

CAIE Chemistry A-level

Topic 34 - Nitrogen Compounds

(A level only)

Flashcards

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Describe how to form an amine from a halogenoalkane



Describe how to form an amine from a halogenoalkane

Heat the halogenoalkane in a sealed tube with concentrated ammonia and an ethanol solvent.



Why is excess ammonia used when forming a primary amine from a halogenoalkane?



Why is excess ammonia used when forming a primary amine from a halogenoalkane?

So that further substitution doesn't occur. If ammonia is not in excess then a secondary or tertiary amine or a quaternary ammonium salt may form.



Describe how to form a primary amine
from a amide



Describe how to form a primary amine from an amide

Reduction using LiAlH_4 as a reducing agent.



Write an equation for the formation of ethylamine from ethanamide



Write an equation for the formation of ethylamine from ethanamide



Describe how to form a primary amine
from a nitrile



Describe how to form a primary amine from a nitrile

Two options:

- Reduction using LiAlH_4 as a reducing agent.
- Reduction using nickel catalyst and H_2 gas.



Write an equation for the formation of ethylamine from ethanenitrile

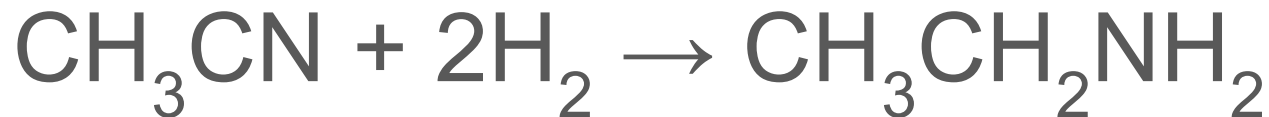


Write an equation for the formation of ethylamine from ethanenitrile

If LiAlH_4 is used:



If Ni/H_2 is used:



Describe how to form phenylamine



Describe how to form phenylamine

Reduction of nitrobenzene with tin and concentrated HCl. Reflux for 30 minutes.



When synthesising phenylamine from nitrobenzene, why is NaOH added after the mixture has been refluxed?



When synthesising phenylamine from nitrobenzene, why is NaOH added after the mixture has been refluxed?

To remove a proton from the -NH_3^+ group.



Write the overall equation for the synthesis of phenylamine



Write the overall equation for the synthesis of phenylamine



Why are amines basic?



Why are amines basic?

The lone pair on the nitrogen in the amine group can accept a proton/hydrogen ion.



What affects the strength of a base?



What affects the strength of a base?

- How easily the lone pair can accept a hydrogen ion.
- The stability of the ions formed.



Put the following compounds in order of relative basicity: ammonia, ethylamine and phenylamine



Put the following compounds in order of relative basicity: ammonia, ethylamine and phenylamine

Ethylamine > ammonia > phenylamine

Ethylamine is the most basic.

Phenylamine is the least basic.



Why is ethylamine a stronger base than ammonia?



Why is ethylamine a stronger base than ammonia?

- Alkyl groups tend to push electrons away from themselves. This is the positive inductive effect.
- This increases the negative charge of the nitrogen in ethylamine, making the lone pair more attracted to hydrogen ions.
- The electron-pushing effect also spreads the charge more, meaning the ethylammonium ion is more stable than the ammonium ion.



Why is phenylamine a weaker base than ammonia?



Why is phenylamine a weaker base than ammonia?

- In phenylamine, the amine group is directly attached to the benzene ring so the lone pair on nitrogen is delocalised into the pi system.
- This makes the lone pair less available.
- The very electronegative nitrogen atom draws electrons towards itself. This charge is much weaker than in ammonia.
- If the lone pair combined with a proton, the pi system would be disrupted making the ion less stable.



Why is phenylamine more reactive than benzene?



Why is phenylamine more reactive than benzene?

The -NH_2 group in phenylamine activates the benzene ring when the lone pair on the nitrogen is delocalised into the pi system. This makes phenylamine more reactive because the electron density of the pi system is increased so electrophiles are more attracted.



Describe the conditions for the reaction
between phenylamine and aqueous
bromine



Describe the conditions for the reaction between phenylamine and aqueous bromine

Room temperature

No catalyst



Describe what would be observed when phenylamine reacts with aqueous bromine



Describe what would be observed when phenylamine reacts with aqueous bromine

Bromine water is decolourised.

