FACTFILE:
GCSE CHEMISTRY: UNIT 2.5

Rewarding Learning

Organic Chemistry

Learning outcomes

Student should be able to:

2.5.1 demonstrate knowledge and understanding that carbon can form four covalent bonds and there is a large number of carbon compounds, the study of which is simplified by grouping the compounds into homologous series;

2.5.2 define a homologous series as a family of organic molecules that have the same general formula, show similar chemical properties, show a gradation in their physical properties and differ by a CH_2 group;

2.5.3 recall that a hydrocarbon is a molecule consisting of hydrogen and carbon only;

2.5.4 recall the general formula of the alkanes and the molecular formula, structural formula and state at room temperature and pressure of methane, ethane, propane and butane;

2.5.5 recall that crude oil is a finite resource and is the main source of hydrocarbons and a feedstock for the petrochemical industry;

2.5.6 describe and explain the separation of crude oil by fractional distillation;

2.5.7 describe the fractions as largely a mixture of compounds of formula C_nH_{2n+2}, which are members of the alkane homologous series, and recall the names and uses of the following fractions:

- refinery gases used for bottled gas;
- petrol used as a fuel for cars;
- naphtha used to manufacture chemicals and plastics;
- kerosene as a fuel for aircraft;
- diesel as a fuel for cars and trains;
- fuel oils used for ships;
- bitumen used to surface roads and roofs.

2.5.8 explain that cracking involves the breakdown of larger saturated hydrocarbons (alkanes) into smaller more useful ones, some of which are unsaturated (alkenes);

2.5.9 describe the complete combustion of alkanes to produce carbon dioxide and water, including observations and tests to identify the products;

2.5.10 describe the incomplete combustion of alkanes to produce carbon monoxide and water and sometimes carbon (soot – equations for the production of soot are not required);

2.5.11 demonstrate knowledge and understanding that carbon monoxide is a toxic gas that combines with haemoglobin in the blood, reducing its capacity to carry oxygen;

2.5.12 recall the general formula of the alkenes and the molecular formula, structural formula and state at room temperature and pressure of ethene, propene, but-1-ene and but-2-ene;

2.5.13 describe the complete and incomplete combustion of alkenes;

2.5.14 demonstrate knowledge and understanding that a functional group is a reactive group in a molecule, recognise the functional groups of alkenes, **alcohols and carboxylic acids** and that alkanes do not have a functional group and so are less reactive;

2.5.15 recall and describe the addition reaction across a C=C double covalent bond, including the reaction of ethene with bromine, hydrogen and steam (name of the bromo product is not required);

2.5.16 determine the presence of a C=C using bromine water.

2.5.17 describe how monomers, for example ethene or chloroethene (vinyl chloride), can join together to form very long chain molecules called polymers and recall that the process is known as addition polymerisation;

2.5.18 **write equations for the polymerisation of ethene and chloroethene**;

2.5.19 **deduce the structure of an addition polymer from a simple alkene monomer and vice versa**;

2.5.20 demonstrate knowledge and understanding that addition polymers are non- biodegradable and evaluate the advantages and disadvantages of their disposal by landfill and incineration;

2.5.21 recall the general formula of the alcohols and the molecular formula, structural formula and state at room temperature and pressure of methanol, ethanol, propan-1 ol and propan-2-ol;

2.5.22 describe the complete and incomplete combustion of alcohols;

2.5.23 describe the preparation of ethanol from sugars by fermentation (equation for fermentation of sugars is not required), including the conditions required;

2.5.24 **recall the oxidation of alcohols when exposed to air and by the reaction with acidified potassium dichromate solution (equations are not required) and demonstrate understanding that methanol, ethanol and propan-1-ol are oxidised to the corresponding carboxylic acid (students should know that propan-2-ol can be oxidised but do not need to know the name or structure of the product)**;

2.5.25 **recall the molecular formula, structural formula, state at room temperature and pressure of the carboxylic acids: methanoic acid, ethanoic acid, propanoic acid and butanoic acid**;

2.5.26 demonstrate knowledge that carboxylic acids are weak acids **as they are only partially ionised in solution**; and

2.5.27 investigate experimentally the reactions of carboxylic acids with carbonates, hydroxides and metals, test any gases produced and **write balanced symbol equations for these reactions**.

