KNOWLEDGE — Chemistry Topic C7 Organic Chemistry — ORGANISER

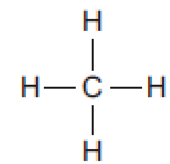
Section 1: Key terms

	A **mixture** of **hydrocarbons** formed over **millions of years** from dead **plankton** subjected to **high pressure & temperature**.
Hydrocarbon	.
Alkane	A **hydrocarbon** containing only _________ **bonds**. Follows the formula C_nH_{2n+2}.
Fractional distillation	The method of **separating hydrocarbons** based on their ________________ _________________________________
Fraction	A fraction contains **similar length** ________________with a **small range of boiling points**.
Intermolecular force	**Weak forces of attraction** that exist between **molecules.**
	The temperature at which a **liquid** turns into a **gas**.
Viscosity	
	The tendency to turn into a gas
	How easily a substance **burns** or **ignites**.
	A **reaction** between a **fuel** and **oxygen** that produces **heat**.
Complete combustion	
	Combustion in **inadequate oxygen**. Incomplete combustion of a hydrocarbon produces **water** and **carbon monoxide or carbon particulates**.
	A **hydrocarbon** containing at least one **double bond**. They follow the formula C_nH_{2n}. Used to make **polymers**.
	A chemical that is **brown/orange** in colour. If added to an **alkene** it reacts and changes to **colourless**. Alkanes do not react hence do not produce a change in colour.
	The process by which less-useful **long-chain hydrocarbons** are **split** to produce an **alkane** and an **alkene**.
Catalyst	

Section 2: Alkanes

Most of the hydrocarbons in crude oil are alkanes. The general formula of an alkane is C_nH_{2n+2} The alkanes are **saturated hydrocarbons** with all the **carbon-carbon bonds** being **single covalent bonds**.

Prefix	Number of carbon atoms
Meth-	1
	2
	3
But-	



Methane CH_4

Ethane C_2H_6

Propane C_3H_8

Butane C_4H_{10}

Section 3: The properties of the alkanes

Boiling points	Alkanes have ______**boiling points** (the first four alkanes are gases at room temp.) Between these simple molecules are _____ **intermolecular forces** of attraction which **don't require much energy** to overcome.
Viscosity	Longer chain alkanes are _____ **viscous** because they have _________ **intermolecular forces** and stick together more making them thicker liquids.
Volatility	**Shorter chain** alkanes are _____ **volatile** than larger chain alkanes because they **have** _______ **forces of attraction** between their molecules than longer chain
Flammability	Flammability ___________ with **chain length** because more oxygen is needed for combustion (burning) so they don't burn as well.

KNOWLEDGE

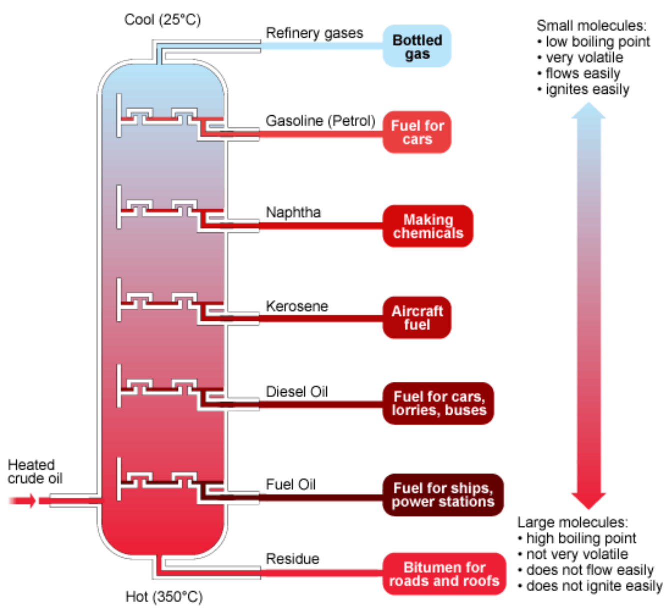
Chemistry Topic C7
Organic Chemistry

ORGANISER

Section 4: Fractional distillation of oil

Crude oil is separated into hydrocarbons with similar boiling points. Each hydrocarbon fraction contains molecules with similar numbers of carbons.

