-substituted amides, esters and carboxylic acids?



What different reactants are required for acyl chlorides to produce primary amides, N-substituted amides, esters and carboxylic acids?

Reactant	Product
Ammonia, NH_3	Primary amide
Amine	N-substituted amide
Alcohol	Ester
Water, H_2O	Carboxylic acid



Give the reactants and mechanism name for the production of a phenylketone from benzene



Give the reactants and mechanism name for the production of a phenylketone from benzene

Reactants: Acyl chloride and AlCl_3 catalyst

Mechanism: Electrophilic substitution

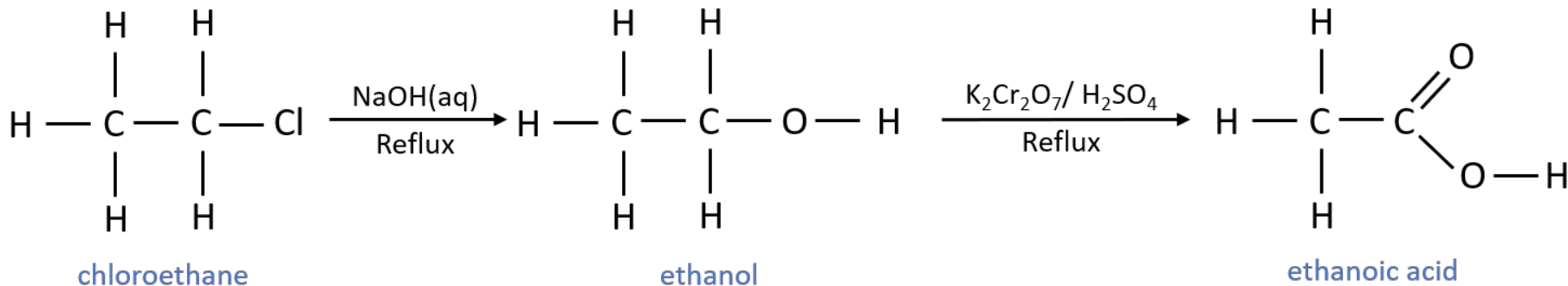


How can ethanoic acid be formed from
chloroethane?



How can ethanoic acid be formed from chloroethane?

Nucleophilic substitution with aqueous NaOH followed by oxidation with the oxidising agent acidified potassium dichromate(VI):

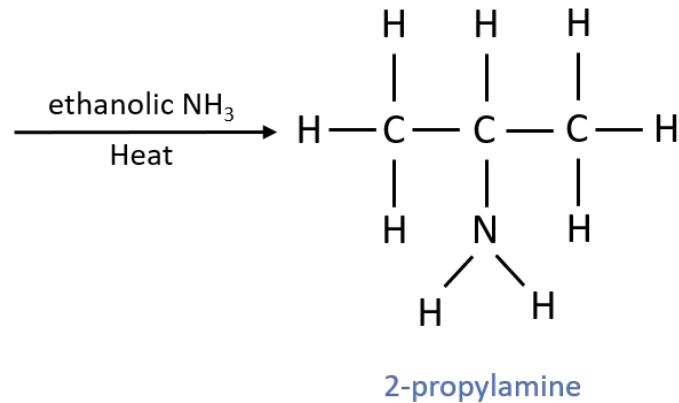
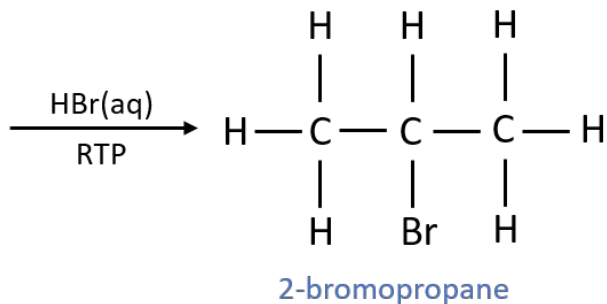
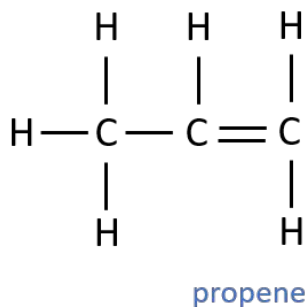


How can 2-propylamine be formed from propene?



How can 2-propylamine be formed from propene?

Electrophilic addition with HBr followed by nucleophilic substitution with NH_3 :



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 minimal 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 are fewer safety and environmental concerns. The process is more sustainable if the by-products can be used in another industry.



What condition is required to ensure a primary alcohol forms a carboxylic acid upon oxidation?



What condition is required to ensure a primary alcohol forms a carboxylic acid upon oxidation?

The reaction needs to be setup in reflux.

Reflux is the boiling setup with a vertical condenser that allows the vapours to return to the same mixture once they condense.



How can you separate an insoluble product from a solution?



How can you separate an insoluble product from a solution?