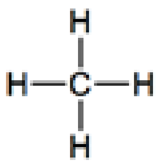
2.5.28 demonstrate knowledge that the combustion of fuels is a major source of atmospheric pollution due to:

- combustion of hydrocarbons producing carbon dioxide, which leads to the greenhouse effect causing sea level rises, flooding and climate change;
- incomplete combustion producing carbon monoxide (toxic) and soot (carbon particles), which cause lung damage;
- presence of sulfur impurities in fuels, which leads to acid rain damaging buildings, destroying vegetation and killing fish.

2.5.29 identify alkanes, alkenes, **alcohols** and carboxylic acids using chemical tests.

Organic Chemistry

Carbon is a very special element – its presence in group 4 of the Periodic table means that it has the ability to form 4 covalent bonds. In all organic compounds, each carbon can covalently bond to other carbon atoms as well as hydrogen atoms and some other elements.

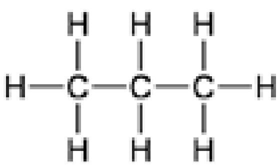


Carbon's ability to bond repeatedly to other carbon atoms allows for the formation of many thousands of organic compounds. A hydrocarbon is a covalently bonded compound consisting of carbon and hydrogen atoms only. Some hydrocarbons only have a few carbon atoms in each molecule, others can have over 70 carbon atoms.

There are 2 ways of drawing the formula of an organic compound –

1. Molecular formula tells us the actual number of each atom, e.g. CH_4 or C_2H_4

2. Structural formula shows us how the atoms are bonded to each other.



Organic compounds can be arranged into families or homologous series. The members of each family differ only in the number of carbon atoms in the chain. Each member of the series has a chemical formula that follows a **general formula**, they differ by a 'CH_2' unit. Homologous series applies to; **alkanes, alkenes, alcohols and carboxylic acids**. Each member of a homologous series:

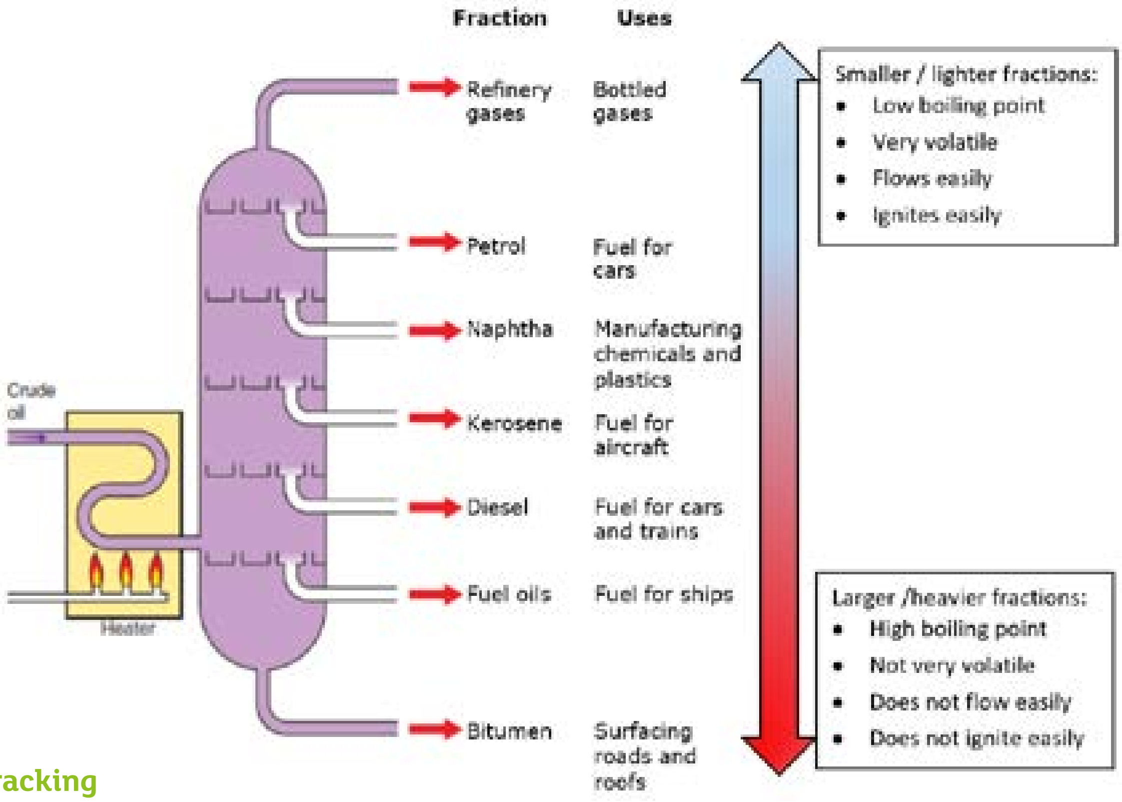
- has the same general formula;
- has similar chemical properties;
- has a gradation in their physical properties and
- differs by a CH_2 group