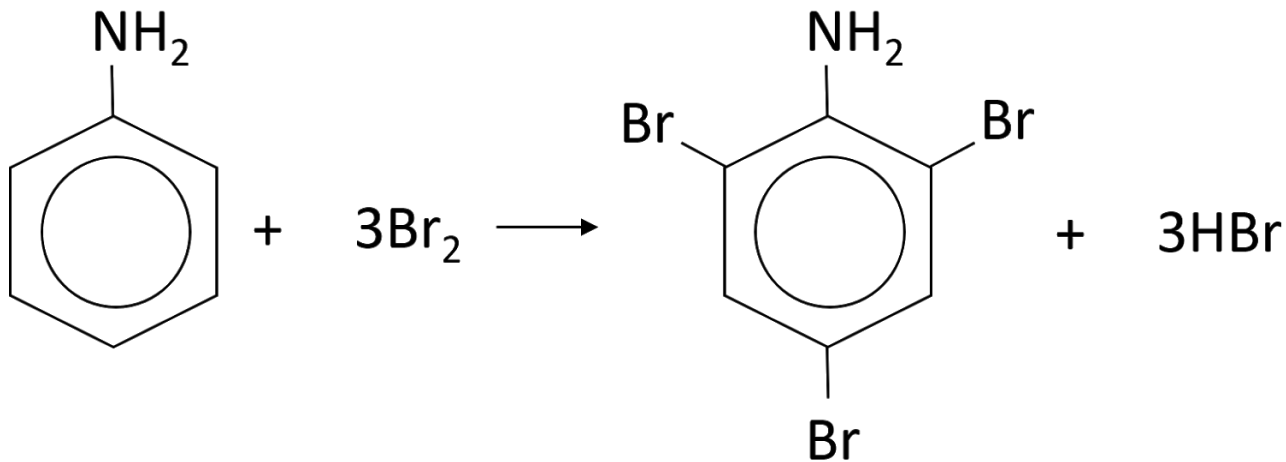
White precipitate forms.



Write an equation for the reaction
between phenylamine and aqueous
bromine



Write an equation for the reaction between phenylamine and aqueous bromine



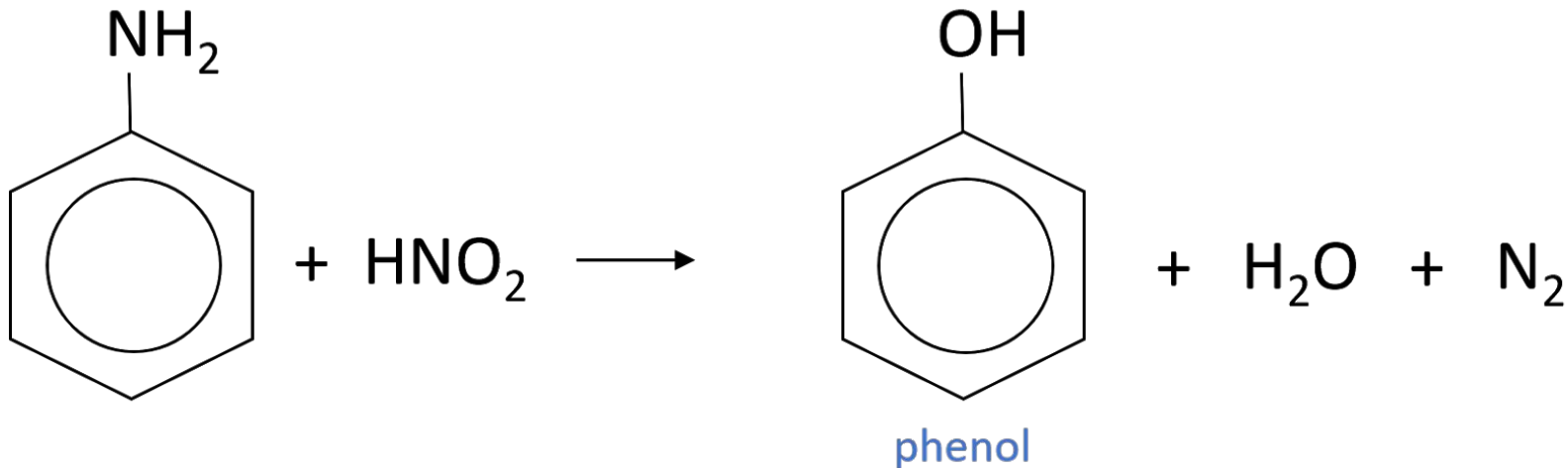
2,4,6-tribromophenylamine



Write an equation for the reaction between phenylamine and nitrous acid when the reaction mixture is warmed



Write an equation for the reaction between phenylamine and nitrous acid when the reaction mixture is warmed



When reacting phenylamine with nitrous acid, why is the nitrous acid typically made in situ? How is this done?



