

ALKANES

- General**
- a homologous series with **general formula C_nH_{2n+2}** - non-cyclic only
 - **saturated hydrocarbons** - all carbon-carbon bonding is single
 - **aliphatic** - C atoms are in straight chains, branches or non-aromatic rings
 - C-C and C-H bonds are called **sigma (σ) bonds**; formed by overlap of orbitals
 - σ bonds can **rotate freely**
 - bonds are **spaced tetrahedrally** about carbon atoms.

- Isomerism**
- the first example of structural isomerism occurs with C_4H_{10}
 - two structural isomers exist



Q.1 Draw out and name the structural isomers of C_5H_{12} and C_6H_{14} .

Physical properties of alkanes

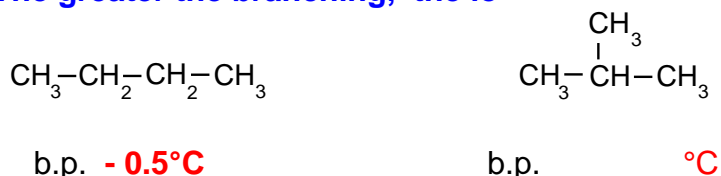
- Boiling point**
- increases as they get more carbon atoms in their formula
 - the more atoms there are the greater the induced dipole-dipole interactions
 - greater intermolecular force = more energy needed to separate the molecules
 - the more energy required, the higher the boiling point



difference gets less - mass is increasing by a smaller percentage each time

- straight chains have larger surface areas giving greater molecular interaction
- branched molecules are more compact and have less intermolecular attraction
- the lower the intermolecular forces, the lower the boiling point

“The greater the branching, the lower the boiling point ”



Q.2 Arrange the isomers of C_5H_{12} in ascending boiling point order.

Melting point A general increase with molecular mass BUT not as regular as for boiling point.

Solubility Are **non-polar** so are **immiscible with water** but soluble in most organic solvents.

CHEMICAL PROPERTIES OF ALKANES

Introduction

- **fairly unreactive** - *their old family name, paraffin, means little reactivity*
- consist of relatively strong, almost **non-polar** covalent bonds
- have no real sites that will encourage substances to attack them

Combustion

- alkanes make useful fuels - *especially the lower members of the series*
- combine with oxygen in an **exothermic reaction**



- the **greater the number of carbon atoms, the more energy produced** but...
- the greater the amount of oxygen needed for complete combustion.

Handy tip *When balancing equations involving complete combustion, every carbon in the original hydrocarbon gives a carbon dioxide and every two hydrogens give a water molecule. Put these numbers into the equation, count up the O and H atoms on the RHS of the equation then balance the oxygen molecules on the LHS.*

Q.3 • Write out the equation for the complete combustion of

butane

hexane

decane

- List uses of *methane*
- propane*
- butane*

Q.4 • Discuss the dangers of being over reliant on fossil fuels for providing energy.

- What alternative fuels are available?
- List any problems associated with an increase of CO_2 in the atmosphere.

Pollution Processes involving combustion give rise to a variety of pollutants ...
 power stations **SO₂** emissions produce acid rain
 internal combustion engines **CO, NO_x** and **unburnt hydrocarbons**

Q.5 What does the formula NO_x stand for ?

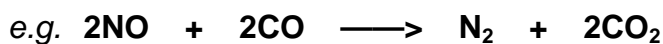
Q.6 Why are the following classed as pollutants ?

- CO
- NO_x
- unburnt hydrocarbons

AQA

Removal SO_2 react effluent gases with a suitable basic compound (e.g. CaO)
 CO and NO_x pass exhaust gases through a catalytic converter

Catalytic converters In the catalytic converter ... CO is converted to CO_2
 NO_x are converted to N_2
 Unburnt hydrocarbons to CO_2 and H_2O



- catalysts are made of finely divided rare metals
- leaded petrol must not pass through the catalyst as the lead deposits on the catalyst's surface and "poisons" it, thus blocking sites for reactions to take place.

Q.7 • Which metals are used in catalytic converters ?

- Why is the catalyst used in a finely divided form ?

Chlorination of methane

Reagents chlorine and methane

Conditions UV light or sunlight - *heat could be used as an alternative energy source*

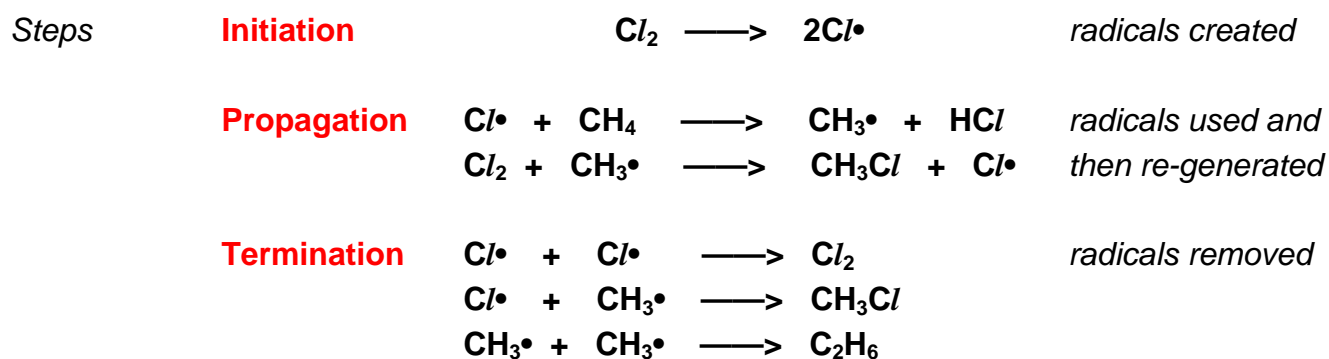


Mixture

- free radicals are very reactive as they are trying to pair up their unpaired electron
- if there is sufficient chlorine, every hydrogen will eventually be replaced.