Crude oil

Crude oil is dark brown, sticky substance which is a rich source of hydrocarbons, mainly alkanes. The hydrocarbons in crude oil, having varying chain length, have different boiling points and because of this they can be separated using **fractional distillation**.

During fractional distillation, crude oil is separated into groups of hydrocarbons that have a similar number of carbon atoms in each molecule. These groups are called fractions.

Fractional distillation takes place industrially in a steel tower. The tower is very hot at the base and cooler at the top. Crude oil is fed into a furnace and heated until it becomes a vapour. The vaporised oil is then fed into the fractionating tower. As the vapour mixture rises up the tower, different vapours condense at different levels and are separated. The small hydrocarbon molecules, with the shortest carbon chains have the lowest boiling points and so will rise to the top of the tower, while the larger hydrocarbons with the longest carbon chains and highest boiling points will condense lower down in the tower.



Cracking

The lighter fractions of crude oil, e.g. refinery gases and petrol are in greater demand than the heavier fractions like bitumen. As a result, chemists convert the heavier fractions into shorter, lighter more useful molecules by effectively "cutting" the longer chains up in a process known as cracking.

An example of this process is shown below, where the cracking of decane produces an alkene and an alkane as products of the reaction.

$$C_{10}H_{22} \rightarrow C_2H_4 + C_8H_{18}$$

decane ethene octane

Functional Groups

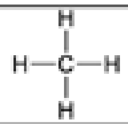
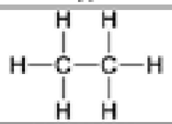
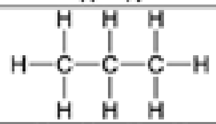
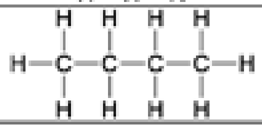
A functional group is a reactive group in a molecule. The presence of a particular functional group determines the physical and chemical properties of the organic compound and it dictates which homologous series it will belong to:

- **Alkanes** – do not have a functional group and therefore are less reactive.
- **Alkenes** – have a C=C double bond present between two carbons in the hydrocarbon chain
- **Alcohols** – have a hydroxyl group, –OH
- **Carboxylic acids** – have a COOH group present

Alkanes

General formula – C_nH_{2n+2} (where n is the number of carbon atoms)

We get alkanes from crude oil, they are the simplest organic compounds. Alkanes do not have a functional group which makes them relatively unreactive compared to other homologous series.

Name	No of carbon atoms	Molecular Formula	Structural formula	State at room temperature
methane	1	CH_4		Gas
ethane	2	C_2H_6		Gas
propane	3	C_3H_8		Gas
butane	4	C_4H_{10}		Gas

Physical Properties of alkanes

- As you can see the first 4 alkanes are gases at room temperature.
- The boiling points increase as the chains get longer.
- From C_5H_{12} to $C_{17}H_{36}$ are liquids and from $C_{18}H_{38}$ are solids.
- Alkanes are insoluble in water and liquid alkanes are immiscible with water.

