

# CIE Chemistry A-Level

## Topic 19 - Carboxylic Acids and Derivatives

### Flashcards

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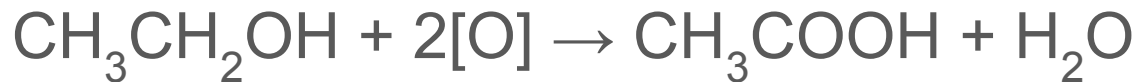


How are primary alcohols oxidised to carboxylic acids?



## How are primary alcohols oxidised to carboxylic acids?

If a primary alcohol is heated under reflux with acidified potassium dichromate(VI), the alcohol will be oxidised to form a carboxylic acid.



The acidified potassium dichromate(VI) will change colour from orange to green.



# How are aldehydes oxidised to carboxylic acids?



## How are aldehydes oxidised to carboxylic acids?

If an aldehyde is heated under reflux with acidified potassium dichromate(VI), the aldehyde will be oxidised to form a carboxylic acid.



The acidified potassium dichromate(VI) will change colour from orange to green.



# How do nitriles react to form carboxylic acids?



## How do nitriles react to form carboxylic acids?

Nitriles react via acid hydrolysis to form carboxylic acids.

Heat the nitrile under reflux with a strong acid catalyst:



# How do carboxylic acids react with metals?





How do carboxylic acids react with metals?

Carboxylic acids react with metals to form a salt and hydrogen gas.



What is the chemical equation for the reaction of ethanoic acid with sodium?



What is the chemical equation for the reaction of ethanoic acid with sodium?



# How do carboxylic acids react with carbonates?



How do carboxylic acids react with carbonates?

Carboxylic acids react with carbonates to form a salt, carbon dioxide and water.



What is the chemical equation for the reaction of ethanoic acid with sodium carbonate?



What is the chemical equation for the reaction of ethanoic acid with sodium carbonate?



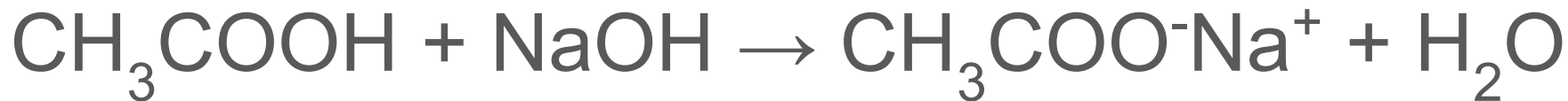
# How do carboxylic acids react with alkalis?





How do carboxylic acids react with alkalis?

Carboxylic acids react with alkalis to form a salt and water:



# How do alcohols react with carboxylic acids?



# How do alcohols react with carboxylic acids?

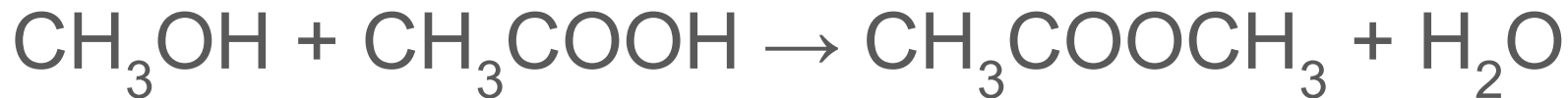
Alcohols react with carboxylic acids to form esters. This process is called esterification and requires heating with a sulfuric acid catalyst.



What is the chemical equation for the reaction between methanol and ethanoic acid? Give the name of the ester formed



What is the chemical equation for the reaction between methanol and ethanoic acid? Give the name of the ester formed



Product  $\text{CH}_3\text{COOCH}_3$  is methyl ethanoate.



# How do carboxylic acids form alcohols?



# How do carboxylic acids form alcohols?

## Reduction with $\text{LiAlH}_4$

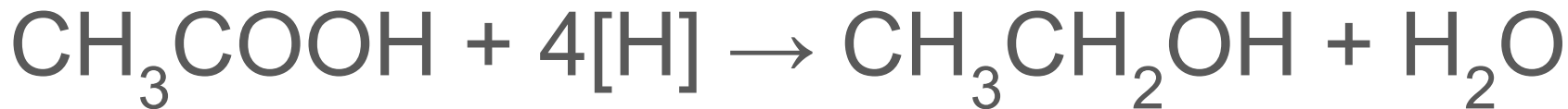


What is the chemical equation for the reduction of ethanoic acid?





What is the chemical equation for the reduction of ethanoic acid?



# How do carboxylic acids react to form acyl chlorides? **(A-Level only)**



How do carboxylic acids react to form acyl chlorides? **(A-Level only)**

Carboxylic acids react with sulfur dichloride oxide to form an acyl chloride, sulfur dioxide and hydrogen chloride.



