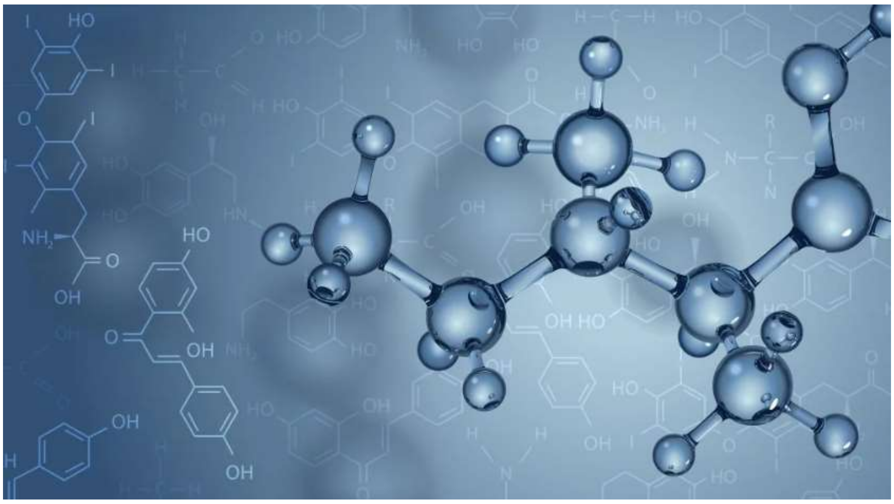
Master

Kirkcaldy High School



Higher Chemistry

Unit 2

Natures Chemistry

Name: ______________________

Class: ______________________

Teacher: ______________________

Assessment Page

Homework

Homework title	Date	Mark/Total Mark
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Notes/comments

Check tests

Test title	Date	Mark/Total Mark
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Notes/comments

Date: _______________

Systematic Carbon Chemistry

Overarching question(s) for this topic

- How are alcohols and carboxylic acids systematically named and how are alcohols classified?

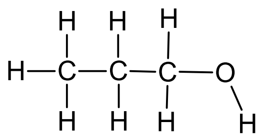
Alcohols

An alcohol is a molecule containing a **hydroxyl** functional group, ─OH group.

General formula: $\mathbf{C_nH_{2n+1}OH}$

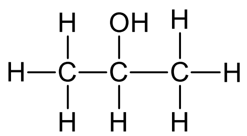
Classification

Alcohols can be classified as primary, secondary or tertiary. This is based on the **position** of the ─OH within the molecule



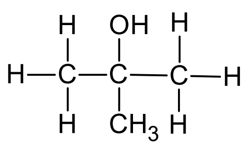
The hydroxyl group is bonded to a carbon which is bonded to **1** other carbon.

Primary alcohol



The hydroxyl group is bonded to a carbon which is bonded to **2** other carbons.

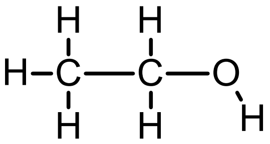
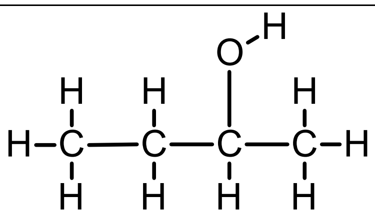
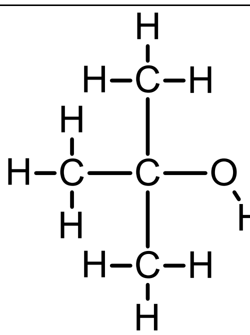
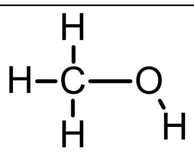
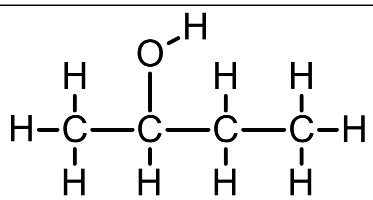
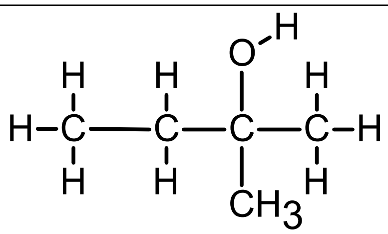
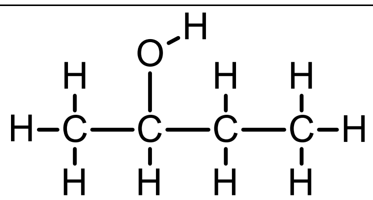
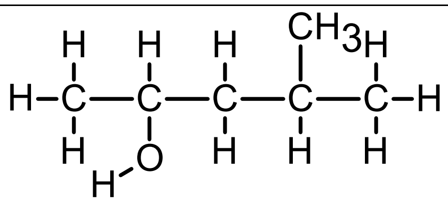
Secondary alcohol

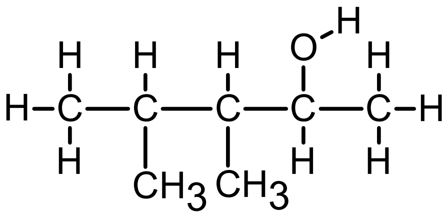
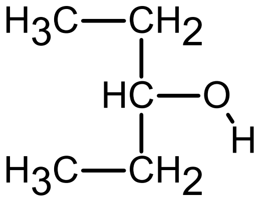
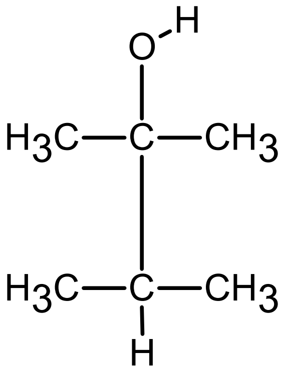
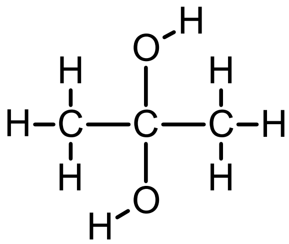
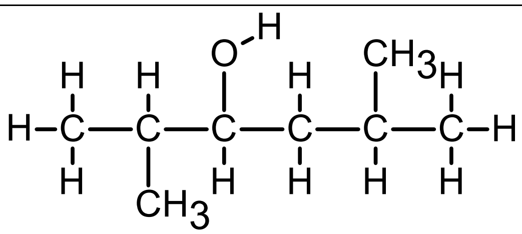
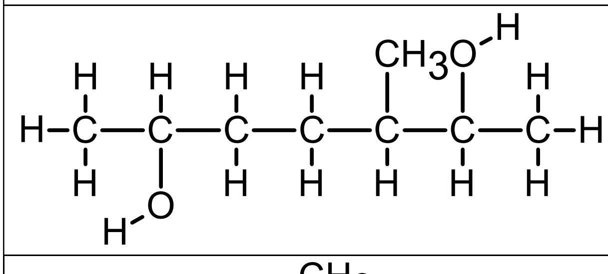
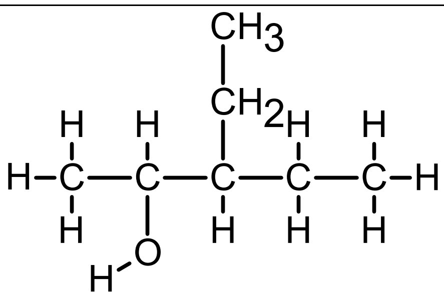


The hydroxyl group is bonded to a carbon which is bonded to **3** other carbons.

Tertiary alcohol

Naming and classification

Full structural formula	Systematic Name	Classification (Primary, Secondary, Tertiary)
		
		
		
		
		
		
		
		

		
		
		
		-
		
		-
		

Drawing alcohols

Draw the full structural formulae for the follwowing alcohols based on their systematic name:

Systematic Name	Full Structural Formula
2-Methylpropan-2-ol	
3-Methylbutan-2-ol	
2,3-Dimethylpentan-3-ol	
2,2-Dimethylbutan-1-ol	
3-Ethylpentan-2-ol	
2,4-Dimethylhexan-3-ol	
3,3-Dimethylpentane-2,4-diol	

2,2,4-Trimethylpentane-1,3-diol	
2,3,4-Trimethylpentane-2,3-diol	
2-Ethyl-2,3-dimethylpentane-1,5-diol	

Extension: classify each of the alcohols that contain only 1 hydroxyl group.