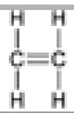
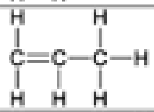
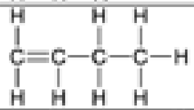
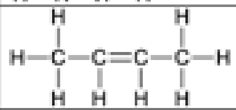
Chemical Properties of Alkanes

Since alkanes only contain single bonds between C atoms they are said to be saturated compounds. A saturated hydrocarbon is a compound which contains only C and H atoms and has a C–C single bonds. They have the maximum number of H atoms attached to the carbons. They are very unreactive because they only contain C–C and C–H single covalent bonds. These single covalent bonds are very strong and difficult to break. Alkanes burn in excess oxygen to produce carbon dioxide and water.

Alkenes

General formula – C_nH_{2n} (where n is the number of carbon atoms)

Alkenes have the C=C functional group.

Name	No of carbon atoms	Molecular Formula C_nH_{2n}	Structural formula	State at room temperature
ethene	2	C_2H_4		Gas
propene	3	C_3H_6		Gas
but-1-ene	4	C_4H_8		Gas
but-2-ene	4	C_4H_8		Gas

Physical Properties of alkenes

- The alkenes shown above are all gases at room temperature.
- The boiling points increase as the chains get longer.
- Alkenes are insoluble in water and liquid alkenes are immiscible with water.

Chemical Properties

Each carbon in an alkene molecule forms four bonds with the atoms around it. All alkenes contain a carbon – carbon double bond, C=C. This bond is said to be unsaturated. An unsaturated hydrocarbon is a compound which contains only carbon and hydrogen atoms and has a carbon – carbon double bond. They do not have the maximum number of hydrogen atoms attached to the carbon atoms. A C=C double bond is reactive. Alkenes burn in excess oxygen to produce carbon dioxide and water.

One of the C=C bonds can easily be broken, and the two carbons can form new single bonds to other atoms. So alkenes can undergo addition reactions.

1. Reaction of Ethene with steam

This reaction is used to produce ethanol which is generally used as an industrial solvent. When water (as steam) adds to the double bond of an alkene, it is called an addition reaction.

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$$

ethene + steam → ethanol

2. Addition reaction between ethene and bromine water

Like steam, bromine adds to the double bond of alkenes. You can tell the difference between an alkane and an alkene by reacting them with bromine water. The bromine water can be added to a liquid alkane or alkene in a test tube or gaseous alkanes / alkenes can be bubbled through bromine water for this reaction to take place.

Left – Alkane with bromine water remains orange/brown
Right – Alkene with bromine water turns from orange/brown to colourless

3. Reaction of ethene with hydrogen

Hydrogen adds to the double bond of alkenes as well. There is only one product which is the corresponding alkane.

$$\text{ethene} + \text{hydrogen} \rightarrow \text{ethane}$$

$$C_2H_4 + H_2 \rightarrow C_2H_6$$

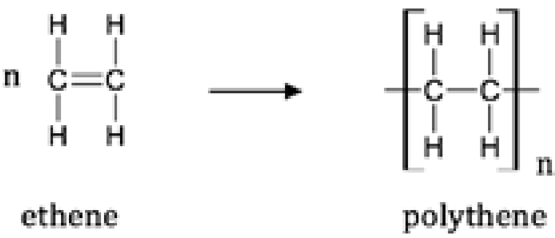
Addition Polymerisation

One of the most important reactions of alkenes is polymerisation. A polymer is formed from lots of small alkene molecules joined together. These small molecules are known as **monomers**. Monomers join together to make polymers. Alkenes can do this reaction because of the C=C double bond.

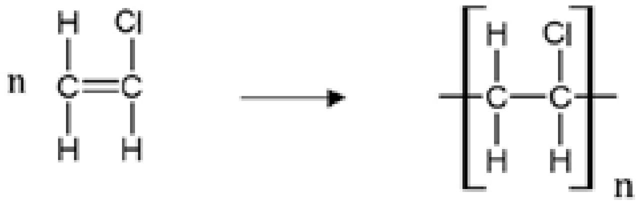
Chemists use the name polythene to describe a molecule that has been made from many ethene molecules chemically joined or added together in a long chain molecule – polymer. A reaction that is used to produce polythene from ethene is called **addition polymerisation**.

Ethene and propene are two of the most important chemicals in the petrochemical industry because they react with many different substances to give a variety of useful chemicals, including polythene and polypropene. Plastics such as polythene, PVC, polystyrene and polypropylene are polymers.

Equation for the addition polymerisation of ethene, where n represents a (very) large number.