Filtration:

- Filter paper placed in a funnel over a conical flask.
- Pour the mixture through the funnel.
- The insoluble product is left on the filter paper.



Describe how to carry out simple distillation



Describe how to carry out simple distillation

Heat a solution in a round bottomed flask using a Bunsen burner. The solvent evaporates then cools in the condenser. The pure liquid is collected in a beaker.



Describe how a solid can be purified by
recrystallisation



Describe how a solid can be purified by recrystallisation

1. Add a minimum volume of hot solvent to the impure solid until it dissolves.
2. Filter the solution to remove any insoluble impurities.
3. Leave the solution to slowly cool. Crystals will start to form.
4. Remove the liquid containing the soluble impurities from the crystals by filtering the mixture under reduced pressure with a Büchner funnel.
5. Wash the crystals with ice cold solvent to remove any soluble impurities from the surface. Leave the crystals to dry.



How can water soluble impurities be separated from an insoluble organic product?



How can water soluble impurities be separated from an insoluble organic product?

Once the reaction is complete, pour the mixture into a separating funnel and add water. Shake the funnel and then leave the mixture to settle. Two distinct layers will form since the organic layer and aqueous layer will not mix. The tap on the separating funnel can then be opened and each layer can be run off separately.



What is the difference between addition polymerisation and condensation polymerisation?



What is the difference between addition polymerisation and condensation polymerisation?

Addition polymerisation is the process by which polymers are formed by the addition of monomers, with no by-products.

Condensation polymerisation usually involves two different types of monomers (each with at least two functional groups) undergoing condensation, resulting in the formation of small molecules such as HCl, water or ammonia as a by-product.



How are polyesters formed?



How are polyesters formed?

Polyesters form when dicarboxylic acids react with diols in a condensation reaction.



How are polyamides formed?



How are polyamides formed?

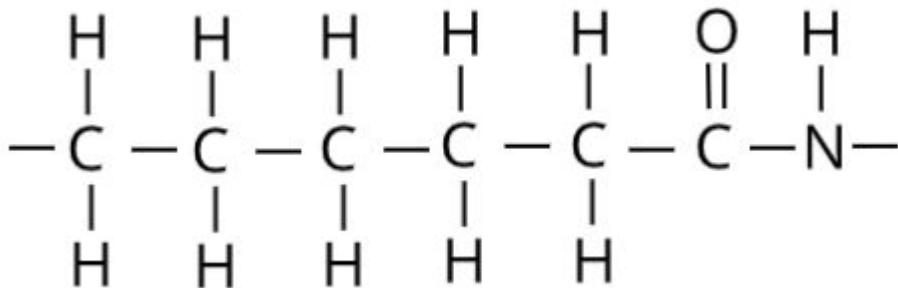
Polyamides form when dicarboxylic acids react with diamines in a condensation reaction.



Draw the repeat unit of nylon-6



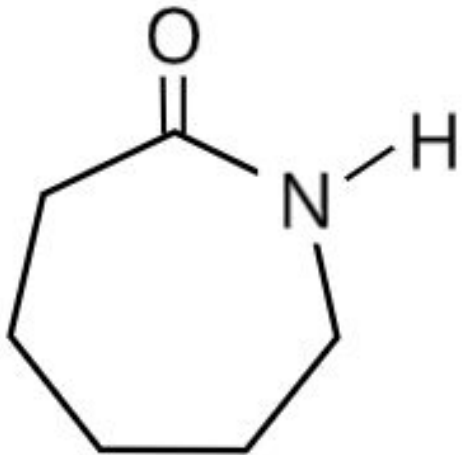
Draw the repeat unit of nylon-6



What is the displayed formula of the monomer used to make nylon-6?



What is the displayed formula of the monomer used to make nylon-6?



Which two monomers are used to make nylon-6,6?



Which two monomers are used to make nylon-6,6?

1,6-diaminohexane

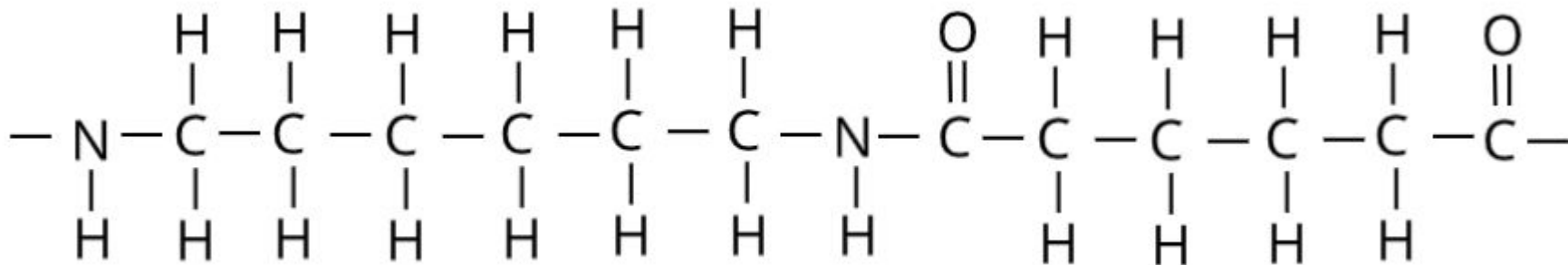
Hexanedioic acid



Draw the repeat unit of nylon-6,6



Draw the repeat unit of nylon-6,6



How is PET produced?



