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

1. Draw the displayed formula for the following molecules:

a. Ethanoyl chloride b. Propanoyl chloride

2. Ethanoyl chloride can be hydrolysed to form a carboxylic acid.

a. Draw the mechanism for this reaction clearly identifying all reactants and products.

b. The mechanism of this reaction is nucleophilic addition-elimination. Identify the addition and elimination steps in this mechanism.

c. What makes a good leaving group?

3. What is formed when ethanoyl chloride reacts with an alcohol?

a. Write an equation for the reaction of ethanoyl chloride with methanol and name all the products of the reaction.

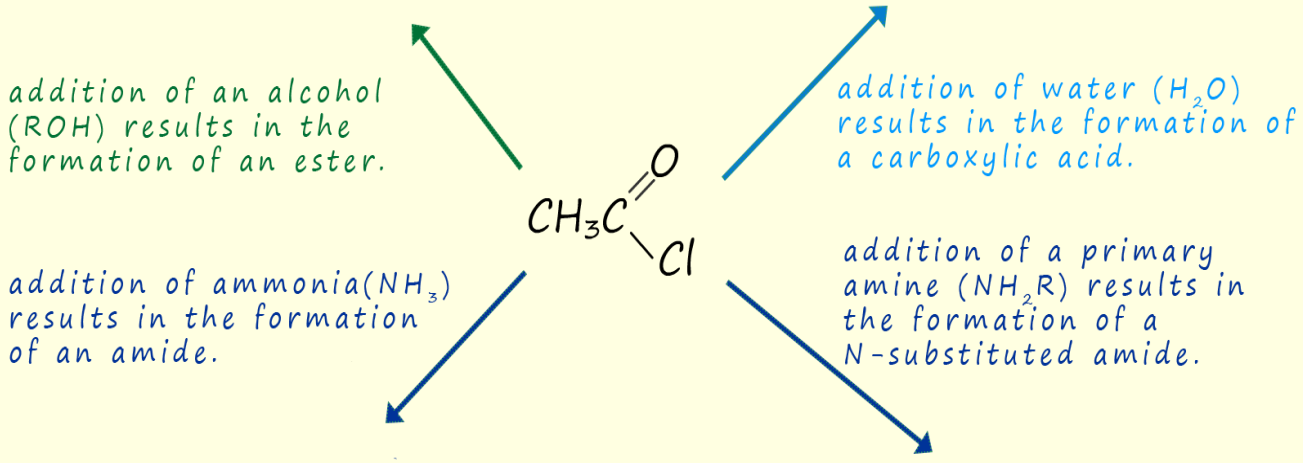
b. Esters can be made by reacting an alcohol with a carboxylic acid. What are the advantages of using an acid chloride instead of a carboxylic acid in an esterification reaction?

4. Draw the mechanism and equation for the reaction of ammonia with ethanoyl chloride.

b. Name the 2 differing roles ammonia plays in this reaction.

c. Why can this reaction be called an acylation reaction?

5. Complete the diagram below to show the structure of the products formed when ethanoyl chloride reacts with water, an alcohol, ammonia and a primary amine.



Answers

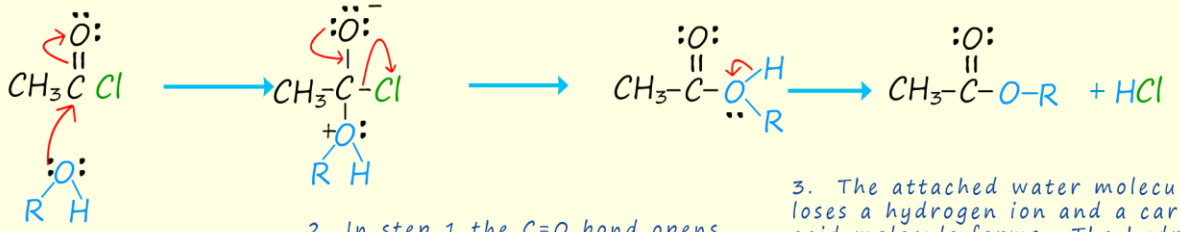
1. Draw the displayed formula for the following molecules:

a. Ethanoyl chloride b. Propanoyl chloride

ethanoyl chloride propanoyl chloride

2. Ethanoyl chloride can be hydrolysed to form a carboxylic acid.

a. Draw the mechanism for this reaction clearly identifying all reactants and products.