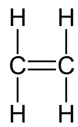
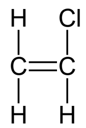


Equation for the addition polymerisation of chloroethene, where n represents a (very) large number.



chloroethene (also known as vinyl chloride) → PVC poly vinyl chloride

Properties of Polymers

Polymer	State	Monomer	Properties	Uses
Polythene	**solid**		Light, flexible and resistant to attack by acids and alkalis	Plastic bags, cling film, cutlery, bottles and basins
PVC	**solid**		Tough, durable, waterproof and a good insulator	Electrical cables, guttering, drain pipes, window and door frames

Polymers and pollution

Most synthetic materials like plastics are non-biodegradable. In other words, they do not decompose or decay naturally because bacteria cannot break them down. If you throw away plastic bags, bottles etc. can cause severe litter problems. As plastics are relatively cheap people tend not to recycle them adding to the filling up of landfill sites and all the problems that causes.

Incineration schemes burn waste plastics and the heat generated can be made to serve useful purposes, either directly or indirectly to generate power. However, burning plastics produces a large amount of very poisonous / toxic gases and these have to be removed before any waste gases can be released into the atmosphere. As a result, recycling of plastic waste is becoming more and more popular.

Polymer Disposal

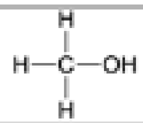
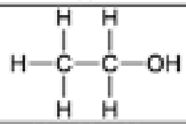
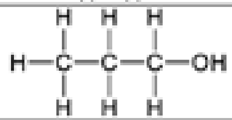
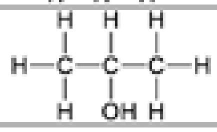
Addition polymers are **non-biodegradable**. This means they are not broken down naturally and therefore require disposal. The methods by which they can be disposed are through incineration or by using landfill. There are advantages and disadvantages to both methods.

Method	Advantages	Disadvantages
Landfill	• No greenhouse or toxic gases produced. • Inexpensive	• Wastes land • Visual eyesore
Incineration	• Heat generated can be used • No land wasted	• Greenhouse gases produced. • Poisonous gases given off (carbon monoxide, hydrogen chloride and hydrogen cyanide) • Expensive

Recycling of the plastics is an alternative way to managing the waste. It is an expensive process but it reduces the environmental concerns associated with landfill and incineration. The production of more biodegradable polymers will be important for the future.

Alcohols

Alcohols are another family or homologous series of organic compounds. All alcohols contain the -OH functional group and have the general formula $\mathbf{C_nH_{2n+1}OH}$.

Name	No of carbon atoms	Molecular Formula	Structural formula	State at room temperature
methanol	1	CH_3OH		liquid
ethanol	2	C_2H_5OH		liquid
propan-1-ol	3	C_3H_7OH		liquid
propan-2-ol	3	C_3H_7OH		liquid

Physical Properties of Alcohols

The two simplest alcohols are methanol and ethanol. Both are liquids at room temperature. Ethanol is the best known of all alcohols. In fact, it is often just called "**alcohol**". It is a good **solvent**, dissolving many things that are insoluble in water and is used in perfumes and aftershaves.

Ethanol is the substance in beer, wine etc .that makes people drunk. It can also be used as a **fuel**. Cars in some countries use ethanol instead of petrol and many camping stoves use methylated spirits as a fuel which is mainly ethanol.

The Production of Ethanol

1. Hydration of ethene (with steam)

2. Fermentation (or anaerobic respiration) – the ethanol produced is for use in alcoholic drinks. If yeast is added to a sugar solution and left in warm conditions, enzymes in the yeast will change the sugar to alcohol and carbon dioxide.

Combustion of fuels

Complete combustion of alkanes, alkenes and alcohols produces carbon dioxide, water and releases heat.

Alkanes

ethane + oxygen ⟶ carbon dioxide + water

$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

Alkenes

ethene + oxygen → carbon dioxide + water

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

Alcohols

ethanol + oxygen → carbon dioxide + water

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

Incomplete combustion of alkanes, alkenes and alcohols produces carbon monoxide, water and sometimes carbon (soot) and heat is released.

