Crude Oil, Fractional Distillation and Hydrocarbons

The formation of Crude Oil, how it is processed to produce a range of useful materials, including Plastics via Polymerisation.

Crude Oil

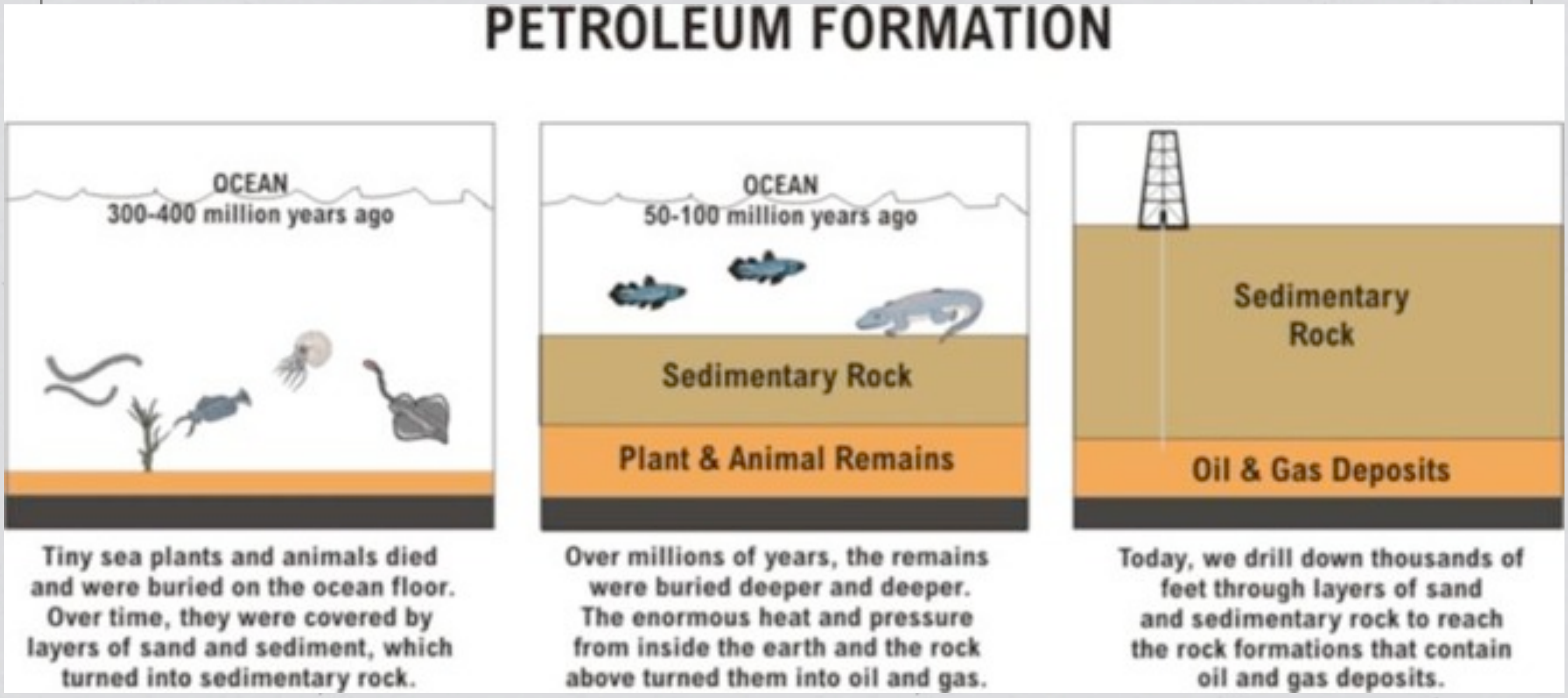
Crude oil is obtained from the Earth's crust.

It was formed from the remains of organisms which lived millions of years ago.

It is a fossil fuel.

The fossil fuels coal, oil and natural gas have resulted from the action of **heat** and **pressure** over **millions** of years, in the absence of air, on material from animals and plants (organic material) which has been covered by layers of sedimentary rock.

Like all fossil fuels, Crude Oil was formed millions of years ago.



Crude oil is a mixture of compounds.