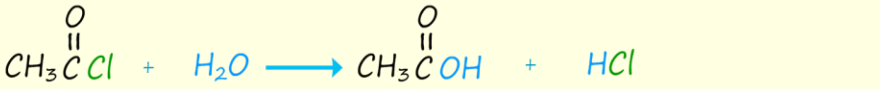


1. The water acts as a nucleophile and uses one of its lone pairs of electrons to attack the (δ^+) carbon atom in the carbonyl group.

2 In step 1 the C=O bond opens up to allow the water molecule to bond to the carbon atom. In this tetrahedral intermediate the carbonyl group reforms and the chlorine atom leaves as a chloride ion (Cl^-)

3. The attached water molecule now loses a hydrogen ion and a carboxylic acid molecule forms. The hydrogen ion (H^+) and the chloride ion (Cl^-) will combine to form hydrogen chloride gas (HCl).

The Overall reaction for an acid chloride and water is:



ethanoyl chloride$_{(l)}$ + water$_{(l)}$ → ethanoic acid$_{(l)}$ + hydrogen chloride$_{(g)}$

b. The mechanism of this reaction is nucleophilic addition-elimination. Identify the addition and elimination steps in this mechanism.

The addition step is step 1 above, the nucleophilic attack of the water molecule on the acid chloride molecule. The water molecule ADDS to the acid chloride. The elimination step is the loss of the chloride ion (Cl^-)

c. What makes a good leaving group?

A group that is able to stabilise a negative charge or an atom with a high electronegativity value will make good leaving groups.

3. What is formed when ethanoyl chloride reacts with an alcohol?

An ester

a. Write an equation for the reaction of ethanoyl chloride with methanol and name all the products of the reaction.

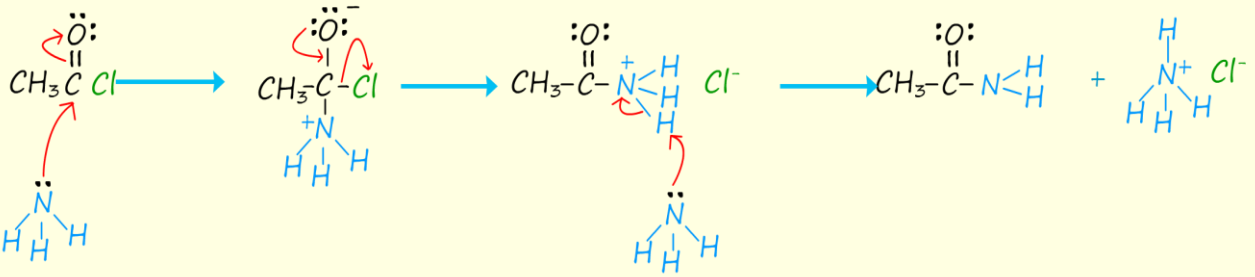
Ethanoyl chloride + methanol ⟶ methyl Ethanoate + hydrogen chloride

$CH_3COCl + CH_3OH \longrightarrow CH_3COOCH_3 + HCl$

b. Esters can be made by reacting an alcohol with a carboxylic acid. What are the advantages of using an acid chloride instead of a carboxylic acid in an esterification reaction?

Esterification reaction using an alcohol and a carboxylic acid produce equilibrium mixtures and do not go to completion. This will lead to a lower yield of eater and also lead to additional expense due to separation problems. Using acid chlorides instead of carboxylic acids gives a reaction that goes to completion and so will lead to a much higher yield of ester.

4. Draw the mechanism and equation for the reaction of ammonia with ethanoyl chloride.



1. Here the ammonia molecule is acting as a nucleophile. It is using its lone pair to attack the δ^+ carbon atom.

2. Loss of a hydrogen ion in the intermediate ion leads to formation of the amide. Ammonia acts as a base here to remove a H^+ ion. This results in the formation of an ammonium ion (NH_4^+).

Overall we have:

ethanoyl chloride + ammonia ⟶ ethanamide + ammonium chloride

b. Name the 2 differing roles ammonia plays in this reaction.

In step 1 above ammonia acts as a nucleophile to attack the carbonyl carbon atom, while in step 2 it acts as a Brønsted-Lowry base by accepting a proton or hydrogen ion (H^+)

c. Why can this reaction be called an acylation reaction?

If you study the reactions of acid chlorides you will see that the end results of the reactions are the acid chloride effectively add an acyl group (RCO) to the nucleophile that attacks it

5. Complete the diagram below to show the structure of the products formed when ethanoyl chloride reacts with water, an alcohol, ammonia and a primary amine.