When reacting phenylamine with nitrous acid, why is the nitrous acid typically made in situ? How is this done?

Nitrous acid is made in situ because it decomposes rapidly.

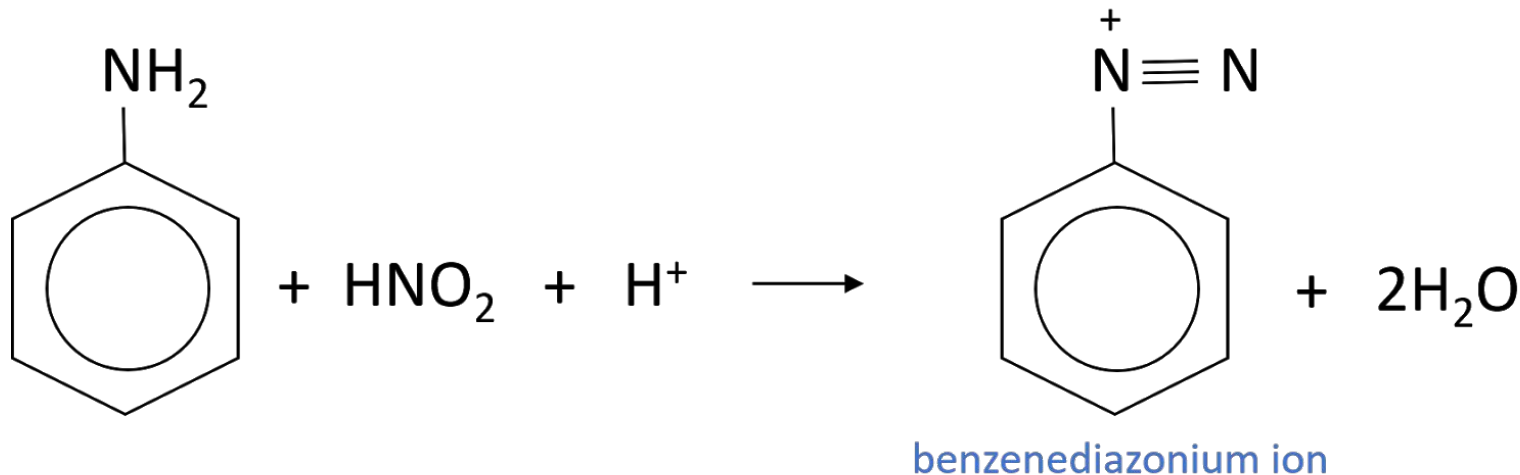
Nitrous acid is made by reacting hydrochloric acid with sodium or potassium nitrate so phenylamine is added to hydrochloric acid and sodium nitrate at the same time.



Write an equation for the reaction between phenylamine and nitrous acid when the reaction vessel is stood in ice (temperature stays below 5°C)



Write an equation for the reaction between phenylamine and nitrous acid when the reaction vessel is stood in ice (temperature stays below 5°C)



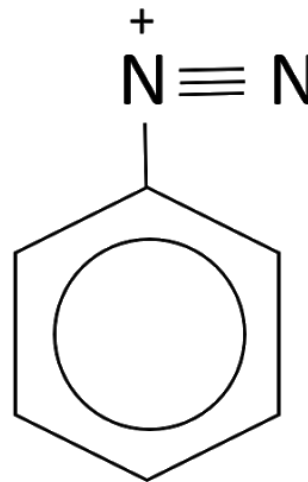
What group does a diazonium ion contain?



What group does a diazonium ion contain?