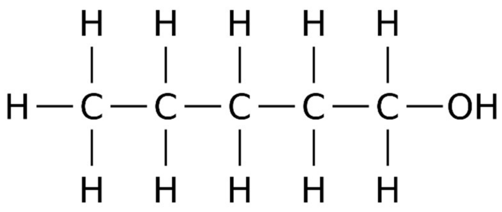
Shortened Structural Formula

Write the full systematic name for the following alcohols based on their shortened structural formula (you may wish to draw them out first):

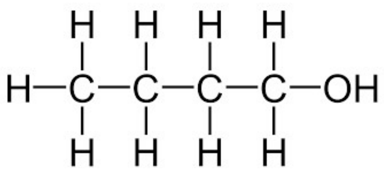
1. $CH_3CH(OH)CH_3$
2. $CH_3CH(OH)CH_2CH_3$
3. $CH_3C(CH_3)_2CH(OH)CH_3$
4. $CH_3CH_2C(OH)(CH_3)CH_2CH_3$
5. $CH_3CH(CH_3)CH(OH)CH_3$
6. $CH_3CH_2CH(OH)CH(CH_3)_2$
7. $(CH_3)_2CHCH_2CH(OH)CH_3$

Isomers

Draw 3 isomers for each of the following alcohol:

 Pentan-1-ol	

Draw 3 isomers for each of the following alcohol:

 butan-1-ol	

Properties

Hydroxyl groups make alcohols polar and this gives rise to hydrogen bonding. Hydrogen bonding can be used to explain the properties of alcohols, including boiling points, melting points, viscosity and solubility/miscibility in water.

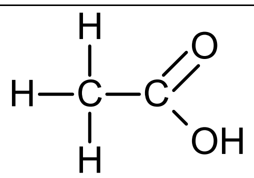
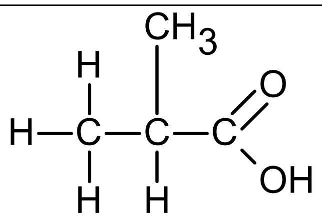
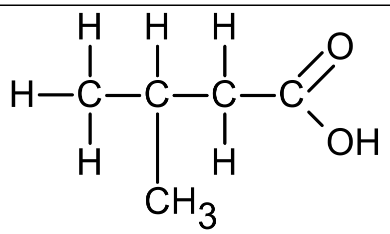
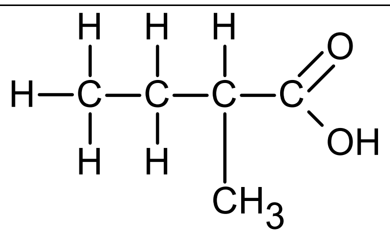
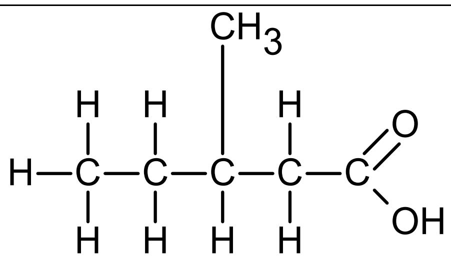
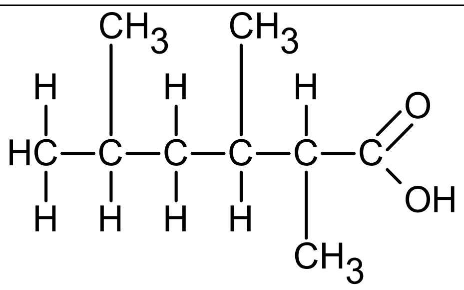
Summarise the effect hydrogen bonding has on the boiling, melting points, viscosity and solubility in water in alcohol molecules. (unit 1 revision)

Carboxylic Acids

A carboxylic acid is a molecule containing the **carboxyl** functional group, **─COOH**. Carboxylic acid names end in **─anoic acid.**

General formula: $\mathbf{C_nH_{2n+1}COOH}$

Naming

Full structural formula	Systematic Name	Classification (Primary, Secondary, Tertiary)
		
		
		
		
		
		

Drawing

Systematic Name	Full Structural Formula
2-Methylpropanoic acid	
3-Methylbutanoic acid	
2,2-Dimethylpropanoic acid	
3-Ethylpentanoic acid	
2,2-Dimethylbutanoic acid	
2-Methylpentanoic acid	
3,3-Dimethylpentanoic acid	
2,2,3-Trimethylbutanoic acid	

Shortened Structural Formula

Write the full systematic name for the following carboxylic acids based on their shortened structural formula (you may wish to draw them out first):

1. CH_3CH_2COOH

2. $CH_3CH(CH_3)COOH$

3. $CH_3CH_2CH_2COOH$

4. $CH_3C(CH_3)_2COOH$

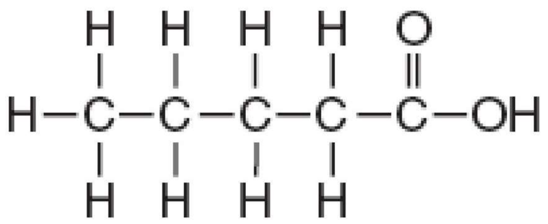
5. $CH_3CH(CH_3)CH_2COOH$

6. $(CH_3)_2CHCH_2COOH$

7. $CH_3CH_2CH(CH_2CH_3)COOH$

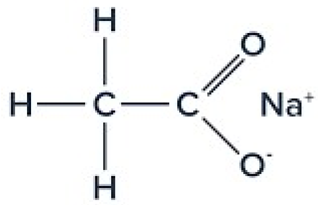
Isomers

Draw 3 isomers for each of the following alcohol:

 Pentanoic acid	

Reactions of Carboxylic acids

Carboxylic acids can react with bases to form **salts**. The first part of the salt name is derived from the metal in the base, the second part of the salt name is derived from the carboxylic acid but the name will now end in –**anoate**:



Sodium ethanoate

---

a metal oxide + a carboxylic acid → a salt + water

e.g.

Sodium oxide + ethanoic acid → sodium ethanoate + water

---

a metal hydroxide + a carboxylic acid → a salt + water

e.g.

potassium hydroxide + propanoic acid → potassium propanoate + water

---

a metal carbonate + a carboxylic acid → a salt + water + carbon dioxide

e.g.

calcium carbonate + butanoic acid → calcium butanoate + water + carbon dioxide

---

Questions

Name the salt produced by the following base and carboxylic acid:

Name of Base	Name of Carboxylic acid	Name of salt produced
Lithium oxide	Methanoic acid	
Magnesium Hydroxide	Propanoic acid	
Calcium Carbonate	Octanoic acid	
Sodium Oxide	Hexanoic acid	
Strontium Hydroxide	Ethanoic acid	

Date: ________________

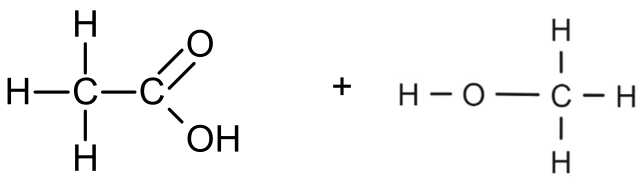
Esters

Overarching question(s) for this topic

- What is the family of products produced when an alcohol and carboxylic acid react together, how do we name them and what are their properties.

Formation and properties

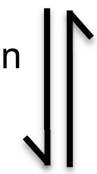
An ester is a molecule containing an **ester link**: —COO—. Esters are formed by a condensation reaction between an **alcohol** and a **carboxylic acid**. Esters are used as flavourings and fragrances as many have **pleasant**, **fruity smells**. Esters are also used as **solvents** for **non-polar compounds** that **do not dissolve in water**.



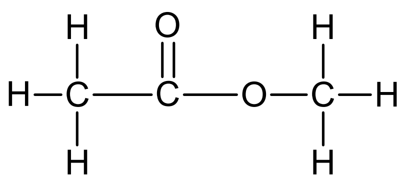
Carboxylic acid **alcohol**

Ethanoic acid **methanol**

Esterification/condensation reaction
Catalyst: concentrated sulfuric acid



hydrolysis



+ H_2O

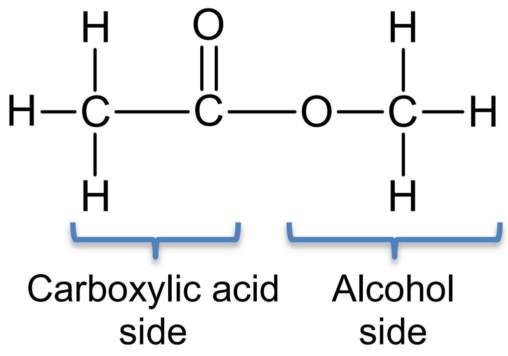
Ester

methyl ethanoate

In a condensation reaction, two molecules are joined together to form a larger molecule with the elimination of a small molecule (not always water!).

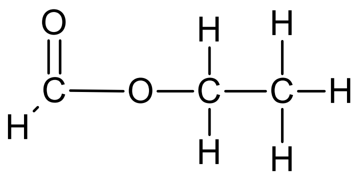
In a hydrolysis reaction, a molecule reacts with water to break down into smaller molecules.

