CHURCH STRETTON SCHOOL

Triple Science - Chemistry

SC20-21 Knowledge organiser

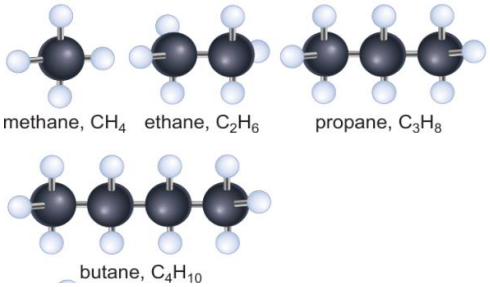
SC20-21: Fuels and the atmosphere

Lesson sequence

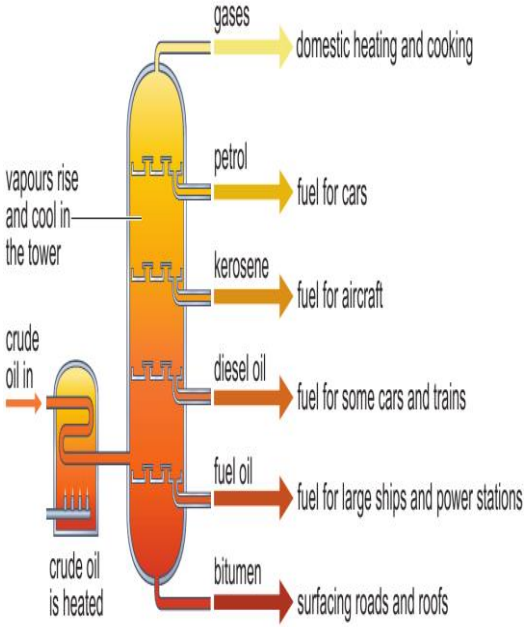
1. Hydrocarbons
2. Fractional distillation of crude oil
3. The alkanes
4. Complete and incomplete combustion
5. Fuels and pollution
6. Cracking
7. The early atmosphere
8. The changing atmosphere
9. The atmosphere today
10. Climate change

1. Hydrocarbons	
Hydrocarbon	A compound containing only hydrogen and carbon.
Crude oil	A thick brown liquid made of a mixture of many different hydrocarbons found in deposits underground.
Molecules in crude oil	Hydrocarbons in many different forms with carbons joined together into both chain- and ring-shaped molecules.
Properties of hydrocarbons in crude oil	Most of the hydrocarbons in crude oil are liquids, but each of them has a different boiling point.
Hydrocarbons in crude oil	Mostly alkanes.
Uses of crude oil	Fuel, feedstock (supply of basic chemicals) for the chemical industry.
Crude oil as a finite resource	There is a limited amount: at some point it will run out.
Non-renewable	A resource that will eventually run out.

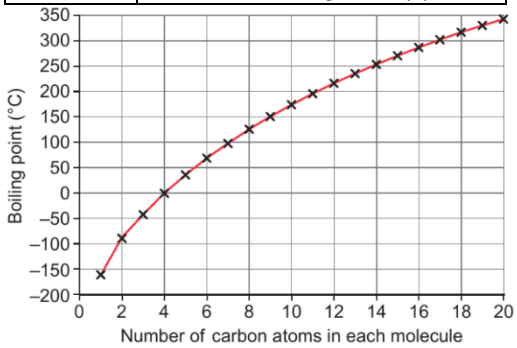
2. Fractional distillation of crude oil	
Fractional distillation	A type of distillation used to separate mixtures of two or more liquids.
Separation in fractional distillation	Fractional distillation separate compounds according to their boiling point.
Heating crude oil	Crude oil is passed through a heater to heat it to about 400^{O}C so that nearly everything is a gas.
Separating crude oil in a fractionating column	The hot gases rise up the fractionating column until cool enough to condense.
Fractions of crude oil	The separated liquids and gases collected at different temperatures. The main ones are gases, petrol, kerosene, diesel oil, fuel oil, and bitumen.
Fractions in order	Gases, petrol, kerosene, diesel, fuel oil, bitumen: - Smallest to biggest molecules - Lowest to highest boiling point - Lowest to highest viscosity - Easiest to hardest ignition
Viscosity	How easily a fluid flows – higher viscosity = runnier.
Ease of ignition	How easily a substance catches fire.
Gases	Used for domestic heating and cooking.
Petrol	Used as a fuel for cars.
Kerosene	Fuel for aircraft
Diesel oil	Fuel for larger vehicles such as lorries and trains
Fuel oil	Fuel for ships and power stations
Bitumen	Surfacing roads and roofs