$-N_2^+$ group

E.g. Benzenediazonium ion:



Describe the formation of dyes from benzenediazonium chloride and phenol



Describe the formation of dyes from benzenediazonium chloride and phenol

- Phenol is reacted with sodium hydroxide to form a solution of sodium phenoxide.
- Sodium phenoxide is cooled in ice. A cool solution of benzenediazonium chloride is added.
- A yellow-orange precipitate forms. This is the azo compound.



What is an azo compound?



What is an azo compound?

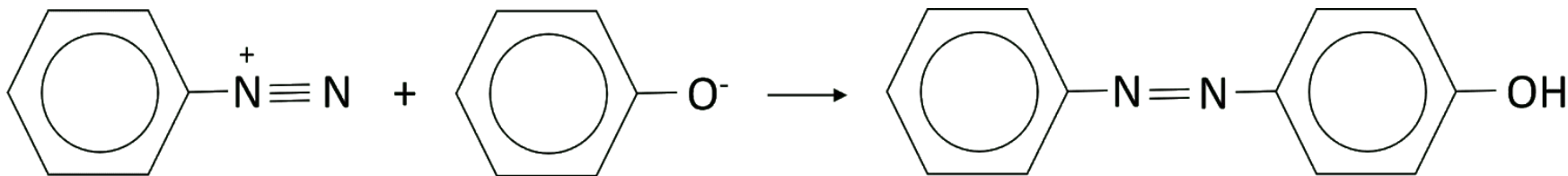
A compound containing two benzene rings joined by a nitrogen bridge.



Write an ionic chemical equation for the reaction between sodium phenoxide and benzenediazonium chloride



Write an ionic chemical equation for the reaction between sodium phenoxide and benzenediazonium chloride



During the formation of azo compounds,
at which position does coupling typically
take place?



During the formation of azo compounds, at which position does coupling typically take place?

At the 4-position.

If the 4-position is occupied, coupling will take place at the 2-position.



What functional group do amides contain?



What functional group do amides contain?



Are amides acidic, neutral or basic?



Are amides acidic, neutral or basic?

Neutral



Describe how an amide can be formed
from ammonia



Describe how an amide can be formed from ammonia

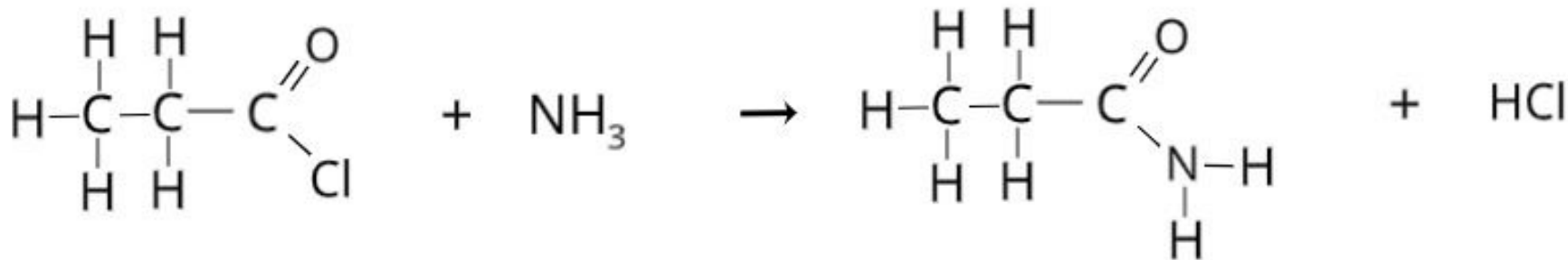
React ammonia with an acyl chloride.
HCl gas is also produced.



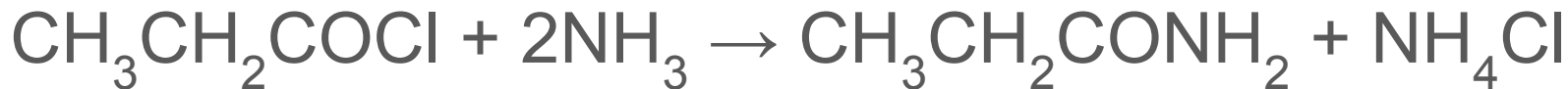
Write an equation for the reaction
between ammonia and propanoyl
chloride



