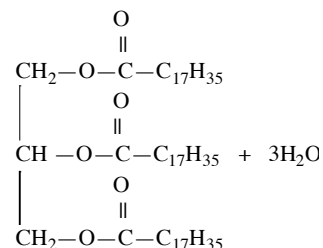


# Higher Chemistry

## Unit 2: The World of Carbon



## Section 7:

# Acids, Esters & Fats

Student:

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

## 7.1 Alkanoic Acids

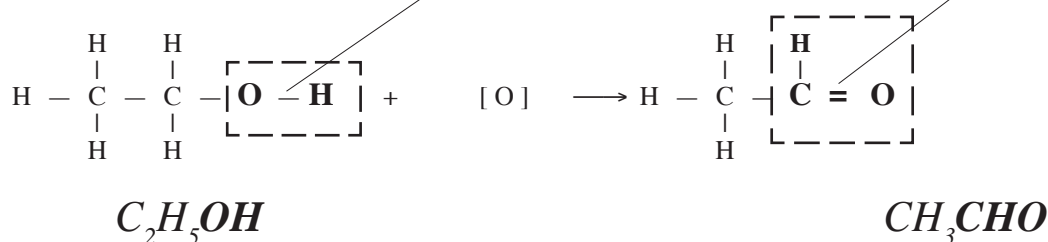
This first topic deals with the names, formulae and structures of the family of acids called the alkanoic acids

### Ethanoic Acid

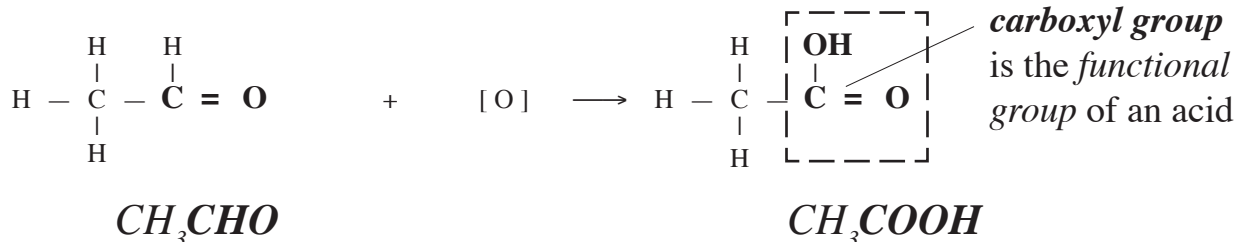
This activity considers the formation and structure of the alkanoic acid called ethanoic acid.

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

During the first *oxi* step, the *hydroxyl group* is converted into a *carbonyl group*: *ethanol* is converted into *ethanal*



During the second *oxi* step, an *oxy* atom is inserted to convert the *carbonyl group* into a *carboxyl group*: *ethanal* is converted into *ethanoic acid*.

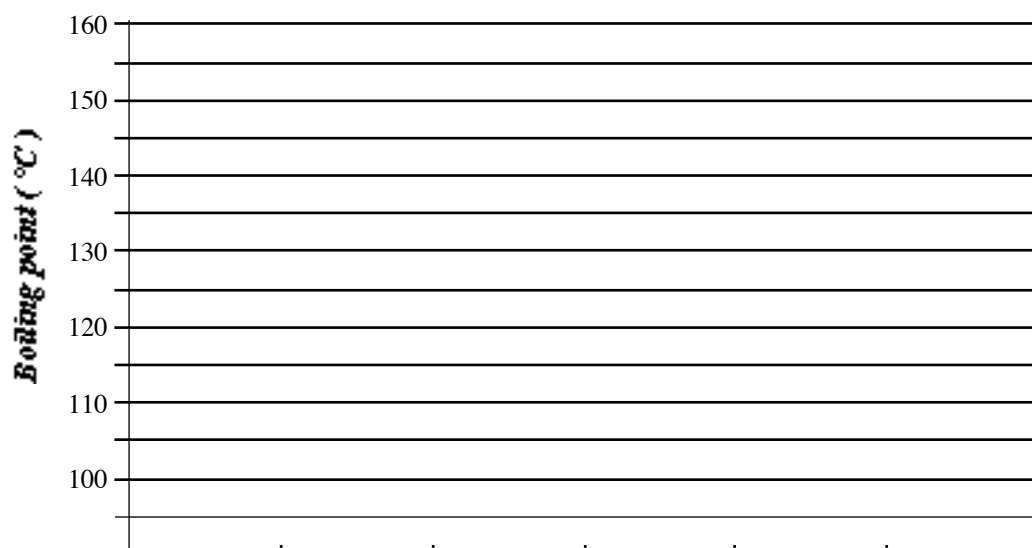


### Ethanoic Acid

This activity considers the alkanoic acids as a homologous series.