What is the chemical equation for the reaction between ethanoic acid and sulfur dichloride oxide?  
**(A-Level only)**



What is the chemical equation for the reaction between ethanoic acid and sulfur dichloride oxide?  
**(A-Level only)**

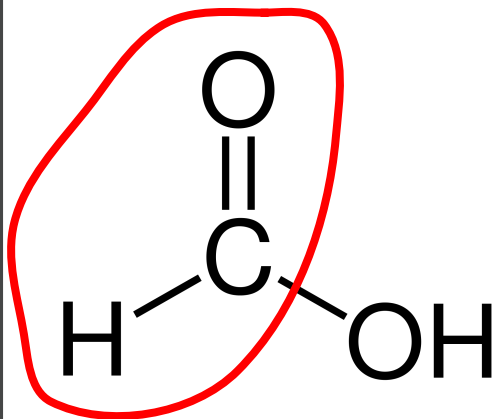


# How is methanoic acid further oxidised? **(A-Level only)**



## How is methanoic acid further oxidised?

**(A-Level only)**



Although methanoic acid is a carboxylic acid, it also has an aldehyde functional group. This means the aldehyde group can be oxidised further by using Tollens' reagent or Fehling's solution.

The methanoic acid is oxidised to carbon dioxide and water.

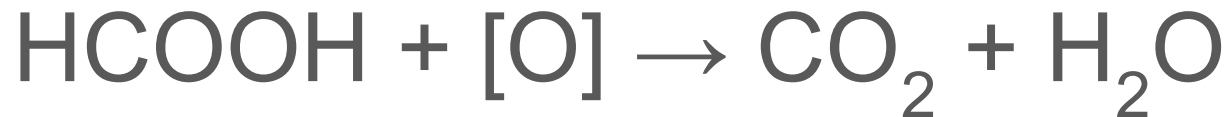


What is the chemical equation for the  
oxidation of methanoic acid?  
**(A-Level only)**





What is the chemical equation for the oxidation of methanoic acid? **(A-Level only)**



How is ethanedioic acid oxidised further?  
**(A-Level only)**



How is ethanedioic acid oxidised further?  
**(A-Level only)**

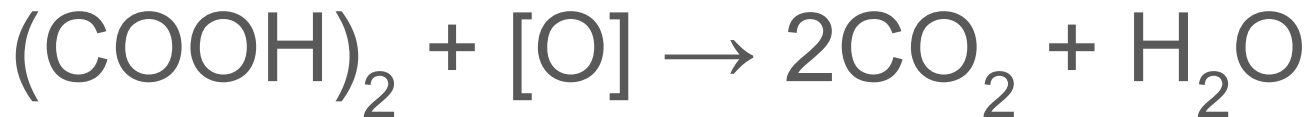
Ethanedioic acid is oxidised to carbon dioxide and water using warm acidified potassium manganate(VII) solution.



What is the chemical equation for the  
oxidation of ethanedioic acid?  
**(A-Level only)**



What is the chemical equation for the oxidation of ethanedioic acid? **(A-Level only)**



State the relative acidities of carboxylic acids, alcohols and phenols  
**(A-Level only)**



State the relative acidities of carboxylic acids, alcohols and phenols **(A-Level only)**

Carboxylic acids → Phenol → Alcohols  
→ **Decreasing acidity** →



# Explain the relative acidities of carboxylic acids, alcohols and phenols (A-Level only)





# Explain the relative acidities of carboxylic acids, alcohols and phenols **(A-Level only)**

- Carboxylic acids are the most acidic as the carboxylate ion has a delocalised pi system that develops over the  $\text{-COO}^-$  group. This distributes the negative charge, making the carboxylate ion more stable.
- Phenols are more acidic than alcohols because the phenoxide ion is relatively stable. The lone pair on the oxygen is delocalised into the pi system so the negative charge is dispersed. This makes phenol more likely to donate a hydrogen ion compared with alcohols.
- Alcohols are the least acidic because of the positive inductive effect. In the alkoxide ion, the alkyl groups “push” electrons away from themselves, increasing the electron density of the oxygen, making it more likely to bond to a hydrogen ion and reform an alcohol.



What determines the acidity of chlorine substituted ethanoic acids?  
**(A-Level only)**



## What determines the acidity of chlorine substituted ethanoic acids? **(A-Level only)**

- You can strengthen an acid by pulling charge away from the  $\text{-COO}^-$  end. This can be done by adding a chlorine atom to the chain.
- Chlorine is very electronegative and so will have a tendency to attract electrons towards itself.
- The more chlorines bonded, the stronger the acid.