Write an equation for the reaction between ammonia and propanoyl chloride



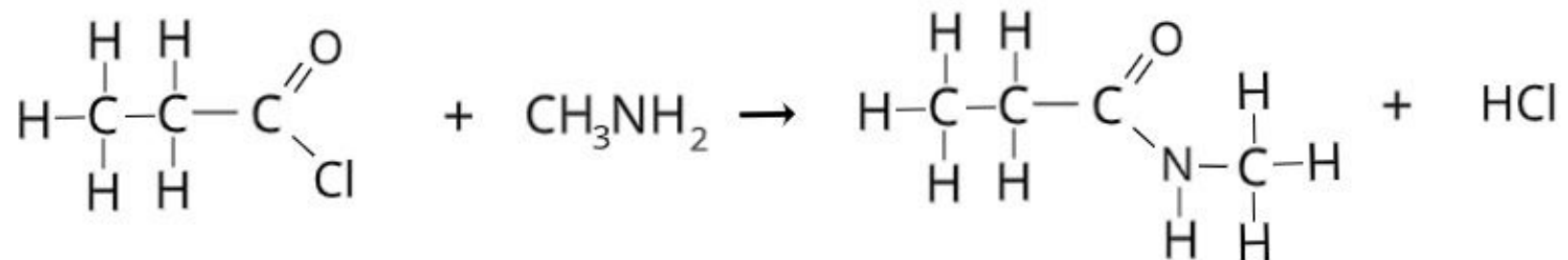
If excess ammonia is used, the overall equation is:



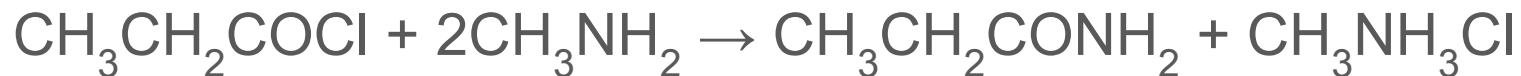
Write an equation for the reaction
between propanoyl chloride and
methylamine



Write an equation for the reaction between propanoyl chloride and methylamine



This reaction produces N-methylpropanamide, an N-substituted amide. HCl reacts with excess methylamine so the overall equation is:



Describe the acid hydrolysis of amides



Describe the acid hydrolysis of amides

Upon heating with acid, an amide will be broken down into a carboxylic acid and either ammonium ions or RNH_3^+ ions.



Describe the alkaline hydrolysis of amides



Describe the alkaline hydrolysis of amides

Upon heating with sodium hydroxide, an amide will be broken down into a carboxylate salt and either ammonia or an amine.



Describe the reduction of amides



Describe the reduction of amides

LiAlH_4 reducing agent followed by treatment with dilute acid.

Forms an amine and water.



Write an equation for the reduction of
propanamide



Write an equation for the reduction of propanamide



What functional groups do all amino acids contain?



What functional groups do all amino acids contain?

Carboxylic acid group (-COOH)

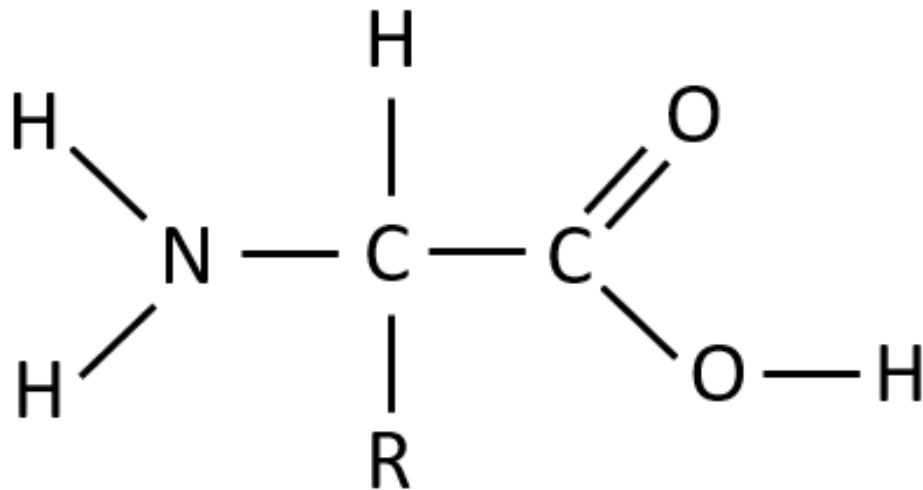
Amine group (-NH₂)



Draw a diagram to show the general formula of an amino acid



Draw a diagram to show the general formula of an amino acid



Why can amino acids act as both acids and bases?