How is PET produced?

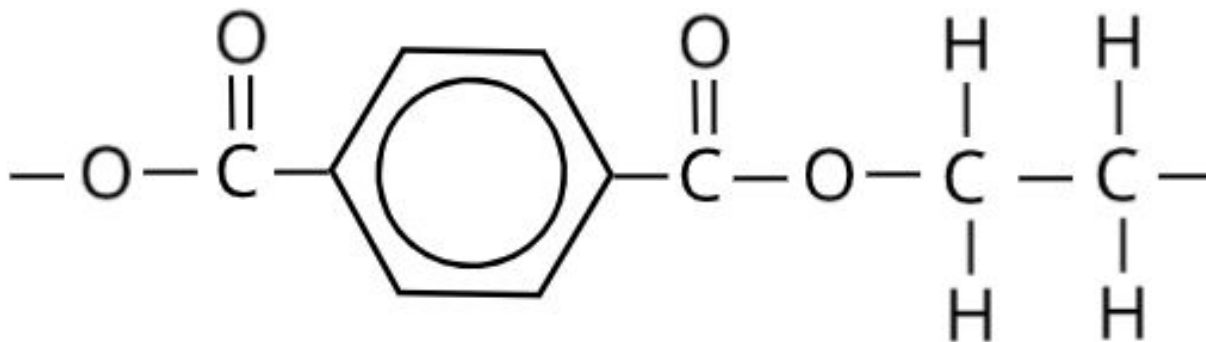
PET is formed from benzene-1,4-dicarboxylic acid and ethane-1,2-diol. The two monomers react together and ester links form between them.



Draw the displayed structure of the repeat unit of PET



Draw the displayed structure of the repeat unit of PET



How can you determine the melting point of an organic solid?



How can you determine the melting point of an organic solid?

1. Pack a small sample of the solid into a capillary tube. Place the tube inside a heating element.
2. Increase the temperature of the heating element until the sample turns to liquid.
3. Compare the melting point to data book values to identify the solid.



How can the melting point of a substance be used to evaluate its purity?



How can the melting point of a substance be used to evaluate its purity?

A pure substance will have an exact sharp melting point. An impure substance will melt over a range of temperatures.



How can NMR be used to identify a molecule?



How can NMR be used to identify a molecule?

NMR allows you to identify the different fragments in the molecule which can then be used to predict the structure of the molecule.



How can a proton environment be identified using a proton NMR spectrum?



How can a proton environment be identified using a proton NMR spectrum?

Compare the chemical shift values of the peaks in an NMR spectrum to values in a data book.



On a proton NMR spectrum, what does the ratio of the areas under the peaks indicate?



On a proton NMR spectrum, what does the ratio of the areas under the peaks indicate?

The relative number of protons in each environment.



What are equivalent protons?



What are equivalent protons?

Protons in the same environment. These may be on the same or different carbons.



What is chromatography?



What is chromatography?

Chromatography is a process used to separate a mixture into different components. All chromatography processes involve a mobile phase, where the molecules can move, and a stationary phase, where the molecules can't move.



How can TLC be used to separate mixtures?



How can TLC be used to separate mixtures?

A glass plate has a thin layer of silica or alumina fixed to it which acts as the stationary phase. The mixture to be separated is dotted on a baseline near the bottom of the plate. The plate is then put in a solvent (the solvent must be below the baseline). As this mobile phase moves up the plate, the mixture separates out depending on how soluble it is in the solvent. The distance each component travels up the plate can be measured and an R_f value can be calculated to help identify which components are present.



What is an R_f value and how can it be calculated?



What is an Rf value and how can it be calculated?

The Rf value is the retention factor. It is unique to each component in the mixture being analysed so can be used to identify particular components:

$$R_f = \frac{\text{distance moved by component}}{\text{distance moved by solvent}}$$



How can gas chromatography be used to find the composition of mixtures?



How can gas chromatography be used to find the composition of mixtures?

The stationary phase is a solid packed into a long tube and the mobile phase is an unreactive carrier gas, such as nitrogen. The time it takes for a component to be injected into the tube and then recorded at the other end is called the retention time and can be used to identify the components in a mixture.



How can HPLC be used to find the composition of mixtures?



How can HPLC be used to find the composition of mixtures?

A vertical column is packed with a solid, which acts as the stationary phase. A solvent containing the mixture being analysed is then added as the mobile phase. As the mixture washes through the column, the components separate out depending on how soluble they are in the mobile phase. The time it takes for a component to pass through the column is called the retention time and can be used for identification.