The compounds are mainly made up of the Elements:

Carbon (C)

and

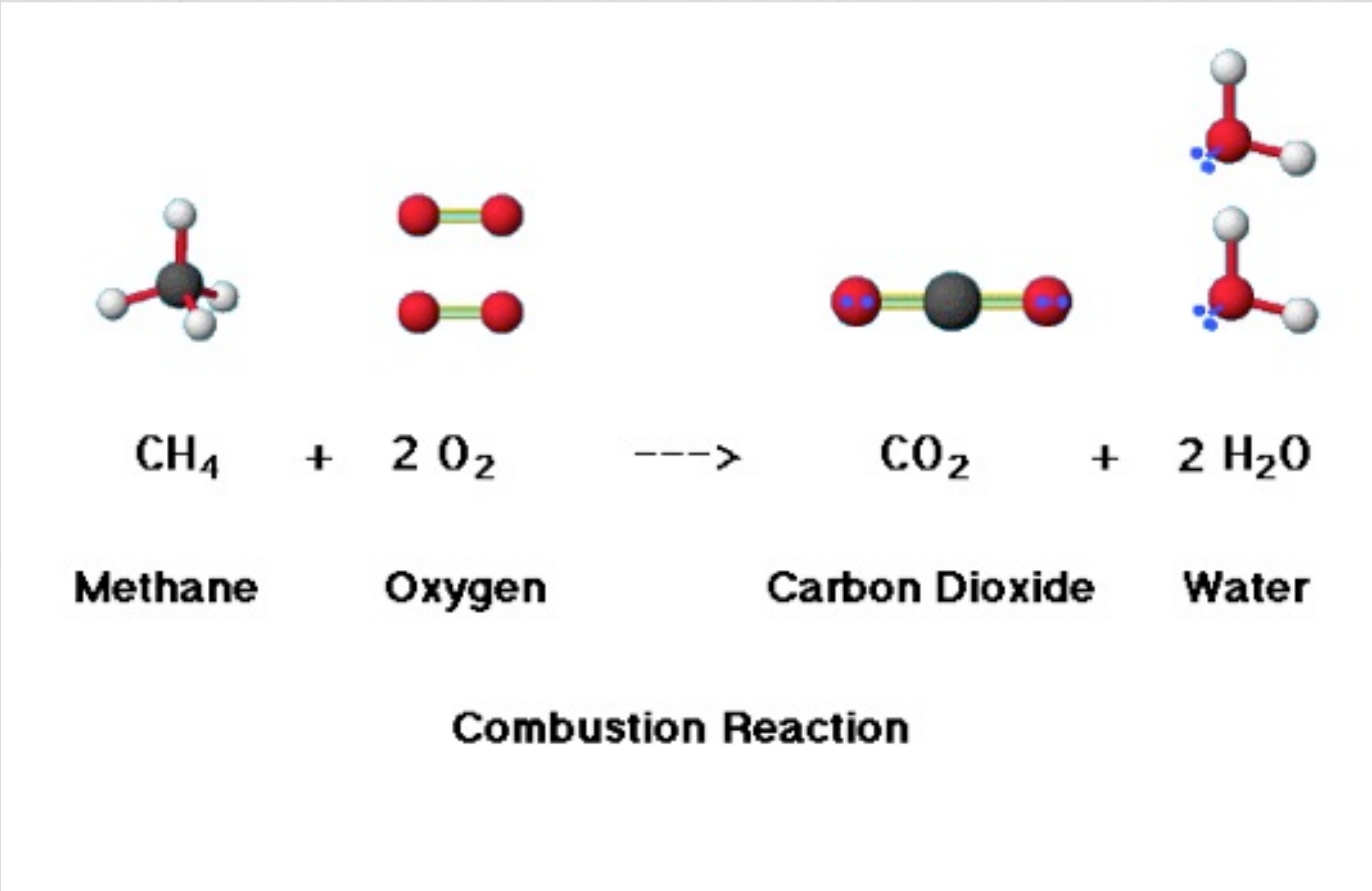
Hydrogen (H)