Naming Esters



1. Identify the alcohol and carboxylic acid that make up the ester
2. Change the alcohol's name to end in "-yl"
3. Change the carboxylic acid's name to end in "-oate"
4. Put the alcohol name first, followed by the acid name

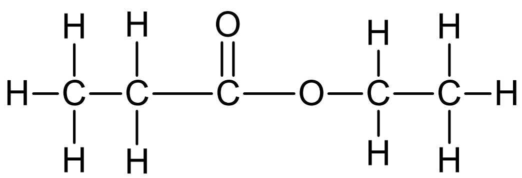
Questions



Systematic name: ______________________________

Name of alcohol used to produce the ester: ______________________________

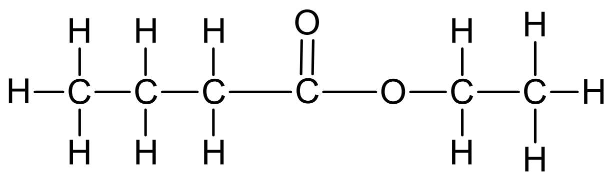
Name of the carboxylic acid used to produce the ester: ___________________________



Systematic name: ______________________________

Name of alcohol used to produce the ester: ______________________________

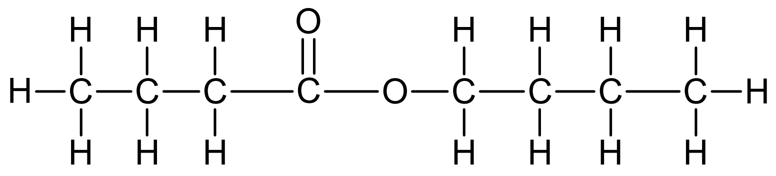
Name of the carboxylic acid used to produce the ester: ___________________________



Systematic name: ____________________________

Name of alcohol used to produce the ester: ____________________________

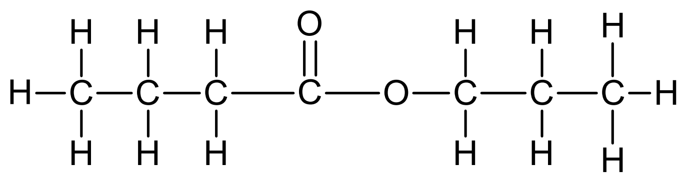
Name of the carboxylic acid used to produce the ester: _________________________



Systematic name: ____________________________

Name of alcohol used to produce the ester: ____________________________

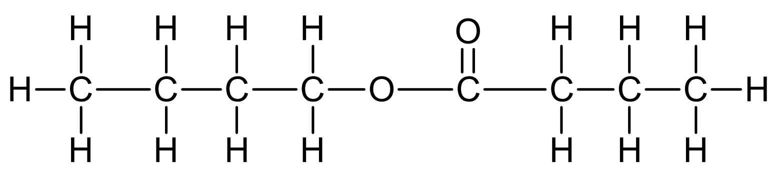
Name of the carboxylic acid used to produce the ester: _________________________



Systematic name: ____________________________

Name of alcohol used to produce the ester: ____________________________

Name of the carboxylic acid used to produce the ester: _________________________



Systematic name: ____________________________

Name of alcohol used to produce the ester: ____________________________

Name of the carboxylic acid used to produce the ester: _________________________

Drawing esters

Systematic Name	Full Structural formula
Methyl ethanoate	
Ethyl propanoate	
Propyl methanoate	
Pentyl pentanoate	
Butyl ethanoate	

Shortened Structural formula

Write the full systematic name for the following esters based on their shortened structural formula (you may wish to draw them out first):

1. $HCOOCH_3$

2. $CH_3COOCH_2CH_3$

3. $CH_3CH_2COOCH_2CH_3$

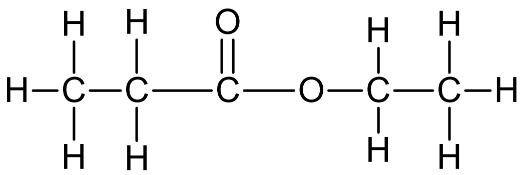
4. $CH_3CH_2CH_2COOCH_2CH_2CH_2CH_3$

5. $CH_3CH_2COOCH_2CH_2CH_2CH_3$

Isomers of esters

Esters can have isomers that are either esters or carboxylic acids.

Draw and name 5 isomers for each of the following ester:

 Ethyl propanoate	

Date: ________________

Fats and Oils

Overarching question(s) for this topic

- How does the structure of fats and oils relate to their properties?

Introduction

Fats and oils are large **non-polar** molecules. This means that they are immiscible with water, causing them to **separate**.

Fats tend be sourced from **animals** and oils tend to be sourced from **plants**.

They tend to have **relatively high boiling** points considering they are **non-polar** due to them having a very large number of **electrons**, **increasing** the **strength** of **LDF** between the molecules.

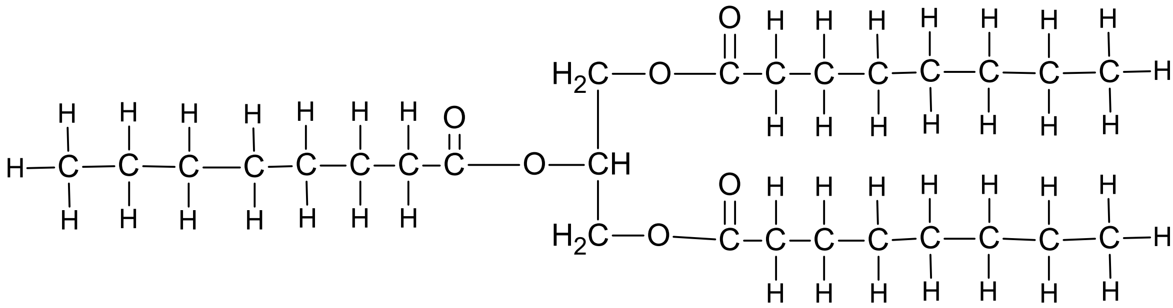
At room temperature, **fats** tend to be **solid** and **oils** tend to be **liquid**.

Oil

Fat

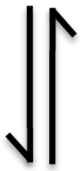
Structure and Reaction

Hydrolysis of edible fats and edible oils can form **glycerol** (propane-1,2,3-triol) and **three** long-chain carboxylic acid molecules (‘**fatty acids**’).

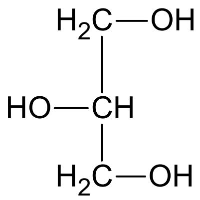


Fat/oil/triglyceride

hydrolysis



Esterification/condensation reaction



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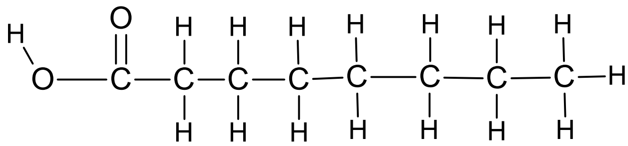


Glycerol **long chain carboxylic acids – ‘fatty acids’**

Propane-1,2,3-triol

This reaction is **reversible** and therefore edible fats and edible oils can be formed from the **condensation** of glycerol (propane-1,2,3-triol) and three long-chain carboxylic acid molecules (‘fatty acids’).

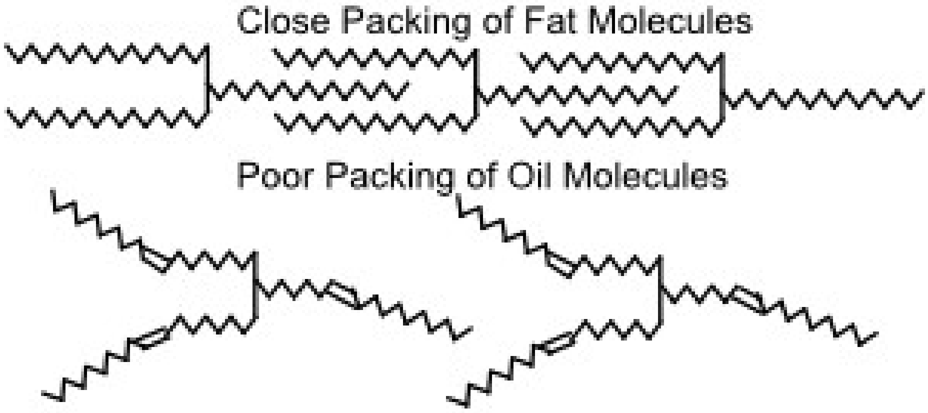
The long-chain carboxylic acids are known as ‘fatty acids’ and can be **saturated** or **unsaturated** straight-chain carboxylic acids, usually with long chains of carbon atoms.

Triglycerides with a **high proportion** of **saturated** fatty acids tend to be **fats**.

Triglycerides with a **high proportion** of **unsaturated** fatty acids tend to be **oils**.

Melting points of fats and oils

Edible oils have **lower melting** points than edible fats.

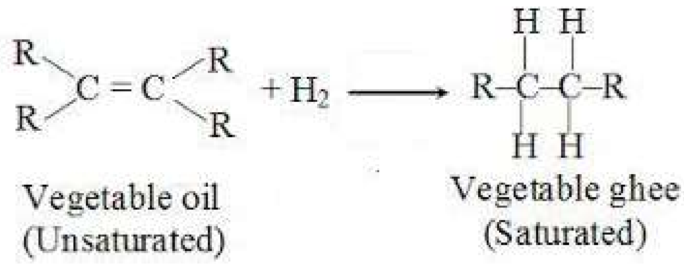


Double bonds in fatty acid chains **prevent** oil molecules from **packing** closely together, so the **greater** the number of **double bonds** present, the **weaker** the van der Waals forces of attraction (LDF).

