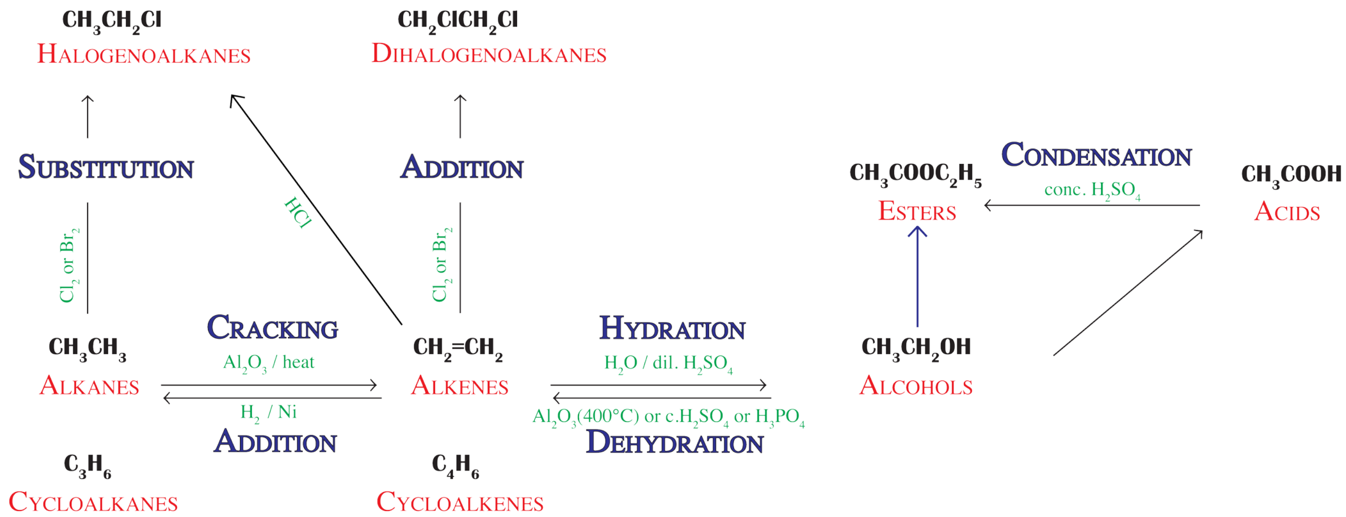
5.1 Systematic Organic in Context

This first lesson topic takes an overview of the Organic reactions met in this and previous courses and some of the contexts in which these reactions are met.

Previous Chemistry

This activity examines the systematic approach to the reactions met in previous courses.



Learn:

- ***Names*** - ***RULES for naming !***
- ***Structures*** of both reactant molecule and product molecule
- ***Title*** of the reaction
- ***Reagents*** used to carry out the reaction

Substitution - an *atom* or *group* will be ***removed*** from a normally ***saturated*** molecule to allow a ***different*** *atom* or *group* to take its place.

Normally, the product formed is also ***saturated*** and ***2 reactant*** molecules react to form ***2 product*** molecules

Equation using systematic names:

methane + ***chlorine*** ⟶ *chloromethane* + ***hydrogen chloride***

Equation using full structural formulae:

$$\mathrm{H{-}\overset{\displaystyle H}{\underset{\displaystyle H}{C}}{-}H} + Cl{-}Cl \longrightarrow H{-}\overset{\displaystyle H}{\underset{\displaystyle H}{C}}{-}Cl + H{-}Cl$$

