Fuels

Fossil fuels are a source of **feedstocks** and **fuels**.

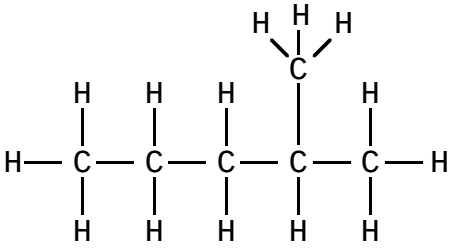
Feedstocks are chemicals from which other substances can be extracted or synthesised e.g. Ethene is a feedstock for the textiles and plastics industry.

Fuels are substances which burn in Oxygen to produce energy e.g. the burning of Octane:

$C_8H_{18} + O_2 \rightarrow CO_2 + H_2O \qquad \Delta H = -5512 \text{ kJ mol}^{-1}$

Naming Hydrocarbons

Example:

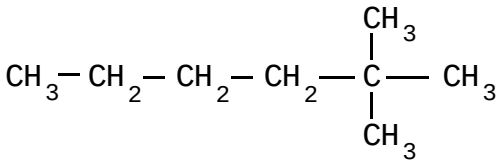


The above hydrocarbon is called 2-Methylpentane.

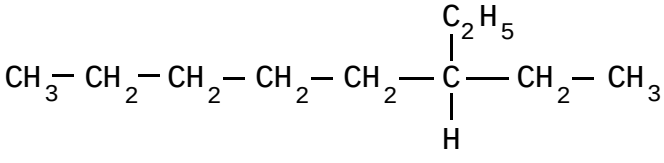
Select the longest carbon chain and number from the end nearest the branch.

The longest carbon chain is a 5-membered (Pentane) chain and there is a methyl CH_3- group on position 2.

A further two examples :



2,2-Dimethylhexane



3-Ethyloctane

Coal

Coal contains 95% Carbon and, as such, can be converted into a mixture of Carbon monoxide and Hydrogen (synthesis gas) by reaction with steam :

$C + H_2O \rightarrow CO + H_2$

Natural Gas

Natural gas contains mainly Methane, Ethane and a little Propane in varying proportions. These gases can be separated for specific purposes.

- The Methane can be converted into synthesis gas by reaction with steam :

$$CH_4 + H_2O \rightarrow CO + 3\ H_2$$

- Ethene can be obtained by cracking Ethane:

$$C_2H_6 \xrightarrow{\text{heat}} C_2H_4 + H_2$$

- Propene can be obtained by cracking Propane:

$$C_3H_8 \xrightarrow{\text{heat}} C_3H_6 + H_2$$

- Both Ethene and Propene can be obtained by cracking naptha e.g.:

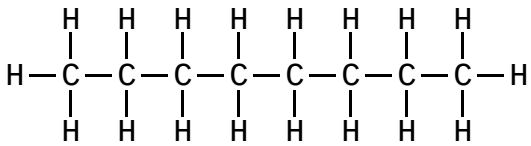
$$C_9H_{20} \xrightarrow{\text{heat}} 3\ C_2H_4 + C_3H_6 + H_2$$

Crude Oil

Crude oil is a mixture of hydrocarbons separable by distillation. Unfortunately crude oil contains very little of the C_5 - C_{10} fraction required for petrol. Since there are plenty larger molecules, **catalytic cracking** is used to convert these into smaller molecules more useful in petrol e.g.

$$C_{21}H_{44} \xrightarrow{\text{heat}} C_7H_{14} + C_6H_{12} + C_8H_{18}$$

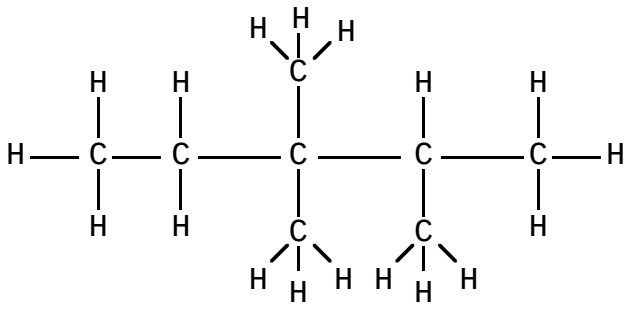
Most of the C_5 - C_{10} hydrocarbons obtained by distillation and/or cracking are straight-chained e.g.



Octane

Straight-chain hydrocarbons in petrol cause pre-ignition (knocking) in the engine - the petrol ignites during the compression stroke, **before** the spark is passed, reducing the efficiency of the engine. Lead tetraethyl was added to prevent pre-ignition but Lead is toxic and its use is now being phased out.

Branched-chain hydrocarbons do not cause pre-ignition e.g.