The greater the degree of unsaturation, the **lower** the melting point.

Hardening of oils

Oils can be **hydrogenated** (addition reaction with hydrogen) to saturate the fatty acid chains. This causes the **packing** of the molecules to improve which **increases** the melting point of oils resulting in more ‘fat’ like properties.



Hydrogenated oils are used to make margarine and other oil-spread butter alternatives such as ‘I can’t believe it's not butter’.

Uses for fats and oils

Fats and oils are:

- a concentrated source of **energy**
- essential for the transport and storage of **fat-soluble vitamins** in the body

Degree of Unsaturation

Unsaturated compounds quickly **decolourise bromine/iodine** solution.

The **bromine/iodine** molecules **add** across the carbon–carbon double bonds in an **addition** reaction.

The greater the number of **double bonds** present in a substance, the more bromine/iodine solution can be decolourised.

A titration can be used to determine the 'iodine number' of an oil. The greater the iodine number, the higher the degree of unsaturation. The greater the degree of unsaturation the lower the melting/boiling point.

Questions

1.

Oils contain carbon to carbon double bonds which can undergo addition reactions with iodine.

The iodine number of an oil is the mass of iodine in grams that will react with 100 g of oil.

Which line in the table shows the oil that is likely to have the lowest melting point?

	Oil	*Iodine number*
A	Corn	123
B	Linseed	179
C	Olive	81
D	Soya	130

2.

The iodine number of an oil is the mass of iodine, in grams, that will react with 100 g of oil and is a measure of the degree of saturation.

Olive oil has an iodine number of 84 and palm oil has an iodine number of 48.

Which of the following statements is correct?

A Palm oil is more saturated and has a lower melting point than olive oil.

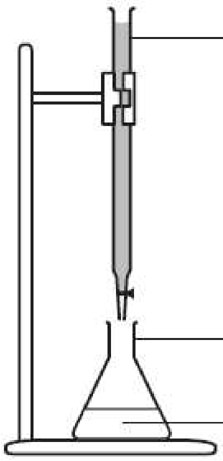
B Palm oil is more saturated and has a higher melting point than olive oil.

C Palm oil is less saturated and has a lower melting point than olive oil.

D Palm oil is less saturated and has a higher melting point than olive oil.

3.

The following apparatus can be used to compare the degree of unsaturation of different oils.



(i) Describe how this apparatus could be used to show that olive oil has a greater degree of unsaturation than coconut oil. **2**

(ii) Suggest why hexane is used as the solvent, rather than water. **1**

Determining the number of double bonds in a fatty acid molecule

To determine the number of double bonds present in an unsaturated fatty acid chain the general formula for carboxylic acids may be used:

General formula for carboxylic acids: **$C_nH_{2n+1}COOH$ when fully saturated.**

Every double bond **removes 2 hydrogens** from this formula.

Questions

Determine the number of double bonds in the following fatty acid molecules:

Molecular formula	No. of C=C
$C_{17}H_{33}COOH$	
$C_{17}H_{31}COOH$	
$C_{17}H_{35}COOH$	
$C_{19}H_{37}COOH$	
$C_{19}H_{33}COOH$	
$C_{16}H_{29}COOH$	

Date: ________________

Soaps, Detergents and Emulsions

Overarching question(s) for this topic

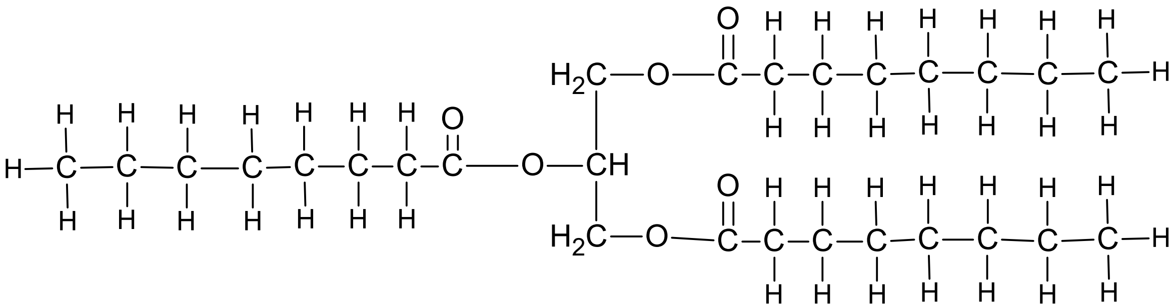
- How can we create soaps from fats and oils and how do soaps work?
- How are soaps different from detergents and emulsions?

Forming Soaps

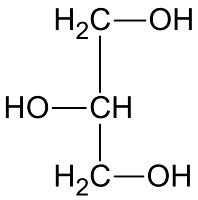
Soaps are produced by the **alkaline hydrolysis** of edible fats and edible oils.

Hydrolysis produces three fatty acid molecules and one glycerol molecule.

The fatty acid molecules are neutralised by the alkali, forming water-soluble, ionic salts called soaps



Alkaline hydrolysis (with NaOH)
A.k.a. **saponification**



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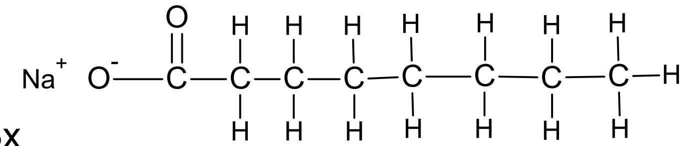


Glycerol

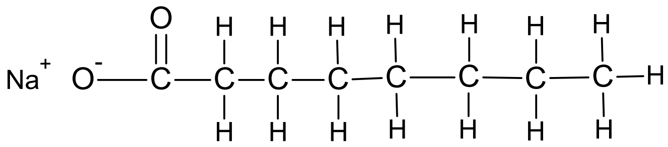
salts of fatty acids

'Soap'

Cleansing Action of Soaps

Soaps can be used to remove **non-polar substances** such as **oil** and **grease**.

Soap ions have long **non-polar tails**, readily soluble in non-polar compounds (**hydrophobic**), and **ionic heads** that are water-soluble (**hydrophilic**).



Simplified structure:

Step 1

The **hydrophobic tails** dissolve in the **oil** or grease. The **negatively**-**charged hydrophilic** heads remain in the surrounding **water**.

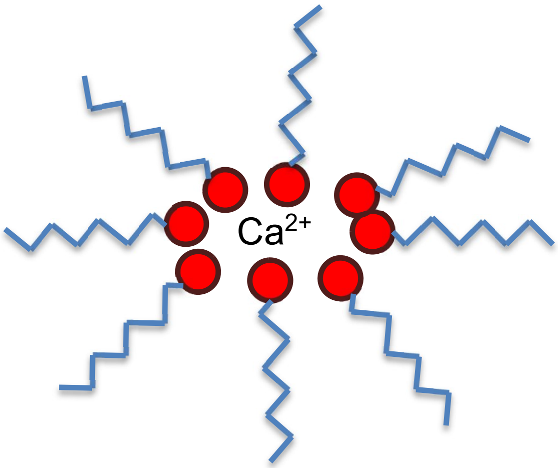
Step 2

Agitation causes **ball-like** structures (**micelles**) to form. The negatively-charged ball-like structures **repel** each other and the oil or grease is kept **suspended** in the **water**. As the oil or grease is now suspended in water, it can be rinsed away.

Detergents

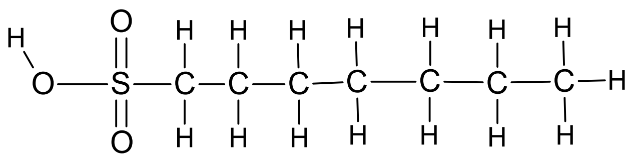
Hard water is a term used to describe water containing **high** levels of **dissolved metal** ions (e.g. Ca^{2+}, Mg^{2+}).

When soap is used in hard water, **soap scum**, an insoluble **precipitate**, is formed.



Soap scum

Soapless detergents are substances with non-polar hydrophobic tails and **ionic hydrophilic** heads.



Soapless detergent

Sodium laureth sulfate

These remove oil and grease in the **same** way as **soap**.

<u>Soapless detergents **do not form scum** with hard water.</u>

Emulsifiers

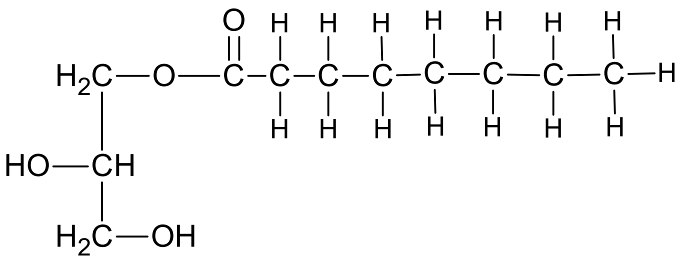
An emulsifier can be used to prevent **non-polar** and **polar** liquids **separating** into layers.

An emulsion contains **small droplets** of one liquid **dispersed** in another liquid.

