



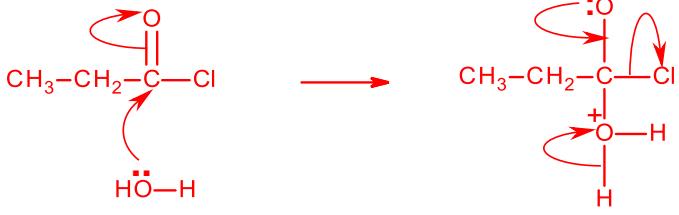
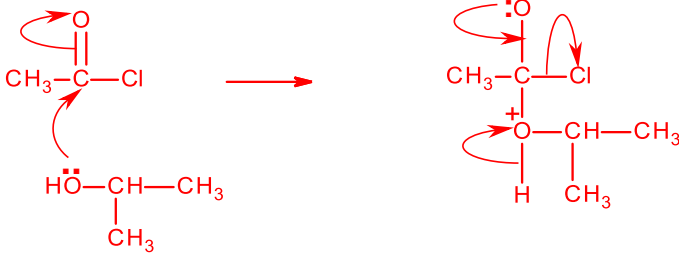
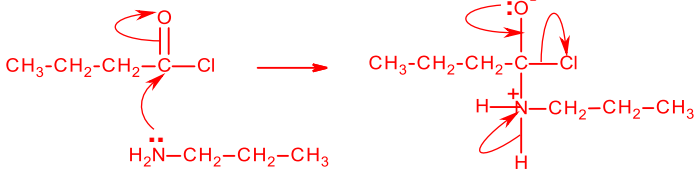
ACYLATION of ALCOHOLS / AMINES

NUCLEOPHILIC ADDITION-ELIMINATION – acylation	
Reagent	acyl chloride (RCOCl) or acid anhydride (RCOOCOR)
Conditions	
What happens	<ul style="list-style-type: none">The acyl group is $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}$Acylation is the insertion of an acyl group into a compound.The H on the O of an alcohol/water is replaced by an acyl group.The H on the N of an amine/ammonia is replaced by an acyl group.The other product is an acid. With amines/ammonia, this acid reacts with a second molecule of the amine/ammonia to form an ammonium salt of the acid. <p>OVERALL</p> <ol style="list-style-type: none">Replace an H on the O/N to give the main product.If using an amine/ammonia, the acid by-product donates H^+ to another molecule of amine/ammonia
Products	Carboxylic acid (from water) Ester (from alcohols) Amide (from ammonia) N-substituted amide (from amines)
Overall equation	<p>e.g. acylation of an alcohol (using an acyl chloride)</p> $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{Cl} + \text{R}'-\text{O}-\boxed{\text{H}} \longrightarrow \text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{R}' + \text{HCl}$ <p>e.g. acylation of an amine (using an acyl chloride)</p> $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{Cl} + \text{R}'-\overset{\text{H}}{\underset{\text{H}}{\text{N}}}-\boxed{\text{H}} \longrightarrow \text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\overset{\text{H}}{\underset{\text{H}}{\text{N}}}-\text{R}' + \text{HCl}$ <p>then</p> $\text{R}'-\overset{\text{H}}{\underset{\text{H}}{\text{N}}}-\text{H} + \text{HCl} \longrightarrow \text{R}'-\overset{\text{H}}{\underset{\text{H}}{\text{N}^+}}-\text{H} + \text{Cl}^-$ <p>overall</p> $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{Cl} + 2 \text{R}'-\overset{\text{H}}{\underset{\text{H}}{\text{N}}}-\boxed{\text{H}} \longrightarrow \text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\overset{\text{H}}{\underset{\text{H}}{\text{N}}}-\text{R}' + \text{R}'-\overset{\text{H}}{\underset{\text{H}}{\text{N}^+}}-\text{H} + \text{Cl}^-$