They are referred to as **Hydrocarbons**

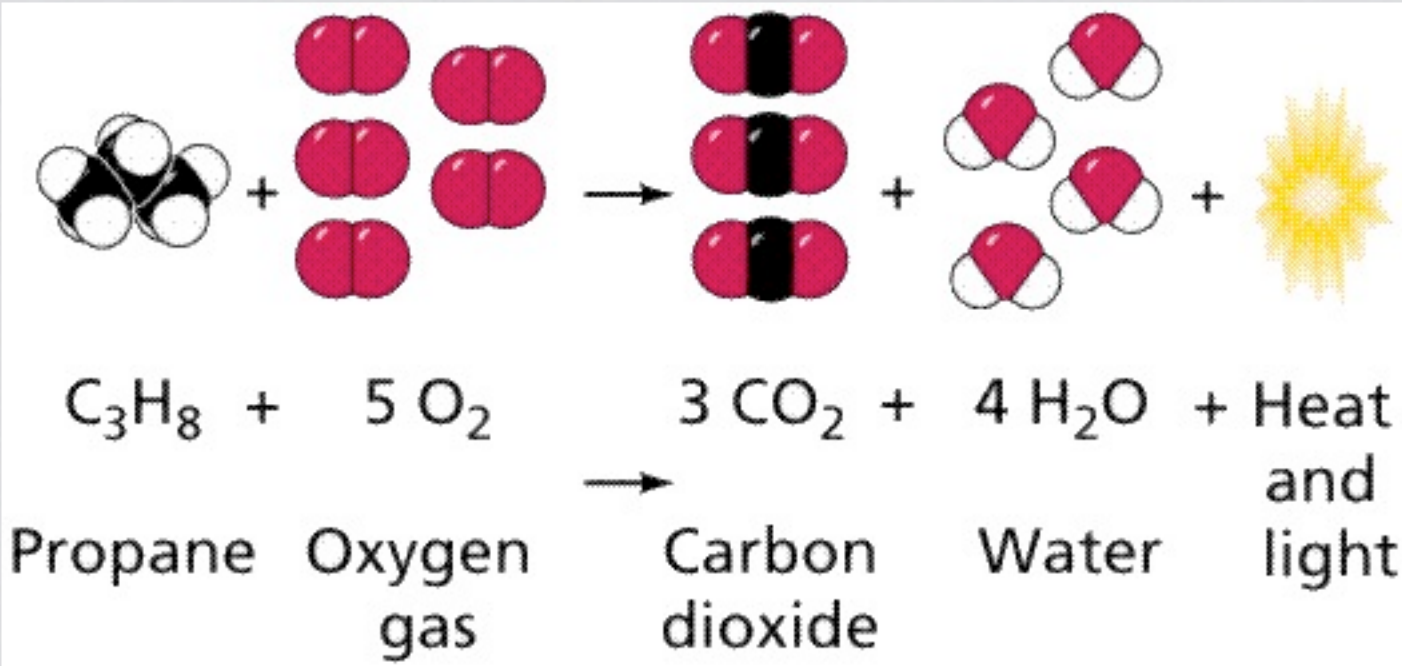
Properties of Hydrocarbons

* Typically non-polar, and thus unsoluble in water.
* Most saturated hydrocarbons are generally unreactive.
* All hydrocarbons can undergo combustion

