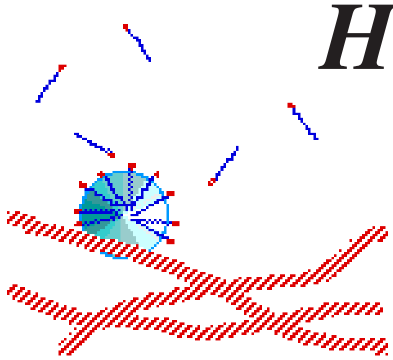
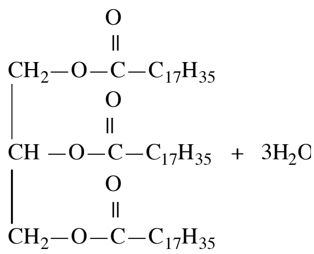
Higher Chemistry

Unit 2: The World of Carbon





Section 7:

Acids, Esters & Fats

Student:

Lesson		Activities		Done	Checked
7.1 *Alkanoic Acids*	1.	Ethanoic Acid			
	2.	Homologous Series			
	3.	Structures, Names & Formulae			
		Check Test	Score: /		
		Home Practice	Score: /		
7.2 *Flavour Molecules*	1.	Properties & Uses			
	2.	Ester Names			
	3.	Functional Group			
		Check Test	Score: /		
		Home Practice	Score: /		
7.3 *Ester Structures*	1.	Formation Reaction			
	2.	Making An Ester			
	3.	Formulae & Names			
		Check Test	Score: /		
		Home Practice	Score: /		
7.4 *Hydrolysing Esters*	1.	Hydrolysing Ethyl Ethanoate			
	2.	Structural Explanation			
	3.	Reversible Reactions			
		Check Test	Score: /		
		Home Practice	Score: /		
7.5 *Fats & Oils*	1.	Sources of Fats & Oils			
	2.	Melting Point Difference			
	3.	Health and Diet			
		Check Test	Score: /		
		Home Practice	Score: /		
7.6 *Structures of Fats & Oils*	1.	Ester Molecules			
	2.	Fatty Acids			
	3.	Hardening Oils			
		Check Test	Score: /		
		Home Practice	Score: /		
7.7 *From Fats To Soaps*	1.	Glycerides & Their Fatty Acid Content			
	2.	Soaps & Cleansing Action			
	3.	Percentage Yield			
		Check Test	Score: /		
		Home Practice	Score: /		
Consolidation Work		Consolidation A	Score: /		
		Consolidation B	Score: /		
		Consolidation C	Score: /		
		Consolidation D	Score: /		
End-of-Section Assessment		Score: %	Grade:		

7.1 Alkanoic Acids

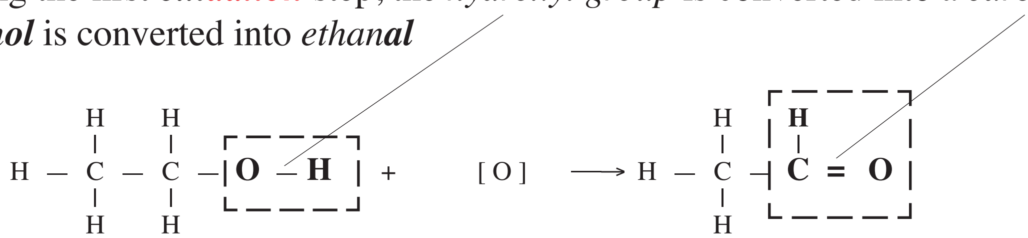
This first topic deals with the names, formulae and structures of the family of acids called the alkanoic acids

Ethanoic Acid

This activity considers the formation and structure of the alkanoic acid called ethanoic acid.

Ethanoic acid is normally manufactured from ***ethanol***. The ***oxygen*** required for the ***oxidation*** reaction can come from the ***air*** or from an ***oxidising agent*** such as *copper(II) oxide*.

During the first ***oxidation*** step, the *hydroxyl group* is converted into a *carbonyl group*: *ethan**ol*** is converted into *ethan**al***



C_2H_5OH CH_3CHO

During the second ***oxidation*** step, an ***oxygen*** atom is inserted to convert the *carbonyl group* into a *carboxyl group*: *ethan**al*** is converted into *ethan**oic** acid*.

carboxyl group is the *functional group* of an acid

CH_3CHO CH_3COOH

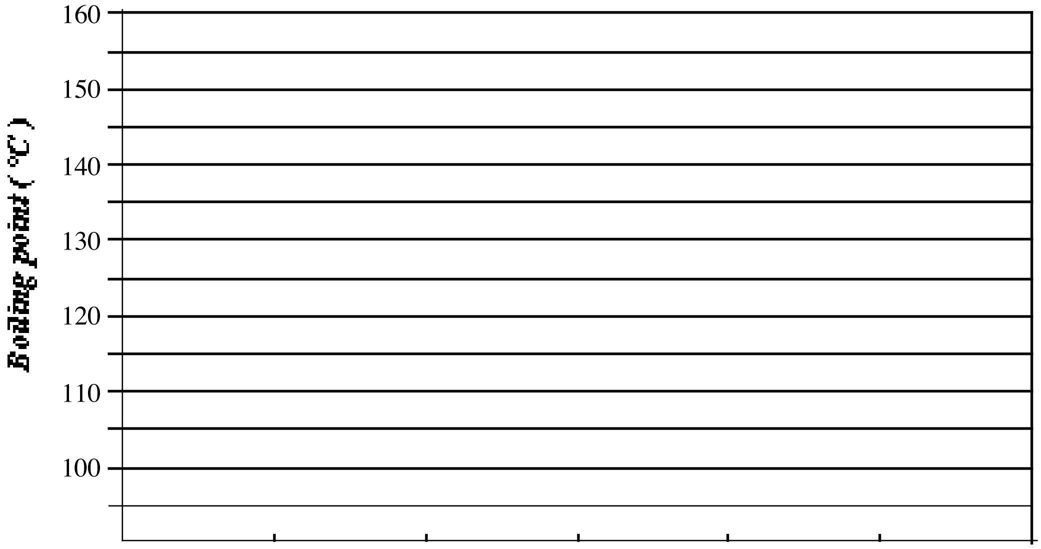
Ethanoic Acid

This activity considers the alkanoic acids as a homologous series.

a)

Chemical properties	***Ethanoic acid***	***Propanoic acid***
Smell & Appearance		
Universal indicator		
Magnesium		
Calcium carbonate		

b) Boiling point trend



c) General formula

The general formula for the alkanoic acids is:-

$$C_nH \; \boxed{COOH}$$

Notice that one of the ***carbon*** atoms is not included in the C_n '*chain*'. This is to enable the ***carboxyl functional group*** to be emphasised. ***WARNING !*** - this means that for each acid **n** is one less than you'd expect; *methanoic* **n = 0**, *ethanoic* **n = 1**, etc.