3. The alkanes	
Homologous series	A family of closely related compounds with molecular formulae that differ only in the number of 'CH_2's.
Physical properties in a homologous series	Vary gradually, for example the boiling point gradually increases.
Chemical properties in a homologous series	Very similar with a gradual variation.
General formula	Describes the number of each atom in any member of a homologous series.
Alkanes	Hydrocarbons containing only single bonds. The names end with '-ane'.
First three alkanes	Methane – CH_4 Ethane – C_2H_6 Propane – C_3H_8
General formula of alkanes	C_nH_{2n+2}



4. Complete and incomplete combustion	
Combustion	When a compound reacts with oxygen producing a flame.
Complete combustion	Combustion that produces only water and carbon dioxide and releases the most possible energy.
Complete combustion equation	Fuel + oxygen → carbon dioxide + water E.g: Ethane + oxygen → carbon dioxide + water $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
Incomplete combustion	Combustion that produces a mixture of carbon dioxide, carbon monoxide, carbon and water and produces less energy.
Why incomplete combustion happens	When there is not enough oxygen for all of the reactants to be fully oxidised.
Carbon monoxide	CO. A colourless odourless a highly toxic gas.
How carbon monoxide kills	It sticks to haemoglobin in the blood which prevents it from carrying oxygen.
Soot	The small particles of carbon produced by incomplete combustion.
Problems with soot	- Causes lung problems when breathed in. - Blackens and dirties buildings
Preventing incomplete combustion	It is important that boilers at home have a good air supply to prevent incomplete combustion. For this reason, a boiler's flue pipe should be checked for blockages every year.



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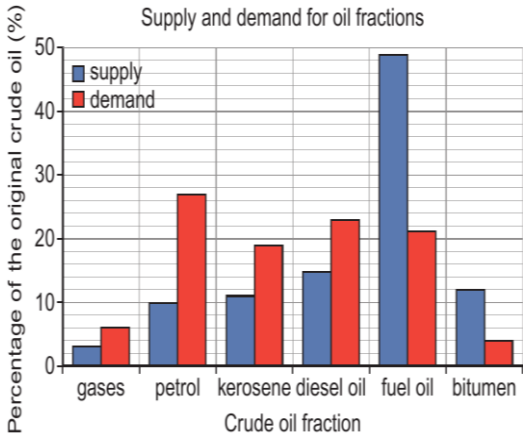
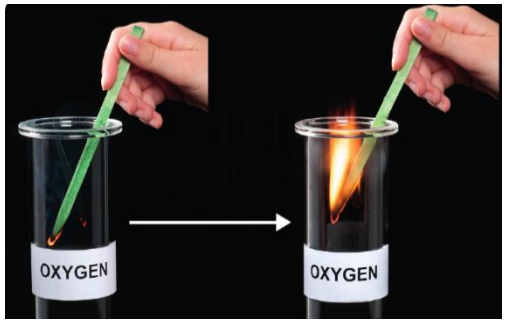
5. Combustible fuels and pollution	
Sulfur	An impurity that is naturally present in small amounts in oil and coal.
Sulfur dioxide	SO_2. A gas formed from the sulfur in oil and coal when it is burnt.
Acid rain	Rain with a pH lower than 5.2
Formation of acid rain	Sulfur dioxide dissolves in water in clouds to form sulfurous acid (H_2SO_3) which oxidises to become sulfuric acid (H_2SO_4)
Effects of acid rain	- Soil becomes too acidic for crops and plants to grow well - Acid in rivers and lakes prevents fish eggs from hatching and kills some insects. - Acid rain increases corrosion of limestone which damages buildings and statues
Nitrogen oxides	NO_x. Various gases formed at high temperatures inside internal combustion engines.
Problems of nitrogen oxides	- Dissolves in clouds forming acid rain - NO_2 causes lung damage - NO_x can cause smog to form