Mechanism Mechanisms portray what chemists think is actually going on in the reaction, whereas an equation tells you the ratio of products and reactants. The chlorination of methane proceeds via a mechanism known as **FREE RADICAL SUBSTITUTION**. It gets its name because the methane is attacked by free radicals resulting in a hydrogen atom being substituted by a chlorine atom.

The process is an example of a **chain reaction**. Notice how, in the propagation step, one chlorine radical is produced for every one used up.



Q.9 Write out the two **propagation** steps involved in the conversion of CH_3Cl into CH_2Cl_2 .

Four chlorinated compounds can be produced from chlorine. State how many different chlorinated compounds can be made from...

(i) ethane

(ii) propane

CRACKING

Process

- involves the breaking of C-C (and C-H) bonds in alkanes
- converts heavy fractions into smaller, higher value products such as alkenes

- two types

THERMAL	Free radical mechanism
CATALYTIC	Carbocation (carbonium ion) mechanism

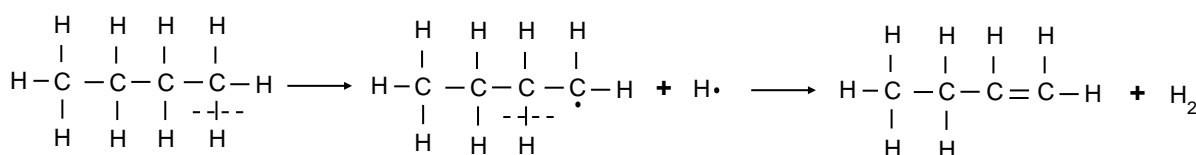
THERMAL

- HIGH PRESSURE ... 7000 kPa
- HIGH TEMPERATURE ... 400°C to 900°C
- FREE RADICAL MECHANISM
- HOMOLYTIC FISSION
- PRODUCES MOSTLY ALKENES e.g. *ETHENE* for making polymers / ethanol
- PRODUCES HYDROGEN used in the Haber Process / margarine manufacture

AQA

Examples Bonds can be broken anywhere by C-C bond fission or C-H bond fission

C-H fission

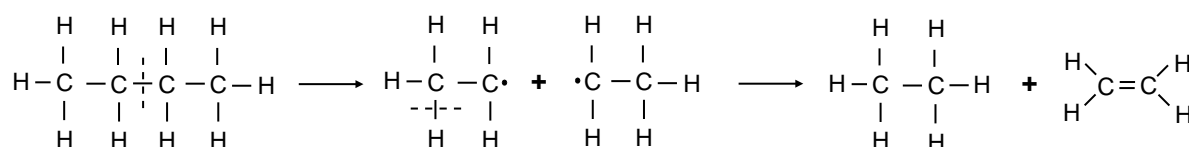


A C-H bond breaks to give a hydrogen radical and a butyl radical.

The hydrogen radical abstracts another hydrogen leaving two unpaired electrons on adjacent carbon atoms. These join together to form a second bond between the atoms.

an alkene and hydrogen are formed

C-C fission



C-C bond breaks to give two ethyl radicals.

One ethyl radical abstracts a hydrogen from the other, thus forming ethane. The unpaired electrons on adjacent carbons join together to form a second bond.

an alkene and an alkane are formed

CATALYTIC

- SLIGHT PRESSURE
- HIGH TEMPERATURE ... 450°C
- ZEOLITE (Crystalline aluminosilicates; clay like substances) CATALYST
- CARBOCATION (carbonium ion) MECHANISM
- HETEROLYTIC FISSION
- MAKES BRANCHED / CYCLIC ALKANES & AROMATIC HYDROCARBONS
- MOTOR FUELS ARE A PRODUCT

The Petrochemical Industry

Crude Oil In the past, most important organic chemicals were derived from coal. Nowadays, natural gas and crude petroleum provide an alternative source.

- the composition of crude petroleum varies according to its source
- it is a dark coloured, viscous liquid
- consists mostly of alkanes with up to 40 carbon atoms +water, sulphur and sand
- can be split up into fractions by fractional distillation
- distillation separates the compounds according to their boiling point
- at each level a mixture of compounds in a similar boiling range is taken off
- rough fractions can then be distilled further to obtain narrower boiling ranges
- some fractions are more important - *usually the lower boiling point ones*
- high boiling fractions may be broken down into useful lower ones - **CRACKING**

	Approximate boiling range / °C	C's per molecule	Name of fraction	Use(s)
	< 25	1 - 4	LPG (Liquefied Petroleum Gas)	Calor Gas Camping Gas
	40-100	6 - 12	GASOLINE	Petrol
	100-150	7 - 14	NAPHTHA	Petrochemicals
	150-200	11 - 15	KEROSINE	Aviation Fuel
	220-350	15 - 19	GAS OIL	Central Heating Fuel
	> 350	20 - 30	LUBRICATING OIL	Lubrication Oil
	> 400	30 - 40	FUEL OIL	Power Station Fuel Ship Fuel
	> 400	40 - 50	WAX, GREASE	Candles, Grease for bearings
	> 400	> 50	BITUMEN	Road and roofing surfaces

Q.10 Not all fractions are of equal importance. Why is this? What is done to get a greater amount of the more useful products?