Oxidation of alcohols

Alcohols can be oxidised to carboxylic acids when in contact with the air. When wine is left sitting overnight the ethanol in the wine is oxidised to ethanoic acid which is more commonly known as vinegar. Alcohols can also be oxidised using acidified potassium dichromate solution. In this reaction the orange potassium dichromate will turn green.

Colour change that accompanies the oxidation of an alcohol by potassium dichromate solution. The orange acidified potassium dichromate solution (left) changes to green (right) as oxidation of the alcohol occurs.

Methanol is oxidised to methanoic acid, ethanol is oxidised to ethanoic acid and propan-1-ol is oxidised to propanoic acid. Propan-2-ol is oxidised but the name and structure of the product are not required. All react when warmed with acidified potassium dichromate solution and the solution changes from orange to green.

Pollution caused from combustion of fuels

1. Carbon dioxide

Some gases in the atmosphere act like the glass in a greenhouse – the gas forms a "blanket" around the earth. This is called the **greenhouse effect**. Scientists are worried that the atmosphere is gradually warming up (**global warming**). The amounts of gases which trap the Sun's heat are increasing. The most important of these gases is carbon dioxide. Causes of the increased amounts of carbon dioxide in the atmosphere are:

- Coal, oil, petrol, wood and natural gas all contain carbon. When these fuels are burned in air carbon dioxide gas is released.
- Massive areas of forests have been cleared for development. Cutting down trees reduces the amount of carbon dioxide removed from the air for photosynthesis.

The increase in temperature caused by the greenhouse effect could have drastic effects on the world's climate. Ice caps at the poles have been melting. Heat will also cause the water in the oceans to expand. This will lead to flooding of low lying countries.

Test for Carbon dioxide

When carbon dioxide is bubbled through limewater (calcium hydroxide) the limewater changes from colourless to milky. The white precipitate formed is calcium carbonate.

carbon dioxide + calcium hydroxide ⟶ water + calcium carbonate (white precipitate)

$$CO_2 + Ca(OH)_2 \longrightarrow CaCO_3 + H_2O$$

If CO_2 continues to be bubbled into the solution, the precipitate dissolves to form a colourless solution.

calcium carbonate + carbon dioxide + water ⟶ calcium hydrogencarbonate (colourless solution)

$$CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2$$

2. Carbon monoxide / soot

Carbon monoxide is a dangerous gas if inhaled because CO displaces oxygen from haemoglobin molecules in the blood, reducing its capacity to carry oxygen. It is dangerous because it has no colour or odour, therefore we are unable to detect its presence. Special carbon monoxide monitors are now available to install in homes to help protect us from carbon monoxide poisoning, which can be fatal.

Soot particles can become trapped in the lungs and cause lung damage if inhaled.

3. Sulfur impurities

Unfortunately, most fossil fuels contain some sulfur and so when they are burned, sulfur dioxide is released into the air. Sulfur dioxide is a colourless, pungent gas. It is denser than air and is soluble in water.

$$\mathbf{S + O_2 \longrightarrow O_2}$$

Sulfur dioxide gas reacts with water in the air to form sulfurous acid, which is returned to the ground in the rain.

$$\mathbf{SO_2 + H_2O \longrightarrow H_2SO_3}$$

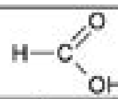
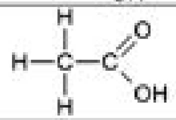
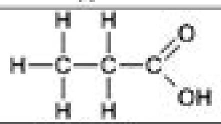
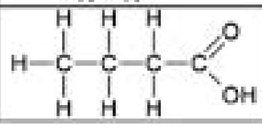
The acid rain is responsible for the corrosion of limestone and marble buildings, statues and pavements. It causes defoliation of trees (leaves fall off) and it is also responsible for killing fish in rivers, lakes and waterways.

Carboxylic Acids

Ethanoic acid is an organic acid and a member of another family of organic compounds. This homologous series is called the carboxylic acids.

Ethanoic acid has the chemical formula CH_3COOH and is a weak acid. Dilute ethanoic acid is used as a vinegar to flavor food.

Other members of this homologous series include methanoic acid, propanoic acid and butanoic acid.