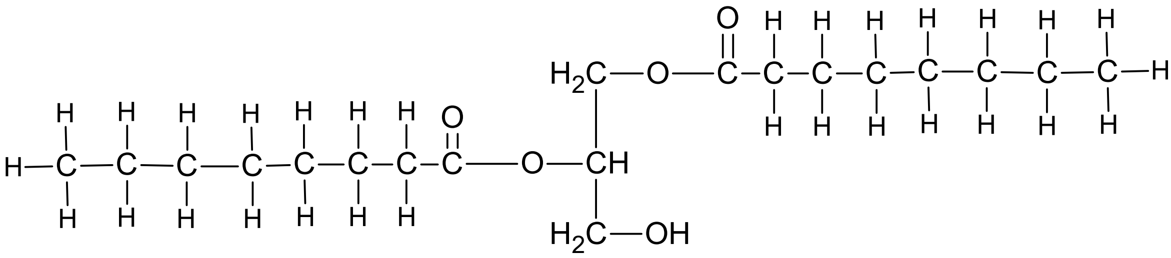
<u>Emulsifiers for use in food can be made by reacting **edible oils** with **glycerol**.</u>

In the molecules formed, only one or two fatty acid groups are linked to each glycerol backbone.

These are called <u>monoglycerides and diglycerides which can be formed by reaction **glycerol** with **edible oils**</u>.



monoglyceride



diglyceride

The hydroxyl groups present in the emulsifier are **hydrophilic** whilst the fatty acid chains are **hydrophobic**.

The **hydrophobic** fatty acid chains dissolve in **oil** whilst the **hydrophilic** hydroxyl groups dissolve in water, forming a **stable** emulsion.

Date: ________________

Proteins

Overarching question(s) for this topic

- What is the chemistry of amino acids and proteins?

Introduction

Proteins are the major structural materials of animal tissue and are also involved in the maintenance and regulation of life processes.

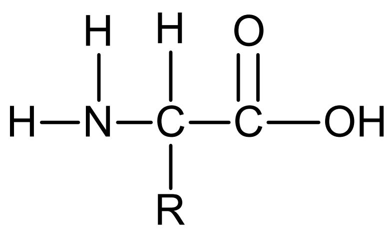
Enzymes are proteins which act as **biological catalysts**.

Proteins are **polymers**, made up of specific **amino acid** sequences. There are 20 different types of amino acid, each with different molecular structures. Proteins which fulfil different roles in the body are formed by linking together differing sequences of amino acids.

The body cannot make all of the amino acids required for protein synthesis and certain amino acids, known as **essential amino acids**, must be acquired from the **diet**.

Amino acid structure

Amino acids, the building blocks from which proteins are formed, are relatively small **polar molecules** which all contain an **amino** group, —NH_2, and a carboxyl group, —COOH.



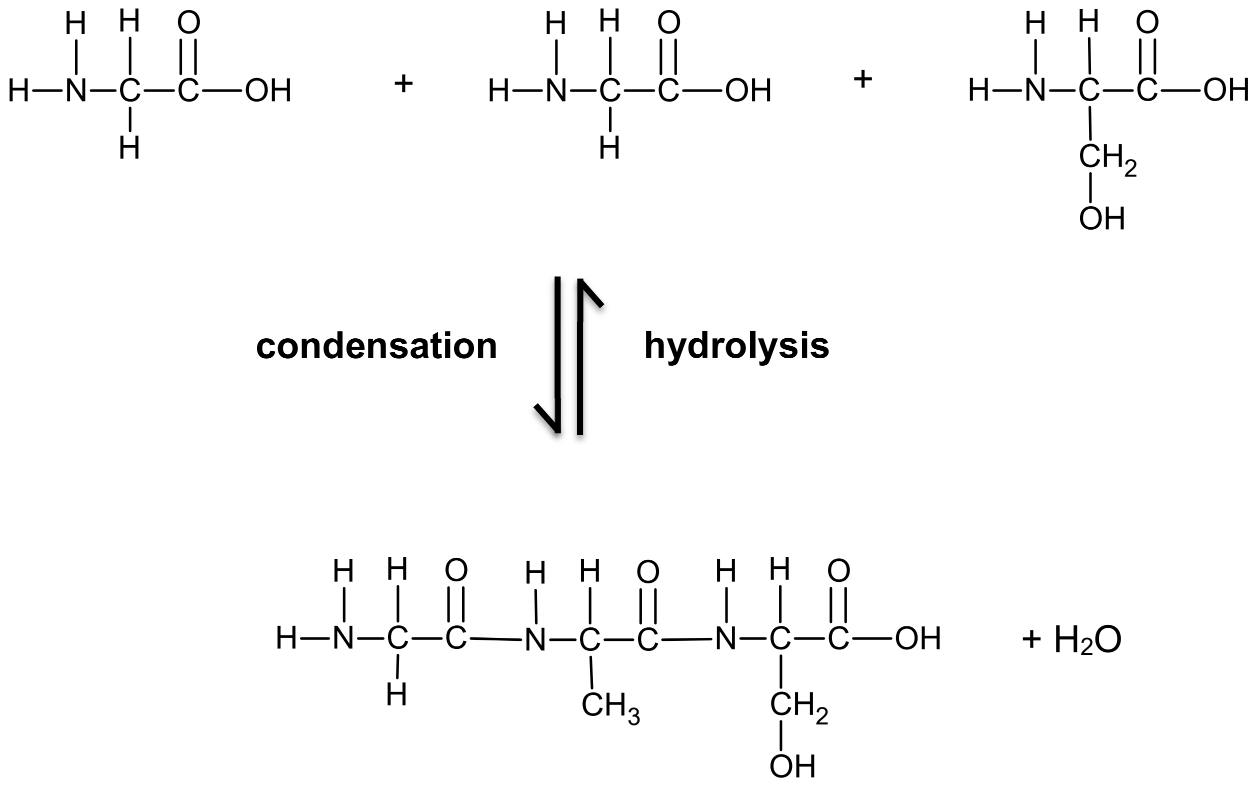
Amino acid

In different types of amino acid, the R group changes. The 'R' can represent: H, –CH_3, –CH_2OH, etc.

Peptide/Protein chain formation

Proteins are made of many amino acid molecules linked together by **condensation** reactions. In these reactions, the amino group of one amino acid and the carboxyl group of another amino acid join, with the elimination of water.

The link which forms between two amino acids is known as a peptide link, —**CONH**—, or also as an **amide** link.

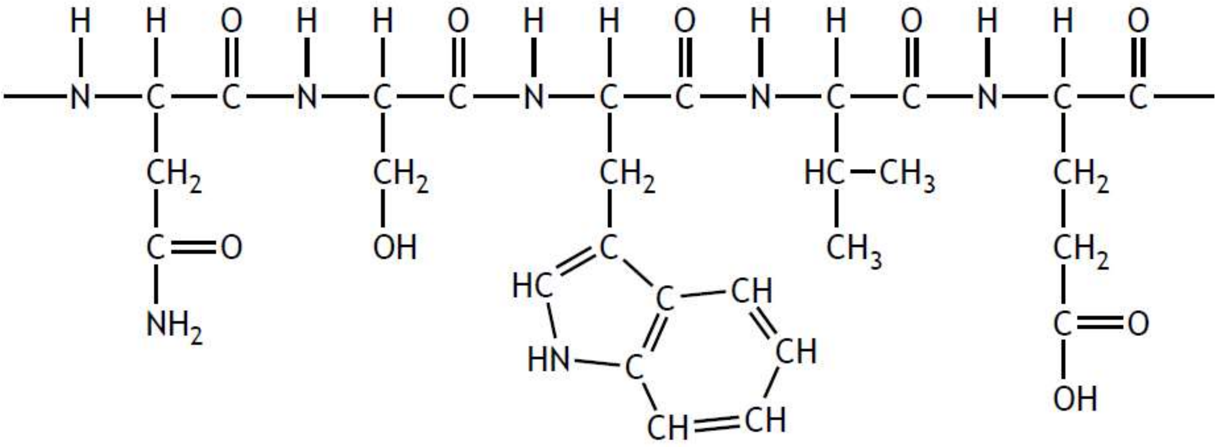


Tripeptide chain

You must be able to count the number of amino acids in a peptide chain and be able to draw an amino acid from the sequence.

Questions

1.