Equation using shortened structural formulae:

$$CH_{4(g)} + Cl_{2(g)} \longrightarrow CH_3Cl_{(g)} + HCl_{(g)}$$

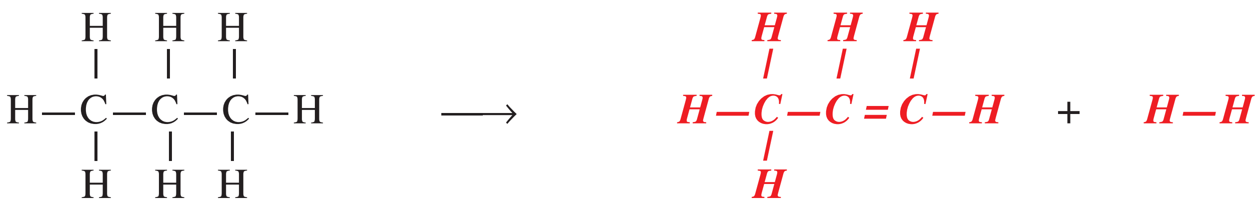
Cracking - a *larger **saturated*** molecule is *broken apart* to produce *smaller* molecules, at least one of which will be ***unsaturated***.

Normally, a ***catalyst*** will be used. Sometimes only a couple of *neighbouring **hydrogen*** atoms will be '*cracked*' off to produce a single ***unsaturated*** product. This reaction can also be called ***elimination***.

Equation using systematic names:

propane ⟶ *propene* + ***hydrogen***

Equation using full structural formulae:



Equation using shortened structural formulae:

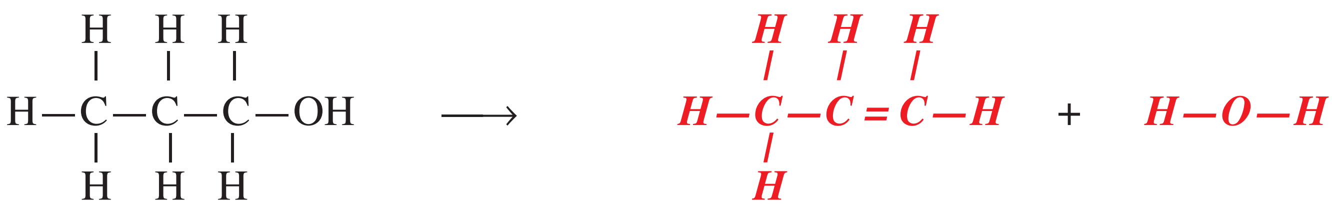
$C_3H_{8(g)} \longrightarrow C_3H_{6(g)} + H_{2(g)}$

Dehydration - a specific ***elimination*** reaction in which *neighbouring **hydrogen*** atom and ***hydroxyl*** group (—OH) will be '*cracked*' off to produce an ***unsaturated*** product. The eliminated atoms form a stable ***water*** molecule.

Equation using systematic names:

propan-1-ol ⟶ *propene* + ***water***

Equation using full structural formulae:



Equation using shortened structural formulae:

$C_3H_7OH_{(l)} \longrightarrow C_3H_{6(g)} + H_2O_{(l)}$

Elimination is the reverse reaction to ***addition***.

Addition - a small molecule reacts with an ***unsaturated*** molecule and adds *across* the ***double*** bond to make a ***saturated*** product.

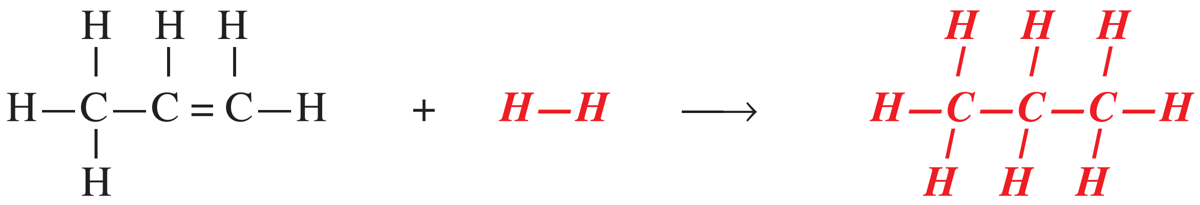
Many different molecules can be added and many of these reactions have their own names.