a)

<i>Chemical properties</i>	<i>Ethanoic acid</i>	<i>Propanoic acid</i>
<i>Smell &amp; Appearance</i>		
<i>Universal indicator</i>		
<i>Magnesium</i>		
<i>Calcium carbonate</i>		

b) **Boiling point trend**c) **General formula**

The general formula for the alkanoic acids is:-



Notice that one of the *car* atoms is not included in the  $\text{C}_n$  'chain'. This is to enable the *carboxyl func* 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 *alk* acids have:

- ① *sim chem* properties
- ② *phy* properties that show a *steady tre*

and ③ a *common gen* formula,

so they belong to a *homo* 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 *carb* group,  $-\text{COOH}$ , can be considered as a *carboxylic acid*. The molecule could have a *cha* structure, a *ri* structure or even be *aromatic*, it could be *urated* ( $\text{C}-\text{C}$ ) or *urated* ( $\text{C}=\text{C}$  or  $\text{C}\equiv\text{C}$ ).

*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 *car* of the *car func* group is always taken as number 1, and the 'longest' chain always starts with the *func* 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)*

<i>Property</i>	<i>Result</i>
<i>Appearance</i>	
<i>Smell</i>	
<i>Solubility</i>	
<i>pH</i>	
<i>Solvent action</i>	

The 3 main uses of esters are as:

- ① **flav** - in foodstuffs
- ② **solv** - e.g used in nail varnish
- and ③ **perf** - are **vol** , so quickly release vapour

Being **vol** often makes them very **flam** .

### **Ester Names**

*This activity considers the names of 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 **es** can be thought of as having a '**parent**' **alc** from which it is formed. The '**parent alc**' provides the '*christian name*' of the **est** . The **alc** name has the '-ol' ending replaced with an '-yl' ending.

<b>'parent alcohol'</b>	<b>ester '<i>christian name</i>'</b>
<i>meth</i>	<i>methyl</i>
<i>eth</i>	<i>ethyl</i>
<i>prop</i>	<i>propyl</i>
<i>but</i>	<i>butyl</i>

Each **es** also has a '**parent**' **carb** **acid** from which it is formed. The '**parent ac**' provides the '*surname*' of the **est** . The **a** name has the '-oic' ending replaced with an '-oate' ending.

<b>'parent acid'</b>	<b>ester '<i>surname</i>'</b>
<i>meth</i>	<i>methanoate</i>
<i>eth</i>	<i>ethanoate</i>
<i>prop</i>	<i>propanoate</i>
<i>but</i>	<i>butanoate</i>

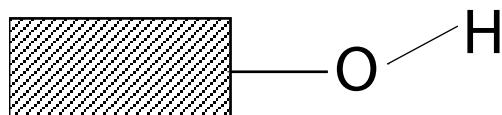
For example,



<i>parent alcohol</i>	<i>parent carboxylic acid</i>	<i>ester name</i>	<i>ester flavour</i>
<i>ethanol</i>	<i>methanoic acid</i>		<i>rum</i>
<i>ethanol</i>	<i>ethanoic acid</i>		<i>sweet wine</i>
		<i>pentyl ethanoate</i>	
		<i>ethyl butanoate</i>	<i>pineapple</i>

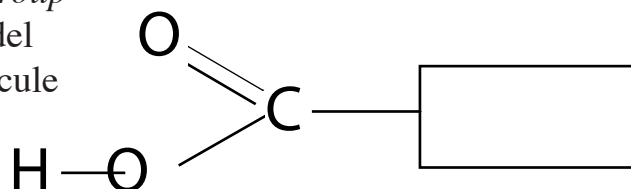
### Functional Group

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 *alc* have the *hydr* 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*.