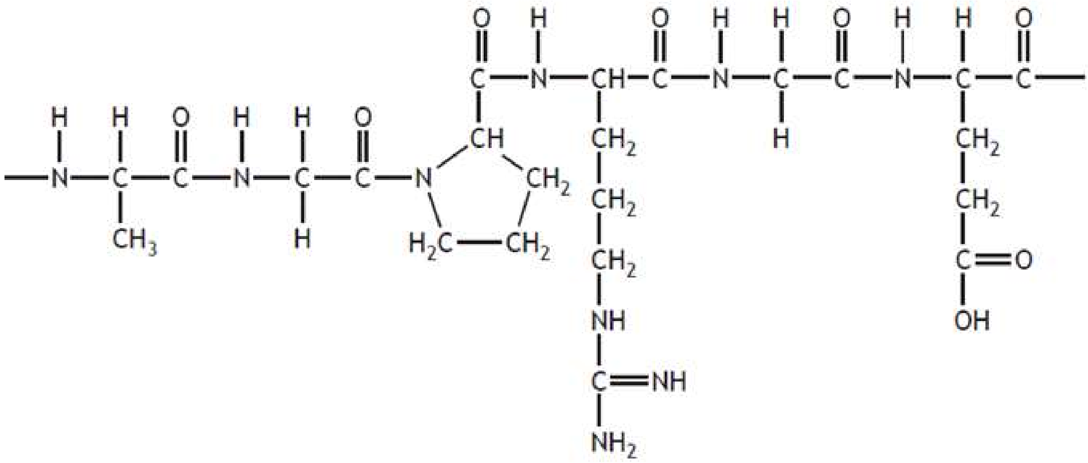
(A) State how many amino acid molecules joined to form this section of protein. **1**

(B) Draw the structure of one amino acid that would be produced when this section of the protein chain is broken down. **1**

2.

Gelatin is a soluble protein that can be added to different food products.

(a) A structure for a section of a protein chain in gelatin is shown.



(i) State the number of amino acids that joined together to form the section of the protein chain shown. **1**

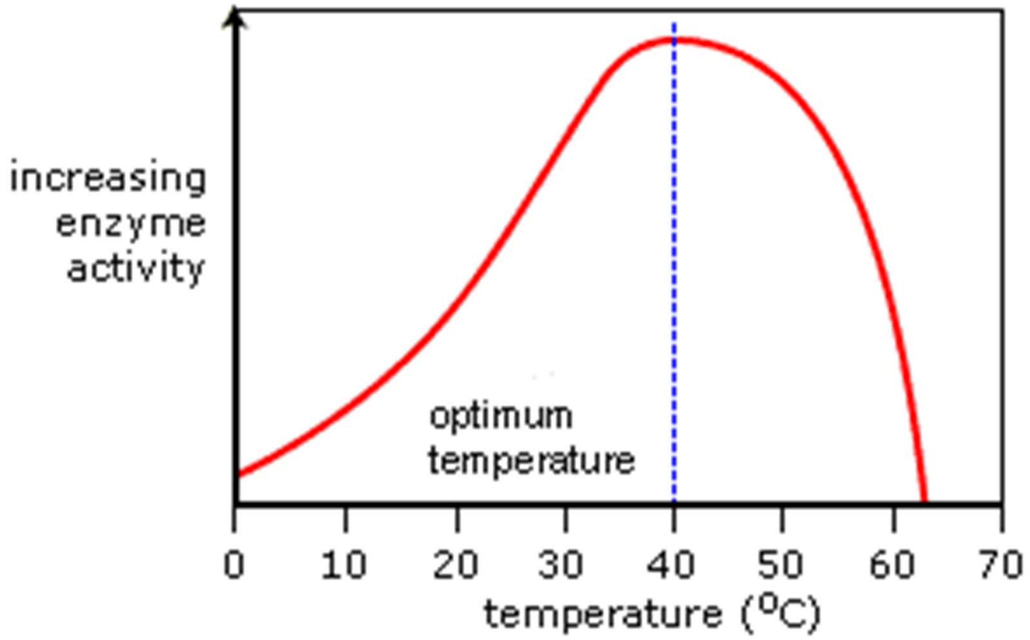
(ii) Name the weakest van der Waals' force between water and gelatin molecules. **1**

Digestion Specific Hydrolysis

During digestion, **enzyme hydrolysis** of protein produces **amino acids**.

Enzymes only function under specific conditions, such as **temperature** and **pH**.

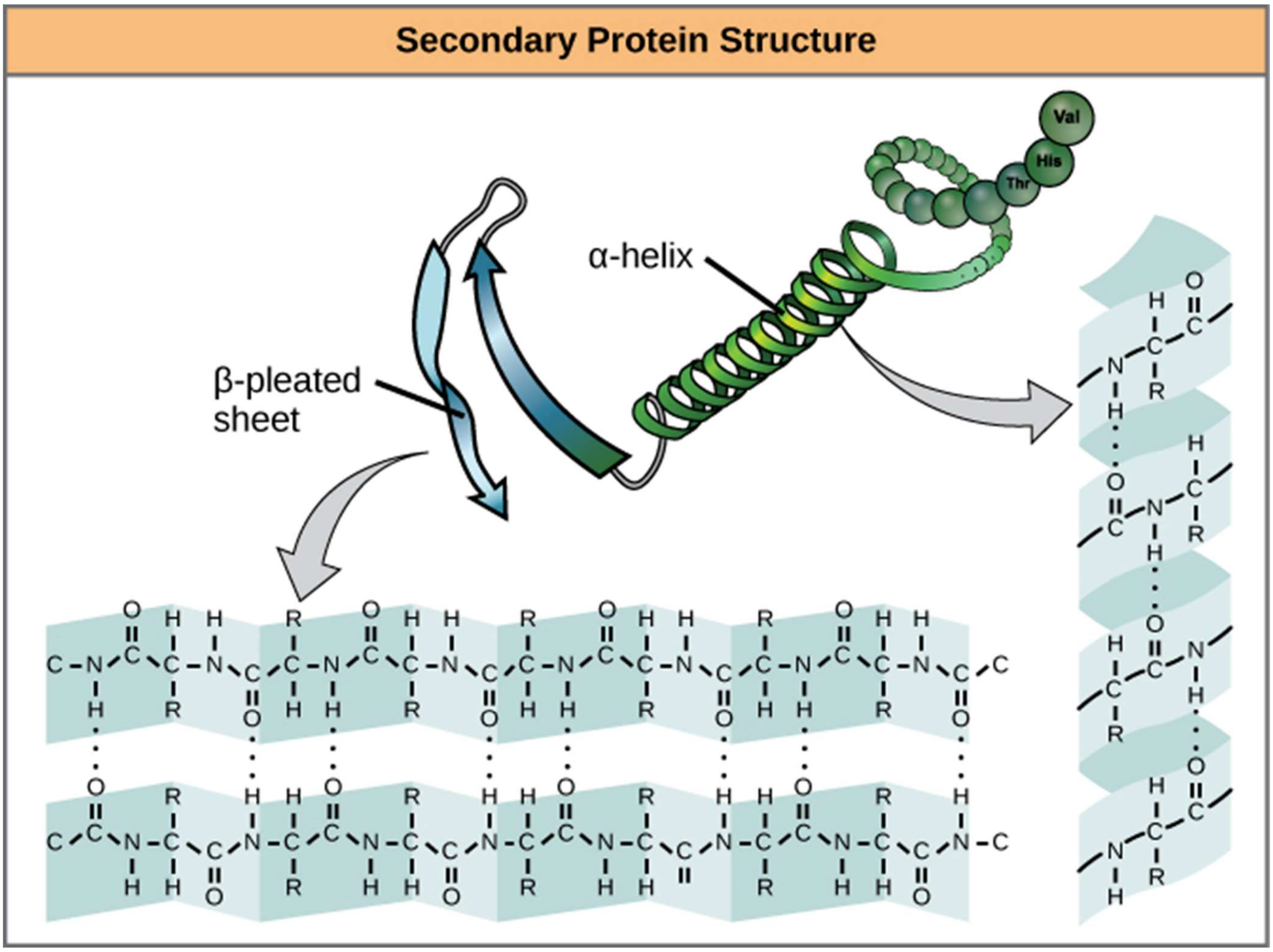
Rate of Enzyme Reaction with **temperature**:



If the temperature increases too high, the enzyme can become **denatured** and will no longer function, even if the temperature is brought back to an optimal range.

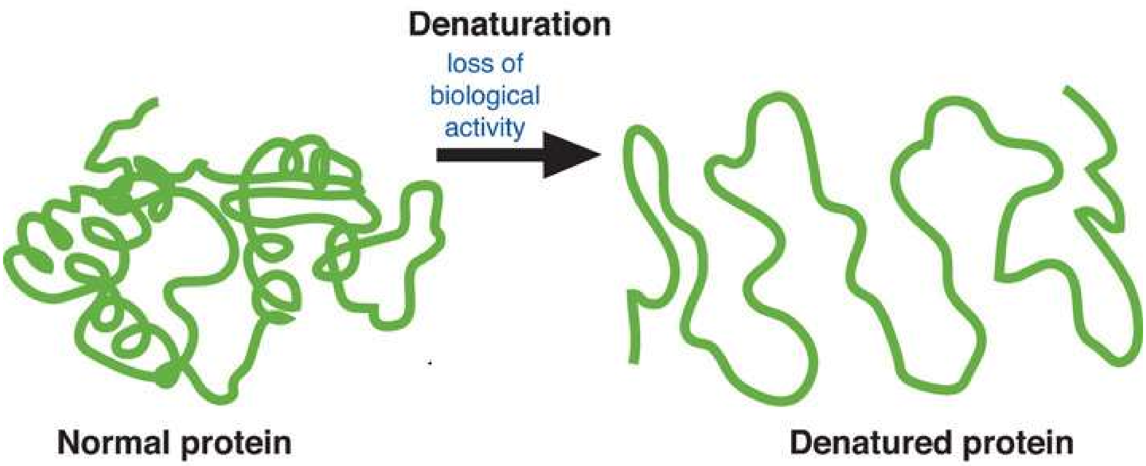
Denaturing of Proteins

Within proteins, the long-chain molecules form **spirals**, **sheets**, or other **complex** shapes.