Hydrogenation - addition of hydrogen

Equation using systematic names:

propene + *hydrogen* $\xrightarrow{\text{Ni catalyst}}$ ***propane***

Equation using full structural formulae:



Equation using shortened structural formulae:

$C_3H_{6(g)} + H_{2(g)} \longrightarrow C_3H_{8(g)}$

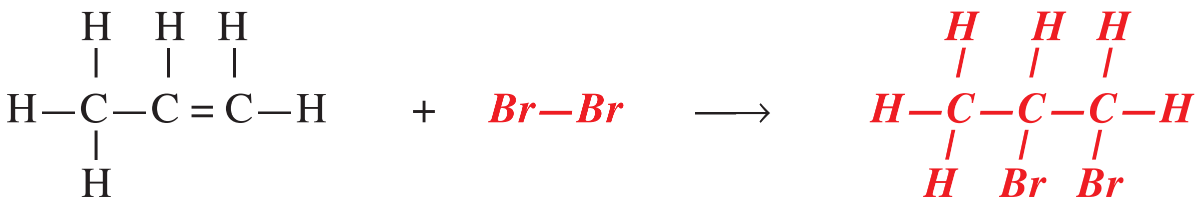
Hydrogenation is mainly used to convert *highly* ***unsaturated oils*** into *more* ***saturated fats***. E.g. *vegetable oil* can be thickened and solidified to make *margarine* by ***hydrogenation***.

Halogenogenation - addition of halogen

Equation using systematic names:

propene + ***bromine*** $\longrightarrow$ ***1,2-dibromopropane***

Equation using full structural formulae:



Equation using shortened structural formulae:

$C_3H_{6(g)} + Br_{2(g)} \longrightarrow C_3H_6Br_{2(l)}$

The ***addition*** reaction with a ***halogen***, usually ***bromine***, remains the accepted test for ***unsaturation*** - the presence of a C = C ***double*** or C ≡ C ***triple*** bond.

The ***halogen*** is decol***ourised***

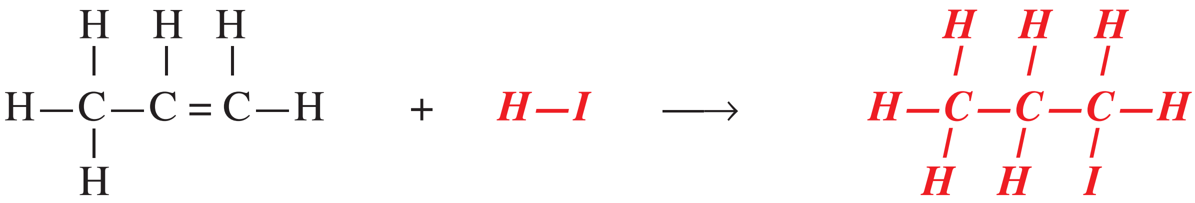
bromine,	***orange***	$\longrightarrow$	*colourless*
chlorine,	***green***	$\longrightarrow$	*colourless*
iodine,	***brown***	$\longrightarrow$	*colourless*

Hydrohalogenation - addition of *hydrogen halide*

Equation using systematic names:

propene + *hydrogen iodide* ⟶ ***1-iodopropane***

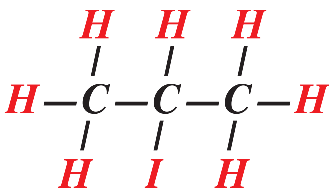
Equation using full structural formulae:



Equation using shortened structural formulae:

$C_3H_{6(g)}$ + $HI_{(g)}$ ⟶ $C_3H_7I_{(l)}$

Hydrohalogenation is an alternative when only ***one halogen*** atom is wanted on the product molecule. Depending on the position of the ***double bond***, however, more than one ***isomer*** is possible. In the above example, *2-iodopropane* is another possible product.