From all this it can be seen that the ***alkanoic** acids* have:

① ***similar chemical** properties*

② ***physical** properties* that show a *steady* ***trend***

and ③ a *common* ***general** formula*,

so they belong to a ***homologous** series*

Structures, Names & Formulae

This activity considers the structures, formulae and systematic names of some of the members of the alkanoic acid family.

Any molecule that contains the *carboxyl group*, —COOH, can be considered as a *carboxylic acid*. The molecule could have a ***chain*** structure, a ***ring*** structure or even be ***aromatic***, it could be ***saturated*** (C—C) or ***unsaturated*** (C=C or C≡ C).

*The **alkanoic acids** are compounds which contain the **carboxyl group** joined to a hydrocarbon **chain** in which all the carbon atoms are joined by **single** bonds.*

As usual, there are three ways to represent the formula of, for example, *pentanoic acid*

full structural formula

shortened structural formula

functional molecular formula

For naming purposes, the ***carbon*** of the ***carboxyl functional*** *group* is always taken as number 1, and the *'longest'* chain always starts with the ***functional*** *group*. For example:

7.2 Flavour Molecules

This second topic introduces the group of substances known as esters and looks at their properties, their uses, and how they are related to alcohols and carboxylic acids.

Properties & Uses

This activity is about the properties and uses of esters, in particular an ester called pentyl ethanoate (amyl acetate)

Property	***Result***
Appearance	
Smell	
Solubility	
pH	
Solvent action	

The 3 main uses of esters are as:

① ***flavourings*** - in foodstuffs

② ***solvents*** - e.g used in nail varnish

and ③ ***perfumes*** - are ***volatile***, so quickly relese vapour

Being ***volatile*** often makes them very ***flammable***.

Ester Names

This activity considers the namesof esters and how they relate to the alcohol and carboxylic acid from which the ester can be made

*An **ester** is a substance which is formed by the reaction of an alcohol with a carboxylic acid.*

Each ***ester*** can thought of as having a ***'parent' alcohol*** from which it is formed. The ***'parent alcohol'*** provides the *'christian name'* of the ***ester***. The ***alcohol*** name has the '*—ol*' ending replaced with an '*—yl*' ending.

'parent alcohol'	***ester 'christian name'***
methanol	*meth**yl***
ethanol	*ethyl*
propanol	*propyl*
butanol	*butyl*

Each ***ester*** also has a ***'parent' carboxylic acid*** from which it is formed. The ***'parent acid'*** provides the *'surname'* of the ***ester***. The ***acid*** name has the *'—oic'* ending replaced with an *'—oate'* ending.

'parent acid'	***ester 'surname'***
methanol	*methan**oate***
ethanol	*ethyl*
propanol	*propyl*
butanol	*butyl*

For example,

pentyl ethanoate

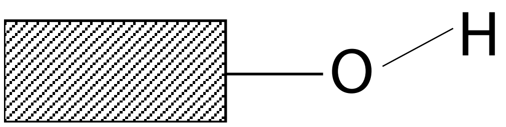
parent alcohol = ***pentanol***

parent acid = ***ethanoic acid***

parent alcohol	*parent carboxylic acid*	*ester name*	*ester flavour*
ethanol	*methanoic acid*	***ethyl methanoate***	*rum*
ethanol	*ethanoic acid*	***ethyl ethanoate***	*sweet wine*
pentanol	***ethanoic acid***	*pentyl ethanoate*	***pear drop***
ethanol	***butanoic acid***	*ethyl butanoate*	*pineapple*

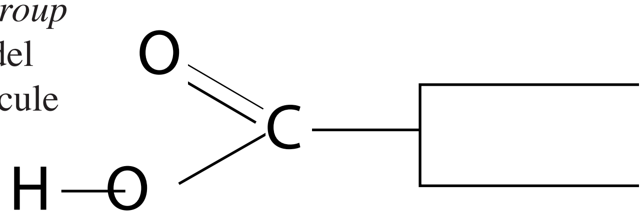
Functional Group

This activity considers the functional group in an ester molecule by looking at how it is formed from the parent alcohol and the parent carboxylic acid



Since all ***alcohols*** have the ***hydroxyl*** *functional group* they can be all be represented by the simple model shown. The block stands for the rest of the molecule which, in *alkanols*, would be a ***hydrocarbon chain***.

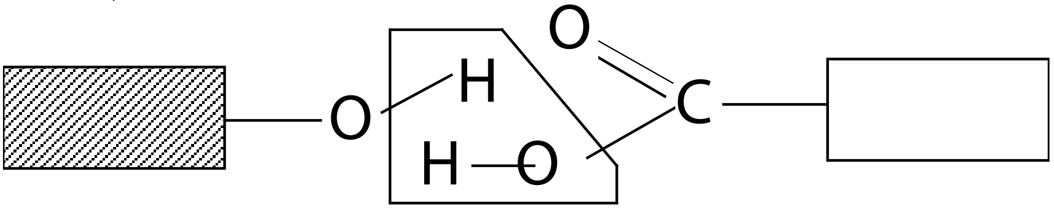
Since all ***acids*** have the ***carboxoxyl*** *functional group* they can be all be represented by the simple model shown. The block stands for the rest of the molecule which, in *alkanoic acids*, would be a ***hydrocarbon chain***.