Example 1	e.g. ethanol + propanoyl chloride $\text{CH}_3\text{-CH}_2\text{-C(=O)-Cl} + \text{HO-CH}_2\text{-CH}_3 \longrightarrow \text{CH}_3\text{-CH}_2\text{-C(=O)-O-CH}_2\text{-CH}_3 + \text{HCl}$ <p style="text-align: center;">ethyl propanoate</p>
Example 2	e.g. methylamine + ethanoic anhydride $\text{CH}_3\text{-C(=O)-O-C(=O)-CH}_3 + 2 \text{H}_2\text{N-CH}_3 \longrightarrow \text{CH}_3\text{-C(=O)-NH-CH}_3 + \text{CH}_3\text{-C(=O)-O}^- + \text{H}_3\text{N}^+\text{-CH}_3$ <p style="text-align: center;">N-methyl ethanamide</p>
Example 3	e.g. water + propanoyl chloride $\text{CH}_3\text{-CH}_2\text{-C(=O)-Cl} + \text{HO-H} \longrightarrow \text{CH}_3\text{-CH}_2\text{-C(=O)-OH} + \text{HCl}$ <p style="text-align: center;">propanoic acid</p>
Example 4	e.g. ammonia + ethanoyl chloride $\text{CH}_3\text{-C(=O)-Cl} + 2 \text{H}_2\text{N-H} \longrightarrow \text{CH}_3\text{-C(=O)-NH}_2 + \text{Cl}^- + \text{NH}_4^+$ <p style="text-align: center;">ethanamide</p>
Example 5	e.g. propan-2-ol + ethanoyl chloride $\text{CH}_3\text{-C(=O)-Cl} + \text{HO-CH(CH}_3\text{)-CH}_3 \longrightarrow \text{CH}_3\text{-C(=O)-O-CH(CH}_3\text{)-CH}_3 + \text{HCl}$ <p style="text-align: center;">methylethyl ethanoate</p>
Example 6	e.g. ethylamine + propanoic anhydride $\text{CH}_3\text{-CH}_2\text{-C(=O)-O-C(=O)-CH}_2\text{-CH}_3 + 2 \text{H}_2\text{N-CH}_2\text{-CH}_3 \longrightarrow$ $\text{CH}_3\text{-CH}_2\text{-C(=O)-NH-CH}_2\text{-CH}_3 + \text{CH}_3\text{-CH}_2\text{-C(=O)-O}^- + \text{H}_3\text{N}^+\text{-CH}_2\text{-CH}_3$ <p style="text-align: center;">N-ethyl propanamide</p>
Example 7	e.g. propylamine + butanoyl chloride $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-C(=O)-Cl} + 2 \text{H}_2\text{N-CH}_2\text{-CH}_2\text{-CH}_3 \longrightarrow$ $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-C(=O)-NH-CH}_2\text{-CH}_2\text{-CH}_3 + \text{H}_3\text{N}^+\text{-CH}_2\text{-CH}_2\text{-CH}_3 + \text{Cl}^-$ <p style="text-align: center;">N-propyl butanamide</p>

Example 8	e.g. propan-1-ol + ethanoic anhydride $\text{CH}_3\text{-}\overset{\text{O}}{\parallel}\text{C}\text{-O-}\overset{\text{O}}{\parallel}\text{C}\text{-CH}_3 + \text{HO-CH}_2\text{-CH}_2\text{-CH}_3 \longrightarrow \text{CH}_3\text{-}\overset{\text{O}}{\parallel}\text{C}\text{-O-CH}_2\text{-CH}_2\text{-CH}_3 + \text{CH}_3\text{-}\overset{\text{O}}{\parallel}\text{C}\text{-OH}$ <p style="text-align: center;">propyl ethanoate</p>
Example 9	e.g. water + butanoic anhydride $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-}\overset{\text{O}}{\parallel}\text{C}\text{-O-}\overset{\text{O}}{\parallel}\text{C}\text{-CH}_2\text{-CH}_2\text{-CH}_3 + \text{HO-H} \longrightarrow 2 \text{CH}_3\text{-CH}_2\text{-CH}_2\text{-}\overset{\text{O}}{\parallel}\text{C}\text{-OH}$ <p style="text-align: center;">butanoic acid</p>
Example 10	e.g. ammonia + propanoic anhydride $\text{CH}_3\text{-CH}_2\text{-}\overset{\text{O}}{\parallel}\text{C}\text{-O-}\overset{\text{O}}{\parallel}\text{C}\text{-CH}_2\text{-CH}_3 + 2 \text{H}_2\text{N-H} \longrightarrow$ $\text{CH}_3\text{-CH}_2\text{-}\overset{\text{O}}{\parallel}\text{C}\text{-NH}_2 + \text{CH}_3\text{-CH}_2\text{-}\overset{\text{O}}{\parallel}\text{C}\text{-O}^-$ <p style="text-align: center;">propanamide + NH₄⁺</p>

Mechanism for acyl chlorides	nucleophilic addition-elimination	
	alcohols / water	amines / ammonia
Example 1	e.g. ethanol + propanoyl chloride nucleophilic addition-elimination 	
Example 4	e.g. ammonia + ethanoyl chloride nucleophilic addition-elimination 	

Example 3	<p>e.g. water + propanoyl chloride</p> <p>nucleophilic addition-elimination</p> 
Example 5	<p>e.g. propan-2-ol + ethanoyl chloride</p> <p>nucleophilic addition-elimination</p> 
Example 7	<p>e.g. propylamine + butanoyl chloride</p> <p>nucleophilic addition-elimination</p>  <p>then</p> $\text{H}^+ + \text{H}_2\text{N}-\text{CH}_2-\text{CH}_2-\text{CH}_3 \longrightarrow \text{H}_3\text{N}^+-\text{CH}_2-\text{CH}_2-\text{CH}_3$