Name	No of carbon atoms	Molecular Formula	Structural formula	State at room temperature
methanoic acid	1	$CHOOH$		Liquid
ethanoic acid	2	CH_3COOH		Liquid
propanoic acid	3	C_2H_5COOH		Liquid
butanoic acid	4	C_3H_7COOH		Liquid

Physical Properties of carboxylic acids

Ethanoic acid is a colourless liquid with a strong vinegary smell and sour taste. Vinegar is a solution of ethanoic acid in water. Pure ethanoic acid is a liquid. We can describe ethanoic acid as a weak acid. All carboxylic acids are weak acids as they are only partially ionised in solution.

Naming carboxylic acid salts

The metal part of the name comes first followed by the type of salt produced by the acid.

Carboxylic acid	Name of salt	Anion
methanoic acid	methanoate	$HCOO^-$
ethanoic acid	ethanoate	CH_3COO^-
propanoic acid	propanoate	$C_2H_5COO^-$
butanoic acid	butanoate	$C_3H_7COO^-$

Chemical Reactions

Carboxylic acids react like other acids as shown below.

1. With metals:

acid + metal → salt + hydrogen

For example magnesium and ethanoic acid:
magnesium + ethanoic acid → magnesium ethanoate + hydrogen
$Mg + 2C_2H_5COOH \rightarrow (C_2H_5COO)_2Mg + H_2$

zinc + propanoic acid → zinc propanoate + hydrogen
For example zinc and propanoic acid:
$Zn + 2C_2H_5COOH \rightarrow (C_2H_5COO)_2Zn + H_2$

2. With bases/alkalis (metal oxide and metal hydroxides)

acid + alkali / base → salt + water

For example sodium hydroxide and methanoic acid
methanoic acid + sodium hydroxide → sodium methanoate + water
$HCOOH + NaOH \rightarrow HCOONa + H_2O$

3. With metal carbonates:

Acid + metal carbonate → salt + carbon dioxide + water

For example zinc carbonate and butanoic acid:
butanoic acid + zinc carbonate → zinc butanoate + carbon dioxide + water
$2C_3H_7COOH + ZnCO_3 \rightarrow (C_3H_7COO)_2Zn + CO_2 + H_2O$

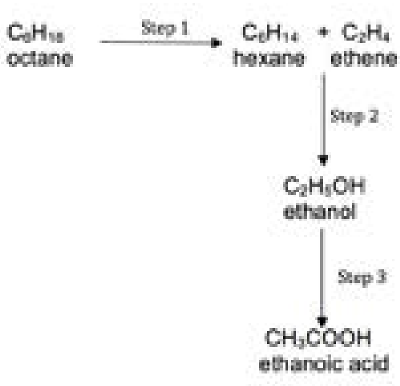
Identifying organic compounds

The table below summarises the tests that can be used to identify each of the homologous series:

Organic compound	Test	Result
Alkane	Add bromine water to the alkane and shake.	Solution remains orange/brown.
Alkene	Add bromine water to the alkene and shake.	Solution turns from orange/brown to colourless.
Alcohol	Add acidified potassium dichromate to the alcohol and gently warm in a water bath.	Solution turns from orange to green.
Carboxylic acid	Add a metal carbonate to the carboxylic acid and bubble any gas produced through limewater.	The solution will fizz and the limewater will turn milky.

REVISION QUESTIONS

1. Ethanoic acid belongs to the homologous series known as the carboxylic acids and can be manufactured as shown in the following scheme:



(a) Explain what is meant by the term “homologous series”.

____

____

____ [2]

b) Ethanoic acid is a weak acid. Draw the structural formula of ethanoic acid clearly showing **all** the bonds in the molecule.

[1]

(c) What is the name of the **type** of reaction taking place in step 1 where a large hydrocarbon molecule is broken down into more useful, smaller molecules?

____ [1]

(d) Step 2 is known as the "hydration of ethene".

(i) Write a balanced symbol equation to show the formation of ethanol from ethene in step 2.

____ [2]

(ii) Name another important commercial method of producing ethanol.

____ [1]

(iii) Write a balanced symbol equation to show the complete combustion of ethanol in oxygen.

____ [3]

(iv) Ethanol is an important fuel in some countries. Give two other important uses of ethanol.