Combustion of Hydrocarbons



Exothermic Reactions

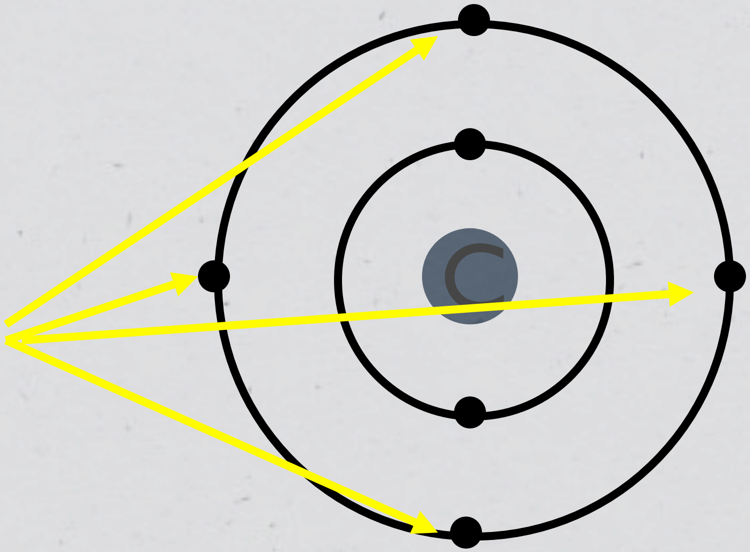


Incomplete Combustion

- hydrocarbon + oxygen → carbon monoxide + carbon + water

Hydrocarbons are made up of the elements Carbon and Hydrogen only

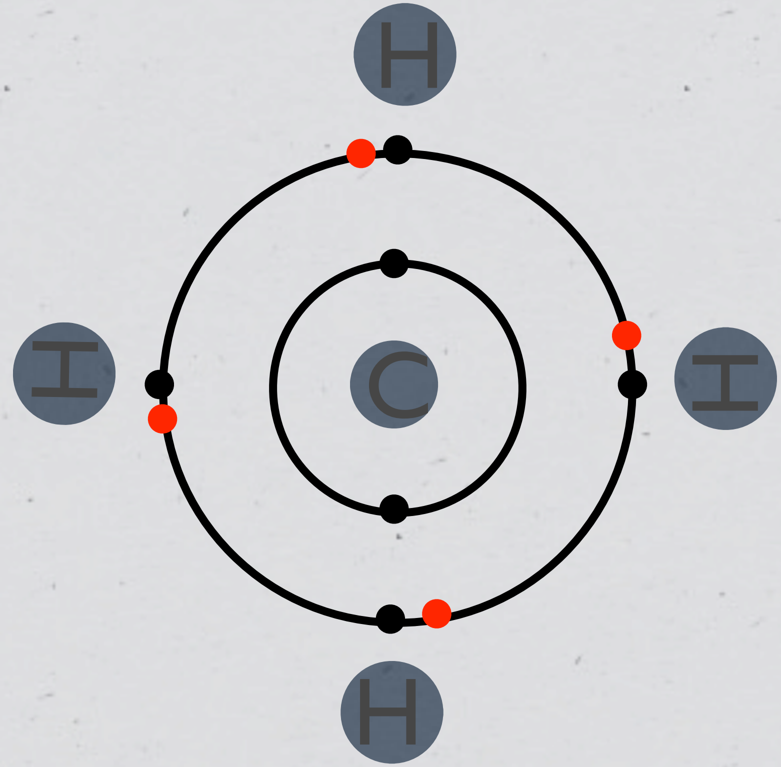
Carbon atoms have four electrons in their outer energy level which they use to form bonds with.

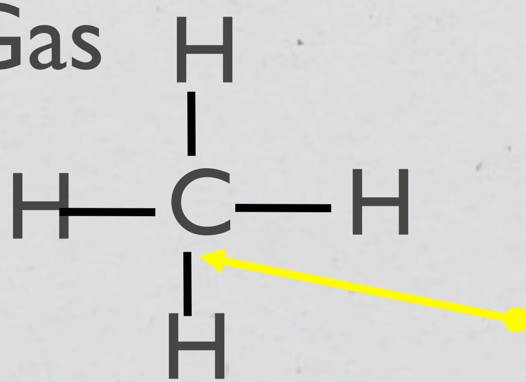


This means that they can make four covalent bonds with other things.

This diagram represents the hydrocarbon molecule Methane CH_4.

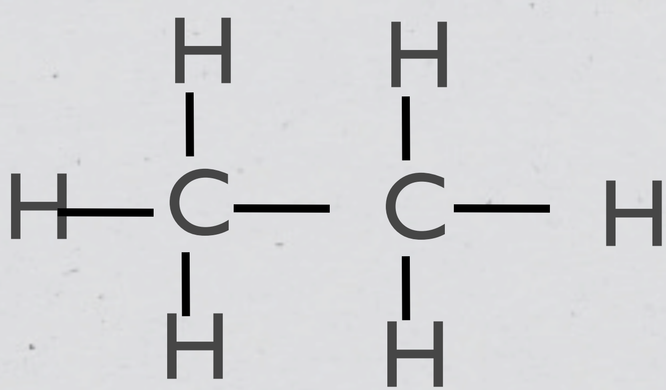
You will know it as Natural Gas





Structural formula

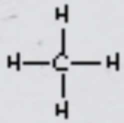
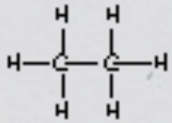
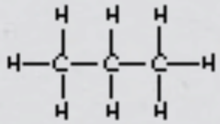
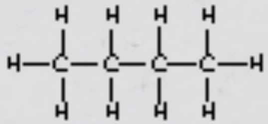
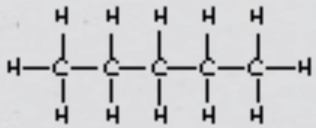
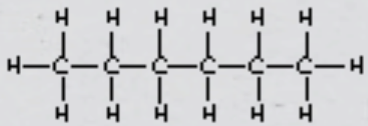
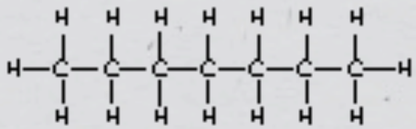
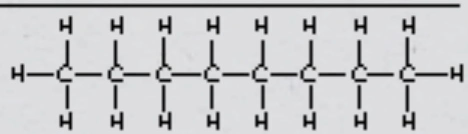
Carbon atoms can also form covalent bonds to other Carbon atoms, forming ‘Carbon chains’



This would represent a molecule of the Hydrocarbon Ethane,

formula C_2H_6

How would molecules of Propane C_3H_8 and Butane C_4H_{10} be drawn?