Why can amino acids act as both acids and bases?

The -COOH group can donate a proton (acid).

The -NH_2 group can accept a proton (base).

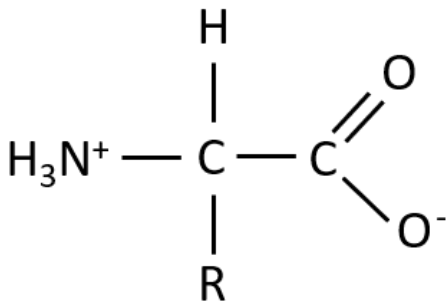


What is a zwitterion? How do amino acids form zwitterions?



What is a zwitterion? How do amino acids form zwitterions?

A zwitterion is an ion containing a positive and negative charge. It has no overall charge. Amino acids form zwitterions when the carboxylic acid group donates a proton to the amine group.



What happens when an alkali is added to an amino acid zwitterion?



What happens when an alkali is added to an amino acid zwitterion?

The NH_3^+ group donates a hydrogen ion to the OH^- ions of the alkali to form water. The organic compound is no longer a zwitterion because it only contains a negative charge.



What happens when an acid is added to an amino acid zwitterion?



What happens when an acid is added to an amino acid zwitterion?

The COO^- group accepts a hydrogen ion from the acid. The organic compound is no longer a zwitterion as it only contains a positive charge.



How does a peptide bond form?



How does a peptide bond form?

A peptide bond is formed during a condensation reaction between two amino acids. A water molecule is lost.



What is the difference between a dipeptide and a tripeptide?

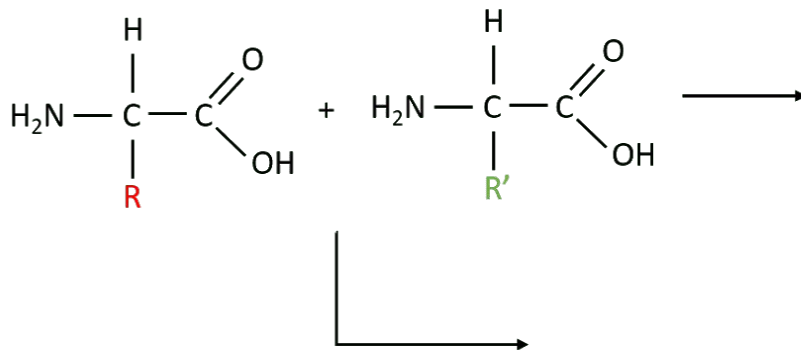


What is the difference between a dipeptide and a tripeptide?

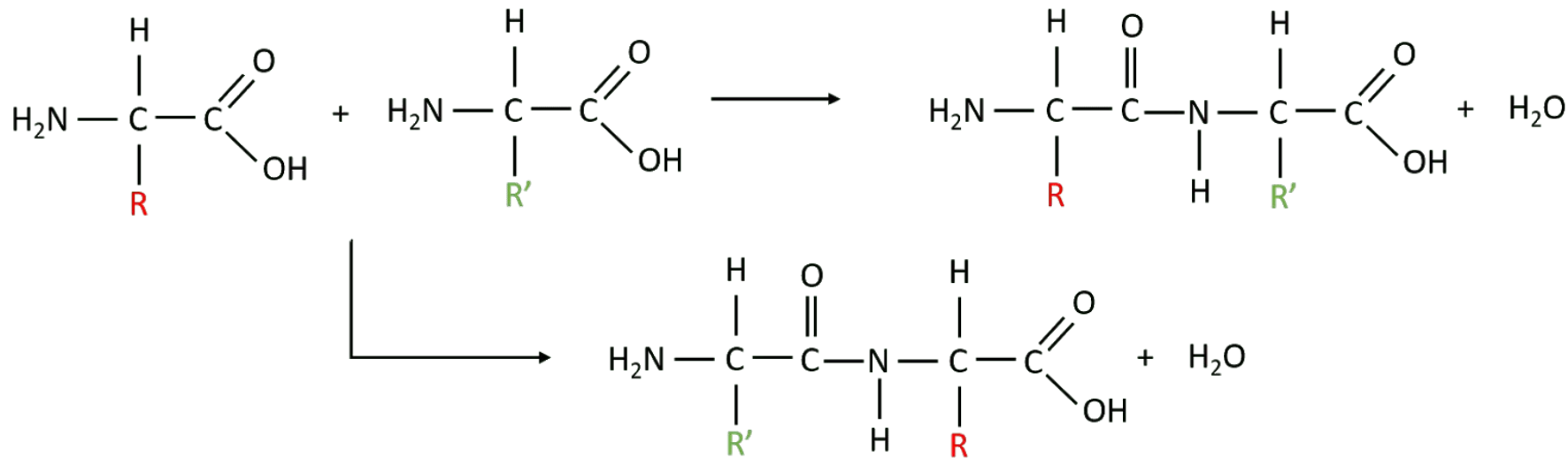
A dipeptide is formed from two amino acids while a tripeptide is formed from three amino acids.



