Alkanes Summary Map

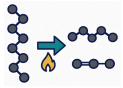
AQA A-level Chemistry · 3.3.2 Alkanes

1 Crude oil 3.3.2.1

- A mixture of hydrocarbons, mostly alkanes
- **Fractional distillation**: separates by boiling point
- Column: hot at the bottom, cool at the top
- Longer chains: stronger London forces, higher boiling point, condense lower
- Fractions: gases, petrol, naphtha, kerosene, diesel, fuel oil, bitumen

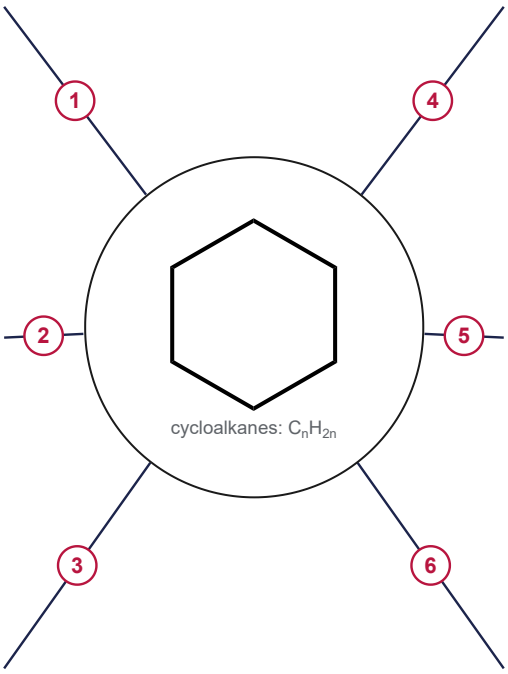
2 Cracking 3.3.2.2

- Long chains → shorter alkanes + alkenes
- Economics: more demand for petrol and alkenes (polymers)
- Breaks C–C bonds: a chemical change
- e.g. $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$
- Balance C and H: the alkene is C_nH_{2n}



3 Thermal and catalytic 3.3.2.2

- **Thermal**: high temperature, high pressure
- Thermal gives a high percentage of alkenes
- **Catalytic**: zeolite, high temperature, slight pressure
- Catalytic gives motor fuels and aromatic hydrocarbons
- Mechanisms not required



4 Combustion 3.3.2.3

- **Complete** (excess O_2): $CO_2 + H_2O$
- **Incomplete** (limited O_2): CO or C + H_2O
- Very exothermic: alkanes are fuels
- Balance C, then H, then O last (halves allowed)
- Incomplete burning releases less energy



5 Pollutants 3.3.2.3

- **CO**: toxic, binds to haemoglobin, less O_2 carried
- **NO_x**: $N_2 + O_2$ from the air at high engine temperatures
- **SO_2**: sulfur impurities in the fuel
- NO_x and SO_2 dissolve in rain: acid rain
- Soot (lungs), unburned hydrocarbons (smog)
- Engines: NO_x, CO, carbon, unburned hydrocarbons

6 Removing pollutants 3.3.2.3

- **Catalytic converter**: removes NO_x, CO and unburned hydrocarbons
- $2CO + 2NO \rightarrow 2CO_2 + N_2$
- Pt and Rh on a ceramic honeycomb
- **Flue gases**: SO_2 removed by CaO or $CaCO_3$
- $CaO + SO_2 \rightarrow CaSO_3$; $CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$

Free radical substitution: methane and chlorine

UV light; a dot marks the unpaired electron (Cl•, •CH_3); curly arrows not required

Stage	What happens	Equation
initiation	UV light breaks Cl–Cl (homolytic fission)	$Cl_2 \rightarrow 2Cl•$
propagation 1	Cl• takes an H atom	$Cl• + CH_4 \rightarrow HCl + •CH_3$
propagation 2	•CH_3 takes a Cl atom; Cl• is remade	$•CH_3 + Cl_2 \rightarrow CH_3Cl + Cl•$
termination	two radicals pair their electrons	$Cl• + Cl• \rightarrow Cl_2$; $•CH_3 + Cl• \rightarrow CH_3Cl$; $2•CH_3 \rightarrow C_2H_6$
overall	Cl replaces H: substitution	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$
a chain reaction	Cl• made in step 2 starts step 1 again	one Cl• makes many CH_3Cl

Worked examples

Choosing a cracking method

- Ethene for polymers: **thermal** (many alkenes)
- Petrol: **catalytic** (motor fuels)
- Both: products worth more than heavy fractions
- Zeolite honeycomb: a large surface area

Balancing: a worked example

- Octane, complete: $C_8H_{18} + O_2 \rightarrow 8CO_2 + 9H_2O$
- O atoms: 16 + 9 = 25
- → **$C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$**
- To CO: $C_8H_{18} + 8½O_2 \rightarrow 8CO + 9H_2O$

Sulfur dioxide

- From sulfur in fuels: $S + O_2 \rightarrow SO_2$
- Dissolves in rain: acid rain
- Acidic oxide: removed by bases (CaO, $CaCO_3$)
- Product: calcium sulfite, then gypsum

Ethane among the products of chlorinating methane is evidence for methyl radicals ($2•CH_3 \rightarrow C_2H_6$).

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