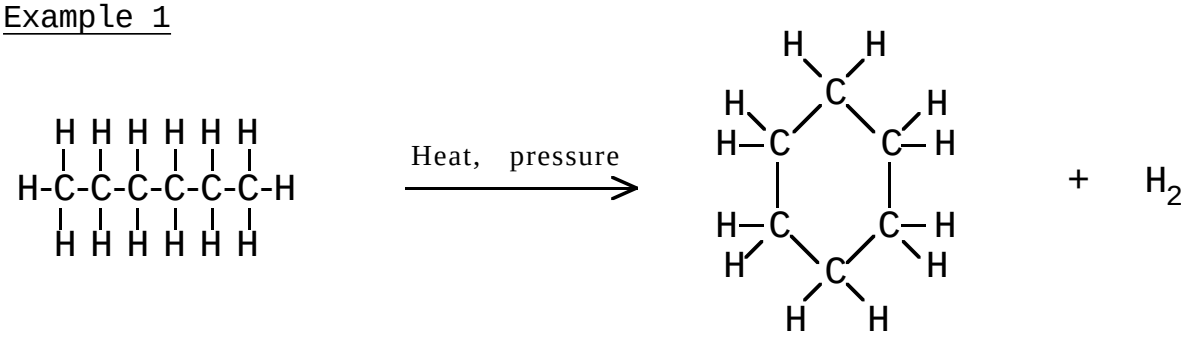
2,3,3-Trimethylpentane

The presence of cycloalkanes in petrol also reduces pre-ignition e.g. Cyclohexane.

Modern unleaded petrol therefore contains a high percentage of branched chain hydrocarbons and cycloalkanes made by **reforming**.

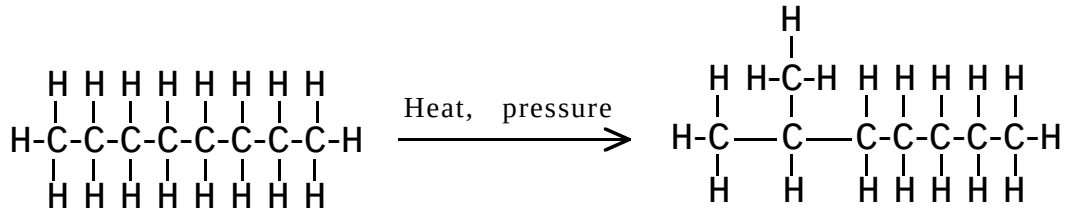
Reforming is closely related to cracking. Light hydrocarbons are heated to a temperature high enough to cause partial molecular breakdown, but at a pressure high enough to encourage recombination of the molecular fragments such that the size of the original molecule is not significantly reduced e.g. the conversion of straight chain naphtha fractions into branched-chain isomers or cycloalkanes.

Example 1



Hexane Cyclohexane

Example 2



Octane 2-Methyl heptane

Petrol is a blend of hydrocarbons of different volatilities which takes account of prevailing temperatures. During the summer, petrol companies add more hydrocarbons with higher boiling points (C_9-C_{12}) otherwise the petrol would evaporate too easily in hot weather. During the winter, more hydrocarbons with lower boiling points (C_5-C_8) are added to ensure that the petrol vapourises easily in cold weather.

POLLUTION

Burning fossil fuels causes pollution. Carbon dioxide is a 'Greenhouse' gas : it traps the Sun's infra-red radiation causing global warming. Most fossil fuels contain traces of Sulphur compounds which burn forming toxic Sulphur dioxide gas. It would seem sensible therefore to use the remaining fossil fuels as feedstocks and to develop renewable sources of energy (wind, solar, waves etc)

Alternative Fuels

1. Ethanol

Ethanol can be made by fermentation of the sugars obtained from plants - a renewable source of energy. Mixed with petrol, Ethanol can be used as a fuel in the car's engine !

2. Methanol

Methanol is prepared industrially by passing synthesis gas over a Zinc oxide/Chromium oxide catalyst at 300 ^{0}C and 260 atm.

$CO + 2H_2 \rightarrow CH_3OH \qquad \Delta H = -90 \text{ kJ mol}^{-1}$

Advantages of using Methanol as a fuel in cars:

- No modifications are required to the engine.
- No Sulphur dioxide emissions.
- High octane rating (low tendency to pre-ignite)

Disadvantages of using Methanol as a fuel in cars:

- Only half the energy produced by an equal volume of petrol so fuel tanks will need to be enlarged.
- Absorbs water which could clog filters and cause corrosion.

[http://ecep1.usl.edu/ecep/auto/m/m.htm]

3. Hydrogen

Burning Hydrogen instead of petrol (in cars) would reduce CO_2 emissions. The Hydrogen could be produced by electrolysis of sea water using solar energy - a renewable source of energy.

The Hydrogen could be stored in the car as a gas or liquid but large tanks would be required owing to the low density of the gas.

The Hydrogen could also be produced in situ by electrolysis of water while the car is running.

The Hydrogen could also be stored absorbed in powdered metals.

4. Biogas

The decay, in the absence of oxygen, of animal and plant remains (anaerobic fermentation) produces biogas - mainly Methane.