Complete the equation below to show the dipeptides that could be formed from these amino acids:



Complete the equation below to show the dipeptides that could be formed from these amino acids:



Describe how electrophoresis can be used to separate amino acids



Describe how electrophoresis can be used to separate amino acids

1. Place a piece of moist filter paper on a microscope slide.
2. Attach crocodile clips to each end of the paper and connect to a battery.
3. Add a drop of amino acid solution to the middle of the paper.
4. Leave the apparatus for separation to occur.
5. Spray the paper with ninhydrin to make the colourless amino acid solution visible. Dry and gently warm the paper to make the amino acids visible as coloured spots.



What must the pH be for a specific amino acid to form its zwitterion?



What must the pH be for a specific amino acid to form its zwitterion?

The pH must be the isoelectric point of that amino acid.



When the pH is the isoelectric point of an amino acid, why doesn't this amino acid move during electrophoresis?



When the pH is the isoelectric point of an amino acid, why doesn't this amino acid move during electrophoresis?

The amino acid forms its zwitterion meaning it has no overall charge. As a result, it is not attracted to the positively charged anode or the negatively charged cathode.



When do amino acids move towards the cathode during electrophoresis?



When do amino acids move towards the cathode during electrophoresis?

When they are positively charged. This may occur when an amino acid has an extra hydrogen added to the amine group.



When do amino acids move towards the anode during electrophoresis?



When do amino acids move towards the anode during electrophoresis?

When they are negatively charged. This may occur when an amino acid has lost a hydrogen ion from the carboxylic acid group.



How is the size of ions related to the speed at which they travel during electrophoresis?



How is the size of ions related to the speed at which they travel during electrophoresis?

Smaller ions travel faster because there is less resistance to their movement through the fibres of the paper (or the matrix of the gel if a gel is used instead).



How does using a buffer with a low pH affect the results when using electrophoresis to separate amino acids?



How does using a buffer with a low pH affect the results when using electrophoresis to separate amino acids?

The -COOH groups remain as -COOH .

The -NH_2 groups accept a proton to become -NH_3^+ .

All amino acids will be positively charged so they will move towards the cathode.



How does using a buffer with a high pH affect the results when using electrophoresis to separate amino acids?



How does using a buffer with a high pH affect the results when using electrophoresis to separate amino acids?

The -COOH groups donate a proton to become -COO^- .

The -NH_2 groups remain as -NH_2 .

All amino acids will be negatively charged so they will move towards the anode.



In terms of peptides, what can electrophoresis be used for?



In terms of peptides, what can electrophoresis be used for?

- To separate peptides in order of relative molecular mass.
- To estimate the relative molecular mass of a peptide.



What must be done before peptides can undergo electrophoresis? Describe how the molecules are changed.



What must be done before peptides can undergo electrophoresis? Describe how the molecules are changed.

- Treat the peptides with SDS and denature them by heating.
- The secondary and tertiary structures are lost. The molecules become amino acid chains surrounded by negative charges (from the SDS molecules that cover the chain).



During electrophoresis of peptides, what do the molecules move towards? What sized molecules move fastest?



During electrophoresis of peptides, what do the molecules move towards? What sized molecules move fastest?

- Move towards the anode because the molecules are negatively charged.
- Smaller molecules move fastest.