1. ____

2. ____ [2]

(ii) Describe two things you would observe if some magnesium carbonate was added to a solution of ethanoic acid.

1. ____

2. ____ [2]

(iii) Complete the word equation for the reaction between magnesium carbonate and ethanoic acid.

magnesium carbonate + ethanoic acid → + + carbon dioxide

[2]

2. Propane and ethene are important industrial organic chemicals which can be obtained from the cracking of pentane as shown below.

$$C_5H_{12} \longrightarrow C_3H_8 + C_2H_4$$

pentane ⟶ propane + ethene

(i) Name the homologous series to which propane belongs.

____ [1]

(ii) What is meant by cracking?

____

____ [2]

(iii) Draw the structural formulae of propane and ethene.

propane ethene

[2]

(iv) Describe a chemical test which you could use to distinguish between propane and ethene.

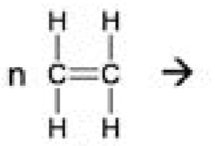
____

____

____ [3]

3. Ethene is used to make ethanol and addition polymers such as polythene.

(i) Complete the equation to show how polythene is made from ethene.



ethene polythene

[2]

The table below gives information about some of the hydrocarbon fuels obtained by fractional distillation of crude oil.

Fuel	**Boiling range (°C)**	**Number of carbon atoms In each molecule**
Petroleum gas	Below 25	1–4
Petrol	40–100	4–12
Kerosene	150–240	9–16
Diesel	220–250	15–25

(ii) What is a hydrocarbon?

____

____ [1]

(iii) The fuels listed above are all fossil fuels. Give one other example of a fossil fuel.

____ [1]

(iv) Explain how the different fuels are separated from each other by fractional distillation.

____

____ [2]

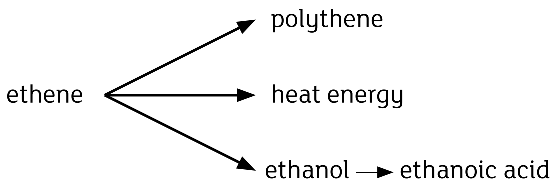
(v) What is the name of the process used to break up long chain molecules in order to form more useful shorter chain molecules?

____ [1]

(vi) Ethene and propene are unsaturated hydrocarbons which belong to the same homologous series. Name the homologous series to which ethene and propene belong.

____ [1]

4. Ethene is a very useful chemical which can be burned as a fuel or used in the manufacture of polythene and ethanol.



(i) Give **two** uses of polythene.

______________________________ and ______________________________ [2]

(ii) What type of reaction is represented by: ethene → polythene?

____ [1]

(iii) Heat energy is produced when ethene burns in air.
Write a balanced symbol equation for the complete combustion of ethene.

____ [3]

(iv) Crude oil is a source of compounds called alkanes. Name the first member of the alkanes and draw its structural formula.

Name: ______________________________

Structural formula:

[2]

(v) Alkanes can be used as fuels. Write a balanced chemical equation for the complete combustion of propane, C_3H_8

____ [3]

5. Give the molecular and structural formula of the alkene, propene.

molecular formula: structural formula:

[2]

(i) Petrol is a fossil fuel, obtained from crude oil by fractional distillation. Name the element which all fossil fuels contain.

____ [1]

(ii) Why can petrol be described as a non-renewable energy source?

____

____ [1]

(iii) Give two other examples of non-renewable energy sources.

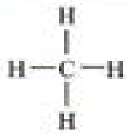
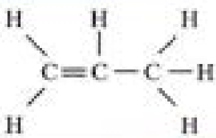
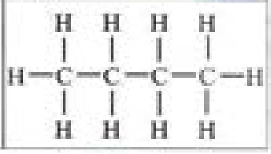
__________________________ and __________________________ [2]

(iv) Explain how petrol is separated from the other fractions in crude oil by distillation.

____

____ [2]

(v) Complete the table below which gives information about some alkanes and alkenes.

Name	Molecular formula	Structural formula
Methane	CH_4	
Ethene	C_2H_4	
	C_3H_6	
Butane		

[3]

(vi) Ethanol, C_2H_5OH, is an alternative fuel to petrol. Give **one other** use of ethanol.

____ [1]

(ii) Draw the structural formula of ethanol.

[1]