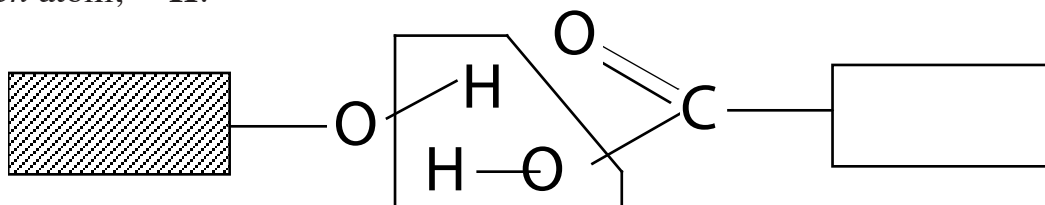
Since all *acids* have the *carbox* functional group they can be all be represented by the simple model shown. The block stands for the rest of the molecule which, in *alkanoic acids*, would be a *hydrocarbon chain*.



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

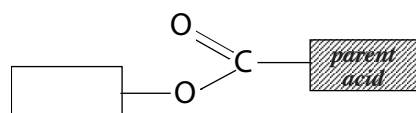
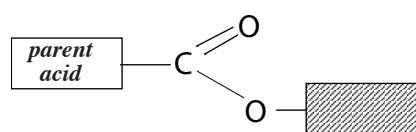
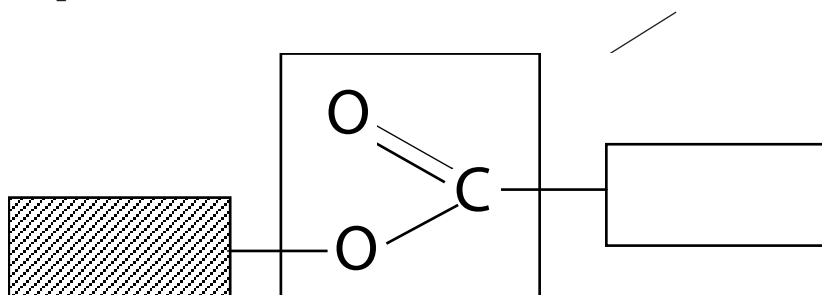
The *hydr* group on the *alc* will have to lose its *hydrogen* atom, —**H**.

The *carb* group on the *ac* 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 *small* molecule, *water* ( $\text{H}_2\text{O}$ ).

The resulting *es* molecule, formed by *joining* an *alc* to an *ac*, 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 *es link* no matter how it is drawn.

You will also be expected to be able to redraw the *parent ac* and *parent alcohol* molecules, so whichever *car chain* is directly attached to the *carb group*, C = O, must have been the *parent ac* and the other chain belonged to the *alc*

## 7.3 Ester Structures

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

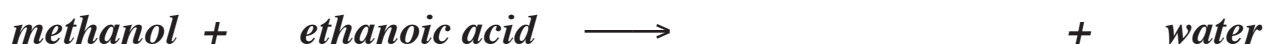
### Formation Reaction

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:



Equation using full structural formulae:



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



### 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*

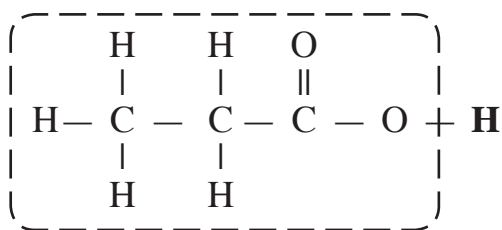
*Two ways in which the production of an ester could be recognised*

**Equations:**



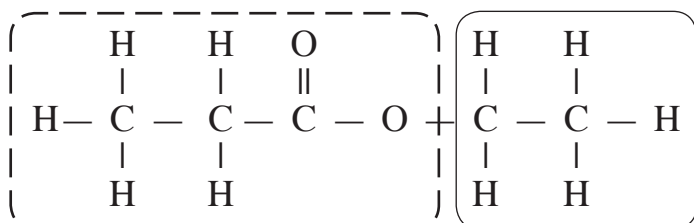
**Formulae & Names**

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 *hydroxyl atom* replaced by a *carbon chain* (an *alkyl group*).

Learn to draw acids and you should find esters easy.



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 *suffix* by changing the *-oic* ending to *-oate*.

