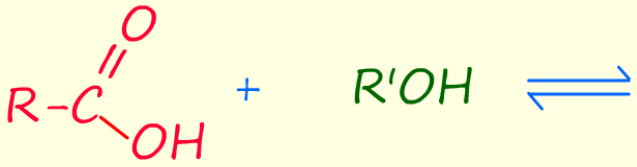
Answer all the questions below as fully as you can then check your answers

1. Complete the esterification equation below:

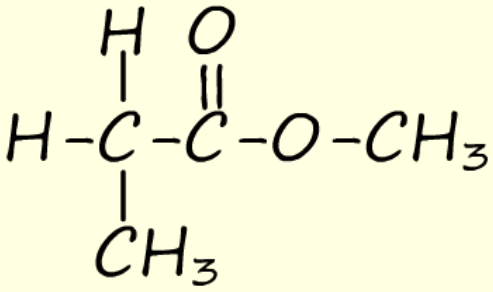


a. Name the catalyst used in this reaction.

2. Methyl ethanoate can be prepared by reacting a carboxylic acid or an acid chloride with methanol. Write equations for these two reactions.

a. Suggest an advantage of using the acid anhydride or an acid chloride instead of the carboxylic acid to prepare the ester.

3. Name the ester shown opposite:



a. Draw a circle round the ester functional group in this molecule.

b. Which carboxylic acid and which alcohol would be used to prepare this ester?

c. Write an equation to show esterification reaction which would be used to prepare this ester.

d. Esterification is often described as a condensation reaction. What is a condensation reaction?

e. The ester shown can be prepared by refluxing together a carboxylic acid and an alcohol in the presence of a catalyst.

i. Sketch the apparatus that could be used to prepare the ester under reflux and describe briefly what happens during reflux.

ii. A few anti-bumping granules were added to the flask during reflux, explain why they are needed.

iii. A few drops of concentrated sulphuric acid was also added to the alcohol/carboxylic acid mixture, explain why it was added.

e. After refluxing the ester was separated from the reaction mixture by distillation.

i. Why is this a suitable method to separate out the ester?

ii. The ester obtained by distillation was treated with sodium carbonate solution in a separating funnel. Why was this done?

iii. How can the ester and sodium carbonate solution n ow be separated into two separate layers?

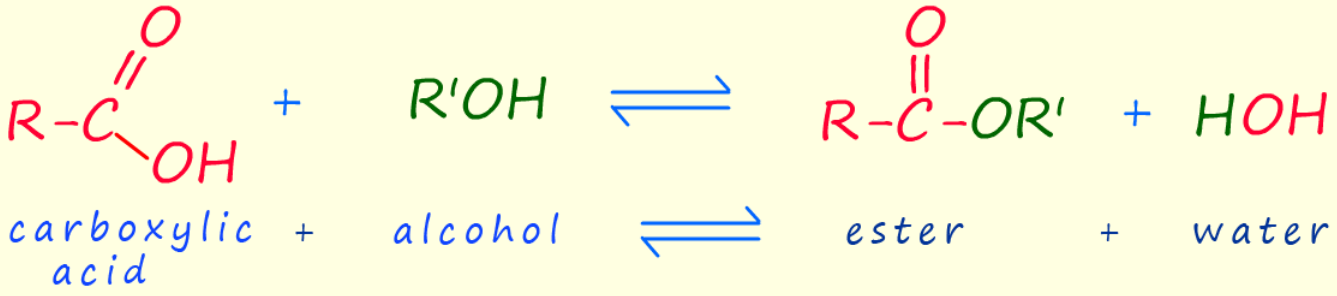
iv. The ester was removed from the separating funnel and solid anhydrous sodium sulphate and the mixture swirled in a flask. Why was sodium sulphate added to the ester?

v. Suggest another reagent that could be used instead of anhydrous sodium sulphate.

3. List common uses for esters.

Answers

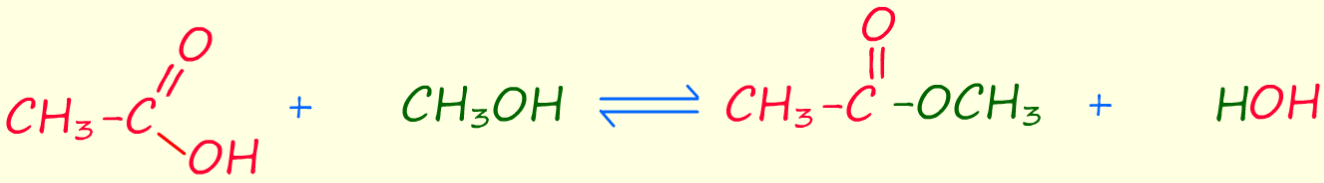
1. Complete the esterification equation below:



a. Name the catalyst used in this reaction.