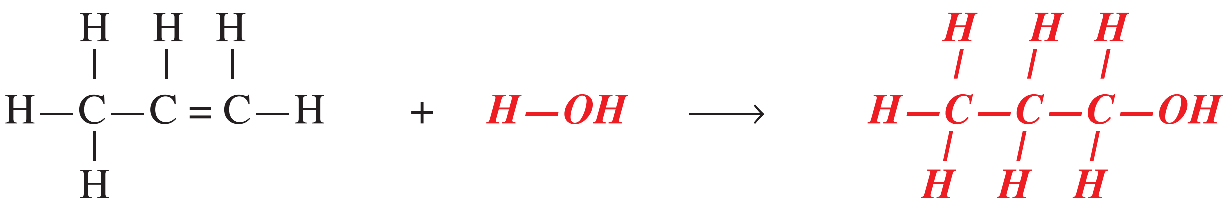


Hydration - addition of *water*

Equation using systematic names:

propene + ***water*** ⟶ ***propan-1-ol***

Equation using full structural formulae:

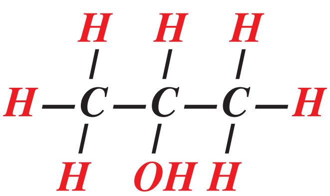


Equation using shortened structural formulae:

$C_3H_{6(g)}$ + $H_2O_{(l)}$ ⟶ $C_3H_7OH_{(l)}$

Hydration of an ***alkene*** is an important method for making *alcohols* but, like the previous example, more than one product can be formed.

In this case, the second ***isomer*** would be *propan-2-ol*.



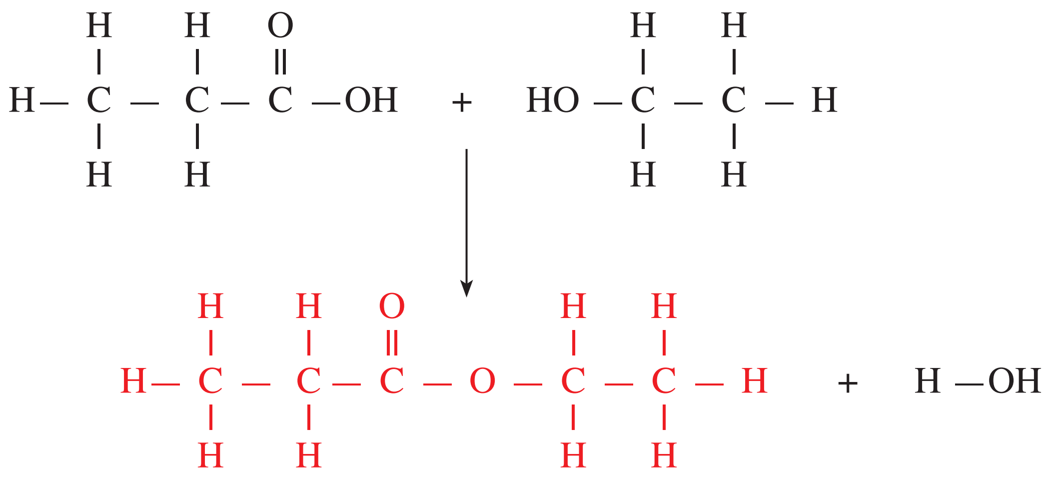
Propan-1-ol is a ***primary alcohol*** while *propan-2-ol* is a ***secondary alcohol***. The significance of these labels will become clearer in later lessons.

Condensation - two smaller molecule react to ***join together*** and form a larger molecule, ***eliminating*** a *small stable molecule*, usually ***water*** through one molecule losing ***an —H atom*** whilst the other molecule loses ***an —OH*** (*hydroxyl*) group.

Equation using systematic names:

propanoic acid + *ethanol* ⟶ ***ethyl propanoate***

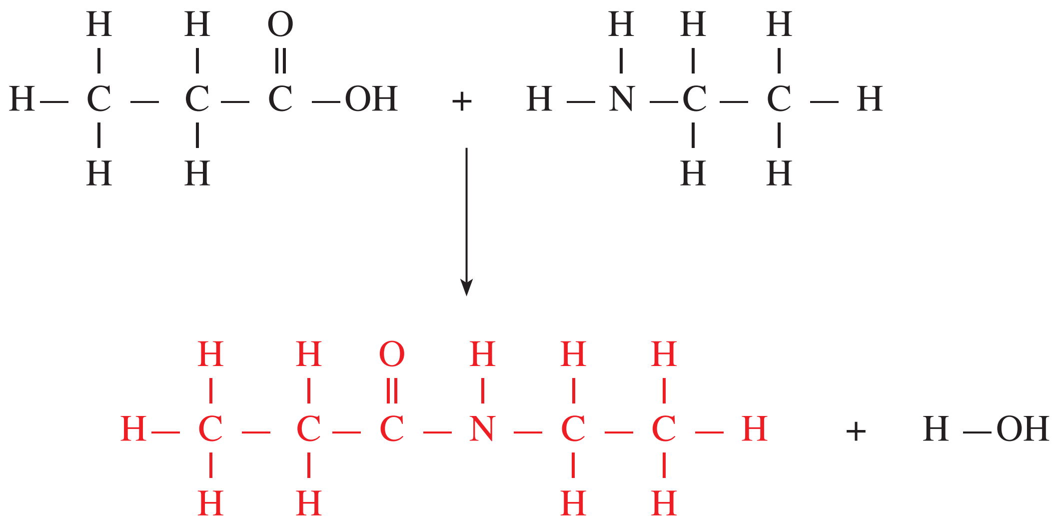
Equation using full structural formulae:



Equation using shortened structural formulae:

$$C_2H_5COOH_{(l)} + C_2H_5OH_{(l)} \longrightarrow C_2H_5COOC_2H_{5(l)}$$

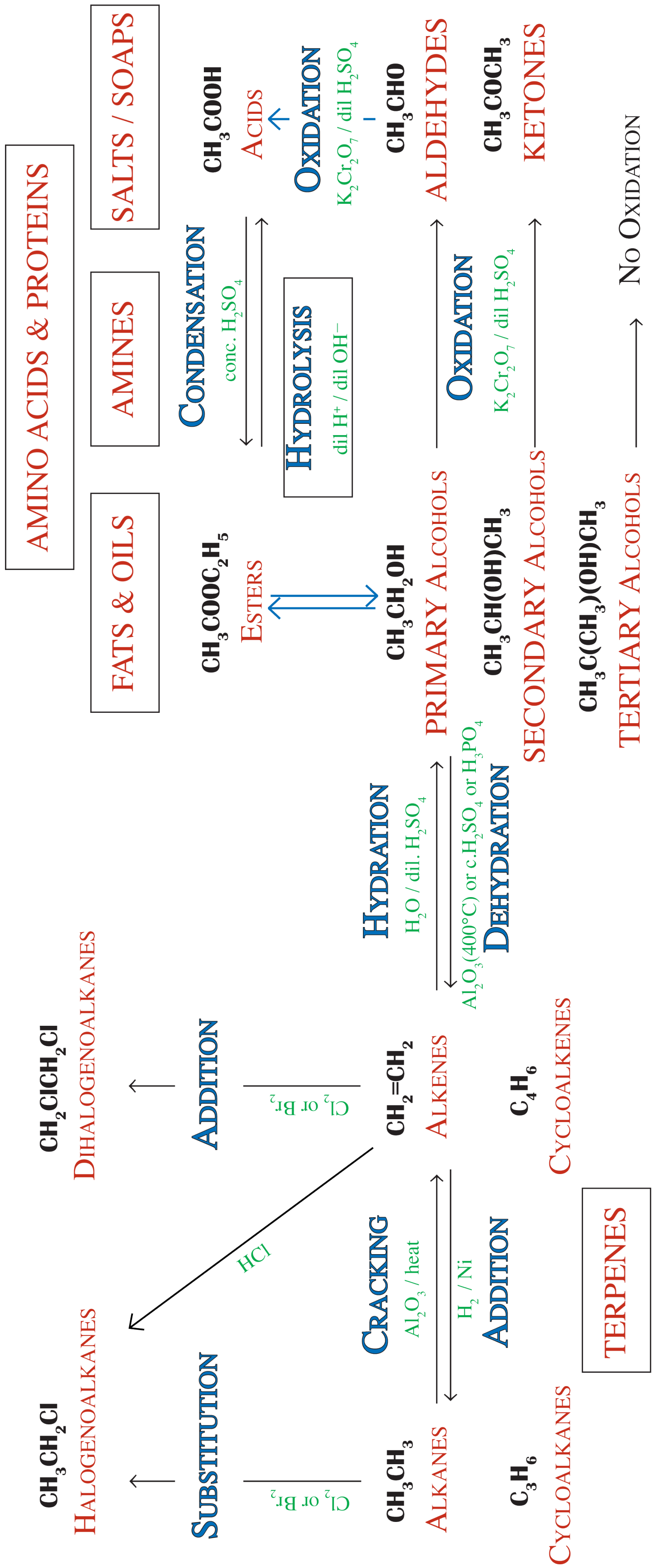
The other main ***condensation*** reaction that you will meet will involve an *acid* reacting with an *amine* to form an *amide*. This is very similar to the *ester* forming reaction above.