*ethyl propanoate*

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

### Ester Structures & Names

Name:	
Full Structural Formula:	$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & \text{O} & & \text{H} \\ &   &   &   &    & &   \\ \text{H} - & \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{O} & - \text{C} - \text{H} \\ &   &   &   & & &   \\ & \text{H} & \text{H} & \text{H} & & & \text{H} \end{array}$
Shortened Structural Formula:	
Name:	pentyl propanoate
Full Structural Formula:	
Shortened Structural Formula:	
Name:	
Full Structural Formula:	
Shortened Structural Formula:	$\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

<b><i>Ester Structures &amp; Names</i></b>	
<i>Name:</i>	
<i>Full Structural Formula:</i>	$  \begin{array}{ccccccccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{O} & & \text{H} & \\  &   &   &   &   &   &   &    & &   & \\  \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{O} & -\text{C} & -\text{H} \\  &   &   &   &   &   &   & & &   & \\  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & & & \text{H} & \\  \end{array}  $
<i>Shortened Structural Formula:</i>	

## 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:**

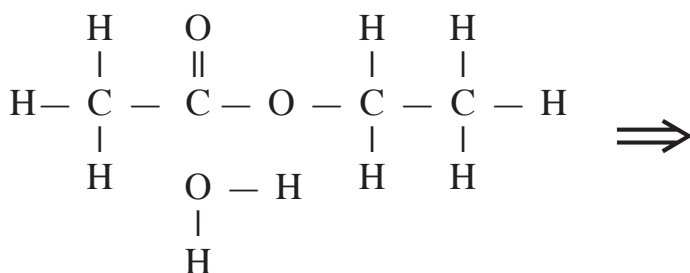
**Result:**

**Equation:**

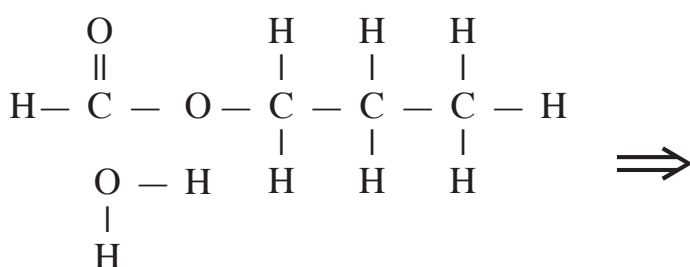


### Structural Explanation

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



*ethyl ethanoate + water*



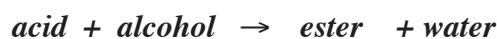
*+ water*

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 **acid** and the **alcohol** molecules are **reactants** while the **ester** and **water** are **products**.



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



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**.



## 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 *fa* and *oi* are esters - formed by *joi carb acids* to *alco*. Both *fa* and *oi* are *gre* to touch, but *fats are sol* while *oils are liq* at *ro temperature*. They are found in a variety of *liv* things and form an important part of the *hu diet*. They are usually *classified* according to whether their *source* is *ani*, *veg* or *mar*.

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 *fa* and *oi* are both *est* we can expect *intermolecular forces* (such as *Van der Wa forces, po -pol attr* or (unlikely) *hydr bonding*) to be very *sim*, unless there is a *big difference* in *mol size*.

In fact, all fats & oils have *sim sized molecules* so their *different mel points* must be due to *struc differences*.

Sample	Melting Point	Drops of bromine solution decolourised
<i>lard</i>	<i>'high'</i>	
<i>margarine</i>	<i>medium</i>	
<i>corn oil</i>	<i>low</i>	

The more drops of *bro* that can be *decol*, the more C = C *dou bonds* the molecules must contain, the *more urated* they must be.

**Conclusions:**

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

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

**Health and Diet**

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

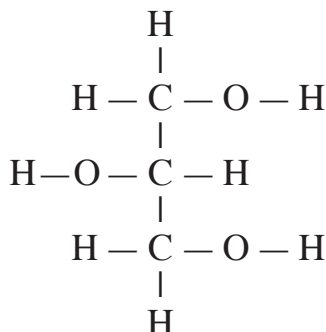


# 7.6 Structures Of Fats & Oils

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

## Ester Molecules

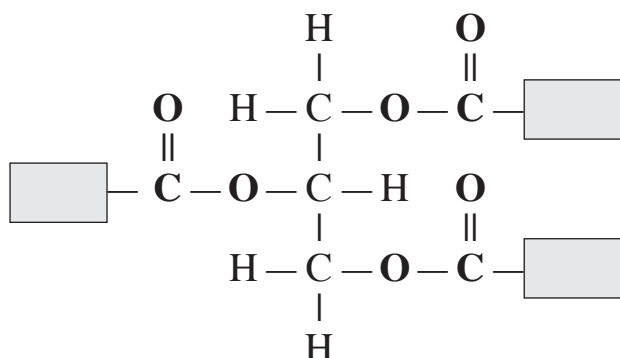
This activity looks at the structures of fats and oils as esters of the same alcohol.



Both **fat** and **oil** are esters - formed by **joining carb acids** to **alcohol**.