To ***join together***, each molecule must ***lose*** some of the existing atoms attached to the ***carbon*** atom with the ***functional group***.

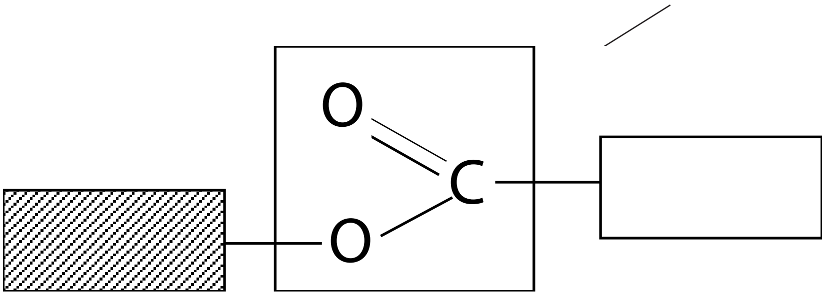
The ***hydroxyl group*** on the ***alcohol*** will have to lose its *hydrogen* atom, —**H**.

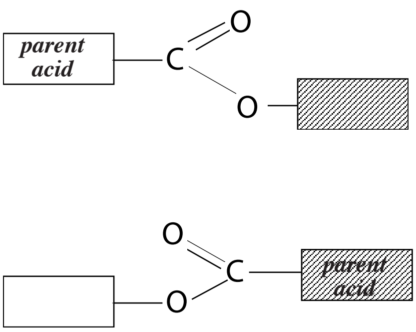
The ***carboxyl group*** on the ***acid*** loses its —**OH** group.



The whole reaction is helped by the fact that an —**OH** group and an —**H** atom will then be able to form a ***stable molecule***, *water* (H_2O).

The resulting ***ester*** molecule, formed by *joining* an ***alcohol*** to an ***acid***, owes its *properties* to the group of atoms that now *link* the two molecules together. This can be called the ***carboxylate group***, but is more often referred to as the ***'ester link'.***





It is important to be able to recognise the ***ester link*** no matter how it is drawn.

You will also be expected to be able to redraw the ***parent acid*** and ***parent alcohol*** molecules, so whichever ***carbon chain*** is directly attached to the ***carbonyl group***, C = O, must have been the ***parent acid*** and the other chain belonged to the ***alcohol***.

7.3 Ester Structures

This topic looks in more detail at the names and structures of esters, and how the can be made from their parent compounds

Formation Reaction

This activity considers the structural formulae of the molecules involved in the formation of an ester by the condensation reaction between methanol and ethanoic acid

> *A **condensation reaction** occurs when **two molecules** each lose one or more atoms in order to **join together**. Another small molecule is also formed by the 'lost' atoms.*

The other small molecule formed is often ***water***, hence the use of the name ***condensation***. However, other reactions that *'form water'* ,such as *neutralisation* or the *dehydration of alkanols* to form alkenes, are ***not*** condensations because they ***do not*** result in the ***joining together*** of two molecules.

Word equation:

methanol + ethanoic acid ⟶ **+ *water***

Equation using full structural formulae:

\+ ⟶

A ***general word equation*** can be written for the ***formation*** of an ***ester***.

alcohol **+** $\longrightarrow$ **+** ***water***

Making An Ester

PPA

The aim of this activity is to prepare an ester using the condensation reaction and to detect the formation of an ester by its smell

Aim:

Labelled diagram:

Procedure: *Two ways in which the rate of the reaction was increased*

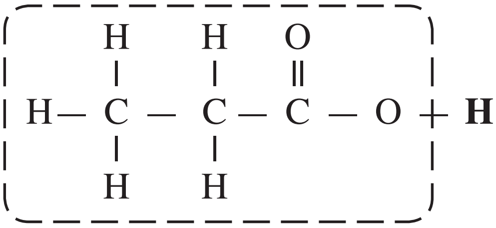
The purpose of the cold test-tube condenser

Two ways in which the production of an ester could be recognised

Equations:

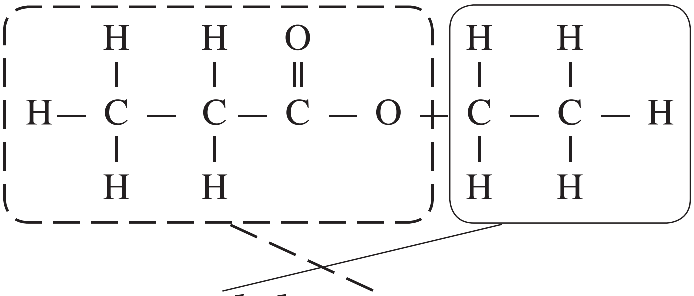
Formulae & Names

This activity deals with naming and drawing full and structural formulae for esters.



The 'best' way to think about an ***ester*** is to consider it as an ***acid molecule*** which has had its ***hydrogen atom*** replaced by a ***carbon chain*** (an *alkyl group*).

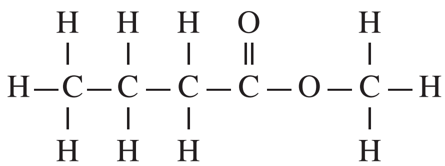
Learn to draw acids and you should find esters easy.

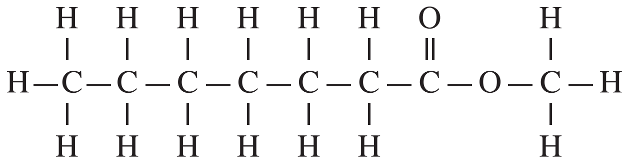


ethyl propanoate

As is often the case, we 'start' at the end of the name. *Identify the acid* (look for the ***carbonyl*** C = O) and give the ***ester*** its ***surname*** by changing the *—oic* ending to ***—oate***.

The *carbon chain* (derived from the parent ***alcohol***) is the ***'christian' name***, *—ol* changed to ***—yl***.