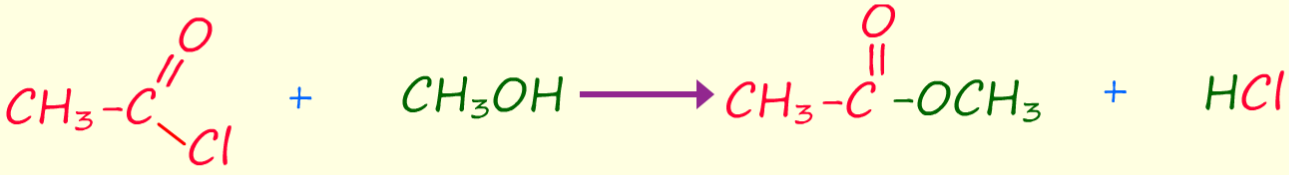
Concentrated sulphuric acid.

2. Methyl ethanoate can be prepared by reacting a carboxylic acid or an acid chloride with methanol. Write equations for these two reactions.



CH_3COOH + CH_3OH ⇌ CH_3COOCH_3 + H_2O

ethanoic acid + methanol ⇌ methyl ethanoate + water



CH_3COCl + CH_3OH → CH_3COOCH_3 + HCl

ethanoyl chloride + methanol → methyl ethanoate + hydrogen chloride

a. Suggest an advantage of using the acid anhydride or an acid chloride instead of the carboxylic acid to prepare the ester.

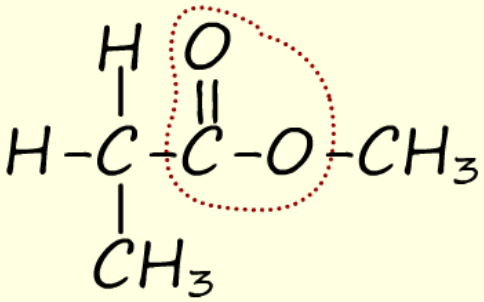
Esterification using a carboxylic acid and an alcohol is a reversible reaction that involves equilibrium; this means that a reaction mixture of reactants and products will be obtained. This means a reduced yield of ester and separation problems. Reactions involving acid chlorides and acid anhydrides go to completion, there is no equilibrium involved, so a much higher yield of ester is produced.

3. Name the ester shown opposite:

Methyl propanoate

a. Draw a circle round the ester functional group in this molecule.

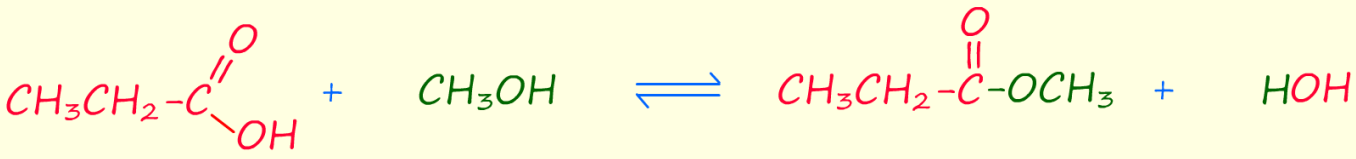
See image opposite

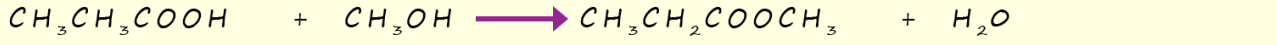


b. Which carboxylic acid and which alcohol would be used to prepare this ester?