The chains are held in these forms by **hydrogen bonding** between the side chains of the constituent amino acids.

When proteins are heated, these **hydrogen bonds** are broken, allowing the proteins to **change shape** (denature).



The **denaturing** of proteins in foods causes the **texture** to **change** when it is **cooked**. This is why egg 'whites' turn from colourless to white when cooked.

Partial Hydrolysis

Type of peptide	*Example of amino acid sequence*
dipeptide	aspartic acid-phenylalanine
tripeptide	isoleucine-proline-proline
tetrapeptide	lysine-proline-proline-arginine
pentapeptide	serine-glycine-tyrosine-alanine-leucine
	alanine-glycine-valine-proline-tyrosine-serine
polypeptide	many amino acids

(a) Complete the table to identify the type of peptide with the following amino acid sequence

alanine-glycine-valine-proline-tyrosine-serine **1**

(b) Partial hydrolysis of another pentapeptide molecule gave a mixture of three smaller peptide molecules with the following amino acid sequences.

leucine-glycine-valine

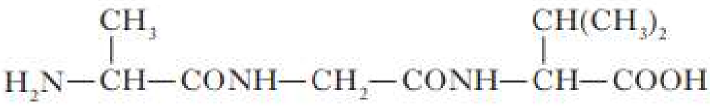
isoleucine-leucine

glycine-valine-serine

Write the amino acid sequence for the original pentapeptide molecule. **1**

.... – .... – .... – .... – ....

A tripeptide **X** has the structure



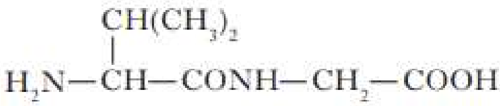
Partial hydrolysis of **X** yields a mixture of dipeptides.

Which of the following dipeptides could be produced on hydrolysing **X**?

A

B

C



D

Date: ________________

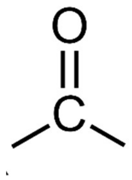
Aldehydes and Ketones

Overarching question(s) for this topic

- How can we identify and name aldehydes and ketones?

Structure of aldehyde and ketones

Aldehydes and ketones both have a **carbonyl** group present in their molecules



Carbonyl group

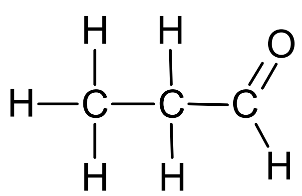
Whether a **carbonyl** containing molecule is classified as an **aldehyde** or **ketone** is determined by the **position** of the **carbonyl** group.

Aldehydes have the **carbonyl** group on an **end** (**terminal**) **carbon** atom.

Ketones have the **carbonyl** group on an **central carbon** atom.

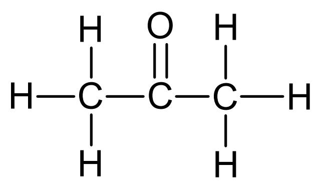
The same systematic naming rules apply. Aldehyde names end in **–al**, ketones names in **–one**. The position of the carbonyl must be specified with ketones.

Aldehyde



Propanal

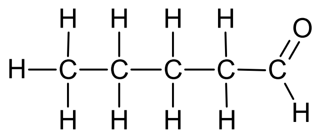
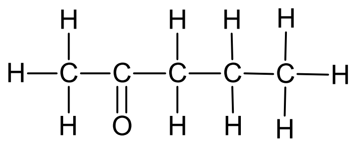
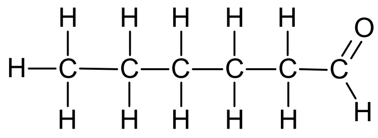
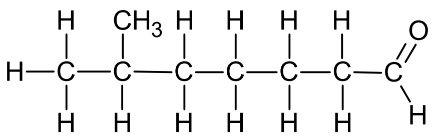
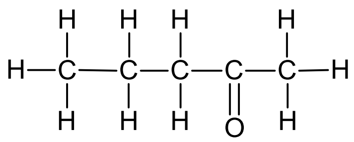
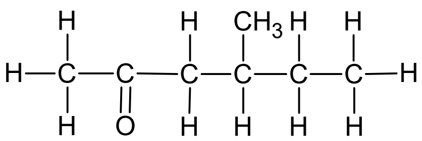
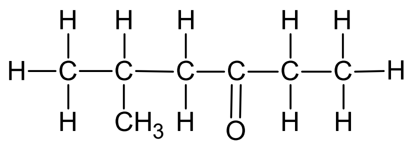
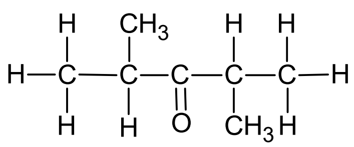
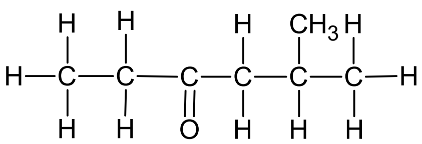
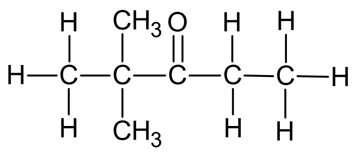
Ketone



propanone

Many **flavour** and **aroma** molecules are aldehydes.

Naming

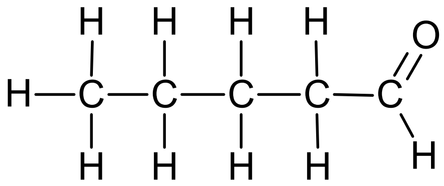
Full structural formula	Aldehyde or ketone?	Systematic Name
		
		
		
		
		
		
		
		
		
		

Drawing aldehydes and ketones

Systematic Name	Full Structural Formula
Ethanal	
2-Methylpropanal	
3-Methylbutanal	
Propanone	
3-methylbutanone	
Pentan-2-one	
3-Methylpentan-2-one	
4-Ethylhexan-3-one	

Isomers

Draw 3 isomers for each of the following aldehyde/ketone:

 **pentanal**	

Date: ________________

Oxidation of Food

Overarching question(s) for this topic

- What is the chemistry of the spoiling of food when it is exposed to oxygen?

Oxidation and Reduction in carbon compounds

For carbon compounds:

- oxidation is an increase in the oxygen to hydrogen ratio

In terms of the change in functional groups:

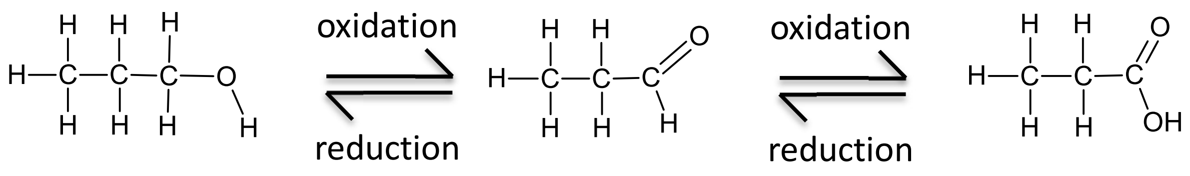
- reduction is a decrease in the oxygen to hydrogen ratio

In terms of the change in functional groups:

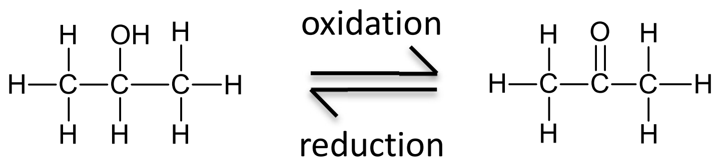
Oxidation of alcohols

The products of oxidation of alcohols depends on the classification of the alcohol (primary, secondary or tertiary)

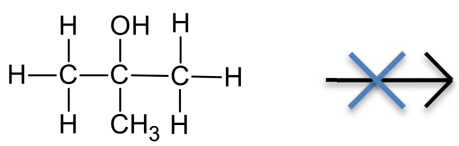
Hot **copper(II) oxide** or **acidified dichromate(VI) solutions** can be used to oxidise:



Primary alcohol **aldehyde** **carboxylic acid**



Secondary alcohol **ketone**



Tertiary alcohol

During these reactions black copper(II) oxide forms a brown solid, and orange dichromate solution turns green.

Examples of Oxidising agents

Aldehydes, but not ketones, can be **oxidised** to **carboxylic acids**.

Oxidising agents can be used to differentiate between an aldehyde and a ketone.