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 **alcohol** molecules to join onto **glycerol** - forming 3 **ester links** and fats & oils can be described as **tri esters**.

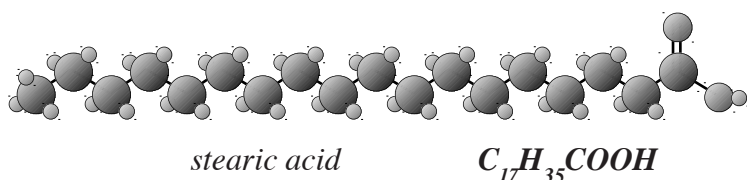
When **hydrolysed**, fats & oils always produce **3 moles** of acid molecules to **1 mole** of **glycerol**.

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

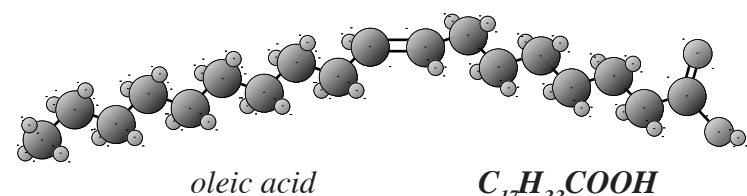
## Fatty Acids

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



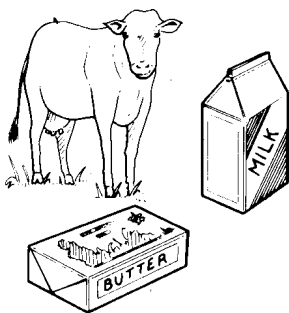
Oleic acid is a typical **unsaturated fatty acid** and is found in **olive oil**. Somewhere along its **carbon chain** is found a **C = C double bond**.

**Fa** *acids* are quite **lo** *chained carboxylic acids*, typically **carbons** per molecule.  
**Ani** *fats* tend to have **mainly** *aturated fatty acids* while **mar** *oils* and  
**vege** *oils* usually have **some** *aturated fatty acids*.

### Hardening Oils

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

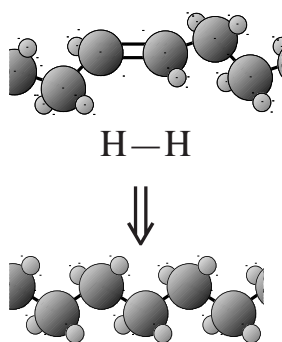
*Hardening a fat or oil means **hydrogenating** it to increase its melting point.*



Foods that are high in **ani** *fats*, such as **milk** and **bu**, pose **he** *risks* because of the **aturated fatty acids** they contain.

**Veg** *oils* are considered **heal** because of the **higher** level of **aturated acids** they contain. In many cases, e.g. **fry-**  
**ing food**, oils can do the same job that fats such as **lard** and **bu-**  
**used** to do.

**Veg** *oils* are **ru** *liquids* and unsuitable for **spre** on bread. However, if some of the **aturated acids** are converted into **aturated acids** by reacting with **hyd**, then the **mel** *point* of the oil will be **eased** and it will be **more sol** at **room temperature**.



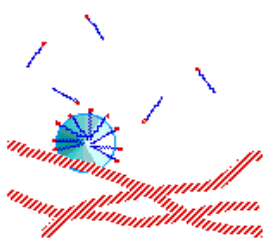
This is the same **add** *reaction* met earlier in the course that can be used to **convert** an **alk** into an **alk** and requires the same **catalyst**, **ni** (p4 of *Hydrocarbons & Fuels* notes).

As more and more of the **aturated acids** are **converted**, the **marg** becomes **more and more sol**. However, it must not be allowed to become **too** *aturated* or it will be **too sol** and will lose its ability to 'spread straight from the fridge'.

Even more importantly, if allowed to become **too** *aturated* the **he** *advantages* that **aturated marg** enjoys over **aturated but** will be lost. For both these reasons only **partial** *ation* 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*

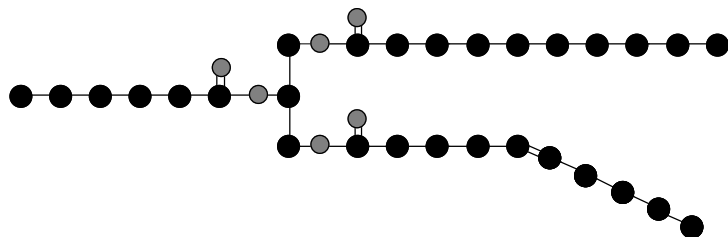


**So** are molecules that help **wa** cope with awkward molecules, such as **fats & oils**, that would be difficult for **wa** alone to wash away.