Ester Structures & Names	
Name:	
Full Structural Formula:	
Shortened Structural Formula:	
Name:	pentyl propanoate
Full Structural Formula:	
Shortened Structural Formula:	
Name:	
Full Structural Formula:	
Shortened Structural Formula:	$CH_3CH_2COOCH_2CH_2CH_2CH_2CH_3$

Ester Structures & Names	
Name:	
Full Structural Formula:	
Shortened Structural Formula:	

7.4 Hydrolysing Esters

This topic looks at hydrolysing esters, that is, breaking them down by their reaction with water.

Hydrolysing Ethyl Ethanoate

The aim of this experiment is to hydrolyse ethyl ethanoate and to show that an acid is produced in the reaction.

***Hydrolysis** is a reaction in which a molecule is **split up** by the chemical action of **water**.*

Labelled diagram:

Procedure:

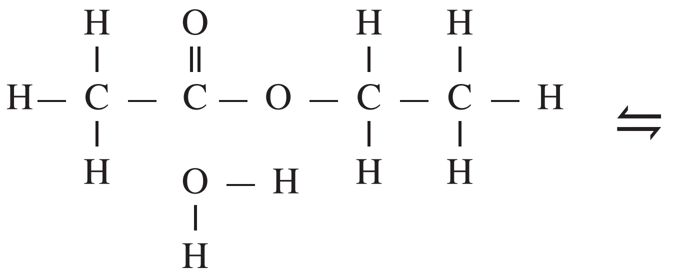
Result:

Equation:

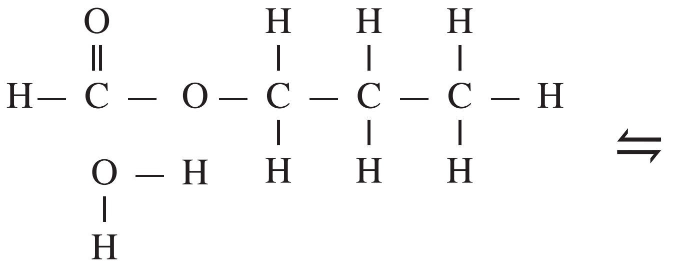
ester + water ⟶ alcohol + carboxylic acid

Structural Explanation

This activity looks at the hydrolysis of an ester in terms of the molecular structures of the substances involved.



ethyl ethanoate + water



ethyl ethanoate + water

As before, the ***carbonyl group*** (C = O) helps you to identify which part of the ***ester*** will go on to gain the ***hydroxyl group*** (—OH) and form the ***acid***. The other part of the ***ester*** will gain a ***hydrogen atom*** and form the ***alcohol***.

Reversible Reactions

This activity deals with the idea of a reversible reaction, i.e. a reaction that can go in both the forward direction and in the reverse direction

In the ***condensation reaction***, the ***alcohol*** and the ***acid*** molecules are *reactants* while the ***ester*** and ***water*** are *products*.

acid + alcohol → ester + water

During ***hydrolysis***, the *ester* and *water* were the ***reactants*** while the *acid* and *alcohol* molecules were ***products*** of the reaction

ester + water → acid + alcohol

In reality, since ***both reactions*** take place under the ***same conditions*** (*temperature etc*), ***both reactions*** were taking place ***both times***. This is an example of a ***reversible reaction*** and they are signified by the use of *double half arrow heads*.

acid + alcohol ester + water

7.5 Fats & Oils

This lesson topic introduces fats and oils, substances which are both examples of esters and are closely related to each other

Sources of Fats & Oils

This activity considers the three main sources of fats and oils - animal, vegetable and marine

Both ***fats*** and ***oils*** are esters - formed by ***joining carboxylic acids*** to ***alcohols***. Both ***fats*** and ***oils*** are ***greasy*** to touch, but ***fats are solid*** while ***oils are liquid*** at ***room temperature***. They are found in a variety of ***living*** things and form an important part of the ***human diet***. They are usually *classified* according to whether their *source* is ***animal*** , ***vegetable*** or ***marine***.

Types of Fats & Oils		
Animal	***Vegetable***	***Marine***

Melting Point Difference

This activity examines the reason for the difference in melting point between fats & oils

Since ***fats*** and ***oils*** are both ***esters*** we can expect *intermolecular forces* (such as ***Van der Waals forces***, ***polar-polar attractions*** or (unlikely) ***hydrogen bonding***) to be very ***similar***, unless there is a *big difference* in ***molecular size***.

In fact, all fats & oils have ***similar*** *sized molecules* so their *different* ***melting*** *points* must be due to ***structural*** *differences*.

Sample	*Melting Point*	*Drops of bromine solution decolourised*
lard	*'high'*	
margarine	*medium*	
corn oil	*low*	

The more drops of ***bromine*** that can be ***decolourised***, the more C = C ***double bonds*** the molecules must contain, the ***more unsaturated*** they must be.

Conclusions:

*fats are more **saturated** than oils and have **higher** melting points*

*oils are more **unsaturated** than fats and have **lower** melting points*

Health and Diet

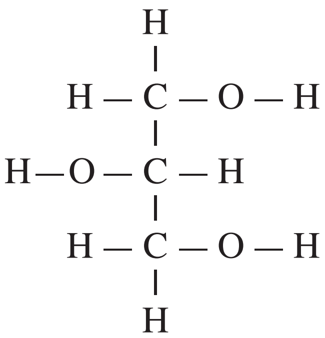
This activity looks at some of the benefits and some of the problems associated with fats and oils

7.6 Structures Of Fats & Oils

This lesson topic considers fats and oils in terms of their molecular structures.

Ester Molecules

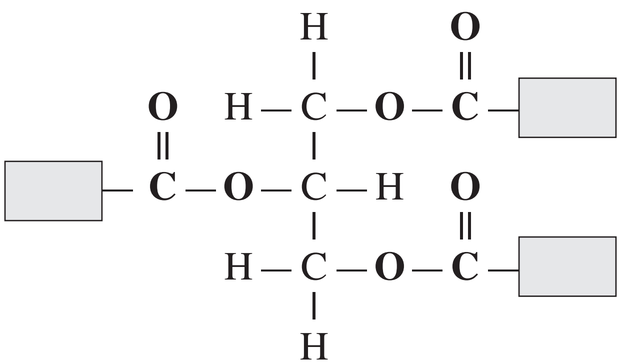
This activity looks at the structures of fats and oils as esters of the same alcohol.



