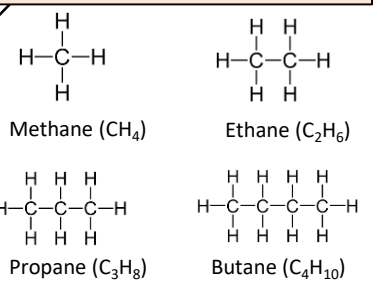
Trilogy Chemistry Organic Chemistry Topic 7

Carbon compounds as fuels and feedstock

Crude oil, hydrocarbons and alkanes

Crude oil	***A finite resource***	Consisting mainly of plankton that was buried in the mud, crude oil is the remains of ancient biomass.
Hydrocarbons	***These make up the majority of the compounds in crude oil***	Compounds containing hydrogen and carbon atoms only. Most of these hydrocarbons are called alkanes.
General formula for alkanes	C_nH_{2n+2}	For example: C_2H_6 C_6H_{14}

Display formula for first four alkanes



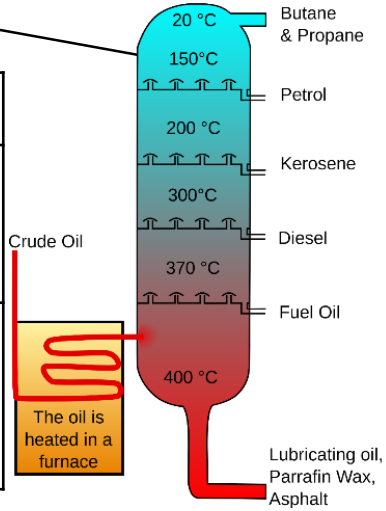
Fractional distillation and petrochemicals

Fractions	***The hydrocarbons in crude oil can be split into fractions***	Each fraction contains molecules with a similar number of carbon atoms in them. The process used to do this is called fractional distillation.
Using fractions	***Fractions can be processed to produce fuels and feedstock for petrochemical industry***	We depend on many of these fuels; petrol, diesel and kerosene. Many useful materials are made by the petrochemical industry; solvents, lubricants and polymers.

Hydrocarbon chains

In oil	Hydrocarbon chains in crude oil come in lots of different lengths.
Boiling points	The boiling point of the chain depends on its length. During fractional distillation, they boil and separate at different temperatures due to this.

During fractional distillation, the crude oil is heated until it ***evaporates***. The vapours rise up the tower, where fractions ***condense*** at their different boiling points. The long chains condense at the bottom of the column, the shorter chains condense near the top.



Cracking and alkenes

Alkanes to alkenes	***Long chain alkanes are cracked into short chain alkenes.***
Alkenes	***Alkenes are hydrocarbons with a double bond (some are formed during the cracking process).***
Properties of alkenes	***Alkenes are more reactive that alkanes and react with bromine water. Bromine water changes from orange to colourless in the presence of alkenes.***

Cracking	***The breaking down of long chain hydrocarbons into smaller chains***	The smaller chains are more useful. Cracking can be done by various methods including catalytic cracking and steam cracking.
Catalytic cracking	***The heavy fraction is heated until vaporised***	After vaporisation, the vapour is passed over a hot catalyst forming smaller, more useful hydrocarbons.
Steam cracking	***The heavy fraction is heated until vaporised***	After vaporisation, the vapour is mixed with steam and heated to a very high temperature forming smaller, more useful hydrocarbons.

Cracking general equation:

Long chain alkane → shorter chain alkane + alkene

E.g. Decane → hexane + butene

$C_{10}H_{22}$ → C_6H_{14} + C_4H_8

Properties of hydrocarbons

Combustion	During the complete combustion of hydrocarbons, the carbon and hydrogen in the fuels are oxidised, releasing carbon dioxide, water and energy.

Example: complete combustion of methane:

Methane + oxygen → carbon dioxide + water

CH_4 (g) + $2O_2$ (g) → CO_2 (g) + $2H_2O$ (l)

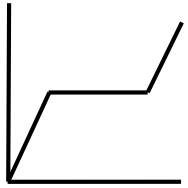
Boiling point (temperature at which liquid boils)	***As the hydrocarbon chain length increases, boiling point increases.***
Viscosity (how easily it flows)	***As the hydrocarbon chain length increases, viscosity increases.***
Flammability (how easily it burns)	***As the hydrocarbon chain length increases, flammability decreases.***

Alkenes and uses as polymers	***Used to produce polymers. They are also used as the starting materials of many other chemicals, such as alcohol, plastics and detergents.***
Why do we crack long chains?	***Without cracking, many of the long hydrocarbons would be wasted as there is not much demand for these as for the shorter chains.***

Topic 8 Chemical Analysis

Pure substances

Pure substances	***A pure substances is a single element or compound, not mixed with any other substance.***	Pure substances melt and boil at specific temperatures. Heating graphs can be used to distinguish pure substances from impure.