With an aldehyde:

- **blue Fehling's** solution forms a **brick red precipitate**
- **clear**, colourless **Tollens'** reagent forms a **silver mirror**
- **orange** acidified dichromate solution turns **green**

Oxidation of oils

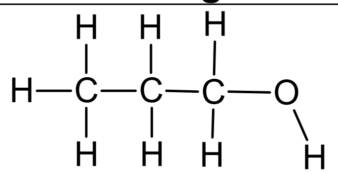
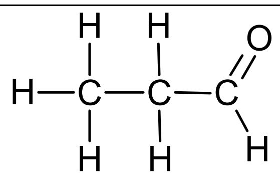
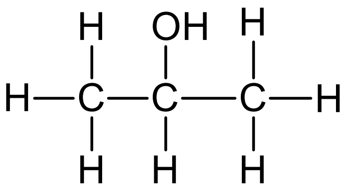
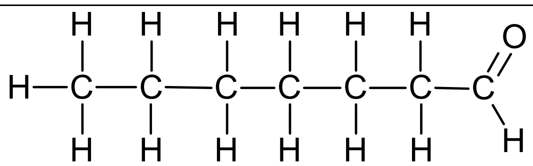
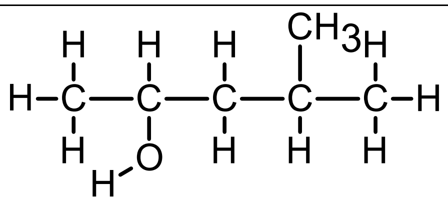
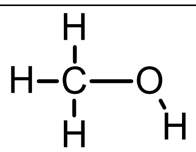
Oxygen from the air causes the oxidation of food. The oxidation of edible oils gives food a rancid flavour.

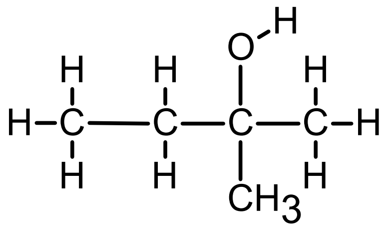
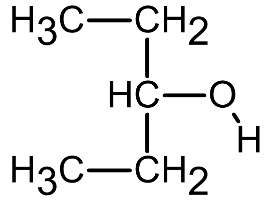
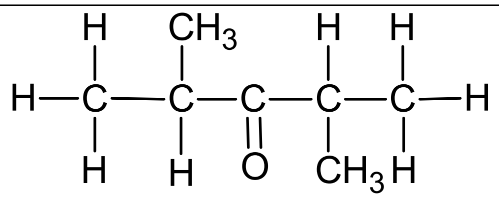
Antioxidants

- are molecules that prevent unwanted oxidation reactions occurring
- are substances that are easily oxidised, and oxidise in place of the compounds they have been added to protect
- can be identified as the substance being oxidised in a redox equation

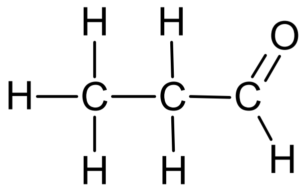
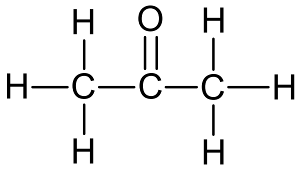
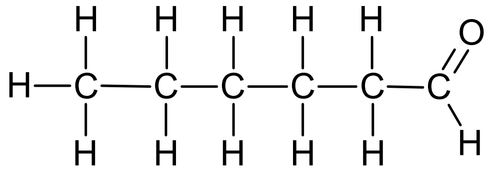
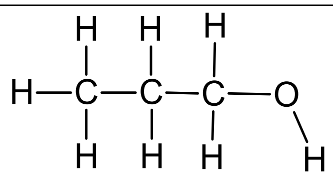
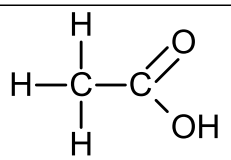
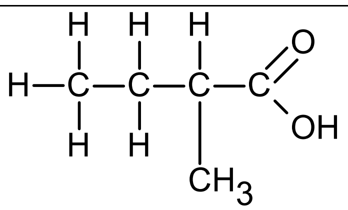
Questions

Draw the possible products of oxidation for the following:

Molecule being oxidised	Possible products of oxidation
	
	
	
	
	
	

Draw the possible products of reduction for the following:

Molecule being Reduced	**Possible products of reduction**
	
	
	
	
	
	

Date: ________________

Fragrances

Overarching question(s) for this topic

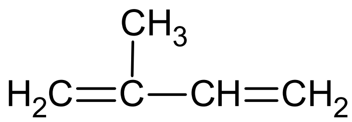
- What is the chemistry of common molecules found in essential oils

Essential oils

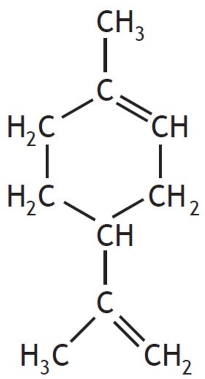
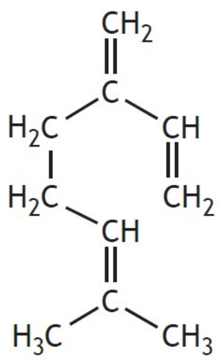
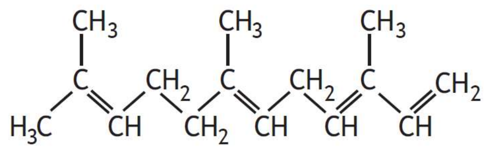
Essential oils are concentrated extracts of the volatile, non-water soluble aroma compounds from plants. They are mixtures of many different compounds. They are widely used in perfumes, cosmetic products, cleaning products and as flavourings in foods.

Terpenes are key components in most essential oils. They are unsaturated compounds formed by joining together isoprene (2-methylbuta-1,3-diene) units.

As isoprene units have 5 carbons, terpenes must have a **multiple** of **5** total carbons, e.g. 10 carbons, 15 carbons, etc.



Isoprene (2-methylbuta-1,3-diene)

Name of Terpene	limonene	Humulene	farnesene
Terpene structure			
Molecular formula			
No. of isoprene units			

Terpenes can be **oxidised** within plants to produce some of the compounds responsible for the distinctive **aromas** of **spices**.

Date: ________________

Skincare

Overarching question(s) for this topic

- Why does the sun cause damage to body tissues?

Free radicals

Ultraviolet (UV) radiation is a high-energy form of light, present in sunlight. UV light can provide sufficient energy to break bonds within molecules. This causes sunburn, accelerates ageing of the skin and can cause cancer.

Sun-block products prevent UV light reaching the skin.

When UV light breaks bonds, **free radicals** are formed.

Your teacher will draw a diagram of free radical formation:

Free radicals are atoms or molecules that are **highly reactive** due to the presence of **unpaired electrons**.

These free radicals can react with **proteins** and **DNA** molecules within the body, leading to **premature aging** and higher chances of cancer.

Free Radical Chain Reactions

When radicals form, they rapidly undergo a chain of reactions producing many different products. **UV light** is used to begin the reaction, which follows a three-step mechanism: **initiation**, **propagation**, and **termination**.

Initiation:

The reaction begins with small molecules, usually halogens, forming radicals due to ultraviolet (UV) light:

$$Cl_2 \rightarrow 2Cl\bullet$$

Propagation:

Once a radical has been formed it can react with any non- radical available, forming another radical and a non-radical.

$$Cl\bullet + CH_4 \rightarrow CH_3\bullet + HCl$$

The radicals formed can then form more radicals.

$$CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$$

This cycle continues, leading to multiple chlorination steps.

Termination:

The chain reaction eventually stops when two radicals combine, forming stable molecules:

$$Cl\bullet + Cl\bullet \rightarrow Cl_2$$

$$CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$$

$$CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$$

The termination step can only occur with radicals that have formed during **initation** or **propagation**.

Free Radical Scavengers

Free radical scavengers are molecules that react with free radicals to form **stable molecules** and **prevent chain reactions** from occurring.

Free radical scavengers are added to many products including **cosmetics**, **food products** and **plastics**.

Questions

Determine which step of a free radical chain reaction these reactions belong to:

Reaction	Which Step? (Initiation, Propagation, or Termination?)
$Br_2 \rightarrow 2Br\bullet$	
$Br\bullet + H_2 \rightarrow H\bullet + HBr$	
$H\bullet + Br_2 \rightarrow HBr + Br\bullet$	
$Br\bullet + CH_3CH_3 \rightarrow CH_3CH_2\bullet + HBr$	
$CH_3CH_2\bullet + Br_2 \rightarrow CH_3CH_2Br + Br\bullet$	
$CH_3\bullet + O_2 \rightarrow CH_3O_2\bullet$	
$CH_3O_2\bullet + NO \rightarrow CH_3O\bullet + NO_2$	
$CH_3O\bullet + O_2 \rightarrow HCHO + HO_2\bullet$	
$HO_2\bullet + NO \rightarrow OH\bullet + NO_2$	
$CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$	

Alkanes can react with group 7 molecules in free radical reactions to form haloalkanes.

Reaction step	Name of step
$Br_2 \rightarrow 2Br\bullet$	Initiation
$Br\bullet + CH_4 \rightarrow HBr + \bullet CH_3$ $\bullet CH_3 + Br_2 \rightarrow CH_3Br + Br\bullet$	Propagation
	Termination

(ii) Complete the table to show a possible termination step. **1**