Both ***fats*** and ***oils*** are esters - formed by ***joining carboxylic acids*** to ***alcohols***.

Surprisingly, all ***fat*** and ***oil*** molecules are formed from the ***same alcohol***. It has 3 carbon atoms each of which has a ***hydroxyl*** *group* (—OH) attached - it is the ***triol*** called ***propan-1,2,3-triol***

It is a clear, colourless but very ***viscous*** liquid (*very strong* ***hydrogen bonding*** *between* molecules) and is better known as ***glycerol***.



Having 3 ***hydroxyl groups*** allows 3 ***acid*** molecules to join onto ***glycerol*** - forming 3 ***ester links*** and fats & oils can be described as ***triple esters***.

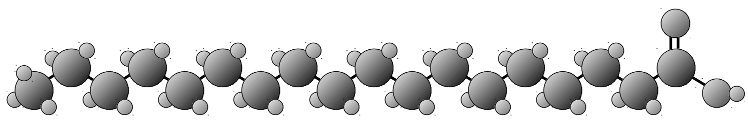
When *hydrolysed*, fats & oils always produce *moles* of acid molecules to *1 mole* of ***glycerol***.

Different fats & oils produce *different* ***acids*** when ***hydrolysed***. These acids are called ***fatty acids*** and *differences* in the ***structures*** of these ***acid*** *molecules* account for the *different* ***properties*** of fats and oils.

Fatty Acids

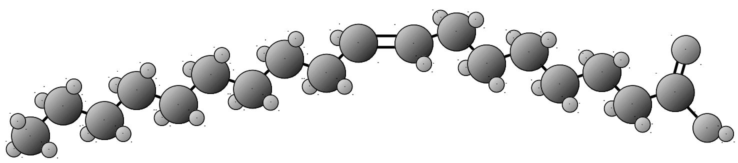
This activity looks at the structures of the carboxylic acids, i.e. the fatty acids, obtained by hydrolysing fats and oils

> ***Fatty acids*** *are saturated or unsaturated carboxylic acids, usually with long carbon chains, which are obtained from the hydrolysis of fats and oils*



stearic acid $C_{17}H_{35}COOH$

Stearic acid is a typical ***saturated fatty acid*** and is found in ***animal fat***. All along its *carbon chain* are found C—C ***single bonds***.



oleic acid $C_{17}H_{33}COOH$

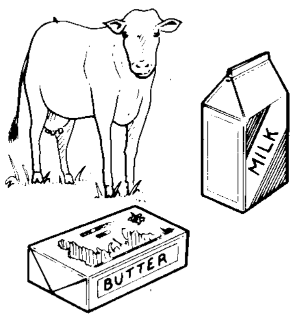
Oleic acid is a typical ***unsaturated fatty acid*** and is found in ***olive oil*** Somewhere along its *carbon chain* is found a C = C ***double bond***.

Fatty acids are quite ***long chained*** *carboxylic acids*, typically 18 carbons per molecule. ***Animal fats*** tend to have *mainly* ***saturated fatty acids*** while ***marine oils*** and ***vegetable oils*** usually have *some* ***unsaturated fatty acids***.

Hardening Oils

This activity deals with the way in which oils can be converted into solids by hardening

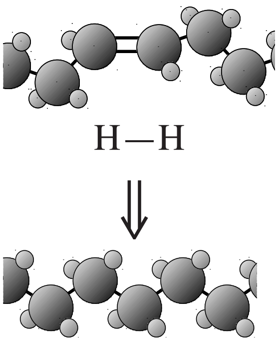
***Hardening** a fat or oil means **hydrogenating** it to increase its melting point.*



Foods that are high in ***animal fats***, such as *milk* and ***butter***, pose ***health risks*** because of the ***saturated fatty acids*** they contain.

Vegetable oils are considered ***healthier*** because of the *higher level* of ***unsaturated acids*** they contain. In many cases, e.g. *frying food*, oils can do the same job that fats such as ***lard*** and ***butter*** used to do.

Vegetable oils are ***runny liquids*** and unsuitable for ***spreading*** on bread. However, if some of the ***unsaturated acids*** are converted into ***saturated acids*** by reacting with ***hydrogen***, then the ***melting point*** of the oil will be ***increased*** and it will be ***more solid*** at *room temperature*.



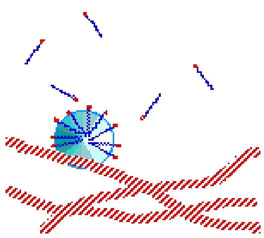
This is the same ***addition reaction*** met earlier in the course that can be used to *convert* an ***alkane*** into an ***alkene*** and requires the same *catalyst*, ***nickel*** (p4 of *Hydrocarbons & Fuels* notes).

As more and more of the ***unsaturated acids*** are *converted*, the ***margarine*** becomes *more and more* ***solid***. However, it must not be allowed to become ***too saturated*** or it will be *too* ***solid*** and will loose it ability to *'spread straight from the fridge'*.

Even more importantly, if allowed to become *too* ***saturated*** the ***health advantages*** that ***unsaturated margarine*** enjoys over ***saturated butter*** will be lost. For both these reasons only ***partial hydrogenation*** takes place

7.7 From Fats To Soaps

This final topic is about fats and oils as sources of fatty acids, how soaps can be made from fats and oils, and how chemists calculate the yield of a reaction

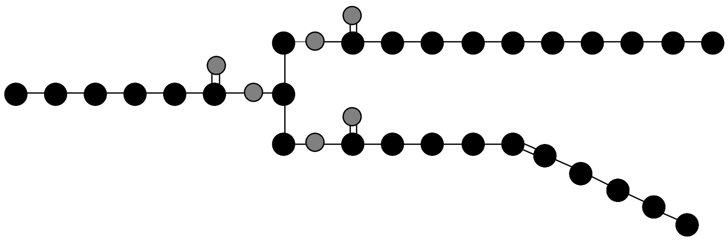


Soaps are molecules that help ***water*** cope with awkward molecules, such as ***fats*** & ***oils***, that would be difficult for ***water*** *alone* to wash away.