Melting point of a <u>pure substance</u> – melt and boil at fixed temperatures

Melting point of an <u>impure substance</u> – do not have a fixed melting or boiling point

Formulations

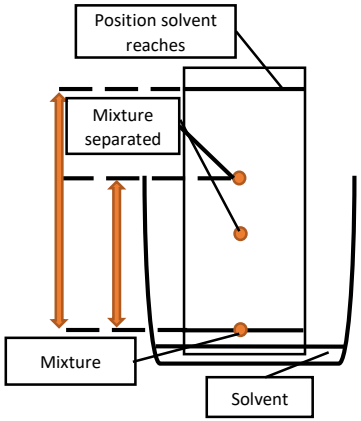
Formulation	***A formulation is a mixture that has been designed as a useful product.***
How are formulations made?	***By mixing chemicals that have a particular purpose in careful quantities.***
Examples of formulations.	***Fuels, cleaning agents, paints, medicines and fertilisers.***

Identification of common gases

Gas	Test	Positive result
Hydrogen	***Burning splint***	'Pop' sound.
Oxygen	***Glowing splint***	Re-lights the splint.
Chlorine	***Litmus paper (damp)***	Bleaches the paper white.
Carbon dioxide	***Limewater***	Goes cloudy (as a solid calcium carbonate forms).

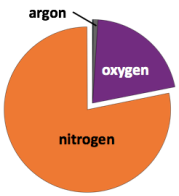
Chromatography

Chromatography	***Can be used to separate mixtures and help identify substances.***	Involves a mobile phase (e.g. water or ethanol) and a stationary phase (e.g. chromatography paper).
R_f Values	***The ratio of the distance moved by a compound to the distance moved by solvent.***	$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$
Pure substances	***The compounds in a mixture separate into different spots.***	This depends on the solvent used. A pure substance will produce a single spot in all solvents whereas an impure substance will produce multiple spots.



Trilogy Higher Chemistry of the atmosphere Topic 9

Composition and evolution of the atmosphere



Proportions of gases in the atmosphere

Gas	Percentage
Nitrogen	~80%
Oxygen	~20%
Argon	0.93%
Carbon dioxide	0.04%

How oxygen increased

Algae and plants	These produced the oxygen that is now in the atmosphere, through photosynthesis.	carbon dioxide + water → glucose + oxygen $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
Oxygen in the atmosphere	First produced by algae 2.7 billion years ago.	Over the next billion years plants evolved to gradually produce more oxygen. This gradually increased to a level that enabled animals to evolve.

The Earth's early atmosphere

Volcano activity 1st Billion years	Billions of years ago there was intense volcanic activity	This released gases (mainly CO_2) that formed to early atmosphere and water vapour that condensed to form the oceans.
Other gases	Released from volcanic eruptions	Nitrogen was also released, gradually building up in the atmosphere. Small proportions of ammonia and methane also produced.
Reducing carbon dioxide in the atmosphere	When the oceans formed, carbon dioxide dissolved into it	This formed carbonate precipitates, forming sediments. This reduced the levels of carbon dioxide in the atmosphere.

How carbon dioxide decreased

Reducing carbon dioxide in the atmosphere	Algae and plants	These gradually reduced the carbon dioxide levels in the atmosphere by absorbing it for photosynthesis.
Formation of sedimentary rocks and fossil fuels	These are made out of the remains of biological matter, formed over millions of years	Remains of biomass which fell to the bottom of oceans. Over millions of years layers of sediment settled on top of them and the huge pressures turned them into coal, oil, natural gas and sedimentary rocks. The sedimentary rocks contains "locked up" carbon dioxide from the biological matter.

Common atmospheric pollutants

Atmospheric pollutants from fuels

Properties and effects of atmospheric pollutants

carbon monoxide	incomplete combustion	Toxic, colourless and odourless gas. Not easily detected, can kill.
sulfur dioxide	sulfur impurities in fuel	Cause respiratory problems in humans and acid rain which affects the environment.
oxides of nitrogen	nitrogen and oxygen in the air react at high temperatures in the engine	Cause respiratory problems in humans and acid rain which affects the environment.
carbon dioxide	complete combustion	Global warming
particulates (of carbon)	incomplete combustion	Cause global dimming and health problems in humans.

