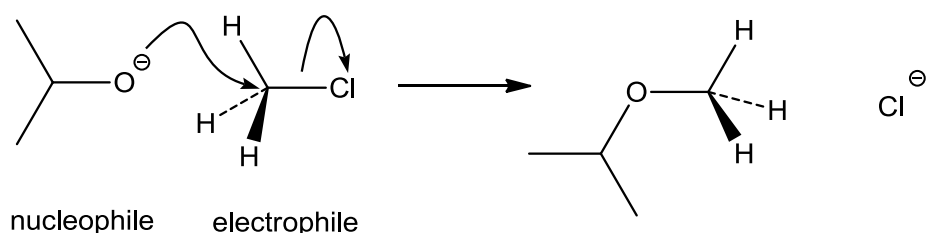


CHEM1405 Worksheet 11: Substitution Reactions

Model 1: Nucleophilic Substitution

In Model 3 of week 8, you practised drawing curly arrows in the reaction below in which *substitution* occurs.



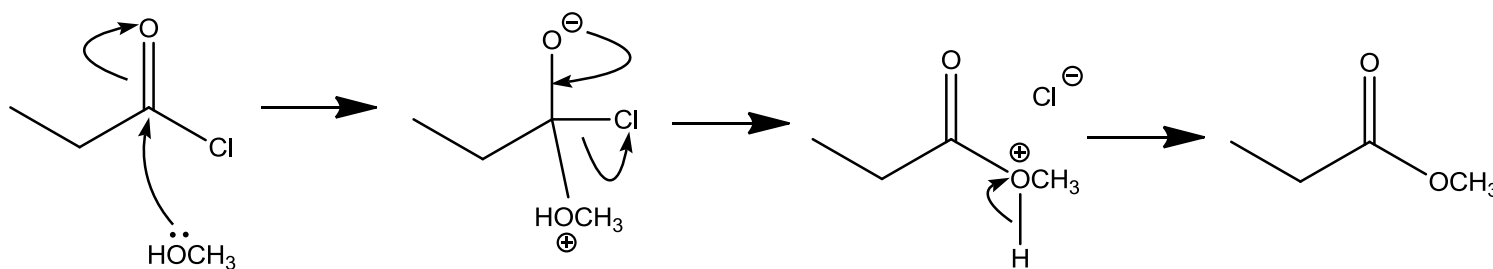
Critical thinking questions

1. Describe *in words* what is happening to the C atom in the alkyl chloride above. (What type of reagent is it being attacked by? What is happening to the groups it is attached to?)
2. The reaction above has been drawn as a one step ('concerted') process. Can you draw an alternative two-step mechanism? (*Hint*: make sure you never draw *more* than 4 bonds to carbon, so break a bond first. The first step will lead to a carbocation.)
3. The first mechanism is called S_N2 , the second S_N1 . Can you suggest what each component of these names might refer to?
4. Predict whether the following reactions would proceed via an S_N1 or S_N2 mechanism. To do this, you will need to consider (i) steric requirements (does crowding prevent attack) and (ii) the stability of any intermediates. (*Hint*: NaCN reacts like $\text{Na}^+ \text{CN}^-$).



Model 2: Carboxylic Acid Derivatives

Carboxylic acid derivatives are formed from the condensation of a carboxylic acid with a second functional group, such as an alcohol or an amine. In some cases they can be formed directly. More often, the carboxylic acid must be converted to a more reactive intermediate, such as an acid chloride but the **process of condensation is essentially the same**:

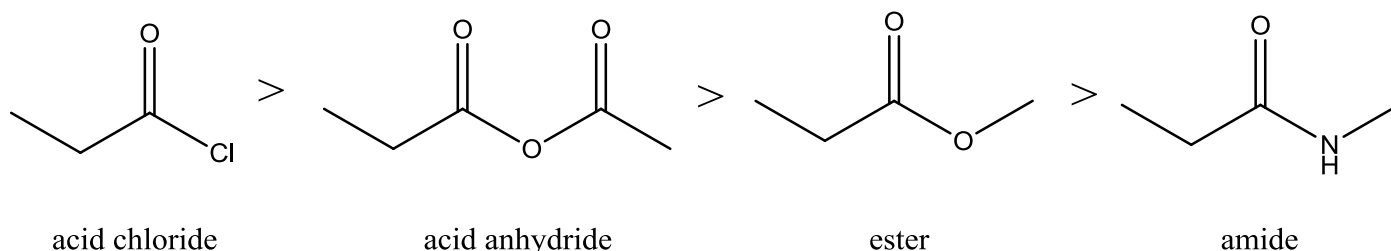


Critical thinking questions

- Using the reaction above as a model, try to devise a mechanism for the condensation of an acid chloride with an amine to form an amide.