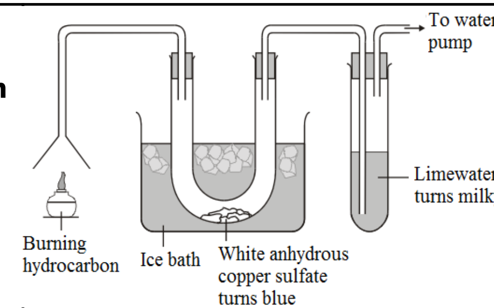
- The crude oil is **heated** to about 370°C and fed into bottom of a fractionating column.
- The fractionating column is hottest at the bottom & coolest at the top.
- Most fractions **evaporate** and become **vapours**. The residue (heavier long chain molecules) doesn't boil & flows to the bottom of the column.
- Hot vapours (shorter chain molecules) **rise** up the column & **cool down**.
- When the vapours **cool** to their **boiling point** they **condense** and flow out of the column.
- Those with **lower boiling points rise further** before cooling down.
- Refinery gases do not cool down to their boiling point so **remain as gases**.
- Large chain fractions are cracked producing smaller more useful fuels.



Section 5: Burning hydrocarbon fuels

Obtained from the **fractional distillation and cracking** of crude oil.
The combustion of hydrocarbon **fuels releases energy**.
During combustion, the carbon and hydrogen in the fuels are **oxidised.**
Complete combustion – alkanes will burn in oxygen to produce carbon dioxide and water. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
Incomplete combustion – when there is **not enough oxygen**, **carbon monoxide and carbon particulates** also form.

You can **test the products** given off when a **hydrocarbon burns** using the apparatus opposite. As well as using anhydrous copper sulfate, you can also use **blue cobalt chloride paper** which turns **pink** when water is present.

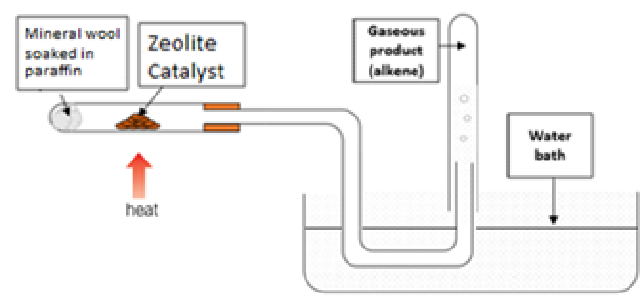


Section 6: Cracking

Cracking – breaks long chain hydrocarbons into more useful shorter chain hydrocarbons. Cracking can be done by either catalytic cracking or steam cracking. Cracking can also be described as a **thermal decomposition**.

Method	Process	Temperature
Catalytic Cracking	passed over a hot zeolite catalyst	**500°C.**
Steam Cracking	mixed with steam and heated to a very high temperature.	**850°C.**

e.g. Cracking of Decane. $C_{10}H_{22} \rightarrow C_5H_{12} + C_3H_6 + C_2H_4$



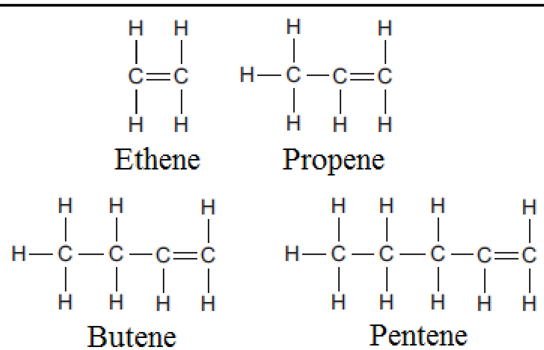
KNOWLEDGE | Chemistry Topic C7 Organic Chemistry (triple) | ORGANISER

Section 1: Key terms

Functional group	An atom or group of atoms that give organic compounds their characteristic reactions.
Homologous series	Family of organic compounds with the same functional group.
Double bond	A covalent bond made by the sharing of two pairs of electrons.
Unsaturated hydrocarbon	A hydrocarbon whose molecule contains at least one carbon-carbon double bond.
Alkene	A **hydrocarbon** containing at least one **double bond**. They follow the formula $\mathbf{C_nH_{2n}}$. Used to make **polymers**.
Bromine water	A chemical that is **brown/orange** in colour. If added to an **alkene** it reacts and changes to **colourless**. Alkanes do not produce a change in colour.
Addition	two molecules add together to form a single product with 100% atom economy.
Oxidising agent	A substance that has the ability to oxidise other substances. Its symbol is [O]