The names of some **so**, e.g. **Palmolive**, betray the fact that **so** themselves are made from **fa** and **oi** - **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<sub>2</sub> to C<sub>24</sub>.

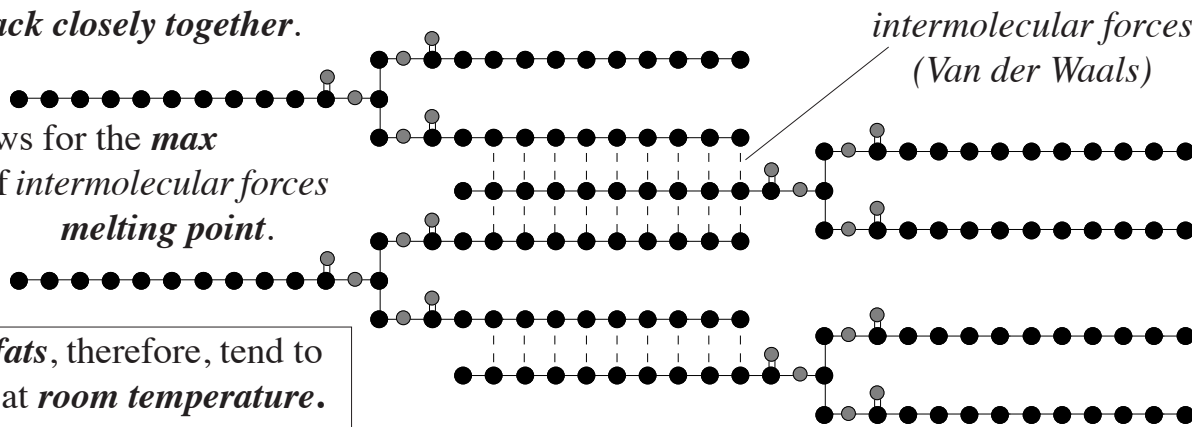
*Fa* and *oi* are *tri esters* based on the *alc glyc*. They are often called *glycerides* or even *triglycerides*.

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

In *ani fats* most of the *fatty ac* are *urated*. This makes their *car chains* *linear*. As a result, the *glyceride* molecules are able to *pack closely together*.

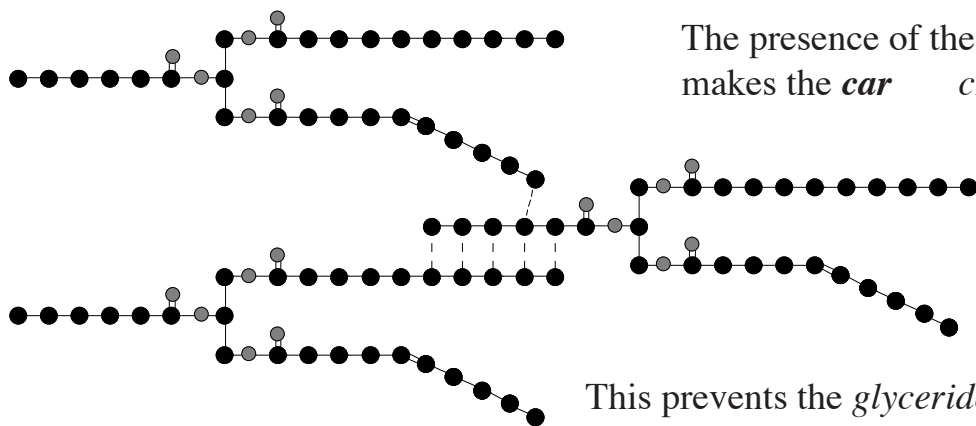
This allows for the *max* amount of *intermolecular forces* and a *hi melting point*.

*Ani fats*, therefore, tend to be *so* at *room temperature*.



*Veg oils* and *mar oils* contain *more urated fatty acids* in their *glyceride* molecules.

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



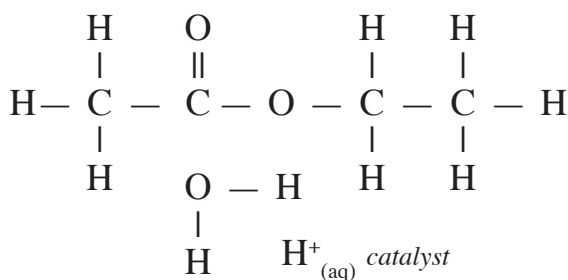
This prevents the *glyceride* molecules *pa* so close together, so *fe intermolecular forces* can be established, and the *mel point* is *lo*.