The names of some ***soaps***, e.g *Palmolive*, betray the fact that ***soaps*** themselves are made from ***fats*** and ***oils*** - *palm oil* and *olive oil*.

Glycerides & Their Fatty Acid Content

This activity considers glycerides and the effect of their parent fatty acids on their properties.

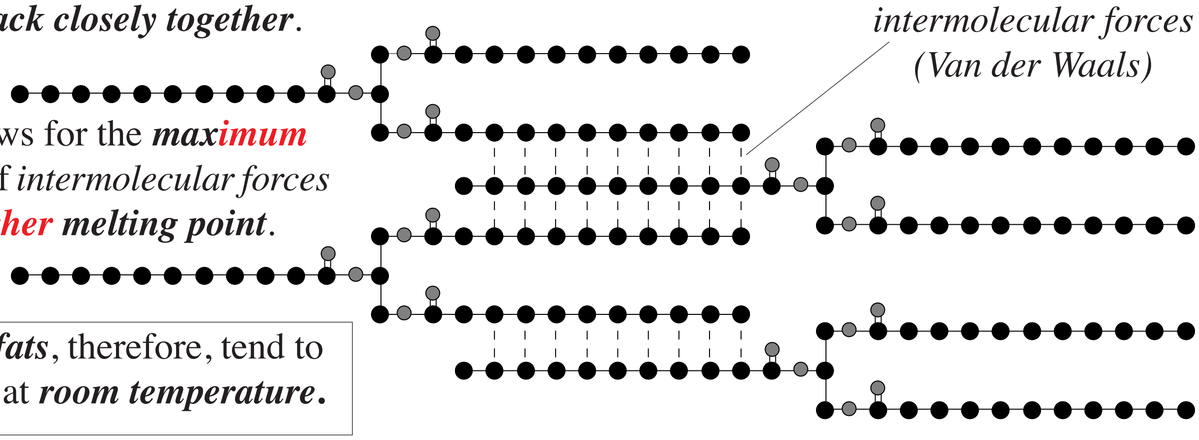


Fatty acids with odd numbers of carbon atoms are rare in nature - they are usually in the range C_2 to C_{24}.

Fats and ***oils*** are ***triple esters*** based on the ***alcohol glycerol***. They are often called *glycerides* or even *triglycerides*.

The 3 ***acids*** linked to the central ***glycerol*** molecule can be *identical* or *different*, ***saturated*** or ***unsaturated***. This explains the variety of fats & oils that exist and their *different* ***properties***.

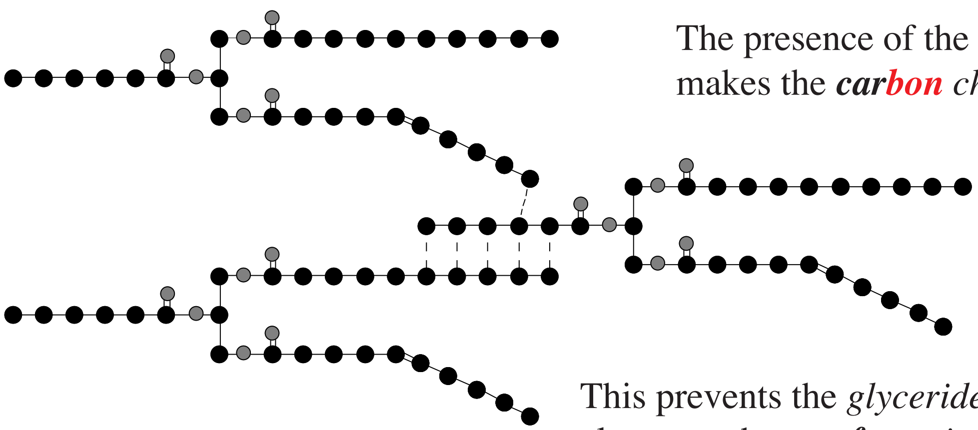
In ***animal fats*** *most* of the ***fatty acids*** are ***saturated***. This makes their ***carbon*** *chains* ***linear***. As a result, the *glyceride* molecules are able to ***pack closely together***.



This allows for the ***maximum*** amount of *intermolecular forces* and a ***higher melting point***.

Animal fats, therefore, tend to be ***solids*** at ***room temperature***.

Vegetable oils and ***marine oils*** contain *more* ***unsaturated fatty acids*** in their *glyceride* molecules.



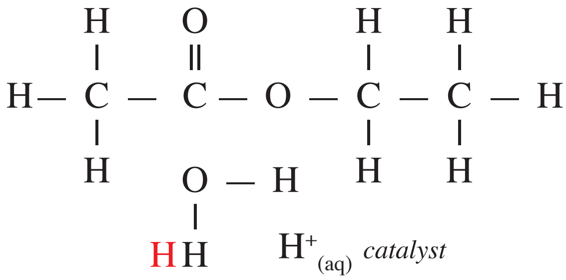
The presence of the C = C ***double bond*** makes the ***carbon*** *chain* ***non-linear*** or *'bent'*.

This prevents the *glyceride* molecules ***packing*** so close together, so ***fewer*** *intermolecular forces* can be established, and the ***melting point*** is ***lower***.

Vegetable oils and ***marine oils*** tend to be ***liquids*** at *room temperature*.