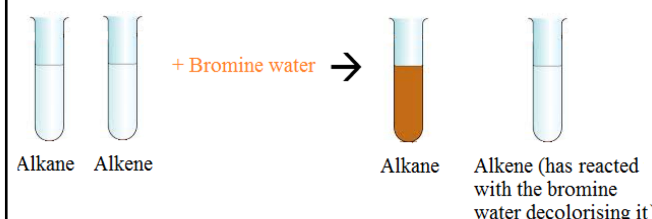
Section 2a: Structure of Alkenes

Alkenes are unsaturated hydrocarbons. The general formula of the alkenes containing one double bond is $\mathbf{C_nH_{2n}}$



Section2b: Reactions of the alkenes

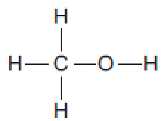
It is the **C=C double bond** that makes the **alkenes far more reactive than the alkanes**. Alkenes will react with hydrogen, water (steam) and the halogens, by addition of atoms across the C=C double bond so that the double bond becomes a single carbon-carbon bond.

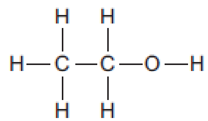
Combustion	Alkenes will burn in oxygen to produce carbon dioxide and water. $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ **Alkenes release less energy** per mole in combustion **than alkanes** hence the **alkanes tend to be used as fuels**, whereas the alkenes are not.
Reaction with halogens	Ethene reacts with bromine to form dibromoethane in an **addition** reaction. $CH_2{=}CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$ When you test ethene with **orange bromine water** it turns the bromine water from orange to colourless.  The alkenes also react in a similar way with the other halogens, chlorine and iodine.
Reaction with hydrogen	Alkenes **reacts with hydrogen** in the presence of a **nickel catalyst** at a temperature of about 150°C to **produce an alkane**. $C_2H_4 + H_2 \rightarrow C_2H_6$ This reaction is used to add hydrogen across double bonds in unsaturated oils making margarine.
Reaction with water (steam)	Ethene **reacts with steam** in the presence of a **catalyst** to make ethanol. $C_2H_4 + H_2O \rightleftharpoons C_2H_5OH$ The reaction also requires heat and high pressure. The reaction is **reversible** so unreacted steam and ethane are recycled over the catalyst.

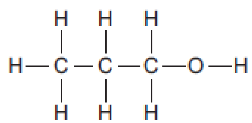
KNOWLEDGE — Chemistry Topic C7 Organic Chemistry (triple) — ORGANISER

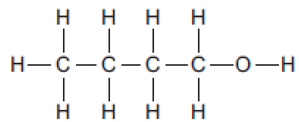
Section 3a : Structure of Alcohols

Alcohols contain the -OH functional group.


Methanol


Ethanol


Propanol


Butanol

Section 3b: Reactions of the alcohols

Combustion	Alcohols are **flammable** and will burn in oxygen with a **clean blue flame** to produce **carbon dioxide** and **water**. $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
With sodium	React with sodium metal to produce a solution **of sodium alkoxide and hydrogen gas.** $2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2$ If sodium ethoxide, or any other sodium alkoxide is dissolved in water, **effervescence (bubbles)** are observed and you get a **strongly alkaline solution**.
Oxidation	Combustion is one way to oxidise an alcohol, however you can also oxide an alcohol using an **oxidizing agent** such as **potassium dichromate**. An alcohol is oxidized to a **carboxylic acid** when boiled with **acidified** potassium dichromate. $C_2H_5OH + 2[O] \rightarrow CH_3COOH + H_2O$
With water	Alcohols dissolve many of the same substances as water. They also dissolves some organic compounds that water cannot, making them **excellent solvents**. The first four alcohols dissolve well with water making a neutral solution.

Section 3c: Uses of alcohols

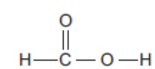
Alcohols are used as solvents in products such as perfumes, aftershaves and mouthwashes. Ethanol is the main alcohol in alcoholic drinks. Ethanol is also used in spirit burners and as a fuel, for e.g. as a biofuel in cars.