6. Cracking	
Cracking	Breaking down longer less useful hydrocarbons into shorter more useful ones.
How to crack hydrocarbons	Heat the hydrocarbons and pass the vapours over an aluminium oxide catalyst heated to 650^{O}C.
Products of cracking an alkane	An alkane and an alkene. E.g.: Hexane → butane + ethene $C_6H_{14} \rightarrow C_4H_{10} + C_2H_4$
Alkene	A hydrocarbon containing a C=C double bond.
Usefulness of cracking	There is more demand for shorter hydrocarbons – such as petrol and gas – than longer ones such as bitumen. Cracking turns the less useful ones into more useful ones.
Hydrogen gas as a fuel	H_2. Hydrogen has the potential to be used as a fuel for cars.
Advantages of hydrogen as a fuel	- It only produces H_2O when burnt so does not directly contribute to global warming - It can be produced using renewable energy
Disadvantages of hydrogen as a fuel	- Most of it is currently produced in ways that also produce CO_2 which contributes to global warming - It is difficult to store

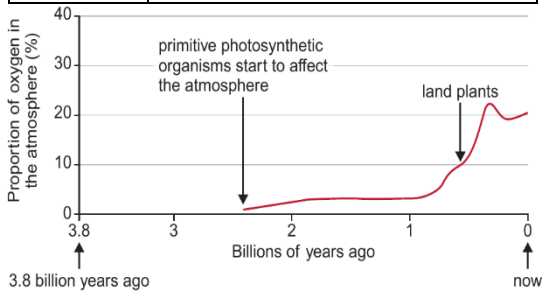


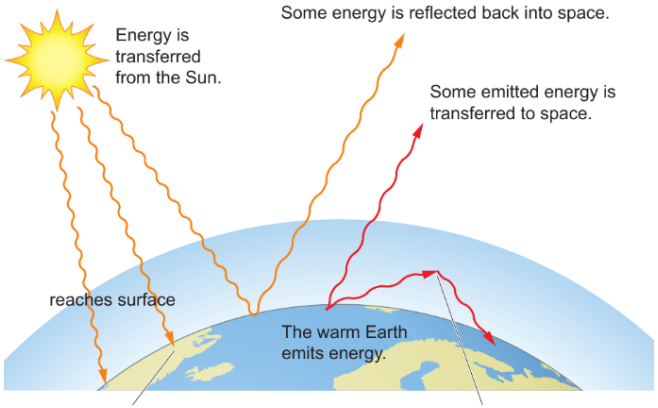
7. The early atmosphere	
The early Earth	4.5-3.5 billion years ago the Earth was extremely hot and there were many volcanoes.
The early atmosphere	Little or no oxygen, a lot of carbon dioxide, water vapour, small amounts of other gases such as nitrogen.
Origin of the early atmosphere	Gases from volcanoes.
Evidence for a lack of oxygen	The oldest rocks on Earth contain compounds such as iron pyrite that cannot form in the presence of oxygen.
Formation of the oceans	As the Earth cooled, water vapour in the air condensed to liquid water, forming the oceans.

8. The changing atmosphere	
Changes to the atmosphere	The amount of carbon dioxide decreased, water vapour decreased, oxygen increased.
Photosynthesis and the atmosphere	Photosynthesis – by cyanobacteria and plants – consumes carbon dioxide (decreasing it) and produces oxygen (increasing it).
Oceans and carbon dioxide	Carbon dioxide dissolves in the ocean and is used by sea creatures to make their shells, enabling even more CO_2 to dissolve.
Test for oxygen	A glowing splint (stick) placed in oxygen will relight.