This is the reaction used to ***join*** many *amino acids* together to form *proteins*.

New Chemistry

This activity looks at some of the new reactions / families that you will meet in this Unit.



Much of the new Chemistry revolves round learning ***Oxidation*** in more detail.

As can be seen, there are 3 types of ***Alcohols*** to be learnt and they have different products - ***Aldehydes*** or ***Ketones***, or none - when oxidised.

Aldehydes are the intermediates formed when a ***Primary Alcohol*** is oxidised to eventually form an ***Acid***.

Condensation becomes even more important - along with the reverse reaction, ***Hydrolysis***.

Not just ***Esters*** are formed by a ***Condensation*** reaction - ***Proteins*** and ***Fats & Oils*** are also formed by ***Condensation*** and broken down by the ***Hydrolysis*** reaction.

Soaps are the ***Salts*** of *Fatty Acids* formed when ***Alkali Hydrolysis*** is done to a ***Fat*** or ***Oil***.

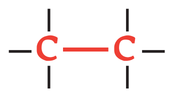
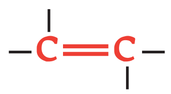
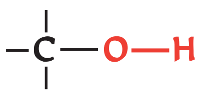
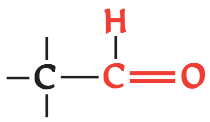
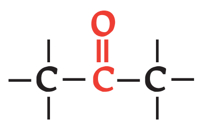
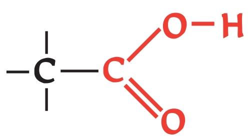
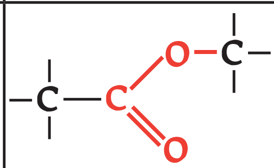
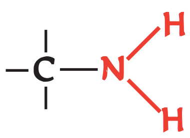
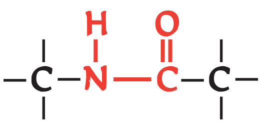
Terpenes are natural *hydrocarbons*, found mainly in plants, formed by joining together smaller molecules called ***isoprene***,

2-methylbuta-1,3-diene.