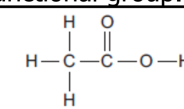
Section 3d: Manufacture of ethanol

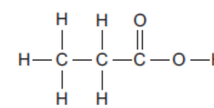
Fermentation	Ethanol is made by **fermenting sugars** from plant material with **yeast**. The reaction is typically carried out between **20-30˚C**. $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ All equipment must be **sterile** at the start. It also has to be carried out under **anaerobic (without air)** conditions, otherwise the ethanol would react with oxygen and turn into vinegar. Ethanol made by fermentation is termed a **biofuel.**
From ethene	Ethanol can also be made from reacting ethene (obtained from cracking of crude oil) and steam in the presence of a catalyst. This method uses up crude oil, a non renewable resource.

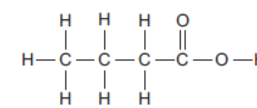
Section 4a : Structure of Carboxylic acids

Carboxylic acids contain the -COOH functional group.


Methanoic acid


Ethanoic acid


Propanoic acid


Butanoic acid

Section 4b : Reactions of Carboxylic acids

With metal carbonates	Forms a salt, water and carbon dioxide $2CH_3COOH + Na_2CO_3 \rightleftharpoons 2CH_3COONa + H_2O + CO_2$ Effervescence (bubbles) observed as $CO_{2(g)}$ forms
In water (HT)	Aqueous solutions of carboxylic acids are **weak acids** & only **partially ionise** (have higher pH than strong acids of same concentration). $CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$
With alcohols	**Esters** are formed. **A sulfuric acid catalyst** is required. $CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$ In this reaction, the ester **ethyl ethanoate** forms. Esters are **sweet/fruity smelling** & used in perfumes & food flavourings.

KNOWLEDGE

Chemistry Topic C7
Organic Chemistry (triple)

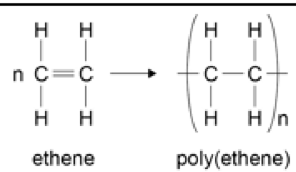
ORGANISER

Section 1: Key terms

Polymer	**Very large covalently bonded** molecules with **many repeating units** (poly means many).
Monomer	**Small reactive molecules** which join together to make a polymer (mono means one).
Plastics	Made of very large covalently bonded molecules called polymers
Addition polymerisation	The reaction between **alkene monomers** to form a polymer
Condensation polymerisation	Usually involves a **small molecule released** in the reaction (like **water or HCl**), as the polymer forms.
Monosaccharide	Simple **carbohydrates** made from **one sugar unit** e.g. glucose.
Polysaccharide	A polymer made from monosaccharide monomers e.g. starch or cellulose).
Protein	Polymers of **amino acids**
DNA	**D**eoxyribo**n**ucleic **a**cid is made up from monomers called **nucleotides**
Nucleotides	**Monomers** used to make DNA. There are four different types that can react to form DNA polymers.

Section 2: Addition polymerisation

One of the most important ways that chemicals from crude oil are used is to make polymers. Alkenes can be used to make polymers such as poly(ethene) and poly(propene) by addition polymerisation.

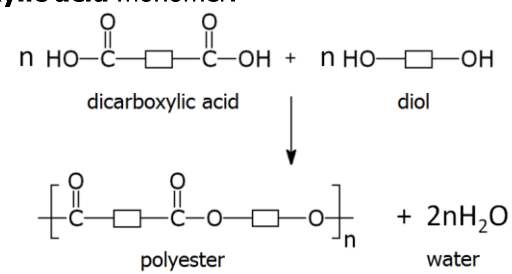
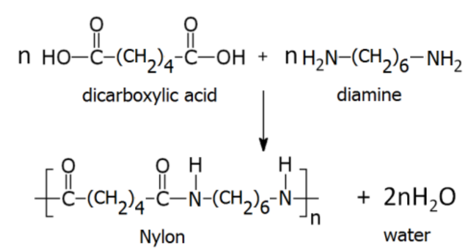
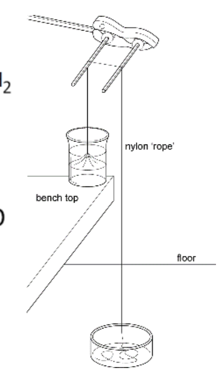


In addition polymers the repeating unit has the **same atoms as the monomer** because when the C=C bond "**opens up**" in polymerisation, **no other molecule** is formed in the reaction.