# Carbons	Name	Structure
1	methane	
2	ethane	
3	propane	
4	butane	
5	pentane	
6	hexane	
7	heptane	
8	octane	

The molecules with the least number of carbon atoms in them have the lowest boiling point.

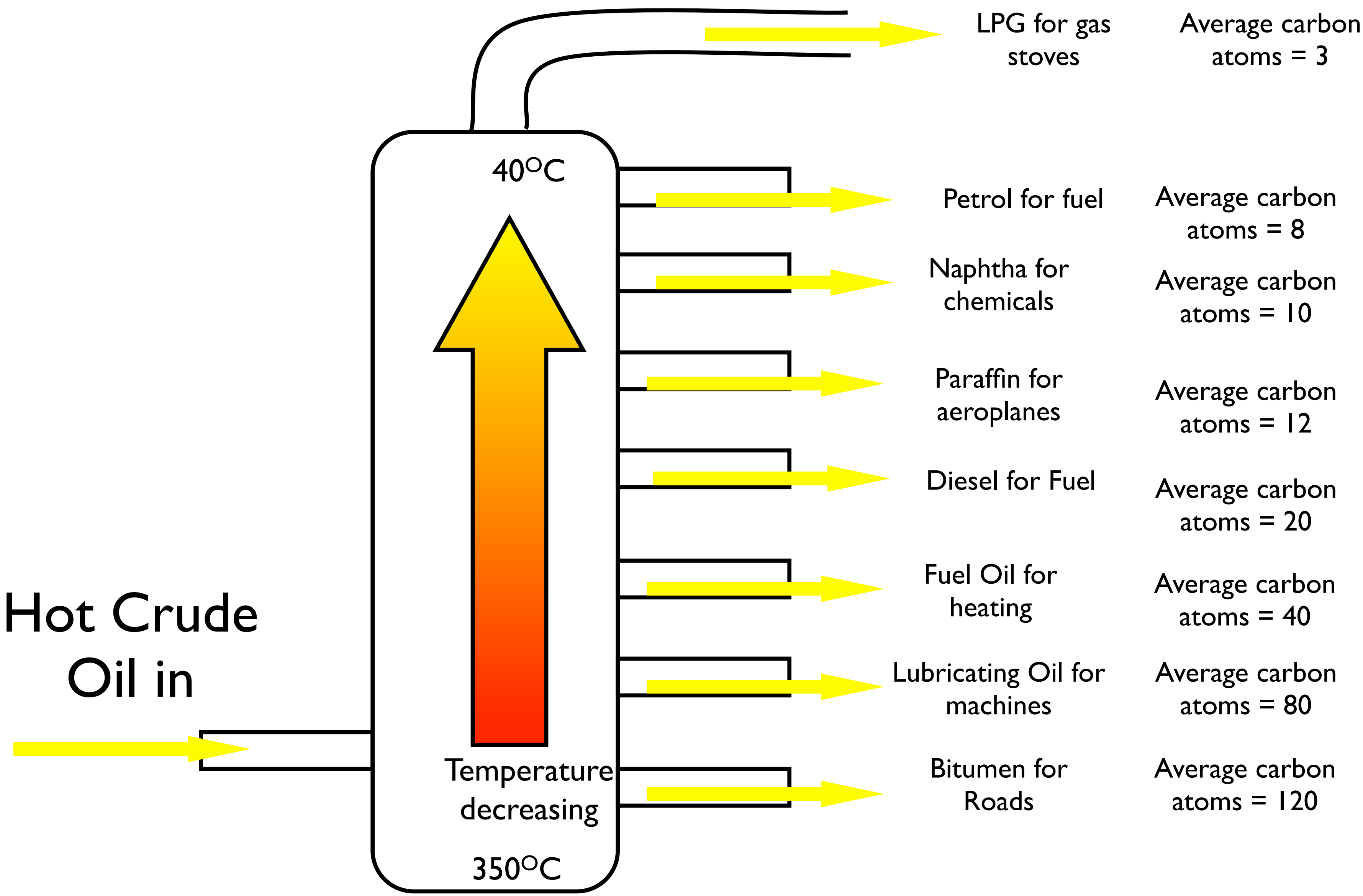
Methane CH_4	Boiling Point = - 163 Celsius
Ethane C_2H_6	Boiling Point = - 87 Celsius
Propane C_3H_8	Boiling Point = - 43 Celsius
Butane C_4H_{10}	Boiling Point = - 0.5 Celsius