CO_2 and methane as greenhouse gases

Greenhouse gases

Carbon dioxide, water vapour and methane	Examples of greenhouse gases that maintain temperatures on Earth in order to support life
The greenhouse effect	Radiation from the Sun enters the Earth's atmosphere and reflects off of the Earth. Some of this radiation is re-radiated back by the atmosphere to the Earth, warming up the global temperature.

Carbon footprints

The total amount of greenhouse gases emitted over the full life cycle of a product/event. This can be reduced by reducing emissions of carbon dioxide and methane.

Global climate change

Effects of climate change

- Rising sea levels
- Extreme weather events such as severe storms
- Change in amount and distribution of rainfall
- Changes to distribution of wildlife species with some becoming extinct

Human activities and greenhouse gases

Carbon dioxide	Human activities that increase carbon dioxide levels include burning fossil fuels and deforestation.
Methane	Human activities that increase methane levels include raising livestock (for food) and using landfills (the decay of organic matter released methane).
Climate change	There is evidence to suggest that human activities will cause the Earth's atmospheric temperature to increase and cause climate change.

Trilogy Chemistry H Topic 10 Using resources 1

Using the Earth's resources and obtaining potable water

Using the Earth's resources and sustainable development

Earth's resources	*Used to provide warmth, shelter, food and transport for humans*	Natural resources and resources from agriculture provide: timber, food, clothing and fuels.
		Finite resources from the Earth, oceans and atmosphere are processed to provide energy and materials.
Chemistry and resources	*Research and techniques improve agricultural and industrial processes*	These improvements provide new products and improve sustainability.
Plastics	*Normally made using ethene from crude oil*	However, the raw material ethene can also be obtained from ethanol, which can be produced during fermentation. Industries are now starting to use a renewable crop for this process.

Potable water

Potable water	*Water of an appropriate quality is essential for life and contains low levels of dissolved compounds so it is safe to drink.*	Human drinking water should have low levels of dissolved salts and microbes. This is called potable water.
UK water	*Rain provides water with low levels of dissolved substances*	This water collects in the ground/lakes/rivers. To make potable water an appropriate source is chosen, which is then passed through filter beds and then sterilised.
Desalination	*Needs to occur is fresh water is limited and salty/sea water is needed f*	This can be achieved by distillation or by using large membranes e.g. reverse osmosis. These processes arge amounts of energy.

Sterilising agents include chlorine, ozone and UV light.

Waste water treatment

Waste water	*Produced from urban lifestyles and industrial processes*	These require treatment before used in the environment. Sewage needs the organic matter and harmful microbes removed.
Sewage treatment	*Includes many stages*	- Screening and grit removal - Sedimentation to produce sludge and effluent (liquid waste or sewage). - Anaerobic digestion of sludge - Aerobic biological treatment of effluent

Life cycle assessment and recycling

Life cycle assessment

LCAS	*Life cycle assessments are carried out to assess the environmental impact of products*	They are assessed at these stages: - Extraction and processing raw materials - Manufacturing and packaging - Use and operation during lifetime - Disposal
Values	*Allocating numerical values to*	Value judgments are allocated to the effects of pollutants so LCA is not a purely objective process.

Ways of reducing the use of resources

This strategy reduces the use of limited resources

Reduce, reuse and recycle		This, therefore, reduces energy sources being used, reduces waste (landfill) and reduces environmental impacts.
Limited raw materials	*Used for metals, glass, building materials, plastics and clay ceramics*	Most of the energy required for these processes comes from limited resources. Obtaining raw materials from the Earth by quarrying and mining causes environmental impacts.
Reusing and recycling	*Metals can be recycled by melting and recasting/reforming*	Glass bottles can be reused. They are crushed and melted to make different glass products. Products that cannot be reused are recycled.

Alternative methods of extracting metals (HT)

Metals ores	*These resources are limited*	Copper ores especially are becoming sparse. New ways of extracting copper from low-grade ores are being developed.
Phytomining	*Plants absorb metal compounds through their roots*	These plants are then harvested and burned; their ash contains the metal compounds. The metal compounds can be processed to obtain the metal from it e.g. copper can be obtained from its compounds by displacement or electrolysis.
Bioleaching	*Bacteria is used to produce leachate solutions that contain metal compounds*	The metal compounds can be processed to obtain the metal from it e.g. copper can be obtained from its compounds by displacement or electrolysis.