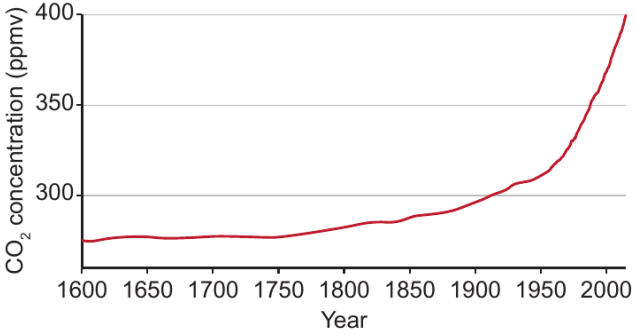
9. Global warming	
Greenhouse effect	Infrared radiation (heat) from the sun travels through the atmosphere and warms the ground. The ground re-emits slightly different infrared radiation that is not able to pass back through the atmosphere and is trapped by gases called greenhouse gases.
Greenhouse gases	Gases that trap re-emitted infrared radiation – including carbon dioxide, methane and water vapour.
Importance of the greenhouse effect	The greenhouse effect is extremely important; without it the average global temperature would be 32 ^{O}C lower and most life could not exist.
Increased greenhouse effect	Human activities are increasing the concentration of greenhouse gases such as carbon dioxide and methane, meaning the greenhouse effect is strong and traps more heat.
Global warming	An increase in global temperatures caused by the increased greenhouse effect.
Climate change	Change in global weather patterns caused by global warming.
Correlation between carbon dioxide and temperature	In Earth's history, every time CO_2 concentrations have been high, the temperature has also been high. This makes scientists think that the current increase in CO_2 is what is increasing the temperature.
Uncertainty in the data	Scientists measurements of past temperature and CO_2 are not perfect which makes some people doubt them. However, many different sets of data say very similar things, so most scientists believe them.



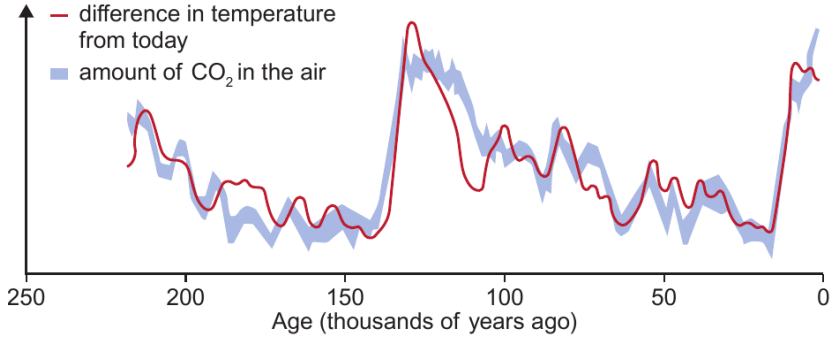


A The greenhouse effect keeps the Earth warm.

10. Impact of climate change	
Two main causes of climate change	- Carbon dioxide produced by burning fossil fuels - Methane produced by farming (especially cows)
Effects of climate change	- Rising average global temperature - Increased sea level from melting ice - Increased drought in some areas and flooding in others - Increase in dangerous weather
Effect of climate change on life	Living organisms are adapted to the conditions where they live. If these conditions change they may struggle to survive. Climate change is causing many species to struggle and some to go extinct.
Ocean acidification	The carbon dioxide we produce dissolves in the oceans, lowering the pH making it harder for many sea-creatures to build their shells.
Limiting climate change	- Reduce emissions of greenhouse gases by using renewable energy and eating less meat. - Geoengineering – perhaps placing giant mirrors in space to reflect some of the sun's heat.



B CO_2 levels have risen dramatically since about 1850.



C Average global temperatures and atmospheric carbon dioxide levels are correlated.

D Gases are trapped in ice cores.

A Methane being released and burnt off on an oil rig.

B Rice paddy fields produce significant amounts of methane.

C If coral remain 'bleached' for too long they can die.