Uses	**Polyethene** is very useful as it is strong, transparent and easily shaped. Used to make drinks bottles, washing up bowls, dustbins and cling film. **Polypropene** forms a very strong tough plastic. Used to make carpets, milk crates and ropes.

Section 3: Condensation polymerisation (HT)

As well as addition polymerisation (which requires monomers with a C=C), chemists can also make polymers from another type of reaction called **condensation polymerisation.**
Condensation polymerisation involves monomers with **two functional groups.** When these types of monomers join together, they usually lose small molecules such as water or HCl, and so the reactions are called condensation reactions. Two products are usually formed.

Examples	Polyester (used to make clothing) and nylon (used to make rope and stockings).
Forming a polyester	Requires an **diol (dialcohol)** monomer and a **dicarboxylic acid** monomer. 
Forming nylon	Requires a **diamine** monomer and a **dicarboxylic** acid monomer.   Nylon thread can be made using the apparatus shown in the diagram

KNOWLEDGE — Chemistry Topic C7 Organic Chemistry (triple) — ORGANISER

Section 4: Natural polymers

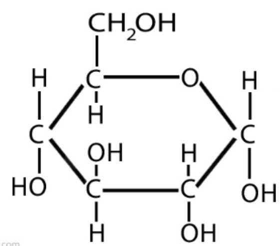
Naturally occurring polymers are found in all living things (e.g. polymers that make up starch, cellulose, proteins and DNA. They are formed during **condensation polymerisation** reactions.

Section 4a: Making polysaccharides from sugars

Simple carbohydrates (monosaccharides) are compounds containing carbon, hydrogen and oxygen e.g. glucose $C_6H_{12}O_6$

Monosaccharides can bond together to make polymers (polysaccharides). **Starch and cellulose are polysaccharides** made from **glucose** monomers. Plants use the starch they make from glucose as energy stores.

Glucose monomers → Starch polymer + water



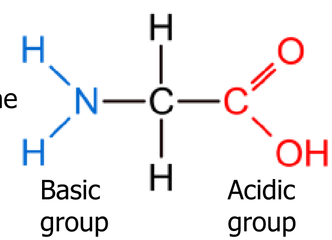
Glucose

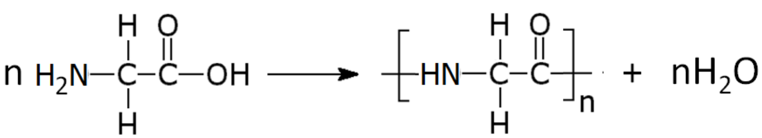
Section 4b: Making polypeptides and proteins from amino acids. (HT)

The monomers of proteins are called **amino acids**. Amino acids have **two functional groups**, one basic (the amine group – NH_2) and one acidic (carboxylic acid group -COOH). The simplest amino acid is glycine.

Many more glycine monomers can link together form a polypeptide molecule. There are about 20 amino acids that join together in a variety of sequences that make up more than 1000 proteins in your body.

Glycine

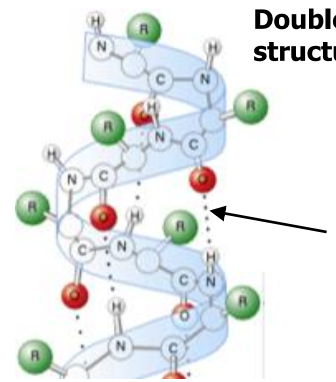




Glycine Polypeptide water

Section 5: DNA

DNA (**d**eoxyribo**n**ucleic **a**cid) is a natural polymer **essential for life** because it enables living things to develop and function. It is made up from monomers called **nucleotides**. DNA's structure contains a **genetic code** that determines the different **amino acid sequences** of every protein in living organisms and viruses.

Nucleotide	Based on the sugar **deoxyribose**, bonded to a phosphate group and a base.
How is DNA made	By the condensation polymerisation of repeating units of nucleotide monomers. DNA is a **polynucleotide**.
Structure of DNA	Most DNA molecules are **two polymer chains**, made from **four different nucleotide** monomers, in the form of a **double helix**. The two polymer strands run in opposite directions to each other and are held in place by the **intermolecular forces** down the length of each polymer strand. **Double helix structure of DNA**  Intermolecular forces There are **four different nucleotide** monomers that can react to form DNA polymers.