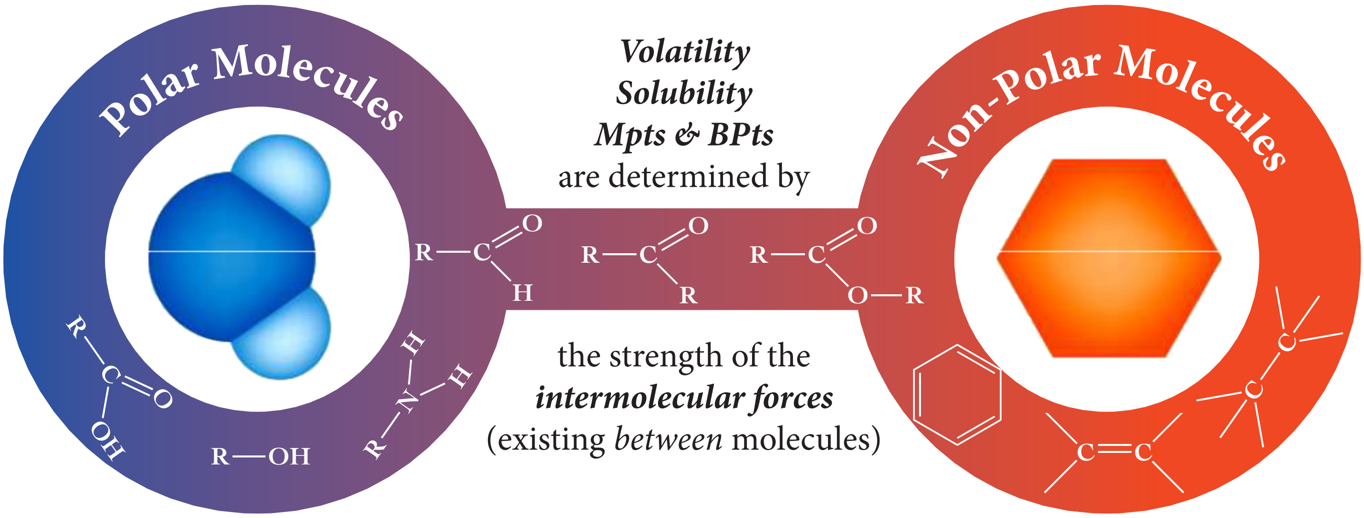
Terpenes belong to a group of chemicals usually referred to as *essential oils* which should not be mixed up with *edible oils* (***Fats & Oils***) and *mineral oils* derived from *Crude Oil* and made by the *Petrochemical* industry.

Functional Groups & Properties

This activity explains the functional groups found in these molecules and their possible effect on the chemical and physical properties of the molecule.

Family Name	*Functional Group*	*Name of Group*	*Chemical Reactions*	*Intermolecular Forces*	*Solubility in Water*
alkane		carbon to carbon single	substitution	london dispersion forces	insoluble
alkene		carbon to carbon double	addition	london dispersion forces	insoluble
alcohol		hydroxyl group	oxidation condensation	hydrogen bonding	very soluble
aldehyde		carbonyl group	oxidation	polar-polar	limited solubility
ketone		carbonyl group	none	polar-polar	limited solubility
acid		carboxyl group	condensation	hydrogen bonding	very soluble
ester		carboxylate group	hydrolysis	polar-polar	insoluble
amine		amino group	condensation	hydrogen bonding	very soluble
amide		amide link	hydrolysis	hydrogen bonding	only small amides soluble

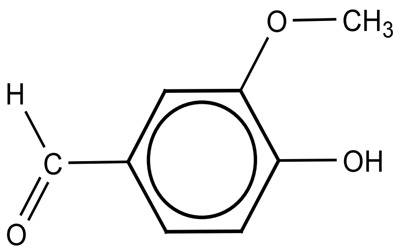
As well as determining their ***Chemical Reactions***, ***Functional Groups*** can also effect the ***Physical Properties***. Properties such as



hydrogen bonding → ***polar-polar attractions*** → ***london dispersion***

Acids Alcohols Amines	***Aldehydes Ketones Esters***	***Aromatics Alkenes Alkanes***

For example, the *vanilla bean* produces a compound called *vanillin*, which is used as a flavouring additive in sweet foods such as ice cream.



Vanillin

This molecule has effectively, 4 ***functional groups***:-

The ***benzene ring*** and the *ether* group (—O—CH_3) are dealt with in *Advanced Higher*.

The ***hydroxyl*** group (—OH) and the ***carbonyl*** group (—CH=O) will be expected to be learnt well this year.

Within the same molecule there can be ***non-polar groups*** such as the ***aromatic benzene*** ring, whilst the *ether* and ***aldehyde*** (***carbonyl***) are ***slightly polar***.

Probably the most influential group will be the ***very polar hydroxyl*** group which is capable of ***hydrogen bonding*** and may make this molecule ***water soluble***.

Context - Kitchen Chemistry

This activity demonstrates how much of the Organic Chemistry met in this Unit will be taught within the context of Kitchen Chemistry