Soaps & Cleansing Action

This activity considers how soaps are made and how the structure of the soap molecule allows it to act as a cleansing agent

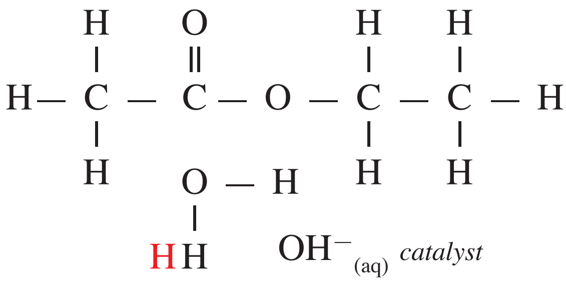


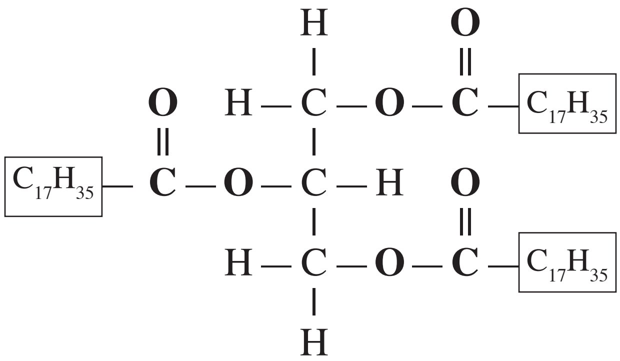
Earlier in this Section (p10) you learnt that ***water*** can be used to *break an **ester** apart* to reform the *parent **acid*** and *parent **alcohol***.

The reaction benefits from the presence of $H^+_{(aq)}$ ions provided by ***dilute sulphuric acid*** $H_2SO_{4(l)}$. This is often called ***acid hydrolysis***.

Alkaline hydrolysis, heating the ***ester*** with *sodium hydroxide solution*, will also *break apart an **ester*** to reform the *parent **alcohol***,

The ***acid***, however, goes on to ***react*** with the ***alkali*** so the *salt of the acid* is formed instead. In this case ***sodium** ethanoate* ($CH_3COO^- \ Na^+$) would be made.

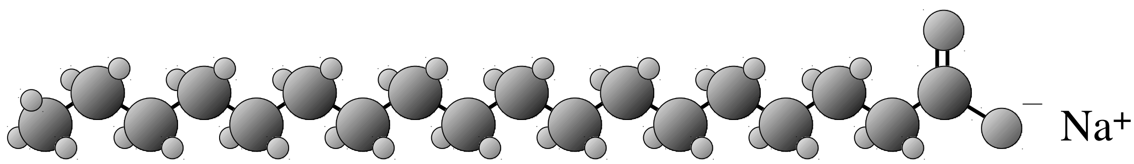




Alkaline hydrolysis of a ***glyceride*** molecule will yield ***glycerol*** and the ***sodium salts*** of its ***fatty acids***.

Glyceryl tristearate (found in most animal fats) will produce ***sodium stearate*** which was one of the earliest and most common ***soaps*** ever made.

Thousands of years ago, probably by accident, people discovered that boiling animal fat with alkali rocks produced a scum that, when cooled and solidified, could be use as a cleansing agent



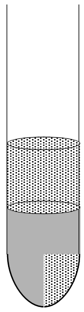
Structurally, what makes these molecules capable of acting as a ***cleansing agent*** is their '*ionic head*' - COO^- , and long '*covalent tail*' - $C_{17}H_{35}$.

Covalent Tail - most of the ***hydrocarbon tail*** is far enough away from the ***ionic** head* that it maintains the ***properties*** of a typical ***covalent*** molecule - namely, *weak Van der Waals forces* between neighbouring molecules.

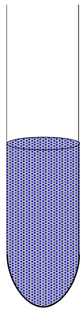
Ionic Head - the ***ionic** heads* can set up *strong attractions* - of similar strength to the ***hydrogen bonding*** between ***water*** molecules - allowing the *heads to dissolve in **water***.

Water, particularly ***hot water***, is a very effective ***cleansing agent***. The strength of the ***hydrogen bonding*** between its ***polar molecules*** is *similar* to the strength of ***attractions*** in many *ionic substances*, which allows ***water*** to *dissolve* them.

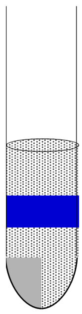
Many ***covalent*** *substances* are *polar enough* to also dissolve in water. The main problem is with ***covalent*** *substances* with *very weak* ***polar attractions*** or only *Van der Waals attractions*



When *mixed* with ***water***, these ***pure*** *covalent liquids* form ***separate*** *layers* as the *difference in intermolecular forces* is too ***great*** to allow *mixing*.

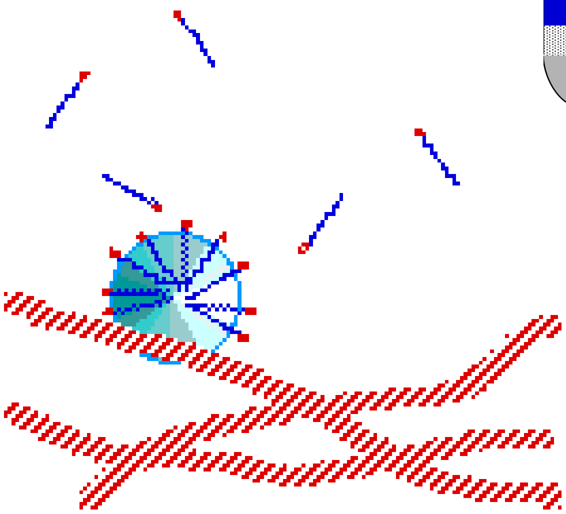


Shaking can form a *temporary* ***emulsion*** as small drops of 'oil' float in the water.



On standing, the two liquids will ***separate*** out again.

This makes it very difficult for water to remove *greasy* or oily *stains* from *clothes*, *plates* or even *people*.



Soap *molecules* cannot make grease ***'dissolve'*** in water, but they can prevent the tiny *droplets* of ***grease*** from *reforming* into large *blobs* which would stick to the surface of the ***clothes***, ***plates*** or *skin of a person*.

Instead they keep the tiny *globules* ***suspended*** in the water so that they can be ***rinsed*** away with the water.

Percentage Yield

This activity is about calculating the percentage yield of a product in a chemical reaction.