There are many Hydrocarbon compounds in Crude Oil and this complex mixture is separated into a simpler mixture.

This simper mixture is made up of **Fractions**, groups of Hydrocarbons with similar carbon chain lengths.

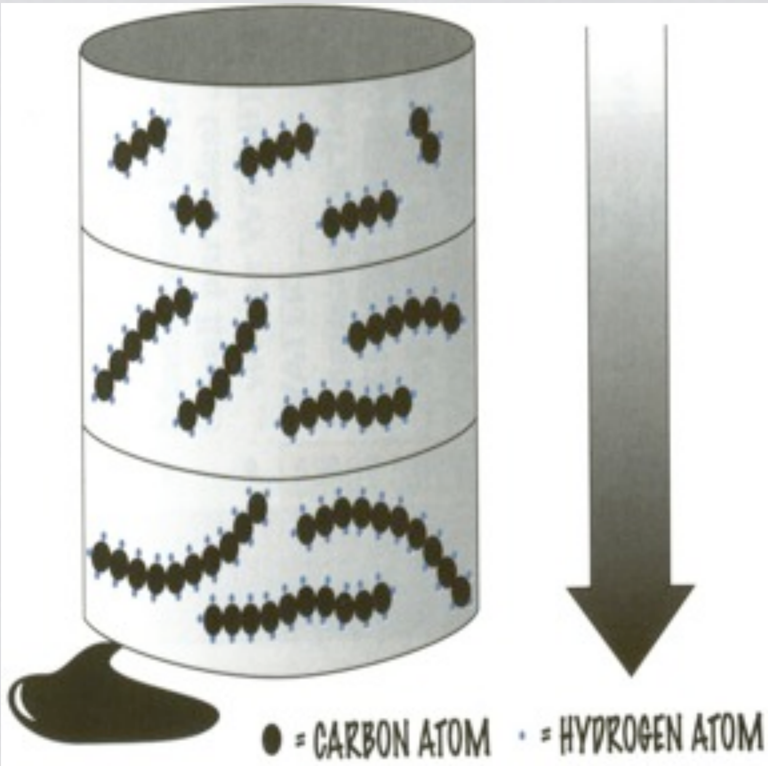
The Crude Oil is first heated to make it **Evaporate**, then it is allowed to cool at different temperatures, so that different Fractions **Condense** at different points.

This process is called **Fractional Distillation**.


LPG for gas stoves
Average carbon atoms = 3
40°C
Petrol for fuel
Average carbon atoms = 8
Naphtha for chemicals
Average carbon atoms = 10
Paraffin for aeroplanes
Average carbon atoms = 12
Diesel for Fuel
Average carbon atoms = 20
Fuel Oil for heating
Average carbon atoms = 40
Lubricating Oil for machines
Average carbon atoms = 80
Hot Crude Oil in
Temperature decreasing
Bitumen for Roads
Average carbon atoms = 120
350°C

The larger the molecule,

(the more Carbons atoms there are) :



The more **Viscous** it is (the less easily it flows).