Methanol and propanoic acid

c. Write an equation to show esterification reaction which would be used to prepare this ester.





propanoic acid + methanol ⟶ methyl propanoate + water

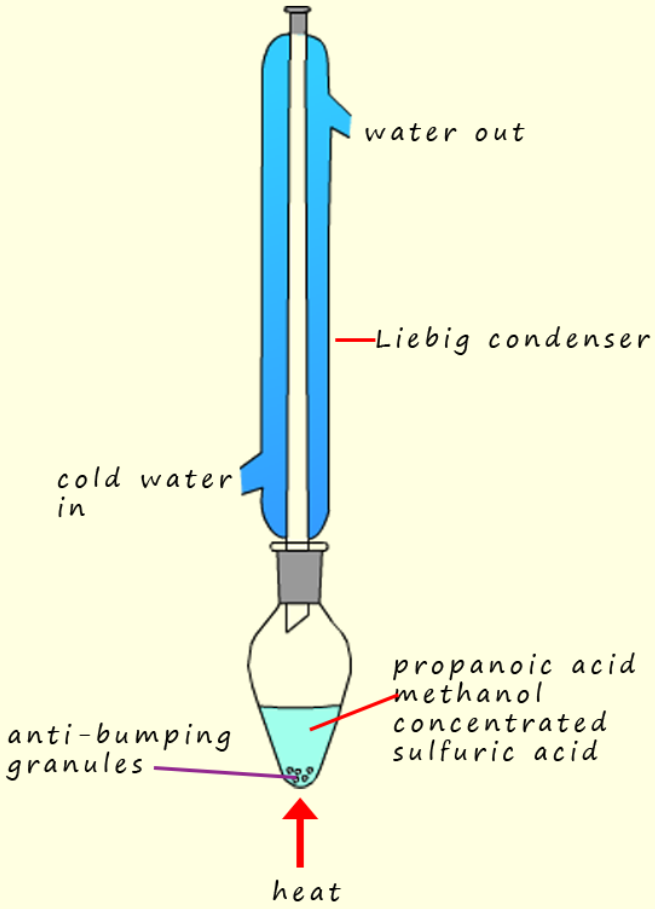
d. Esterification is often described as a condensation reaction. What is a condensation reaction?

A condensation reaction is one where small molecules join together to make a larger one and release a small molecule, normally water or hydrogen chloride.

e. The ester shown can be prepared by refluxing together a carboxylic acid and an alcohol in the presence of a catalyst.

i. Sketch the apparatus that could be used to prepare the ester under reflux and describe briefly what happens during reflux.

During reflux the mixture of the carboxylic acid and alcohol are heated using an electrical heater since the ester and alcohol are both volatile and flammable. As they are heated they will react but some of the reactants and the ester product will evaporate, they will enter the Liebig condenser where they will condense and fall back into the pear shaped flask to ensure as much of the reactants as possible turn into products.



ii. A few anti-bumping granules were added to the flask during reflux, explain why they are needed.

To ensure the liquids in the pear shaped flask boils smoothly and do not shoot up the Liebig condenser. The anti-bumping granules provide a surface on which boiling can occur. They provide a nucleus or point surface on which gas bubbles grow, therefore avoiding the sudden production of large gas bubbles which can lead to bumping.

iii. A few drops of concentrated sulphuric acid was also added to the alcohol/carboxylic acid mixture, explain why it was added.

Sulfuric acid is a catalyst for the reaction; it is also a dehydrating agent and can remove water and help force the position of the esterification equilibrium to the products side.

e. After refluxing the ester was separated from the reaction mixture by distillation.

i. Why is this a suitable method to separate out the ester?

Esters are volatile and will evaporate before the other reagents in the flask.

ii. The ester obtained by distillation was treated with sodium carbonate solution in a separating funnel. Why was this done?

The distillate (the ester) is likely to contain traces of the carboxylic acid and sulfuric acid. Sodium carbonate solution is a basic solution and will neutralise any acid residues present. It will fizz in the acid, that is release carbon dioxide gas, so ensure the separating funnel is not stoppered!

iii. How can the ester and sodium carbonate solution n ow be separated into two separate layers?

The ester and the sodium carbonate solution will be on separate layers in the separating funnel, the aqueous layer, the sodium carbonate solution will be on the bottom and the top layer will be the organic ester layer, simply open the tap and run out the aqueous layer and you will be left with the ester layer.

iv. The ester was removed from the separating funnel and solid anhydrous sodium sulphate and the mixture swirled in a flask. Why was sodium sulphate added to the ester?

Anhydrous means dry, anhydrous sodium sulphate is a drying agent and will remove water from the organic layer containing the ester. Simply mix the two layers together in a flask, swirl and then filter using DRY apparatus to remove the solid sodium sulfate.

v. Suggest another reagent that could be used instead of anhydrous sodium sulphate.

Anhydrous calcium chloride is another common drying agent.

3. List common uses for esters.

Solvents/plasticisers/food flavouring/artificial odours.