# How do acyl chlorides react with water?

## (A-Level only)



# How do acyl chlorides react with water?

## (A-Level only)

Hydrolysis reaction:

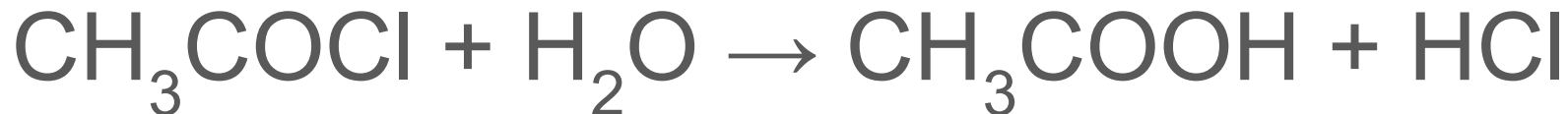
The acyl chloride reacts with water to form a carboxylic acid and hydrochloric acid.



What is the chemical equation for the hydrolysis of ethanoyl chloride?  
**(A-Level only)**



What is the chemical equation for the hydrolysis of ethanoyl chloride? **(A-Level only)**



# How do acyl chlorides react with alcohols? **(A-Level only)**





How do acyl chlorides react with alcohols?

**(A-Level only)**

Acyl chlorides react with alcohols to form an ester and hydrochloric acid:



# How do acyl chlorides react with phenol?

## **(A-Level only)**



# How do acyl chlorides react with phenol?

**(A-Level only)**

An acyl chloride reacts with phenol to form an ester and hydrochloric acid.



# How do acyl chlorides react with ammonia?

## **(A-Level only)**



How do acyl chlorides react with ammonia?

**(A-Level only)**

Acyl chlorides react with ammonia to form a primary amide and hydrochloric acid:



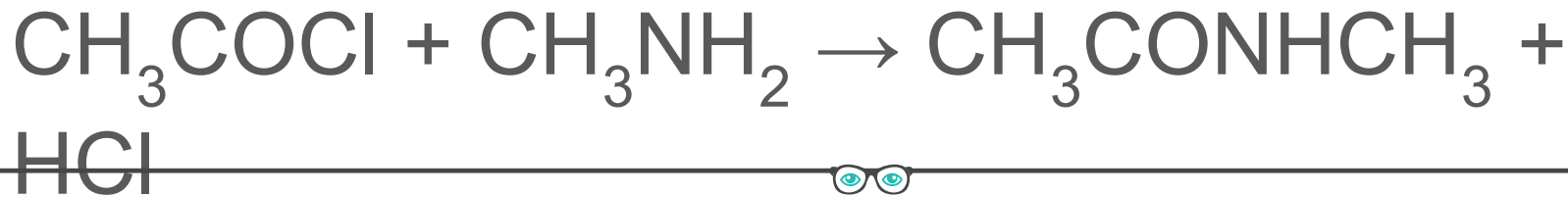
How do acyl chlorides react with a  
primary amine?  
**(A-Level only)**



How do acyl chlorides react with a primary amine?

**(A-Level only)**

Acyl chlorides react with a primary amine to form a secondary amide and hydrochloric acid:



# Compare the relative ease of hydrolysis of acyl chlorides, alkyl chlorides and aryl chlorides **(A-Level only)**





# Compare the relative ease of hydrolysis of acyl chlorides, alkyl chlorides and aryl chlorides

## (A-Level only)

- Acyl chlorides react vigorously with cold water to produce a carboxylic acid and hydrogen chloride gas.  
E.g.  $\text{CH}_3\text{COCl} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COOH} + \text{HCl}$
- Alkyl chlorides have almost no reaction with water.
- Aryl chlorides have no reaction with water.



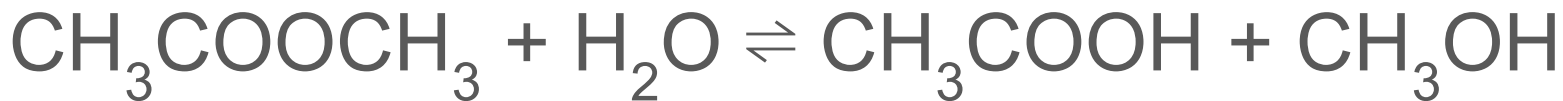
# How do esters undergo acid hydrolysis?



## How do esters undergo acid hydrolysis?

Heat the ester under reflux with dilute aqueous acid. The ester will be hydrolysed into a carboxylic acid and alcohol.

The reaction is slow and reversible.



# How do esters undergo base hydrolysis?



## How do esters undergo base hydrolysis?

Heat the ester under reflux with a dilute alkali.

The ester will be hydrolysed into the salt of the carboxylic acid, and the alcohol. The reaction is one-way and faster than acid hydrolysis.



State the major commercial uses of esters



# State the major commercial uses of esters

- Perfumes
- Solvents
- Flavourings