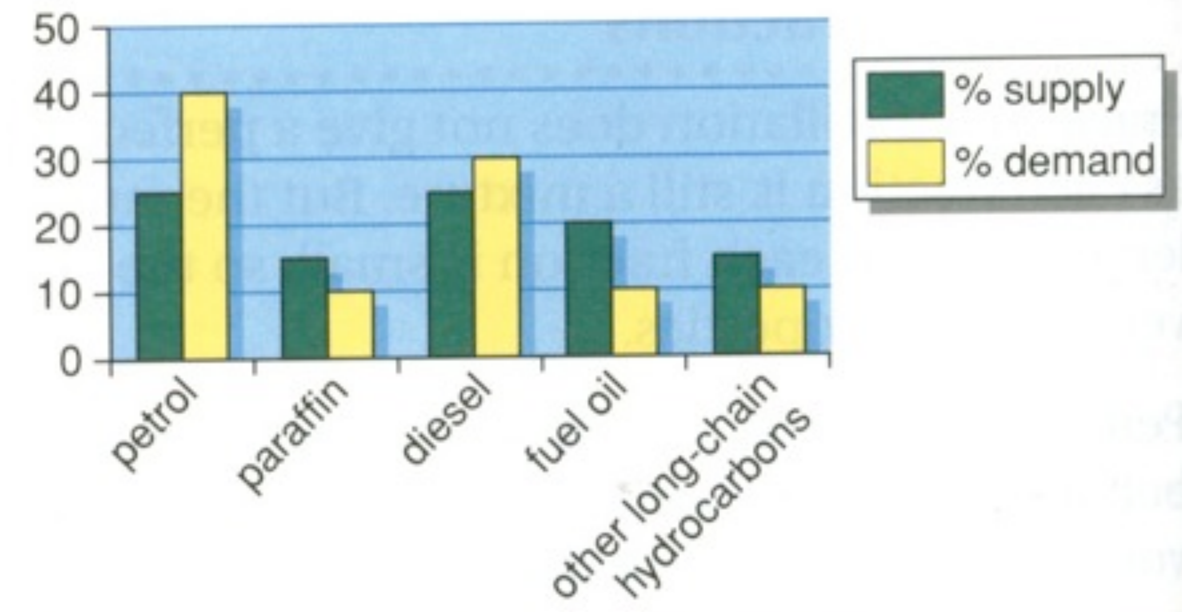
The less easily it ignites (the less **Flammable** it is).

The less **Volatile** it is (the harder it is to turn from a liquid into a vapour).

The higher its Boiling Point is.

Large hydrocarbons are thus less useful as fuels.

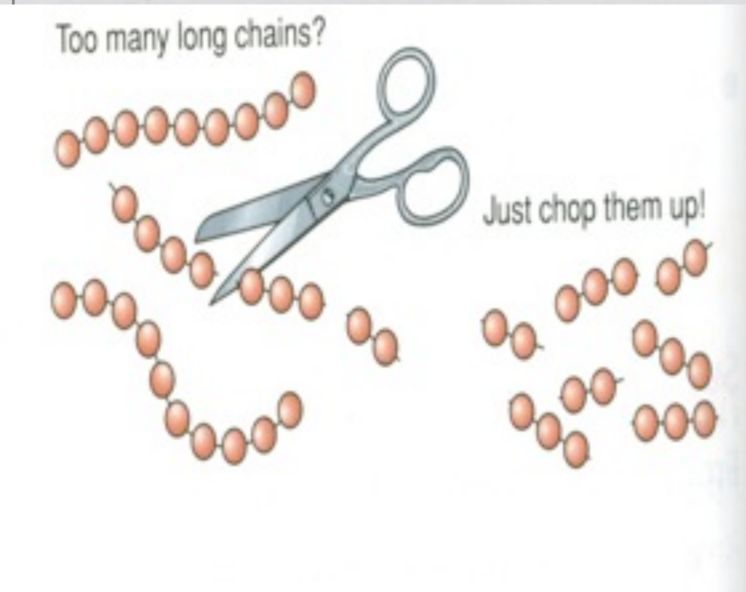
Since shorter molecules release energy quicker by burning, there is a greater demand for shorter molecules than for longer ones.