Many of the ***organic*** *reactions* met in the last few sections are ***reversible***. During ***organic*** *reactions* ***side-reactions*** producing various ***by-products*** are also possible. For both these reasons *actual mass* of ***products*** are often ***much lower*** than the expected *theoretical mass*.

Balanced equations provide us with ***molar relationships*** between *reactants* and *products* which allow the *calculation* of the ***theoretical product mass.***

Percentage Yields are calculated as follows:

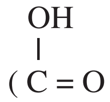
$$Yield = \frac{actual\ product\ mass}{theoretical\ product\ mass} \times 100\ \%$$

UNIT 2. THE WORLD of CARBON

Section 7: Acids, Esters & Fats

Carboxylic acids

1. *A carboxylic acid can be identified from the* ***carboxyl*** *functional group and the '**-oic**' name ending*

Carboxyl group = COOH 

methanoic acid, ethanoic acid, benzoic acid

2. ***Alkanoic*** *acids are a homologous series of carboxylic acids based on the corresponding parent alkanes*

methane, CH_4 → methanoic acid, HCOOH
ethane, C_2H_6 → ethanoic acid, CH_3COOH

3. *Systematic names, full and shortened structural formulae can be used for straight- and branched- chain alkanoic acids (C_1 - C_8)*

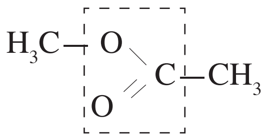
2,methylbutanoic acid

4. *Carboxylic acids are used in a variety of ways*

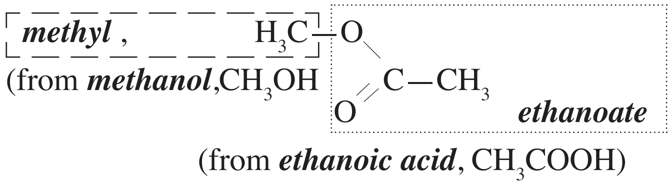
ethanoic acid is used in vinegar, *benzoic acid* is used as a food preservative, terylene is made from *terepthalic acid*, nylon is made from *hexanedioc acid*, and salts of carboxylic acids, mainly *stearic*, *oleic* and *palmatic*, are used in soap manufacture

Esters

5. *An ester can be identified from the functional group (**ester link**) and the '**-oate**' ending*

methyl ethanoate, 

6. *An ester can be named given the names of the the **parent alkanol** and **alkanoic acid**, or from shortened and full structural formula*



7. *Uses of esters include **flavourings**, **perfumes** and **solvents***

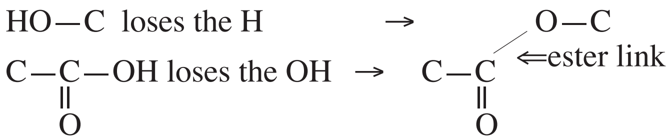
Making and Breaking Esters

8. *Esters are formed by the **condensation** reaction between a carboxylic and an acid*

condensation = ***joining together*** by the elimination of a small molecule (usually H_2O)

acid + alcohol ⇔ ester + H_2O

9. *The **ester link** is formed by the reaction of the hydroxyl group with a carboxylic group*



10. *Shortened and full structural formulae for esters can be drawn given the names of the parent alkanol and alkanoic acid or the name of the ester.*

Practice! Practice! Practice!

*11. The parent carboxylic acid and the parent alcohol can be obtained by **hydrolysis** of the ester*

hydrolysis = ***splitting apart*** by the insertion of a small molecule (usually H_2O)

ester + H_2O ⇋ acid + alcohol

12. *The formation and hydrolysis of an ester is a reversible reaction*

ester + H_2O ⇋ acid + alcohol
(unusually the E_a for both reactions are so similar that you usually end up with a 50:50 mixture)

13. *The products of the breakdown of an ester can be named, or shortened and full structural formulae can be drawn, given the name of the ester or the shortened or full structural formula of the ester*

Practice! Practice! Practice!

Fats & Oils

14. *Natural fats and oils can be classified according to their origin as animal, vegetable or marine*

Plants tend to produce (liquid) ***oils***, most ***animals*** (solid) ***fats*** but many ***marine animals*** (liquid) ***oils***

15. *Fats and oils are **esters***

All based on the alcohol glycerol

16. ***Glycerol** (Propane-1,2,3-triol) is a triyhydric alcohol*

contains **3 —OH** groups. Each glycerol molecule can have **3 acid** molecules joined to it to form a **triester** or **triglyceride**

17. *Fats and oils consist largely of **mixtures** of **triglycerides** in which the 3 acid molecules joined to the glycerol **may not be identical***

18. ***Fatty acids** are **saturated** or **unsaturated** straight-chain carboxylic acids containing **even** numbers of carbon atoms*

From C_4 to C_{24} Mainly C_{16} to C_{18}

*19. The **hydrolysis** of fats and oils, produces fatty acids and glycerol in the ratio **3:1***

(3 acid: 1 glycerol)

*20. **Soaps** are produced by the hydrolysis of fats and oils*

A soap is the **sodium salt** of a fatty acid (**ionic** 'head', **covalent** 'tail') produced when an alkali is used to hydrolyse a fat or oil

*21. The **lower melting points** of oils compared with those of fats is related to the higher **unsaturation** of oil molecules*

Oils have a C = C bond somewhere in the chain of the fatty acid(s).

22. *The low melting points of oils is a result of the effect that the **shapes** of the molecules have on **close packing**, hence the strength of **Van der Waal's** forces of attraction.*

The C = C bond prevents the chain rotating freely. The 'kinks' that result prevent the molecules packing closely together and weaken the effect of the Van der Waal's forces

23. *The conversion of oils into **hardened** fats involves the partial removal of unsaturation by the **addition** of hydrogen*

Nickel catalyst. Removal of some C = C bonds allows molecules closer together, so begins to change liquid → solid

24. *Fats and oils in the diet supply the body with **energy** and are a **more concentrated** source of energy than carbohydrates*

Percentage Yields

25. *Percentage yields can be calculated from mass of reactant(s) and product(s) using balanced equations*

This is the ***mole calculation*** that is particularly applicable to organic reactions where yields rarely match expectations