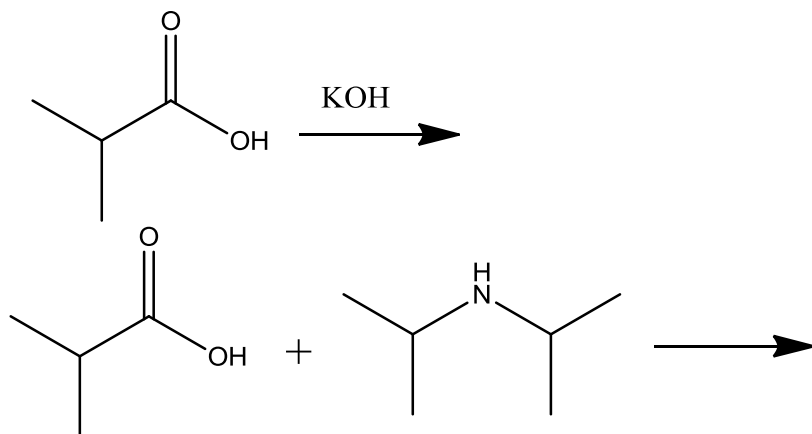


Here are the common carboxylic acid derivatives, arranged from most reactive to least reactive (and hence from least to most stable).

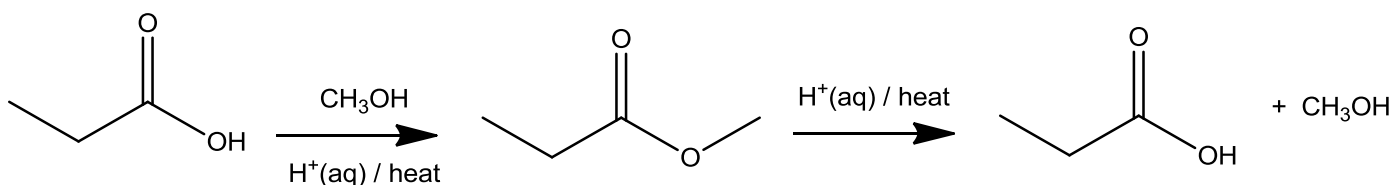


A carboxylic acid derivative can *only* be converted to form a *more* stable derivative.

- How might you convert an ester into an amide? (*Hint*: look at your answer to Question 1).
- What is the by-product of this reaction?
- Carboxylic acids are, as the name suggests, capable of undergoing acid-base reactions. We also know that amines are basic. Use this to predict the outcome of the reactions over the page.

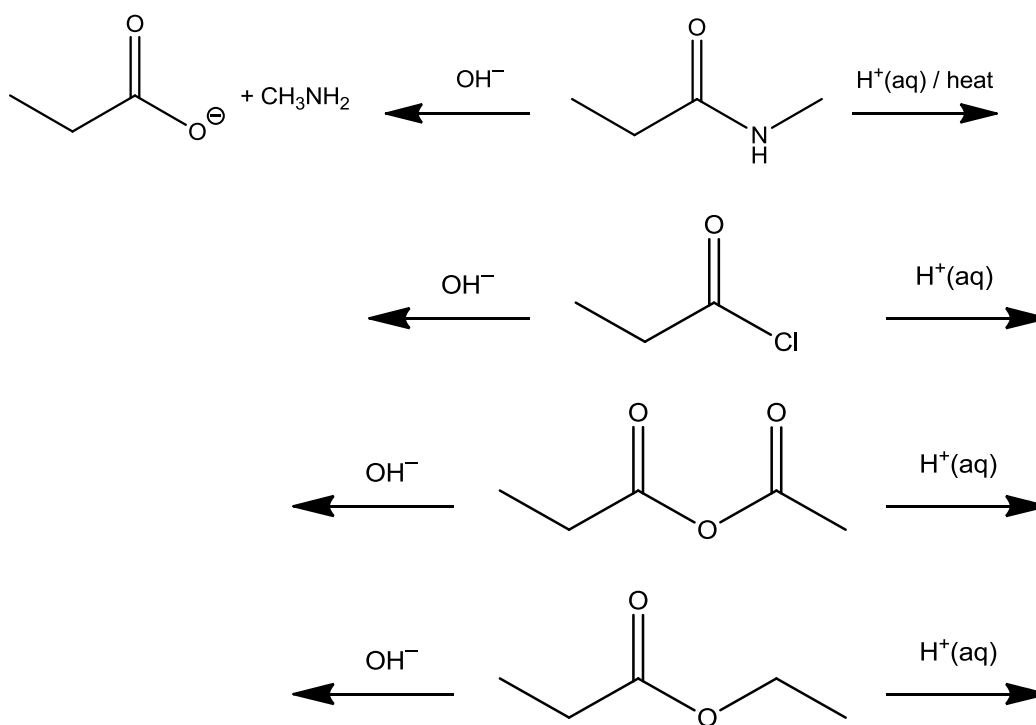


The scheme below shows the *condensation* of a carboxylic acid and an alcohol to give an ester, followed by *hydrolysis* of the ester back to the carboxylic acid and alcohol. Hydrolysis can be catalysed by acid or base.



5. Overall, what is being removed or added in each step? How does this relate to the names we give these reactions (condensation and hydrolysis)?

6. Complete the schemes below.



7. An acid chloride can be hydrolysed using just water, whereas hydrolysis of an amide requires an acid (or base) and heat. Explain the origin of the difference.