*Veg oils* and *mar oils* tend to be *liq* at *room temperature*.



**Soaps & Cleansing Action**

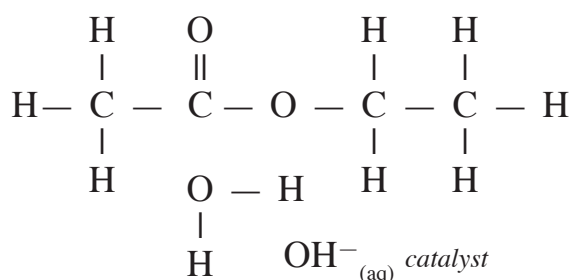
This activity considers how soaps are made and how the structure of the soap molecule allows it to act as a cleansing agent



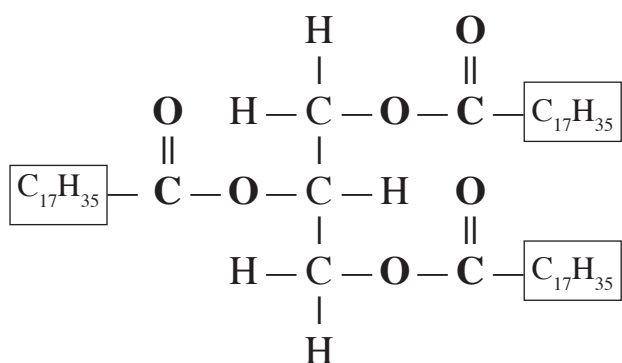
Earlier in this Section (p10) you learnt that *wa* can be used to *break an es* apart to reform the *parent ac* and *parent alc*.

The reaction benefits from the presence of  $\text{H}^{+}_{(aq)}$  ions provided by *dilute sul acid*  $\text{H}_2\text{SO}_{4(l)}$ . This is often called *ac hydr*.

*Alk hydr*, heating the *es* with *sodium hydroxide solution*, will also *break apart an es* to reform the *parent alc*,



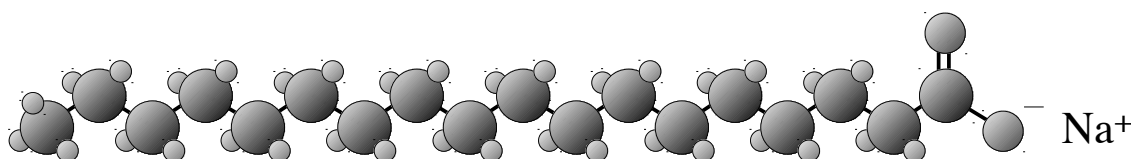
The *ac*, however, goes on to *re* with the *alk* so the *salt of the acid* is formed instead. In this case *sod ethanoate* ( $\text{CH}_3\text{COO}^{-} \text{Na}^{+}$ ) would be made.



*Alk hydrolysis* of a *gly* molecule will yield *gly* and the *sod salts* of its *fatty ac*.

*Glyceryl tristearate* (found in most animal fats) will produce *sodium stearate* which was one of the earliest and most common *so* 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 used as a cleansing agent



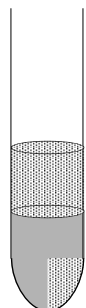
Structurally, what makes these molecules capable of acting as a *clea agent* is their 'ionic head' -  $\text{COO}^{-}$ , and long 'covalent tail' -  $\text{C}_{17}\text{H}_{35}$ .

*Covalent Tail* - most of the *hy car tail* is far enough away from the *io head* that it maintains the *prop* of a typical *cov* molecule - namely, *weak Van der Waals forces* between neighbouring molecules.

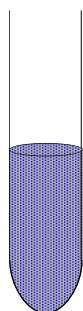
*Ionic Head* - the *io heads* can set up *strong attractions* - of similar strength to the *hyd bonding* between *wa* molecules - allowing the *heads to dissolve in wa*.

Water, particularly hot water, is a very effective cleaning 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.