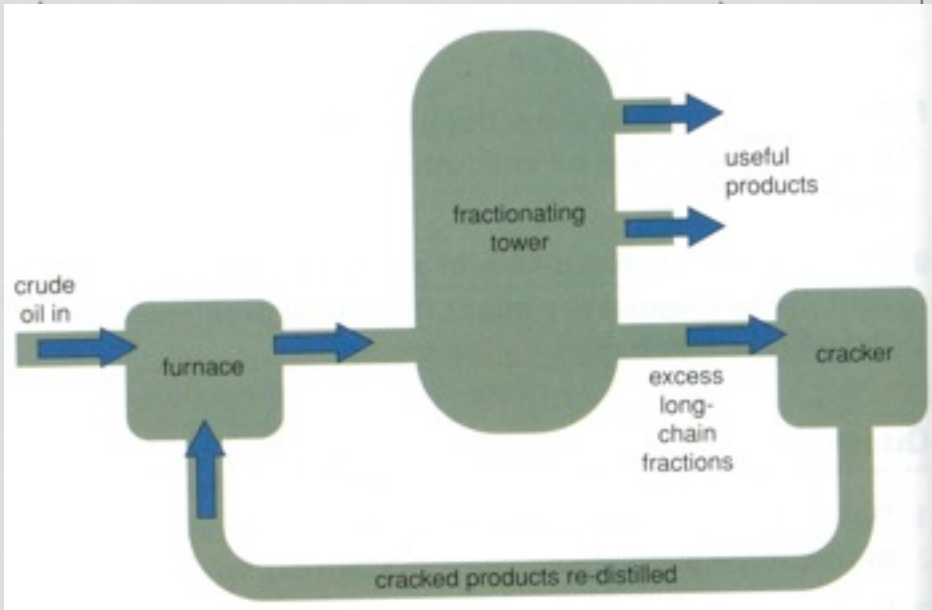


Supply and demand for crude oil products.

Longer molecules are broken down or **Cracked** into shorter, more useful ones.

The process is called **Catalytic Cracking.**



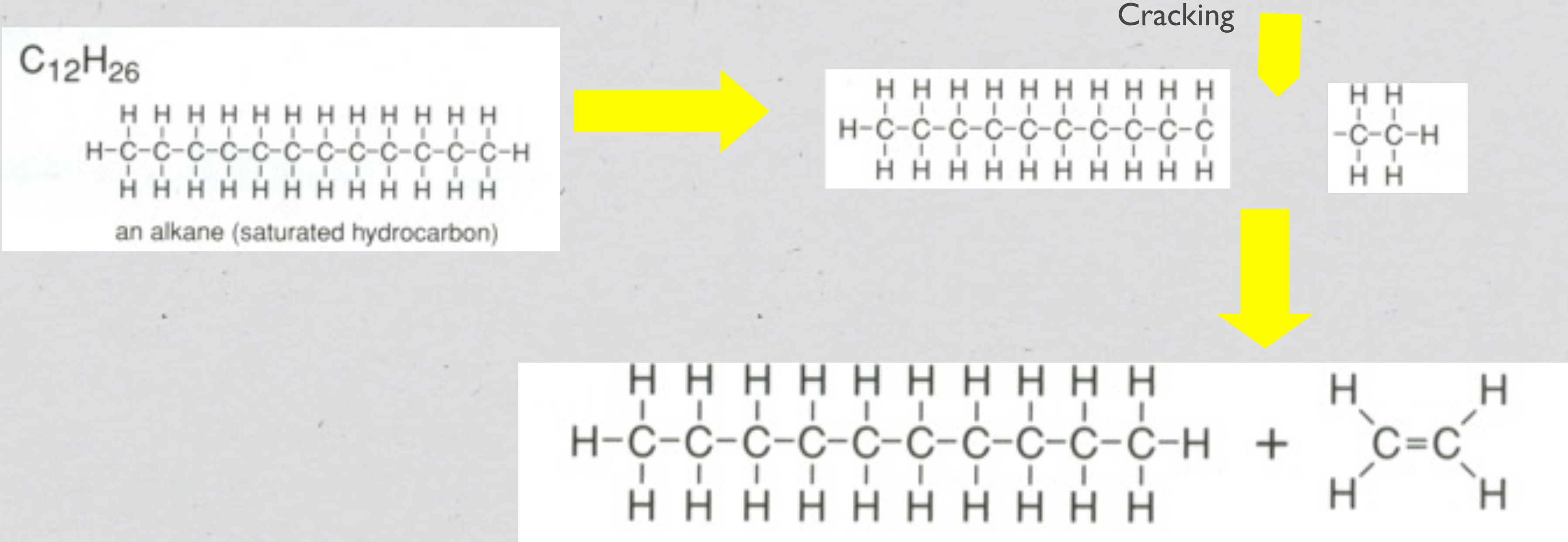


The hot Hydrocarbons are vaporised and passed over a hot Catalyst. A **Thermal Decomposition** reaction occurs. The products contain some molecules which are useful as fuels and some which are useful to make plastics from.

More about Catalytic Cracking

Cracking involves breaking a bond between two carbon Atoms. The ‘free’ ends of the broken bonds are very unstable, so the two new molecules rearrange themselves.

One ‘free’ end picks up a hydrogen atom to make an **Alkane**, the other joins onto the next carbon atom to make a carbon-carbon double bond, to form an **Alkene**.



$C_{10}H_{22}$ C_2H_4

a Saturated Alkane an Unsaturated Alkene