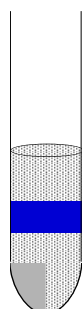
Many covalent substances are polar enough to also dissolve in water. The main problem is with covalent substances with very weak polar attractions or only Van der Waals attractions



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

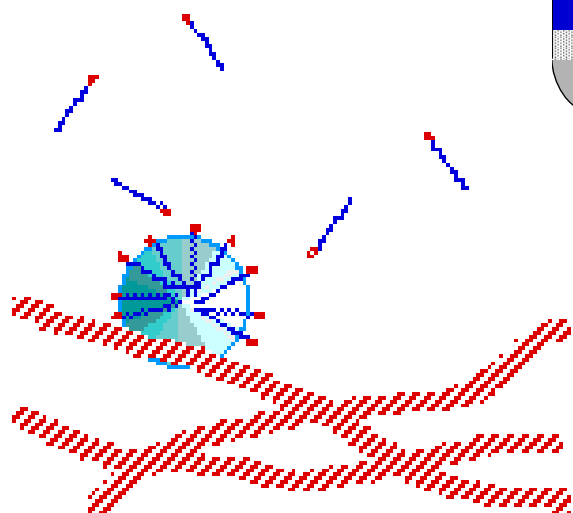


Shaking can form a temporary emulsion as small drops of 'oil' float in the water.



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.



So 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 cloth, plate 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 less than the expected theoretical mass.

Balance 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:

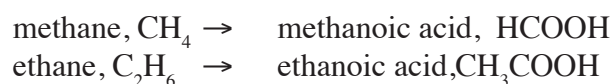
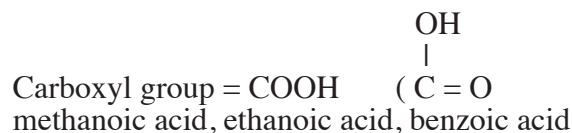
$$\text{Yield} = \frac{\text{actual product mass}}{\text{theoretical product mass}} \times 100 \%$$

## 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
2. **Alkanoic** acids are a homologous series of carboxylic acids based on the corresponding parent alkanes
3. Systematic names, full and shortened structural formulae can be used for straight- and branched- chain alkanoic acids ( $C_1 - C_8$ )
4. Carboxylic acids are used in a variety of ways

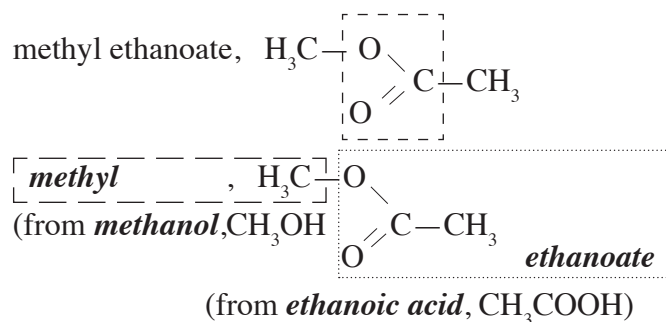


2, methylbutanoic acid

ethanoic acid is used in vinegar, benzoic acid is used as a food preservative, terylene is made from terephthalic acid, nylon is made from hexanedioic acid, and salts of carboxylic acids, mainly stearic, oleic and palmitic, are used in soap manufacture

#### Esters

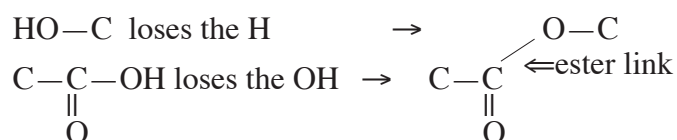
5. An ester can be identified from the functional group (**ester link**) and the **'-oate'** ending
6. An ester can be named given the names of the the **parent alkanol** and **alkanoic acid**, or from shortened and full structural formula
7. Uses of esters include **flavourings**, **perfumes** and **solvents**



#### Making and Breaking Esters

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

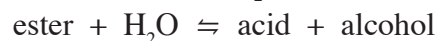
condensation = **joining together** by the elimination of a small molecule (usually  $\text{H}_2\text{O}$ )  
acid + alcohol  $\rightleftharpoons$  ester +  $\text{H}_2\text{O}$



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<sub>2</sub>O)



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

ester + H<sub>2</sub>O  $\rightleftharpoons$  acid + alcohol  
(unusually the E<sub>a</sub> 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 trihydric alcohol

contains **3 —OH** groups. Each glycerol molecule can have **3 acid** molecules joined to it to form a **triest**er 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<sub>4</sub> to C<sub>24</sub> Mainly C<sub>16</sub> to C<sub>18</sub>

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